TCF–10B

FREQUENCY-PROGRAMMABLE FREQUENCY-SHIFT CARRIER TRANSMITTER/RECEIVER

System Manual

CF44–VER02

(Replaces CF44–VER01)

Pulsar
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TCF–10B

System Manual

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Important Change Notification

This document supersedes both the *TCF–10B Frequency-Programmable Frequency-Shift Carrier Transmitter/Receiver System Manual CF44–VER01*, last printed in April 1996, and the *Addendum to CF44–VER01*, printed December 10, 1996. The following list shows the most recent publication date for each chapter. Publication dates in **bold type** indicate changes to that chapter since the previous publication. For these chapters, the specific pages that have changed are listed for easy reference. Note that only significant changes, i.e., those changes which affect the technical use and understanding of the document and the TCF–10B equipment, are reported. Changes in format, typographical corrections, minor word changes, etc. are not reported. Note also that in some cases text and graphics may have flowed to a different page than in the previous publication due to formatting or other changes. The page numbers below show the current pages on which the reported changes appear.

Each reported change is identified in the document by a change bar placed in the margin to its immediate left, just like the one on this page.

Chapter Number & Title	Publication Date	Pages with Changes
Front Section	**April 1997**	ii
1. Product Description	**April 1997**	1-3, 1-13
2. Applications and Ordering Information	December 1996	
3. Installation	**April 1997**	3-10, 3-11
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6. Routine Adjustment Procedures	**April 1997**	6-11
7. Signal Path	**April 1997**	7-3, 7-5
8. Maintenance	January 1996	
9. Power Supply Module	January 1996	
10. Keying Module	January 1996	
11. Transmitter Module	**April 1997**	11-7
12. 10W PA Module	January 1996	
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14. Receiver/Synthesizer Module	April 1996	
15. CLI and Discriminator Module	January 1996	
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17. EM Output Module	January 1996	
18. Optional Voice Adapter Module	**April 1997**	18-9
19. Optional Transfer Trip Test Unit (TTU)	December 1996	

! IMPORTANT

We recommend that you become acquainted with the information in this manual before energizing your TCF–10B system. Failure to do so may result in injury to personnel or damage to the equipment, and may affect the equipment warranty. If you mount the carrier set in a cabinet, it must be bolted to the floor or otherwise secured before you swing out the equipment, to prevent the installation from tipping over.

You should not remove or insert printed circuit modules while the TCF–10B is energized. Failure to observe this precaution can result in undesired tripping output and can cause component damage.

All integrated circuits used on the modules are sensitive to and can be damaged by the discharge of static electricity. You should observe electrostatic discharge precautions when handling modules or individual components.

PULSAR does not assume liability arising out of the application or use of any product or circuit described herein. PULSAR reserves the right to make changes to any products herein to improve reliability, function or design. Specifications and information herein are subject to change without notice. All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If you desire further information regarding a particular installation, operation, or maintenance of equipment, please contact your local Pulsar Technologies, Inc. representative.

Preface

Scope

This manual describes the functions and features of the TCF–10B Power Line Carrier Transmitter Receiver. It is intended primarily for use by engineers and technicians involved in the installation, alignment, operation, and maintenance of the TCF–10B.

Equipment Identification

The TCF–10B equipment is identified by the Catalog Number on the TCF–10B chassis nameplate. You can decode the Catalog Number using the Catalog Number Table in Table 2-4 and Figure 2-15 (see Chapter 2).

Production Changes

When engineering and production changes are made to the TCF–10B equipment, a revision notation (Sub number) is reflected on the style number, related schematic diagram, and associated parts information. A summary of all Sub numbers for the particular release is shown on the following page.

Warranty

Our standard warranty extends for either 18 months after the equipment is in-service or 24 months after shipment, whichever comes first. For all repaired modules or advance replacements, the standard warranty is 90 days or the remaining warranty time, whichever is longer. Damage clearly caused by improper application, repair, or handling of the equipment will void the warranty.

Equipment Return & Repair Procedure

To return equipment for repair or replacement:

1. Call your PULSAR representative at **1–800–785–7274**.
2. Request an **RMA number** for proper authorization and credit.
3. Carefully pack the equipment you are returning.

   Repair work is done most satisfactorily at the factory. When returning any equipment, pack it in the original shipping containers if possible. Be sure to use anti-static material when packing the equipment. Any damage due to improperly packed items will be charged to the customer, even when under warranty.

   Pulsar Technologies, Inc. also makes available interchangeable parts to customers who are equipped to do repair work. When ordering parts (components, modules, etc.), always give the complete PULSAR style number(s).
4. Make sure you include your return address and the RMA number on the package.
5. Ship the package(s) to:

   Pulsar Technologies, Inc.
   Communications Division
   4050 NW 121st Avenue
   Coral Springs, FL 33065

Document Overview

The TCF–10B circuitry is divided into nine (9) standard modules. In addition, Voice Adapter, Electromechanical, and Transfer Trip Test Unit modules are available as options. (See Chapter 7, Figure 7-1, for a Functional Block Diagram.)

Chapter 1 provides the Product Description, which includes specifications; module circuit descriptions and troubleshooting procedures are in Chapters 9 thru 19. Chapter 2 presents applications and related catalog numbers for ordering purposes. The TCF–10B installation is described in Chapter 3, with maintenance procedures in Chapter 8. Chapters 4, 5, and 6 identify test equipment, acceptance tests, and adjustment procedures, respectively, while Chapter 7 describes the TCF–10B signal path (for use during testing).

Contents of Carrier Set

The TCF–10B carrier set includes the style numbers, listed below, with appropriate sub numbers representing revision levels. (To determine related style numbers, you may also refer to Figure 2-15.)

Module	Style	Sub Number
Power Supply	1617C38 GXX	2
Keying	1606C50 GXX	6
Transmitter	1610C01 G01	8
10W PA	1606C33 GXX	20
RF Interface	1609C32 GXX	8
Receiver/discriminator	C020-RXVMN-202	
Receiver Logic	CF20-RXLMN 0XX	1
EM Output	1606C53 G01	6
Voice Adapter	C020-VADMN-001	16
Transmitter w/Trip Test Unit	1610C01G02	3

FIGURES

FIGURES, Cont'd

FIGURES, Cont'd

TABLES

TABLES, Cont'd

TABLES, Cont'd

Trademarks

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Chapter 1. Product Description

1.1 Standard Nomenclature

The standard nomenclature for PULSAR carrier protection equipment is as follows:

Cabinet – contains fixed-racks, swing-racks, or open racks

Rack – contains one or more chassis (e.g., the TCF–10B)

Chassis – contains several printed circuit boards, called modules (e.g., Transmitter or Receiver)

Module – contains a number of functional circuits (e.g., Oscillator or Synthesizer)

Circuit – a complete function on a printed circuit board

1.2 TCF–10B Chassis

The TCF–10B chassis specifications (see Figure 3-3) include standard dimensions of:

Height – 5.25” (133.35 mm), requiring 3 rack units, each measuring 1.75” (44.45 mm)

Width – 19.00” (482.6 mm) **Depth –** 13.50” (342.9 mm)

Each chassis is notched for mounting in a standard relay rack.

1.3 TCF–10B Modules

The TCF–10B circuitry for the standard modules and the optional Voice Adapter, Electro-Mechanical Output and Trip Test Unit modules is shown on the Functional Block Diagram in Chapter 7. Circuit descriptions, complete with schematic diagrams and parts lists for each module, are shown in Chapters 9 through 19, along with sub numbers indicating the current revisions for each module, as follows:

Chapter	Module	Schematic	Parts List
9.	Power Supply	1617C38-2	1617C38-2
10.	Keying	1606C50-6	1606C50-6
11.	Transmitter	1355D71-8	1610C01-11
12.	10W PA	1606C33-20	1606C33-20
13.	RF Interface	1609C32-8	1609C32-8
14.	Receiver	1606C32-21	1606C32-21
	Synthesizer	1585C56-20	1585C56-20
15.	CLI and Discriminator	1606C51-10	1606C51-10
16.	Receiver Logic	CF30RXLMN	CF40RXLMN

Chapter	Module	Schematic	Parts Lists
17.	(Optional) EM Output	1606C53-6	1606C53-6
18.	(Optional) Voice Adapter	1606C39-16	1606C39-16
19.	(Optional) TTU – Trip Test Unit	1614C25-3	1614C27-4

NOTE

See Chapter 2, Applications and Ordering Information, for ordering information. See Chapter 3, Installation, for a summary of jumper controls.

1.4 TCF–10B Configurations

There are three different configurations (or sets) for the TCF–10B:

1) Transceiver (Transmitter with Receiver) set
2) Transmitter (only) set
3) Receiver (only) set

1.4.1 Transceiver Set

The Transceiver set (see Figure 1-1) includes the following modules:

- Power Supply
- Keying
- Transmitter
- 10W PA
- RF Interface
- Receiver/discriminator
- Trip Test Unit (Optional)
- Receiver Logic
- EM Output (Optional)
- Voice Adapter (Optional)

1.4.2 Transmitter (only) Set

The Transmitter (only) set (see Figure 1-2) includes the following modules:

- Power Supply
- Keying
- Transmitter
- 10W PA
- RF Interface
- Trip Test Unit (Optional)

1.4.3 Receiver (only) Set

The Receiver (only) set (see Figure 1-3) includes the following modules:

- Power Supply
- RF Interface
- Receiver Logic
- EM Output (Optional)
- Trip Test Unit (Optional)
- Receiver/Discriminator

1.5 TCF–10B Module Front Panels

The front (control) panel for each module could include the following types of controls:

- Switches
- LEDs
- Meter
- Potentiometers
- Test Jacks

All front panels are the same for all TCF–10B versions, with the exception of the Receiver Logic panel. There are three different Receiver Logic front panels for the TCF–10B, based on the specific application.

1.5.1 2-Frequency, Transfer Trip/Unblock Receiver Logic Front Panel

This panel is shown in Figure 1-4.

Four LEDs provide signal indication for two-frequency, transfer trip/unblock applications:

- Good Channel
- Checkback Trip
- Trip
- Guard

1.5.2 3-Frequency, Transfer Trip/Unblock Receiver Logic Front Panel

This panel is shown in Figure 1-5.

Five LEDs provide signal indication for three-frequency, transfer trip/unblock applications:

- Good Channel
- Checkback Trip
- UB/POTT Trip
- DTT Trip
- Guard

1.5.3 2-Frequency, Phase Comparison Receiver Logic Front Panel

This panel is shown in Figure 1-6.

Three LEDs provide signal indication for two-frequency, Phase Comparison applications:

- Good Channel
- Trip Positive (Space)
- Trip Negative (Mark)

1.6 TCF–10B Printed Circuit Boards (PCBs)

A module's printed circuit board (PCB) could include the following types of controls:

- Switches
- Jumpers
- Variable Capacitors
- Potentiometers
- Test Points
- Impedance Matching Jumpers

1.7 TCF–10B Rear Panel ("Mother Board")

(See Chapter 3, Section 3.5 for a description of the Rear Panel.)

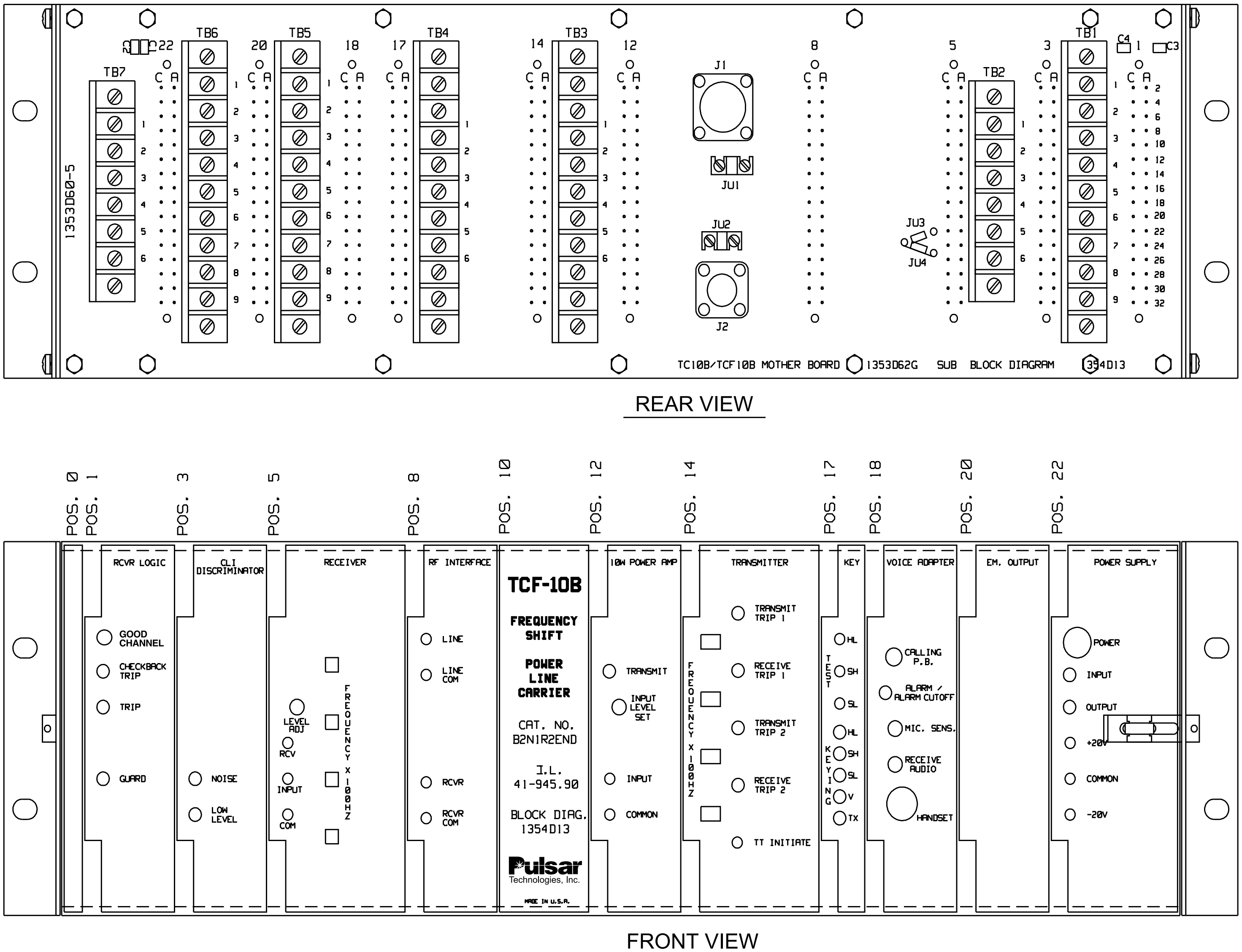
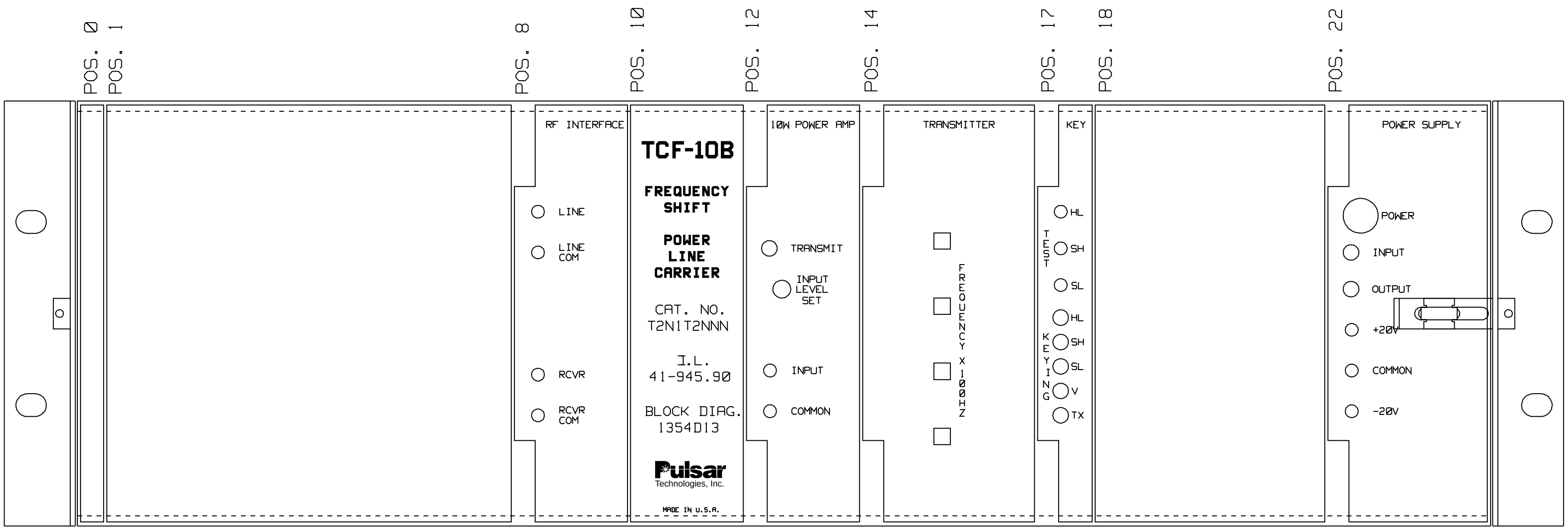


Figure 1–1. TCF–10B Transceiver Set (1355D19; Sheet 1 of 4).



FRONT VIEW

(TRANSMITTER ONLY)

Figure 1–2. TCF–10B Transmitter (only) Set (1355D19; Sheet 2 of 4).

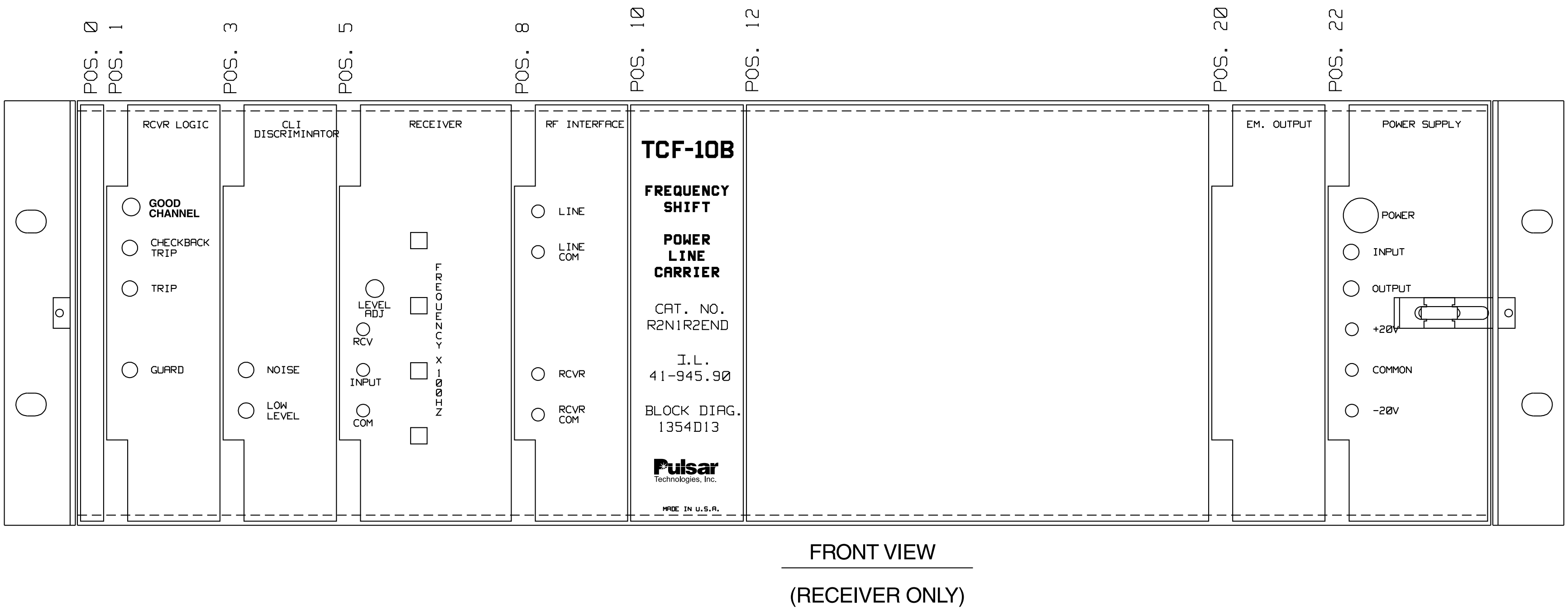


Figure 1–3. TCF–10B Receiver (Only) Set (1355D19; Sheet 3 of 4).

Figure 1–4.
Front Panel for 2-Frequency, Transfer Trip/Unblock Applications.

Figure 1–5.
Front Panel for 3-Frequency, Transfer Trip/Unblock Applications.

Figure 1–6.
Front Panel for 2-Frequency, Phase Comparison Applications.

1.8 Specifications

The TCF–10B meets or exceeds all applicable ANSI/IEEE standards as follows:

Proposed American National Standard
Requirements for Single Function Power-Line Carrier
Transmitter/Receiver Equipment
(ANS C93.5)

1.8.1 System

Table 1-1 lists the system specifications for the TCF–10B.

Frequency Range	30–535 kHz in 0.5 kHz (500 Hz) steps; transmitter selection in 100 Hz steps
4-Wire Receiver Input Impedance	(Nominal unbalanced)
RF Input Impedance	5,000 ohms (1,000 ohms when strapped for high sensitivity)
Output Power	10 watts (max), 0.1 watt (min), 50 or 100 watts (with optional external amplifier)
Modulation Type	Frequency-Shift Keyed (FSK); strappable for either two- or three–frequency operation
Frequency Shift	• Narrow Band, Narrow Shift (± 100 Hz) • Wide Band, Narrow Shift (± 100 Hz: for use when interfacing with older TCF, TCF–10, and TCF–10A Power Line Carrier) • Wide Band, Wide Shift (± 250 Hz) • Extra Wide Band, Extra Wide Shift (± 500 Hz)
Nominal Receiver Bandwidths	• Narrow Band (300 Hz at 3 dB points) • Wide Band (600 Hz at 3 dB points) • Extra Wide Band (1,200 Hz at 3 dB points)
Minimum Receiver Bandwidths	• Narrow Band (220 Hz at 3 dB points) • Wide Band (520 Hz at 3 dB points) • Extra Wide Band (1,020 Hz at 3 dB points)

	Receive Sensitivity	
	Standard Setting	**High Setting**
Narrow or Wide Band	20 mV (min) to 70 V (max)	5 mV (min) to 17 V (max)
Extra Wide Band	60 mV (min) to 70 V (max)	15 mV (min) to 17 V (max)

Table 1–1. System Specifications (Cont'd).

Channel Speed Receiver set for 15 dB margin:	
Narrow Band, Narrow Shift	8.0 ms*
Wide Band, Narrow Shift	6.0 ms*
Wide Band, Wide Shift	5.0 ms*
Extra Wide Band, Extra Wide Shift	3.5 ms*

Frequency Spacing: (For channels without voice; depends on application.)		
Narrow Band	Unblock or Transfer Trip	• (1-way, 500 Hz) • (2-way, 1,000 Hz)†
Wide Band (Narrow or Wide Shift)	Unblock or Transfer Trip	• (1-way, 1,000 Hz) • (2-way, 2,000 Hz)†
	Phase Comparison (SKBU-2A) (60 Hz sq. wave keying)	(1-way, 1,500 Hz) (2-way, 3,000 Hz)†
	Phase Comparison (SPCU-1A) (60 Hz 3 ms pulse keying)	(1-way, 2,000 Hz) (2-way, 4,000 Hz)†
Extra Wide Band	Unblock or Transfer Trip	• (1-way, 2,000 Hz) • (2-way, 4,000 Hz)†
	Phase Comparison (SKBU-2A) (60 Hz sq. wave keying)	(1-way, 2,000 Hz) (2-way, 4,000 Hz)†
	Phase Comparison (SPCU-1A) (60 Hz 3 ms pulse keying)	(1-way, 2,000 Hz) (2-way, 4,000 Hz)†

**** Times do not include logic trip delay or relay operate times.***

† An external hybrid or other device offering at least 20 dB rejection of the adjacent channel must be used in the application.

1.8.2 Alarm & Level Options

This section provides three tables depicting the alarm and level options, broken down as follows:

- Transceiver Chassis Alarms w/CLI (Table 1-2)
- Receiver Only Chassis Alarms w/CLI (Table 1-3)
- Transmitter Only Chassis Alarms (Table 1-4)

Each alarm contact is rated 10 VA (Form A or B).

Table 1–2. Transceiver Chassis Alarms w/CLI.

Power Supply Module	Loss of dc power
Keying Module	Shift High/Shift Low (for guard or trip)
10W PA Module	Loss of Transmitter RF power output
Receiver/Discriminator Module	Low-Signal, RF Signal Received CLI output for External CLI Meter (-20 dB to +10 dB; 0–100 µA)

Table 1–3. Receiver Only Chassis Alarms w/CLI.

Power Supply Module	Loss of dc power
Receiver/Discriminator Module	Low-Signal RF Signal Received CLI output for External CLI Meter (-20 dB to +10 dB; 0–100 µA)

Table 1–4. Transmitter Only Chassis Alarms.

Power Supply Module	Loss of dc power
Keying Module	Shift High/Shift Low
10W PA Module	Loss of Transmitter RF power output

1.8.3 Electro-Mechanical Outputs

This section provides two tables depicting the Electro-Mechanical Output Module's specifications, broken down as follows:

- Electro Mechanical Outputs (Table 1-5)
- Electro Mechanical Output Timing (Table 1-6)

Table 1–5. Electro Mechanical Outputs.

Contacts	Output
Six (6) contacts for Guard or Trip 1 or Trip 2	Make and carry rated 30 A for 1 second; 10 A continuous capability break 50 watts resistive or 25 watts with L/R = .045 seconds

Table 1–6. Electro Mechanical Output Timing.

Operate Time		Release Time	
NO Contact Closes	**NC Contact Opens**	**NO Contact Opens**	**NC Contact Closes**
2.8 ms 1.9 ms bounce	2.0 ms	2.8 ms	3.8 ms 4.0 bounce

1.8.4 Keying

Table 1-7 shows the TCF–10B keying specifications.

Table 1–7. Keying Specifications.

Five (5) optically-isolated keying inputs, strappable at 15/20, 48, 125, 250 Vdc	1) Unblock or Phase Comparison 2) Direct Transfer Trip 3) Power Boost or 52b Keying 4) RF Power On/Off 5) Voice Adapter
Maximum input keying burden	10 mA
Manual keying	Recessed pushbutton switches for high- and low-frequency keying, and power boost

1.8.5 Transmitter

Table 1-8 shows the TCF–10B transmitter specifications.

Table 1–8. Transmitter Specifications.

Harmonic and Spurious Output	55 dB below 10 W
Output Variation	± 1 dB over temperature and voltage range
Frequency Stability: **Narrow Shift** **Wide Shift** **Extra Wide Shift**	± 10 Hz

1.8.6 Receiver

Table 1-9 shows the TCF–10B receiver specifications.

Table 1–9. Receiver Specifications.

Frequency Stability: **Narrow Band, Narrow Shift** **Wide Band, Narrow Shift** **Wide Band, Wide Shift** **Extra Wide Band, Extra Wide Shift**	± 20 Hz
Five 1 A isolated outputs for 15/20 Vdc or station battery circuits	1) Unblock or Trip or Trip-Positive (Space) 2) Low-Level Signal 3) Guard or Trip-Negative (Mark) 4) Noise 5) Checkback Trip (not used with Phase Comparison)

NOTE

An optional 20 V Power Supply is available for use with some Phase Comparison and some Directional Comparison systems. For further information, please see TCF–10B Accessories under Chapter 2, Applications.

1.8.7 Power Requirements

Table 1-10 shows the TCF–10B power requirement specifications.

Table 1–10. Power Requirement Specifications.

Transceiver		Supply Current (Amps) At Nominal Voltage		
Nominal Battery Voltage	Permissible Voltage Range	Receive/ Standby	1 Watt Transmit	10 Watt Transmit
48/60 Vdc	38–70 Vdc	0.630	0.940	1.600
110/125 Vdc	88–140 Vdc	0.240	0.360	0.600
220/250 Vdc	176–280 Vdc	0.120	0.180	0.300

Permissible ripple on incoming Vdc	5%
Maximum allowable frequency of ripple	120 Hz
Carrier frequency on dc input leads when transmitting 10 W	20 mV (max)

1.8.8 Weights and Dimensions

Table 1-11 shows the TCF–10B weight and dimension specifications.

Table 1–11. Weight and Dimension Specifications.

Equipment	Net Weight		Height		Width		Depth		Rack Space
	lbs	Kg	inches	mm	inches	mm	inches	mm	
Transceiver	21	9.53	5.25	133.4	19.00	482.6	13.50	342.9	3 RU
Transmitter	14	6.35	5.25	133.4	19.00	482.6	13.50	342.9	3 RU
Receiver	12	5.45	5.25	133.4	19.00	482.6	13.50	342.9	3 RU

1.8.9 Environmental Requirements

This section provides three tables depicting the environmental requirement specifications, broken down as follows:

- Environmental Requirements (Table 1-12)
- Altitude Dielectric Strength De-Rating for Air Insulation (Table 1-13)
- Altitude Correction For Maximum Temperature Of Cooling Air (ANS C93.5) (Table 1-14)

Table 1–12. Environmental Requirements.

Ambient temperature range	-20 to + 60°C (derated per Table 1-14) of air-contacting equipment
Relative humidity	Up to 95% (non-condensing) at 40°C (for 96 hours cumulative)
Altitude	Up to 1,500 m (without derating) Up to 6,000 m (using Table 1-13 and Table 1-14)
Transient withstand capability	All external user interfaces meet SWC specifications of ANS C37.90.1 (1989)
1-minute withstand	Only isolated inputs and outputs, and all alarms: 2,500 Vdc from each terminal to ground, derated per Table 1-13.
Center conductor of coaxial	3,000 Vdc impulse level, cable to ground using 1.2 x 50 cable to ground msec impulse
Electro-Magnetic Interface Capability	IEEE Standard ANS C37.90.2

Table 1–13.
Altitude Dielectric Strength
De-Rating for Air Insulation

Altitude (Meters)	Correction Factor
1,500	1.00
1,800	0.97
2,100	0.94
2,400	0.91
2,700	0.87
3,000	0.83
3,600	0.79
4,200	0.74
4,800	0.69
5,400	0.64
6,000	0.59

Table 1–14.
Altitude Correction For Maximum
Temperature Of Cooling Air (ANS C93.5)

		Temperatures (Degrees C)		
Altitude (Meters)		Short-Time	Long-Time	Difference From Usual
Usual	1,500	55	40	—
Unusual	2,000	53	38	2
Unusual	3,000	48	33	7
Unusual	4,000	43	28	12

1.8.10 Voice Adapter Option

Table 1-15 shows the specifications for the TCF–10B Voice Adapter option (see Chapter 18 for details).

Table 1–15. Voice Adapter Option Specifications.

Modulation	Amplitude Modulation with compander
Transmission	Full-Duplex
Frequency Response	300 Hz to 2,000 Hz
Signaling	370 Hz AM with signaling pushbutton

If the Voice Adapter option is included, it will have an independent receiver of 4 kHz bandwidth, regardless of whether the system is operating at 1,200 Hz (extra wide band), 600 Hz (wide band), or 300 Hz (narrow band).

USER NOTES

Chapter 2. Applications and Ordering Information

2.1 Protective Relay Applications Using Frequency Shift Carriers

The TCF–10B carrier set is particularly suitable for the following types of protective relay systems:

- Directional Comparison Unblocking
- Permissive Overreaching Transfer Trip (POTT)
- Permissive Underreaching Transfer Trip (PUTT)
- Dual Phase Comparison Unblocking
- Segregated Phase Comparison Unblocking
- Direct Transfer Trip

2.1.1 Directional Comparison Unblocking

The Directional Comparison Unblocking systems transmit a continuous blocking signal, except during internal faults. The channel is generally a frequency-shift keyed (FSK) power line carrier. For an internal fault, the FSK transmitter is shifted to the “unblock” frequency. The transmitted power in many applications is normally 1 W, boosted to 10 W during unblock operation.

The frequency-shift channel is monitored continuously to prevent tripping when a loss of channel occurs. The carrier receiver logic is shown in Figure 2-1. Under normal conditions, a block frequency is transmitted and OR-1 has no input. Because AND-1 and AND-2 are not satisfied, OR-2 is not energized. For an internal fault, the block frequency is removed. Assuming that the unblock signal is shorted out by the fault, OR-1 provides a direct input to AND-2 to satisfy its input requirements for 150 ms. AND-2 inputs to OR-2 to operate the RR or to provide input to the AND shown in Figure 2-2. Without an unblock signal, 150 ms is allowed for tripping. After this period, lock out is initiated as one of the inputs to AND-2 is removed. This resets the RR or removes the input to AND. If the unblock signal is received, it inputs directly to OR-2 to energize the RR or to provide input to AND. The unblock signal also removes an input to AND-1 to stop the timer. A channel failure (no block or unblock signal) provides input to AND-1 and, after 150 ms, locks out the relaying and triggers an alarm. The operation of the scheme shown in Figure 2-2 is given in Table 2-1 for external and internal faults. The phase and ground trip fault detectors at both stations must operate for all internal faults; that is, they must overreach the remote bus.

The dependability and security of Directional Comparison Unblocking systems make them the most attractive of the protective schemes for transmission lines using power line carrier channels. Overtripping is avoided by continuous blocking and continuous channel monitoring. Only an external fault within 150 ms after channel failure can result in overtripping.

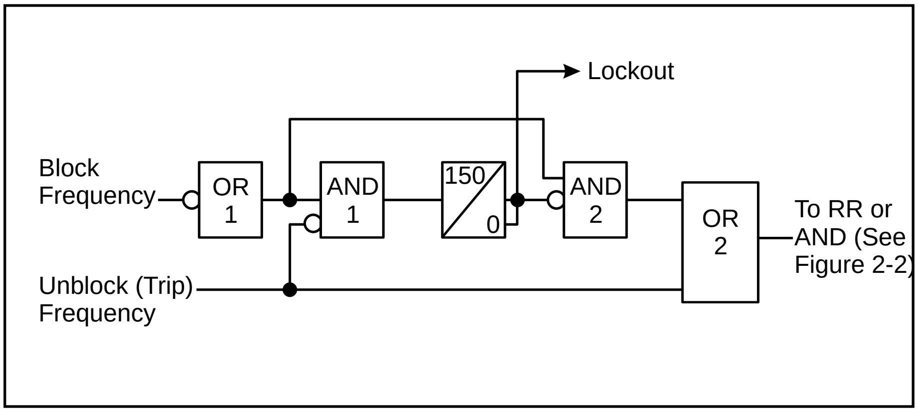


Figure 2-1. Simplified Unblock Receiver Logic.

The scheme is most appropriate for two-terminal lines, but is applicable to multi-terminal lines. Separate channels are required between each terminal and the remote terminal(s).

You may conserve frequency spectrum by using a narrowband frequency shift carrier, but at the expense of channel speed (see Chapter 1, Specifications).

Another consideration is an open breaker situation. When the remote breaker is open for an extended period of time, the relay system must be able to trip. The remote relay system sends a trip signal when detecting a remote open breaker. If

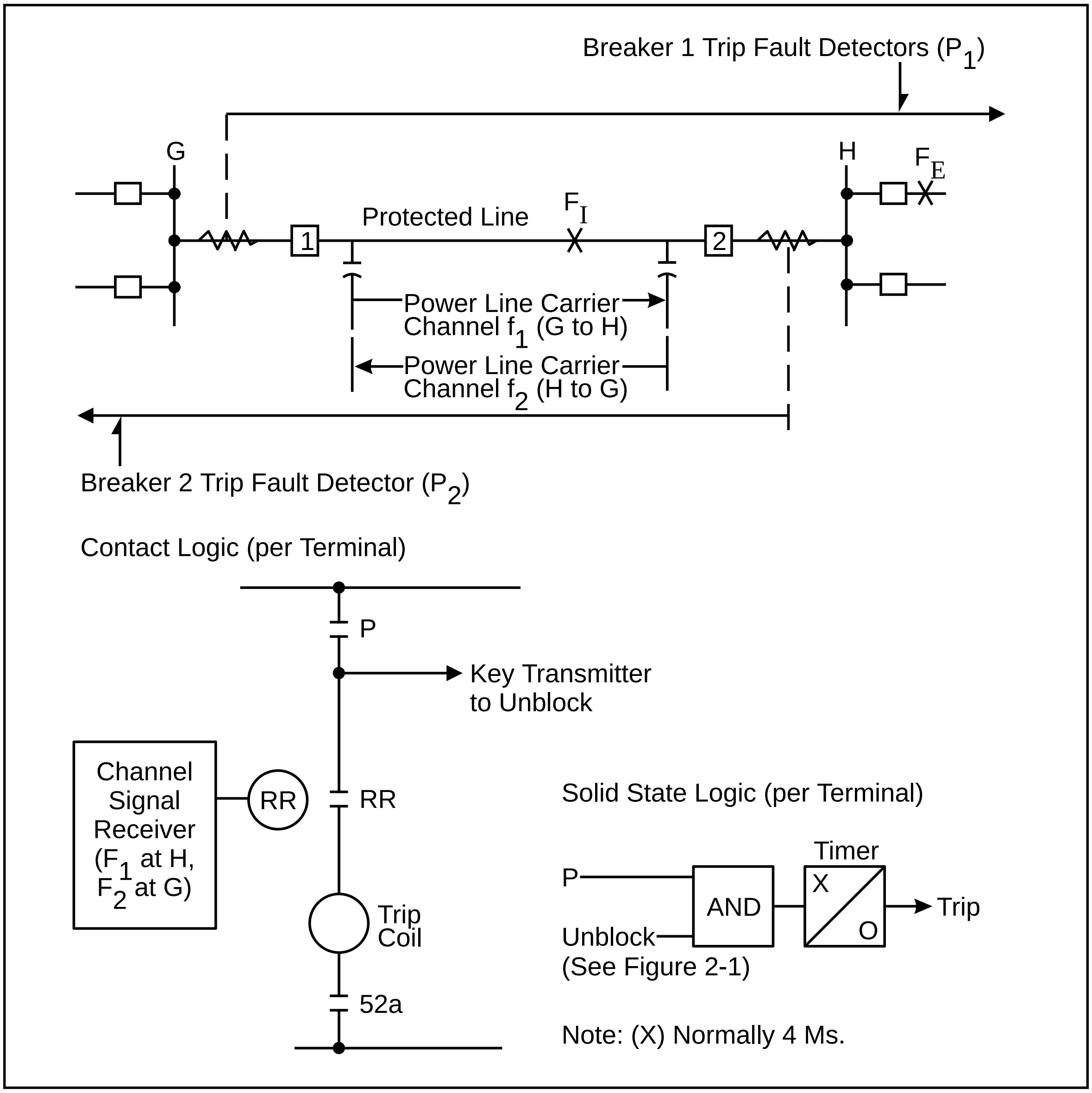


Figure 2–2. Basic Logic Diagrams for Directional Comparison Unblocking.

2

Table 2–1. Operation of the Directional Comparison Unblocking Scheme.

SCHEME FOR EXTERNAL AND INTERNAL FAULTS		
Type of Fault	**Events at Station G**	**Events at Station H**
External (F_E)	P_1 operates. f_1 channel shifts to unblock. f_2 channel continues to block. No trip.	P_2 does not see fault. Loss of block and/or receipt of unblock (f_1) operates RR or inputs AND. No trip.
Internal (F_I)	P_1 operates. f_1 channel to unblock. Loss of block and/ or receipt of unblock (f_2) operates RR or inputs AND. Trip.	P_2 operates. f_2 channel shifts to unblock. Loss of block and/or receipt of unblock (f_1) operates RR or inputs AND. Trip.

Table 2–2. Operation of the Underreaching Transfer Trip Scheme.

SCHEME FOR EXTERNAL AND INTERNAL FAULTS		
Type of Fault	**Events at Station G**	**Events at Station H**
External (F_E)	P_1 does not operate. No channel signal sent to H. No trip.	P_2 does not operate. No channel signal sent to G. No trip.
Internal (F_I) (Fault near station H)	P_1 does not operate. No channel signal sent to H. †(FD_1 operates). Transfer-trip (f_2) from station H operates RR or inputs to AND (or OR if non-permis-sive). Trip.	P_2 operates and trips directly. Transfer-trip signal keyed to station G. †(FD_2 operates). Trip.

† Omitted in non-permissive systems.

this remote signal is received for 1,000 ms (1 sec) or longer, the carrier receiver logic interprets this as an open breaker and allows the local end to trip whenever the local relays detect a fault.

2.1.2 Permissive Overreaching Transfer Trip Systems

Overreaching transfer trip systems require a channel signal to trip, and are used with a frequency-shift audio tone, modulated on a communication channel (e.g., public or private telephone lines). These systems are generally not used with power line carriers. There are, however, successful applications of power-line carrier on POTT schemes where parallel lines allow for cross-coupling of the carrier signal.

2.1.3 Permissive and Non-Permissive Underreaching Transfer Trip Systems

For overreaching systems, the directional phase and ground trip fault detectors (P) must be set to overlap within the transmission line and not overreach any terminals (see Figure 2-3).

That is, at least one trip fault detector (P) must operate for all internal faults, and none should operate for any external fault. In practice, distance relays are normally required for both ground faults and phase faults, although directional instantaneous ground-overcurrent relays might meet these requirements in some cases.

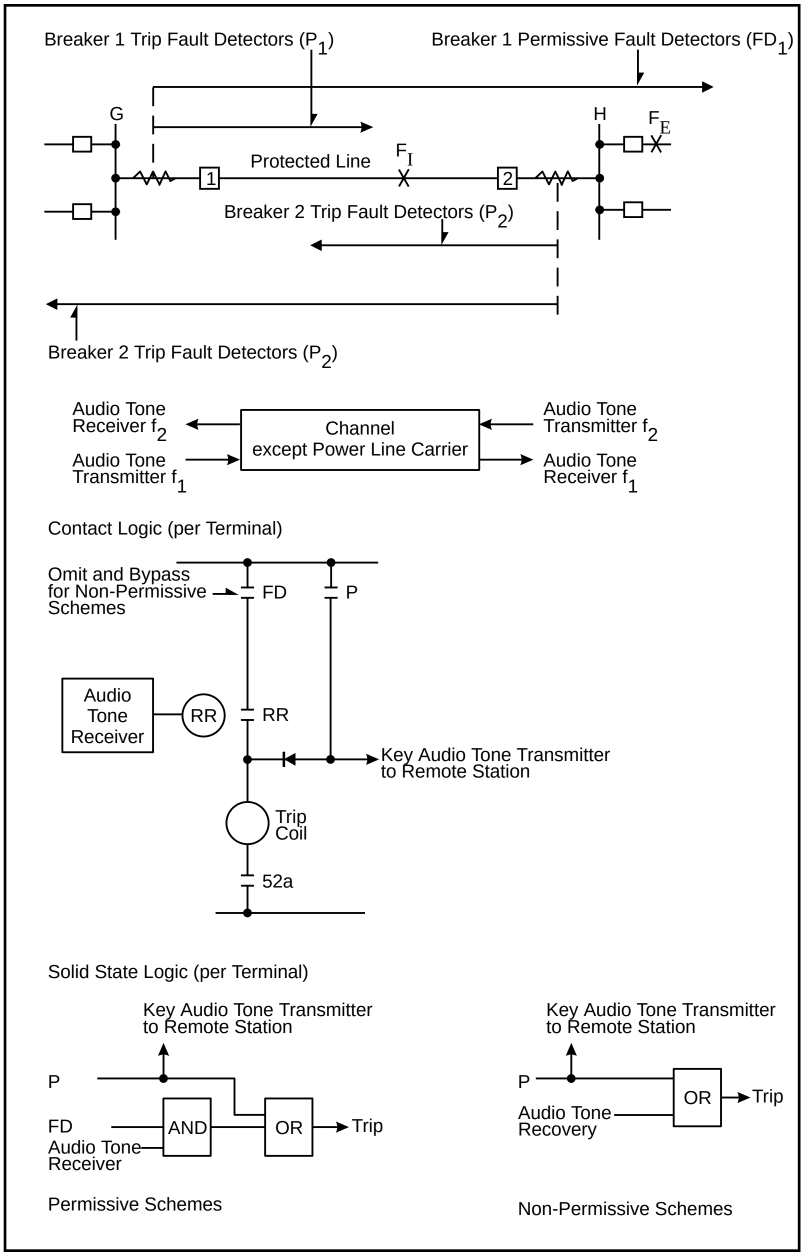


Figure 2–3. Basic Logic Diagrams for Underreaching Transfer Trip Systems.

Though it is the least complex, the non-permissive system is rarely used because of the high potential for false outputs from the channel, which would cause incorrect tripping. If a non-permissive system is used, the channel considerations should be as described later for direct trip systems. The system is made permissive by the additional set of phase and ground overreaching fault detectors (FD), which must operate for all internal faults (see Figure 2-3).

Operation of the underreaching transfer trip scheme shown in Figure 2-3 is described in Table 2-2 for external and internal faults.

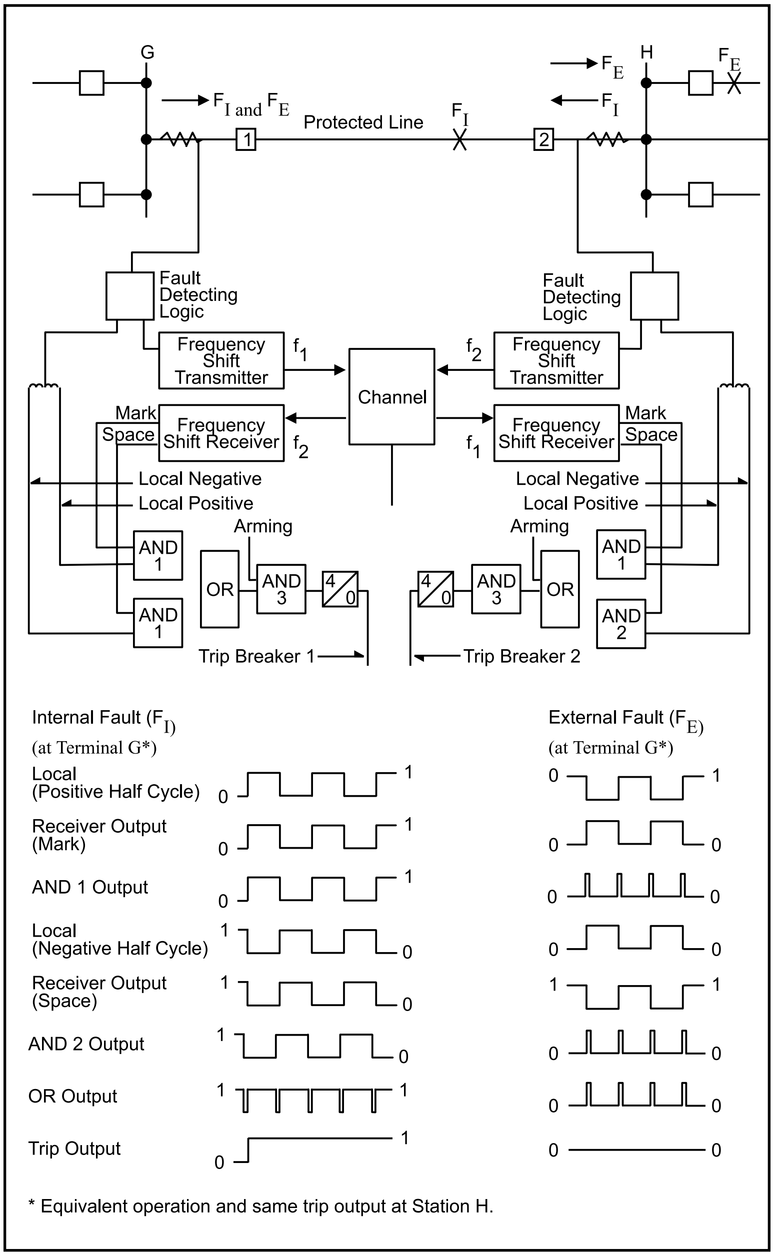


Figure 2–4. Basic Operation of the Dual Phase Comparison Pilot Relaying System.

Because the trip fault detectors (P) do not operate for external faults, underreaching transfer trip systems do not require external fault-clearing coordination circuits (transient blocking) and are, therefore, inherently simpler than any of the other schemes. You obtain maximum security if you use additional permissive fault detectors. These schemes also provide minimum operating times for many faults that are tripped directly, without using the channel.

2.1.4 Dual Phase Comparison Unblocking Systems

Dual comparison systems require a duplex channel: one frequency for each line terminal. The TCF–10B frequency-shift channel equipment is available for this purpose; normally used in an unblocking system. Continuous channel monitoring is also provided, because either a mark or space carrier signal is always transmitted.

The transmitter is keyed to its mark frequency when the square wave from the filter goes positive, and is keyed to its space frequency when the square wave is at zero. There are two outputs at the receiver: the “mark” output is a square wave that goes positive when a mark frequency is received; the “space” output goes positive when a space frequency is received.

The basic operation of the Dual Phase Comparison system is shown in Figure 2-4. For internal faults, the single phase outputs of the sequence current networks are essentially in phase, although such output represents currents 180° apart in the power system. The network output goes through a squaring amplifier that keys the frequency shift transmitter. An adjustable delay circuit delays the local square wave by a time equal to the channel delay time.

The network output is then used to develop two complementary square waves. One wave, which has a positive state during the positive half-cycle of the sequence current network, is compared with the receiver’s mark output. The other wave, which has positive output during the negative half-cycle of the sequence current network, is compared to the receiver's space output in a second comparison circuit.

On internal faults, the positive half-cycle of the local square wave lines up with the received mark output to provide an AND-1 output (see Figure 2-4). On the negative half-cycle, this local square wave lines up with the received space output to provide an AND-2 output. If an arming signal is received (FD_2 and/or 21P) and either AND-1 or AND-2 output exists for 4 ms, an input to the trip flip flop initiates breaker tripping. The same operation occurs at both terminals, tripping breakers 1 and 2 simultaneously on either half-cycle of fault current.

For tripping, both the mark and space frequencies must be transmitted through the internal fault via power line carrier channels. If these frequencies are not received, the receiver detects a loss of channel and clamps both the mark and space outputs to a continuous positive state. This loss of channel clamp enables both comparison circuits, allowing the system to trip on the local square wave input only. After 150 ms, the system output clamps these to the zero state. At this point, the system cannot trip and is locked out. An alarm indicates loss of channel.

For external faults, the reversal of current at one end shifts the square waves essentially 180°. As a result, neither AND-1 nor AND-2 has the sustained output required to operate the 4 ms timer (see Figure 2-4). No trip occurs at either line terminal.

2.1.5 Segregated Phase Comparison System

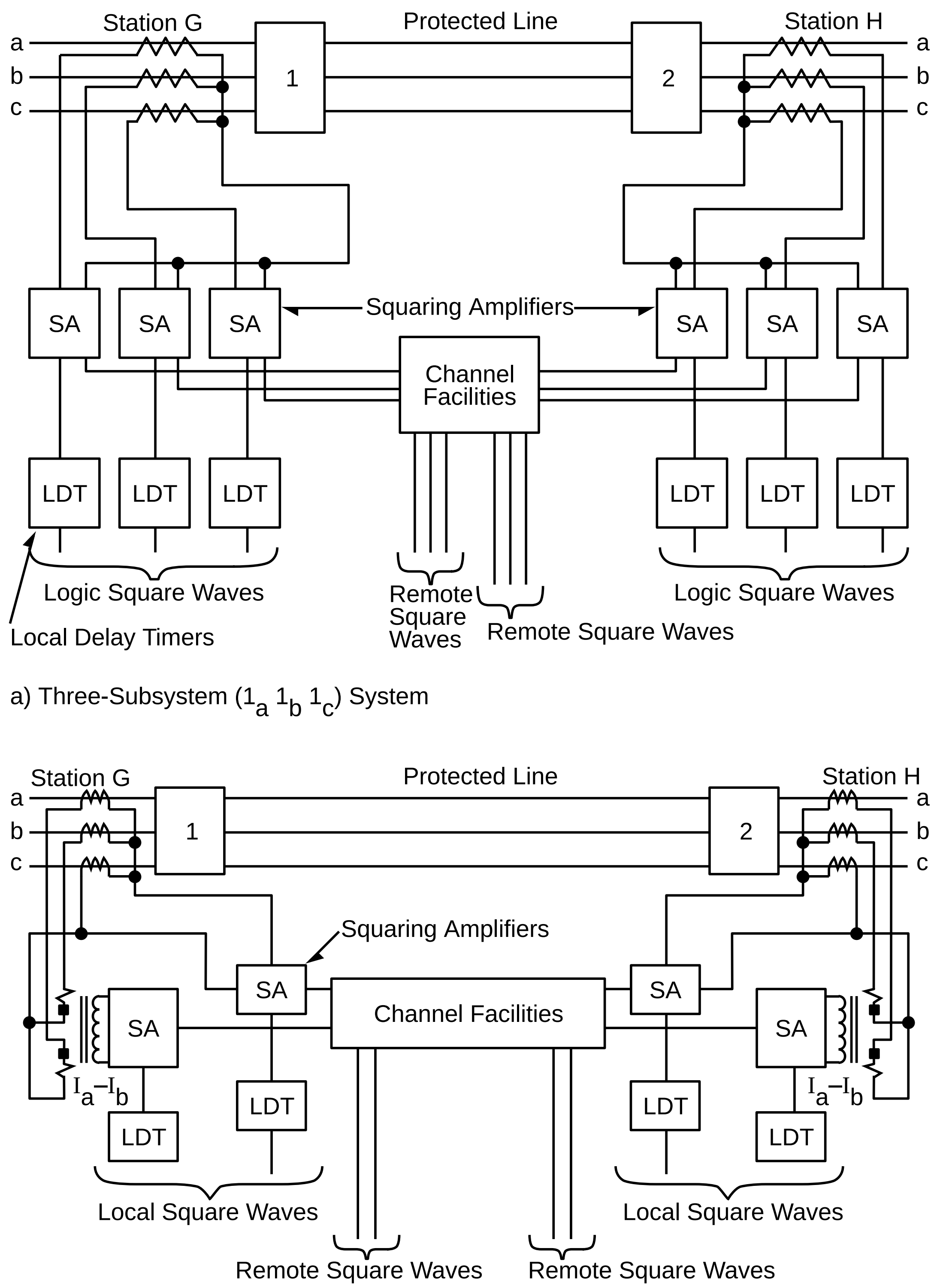
The Segregated Phase Comparison system has been developed to improve pilot relay protection, particularly for the long EHV series capacitor-compensated transmission lines. Long EHV series capacitor-compensated lines are a source of significant transients during the fault period. Under these circumstances, sequence current networks designed to operate at normal system frequency may present a problem. The experience with these Phase Comparison systems has, however, been remarkably good. Directional Comparison systems, on the other hand, are subject to mis-operation on series capacitor-compensated lines, particularly if the capacitor gaps do not short the capacitors on faults. Segregated phase comparison systems, which are current-only, are independent of the following phenomena:

- Power system frequency and wave form
- Effects of impedance unbalance between the power system phase circuits.
- Maximum load/minimum fault current margin.

The segregated phase comparison system can be divided into two types: a two-subsystem scheme and a three-subsystem scheme. In the two-subsystem scheme, one subsystem operates from delta current (I_a-I_b) for all multi-phase faults, and a ground ($3I_0$) current subsystem operates for all ground faults. The three-subsystem scheme has a subsystem for each phase (I_a, I_b, and I_c). Each subsystem consists of one channel (TCF–10B) and one Phase Comparison relay.

Both segregated Phase Comparison systems incorporate "offset keying," enabling them to trip for internal high-resistance ground faults and internal faults with outfeed at one terminal. No other system can clear these types of faults without extra logic or channels. On a 500 kV line with a 2,000:5 current transformer ratio, for example, the three-subsystem scheme will operate for ground-fault resistances up to about 100 ohms primary impedance. Under the same conditions, the two-subsystem scheme will operate up to about 200 ohms primary fault resistance.

The two-subsystem package is suitable for all applications except single-pole tripping, where the three-subsystem package must be applied. The basic operation of the scheme is illustrated in Figure 2-5. Each current is fed through a noninductive resistor, supplying a voltage output to the squaring amplifier (SA) that is exactly proportional to the primary currents. The output of these amplifiers is used to key the individual channels and, through the local delay timers (LDT), to provide the local square waves for comparison. The timers are adjustable between 2 and 20 ms to



a) Three-Subsystem (1_a 1_b 1_c) System

b) Two-Subsystem (I_a I_b I_G) System

Figure 2–5. Basic Segregated Phase Comparison Systems.

compensate for the delay time of the channel. This digital delay circuit translates the pulse train independently of the pulse width ratio, in contrast to the ac phase angle shift used in the other systems. The ac phase shift delay uses frequency-dependent components, which are accurate only at system frequency and can "ring" during transient conditions.

The square wave comparison is made independently for each current in the separate subsystems. Separate channels are required for each of the subsystems. One of the comparison circuits is shown in simplified form in Figure 2-6. In this dual comparison circuit, AND-P is used for the positive half-cycles and AND-N for the negative half-cycles. As shown in Figure 2-6, the received positive square wave corresponds to a "1" input to AND-P, and the received negative square wave to a "0" input, negated to "1", into AND-N. Except for this variation, operation is as shown by the square wave blocks in the lower half of Figure 2-4.

To generate the local and keying square waves, conventional phase comparison systems use thresholds equivalent to (or very near) the zero axis. As a result, an internal fault with outfeed looks like an external fault to those systems (see Figure 2-7). The offset keying technique permits the relay system to trip for internal faults with outfeed current out at one terminal. While the outfeed condition is very unusual, it presents difficult problems to the great majority of pilot relaying systems when it does occur. Outfeed can occur in any of the following cases:

- Series-capacitor-compensated parallel lines.
- Weak-feed or zero-feed applications, particularly with heavy through load.
- Some multi-terminal applications.
- Series-compensated (line-end compensation) line with a source inductive reactance smaller than series capacitor reactance.
- Some single-line-to-ground faults, occurring simultaneously with an open conductor, where the fault is on one side of the open conductor.
- Some single-line-to-ground faults with high fault resistance and heavy through load (such conditions can cause outfeed only in the faulted phase current, not in the ground subsystem).

The offset keying technique allows the relay system to work like a true current differential scheme. The scheme takes advantage of the fact that, for the outfeed condition, the current into the line is greater in magnitude than the current out of the line for the internal fault.

This relationship is illustrated in Figure 2-7, where I_G equals I_F plus I_H. While the two terminal currents may have any angular relationship with one another, most outfeed conditions display a nearly out-of-phase relationship. The out-of-phase condition illustrated is the most difficult case for phase comparison, as well as the most common outfeed condition.

In the offset keying technique, the keying threshold is displaced in the positive direction, away from the zero axis. The local square wave thresholds are displaced negatively. To maintain security, the local thresholds are separated from each other, providing "nesting" during external faults. Typical settings are shown in Figure 2-8.

Figure 2-9 illustrates the square wave characteristics of offset keying for normal internal faults, external faults, and internal faults with outfeed.

The segregated Phase Comparison scheme incorporates a high degree of security. Its design is based on extensive field experience and the model line tests for the very long, series capacitor-compensated EHV lines.

Output trip signals are supervised by an arming input and a number of security checks (see Figure 2-7). Phase arming is performed by a current rate-of-change detector that responds to sudden increases, decreases, or angular shifts in current. It operates on current changes of 0.5 A or more, with an operating time of 2 ms. Ground arming is 3I magnitude—typically 0.8 A secondary.

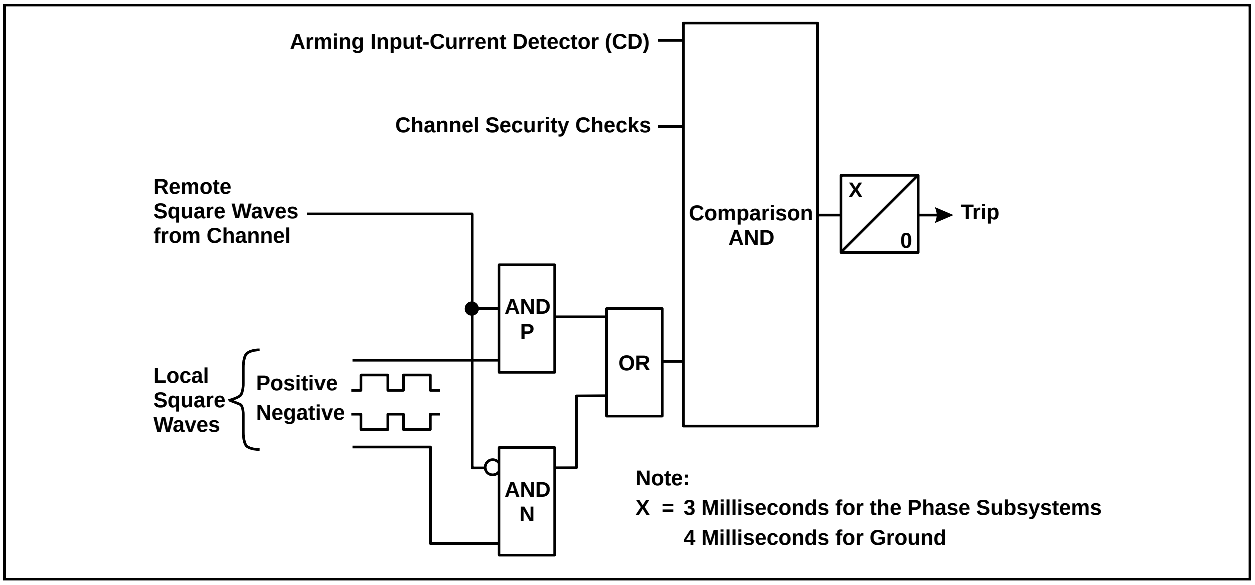


Figure 2–6. Basic Operation of the Segregated Phase Comparison System.

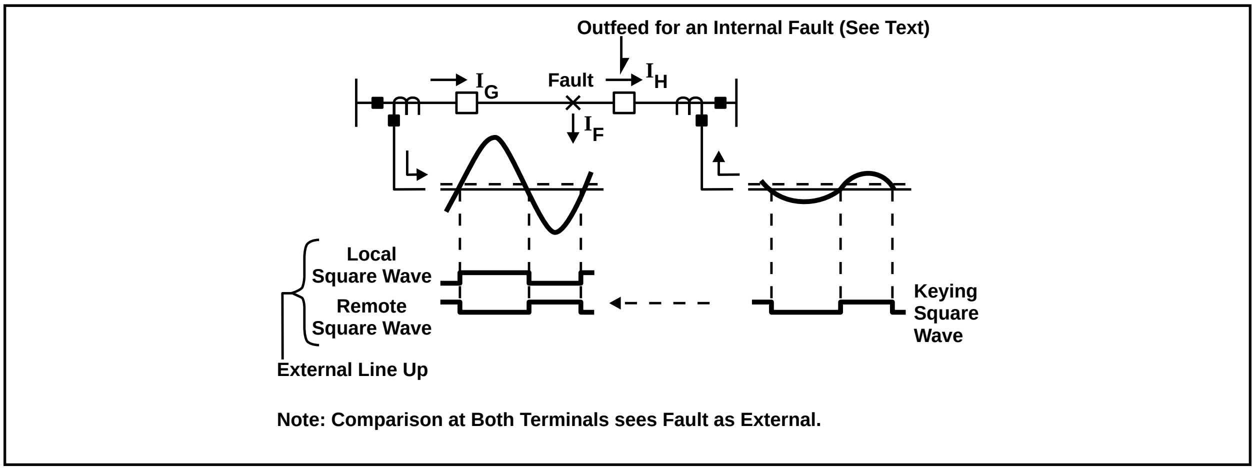


Figure 2–7. Conventional Phase Comparison Response to an Outfeed Condition Block Tripping.

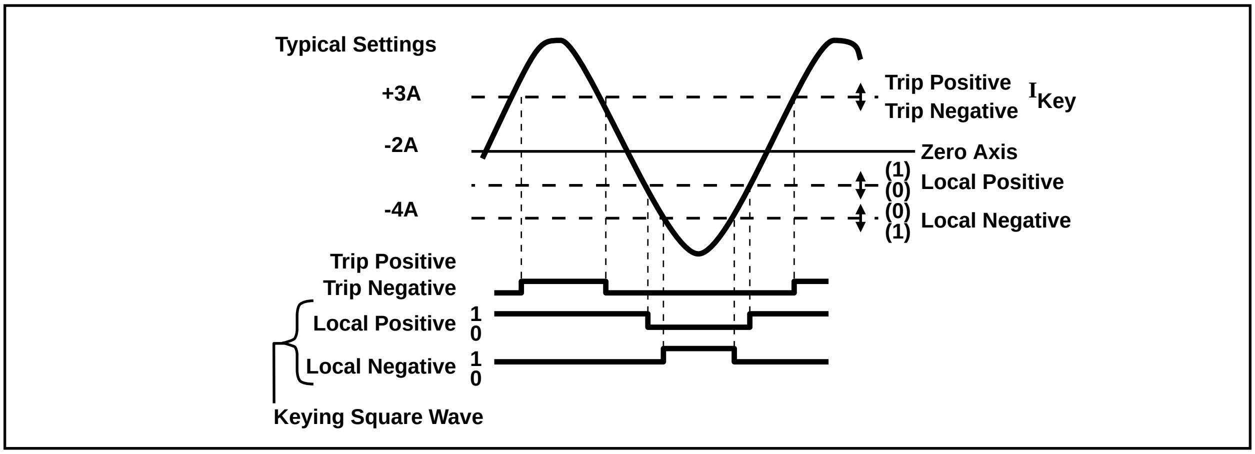


Figure 2–8. Typical Threshold Setting for Offset Keying.

Security checks to comparison AND (see Figure 2-7) include (1) low channel signal blocking, (2) lockout for sustained low channel signal, (3) channel noise clamp, and (4) receive guard block. For the phase subsystems, a trip signal occurs if comparison AND has an output for more than 3 ms (4 ms for the ground subsystem).

2.2 Direct Transfer-Trip Systems

Direct transfer-trip systems provide circuit-breaker tripping at remote or receiver terminals, without any supervision by fault detectors. The most important consideration in a direct transfer-trip system is the type of channel applied. The communications equipment must carry the total burden of system security and dependability.

Direct transfer-trip systems are applied for:

- Line protection with non-permissive under reaching transfer-trip systems.
- Transformer protection where there is no circuit breaker between the transformer and transmission line.
- Shunt reactor protection.
- Remote breaker failure protection.

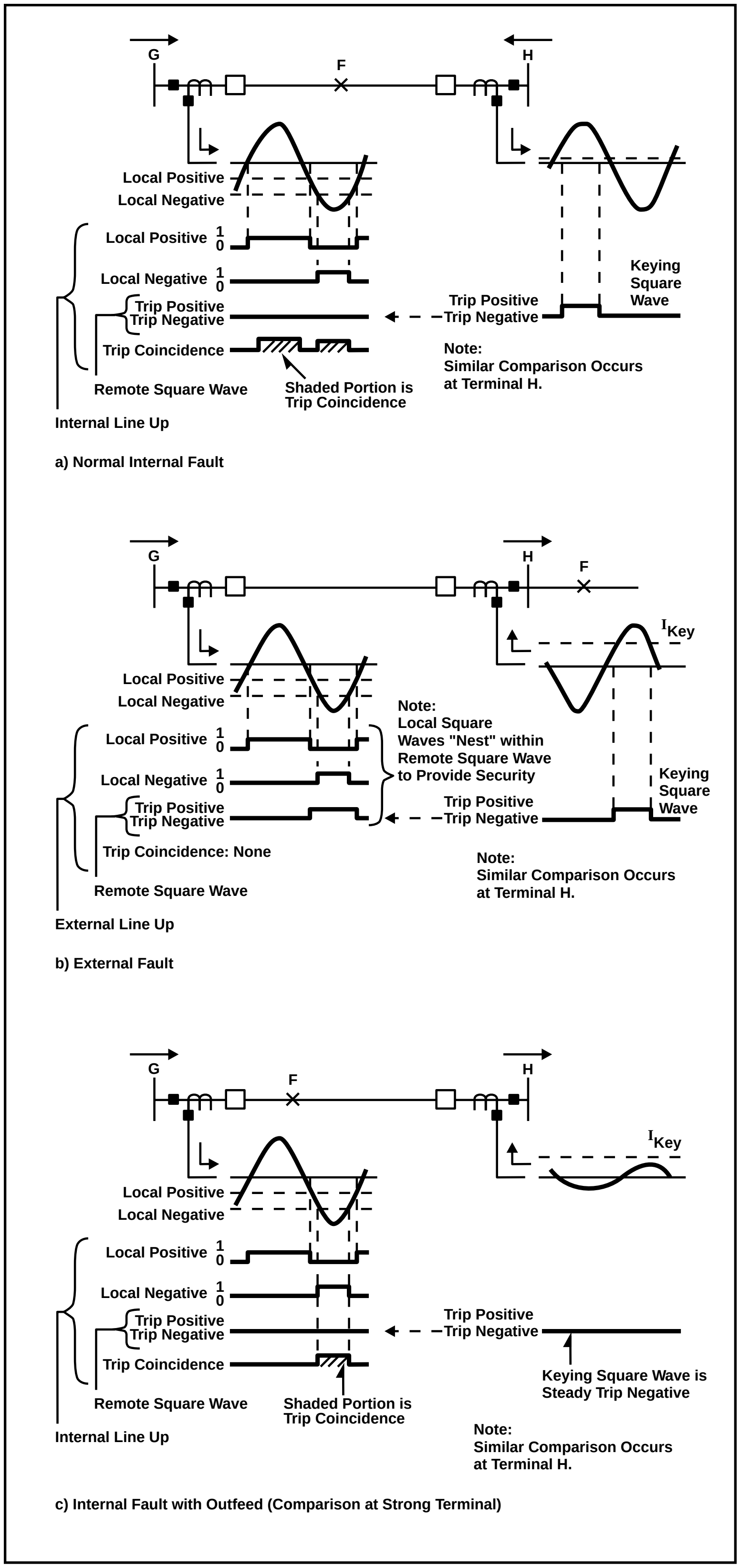


Figure 2–9. Response of Segregated Phase Comparison System with Offset Keying.

2.2.1 Transformer Protection

A typical transformer protection scheme is illustrated in Figure 2-10. A direct trip channel is keyed to the trip state when the transformer protective relays operate. The received trip signal will then trip the remote end breaker and lock out reclosing.

Although it is no longer widely used, you may use a ground switch operated by the transformer protective relays for transformer protection. In this technique, a ground fault is initiated on the transmission line at G, providing adequate fault current for the ground relays at H to trip the breaker at H. This system is slower but is widely used on lower voltage systems and is fairly simple and straightforward. It does not require any secure communication medium between G and H. For this type of application, the ground relays at H can be set to operate for 100 percent of the line and not overreach to bus G.

While a single switch on one phase is normally applied, you may use a double switch on two phases to initiate a double-phase-to-ground fault. In the latter case, both phase and ground relays can operate to ensure redundancy. Fault grounding is not applicable to all systems because of high short-circuit capacity.

2.2.2 Shunt Reactor Protection

Shunt reactors are frequently used on HV and EHV lines. These line reactors are connected on the line side of the circuit breakers (see Figure 2-11). A remote trip channel is thus required for a fault in the shunt reactor.

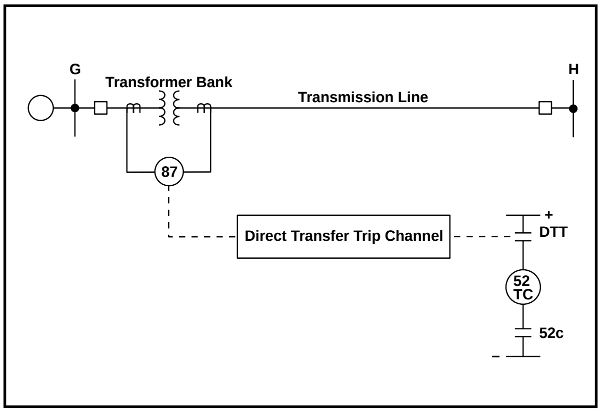


Figure 2–10. Direct Transfer Trip for Transformer Protection.

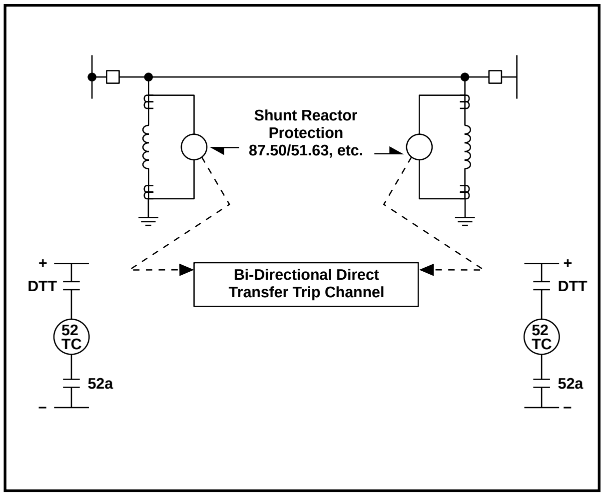


Figure 2–11. Direct Transfer Trip for Shunt Reactor Protection.

2.2.3 Remote Breaker-Failure Protection

A remote breaker-failure system is necessary where a multi-breaker bus, such as a breaker-and-a-half or ring bus scheme, is applied at a transmission line terminal. A direct transfer-trip system will be a part of the remote breaker-failure protection.

2.2.4 Direct Trip Channel Considerations

The channel and its terminal equipment are major factors in the proper operation of the direct transfer-trip system. The channel must neither fail to provide a correct trip signal nor provide a false signal.

While other types of modulation are possible, frequency-shift keyed (FSK) equipment offers the best compromise between noise rejection capability and equipment complexity. Two frequencies are usually transmitted in an FSK system: the “guard” frequency is transmitted during non-trip conditions and the “trip” frequency is transmitted when a breaker trip is required. Because a signal is always present, the FSK system will allow the channel to be continuously monitored. Continuous channel monitoring is necessary in a direct trip

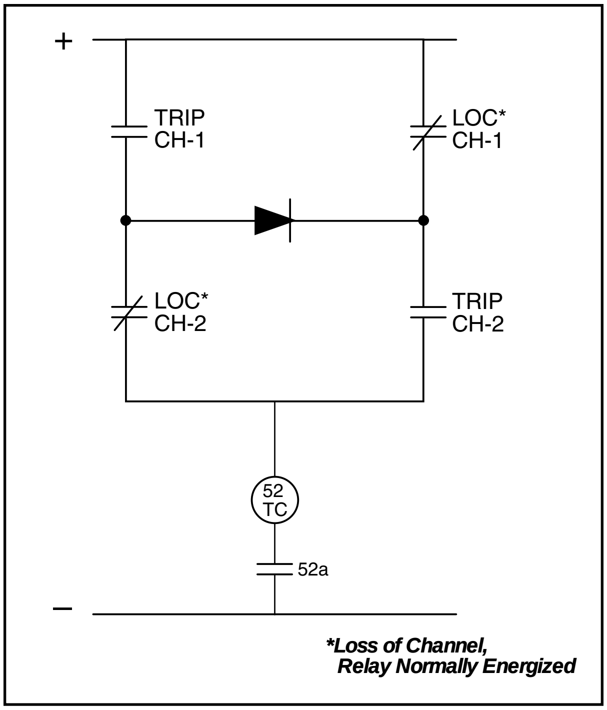


Figure 2–12.
Dual Channel Transfer Trip with Throwover to Single Channel on Loss of One Channel.

system, because breaker tripping is not supervised by any local relays.

As noise in the channel increases, a point is reached where there is a high probability of false tripping. The level of noise at which the channel becomes unreliable must be determined by tests. Signal-to-noise ratio monitors must then be included with any direct trip channel, to block possible false tripping. It is important, however, not to get the noise monitors any more sensitive than required, since their operation will prevent tripping.

There are three important aspects to the application of FSK channels to direct trip systems: channel bandwidth, dual channel systems, and channel protection.

Although faults should be cleared in the shortest possible time, speed is not the only criterion for selecting equipment. ***It is important to use the narrowest bandwidth equipment possible.*** A wide bandwidth channel may give the desired speed, but more noise enters the system. Thus, the channel will block tripping sooner than a narrower bandwidth channel with the same received signal level. A wideband channel will consequently not be as dependable as a narrower channel under equal receive-level conditions.

A dual channel system is recommended for direct trip applications. Two FSK channels should be used in series, so that both must trip before the breaker is tripped. Many tests have indicated that dual channels improve the security of the direct trip system by several orders of magnitude. Use of a dual channel system has very little effect on dependability, even if both channels are on the same transmission medium.

If you want to increase the dependability, you can modify the dual channel transfer trip scheme to allow a single channel trip when there is failure of the other channel. A typical Dual Channel Throwover to Single Channel Scheme is illustrated in Figure 2-12.

2.3 Special Considerations

The TCF–10B frequency-shift equipment can operate in either the two- or three-frequency mode, but ordinarily operates as a two-frequency system. The three basic frequencies are as follows (see Figure 2-13):

- f_C Center frequency
- f_H High-frequency, is a frequency shift (Δf) above f_C
- f_L Low-frequency, is a frequency shift (Δf) below f_C

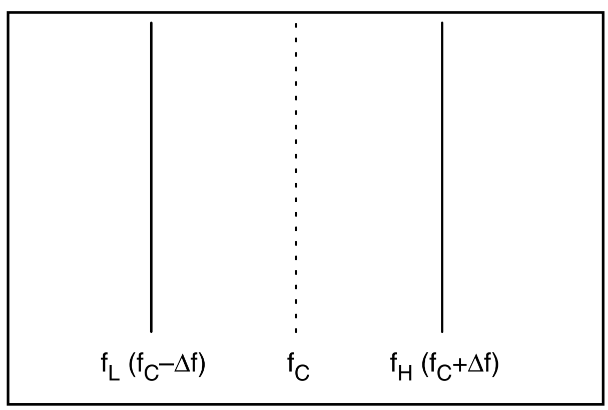


Figure 2–13. TCF–10B 3-Frequency System.

The value of Δf depends on the bandwidth of the TCF–10B set. For a bandwidth of 1,200 Hz, Δf is 500 Hz. A bandwidth of 300 Hz yields a Δf of 100 Hz, while the 600 Hz bandwidth Δf can be either 250 or 100 Hz, depending on the setting of S5 on the Transmitter Board. The center channel frequency (f_C) can vary from 30 to 535 kHz (in 0.5 kHz steps).

In the two-frequency systems, only f_H and f_L are used. The two frequencies function differently and take on different labels when operating with the different types of protective relay systems.

2.3.1 Directional Comparison Unblocking (Two-Frequency)

The higher frequency (f_H), or “Block” frequency, is transmitted continually as a blocking-type signal during normal conditions, to indicate that the channel is operative and to prevent remote relay tripping when external faults occur.

For a fault sensed by the local overreaching pilot relay, the transmitter is frequency-shifted to a low frequency (f_L), called “Unblock” frequency. The transmitted power is normally 1 W, boosted to 10 W for the “Unblock” operation.

The Directional Comparison Unblocking system will generally use the wide band, wide shift (600 Hz BW, ±250 Hz Shift) TCF–10B carrier set. Also, the most common power output level used will be the 1 watt block and 10 watt trip. The type of carrier applied with this scheme may be varied from the normal for special circumstances, e.g., when matching the new TCF–10B equipment at one end of the line with the older TCF, TCF-10, or TCF-10A equipment at the other end. In this case, you must apply the wide band, narrow shift carrier (600 Hz BW, ±100 Hz Shift) to match the older carrier characteristics.

2.3.2 Transfer Trip: Overreaching, Underreaching or Direct (Two-Frequency)

The higher frequency (f_H), or “Guard” frequency, is transmitted continually during normal conditions. For a fault sensed by the overreaching (or underreaching) pilot relay, the transmitter is shifted to the low frequency (f_L), called “Trip” frequency.

When using the TCF–10B for any permissive overreaching or underreaching line relay system, you can apply any bandwidth set. However, the best all around set to use will be the wide band, wide shift (600 Hz BW, ±250 Hz Shift) equipment. If signal-to-noise ratio is of concern, however, you may use the narrow band set; on the other hand, if relay speed is critical, you may apply the extra wide band (1,200 Hz, ±500 Hz Shift) equipment. If, in direct transfer trip systems, security due to S/N is of concern, we strongly recommend that you apply only narrow band equipment. In any of these systems, the usual power level combination will be 1 watt for guard and 10 watts for the trip signal.

2.3.3 Phase Comparison Unblocking: Dual or Segregated (Two-Frequency)

Phase Comparison relays use square wave signals for operation. The transmitter is keyed to a “Trip Positive” (or Mark) frequency when the relay square wave goes positive, and is keyed to a “Trip-Negative” (or Space) frequency when the relay square wave is at zero. The Trip Positive frequency is frequency-shifted below f_C; the “Trip Negative” frequency is frequency-shifted above f_C. Either frequency can function as a trip or block, depending on the local square wave.

For Phase Comparison systems, you can use only the wide band with wide shift or extra wide band TCF–10B. In the interest of conserving spectrum, the wide band, wide shift channel is most common. However, if speed is important, you may apply the extra wide band set. The most often applied power level will be 10 watts for both “Trip-Positive” and “Trip-Negative”.

2.3.4 Three-Frequency Systems

The TCF–10B also provides for three-frequency system applications (see Figure 2-13), e.g., Directional Comparison Unblocking with Direct Transfer Trip, or Permissive Overreaching Transfer Trip with Direct Transfer Trip. All three frequencies are closely-controlled discrete frequencies within the equivalent spacing of a single wideband or extra wideband channel. In applying a three-frequency system, the Direct Transfer Trip keying inputs shifts the channel low (i.e., –250 Hz for 600 Hz bandwidth) and the unblock key shifts the channel high (i.e., +250 Hz for 600 Hz bandwidth).

2.4 Ordering Information

The equipment identification number (catalog number) is located in the center of the TCF–10B front panel. The TCF–10B catalog number comprises nine (9) characters, each in a specific position. This number identifies the unit's technical characteristics and capabilities, as well as any optional modules installed in the unit.

Table 2-4 provides a complete listing of the options for ordering a TCF–10B, as well as a sample catalog number. To order one or more TCF–10Bs, simply identify the features and optional modules you want for each chassis. For example, the typical catalog number shown in Table 2-4 — B 2 N 1 B 2 E N D — orders a TCF–10B with the following features:

Chassis: Transmitter/Receiver

Transmitter Power Output: 1/10 W

Bandwidth/Frequency Shift: 300 Hz BW ±100 Hz Shift (Direct Transfer Trip)

Power Supply: 110/125 Vdc battery input

Alarms & Carrier Level Indication: Receiver alarms and CLI only

Channel Type: 2-Frequency

Receiver Output Interface: Electro-mechanical (six contact outputs)

Voice Adapter/Trip Test Unit: No Voice Adapter Module

Receiver Logic: Directional Comparison (Unblock, POTT, PUTT, DUTT, or Direct Transfer Trip)

The TCF–10B accessories are listed in Table 2-3 below.

Table 2–3. TCF–10B Accessories.

Accessories for Voice Adapter	Module	Style Number
Sonalert (2,900 Hz, 60–250 Vdc)		SC250J
Telephone Hook switch Assembly (panel mounting) with Noise Cancelling Handset (single prong plug)		205C266G01
Telephone Handset, Noise Cancelling		1353D88G02

Other Accessories	Module	Style Number
20 Volt Power Supply†	48 Vdc	1610C07G01
	125 Vdc	1610C07G02
	250 Vdc	1610C07G03
TC–10B/TCF–10B Extender Board		1353D70G01

† *(For use with older solid state equipment.) See Figure 2-14 for Schematic and Figure 3-1 for mounting.*

Table 2–4. TCF–10B Catalog Numbers

Catalog Number Position	1	2	3	4	5	6	7	8	9
Typical Catalog Number	B	2	N	1	B	2	E	N	D

Chassis (Position 1)

Transmitter only	T
Receiver only	R
Transmitter/Receiver	B

Transmitter Power Output (Position 2)

1/1 watt	1
1/10 watt	2
10/10 watt*	3
None (Receiver-only chassis)	6

Bandwidth/Frequency Shift (Position 3)

300 Hz BW ±100 Hz Shift (Direct Transfer Trip)	N
600 Hz BW ±100 Hz Shift (Line relaying, use when matching up with existing wideband TCF, TCF–10, or TCF–10A carrier at the remote end of the line)	W
600 Hz BW ±250 Hz Shift (Line relaying)	M
1,200 Hz BW ±250 Hz Shift (Phase comparison line relaying	P
1,200 Hz BW ±500 Hz Shift (Directional comparison line relaying, use when a higher than normal speed channel is desired)	X

Power Supply (Position 4)

48/60 Vdc battery input	4
110/125 Vdc battery input	1
220/250 Vdc battery input	2

Alarms and Carrier Level Indication (Position 5)

Transmitter alarms only	T
Receiver alarms and CLI only	R
Transmitter and Receiver alarms with CLI	B
No alarms or carrier level indication or carrier level outputs	N

Channel Types (Position 6)

2-Frequency	2
3-Frequency (Directional comparison line relaying plus transfer trip)	3

Receiver Output Interface (Position 7)

Solid state (Transistor outputs)	S
Electro-mechanical (six contact outputs)	E
No outputs (Transmitter-only chassis)	N

Voice Adapter / Trip Test Unit (Position 8)

Voice Adapter Module**	V
No Voice Adapter Module	N
Voice Adapter Module with Trip Test Unit**	W
Trip Test Unit w/o Voice Adapter Module	T

Receiver Logic (Position 9)

Directional Comparison (Unblock, POTT, PUTT, DUTT, or Direct Transfer Trip)	D
Phase Comparison	P
Telemetry (Slow speed Direct Transfer Trip; contains no noise processing or channel logic; not recommended for line relaying applications)	T
No logic (Transmitter-only chassis)	N

**For 50 or 100 watt output, see separate information on the LPA, Linear Power Amplifier*

***Available in Transmitter/Receiver chassis only.*

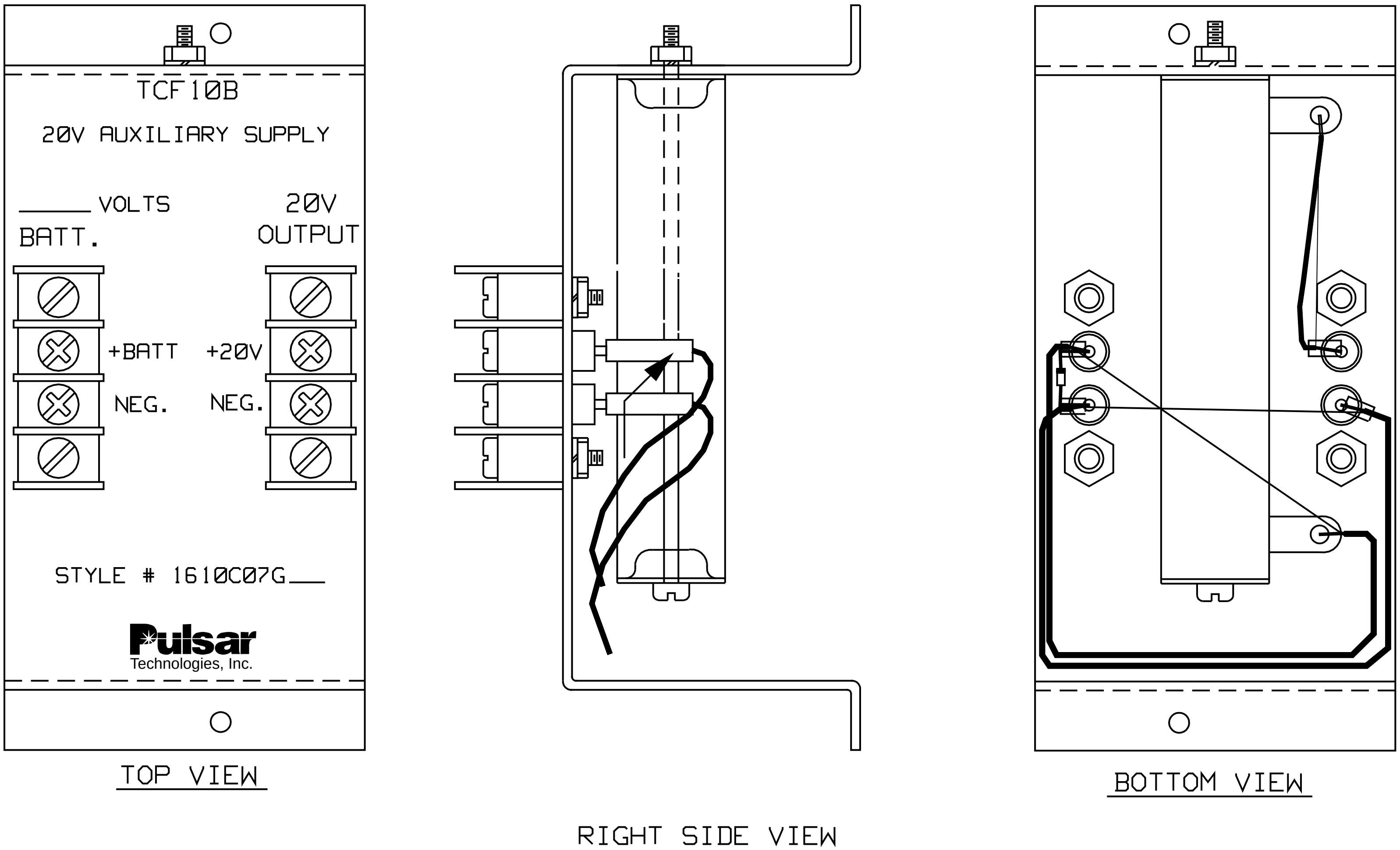
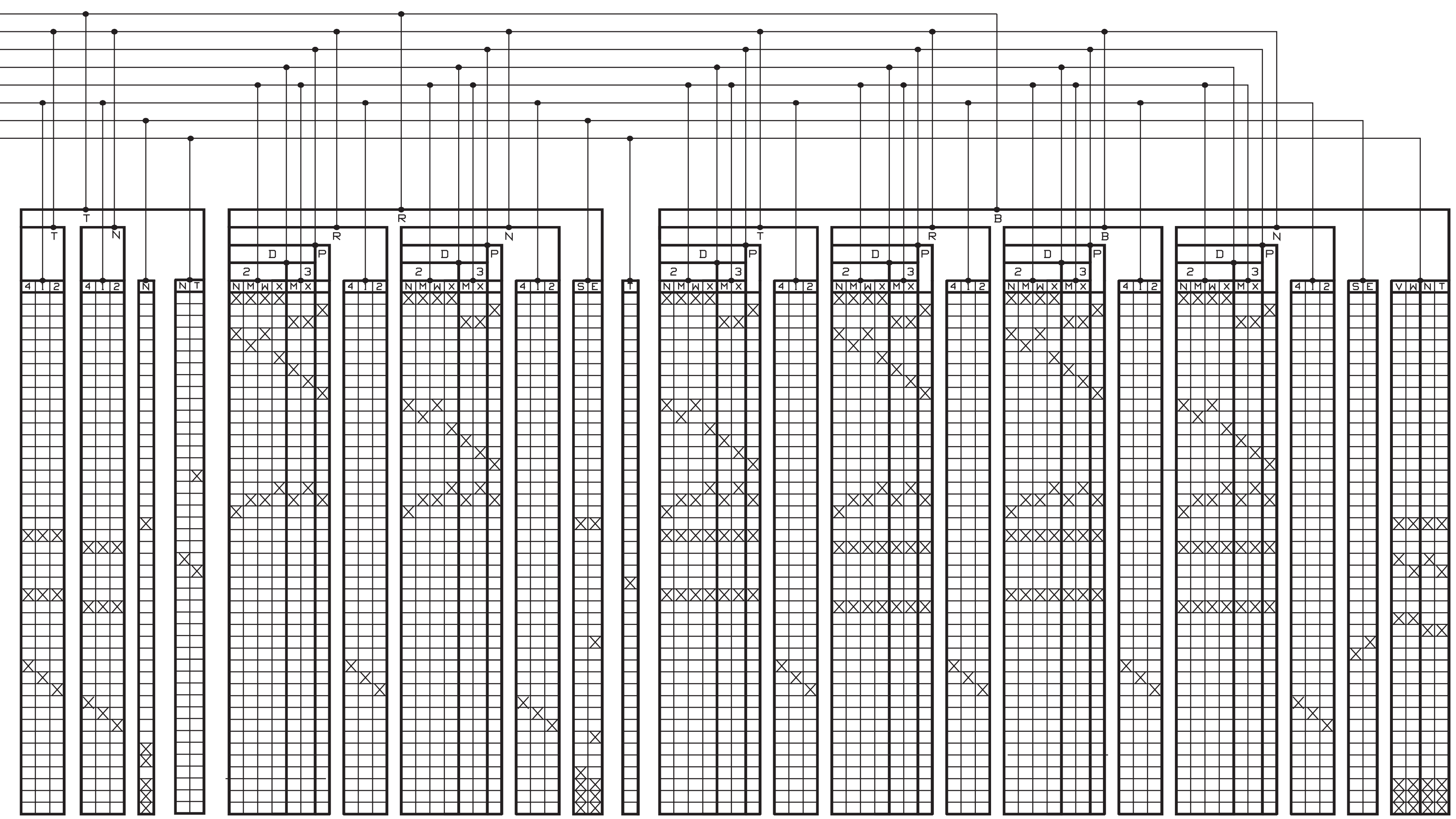


Figure 2–14. 20 Vdc Auxiliary Power Supply (1610C07; Sheet 1 of 2).

B 2 N 1 R 2 E N D
1 2 3 4 5 6 7 8 9

1 CHASSIS T,R,B
5 ALARM AND CARRIER LEVEL INDICATION T,R,B,N
9 APPLICATION D,P,N
6 CHANNEL TYPE 2,3
3 BANDWIDTH/FREQUENCY SHIFT N,M,W,X
4 POWER SUPPLY 4,1,2
7 OUTPUT INTERFACE S,E,N
8 VOICE V,N,W,T



POSITION	DESCRIPTION OF MODULE	STYLE
1	LOGIC AND SOLID STATE OUTPUT FOR 2 FREQUENCY UB, PORTT,DTT	1606C52G01
	LOGIC AND SOLID STATE OUTPUT FOR 2 FREQUENCY PHASE COMPARISON	1606C52G02
	LOGIC AND SOLID STATE OUTPUT FOR 3 FREQUENCY DUAL UB, PORTT, DTT	1606C52G03
3	DISCRIMINATOR CLI AND S/N MONITOR NARROW SHIFT 2 FREQUENCY WITH INT & EXT CLI	1606C51G01
	DISCRIMINATOR CLI AND S/N MONITOR WIDE SHIFT 2 FREQUENCY WITH INT & EXT CLI	1606C51G02
	DISCRIMINATOR CLI AND S/N MONITOR EXTRA WIDE SHIFT 2 FREQUENCY WITH INT & EXT CLI	1606C51G03
	DISCRIMINATOR CLI AND S/N MONITOR WIDE SHIFT 3 FREQUENCY WITH INT & EXT CLI	1606C51G04
	DISCRIMINATOR CLI AND S/N MONITOR EXTRA WIDE SHIFT 3 FREQUENCY WITH INT & EXT CLI	1606C51G05
	DISCRIMINATOR CLI AND S/N MONITOR WIDE SHIFT FOR PHASE COMP. WITH INT & EXT CLI	1606C51G06
	DISCRIMINATOR CLI AND S/N MONITOR NARROW SHIFT 2 FREQUENCY WITHOUT INT & EXT CLI	1606C51G07
	DISCRIMINATOR CLI AND S/N MONITOR WIDE SHIFT 2 FREQUENCY WITHOUT INT & EXT CLI	1606C51G08
	DISCRIMINATOR CLI AND S/N MONITOR EXTRA WIDE SHIFT 2 FREQUENCY WITHOUT INT & EXT CLI	1606C51G09
	DISCRIMINATOR CLI AND S/N MONITOR WIDE SHIFT 3 FREQUENCY WITHOUT INT & EXT CLI	1606C51G10
	DISCRIMINATOR CLI AND S/N MONITOR EXTRA WIDE SHIFT 3 FREQUENCY WITHOUT INT & EXT CLI	1606C51G11
	DISCRIMINATOR CLI AND S/N MONITOR WIDE SHIFT FOR PHASE COMP. WITHOUT INT & EXT CLI	1606C51G12
	TT UNIT JUMPER BOARD (TRANSMITTER CHASSIS)	1614C59G01
5	RECEIVER EXTRA WIDEBAND (1200Hz)	1606C32G01
	RECEIVER WIDEBAND (600Hz)	1606C32G02
	RECEIVER NARROWBAND (300Hz)	1606C32G03
8	RF INTERFACE	1609C32G01
12	10W POWER AMPLIFIER WITH POWER ON RELAY	1606C33G01
	10W POWER AMPLIFIER WITHOUT POWER ON RELAY	1606C33G02
14	TRANSMITTER 2 OR 3 FREQUENCY	1610C01G01
	TRANSMITTER 2 OR 3 FREQUENCY WITH TRANSFER TRIP TEST UNIT	1610C01G02
	TT UNIT JUMPER BOARD (RECEIVER CHASSIS)	1614C59G02
17	KEYING UNIVERSAL DCR,PCR, 2 OR 3 FREQUENCY WITH RELAY CONTACTS	1606C50G01
	KEYING UNIVERSAL DCR,PCR, 2 OR 3 FREQUENCY WITHOUT RELAY CONTACTS	1606C50G02
18	VOICE ADAPTER (TRANSCEIVER ONLY)	1606C39G01
	BLANK PANEL (2 UNITS)	1606C47H03
20	ELECTROMECHANICAL RELAY OUTPUT	1606C53G01
	BLANK PANEL (2 UNITS)	1606C47H03
22	POWER SUPPLY 48V WITH ALARM RELAY	1617C38G01
	POWER SUPPLY 125V WITH ALARM RELAY	1617C38G02
	POWER SUPPLY 250V WITH ALARM RELAY	1617C38G03
	POWER SUPPLY 48V WITHOUT ALARM RELAY	1617C38G04
	POWER SUPPLY 125V WITHOUT ALARM RELAY	1617C38G05
	POWER SUPPLY 250V WITHOUT ALARM RELAY	1617C38G06
12	BLANK PANEL (8 UNITS)	1606C47H09
18	BLANK PANEL (4 UNITS)	1606C47H05
1	BLANK PANEL (7 UNITS)	1606C47H08
12	BLANK PANEL (10 UNITS)	1606C47H11
NONE	CHASSIS ASSEMBLY	1353D63G02
10	NAMEPLATE	1496B80H04
NONE	FRONT COVER ASSEMBLY	1606C49G01

Foigure 2–15. TCF–10B Catalog Numbers/Module Style Numbers (1355D19)

Chapter 3. Installation

3.1 Unpacking

If the TCF–10B is shipped unmounted, it is packed in special cartons that are designed to protect the equipment against damage.

CAUTION

UNPACK EACH PIECE OF EQUIPMENT CAREFULLY SO THAT NO PARTS ARE LOST. INSPECT THE CONDITION OF THE TCF-10B AS IT IS REMOVED FROM ITS CARTONS. ANY DAMAGE TO THE TCF-10B MUST BE REPORTED TO THE CARRIER. DAMAGES ARE THE RESPONSIBILITY OF THE CARRIER, AND ALL DAMAGE CLAIMS ARE MADE GOOD BY THE CARRIER. PLEASE SEND A COPY OF ANY CLAIM TO PULSAR TECHNOLOGIES, INC.

3.2 Storage

If you are setting the equipment aside before use, be sure to store it in its special cartons (in a moisture-free area) away from dust and other foreign matter.

3.3 Installation Location

Install the TCF–10B in an area which is free from:

- Temperature exceeding environmental limits (See “Environmental Requirements” in Chapter 1)
- Corrosive fumes
- Dust
- Vibration

3.4 Assembly

You can assemble the TCF–10B for use either in one of the following configurations:

- Mounted in a fixed-rack cabinet.
- Mounted in a swing-rack cabinet
- Mounted on an open rack.

or in your own, customer-specified configuration. Refer to Figure 3-3 for mounting dimensions.

CAUTION

IF YOU ARE USING THE TCF-10B WITH A SWING-RACK CABINET, MAKE SURE THAT THE CABINET IS FIRMLY FASTENED BEFORE OPENING THE RACK (TO PREVENT TIPPING).

3.5 TCF–10B Rear Panel Connectors

The following connectors are accessible from the Rear Panel (See Figure 3-1, Figure 3-4, and Figure 3-5):

- Terminal Blocks.
- Cable Jacks
- Jumpers
- Input/Output Pins

NOTE

Low-powered microprocessor relays housed in a solid metal case do not allow for the necessary air circulation. If you are using this type of relay, make sure you provide one rack unit (1 RU) of space on the top and bottom of the carrier set to ensure proper air circulation.

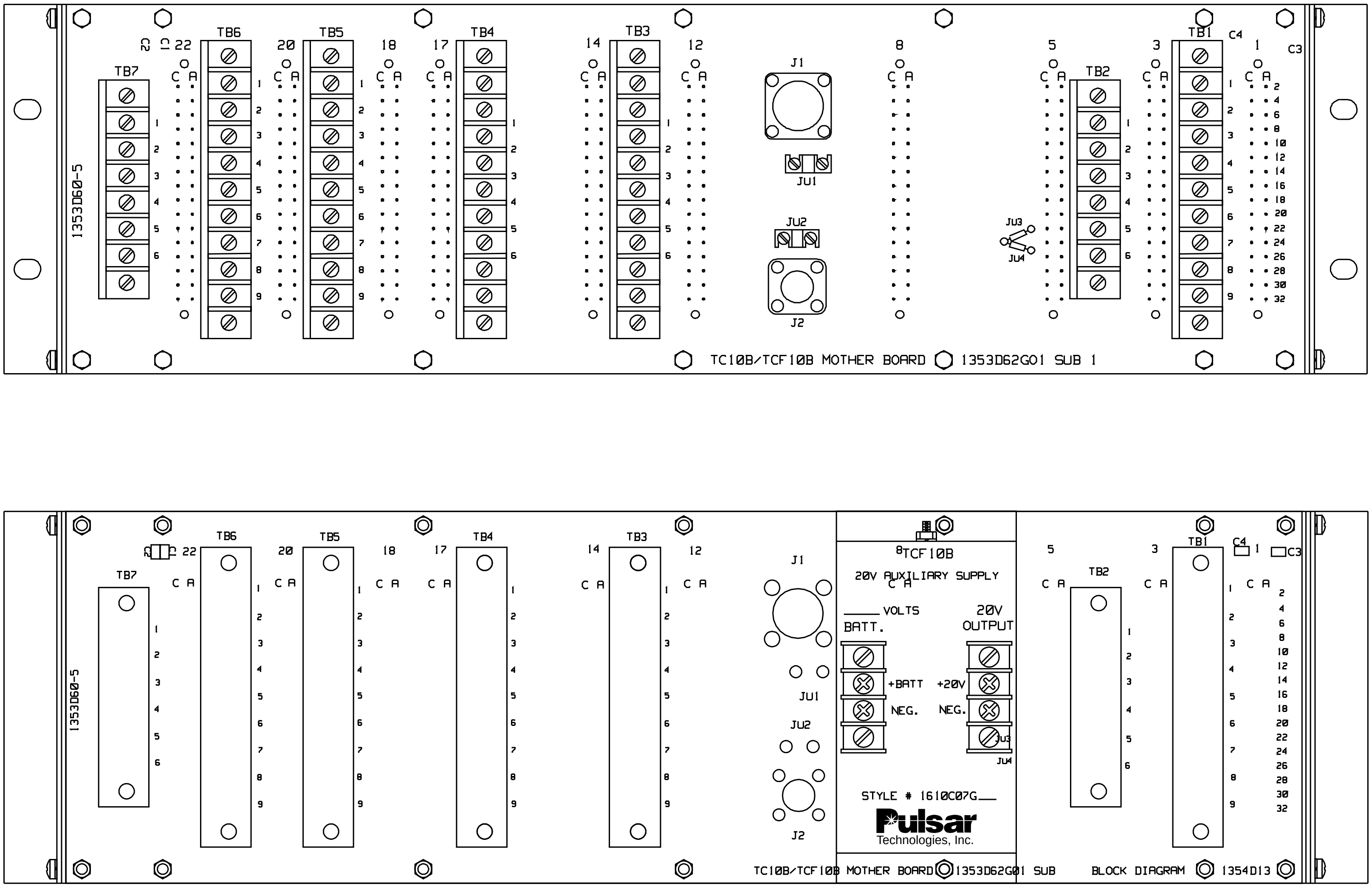


Figure 3–1. TCF–10B Rear Panel (1354D16 /1610C07; Sheet 2 of 2).

3.5.1 Terminal Blocks

(Refer to Figure 3-4 for further information.)

TB7 Power Supply	(Terminals 1 thru 6)
TB6 EM Output	(Terminals 1 thru 9)
TB5 Voice Adapter	(Terminals 1 thru 9)
TB4 Keying	(Terminals 1 thru 6)
TB3 10W PA	(Terminals 1 thru 6)
TB2 CLI and Discriminator	(Terminals 1 thru 6)
TB1 Receiver Logic	(Terminals 1 thru 9)

3.5.2 Cable Jacks

J1 RF Interface module Transmitter, RF output line, thru 2-wire coaxial cable (UHF)

J2 RF Interface module Receiver, RF input line thru 5,000 ohm 4-wire coaxial cable (BNC)

3.5.3 Jumpers

JU1 UHF Chassis Ground (for J1)

JU2 BNC Chassis Ground (for J2)

JU3 5.02 MHz signal for optional Voice Adapter

JU4 20 kHz signal for optional Voice Adapter

3.5.4 Input/Output Pins

Pins labeled C and A provide 16 input/output connections per module (using even numbers 2 through 32 for all modules) as follows:

- Power Supply (pins are to right of TB7)
- EM Output (pins are to right of TB6)
- Voice Adapter (pins are to right of TB5)
- Keying (pins are to left of TB4)
- Transmitter (pins are to left of TB3)
- 10W PA (pins are to right of TB3)
- RF Interface (pins are to right of cable jacks and jumpers)
- Receiver (pins are to left of TB2)
- CLI and Discriminator (pins are to left of TB1)
- Receiver Logic (pins are to right of TB1)

3.5.5 Optional 20 Vdc Auxiliary Supply

- Battery Input (+, -)
- 20 V Output (+20 V, negative)

3.6 Connections

3.6.1 Safety Precautions

Read this Installation Section thoroughly before making any connections to the TCF–10B. ***No one should be permitted to handle any of the equipment that is supplied with high voltage, or connect any external apparatus to the equipment, unless that person is thoroughly familiar with the hazards involved.***

Three types of connections are made:

- TCF–10B equipment ground
- DC power supply and other connections
- Coaxial cables

! CAUTION

PRIOR TO MAKING CONNECTIONS, CLOSE THE PROTECTIVE GROUND KNIFE SWITCH IN THE CABINET.

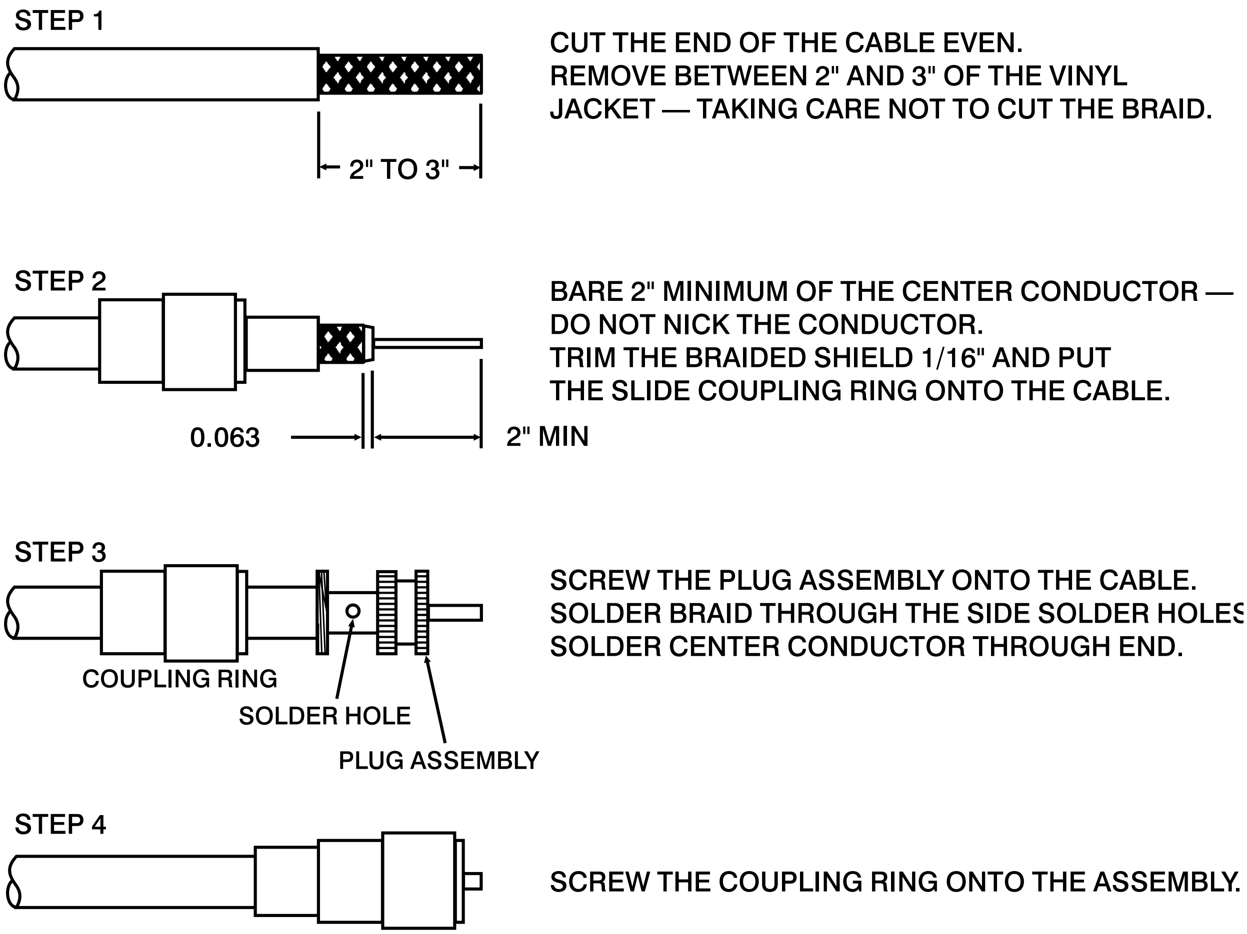


Figure 3–2. Cable Termination Diagram (9651A13).

3.6.2 TCF–10B Equipment Ground

In addition to the TCF–10B chassis ground connection that is made through the cabinet or rack, a ground connection is provided at the Rear Panel Terminal Block (TB7). (See Figure 3-1 and Figure 3-4.) A connection should be made between TB7 Terminal 6 and the ground connection at the TCF–10B cabinet location.

3.6.3 DC Power Supply and Other Connections

Input/Output terminals, on the rear of the TCF–10B chassis, provide the connection points for the power supply (48, 125, and 250 Vdc) and customer interconnections. (See Figure 3-1 and Figure 3-4.)

Any lead coming to or from the switchyard should be shielded twisted pair to protect against transients.

3.6.4 Coaxial Cable

A coaxial cable is required for a low-impedance path between the TCF–10B (Transmitter and Receiver modules) and the Line Tuner (in the switchyard). Connection jacks (J1 & J2), on the Rear Panel, provide the point for coaxial cable connection from the TCF–10B to the switchyard.

The type of coaxial cable we recommend is RG-213/U (52 ohms, 29.5 pf/foot):

- Single-conductor
- #12 AWG
- 7 strand #21 copper
- Polyethylene insulator
- Copper shield
- Vinyl jacket (nominal O.D. 0.405 inch)

If the coaxial cable is to connect to related cabinets enroute to the switchyard, you should connect the RG-58A/U cable from J1 or J2 to the related cabinets, and RG-213/U from the cabinets to the switchyard. Install the coaxial cable according to the following procedures:

1. Attach both ends of the coaxial cable in accordance with the Cable Termination Diagram (see Figure 3-2, terminal block lugs, as required).
2. In order to hold carrier loss to a minimum, keep the cable the shortest possible length.

   The minimum cable bending radius is six times the cable diameter.
3. The copper braid of the cable must be grounded at the end which connects to the TCF–10B.

CAUTION

DO NOT GROUND TO THE END OF THE CABLE THAT IS CONNECTED TO THE LINE TUNER.

4. Without grounding the copper braid of the cable, connect the cable to the ground terminal of the Line Tuner, at either of the following:
   - Impedance Matching Transformer
   - Wideband Filter

   If you are connecting the cable directly to the line tuner, the cable connector can enter the line tuner base either through the side or the bottom of the base.

3.7 Disconnections

CAUTION

NEVER DISCONNECT THE CARRIER LEAD-IN BETWEEN THE LINE TUNER AND THE COUPLING CAPACITOR UNLESS THE LOW POTENTIAL END OF THE COUPLING CAPACITOR IS GROUNDED. BEFORE DISCONNECTING THE CARRIER LEAD-IN CONDUCTORS, CLOSE THE GROUNDING SWITCH AT THE BASE OF THE COUPLING CAPACITOR. IF THIS GROUND IS NOT PROVIDED, DANGEROUS VOLTAGES CAN BUILD UP BETWEEN THE LINE TUNER AND COUPLING CAPACITOR.

3.8 Jumper Controls

Jumpers are set during installation, depending on the particular TCF–10B features and applications involved (see Figure 3-4).

3.8.1 Power Supply PC Board

Jumper (JU1) for the optional Alarm Relay establishes contact type during loss of power condition (NO or NC).

NOTE

JU1 is shipped in the "NC" state.

3.8.2 Keying PC Board

JU1	Transmitter Keying (NORM or INVERT)
JU2	Directional Comparison or Phase Comparison (DCR or PCR)
JU3	1 W Guard, 10 W Trip or 10 W Guard, 10 W Trip (1/10 W or 10/10 W)
JU4	2-Frequency System or 3-Frequency (Optional) System (2F or 3F)
JU6	Activates Shift High Contact Alarm (IN or OUT)
JU7	Activates Shift Low Contact Alarm (IN or OUT)
JU8	Selects NO or NC contact for Shift High (NO or NC)
JU9	Selects NO or NC contact for Shift Low (NO or NC)
JU10–JU14	Input voltage selections for different Keying inputs (15 V, 48 V, 125 V, or 250 V)

3.8.3 Transmitter PC Board

There are no jumpers to be set on the Transmitter PC Board during installation.

3.8.4 10W PA PC Board

Jumper (JU1) for the optional Alarm Relay establishes loss of power condition (NO or NC).

NOTE

JU1 is shipped in the "NC" state.

3.8.5 RF Interface PC Board

Matching Impedance Jumpers:

JU4	50 ohms
JU3	75 ohms
JU2	100 ohms

2-wire or 4-wire RF Termination:

JU1 and JU5	"IN" (2-wire)
JU1 and JU5	"OUT" (4-wire)

Attenuator Override Jumper (JU6):

- NORM Sensitivity (20 mV to 70 V for narrowband or 60 mV to 17 V for wideband)
- HIGH Sensitivity (5 mV to 17 V for narrowband or 15 mV to 17 V for wideband)

3.8.6 Receiver PC Board

Jumper (JU1) has a "Disable" position which allows the Receiver to be turned "OFF" when the Transmitter is keyed; the "Norm" position has no effect.

> **NOTE**
>
> **Do not use the "DISABLE" position on the Receiver board with TCF–10B.**

3.8.7 CLI and Discriminator PC Board

Jumper JU2 provides alternate contact status (NO or NC) for margin relay.

Jumper JU3 should be left untouched.

> **NOTE**
>
> **JU1 is shipped in the "NC" state.**

3.8.8 Receiver Logic PC Board

The Receiver Logic Module (style number CF20-RXLMN-00X) has no jumpers on its PC board. Instead, it provides three banks of DIP switches to control its logic functions. Each board also includes a pre-programmed, plug-in EPLD chip for one of the following types of application:

- 2-Frequency Directional Comparison
- 3-Frequency Directional Comparison
- 2-Frequency Phase Comparison

For complete information and instructions on setting the DIP switches, please refer to "Setting the DIP Switches for Your Application" in Chapter 16. For a diagrammed overview of the possible DIP switch settings and other signal flow information for each application, please refer to Figure 16-7 (2-Frequency Directional Comparison), Figure 16-8 (3-Frequency Directional Comparison), and Figure 16-9 (2-Frequency Directional Comparison).

3.8.9 EM Output Board

There are six relays on the board; six jumpers (JU1 thru JU6) determine the function of the relays. The choice of functions are:

- Guard
- Trip 1
- Trip 2
- Off

There are six additional jumpers which provide "NO" or "NC" contacts for the alarm relays as follows:

- K1 (JU7)
- K2 (JU8)
- K3 (JU9)
- K4 (JU10)
- K5 (JU11)
- K6 (JU12)

3.8.10 Voice Adapter PC Board

Operator controls consist of five jumpers, as follows:

JU1 Receiver Squelch (IN or OUT)

When the jumper is "IN", voice keying squelches the receive audio signal.

JU2/JU3 Compandor (IN or OUT)

When the jumpers are "IN", the audio is compandored; when the jumpers are"OUT", the audio is not compandored. For best performance, we recommend the "IN" position.

JU4 Signaling (TC or TCF)

When the jumper is set for "TC", and the handset (TJ1) is plugged into the handset jack, the alarm cutoff from the handset jack will cause the relay to operate. When the jumper is set for "TCF", the presence of a signaling tone will operate the relay.

JU5 Alarm Contacts (NO or NC)

When the jumper is set in the "NO" position, and the relay is de-energized, the alarm contacts will be "OPEN". When the jumper is in the"NC" position, and the relay is de-energized, the alarm contacts will be "CLOSED".

USER NOTES

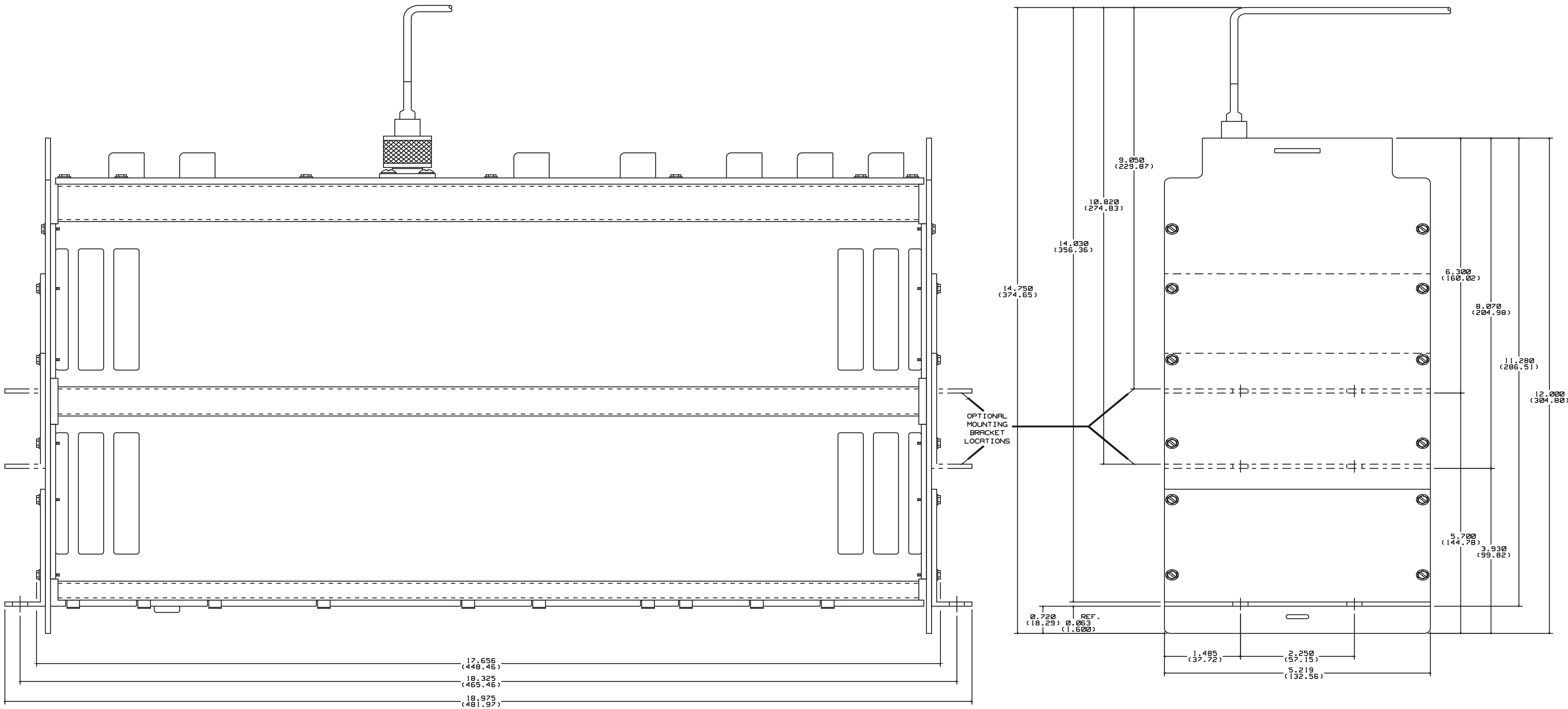
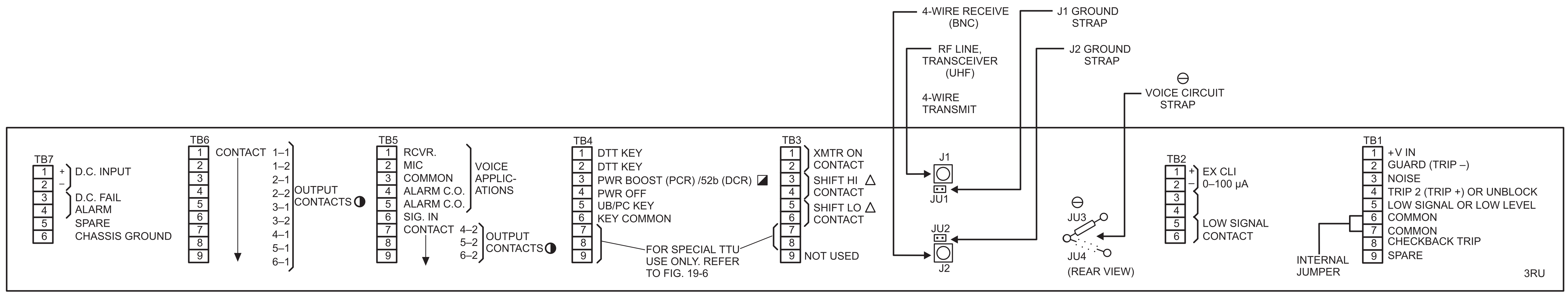


Figure 3–3. TC–10B/TCF–10B Mechanical Outline Drawing. (1354D48)



NOTES:
- ◑ Only on sets with Electro-Mechanical outputs.
- ◪ When JU2 is in the DCR position, this input is used for 52b keying. When JU2 is in the PCR position, this input is used for power boost.
- ⊖ Jumper is always in position JU3. (JU3 applies 5 MHz signal to Voice Adapter.)
- △ Disabled for phase-comparison transmitters.

OPTIONS

ALARM & CLI:
- D.C. FAILURE ALARM
- R.F. OUTPUT ALARM RELAY
- CLI ON MODULE AND ANALOG OUTPUT (0–100 µA)
- TRIP AND GUARD FREQUENCY KEYED*

VOICE – VOICE ADAPTER MODULE

JUMPER OPTIONS

POWER SUPPLY MODULE

JU1 NORMALLY OPEN/ NORMALLY CLOSED ALARM CONTACT

VOICE ADAPTER MODULE

JU1 IN/OUT FOR SQUELCH
JU2 IN/OUT FOR COMPRESSOR
JU3 IN/OUT FOR EXPANDER
JU4 TC/TCF
JU5 NO/NC FOR ALARM

10W POWER AMPLIFIER

JU1 NORMALLY OPEN/ NORMALLY CLOSED CONTACT OUTPUT

RF INTERFACE MODULE

JU1 IN 2-WIRE; OUT 4-WIRE
JU2 IMPEDANCE – 100 OHM
JU3 IMPEDANCE – 75 OHM
JU4 IMPEDANCE – 50 OHM
JU5 IN 2-WIRE; OUT 4-WIRE
JU6 NORM/HIGH SENSITIVITY

CLI/DISCRIMINATOR MODULE

JU1 WIDEBAND ONLY
JU2 NORMALLY OPEN/ NORMALLY CLOSED CONTACT OUTPUT
JU3 FACTORY TEST ONLY

KEYING MODULE

JU1 INV/NORM FOR POWER OFF
JU2 DCR/PCR
JU3 10 W/10 W OR 1 W/1 W
JU4-2F 2 FREQ
JU4-3F 3 FREQ
JU6 HI SHIFT CONTACTS FUNCTIONAL
JU7 LO SHIFT CONTACTS FUNCTIONAL
JU8 N/O OR N/C SHIFT HI CONTACT
JU9 N/O OR N/C SHIFT LO CONTACT
J10 DTT
JU11 EXT VOICE KEY
JU12 POWER BOOST (PCR)/ 52b (DCR)
JU13 POWER OFF
JU14 UB, POTT, PC KEY

(J10–JU14: VOLTAGE SELECTION)

EM (RELAY) OUTPUT MODULE

JU1–JU6 TRIP 1/TRIP 2/GUARD/OFF
JU7–JU12 NORM OPEN/NORM CLOSED

RECEIVER LOGIC MODULE

THIS MODULE USES DIP SWITCHES INSTEAD OF JUMPERS TO CONTROL ITS LOGIC FUNCTIONS. FOR DIP SWITCH SETTINGS, PLEASE SEE TABLES 16-2 THROUGH 16-20 IN CHAPTER 16.

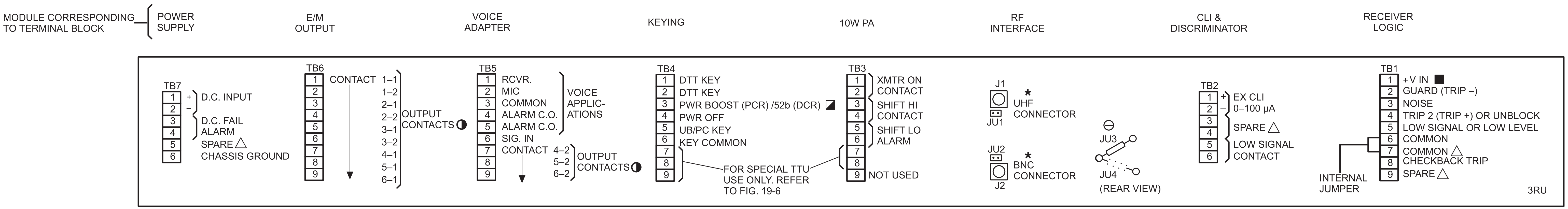
RECEIVER MODULE

JU1 NORMAL/DISABLE ALWAYS "NORMAL" FOR TCF–10B

Figure 3–4. TCF–10B Connection Drawing and Jumper Options. (2064D87; Sheet 1 of 2)

TCF–10B CHASSIS WIRING BREAKDOWN

(Shows which terminals are wired for different catalog number options.)



* J1 and J2 coaxial connectors may be wired out to terminal blocks or connected to RF hybrids. J1 is used for either the 2-wire transceiver output or the 4-wire transmitter output. J2 is used for the 4-wire receive input only.

△ These terminals do not need to be wired out.

■ In applications where 20 VDC is required and is not supplied from the interfacing relay, an auxiliary power supply (style 1610C07G0_) can be supplied. It mounts on the back of the chassis.

Chassis Options	Module Options	Terminal Blocks Used
Transmitter Only	1. None (basic transmitter)	TB4 (1–6), TB7 (1, 2, 6)
	2. Voice adapter	TB5 (1–6)
	3. Alarms/CLI (includes DC fail, shift HI and shift LO contacts, and XMTR ON contact)	TB3 (1–6) TB7 (3, 4)
Receiver Only	1. None (basic receiver)	TB1 (1–6, 8), TB7 (1,2,6))
	2. Voice Adapter	TB1 (1–6, 8), TB7 (1,2,6))
	3. Alarms/CLI (includes DC fail, low signal contact, and external CLI output)	TB2 (1, 2, 5, 6) TB7 (3, 4)
	4. E/M outputs	TB6 (1–9); TB5 (7–9)
Transceiver (Transmitter and Receiver)	(Combine options from above)	(See above)

Figure 3–5. TCF–10B Connection Drawing and Jumper Options. (2064D87; Sheet 2 of 2)

Chapter 4. Test Equipment

Table 4-1 shows the equipment you should use to perform the Acceptance Tests (Chapter 5) and Routine Adjustments (Chapter 6).

Table 4–1. Recommended Test Equipment.

Equipment	Application
High-Impedance Selective Level Meter, 300 Hz to 1 MHz (Rycom 6021A)*	• Impedance Matching • Transmitter Power Adjustment • Receiver Margin Setting
Current Meter (Simpson 260)*	Check dc Supply
Reflected Power Meter, Auto VLF Power SWR Meter (Signal Crafter 70)*	Impedance Matching at Carrier Output
Oscilloscope (Tektronix)*	• Transmitter Power • Adjustment for Optional Voice Adapter Module
Frequency Counter, 80 MHz (H/P5381A)*	• Transmitter Frequency • Offset for three-terminal line applications
Non-Inductive Resistor, 50 Ohm, 25 W (Pacific)*	Transmitter Termination
Signal Generator (H/P 3325A, Signal Crafter Model 90)*	General ac output for lab measurements
Extender Board (1353D70G01)	(See Figure 4-1.)

CAUTION

WE RECOMMEND THAT THE USER OF THIS EQUIPMENT BECOME THOROUGHLY ACQUAINTED WITH THE INFORMATION IN THESE INSTRUCTIONS BEFORE ENERGIZING THE TCF–10B AND ASSOCIATED ASSEMBLIES. YOU SHOULD NOT REMOVE OR INSERT PRINTED CIRCUIT MODULES WHILE THE TCF–10B IS ENERGIZED. ALL INTEGRATED CIRCUITS USED ON THE MODULES ARE SENSITIVE TO AND CAN BE DAMAGED BY THE DISCHARGE OF STATIC ELECTRICITY. YOU SHOULD ALWAYS OBSERVE ELECTRO-STATIC DISCHARGE PRECAUTIONS WHEN HANDLING MODULES OR INDIVIDUAL COMPONENTS. FAILURE TO OBSERVE THESE PRECAUTIONS CAN RESULT IN COMPONENT DAMAGE.

* ***Indicates "or equivalent" of the recommended equipment item.***

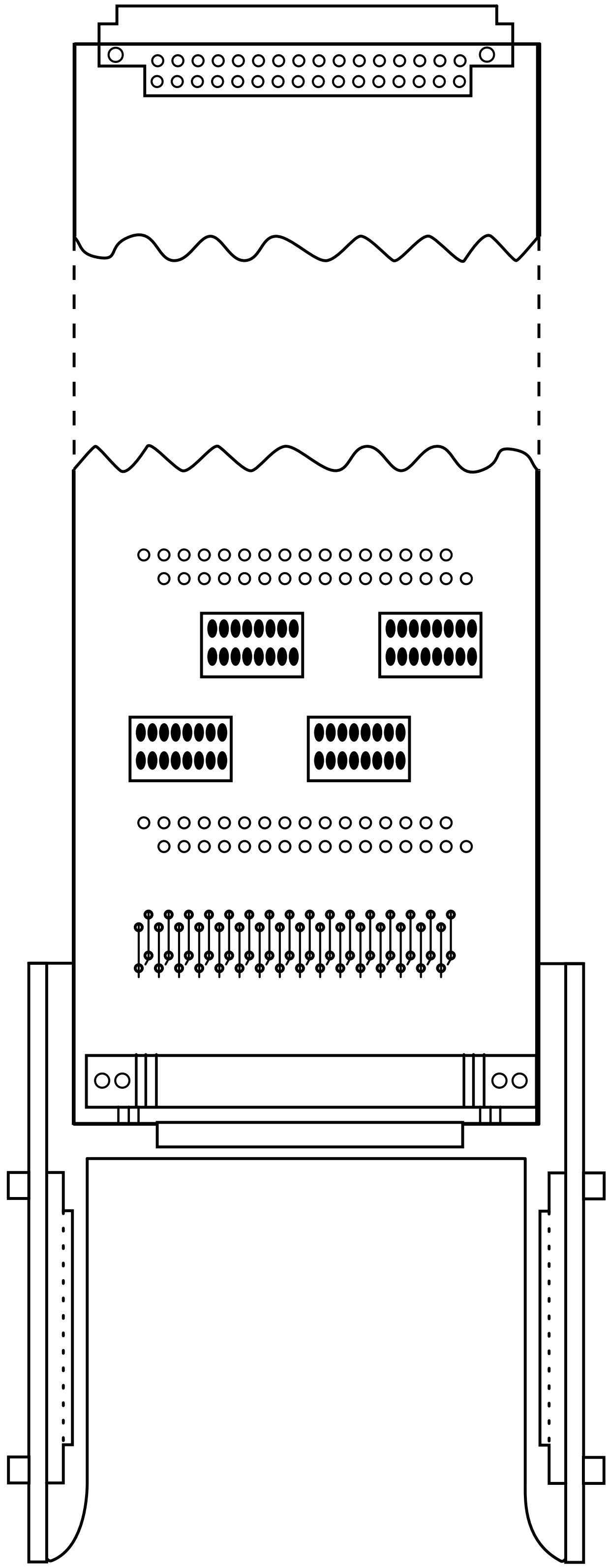


Figure 4–1. Extender Board.

Chapter 5. Acceptance Tests

You may perform the TCF–10B acceptance tests at your installation to determine that the TCF–10B is operational. (See Test Equipment in Chapter 4, and Signal Path in Chapter 7.)

If the TCF–10B is a Transmitter (only) set, perform the following segments: 5.1, 5.2, 5.3, and 5.4. If the TCF–10B is a Receiver (only) set, perform segments 5.1, 5.2, 5.5, and 5.6. If the TCF–10B is a Transceiver set, perform segments 5.1, 5.2, and 5.7.

5.1 Preliminary Checks

5.1.1 Checking the Chassis Nameplate

Verify that the proper dc supply voltage and module options are on the chassis nameplate. Also, check for narrow, wide, or extra wide band; Phase Comparison or Directional Comparison (2- or 3-Frequency).

Check to ensure that all required modules are supplied and are installed in the proper chassis slots. The slots are labeled on the top edge of the chassis.

CAUTION

ALWAYS TURN "OFF" DC POWER WHENEVER REMOVING OR INSTALLING MODULES.

5.1.2 Inspecting for the Correct dc Voltage

With the power "OFF," remove the Power Supply module and inspect it for the correct dc voltage, as specified in Table 5-1.

Table 5–1. Voltage Specifications.

Specified		Group
48 V	with Alarm Relay	G01
125 V	with Alarm Relay	G02
250 V	with Alarm Relay	G03
48 V	w/o Alarm Relay	G04
125 V	w/o Alarm Relay	G05
250 V	w/o Alarm Relay	G06

5.2 TCF–10B Preliminary Connections

1. Refer to the Block Diagram (see Chapter 7, Signal Path) for keying and output connections.
2. Connect the dc supply to the appropriate terminals on the Rear Panel (see Figures 3-1 and 3-4, in Chapter 3, Installation).

NOTE

Perform Steps 3 and 4 only if the chassis contains a transmitter.

3. Terminate the Transmitter output with a non-inductive 50 ohm, 25 W resistor.
4. Connect the Selective Level Meter (Rycom 6021A) across the 50 ohm resistor load.

5.3 TCF–10B Preliminary Settings For Transmitter (Only) Sets

Make the following preliminary jumper and switch settings before proceeding with the tests.

5.3.1 Power Supply Module

JU1 N.C. (G01, 02, or 03)

5.3.2 Keying Module

JU1 Invert

JU2 DCR

JU3 1W/10W

JU4 3 frequency

JU6 IN (G01 only)*

JU7 IN (G01 only)*

JU8 N.O. (G01 only)

JU9 N.O. (G01 only)

JU10 Voltage per chassis nameplate

JU11 Voltage per chassis nameplate

JU12 Voltage per chassis nameplate

JU13 Voltage per chassis nameplate

JU14 Voltage per chassis nameplate

5.3.3 Transmitter Module

Set the four rotary switches to 250.0 kHz or the desired frequency.

5.3.4 10W PA Module

JU1 N.O. (G01 only)

5.3.5 RF Interface Module

Matching Impedance Jumpers

JU2 (out)

JU3 (out)

JU4 (IN, 50 ohms)

**Place in the "OUT" position when using with the Phase Comparison relay systems.*

2-Wire or 4-Wire RF Termination

JU1 (out, 4 wire)

JU5 (out, 4 wire)

Attenuator Override Jumper

JU6 (NORM, Sensitivity)

5.4 Tests of TCF–10B Transmitter (Only) Sets

CAUTION

ALWAYS TURN DC POWER "OFF" BEFORE REMOVING OR INSTALLING CHASSIS MODULES.

5.4.1 Power Supply Module Tests

1. Turn "ON" dc power. Both LEDs (D3, Input and D11, Output) on the Power Supply Module should be "ON". Measure dc voltage at Power Supply test jacks:
   - TJ1/TJ2 (+20 Vdc ± 1 Vdc)
   - TJ3/TJ2 (-20 Vdc ± 1 Vdc)

   If the voltage is not within the above limits, ***do not*** proceed further. Have the power supply repaired or replaced.
2. Turn "OFF" the dc power. The Input LED (D3) should be "OFF".
3. Place the current meter (Simpson 260 or equivalent) in series with the input dc supply and check the current for the appropriate voltage source, according to the specifications in Table 5-2:
4. Vary the input dc voltage to the minimum and maximum levels per the following chart:

Nominal	Min	Max
48 V	38 V	70 V
125 V	88 V	140 V
250 V	176 V	280 V

Table 5–2. Voltage Specifications.

VOLTAGE	CURRENT (Amps)		
	TX Only Key @ 1 W	RCV Only	TXCVR Key @ 10 W
48 Vdc	0.7 – 0.9	0.3 – 0.6	0.9 – 1.1
125 Vdc	0.2 – 0.4	0.15 – 0.25	0.3 – 0.5
250 Vdc	0.1 – 0.2	0.05 – 0.15	0.15 – 0.25

Table 5–3. Transmitter Output Levels.

Keyed Level	10W PA Input	Output Across 50 Ohms	RF Interface Line-Common ***	10W PA* Control	XMTR Adjust
Normal (1 W)	-10.2 to -9.8 dBm (69.1 to 72.35 mVrms)	29.8 to 30.2 dBm (6.91 to 7.235 Vrms)	29.8 to 30.2 dBm (6.91 to 7.235 Vrms)	—-	R12
HL (10 W)**	-0.2 to + 0.2 dBm (210 to 230 mVrms)	39.8 to 40.2 dBm (21.00 to 23.00 Vrms)	39.8 to 40.2 dBm (21.00 to 23.00 Vrms)	Input Level	R13

* Set the 10W PA control first, so that the output across 50 Ohms is 40 dB greater than the input to the 10W PA. Then adjust R12 (or R13) to obtain specified levels across 50 ohms.

** Push HL test button on the Keying module to obtain a 10 W level.

*** When strapped for 50 ohm and terminated in 50 ohm; values will be different for 75 ohm and for 100 ohm.

5. Observe the front panel voltages to make sure they are as specified in Step 2 above. Both LEDs should be “ON”.
6. Return to nominal dc voltage.

5.4.2 Transmitter Tests

Input/Output Levels

Use the Selective Level Meter to measure levels per Table 5-3. If the 10W PA input level is not within limits, place the Transmitter module on an extender board (see Figure 4-1), and make the adjustments with controls per Table 5-3.

Transmitter Frequencies

Monitor the output frequency of the XMTR with the Selective Level Meter. If this frequency is incorrect by > ± 10 Hz, adjust the unshifted frequency with C19 (on the Transmitter module) to 250 kHz (or the required frequency) ± 1 Hz.

Use the “SH” and “SL” buttons on the Keying module to shift the output frequencies. The shift should be in accordance with Table 5-3 (within ± 10 Hz).

If the shifts are incorrect, set the shift (with S5) on the Transmitter module.

Observe the module LEDs shown in Table 5-4 below:

Table 5–4. Transmitter LEDs.

	Keying		10W PA
	H.L.	“TX”	“TRANSMIT”
1 W	OFF	ON	ON
10 W	ON	ON	ON

Harmonics

1. Use the Selective Level Meter to measure values of the 2nd, 3rd, and 5th harmonics at the set frequency.
2. Push the “HL” test button on the Keying module; observe fundamental and harmonic levels across the load to be:

   Fundamental: +40 dBm (22.4 Vrms) ±0.2 dBm

   Harmonics: Less than -15 dBm (55 dB below fundamental level)

Table 5–5. Output Frequency Shifts.

Type	SH	SL
Narrow or Wide Band, Narrow Shift	+100 Hz	-100 Hz
Wide Band, Wide Shift	+250 Hz	-250 H
Extra Wide Band, Extra Wide Shift	+500 Hz	-500 Hz

Table 5–6. Keying Module Links, LEDs and Output.

Inputs				Keying Module Links								Keying Module LEDs				XMTR Output Across 50 Ohm
PWR OFF Key	DTT Key	UB POTT PC	52b Power Boost	JU1	JU2	JU3	JU4	JU6	JU7	JU8	JU9	D5 TX	D3 SL	D2 SH	D5 TX	
TB4/4 Pos to TB4/6 Neg	TB4/1 Pos to TB4/2 Neg	TB4/5 Pos to TB4/6 Neg	TB4/3 Pos to TB4/6 Neg	PWR ON NORM/ INV	DCR/ PCR 10 W/ 10W	1 W– 10 W/ 10 W– 10 W	2F/ 3F									
0	0	0	0	NORM	DCR	1/10	2F	IN	IN	N.O.	N.O.	0	0	1	0	—
0	0	1	0	NORM	DCR	1/10	2F	IN	IN	N.O.	N.O.	0	1	0	1	—
1	0	0	0	NORM	DCR	1/10	2F	IN	IN	N.O.	N.O.	1	0	0	0	1 W
1	1	0	0	NORM	DCR	1/10	2F	IN	IN	N.O.	N.O.	1	1	0	1	10 W
1	0	1	0	NORM	DCR	1/10	2F	IN	IN	N.O.	N.O.	1	1	0	1	10 W
1	1	0	0	NORM	DCR	1/10	3F	IN	IN	N.O.	N.O.	1	1	0	1	10 W
1	0	0	0	NORM	DCR	1/10	3F	IN	IN	N.O.	N.O.	1	1	0	1	10 W
1	0	0	0	NORM	DCR	1/10	3F	IN	IN	N.O.	N.O.	1	0	0	0	1 W
1	0	0	0	NORM	DCR	10/10	2F	IN	IN	N.O.	N.O.	1	0	1	1	10 W
1	0	0	1	NORM	PCR	1/10	2F	IN	IN	N.O.	N.O.	1	0	1	1	10 W

LEGEND:
0 – No Voltage Applied
1 – Battery Voltage Applied

Keying Logic

Set the Keying module links and apply keying voltage inputs, per Table 5-6. Observe the output levels and Keying module LEDs per Table 5-6.

Residual Noise Output

With the Transmitter unkeyed, observe the output between 20 kHz and 2.0 MHz. There should be ***no*** output indication, and the "noise floor" should be less than -20 dBm (22.4 mVrms).

5.4.3 Final Jumper Positions

Place jumpers on the Power Supply, Keying, 10W PA, and RF Interface modules as required by the final application (see Section 3, Installation, for jumper summary). Set the four rotary switches on the Transmitter Module to the correct frequency.

5.5 TCF–10B Preliminary Settings for Receiver (Only) Sets

Make the following preliminary jumper and switch settings before proceeding with the tests.

5.5.1 Power Supply Module

JU1 N.C. (G01,02, or 03 only)

5.5.2 RF Interface Module

Matching Impedance Jumpers:

JU2 (OUT)

JU3 (OUT)

JU4 (IN, 50 ohms)

Two-wire or four-wire RF Termination:

JU1 (OUT, 4 wire)

JU5 (OUT, 4 wire)

Attenuator Override Jumper:

JU6 (NORM, Sensitivity)

5.5.3 Receiver Module

JU1 NORM

Set the four rotary switches to 535 kHz.

5.5.4 CLI Discriminator Module

JU2 N.O.

JU3 Toward Connector

5.5.5 Receiver Logic Module

Phase Comparison (2 Frequency):

SW1–1	OPEN (OFF)	2 FREQUENCY
SW1–2	CLOSED (ON)	POSITIVE POLARITY
SW1–3	CLOSED (ON)	SKBU

Directional Comparison or Direct Transfer Trip (2-Frequency):

SW1–1	OPEN (OFF)	TRIP DELAY = 16 ms
SW1–2	OPEN (OFF)	
SW1–3	OPEN (OFF)	
SW1–4	CLOSED (ON)	
SW1–5	OPEN (OFF)	TRIP HOLD TIMER
SW1–6	OPEN (OFF)	
SW1–7	OPEN (OFF)	GUARD HOLD TIMER
SW1–8	OPEN (OFF)	
SW2–1	OPEN (OFF)	UNBLOCK TIME = DISABLED
SW2–2	OPEN (OFF)	
SW2–3	OPEN (OFF)	NOISE ALLOWS UB TRIP
SW2–4	CLOSED (ON)	GUARD BEFORE TRIP WITHOUT OVERRIDE
SW2–5	OPEN (OFF)	
SW2–6	OPEN (OFF)	NOT USED
SW2–7	OPEN (OFF)	
SW2–8	OPEN (OFF)	
SW3–1	OPEN (OFF)	NOT USED
SW3–2	OPEN (OFF)	
SW3–3	OPEN (OFF)	
SW3–4	OPEN (OFF)	
SW3–5	OPEN (OFF)	
SW3–6	OPEN (OFF)	
SW3–7	OPEN (OFF)	LOW LEVEL DELAY = DISABLED
SW3–8	OPEN (OFF)	

Directional Comparison and Direct Transfer Trip (3-Frequency):

Switch	Setting	Function
SW1–1	OPEN (OFF)	UB/POTT TRIP DELAY = 0 ms
SW1–2	OPEN (OFF)	
SW1–3	OPEN (OFF)	
SW1–4	OPEN (OFF)	
SW1–5	OPEN (OFF)	TRIP HOLD = 0 ms
SW1–6	OPEN (OFF)	
SW1–7	OPEN (OFF)	GUARD HOLD = 0 ms
SW1–8	OPEN (OFF)	
SW2–1	CLOSED (ON)	UNBLOCK TIME = 500 ms
SW2–2	CLOSED (ON)	
SW2–3	OPEN (OFF)	NOISE ALLOWS UB TRIP
SW2–4	CLOSED (ON)	GUARD BEFORE TRIP WITHOUT OVERRIDE
SW2–5	OPEN (OFF)	
SW2–6	CLOSED (ON)	DTT TRIP DELAY = 30 ms
SW2–7	CLOSED (ON)	
SW2–8	CLOSED (ON)	
SW3–1	CLOSED (ON)	
SW3–2	OPEN (OFF)	TRIP HOLD = 0 ms
SW3–3	OPEN (OFF)	
SW3–4	OPEN (OFF)	GUARD HOLD = 0 ms
SW3–5	OPEN (OFF)	
SW3–6	CLOSED (ON)	CHECKBACK #2
SW3–7	OPEN (OFF)	LOW LEVEL DELAY = DISABLED
SW3–8	OPEN (OFF)	

5.5.6 Optional EM Output Module

	2 Frequency	3 Frequency
JU1	Guard	Guard
JU2	Guard	Guard
JU3	Guard	Trip 1
JU4	Trip 1	Trip 1
JU5	Trip 1	Trip 2
JU6	Trip 1	Trip 2
JU7	N.O.	N.O.
JU8	N.O.	N.O.
JU9	N.O.	N.O.
JU10	N.O.	N.O.
JU11	N.O.	N.O.
JU12	N.O.	N.O.
JU13*	100–200 ms	100–200 ms
JU14*	100–200 ms	100–200 ms

*When supplied.

5.6 Tests of TCF–10B Receiver (Only) Sets

CAUTION

ALWAYS TURN DC POWER "OFF" BEFORE REMOVING OR INSTALLING MODULES IN THE CHASSIS.

5.6.1 Power Supply Module Tests

Repeat steps (1 thru 6) listed under Section 5.4.1, Power Supply Module Tests.

5.6.2 Receiver Module Tests: Preliminary Steps

Received Signal Path

1. Connect the Signal Generator to the RF Interface module Receiver (J2) on the Rear Panel and, with the power "ON", set the Signal Generator to 535 kHz at a level of 1.0 Vrms.
2. At the RF Interface module, measure (at RCVR/RCVR COM terminals) .99 to 1.1 Vrms; do not rely on the Signal Generator display.
3. Using the Selective Level Meter, measure the input signal level at the Receiver front panel (at INPUT, COMMON terminals). The signal level should be between 180 mV and 260 mV.
4. Turn the power "OFF".

NOTE

To prevent the cable's capacitance from affecting the measurement, *do not use coaxial cable* for this measurement.

Receiver Sensitivity

1. Place the Receiver Module on an Extender Card (see Figure 4-1); set the Receiver at 535.0 kHz.
2. Set the Signal Generator at a level to produce the following levels at INPUT and COMMON test points on the Receiver Module:

Bandwidth	Receiver Module	Level (Receiver Input)
Extra Wide Band (1,200 Hz)	1606C32G01	15 mVrms
Wide Band (600 Hz)	1606C32G02	5 mVrms
Narrow Band (300 Hz)	1606C32G03	5 mVrms

3. Turn the power "ON".
4. On the Receiver Module front panel, set the LEVEL ADJ attenuator (R3) to full CW.
5. Using the Selective Level Meter, monitor the 20 kHz output (high impedance input), at pin 28A (20 kHz IF output) 32A/C (common).

NOTE

The 20 kHz IF must be within ±10 Hz before you proceed with the following steps. Adjust C68, on the Receiver PC board, if necessary.

The output should be 65 mVrms ±5 mVrms. If not, go to Step 6.

6. Adjust the IF Gain Control (R68) for the 20 kHz output level of 65 mVrms. If you adjust R68 fully counterclockwise, and the output is greater than 65 mVrms ±5 mVrms, adjust R3 until the output is 65 mVrms.

   If the Voice Adapter Module is supplied, see 5.7.5-3.

7. Turn "OFF" the power. Set the four rotary switches on the Receiver Module to the required frequency, and re-install the module into the chassis.

CLI/Discriminator

1. Place the CLI/Discriminator Module on an Extender Card, and turn "ON" the power.

   For G07 thru G12 modules, ignore all CLI tests; however, the "NOISE" and "LOW LEVEL" LEDs on the front panel should light as indicated in Table 5-7.

2. Set the Signal Generator to 250 kHz or the required frequency.
3. After setting the Signal Generator to 250 kHz or the required frequency, set the Signal Generator to 1,060 mVrms (for Extra Wide Band) or 353 mVrms (for Wide Band or Narrow Band). Adjust R3 on the Receiver until the CLI meter reads "+10."
4. Vary the generator level as shown in Table 5-7. Check the CLI instrument readings on both the Internal CLI and External CLI (when used). The instruments should read within ±2 dB of the specified readings, and within ±2 dB of each other.
5. Adjust the specified potentiometers, if required:
   - Low-Level Adjust (R40)
   - External CLI Full-Scale Adjust (R110)

Extra Wide Band	250.500 kHz or required frequency + 500 Hz
Wide Band Wide Shift Wide Band	250.250 kHz or required frequency + 250 Hz
Narrow Shift ***or*** Narrow	250.100 kHz or required frequency + 100 Hz

6. Replace the CLI/Discriminator Module in the TCF–10B chassis. Adjust the input level for a "0" CLI reading.
7. ***This step is for 2-frequency units (only).*** Change the input frequency per the chart below, while observing the "NOISE" LED:

   The Noise LED should turn "OFF" in all of the above cases, and the GUARD light should be "ON."

5

Receiver Logic Module

Place the Receiver Logic Module on an extender board and set the input signal to 250 kHz, or the required frequency, at a level of:

337 mVrms:	Extra Wide Band (EWB)
112 mVrms:	Narrow Band (NB), Wide Band Narrow Shift (WBNS), ***or*** Wide Band Wide Shift (WBWS)

Make sure R3 on the Receiver Module is adjusted for a CLI meter reading of "0."

Table 5–7. Generator Levels.

EWB Receiver Input Level (mVrms)	WB and NB Input Level (mVrms)	Adjust POT	LEDs Low Level	Noise†	CLI Reading (dB)
33.73	11.24		ON	ON	-20
60.	20.		ON	ON	-15
106.	35.3	R40	OFF*	ON	-10
190.	63.3		OFF	ON	- 5
337.	112.2		OFF	ON	0
600.	200.		OFF	ON	+ 5
1,060.	353.	R1,R104	OFF	ON	+10

† On 3-frequency units (OFF).

** Should just light at this level. This is a low signal clamp on a 10 dBm reduction of signal; you may set other levels as required.*

To test the Phase Comparison Units (Only), complete the five steps depicted in Table 5-8 below.

Table 5–8. Phase Comparison Units (Only) Testing.

Good Channel	Rcvr Logic LEDs		CLI/Discrim. LEDs		Solid State Outputs				Low Signal Contact
	Trip –	Trip +	Noise	Low Level	Noise	$\overline{\text{Low Level}}$	Trip –	Trip +	
1) Check initial LED, output, and contact states:									
OFF	OFF	OFF	ON	OFF	+ V*	+ V*	0 V	0 V	OPEN
2) Remove input signal from chassis; observe states as follows:									
OFF	ON	ON	ON	ON	+ V*	0 V	+ V*	+ V*	CLOSED
3) Open SW1-3 on Receiver Logic Module; observe states as follows:									
OFF	OFF	OFF	ON	ON	+ V*	0 V	0 V	0 V	CLOSED
4) Close SW1-3 (SKBU) and re-connect input signal to chassis. Set input frequency to 250.500 kHz (EWB), or 250.250 kHz (WBWS); or required frequency + 500 Hz (EWB), or required frequency + 250 Hz (WBWS). Observe states as follows:									
ON	ON	OFF	OFF	OFF	0 V	+ V*	+ V*	0 V	OPEN
5) Set input frequency to 249.500 kHz (EWB), or 249.750 kHz (WBWS); or required frequency - 500 Hz (EWB), or required frequency -250 Hz (WBWS). Observe states as follows:									
ON	OFF	ON	OFF	OFF	0 V	+ V*	0 V	+ V*	OPEN

** + V (Nominal) outputs equals the voltage applied to the TB1-1, usually station battery.*

To test the 2-Frequency Directional Comparison Units (Only), complete the 11 steps depicted in Table 5-9 below.

Table 5–9. 2-Frequency Directional Comparison or Direct Transfer Trip Units (Only) Testing.

	Rcvr Logic LEDs.			CLI/Disc LEDs		Optional EM Outputs	Solid State Outputs					
Good Channel	**Grd**	**Trp**	**Cbk Trp**	**Noise**	**LLev**	**1 2 3 4 5 6**	**Noise**	**$\overline{\text{LLEV}}$**	**Cbk Trp**	**Grd**	**Trp 2**	**Low Sig Cont**
1) Check initial LED, output, and contact states:												
OFF	OFF	OFF	OFF	ON	ON	(open)	+ V*	0 V	0 V	0 V	0 V	OP
2) Set input frequency to 250.500 kHz (EWB), or 250.250 kHz (WBWS), or 250.100 kHz (NB or WBNS); or required frequency + 500 Hz (EWB), or required frequency + 250 Hz (WBWS), or required frequency + 100 Hz (NB or WBNS). Observe states as follows:												
ON	ON	OFF	OFF	OFF	OFF	CL CL CL OP OP OP	0 V	+ V*	0 V	+ V*	0 V	OP
3) Set input frequency to 250.000 kHz. Then set input frequency to 249.500 kHz (EWB), or 249.750 kHz (WBWS), or 249.900 kHz (NB or WBNS); or required frequency -500 Hz (EWB), or required frequency -250 Hz (WBWS) or required frequency -100 Hz (NB or WBNS). Observe states as follows:												
ON	OFF	OFF	ON	OFF	OFF	(open)	0 V	+ V*	+ V*	0 V	0 V	OP
4) Set input frequency to 250.500 kHz (EWB), or 250.250 kHz (WBWS), or 250.100 kHz (NB or WBNS); or required frequency +500 Hz (EWB), or required frequency +250 Hz (WBWS), or required frequency +100 Hz (NB or WBNS). Then ***quickly*** shift input frequency to 249.500 kHz (EWB), or 249.750 kHz (WBWS), or 249.900 (NB or WBNS); or required frequency -500 Hz (EWB), or required frequency -250 Hz (WBWS), or required frequency -100 Hz (NB or WBNS). Observe states as follows:												
ON	OFF	ON	ON	OFF	OFF	OP OP OP CL CL CL	0 V	+ V*	+ V*	0 V	+ V*	OP

** + V (Nominal) outputs equals the voltage applied to the TB1-1, usually station battery.*

Table 5–9. 2-Frequency Directional Comparison or Direct Transfer Trip Units (Only) Testing (Cont'd).

	Rcvr Logic LEDs.			CLI/Disc LEDs		Optional EM Outputs						Solid State Outputs					
Good Channel	**Grd**	**Trp**	**Cbk Trp**	**Noise**	**LLev**	**1**	**2**	**3**	**4**	**5**	**6**	**Noise**	**$\overline{\text{LLEV}}$**	**Cbk Trp**	**Grd**	**Trp 2**	**Low Sig Cont**
5) Set input frequency to 250.500 kHz (EWB), or 250.250 kHz (WBWS), or 250.100 kHz (NB or WBNS); or required frequency + 500 Hz (EWB), or required frequency + 250 Hz (WBWS), or required frequency + 100 Hz (NB or WBNS). Remove signal from chassis. Observe the "TRIP" LED on the Receiver Logic module, and the "TRIP 2" SS Output. Neither should ***blink*** when signal is removed. Observe states as follows:																	
OFF	OFF	OFF	OFF	ON	ON	(		open			)	+ V*	0 V	0 V	0 V	0 V	CL
6) Close SW2-4 and open SW2-5 (GBT without override). Reconnect the signal to the chassis. Observe states as follows:																	
ON	ON	OFF	OFF	OFF	OFF	CL	CL	CL	OP	OP	OP	0 V	+ V*	0 V	+ V*	0 V	OP
7) Set input frequency as shown in Step 3 (above). Observe states as follows:																	
ON	OFF	OFF	ON	OFF	OFF	(		open			)	0 V	+ V*	+ V*	0 V	0 V	OP
8) Set input frequency as shown in Step 4 (above). Observe states as follows:																	
ON	OFF	ON	ON	OFF	OFF	OP	OP	OP	CL	CL	CL	0 V	+ V*	+ V*	0 V	+ V*	OP
9) Set input frequency as shown in Step 3 (above). Observe states as follows:																	
ON	OFF	ON	ON	OFF	OFF	OP	OP	OP	CL	CL	CL	0 V	+ V*	+ V*	0 V	+ V*	OP
10) Close SW2-1 and SW2-2 (500 ms). Set input frequency to 250.500 kHz (EWB), or 250.250 kHz (WBWS), or 250.100 kHz (NB or WBNS); or required frequency +500 Hz (EWB), or required frequency +250 Hz (WBWS), or required frequency +100 Hz (NB or WBNS). Observe states as follows:																	
ON	ON	OFF	OFF	OFF	OFF	CL	CL	CL	OP	OP	OP	0 V	+ V*	0 V	+ V*	0 V	OP
11) Remove signal from chassis. Observe the "TRIP" LED and the "TRIP 2" SS Output. Both ***must*** blink when signal is removed.																	
OFF																	

** + V (Nominal) outputs equals the voltage applied to the TB1-1, usually station battery.*

5

To test the 3-Frequency Directional Comparison Units (Only), complete the six steps depicted in Table 5-10 below. Use an input frequency of 250 kHz or the center frequency

Table 5–10. 3-Frequency Directional Comparison and Direct Transfer Trip Units (Only) Testing.

Rcvr Logic LEDs.					CLI/Disc LEDs		Optional EM Outputs						Solid State Outputs					
Good Channel	**Cbk Trp**	**UB/ POTT Trip**	**DTT Trip**	**Grd**	**Noise**	**LLev**	**1**	**2**	**3**	**4**	**5**	**6**	**Noise**	**$\overline{LLEV}$**	**Cbk Trp**	**Grd**	**Trp 2**	**Low Sig Cont**
1) Check initial LED, output, and contact states:																		
ON	OFF	OFF	OFF	ON	OFF	OFF	CL	CL	OP	OP	OP	OP	0 V	+ V*	0 V	+ V*	0 V	OP
2) Remove the input signal from the chassis, and observe the following momentary occurrences: a) UB/POTT LED ***must*** blink. b) DTT LED ***must not*** blink. Observe the following states:																		
OFF	OFF	OFF	OFF	OFF	ON	ON	OP	OP	OP	OP	OP	OP	+ V*	0 V	0 V	0 V	0 V	CL
3) Re-connect signal input to chassis. Set input frequency to 250.500 kHz (EWB), or 250.250 kHz (WBWS), or regular frequency +500 Hz (EWB), or required frequency +250 Hz (WBWS). Observe the following states:																		
ON	ON	ON	OFF	OFF	OFF	OFF	CL	CL	OP	OP	CL	CL	0 V	+ V*	+ V*	0 V	+ V*	CL
4) Set input frequency to 249.500 kHz (EWB), or 249.750 kHz (EWB), or 249.750 kHz (WBWS), or required frequency -500 Hz (EWB); or required frequency -250 Hz (WBWS). Observe the following states:																		
ON	OFF	OFF	ON	OFF	OFF	OFF	OP	OP	CL	CL	OP	OP	0 V	+ V*	0 V	+ V*	0 V	OP

** + V (Nominal) outputs equals the voltage applied to the TB1-1, usually station battery.*

Table 5–10. 3-Frequency Directional Comparison and Direct Transfer Trip Units (Only) Testing (Cont'd).

Rcvr Logic LEDs.					CLI/Disc LEDs		Optional EM Outputs						Solid State Outputs					
Good Channel	**Cbk Trp**	**UB/ POTT Trip**	**DTT Trip**	**Grd**	**Noise**	**LLev**	**1**	**2**	**3**	**4**	**5**	**6**	**Noise**	**$\overline{\text{LLEV}}$**	**Cbk Trp**	**Grd**	**Trp 2**	**Low Sig Cont**
5) Set input frequency to 250.0 kHz. Then ***slowly decrease*** the input frequency to 249.500 kHz (EWB), or 249.750 kHz (WBWS); or required frequency -500 Hz (EWB), or required frequency -250 Hz (WBWS), or required frequency -100 Hz (NB or WBNS). Observe the CLI module "NOISE" LED and "NOISE" SS Output to go "ON" then "OFF" as the frequency is decreased. When final frequency is reached, observe the following states:																		
ON	OFF	OFF	OFF	OFF	OFF	OFF	CL	CL	OP	OP	OP	OP	0 V	+ V*	0 V	+ V*	0 V	OP
6) ***Slowly increase*** the input frequency to 250.500 kHz (EWB), or 250.250 kHz (WBWS); or required frequency +500 Hz (EWB), or required frequency +250 Hz (WBWS). Observe the CLI module "NOISE" LED and "NOISE" SS output to go "ON" then "OFF" twice as the frequency is increased. When the final frequency is reached, observe the following states:																		
ON	ON	OFF	OFF	OFF	OFF	OFF	CL	CL	OP	OP	OP	OP	0 V	+ V*	+ V*	0 V	0 V	OP

** + V (Nominal) outputs equals the voltage applied to the TB1-1, usually station battery.*

5.6.3 Place Jumpers as Required

Place jumpers and switches as required by the final application (see 5.3 or 5.5). Also set the four rotary switches for operation at the proper frequency.

> **CAUTION**
>
> ***ALWAYS TURN DC POWER "OFF" BEFORE REMOVING OR INSTALLING MODULES IN THE TCF–10B CHASSIS.***

5.7 TCF–10B Transceiver Tests

5.7.1 Voice Adapter in System

Check the preliminary settings (earlier in this Section): 5.3.1 thru 5.3.5 and 5.5.1 thru 5.5.6. If The Voice Adapter Module is part of system, set the following jumpers:

JU1	IN
JU2	IN
JU3	IN
JU4	TCF
JU5	N.O.

5.7.2 Power Supply Module Tests

Perform steps 1 through 6 of Section 5.4.1, Power Supply Module Tests, ***except use the current values in Section 5.4.1 Step 5.***

5.7.3 Transmitter Module Tests

Perform the steps in Section 5.4.2, Transmitter Tests.

5.7.4 Receiver Module Tests

Perform the steps in Section 5.6.2, Receiver Tests.

5.7.5 Voice Adapter Module Tests (If Supplied)

1. Plug in the handset to the front panel (TJ1); connect it to the rear panel (TB5) if it is a remote handset. Key the carrier set with the push-to-talk switch. The Transmitter should be keyed at voice-level (4.3 W when high-level is 10 W).
2. The front control panel adjustments: "MIC. SENS" (R63) and "RECEIVE AUDIO" (R24) are factory set to nominal levels. You may turn the "MIC. SENS" adjustment clockwise to compensate for a low-efficiency microphone.

   You may turn the "RECEIVE AUDIO" adjustment as required to obtain a desirable listening level.
3. After adjusting for 63 mVrms (5.6.2 "Receiver Module Tests: Preliminary Steps" – Receiver Sensitivity, Step 5), set the Signal Generator (HP3325A to 5.02 MHz and the output level to 1 V P-P. Remove the 5 MHz crystal on the receiver. Inject the 5.02 MHz between common (A/C-30, 32) and the junction of R69 and R24. Use a two-channel oscilloscope and monitor the junction of R69 and R24 and connector pin 24A with A/C-30, 32 as common. With one volt PP applied at R69/R24, adjust R67 for .33 to .47 volt PP at the output 24A. (R67 is factory adjusted and should not need readjustment unless there is component failure). Remove the test equipment and plug in the 5.0 MHz crystal.

Chapter 6. Routine Adjustment Procedures

You perform routine adjustments in the field for the following purposes:

- Verifying initial TCF–10B factory adjustments.
- Adapting the TCF–10B to your application.
- Setting the TCF–10B operating frequencies.
- Periodic maintenance.

Be sure to run the adjustment tests in the following order:

1. Select the TCF–10B Center Frequency.
2. Review the Adjustment Data Sheets (at the end of this chapter); you should complete the data sheets as you perform the Adjustment Steps.
3. Select the TCF–10B Keying Conditions.
4. Select the TCF–10B Receiver Logic.
5. Select the TCF–10B Transmitter RF Output Impedance.
6. Check the Line Tuning and Matching Equipment.
7. Check the TCF–10B Transmitter Power Levels and Frequency.
8. Check the TCF–10B Internal and External CLI Settings.
9. Check the TCF–10B Receiver Margin.

To prepare the TCF–10B for the routine adjustment tests, perform the following:

- Review the Test Equipment (Chapter 4).
- Review the Adjustment Data Sheets (at the end of this chapter); you should complete the data sheets as you perform the Adjustment Steps.
- Review the TCF–10B Block Diagram as described under Signal Path (Chapter 7).
- Remove the cover from the front of the chassis. After removing the cover, set it in a safe place.

CAUTION

MAKE SURE THAT THE POWER HAS BEEN TURNED "OFF" USING THE POWER SWITCH (S1) ON THE POWER SUPPLY MODULE; THE INPUT (D3) AND OUTPUT (D11) LEDS SHOULD NOT SHOW RED LIGHTS.

If you are using the optional Alarm Relay, set jumper JU1 on the Power Supply Module.

Connect the system in accordance with the connection diagram(s), at end of the Installation section.

6.1 Select TCF–10B Center Frequency and Shift

6.1.1 Transmitter Operating Frequencies

If the Transmitter Module is supplied with the TCF–10B set, remove it from the TCF–10B chassis and select the operating frequencies.

1. Using the module extractors, remove the Transmitter Module.
2. Select the Transmitter center frequency (between 30 and 535 kHz) by turning the four Transmitter rotary programming switches (in 0.1 kHz steps) with a small screwdriver until the desired frequency appears in the (four) windows of the Transmitter Control Panel.
3. Set switch S5 for the appropriate frequency shift, as shown in Table 6-1.
4. Insert the module back into the TCF–10B chassis by seating it with firm pressure.

Table 6–1. Frequency Shift Settings.

	Position Settings				Shift
	1	2	3	4	
Narrow Band, Narrow Shift	Up	Dwn	Up	Up	100 Hz
Wide Band, Narrow Shift	Up	Dwn	Up	Up	100 Hz
Wide Band, Wide Shift	Dwn	Up	Dwn	Up	250 Hz
Extra Wide Band, Wide Shift	Up	Dwn	Up	Dwn	500 Hz

6.1.2 Receiver Center Frequency

If a Receiver Module is supplied with the TCF–10B set, remove the Receiver Module from the TCF–10B chassis. Select the center frequency (between 30 and 535 kHz) by turning the four rotary programming switches on the Receiver Synthesizer with a small screwdriver until the desired frequency appears in the (four) windows of the Receiver Control Panel.

CAUTION

THE RECEIVER MODULE SHOULD NOT BE DISABLED WHILE THE TRANSMITTER MODULE IS KEYED; SET JUMPER JU1 IN THE "NORMAL" POSITION ON THE RECEIVER PCB.

Insert the module back into the TCF–10B chassis by seating it with firm pressure.

6.2 Select TCF–10B Keying Conditions

6.2.1 Test Switches

Three pushbutton switches are provided for test purposes:

S1 High-Level Power (HL)

S2 Shift High (SH)

S3 Shift Low (SL)

Each pushbutton is recessed, and can be activated by sliding an object (e.g., a pen or pencil) through each pushbutton access location on the Keying Module front panel.

6.2.2 Keying Module LEDs

The LEDs at the bottom of the Keying Module front panel indicate the Keying condition:

HL High-Level Key Output

SL Shift High Key Output

SH Shift Low Key Output

V Voice-Level Key Output

TX Any Transmitter Key Output

6.2.3 Keying Module Jumpers

Remove the Keying Module from the chassis and set jumpers (JU1 thru JU14) as desired.

JU-1 Allows you to select between the NORM/INVERT positions. Select the normal (NORM) position to activate a Keying function in the transmitter when proper voltage level (15 V, 48 V, 125 V, 250 V) is applied to the particular function's input terminals. Select the invert (INV) position to activate a Keying function in the Transmitter when voltage is removed from the particular function's input terminals.

JU2 Selects between a Directional Comparison system and Phase Comparison system. Set JU2 to DCR (Directional Comparison).

JU3 This link allows you to select between a 1 W (Guard)/10 W (Trip) or 10 W (Guard)/10 W (Trip) operation by placing the link in the 1/10 W or 10/10 W position, respectively. Select the 1 W/10 W position.

JU4 Selecting the 2-frequency (2F) position will set the Keying Module as a two-frequency system. Selecting the three-frequency (3F) position will set the Keying Module in mode to correctly operate as a three-frequency system. Select the 3F position.

JU6 Placing JU6 to the IN position activates the shift high contact; the OUT position deactivates the shift high contact.*

JU7 Placing JU7 to the IN position activates shift low contact; the OUT position deactivates shift low contact.*

JU8 Places shift high contacts in either the normally open (NO) position or the normally closed (NC) position.

JU9 Places shift low contacts in either the normally open (NO) position or the normally closed (NC) position.

JU10–
JU14 Provides input keying voltage selections: 15/20 V, 48 V, 125 V, 250 V.

After setting the jumpers, insert the Keying Module back into the TCF–10B chassis.

6.3 Select TCF–10B Receiver Logic

Set the Receiver Logic PC Board switches (see Section 16.3) in accordance with the TCF–10B application:

- 2-Frequency, Directional Comparison
- 2-Frequency, Phase Comparison
- 3-Frequency, Directional Comparison

*Place in the "OUT" position when using with the Phase Comparison relay systems.

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6.4 Select TCF–10B Transmitter RF Output Impedance

1. Configure the RF Output Impedance.

   Remove the RF Interface Module from the TCF–10B chassis and configure the output impedance by setting jumpers:

   - JU4 when set, provides 50 ohms
   - JU3 when set, provides 75 ohms
   - JU2 when set, provides 100 ohms

2. Select 2- or 4-wire Receiver Input, using jumpers JU1 and JU5:

   - IN position for 2-wire (not normally used for TCF–10B)
   - OUT position for 4-wire (both JU1 and JU5 must be OUT)

3. If you are using an external hybrid chain, a higher sensitivity may be desirable. Set jumper JU6 to HIGH.

4. Insert the RF Interface Module back into the TCF–10B chassis.

6.5 Check Line Tuning and Matching Equipment

1. Refer to the appropriate instructions for line tuning equipment.
2. Perform the required adjustments.

CAUTION

DO NOT ALLOW INEXPERIENCED PERSONNEL TO MAKE THESE ADJUSTMENTS. PERSONNEL MUST BE COMPLETELY FAMILIAR WITH THE HAZARDS INVOLVED.

6.6 Check TCF–10B Transmitter Power Levels and Frequency

Turn “ON” the power and check the dc voltage outputs from the Power Supply Module. Then, turn “OFF” the power and remove the coaxial cable connection to the Line Tuner and substitute a 50, 75, or non-inductive 100 ohm resistor termination (in accordance with the jumper settings in 6.4-1).

6.6.1 Check High-Level Output

1. Connect the Selective Level Meter to the 10W PA Module control panel, at test jacks:

   TJ1 Input - Top Jack

   TJ2 Common - Bottom Jack

2. Tune the meter to the Transmitter frequency.

3. Turn power “ON” at the Power Supply Module.

4. On the Keying Module control panel, press and hold the top pushbutton (marked HL) to key the Transmitter at High Level power.

   The “HL” and “TX” LEDs should show red.

5. Record the Selective Level Meter reading (at TJ1, TJ2). The meter should measure .224 Vrms (0 dBm at 50 ohm reference) for full High-Level keying (10 W power). If you measure 0 dBm, skip ahead to Step 8.

6. If the meter does not measure 0 dBm, turn the power “OFF” at the Power Supply Module and remove the Transmitter Module from the chassis. Place the extender board into the Transmitter Module position of the chassis. Then plug the Transmitter Module onto the extender board.

7. Turn the Power Supply "ON". Turn the 10W Adjust potentiometer R13 on the Transmitter Module until the Selective Level Meter (at the 10W PA TJ1, TJ2) reads .224 Vrms (0 dBm at 50 ohm reference). Then place the Transmitter Module back in the chassis.

   If it is desirable to set full power at less than 10 W, turn the 10 W adjust potentiometer (R13) accordingly. The level at the RF Interface Module (TJ1, TJ2) is 40 dB higher than at the 10W PA Module (TJ1, TJ2).

   For example: If 22 dBm is desired at RF Interface(TJ1, TJ2), set potentiometer R13 so that 10W PA (TJ1, TJ2) reads -18 dBm. (The PA gain is adjustable with R53 on the 10W PA Module.)

8. Monitor the output of the 10W PA Module at the RF Interface Module test jacks TJ1 (Line)/TJ2 (Line Common). On the 10W PA Module, adjust potentiometer R53 INPUT LEVEL SET for 22.4 Vrms (10 W) output level.

9. On the Keying Module control panel, release the (HL) pushbutton to reduce the Transmitter power.

   The "HL" LED should not be red; but the "TX" LED should remain red.

6.6.2 Check Low-Level Output

1. With the conditions the same as for the High-Level Output check:

   - Selective Level Meter at the 10W PA Module control panel (TJ1, TJ2)
   - Meter tuned to XMTR frequency
   - Power "ON"

   The "TX" LED should show red.

2. With the Transmitter keyed on LL, record the Selective Level Meter reading (at TJ1, TJ2). The meter should measure .0707 Vrms (-10 dBm at 50 ohm reference) for Low-Level keying (1 W power).

3. If the meter does not measure -10 dBm, turn the power "OFF" at the Power Supply Module and remove the Transmitter Module from the chassis. Place the extender board into the Transmitter Module position of the chassis. Then plug the Transmitter Module onto the extender board.

4. Turn the 1 W Adjust potentiometer (R12) on the Transmitter Module until the Selective Level Meter (at the 10W PA TJ1, TJ2) reads .0707 Vrms (-10 dBm at 50 ohm reference).

5. Repeat step 6.6.1-8 (above) at 7.07 Vrms (1 W) output level.

6. Turn "OFF" the power supply.

7. Place the Transmitter Module back in the chassis.

We recommend that you set the low level power 10 dB below full power. You may, however, use any power level between 10 W and 50 mV.

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6.6.3 Check Voice-Level Output

Perform this procedure only if you are using the Voice Level Output option.

1. With the conditions the same as for the High-Level Output check:

   - Selective Level Meter at the 10W PA Module control panel (TJ1, TJ2)
   - Meter tuned to XMTR frequency
   - Power "ON"

2. Key the carrier set by lifting the handset from its cradle, while muting the microphone, to key the Transmitter at Voice-Level (4.3 W power, when the High-Level power is set to 10 W).

   The "V" and "TX" LEDs should show red.

3. Record the Selective Level Meter reading (at TJ1, TJ2). The meter should measure .148 Vrms (-3.6 dBm at 50 ohm reference) for Voice Keying. If you measure -3.6 dBm, skip ahead to Step 6.

4. If the meter does not measure -3.6 dBm, turn the power "OFF" at the Power Supply Module and remove the Transmitter Module from the chassis. Place the extender board into the Transmitter Module position of the chassis.

Then plug the Transmitter Module onto the extender board.

5. Turn the Voice Carrier Adjust potentiometer (R14) on the Transmitter Module until the Selective Level Meter (TJ1, TJ2) reads .148 Vrms (-3.6 dBm at 50 ohm reference). Then place the Transmitter back in the chassis.

   If using a full power level (other than 10 W), you should set the VF level accordingly, i.e., 3.6 dB below the high-level value.

6. Monitor the output of the carrier set with an oscilloscope at the 10W PA Module test jacks:
   - TJ1
   - TJ2

7. Voice key the Transmitter by lifting the handset from its cradle and by whistling loudly (about 1 kHz) to achieve the following voltages:
   - ~ .62 Vp-p (overall)
   - ~ .20 Vp-p (valley)

8. If the voltages above (.62/.20) do not approximate a ratio value of 3, adjust the AM Modulation Adjust potentiometer (R11) on the Transmitter, as follows:
   - Clockwise if not enough signal (a value less than 3).
   - Counterclockwise if too much signal (a value significantly greater than 3).

9. Un-key the Push-to-Talk switch (or handset).

6.6.4 Adjust Transmitter Frequency

1. At the RF Interface Module, connect the Frequency Counter to the two top jacks, TJ1/TJ2 (Line In/Line Common), and note the frequency (should be f_C + f±2 Hz Transmitter Guard frequency). If it is not correct, check the frequency at the Transmitter Module (TP1, A/C-32), and adjust the capacitor (C19) for a reading of 3.27680 MHz ±1 Hz.

2. At the Keying Module, push the recessed pushbutton “SH” to shift the frequency higher:

   f_C + 100 Hz — Narrow Band or Wide Band, Narrow Shift

   f_C + 250 Hz — Wide Band, Wide Shift

   f_C + 500 Hz — Extra Wideband, Wide Shift

If the frequency shift is incorrect on the Transmitter Module, check the position of switch S5 for the correct amount of shift.

3. At the Keying Module, release the “SH” pushbutton and push the “SL” pushbutton to shift the frequency lower:

   f_C – 100 Hz — Narrow Band or Wide Band, Narrow Shift

   f_C – 250 Hz — Wide Band, Wide Shift

   f_C – 500 Hz — Extra Wideband, Wide Shift

If the frequency is incorrect, on the Transmitter Module, check the position of switch S5 for the correct frequency. Release pushbutton “SL”.

6.6.5 Restore Transmitter Module to Normal

1. Turn the power “OFF” at the Power Supply Module.

2. Remove the 50, 75, or 100 ohm resistor termination and replace the coaxial cable connection to the Line Tuner.

3. Move the Selective Level Meter to test jacks marked “LINE” (on the RF Interface control panel):
   - TJ1 (Line)
   - TJ2 (Common)

4. Turn the power “ON” at the Power Supply Module.

5. On the RF Interface Module, configure output impedance by setting a jumper. The Selective Level Meter (TJ1, TJ2) should show a maximum reading (Vrms) for 1 W (+30 dBm) power, as follows:

   JU4 — When set, provides 50 ohms (7.07 Vrms)

   JU3 — When set, provides 75 ohms (8.6 Vrms)

JU2 When set, provides 100 ohms (10.0 Vrms)

6. If the above (Vrms) values are not achieved, recheck the tuning of the coupling system, as it is not presenting the Transmitter with the proper termination.

6.7 Check TCF–10B Internal and External CLI Settings

1. At the Power Supply Module, turn the power “ON”.
2. Place the CLI/Discriminator Module on an Extender board and open switches 24A and 24C (on the Extender board).
3. Using a Signal Generator, apply a 3.16 Vp-p (1.106 Vrms) 20 kHz signal between 24A and 32A. Adjust Internal CLI full-scale potentiometer R1 for a reading of (+10) on the Internal CLI Meter. Adjust the External CLI full-scale potentiometer (R110) for a similar (+10) reading on the External CLI meter.

   The Noise Light (D1) may come “ON”. This is not unusual.

6.8 Check TCF–10B Receiver Margin

This test should be performed with a normal received signal from the far end Transmitter.

At the Receiver Module, adjust the LEVEL ADJUST potentiometer (R3) until there is an indication of 0 dB at the CLI and Discriminator Module (15 dB margin).

If the system is not equipped with a CLI meter, use a Selective Level meter. Adjust the Receive Level potentiometer (R3) until there is a reading, of 158 µVrms (-63 dBm at 50 ohm reference) at the Receiver Module test jacks: TJ2 (RCV)/TJ3 (COM).

6.9 Prepare the TCF–10B for Operation

Be sure that power is “ON” at the Power Supply Module.

1. Restore the Keying Module to the desired settings. (See the TCF–10B Adjustment Data Sheet near the end of this chapter. This data sheet is to be completed by your settings department.)
2. Replace the cover on the TCF–10B control panel.
   a) Secure the latch by pushing inward and sideways until the cover is secure.
   b) You may lock the latches into place using meter seals.

This completes the “Routine Adjustment” procedure. The TCF–10B is ready to be put into operation.

NOTE

When placing the TCF–10B into service, refer to the manual for the relay system you are using with the TCF–10B System.

TCF–10B ADJUSTMENT DATA SHEET

(1) Power Supply

+20 V . . . .(TJ1/TJ2) ______________________

–20 V . . . .(TJ3/TJ2) ______________________

LEDs “ON” . . . . — ______________________

(2) 10W PA

Voice PA “IN” . . . .(TJ1/TJ2) ______________________

LLPA “IN” . . . .(TJ1/TJ2) ______________________

HLPA “IN” . . . .(TJ1/TJ2) ______________________

LEDs “ON” . . . . — ______________________

(3) RF Interface

Residual Noise “OUT” . . . .(TJ1/TJ2) ______________________

XMTR Frequency “OUT”, Shift High . . . .(TJ1/TJ2) ______________________

XMTR Frequency “OUT”, Shift Low . . . .(TJ1/TJ2) ______________________

XMTR Frequency “OUT”, Center Freq. . . . .(TJ1/TJ2) ______________________

Voice Line “OUT” . . . .(TJ1/TJ2) ______________________

LL Line “OUT” . . . .(TJ1/TJ2) ______________________

HL Line “OUT” . . . .(TJ1/TJ2) ______________________

Residual Noise “OUT” w/XMTR Keyed . . . .(TJ1/TJ2) ______________________

Received Frequency, Shift High . . . .(TJ3/TJ4) ______________________

Received Frequency, Shift Low . . . .(TJ3/TJ4) ______________________

Received Frequency, Center Freq. . . . .(TJ3/TJ4) ______________________

Received Line Level . . . .(TJ3/TJ4) ______________________

(4) Receiver

Input Level . . . .(TJ1/TJ3) ______________________

Received Level . . . .(TJ2/TJ3) ______________________

(5) CLI & Discriminator (From Other End)

LL Keyed . . . .(dB) ______________________

HL Keyed . . . .(dB) ______________________

Noise LED Not Lit . . . . – ______________________

Low-Level LED Not Lit . . . . – ______________________

(6) Receiver Logic

Guard (Mark) LED . . . . ______________________

Trip 2 (Space) LED . . . . ______________________

Checkback Trip LED . . . . ______________________

Trip 1 LED . . . . ______________________

(7) Rear of Chassis

Reflected Power . . . .(J1) ________________ (%)

Test Performed By ______________________________ **Date** ________________

TCF–10B JUMPER SETTINGS

(1) POWER SUPPLY

JU1	Power Alarm	NO ❐	NC ❐		

(2) KEYING

JU1	Power On	NORM ❐	INV ❐		
JU2	Directional Comparison/ Phase Comparison	DCR ❐	PC ❐		
JU3	1 W Guard, 10 W Trip or 10 W Guard – 10 W/Trip	1 W/10 W ❐	10 W/10 W ❐		
JU4	2-Frequency or 3-Frequency	2F ❐	3F ❐		
JU5	Shift High Contacts	IN ❐	OUT ❐		
JU7	Shift Low Contacts	IN ❐	OUT ❐		
JU8	NO or NC for Shift High	NO ❐	NC ❐		
JU9	NO or NC for Shift Low	NO ❐	NC ❐		
JU10	DTT Keying Voltage	15 V ❐	48 V ❐	125 V ❐	250 V ❐
JU11	Ext. Voice Keying Logic	15 V ❐	48 V ❐	125 V ❐	250 V ❐
JU12	PWR Boost/52b Keying Voltage	15 V ❐	48 V ❐	125 V ❐	250 V ❐
JU13	Power Off Keying Voltage	15 V ❐	48 V ❐	125 V ❐	250 V ❐
JU14	UB, POTT, PC Keying Voltage	15 V ❐	48 V ❐	125 V ❐	250 V ❐

(3) TRANSMITTER

S5 Frequency–Shift Select

Position	Up	Down
1		
2		
3		
4		

(4) 10W POWER AMPLIFIER

JU1 Power Monitor NO ❐ NC ❐

(5) RF INTERFACE

JU1 2-Wire/4-Wire IN ❐ (2-wire) OUT ❐ (4-wire)

JU2 Impedance-100 Ω IN ❐ OUT ❐

JU3 Impedance- 75 Ω IN ❐ OUT ❐

JU4 Impedance- 50 Ω IN ❐ OUT ❐

JU5 2-Wire/4-Wire IN ❐ (2-wire) OUT ❐ (4-wire)

JU6 Sensitivity HIGH ❐ NORM ❐

(6) RECEIVER

JU1 NORMAL ❐ DISABLE ❐

(7) CLI and DISCRIMINATOR

JU1 Wideband Only IN ❐ OUT ❐

JU2 Detector Contact NO ❐ NC ❐

JU3 Test Only ______ ______

6

(8) RECEIVER LOGIC

❒ CF20–RXLMN–001: 2-FREQUENCY DIRECTIONAL COMPARISON LOGIC

	OPEN (OFF)	CLOSED (ON)	
SW1–1			TRIP DELAY
SW1–2			
SW1–3			
SW1–4			
SW1–5			TRIP HOLD TIMER
SW1–6			
SW1–7			GUARD HOLD TIMER
SW1–8			

	OPEN (OFF)	CLOSED (ON)	
SW2–1			UNBLOCK TIME
SW2–2			
SW2–3			NOISE ALLOWS UB TRIP
SW2–4			GUARD BEFORE TRIP OPTIONS
SW2–5			
SW2–6			NOT USED
SW2–7			
SW2–8			

	OPEN (OFF)	CLOSED (ON)	
SW3–1			NOT USED
SW3–2			
SW3–3			
SW3–4			
SW3–5			
SW3–6			
SW3–7			LOW LEVEL DELAY
SW3–8			

❐ CF20–RXLMN–002: 3-FREQUENCY DIRECTIONAL COMPARISON LOGIC

	OPEN (OFF)	CLOSED (ON)	
SW1–1			UB/POTT TRIP DELAY
SW1–2			
SW1–3			
SW1–4			
SW1–5			TRIP HOLD
SW1–6			
SW1–7			GUARD HOLD
SW1–8			

	OPEN (OFF)	CLOSED (ON)	
SW2–1			UNBLOCK TIME
SW2–2			
SW2–3			NOISE ALLOWS UB TRIP
SW2–4			GUARD BEFORE TRIP OPTIONS
SW2–5			
SW2–6			DTT TRIP DELAY
SW2–7			
SW2–8			
SW3–1			
SW3–2			TRIP HOLD
SW3–3			
SW3–4			GUARD HOLD
SW3–5			
SW3–6			CHECKBACK #2
SW3–7			LOW LEVEL DELAY
SW3–8			

❐ CF20–RXLMN–003: 2-FREQUENCY PHASE COMPARISON LOGIC

	OPEN (OFF)	CLOSED (ON)	
SW1–1			2 FREQUENCY / 3 FREQUENCY
SW1–2			POLARITY
SW1–3			SKBU / SPCU

(9) VOICE

JU1 Squelch.....................................IN ❐ ....OUT ❐

JU2 Compressor ....IN ❐ ....OUT ❐

JU3 Expander..................................IN ❐ ....OUT ❐

JU4 TC/TCF....................................TC ❐ ....TCF ❐

JU5 Alarm Contact ....NO ❐ ....NC ❐

(10) RELAY OUTPUT

JU1 Relay 1 Driver......................Trip 1 ❐ ....Trip 2 ❐ ....Guard ❐

JU2 Relay 2 Driver......................Trip 1 ❐ ....Trip 2 ❐ ....Guard ❐

JU3 Relay 3 Driver......................Trip 1 ❐ ....Trip 2 ❐ ....Guard ❐

JU4 Relay 4 Driver......................Trip 1 ❐ ....Trip 2 ❐ ....Guard ❐

JU5 Relay 5 Driver......................Trip 1 ❐ ....Trip 2 ❐ ....Guard ❐

JU6 Relay 6 Driver......................Trip 1 ❐ ....Trip 2 ❐ ....Guard ❐

JU7 Relay 1 Contact ....NO ❐ ....NC ❐

JU8 Relay 2 Contact ....NO ❐ ....NC ❐

JU9 Relay 3 Contact ....NO ❐ ....NC ❐

JU10 Relay 4 Contact ....NO ❐ ....NC ❐

JU11 Relay 5 Contact ....NO ❐ ....NC ❐

JU12 Relay 6 Contact NO ❐ NC ❐

JU13 Trip Delay—_______________________________________

JU14 Trip Delay—_______________________________________

Chapter 7. Signal Path

The following description of the TCF–10B signal path is in accordance with the Functional Block Diagram (see Figure 7-1), and the rear panel previously shown (in Figure 3-1). The discussion of signal path may be useful during Acceptance Testing (Chapter 5) or Routine Adjustment (Chapter 6).

7.1 Power Supply Module

Terminal Block (TB7)

TB7/1 Positive Vdc (also pins C/A-12)

TB7/2 Negative Vdc (also pins C/A-14)

The Vdc is received from three (3) available groups of station batteries:

- 38–70 Vdc (48 or 60 Vdc nominal)
- 88–140 Vdc (110 or 125 Vdc nominal)
- 176–280 Vdc (220 or 250 Vdc nominal)

TB7/3 Failure Alarm Signal (also pins C/A-16)

TB7/4 Failure Alarm Signal (also pins C/A-18)

TB7/5 Spare

TB7/6 Chassis Ground

Voltage Output to All Other Modules

Positive voltage outputs (+20 Vdc) are available at pins A-2 and A-4, while negative voltage outputs (-20 Vdc) are available at pins C-2 and C-4. Common to ground (pins C/A-30 and C/A-32).

Optional low-voltage power alarm relay outputs

Optional low-voltage power alarm relay outputs are available at pins C/A-16 and C/A-18.

7.2 Keying Module

Voltage Inputs

+20 Vdc Pins A-2 and A-4

-20 Vdc Pins C-2 and C-4

Common Pins C/A-30 and C/A-32

Terminal Block (TB4)

TB4/1 DTT (Direct Transfer Trip) Key (to pin A-10)

TB4/2 DTT Return (to pin C-10)

TB4/3 52b or Pwr Boost (to pin C-16)

TB4/4 Pwr Off (to pin A-16)

TB4/5 UB (Unblock)/PC (Phase Comparison) Key (to pin A-22)

TB4/6 Key Common return for Power Boost, Power Off, and UB/PC key (to pin C-22)

Inputs

- External Voice Key (pins C/A-12)
- Optional Voice Key (pin C-24)

Outputs to Transmitter Module

- Shift Low (pin A-28)
- Shift High (pin A-26)
- High-Level 10W Key (pin A-8)
- Voice Key (pin A-6)
- Any Transmitter Key (pin C-6)

Outputs to 10W PA Module

- Contact Shift Low (pins C/A-20)
- Contact Shift High (pins C/A-14)

Output to Receiver Module

Any Transmitter Key (pin C-6)

7.3 Transmitter Module

Voltage Inputs

+20 Vdc	Pins A-2 and A-4
-20 Vdc	Pins C-2 and C-4
Common	Pins C/A-30 and C/A-32

Inputs from Keying Module (4V Standby, 19V Keyed)

- Shift Low (pins C/A-24)
- Shift High (pin C-10)
- High-Level (10W) Key (pins C/A-8)
- Voice Key (pins C/A-6)
- Any Transmitter Key (pin A-10)

Input from Optional Voice Adapter Module

AM Voice (pin C/A-26)

Output to 10W PA Module

0 dBm for 10 W or -10 dBm for 1 W Transmitter output power (pins C/A-28)

7.4 10W PA Module

Voltage Inputs

+20 Vdc	Pins A-2 and A-4
-20 Vdc	Pins C-2 and C-4
Common	Pins C/A-30 and C/A-32

Terminal Block (TB3)

TB3/1	TX (Transmitter) ON (pins C/A-12)
TB3/2	TX (Transmitter) ON (pins C/A-14)
TB3/3	Contact 1 Shift High, to alarms
TB3/4	Contact 2 Shift High, to alarms
TB3/5	Contact 1 Shift Low, to alarms
TB3/6	Contact 2 Shift Low, to alarms

Input from Transmitter Module

0 dBm for 10 W output or -10 dBm for 1 W output (pins C/A-28)

Output to RF Interface Module

1W, voice or 10W (pins C/A-16 and C/A-18)

7.5 RF Interface Module

Voltage Inputs

+20 Vdc	Pins A-2 and A-4
-20 Vdc	Pins C-2 and C-4
Common	Pins C/A-30 and C/A-32

Input from 10W PA Module

1 W, voice, or 10 W (pins C/A-16 and C/A-18)

Output to Receiver Module

RF Output Signal (pins C/A-28)

Other Outputs

1) Cable Jacks

- J1–RF Interface module (C/A-12 and C/A-10) Transmitter RF output line, through coaxial cable (UHF)
- J2–RF Interface module (C/A-24 and C/A-22) Receiver RF input line through 5,000 ohm coaxial cable (BNC)

2) Jumpers

JU1 UHF Chassis Ground (for J1)

JU2 BNC Chassis Ground (for J2)

7.6 Receiver Module

Voltage Inputs

+20 Vdc	Pins A-2 and A-4
-20 Vdc	Pins C-2 and C-4
Common	Pins C/A-30 and C/A-32

Input from Keying Module

Any Transmitter Key (pin C-6)

Input from RF Interface Module

RF Output Signal (pin C-28)

Output to Discriminator and CLI Module

20 kHz signal (pin A-28)

RF Output to Optional Voice Adapter

- 20 kHz signal through jumper JU4
- 5.02 MHz signal through jumper JU3

7.7 CLI/Discriminator Module

Voltage Inputs

+20 Vdc	Pins A-2 and A-4
-20 Vdc	Pins C-2 and C-4
Common	Pins C/A-30 and C/A-32

Input from Receiver Module

20 kHz signal (pin C/A-24)

Terminal Block (TB2)

TB2/1	Optional External CLI Meter (pins C/A-12)
TB2/2	Optional External CLI Meter (pins C/A-14)
TB2/3	Noise + (pins C/A-16)
TB2/4	Noise - (pins C/A-18)
TB2/5	Low Signal Contact (pins C/A-20)
TB2/6	Low Signal Contact (pins C/A-22)

Output to Receiver Logic Module

- Level (pin C-28)
- High/Low Frequency (pin A-28)
- Center Frequency (pin A-10)
- Noise (pin A-8)

7.8 Receiver Logic Module

Voltage Inputs

+20 Vdc	Pins A-2 and A-4
-20 Vdc	Pins C-2 and C-4
Common	Pins C/A-30 and C/A-32

Input from CLI/Discriminator Module

- Level (pins C/A-26)
- High/Low Frequency (pins C/A-28)
- Center Frequency (pin C-10)
- Noise (pin C-8)

Terminal Block (TB1)

TB1/1	+ V Input from pins C/A-12
TB1/2	Guard or Trip Negative (Mark) from pins C/A-14
TB1/3	Noise from pins C/A-16
TB1/4	Trip 2, Trip Positive (Space) or Unblock from pin C-18
TB1/5	Low Signal or Low Level from pin C-20
TB1/6	Common from pin C-22
TB1/7	Common from pin A-22
TB1/8	Checkback Trip from pin A-20
TB1/9	Unused

Output to EM Output Module

- Trip 1/Trip 2 (pin A-24)
- Guard (pin C-24)

7.9 EM Output Module

Voltage Inputs

+20 Vdc	Pins A-2 and A-4
-20 Vdc	Pins C-2 and C-4
Common	Pins C/A-30 and C/A-32

Input from Receiver Logic Module

- Trip 1/Trip 2 (pin C-20)
- Guard (pin A-20)

Terminal Block (TB6)

TB6/1	Contact 1-1 from pin A/C-8
TB6/2	Contact 1-2 from pin A/C-10
TB6/3	Contact 2-1 from pin A/C-12
TB6/4	Contact 2-2 from pin A/C-14
TB6/5	Contact 3-1 from pin A/C-16
TB6/6	Contact 3-2 from pin A/C-18
TB6/7	Contact 4-1 from pin C-22
TB6/8	Contact 5-1 from pin C-24
TB6/9	Contact 6-1 from pin C-26

Output to Optional Voice Adapter Module

- Contact 4-2 (pin A-22)
- Contact 5-2 (pin A-24)
- Contact 6-2 (pin A-26)

7.10 Optional Voice Adapter Module

Voltage Inputs

+20 Vdc	Pins A-2 and A-4
-20 Vdc	Pins C-2 and C-4
Common	Pins C/A-30 and C/A-32

RF Input from Receiver Module

- 20 kHz signal through jumper JU4 to pin C/A-26
- 5.02 MHz signal through jumper JU3 to pin C/A-26

Output to Keying Module

Voice Key (pin C/A-22)

Output to Transmitter Module

AM Voice (pin A-28)

Terminal Block TB-5

TB5/1	External receiver signal from C/A-8
TB5/2	External microphone input to C/A-10
TB5/3	Common to A/C-12
TB5/4	Alarm contact to C/A-16
TB5/5	Alarm Contact to C/A-18
TB5/6	External signaling input to C/A-20

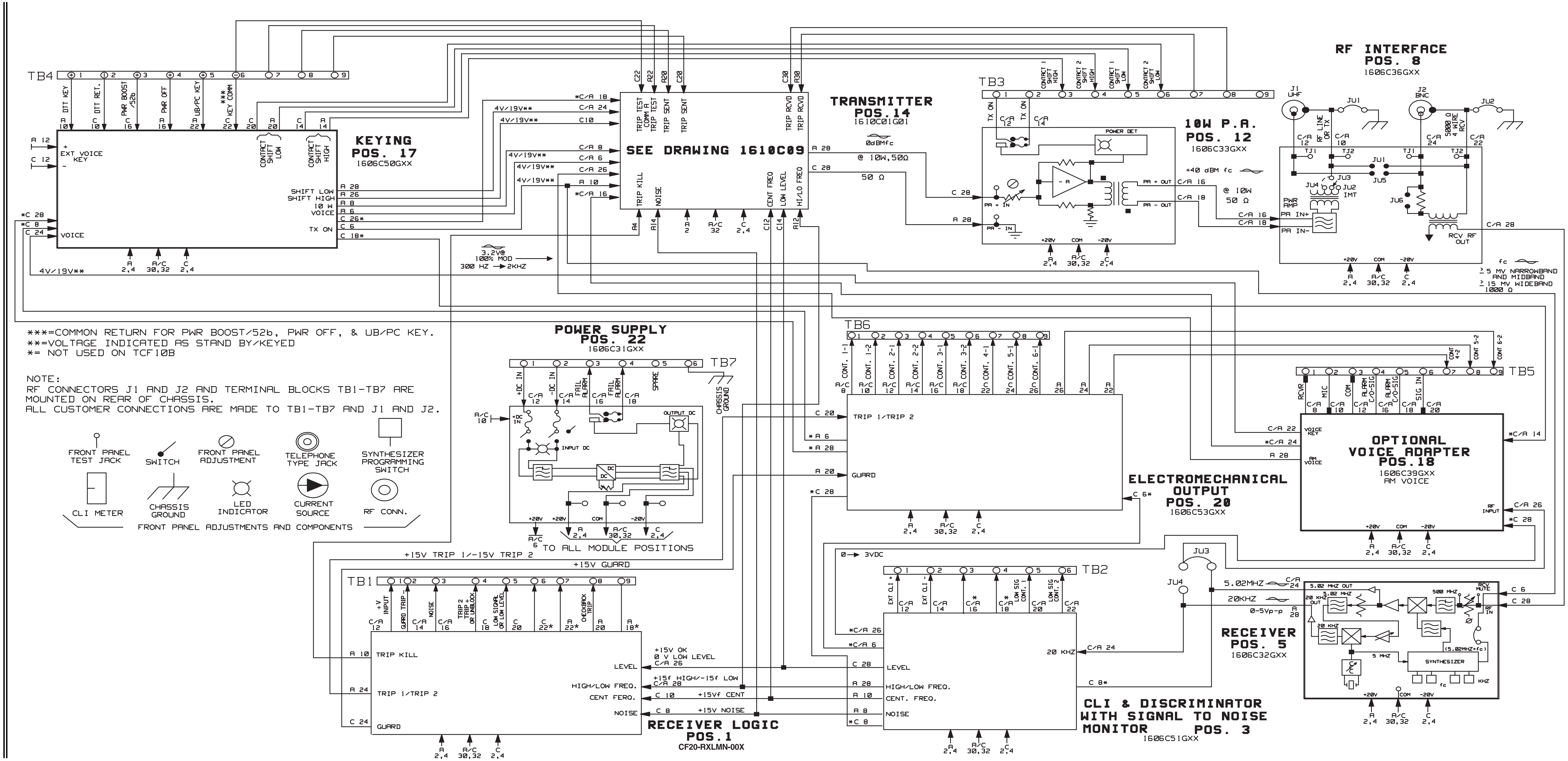

Figure 7–1. TCF–10B Functional Block Diagram. (1354D13)

Chapter 8. Maintenance

When individual module maintenance is required, either at the factory or at the customer installation (beyond the scope of routine alignment), the following procedures are applicable.

8.1 Precautions When Selecting Test Equipment

(See Chapter 4, Test Equipment for test equipment specifications.)

To prevent damage to solid-state components:

1) Use transformer-type signal generators, VTVMs and signal tracers, which isolate the test equipment from the power line. Whenever the test equipment uses a transformerless power supply, use an isolation type transformer. The test equipment ground should be isolated from the ac source ground.
2) Use multimeters with at least 20,000 ohms-per-volt sensitivity.

8.2 Precautions When Using Test Equipment

1. Use a common ground between the chassis of the test equipment and the transistor equipment.

CAUTION

HIGH CURRENTS FROM A LOW-SENSITIVITY METER CAN DAMAGE SOLID STATE DEVICES.

METERING TRANSISTOR CIRCUITS CAN CAUSE DAMAGE.

FOR EXAMPLE: A BASE-TO-COLLECTOR SHORT DURING TRANSISTOR OPERATION CAN DESTROY THE TRANSISTOR.

2. When testing transistors and diodes, give special attention to the polarity of the meter leads.

   For example: When measuring the forward resistance of a diode using a meter that has the internal battery connected to the metering circuit, be sure that:

   - The lead marked (–) touches the diode anode.
   - The lead marked (+) touches the diode cathode.

3. When checking circuits with an oscillographic probe, be sure to discharge any built-up capacitive voltage by touching the probe to a ground before touching the circuit.

8.3 Periodic Checks

Every six months, take the following readings on the TCF–10B Test Jacks (at the control panel).

We recommend that you keep a ***log book*** as a visible record of periodic checks, as well as a source for indicating any gradual degradation in a module’s performance.

8.3.1 Power Supply Module

- TJ1 (+20 Vdc)
- TJ2 (Common)
- TJ3 (-20 Vdc)

8.3.2 Keying Module

None.

8.3.3 Transmitter Module

None.

8.3.4 10W PA Module

- TJ1 (Input)
- TJ2 (Common)

8.3.5 RF Interface Module

- TJ1 (Line In)
- TJ2 (Line Common)
- TJ3 (Receiver In)
- TJ4 (Receiver Common)

8.3.6 Receiver Module

- TJ1 (Input)
- TJ2 (Receive)
- TJ3 (Common)

8.3.7 CLI/Discriminator Module

None.

8.3.8 Receiver Logic Module

None.

8.3.9 EM Output Module

None.

8.3.10 Optional Voice Adapter Module

None.

8.4 Inspection

A program of routine visual inspection should include:

- Condition of cabinet or other housing
- Tightness of mounting hardware and fuses
- Proper seating of plug-in relays and sub-assemblies
- Condition of internal and external wiring (the location where external wiring enters the cabinet should be sealed)
- Appearance of printed circuit boards and components
- Signs of overheating in equipment:
  - Interference with proper heat dissipation from surfaces
  - Clogged air vents (air filters should be removed and washed out)
- Dust which may cause short circuits

8.5 Solid-State Maintenance Techniques

Use the following techniques when servicing solid state equipment.

CAUTION

WE RECOMMEND THAT THE USER OF THIS EQUIPMENT BECOME ACQUAINTED WITH THE INFORMATION IN THESE INSTRUCTIONS BEFORE ENERGIZING THE TCF–10B AND ASSOCIATED ASSEMBLIES.

FAILURE TO OBSERVE THIS PRECAUTION MAY RESULT IN DAMAGE TO THE EQUIPMENT. YOU SHOULD NEITHER REMOVE NOR INSERT PRINTED CIRCUIT MODULES WHILE THE TCF–10B IS ENERGIZED. FAILURE TO OBSERVE THIS PRECAUTION CAN RESULT IN COMPONENT DAMAGE.

ALL INTEGRATED CIRCUITS USED ON THE MODULES ARE SENSITIVE TO AND CAN BE DAMAGED BY THE DISCHARGE OF STATIC ELECTRICITY. BE SURE TO OBSERVE ELECTROSTATIC DISCHARGE PRECAUTIONS WHEN HANDLING MODULES OR INDIVIDUAL COMPONENTS.

8.5.1 Preliminary Precautions

1. To avoid damage to circuits and components from a current surge, disconnect power before replacing or removing components or circuits.
2. Before placing new components into a defective circuit, check the circuit so that it cannot damage the new components.

8.5.2 Trouble-Detection Sequence

1. Evaluate test jack readings and other records of routine alignment.
2. Evaluate any symptoms detected audibly or visually.
3. Replace suspected plug-in components.
4. Further isolation of faults includes:
   - Voltage readings
   - Resistance readings
   - Signal injection
   - Re-alignment
   - Sensitivity measurements
   - Gain measurements
5. Replace suspected faulty components.
6. Check-out and adjust affected circuits.

8.5.3 Servicing Components Soldered Directly to Terminals

1. Avoid overheating from soldering by using a low-wattage soldering iron (60 watt maximum).
2. Make sure there is no current leakage from the soldering iron.

   You may use an isolation transformer to prevent current leakage.
3. When soldering leads from transistors or diodes, use heat sinks, e.g., alligator clips.
4. You can remove molten solder from the board with a solder-sucker.
5. When removing a multi-lead component from a printed circuit board, first cut all leads and then remove the leads individually (to prevent overheating). If there are only a few leads, you can use a broad-tip soldering iron.

8.5.4 Servicing Components Mounted Directly on Heat Sinks

1. Remove the heat sink and bracket from the chassis by loosening the securing devices.
2. Remove the transistor, diode, or other device from the heat sink.
3. When replacing the transistor, diode, or other device, make certain that the device and the heat sink make secure contact for good heat dissipation. Mount a device first on the heat sink, and then on the board. Also, make sure that you replace all insulators, washers, spring washers and other mounting hardware as you originally found them.

   We recommend a very light coating of DC-4 (Dow-Corning 4 Compound Silicon Lubricant) for transistors and diodes that are mounted on heat sinks.

8.5.5 Servicing Metal Oxide Semiconductor (MOS) Devices

MOS devices may be vulnerable to static changes. Be sure to observe the special precautions described below both before and during assembly.

Precautions to take before assembly:

- Avoid wearing silk or nylon clothing, as this contributes to static buildup.
- Avoid carpeted areas and dry environments.
- Discharge body static by placing both hands on a metal, earth-grounded surface.

Precautions to take during assembly to avoid the possibility of electrostatic discharge:

- Wear a ground strap during assembly
- Avoid touching electrically-conductive circuit parts by hand
- When removing a module from the chassis, always place it on a conductive surface which is grounded through a resistance of approximately 100 K ohms
- Make sure that all electrically-powered test equipment is properly grounded.

NOTE

Before touching a module with a test probe, connect the ground lead from the test equipment to the module. Always disconnect the test probe before removing the ground lead equipment.

Chapter 9. Power Supply Module

Table 9–1. 1617C38 Styles and Descriptions.

Group	Description
G01	48 V WITH ALARM RELAY
G02	125 V WITH ALARM RELAY
G03	250 V WITH ALARM RELAY
G04	48 V WITHOUT ALARM RELAY
G05	125 V WITHOUT ALARM RELAY
G06	250 V WITHOUT ALARM RELAY

Schematic	1617C38-2
Parts List	1617C38-2

9.1 Power Supply Module Description

The Power Supply Module for the TC–10B/TCF–10B has dual dc/dc high-frequency switching regulators which generate regulated voltage outputs of ±20 Vdc (between 1.5 and 2.0 Amps) for operation of the TC–10B/TCF–10B modules. It also provides protection from battery surge, transients, short circuits, and reverse voltage. The Power Supply Module can receive inputs from three available groups of station batteries: 38-70 Vdc, 88-140 Vdc, and 176-280 Vdc.

9.1.1 Power Supply Control Panel

(This panel is shown in Figure 1-1.)

Front panel controls are as follows:

1) Pushbutton Switch (with power-on indicator), ON/OFF (S1).
2) LEDs for indicating power:
   - INPUT, Red (LED1)
   - OUTPUT, Red (LED2)
3) Test Jacks:
   - +20 Vdc, Red (TP3)
   - Common, Green (TP2)
   - -20 Vdc, Black (TP1)

An optional low-voltage alarm relay indicating loss of power is available. When the alarm is activated, LED2 is "OFF". LED1 may be "OFF" if input power is lost.

9.1.2 Power Supply PC Board

Figure 9-1 shows component locations for the Power Supply Module.

Control is as follows:

Jumper J1 for optional Alarm Relay; establishes loss of power condition (NO/NC).

> **NOTE**
>
> **When the alarm is part of the system, JU1 is shipped in the NC state.**

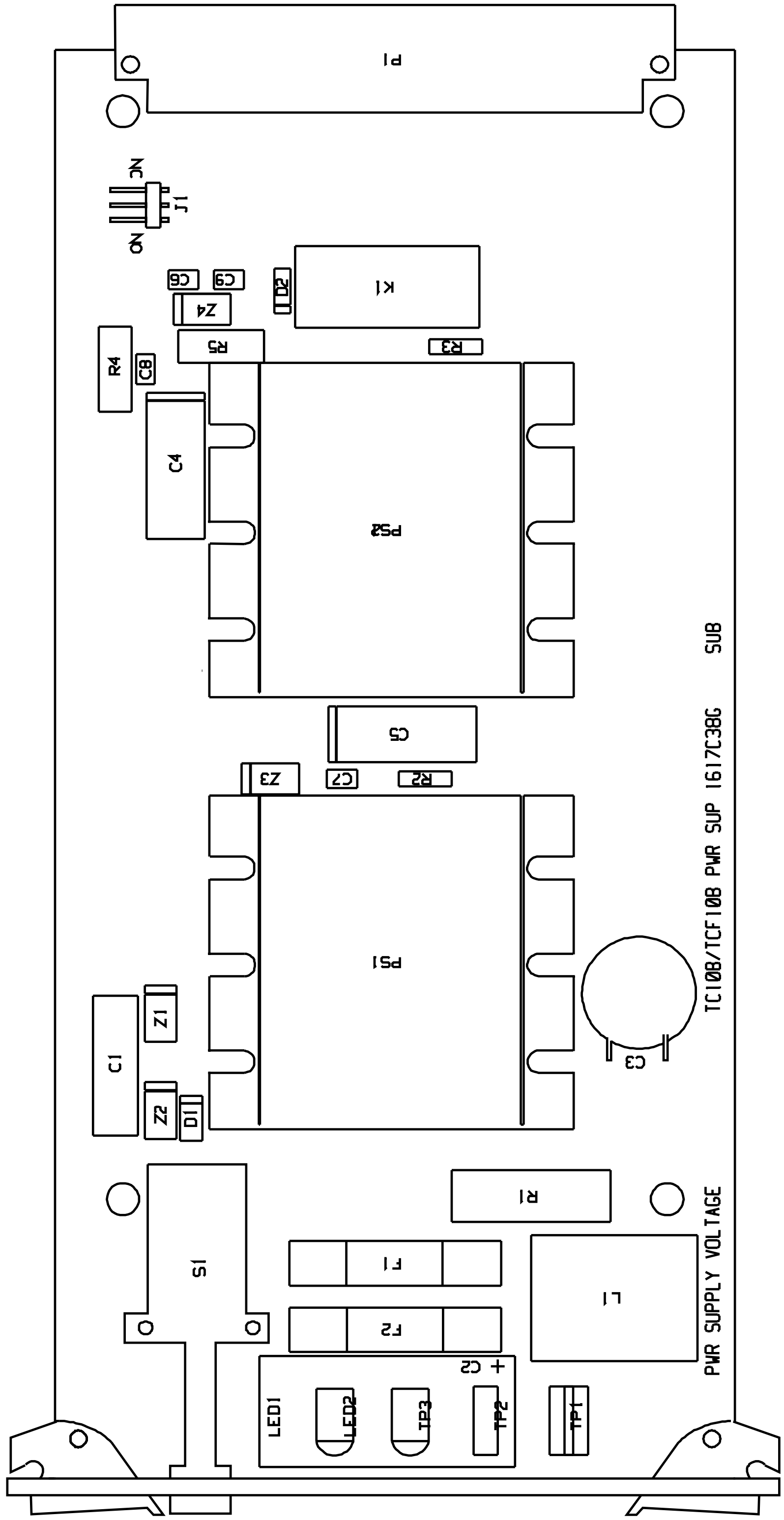

Figure 9–1. TC–10B/TCF–10B Power Supply Component Location (1617C38).

9.2 Power Supply Circuit Description

The module comprises the following circuits:

- Fuses
- ON/OFF Switch
- Input Filter
- Power Alarm Failure Relay
- dc/dc Converter (2)
- Output Filter

Fuses

	48V	125V	250V
F1, F2	3A	1.6A	3/4A

ON/OFF Switch

S1 - Pushbutton Switch (DPDT)

When in the "ON" position (pins 1 and 4), dc current flows through the input filter to the dc/dc converter.

Input Filter

The input filter (C1, C2, C3) contains zener diodes (Z1, Z2) that provide protection against surges, a diode (D1) that provides protection against reverse polarity, a differential choke XFMR (L1), and the Red Input LED1.

Power Alarm Failure Relay

This circuit includes:

- K1 - Alarm Relay
- J1 - Jumper (NO/NC)

Versions G04, G05, and G06 are without alarms.

In versions G01, G02, and G03 the field-selectable option can change the alarm contact de-energized state to NO or NC. (It is currently shipped in the NC de-energized state, and can be changed to NO if desired.)

DC/DC Converter

The two dc/dc converters (PS1 and PS2) operate at a maximum of 1 MHz and, as a result, switching noise is outside the 30-535 kHz range of the TC–10B/TCF–10B. The converter outputs, +20 Vdc and -20 Vdc, is fed to the output filter. (See Figure 9-1.)

Output Filter

The output filter for the +20 V consists of C4, C6, C8, and Z4. The output filter for the -20 V consists of C5, C7, C9, and Z3.

9.3 Power Supply Troubleshooting

The three test jacks on the control panel:

- TP3 (+20 Vdc)
- TP2 (Common)
- TP1 (-20 Vdc)

can be used to determine if the two voltages (+20 Vdc, -20 Vdc) are present. In addition, the LED2 output indicates that the dc/dc converters are generating voltage. The LED1 input indicates that voltage is present at the input of the dc/dc converter.

For basic troubleshooting, perform the following procedure:

1. If LED1 is not on with the module de-energized, remove and check the fuses (F1, F2) with an ohmmeter.
2. With the module de-energized, check the ON/OFF switch (S1) with an ohmmeter to be sure it opens and closes accordingly..
3. If LED2 is not on with the module energized, check the +20 V and -20 V outputs at TP3 and TP1, respectively. The one with voltage absent will require replacement of the associated dc/dc converter.

CAUTION

BE CAREFUL NOT TO MISPLACE SCREWS, SPRING WASHER OR INSULATING WASHER USED FOR MOUNTING TRANSISTORS.

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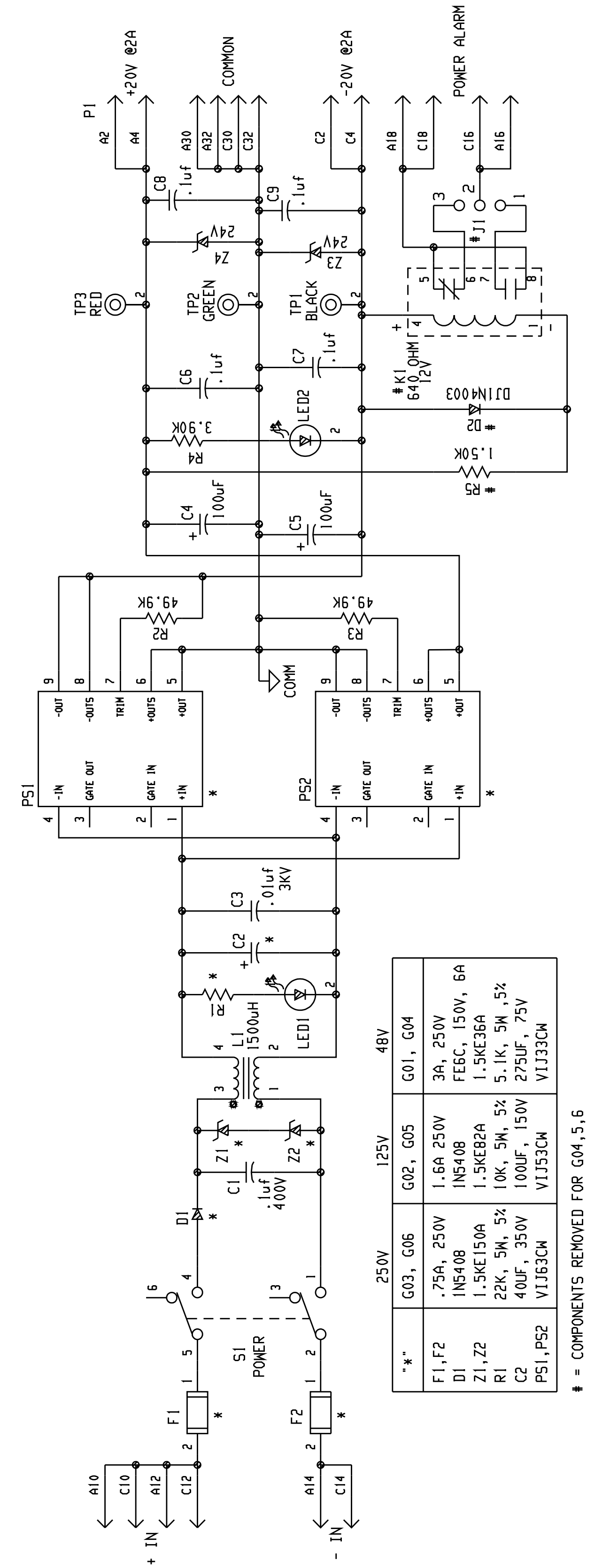

"*"	250V G03, G06	125V G02, G05	48V G01, G04
F1,F2	.75A, 250V	1.6A 250V	3A, 250V
D1	1N5408	1N5408	FE6C, 150V, 6A
Z1,Z2	1.5KE150A	1.5KE82A	1.5KE36A
R1	22K, 5W, 5%	10K, 5W, 5%	5.1K, 5W ,5%
C2	40UF, 350V	100UF, 150V	275UF, 75V
PS1,PS2	VIJ63CW	VIJ53CW	VIJ33CW

= COMPONENTS REMOVED FOR G04,5,6

Figure 9–2. TC–10B/TCF–10B Power Supply Schematic (1617C39).

Table 9–2. Power Supply Module Components (1617C38).

Location	Style	Description	Group
CAPACITORS			
C1	CE1003JU25	0.1 µF 5% 400 V MET POLYESTER	ALL
C2	CA10065N88	100 µF +150-10% 150 V ALUMINUM	02, 05
C2	CA27565K88	275 µF +150-10% 75 V ALUMINUM	01, 04
C2	CA40055T88	40 µF +150-10% 350 V ALUMINUM	03, 06
C3	CQ1002M3E4	.01 µF 3 KV CERAMIC DISC	ALL
C4,C5	CA10063E12	100 µF +75-10% 25 V ALUMINUM	ALL
C6, C7, C8, C9	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	ALL
CONNECTOR			
P1	9646A11H02	32-PIN RIGHT-ANGLE DIN CONNECTOR	ALL
CONVERTOR			
PS1, PS2	9658A45H01	VIJ53CW CONVERTOR	02, 05
PS1, PS2	9658A45H03	VIJ33CW CONVERTOR	01, 04
PS1, PS2	9658A45H02	VIJ63CW CONVERTOR	03, 06
DIODES			
D1	188A342H23	1N540B	02, 03, 05, 06
D1	3529A30H01	GI1303 150 V 6 A FAST	01, 04
D2	836A928H08	1N4007 1000 V 1 A	01, 02, 03
EJECTOR			
	1355D57H01		ALL
FUSE HOLDER			
	9644A50H01	FUSE CLIP	ALL
FUSES			
F1, F2	837A964H17	1.6 A 250 V 3 AG	02, 05
F1, F2	183A981H07	3 A 250 V 3 AG	01, 04
F1, F2	183A981H21	.75 A 250 V 3 AG	03, 06
HEADER			
J1	3533A56H05	3-POS 1-ROW RA HEADER (MAKE FROM 3533A56H06)	01, 02, 03
HEAT SINK			
	1606C65H06		ALL
INDUCTOR			
L1	3535A73H02	1,500 µH	ALL
JUMPER			
	3532A54H01	BLUE CLIP	01, 02, 03
LED			
LED1, LED2	3508A22H01	RED LED (EDGE MOUNT) 550-0406	ALL
PANEL			
	1616C46H05		ALL

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Table 9–2. Power Supply Module Components (Cont'd).

Location	Style	Description	Group
RELAY			
K1	1484B33H01	1A1B 18.8 mA 12 V 640 OHMS	01, 02, 03
RESISTORS			
R1	RW1002J5G0	10 KILOHMS 5% 5 W WIREWOUND	02, 05
R1	RW5101J5G0	5.1 KILOHMS 5% 5 W WIREWOUND	01, 04
R1	RW2202J5G0	22 KILOHMS 5% 5 W WIREWOUND	03, 06
R2, R3	RM4992FQA9	49.9 KILOHMS 1% 0.25 W METAL FILM	ALL
R4	RC3901J167	3.9 KILOHMS 5% 1 W CARBON COMP	ALL
R5	RC1501J167	1.5 KILOHMS 5% 1 W CARBON COMP	01, 02, 03
ROLL PINS			
	9644A92H01	CONNECTOR	ALL
	9654A52H01	EJECTOR	ALL
SCREW			
	877A269H05	138-32 X .375 BND HD	ALL
SPACER			
R1	9640A72H01		ALL
STANDOFF			
	3537A39H06	138-32 X .5 PEMSERT	ALL
SWITCH			
S1	1444C63H06	DPDT ALT ACTION MECH INDICATOR	ALL
TEST JACKS			
TP1	3532A53H03	BLACK	ALL
TP2	3532A53H08	GREEN	ALL
TP3	3532A53H05	RED	ALL
WASHER			
	877A681H01	138 INTERNAL TOOTH	ALL
ZENERS			
Z1, Z2	878A619H10	1.5KE82A 82 V 5% 5 W 1.5 KW SURGE	02, 05
Z1, Z2	878A619H08	1.5KE36A 36 V 5% 5 W 1.5 KW SURGE	01, 04
Z1, Z2	878A619H06	1.5KE150A 150 V 5% 5 W 1.5 KV SURGE	03, 06
Z3, Z4	878A619H12	1.5KE24A 24 V 5% 5 W 1.5 KW SURGE	ALL

Chapter 10. Keying Module

Schematic	1606C50-6
Parts List	1606C50-6

Table 10–1. 1606C50 Styles and Descriptions.

Group	Description
G01	2- or 3-Frequency w/relay contacts
G02	2- or 3-Frequency w/o relay contacts

10.1 Keying Module Description

The TCF–10B Keying Module controls the Transmitter Module as follows:

- Direct Transfer Trip (DTT) Key
- 52b Keying or Power Boost (depending on application)
- Power OFF
- Unblock (UB) or Phase Comparison (PC) Key (depending on application)
- Voice Key (External or Internal)

Keying Module outputs are as follows:

- High-Level (10 W), pin A-8
- Any Transmitter Key, pin C-6
- Voice, pin A-6
- Shift High, pin A-26
- Shift Low, pin A-28

10.1.1 Keying Control Panel

(This panel is shown in Figures 1-1 and 10-1.)

Push-Button Switches (recessed):

High-Level (HL) Power	(S1)
Shift High	(S2)
Shift Low	(S3)

LEDs for indicating Keying condition:

High-Level (10W)	(D1)
Shift High	(D2)
Shift Low	(D3)
Voice	(D4)
Any Transmitter Key	(D5)

10.1.2 Keying PC Board Jumper Controls

(The Keying PC Board Jumper Controls are shown in Figure 10-1.)

JU1 Power "ON" (NORM/INVERT)

JU2 Directional Comparison/Phase Comparison

JU3 1 W (Guard), 10 W (Trip)/10 W (Guard), 10 W (Trip)

JU4 2-Frequency System/3-Frequency (Optional) System

JU6 Activates Shift High Contacts (IN/OUT)

JU7 Activates Shift Low Contacts (IN/OUT)

JU8 Selects NO or NC contacts for Shift High

JU9 Selects NO or NC contacts for Shift Low

JU10–
JU14 (Input Keying voltage selections: 15 V, 48 V, 125 V, 250 V)

10.2 Keying Circuit Description

The Keying Module (see Figure 10-3, Schematic 1606C50S) provides an optically-isolated interface between the carrier and the relay system and controls the operation of the Transmitter Module.

10.2.1 Customer Inputs

Customer inputs operate as described below (see Figure 10-2):

DTT Key

With jumper JU10 set, input will be initiated when the appropriate voltage level (15 V, 48 V, 125 V or 250 V) is applied to pins A-10/C-10.

52b Keying or Power Boost

With jumper JU12 set, input will be power boost initiated when the appropriate voltage level (15 V, 48 V, 125 V or 250 V) is applied to pins C-16/C-22.

Power Off

With jumper JU13 set, when jumper JU1 is in NORM position, the transmitter will be keyed "ON" when proper voltage level (15 V, 48 V, 125 V or 250 V) is applied to pins A-16/C-22. When JU1 is in the INVERT position, the transmitter will be keyed "ON" when voltage is removed from input A-16/C-22.

UB or PC Key

With jumper JU14 set, input will be initiated when the appropriate voltage level (15 V, 48 V, 125 V or 250 V) is applied to pins A-22/C-22.

External Voice Key

With jumper JU11 set, input will be initiated when the appropriate voltage level (15 V, 48 V, 125 V or 250 V) is applied to pins A-12/C-12.

Internal Voice

This input (C-24) will be initiated when the optional voice adapter is installed, and the push-to-talk button switch is pushed.

10.2.2 Jumper Selections

The following jumper selections are available:

JU1 Allows selection between NORM/ INVERT. Selecting the normal (NORM) position will turn "ON" the Transmitter when proper voltage level (15 V, 48 V, 125 V, 250 V) is applied to pins A-16/C-22. Selecting the invert (INV) position will turn "ON" the Transmitter when voltage is removed from input pins A-16/C-22.

JU2 Selects between a directional comparison system and a phase comparison system.

JU3 This link allows selection between 1 W (Guard)/10 W (Trip) or 10 W (Guard)/10 W(Trip) operation by placing link in 1/10 W or 10/10 W position, respectively.

JU4 Selecting the 2-frequency (2F) position will set the Keying Module in mode to correctly operate as a 2-frequency system. Selecting the 3-frequency position will set the Keying Module in mode to correctly operate as a 3-frequency system.

JU6 Placing JU6 to IN position activates the shift high contact; the OUT position deactivates the shift high contact.*

JU7 Placing JU7 to IN position activates shift low contact; OUT position deactivates shift low contact.*

JU8 Places shift high contacts in either normally open (NO) position or normally closed (NC) position.

JU9 Places shift low contacts in either normally open (NO) position or normally closed (NC) position.

JU10–
JU14 Provides input keying voltage selections: 15 V, 48 V, 125 V, 250 V.

10.2.3 Testing

You can also initiate a high-level test by pressing the (recessed) push-button switch (S1) on the front panel. You can also initiate a shift high test by pressing the (recessed) push-button switch (S2) on the front panel. You can also initiate a shift low test by pressing the (recessed) push-button switch (S3) on the front panel.

10.2.4 Voltage Regulation

Zener diodes D10, D12, D14, D16, and D18 limit the input voltage to the optical isolators (I5, I6, I7, I8, and I9, respectively) and also provide reverse voltage protection. Zener diodes D6 and D7 regulate primary power (pins A-2/4, A-30/32, C-30/32) down to 15 V, and also provide reverse voltage protection.

10.3 Keying Troubleshooting

Should a fault occur in the Keying Module, place the module on an extender board.

You may test the five optical isolators (I5 through I9) using the on-board +18.6-Vdc source (D6 cathode). When a logic "1" is applied to any of the 15 V inputs (R43, R46, R40, R34, R37), with the jumper removed, pin 5 of the selected optical isolator (I5, I6, I7, I8 or I9) will go high.

! CAUTION

DO NOT ATTEMPT TO FORCE A LOGIC "1" (+18.6 VDC) ON ANY OUTPUTS OR INPUTS CONNECTED TO OUTPUTS. THIS COULD DAMAGE AN IC. SEE FIGURE 10-3 FOR INTERNAL LOGIC.

You can check other components on the PC Board by conventional means.

When the appropriate jumper is in place on the board, jumpers JU10, JU11, JU12, JU13, and JU14 provide logic "1" or "0" inputs. Logic "1" is +18.6 Vdc; logic "0" is +8.6 Vdc. See Table 10-2, Truth Tables for TCF–10B Keying Modules, which describes the operation of the logic blocks used. Proper voltage levels of these input commands must be observed.

*Place in the "OUT" position when using with the Phase Comparison relay systems.

Table 10–2. Truth Tables for TCF–10B Keying Modules.

PWR OFF	UNBLK KEY	52B PWR	DTT KEY	EXT VOICE	INT VOICE	JU1 LINK	JU2 LINK	JU3 LINK	JU4 LINK	*JU6 LINK	*JU7 LINK	*JU8 LINK	*JU9 LINK	CONT *HI	CONT *LO	D5 TX KEY	D4 VOICE KEY	D3 SHFT LO	D2 SHFT HI	D1 HL KEY
0	0	0	0	0	0	NORM	DCR	1/10	2F	IN	IN	NO	NO	1	0	0	0	0	1	0
0	1	0	0	0	0	NORM	DCR	1/10	2F	IN	IN	NO	NO	0	1	0	0	1	0	1
0	0	0	0	0	1	NORM	PCR	10	2F	OUT	IN	NO	NO	0	0	0	1	0	1	0
0	0	0	1	0	0	NORM	PCR	10	2F	IN	OUT	NO	NO	0	0	0	0	1	0	1
0	0	0	1	0	0	NORM	PCR	1/10	3F	IN	IN	NC	NC	1	0	0	0	1	0	1
0	1	0	0	0	0	NORM	PCR	1/10	3F	IN	IN	NC	NC	0	1	0	0	0	1	0
1	0	0	1	1	0	NORM	PCR	1/10	2F	IN	IN	NO	NO	0	1	1	1	1	0	0
0	0	1	0	1	0	INV	PCR	1/10	2F	IN	IN	NO	N0	1	0	1	0	0	1	1
1	0	1	0	0	0	INV	PCR	1/10	2F	IN	IN	NO	N0	1	0	0	0	0	1	1

PWR OFF	UNBLK KEY	52B PWR	DTT KEY	EXT VOICE	INT VOICE	JU1 LINK	JU2 LINK	JU3 LINK	JU4 LINK	S1 FRONT HL	S2 PANEL SH	S3 SWITCH H SL	CONT *HI	CONT *LO	D5 TX KEY	D4 VOICE KEY	D3 SHFT LO	D2 SHFT HI	D1 HL KEY
0	0	0	0	0	0	NORM	PCR	1/10	2F	0	0	0	1	0	0	0	0	1	0
0	0	0	0	0	0	NORM	PCR	1/10	2F	0	0	1	0	1	0	0	1	0	0
0	1	0	1	0	0	NORM	PCR	1/10	2F	0	1	0	0	1	0	0	1	0	0
0	0	0	0	0	0	NORM	PCR	1/10	2F	1	0	0	1	0	0	0	0	1	1

Link Change

***** Used for G01 Only*

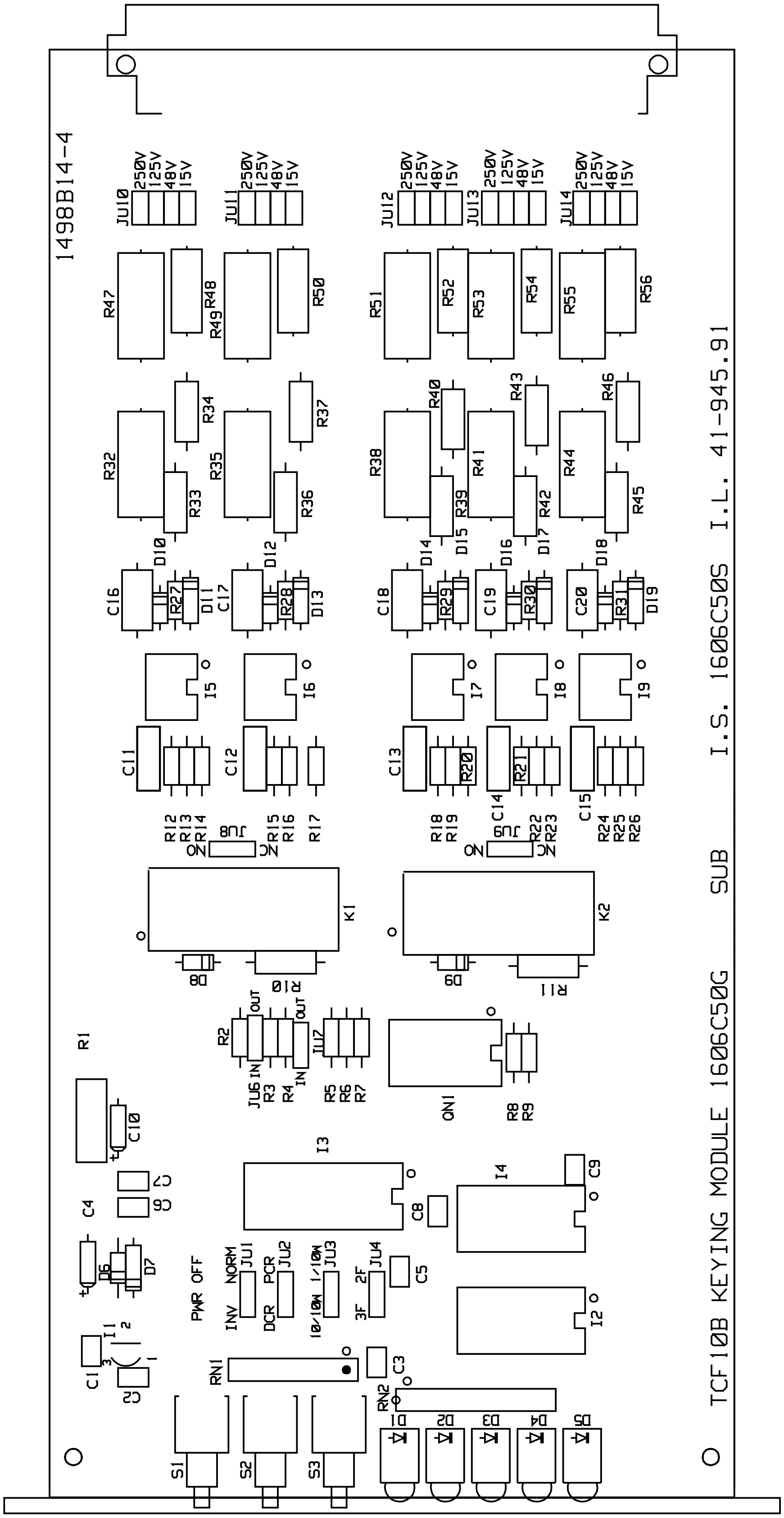

Figure 10–1. TCF–10B Keying PC Board (1606C50S).

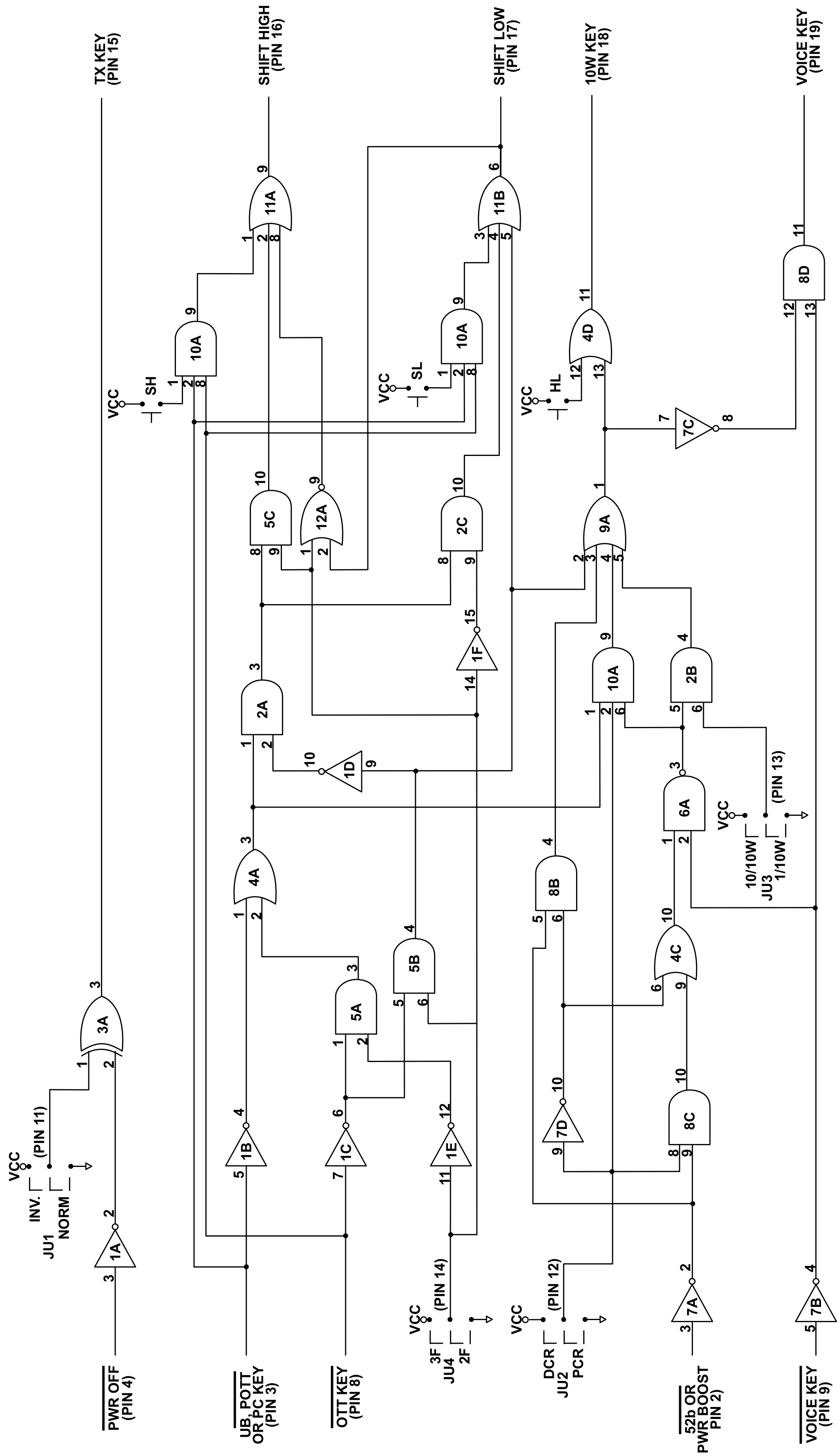

Figure 10–2. TCF–10B Keying Module Internal Logic (1499B63).

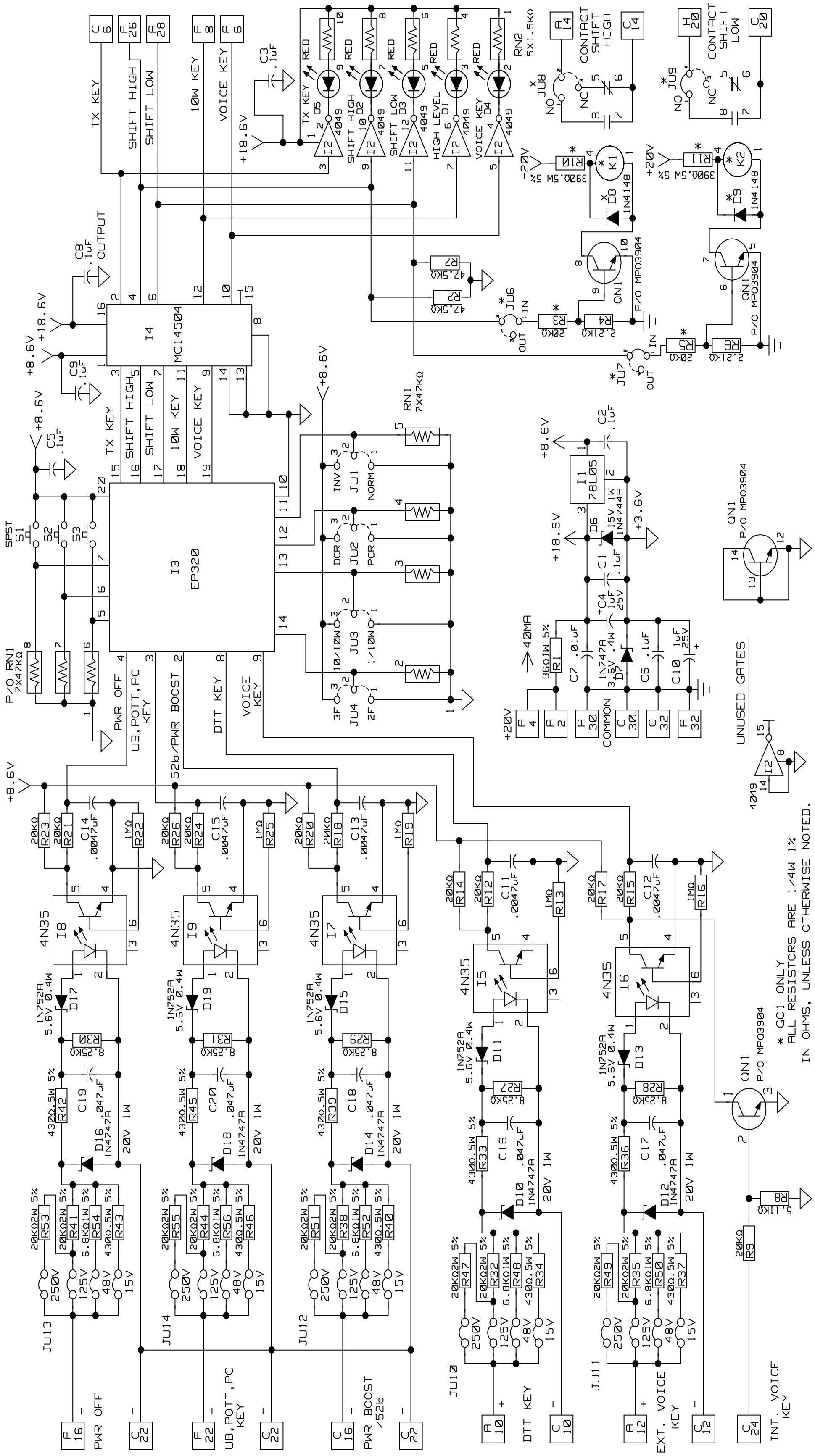

Figure 10–3. TCF–10B Keying Schematic (1606C50).

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Table 10–3. Keying Module Components (1606C50).

Location	Style	Description	Group
CAPACITORS			
C1	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C2	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C3	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C4	CJ1004MD72	1.0 µF 20% 20 V MOLDED TANTALUM	01,02
C5	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C6	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C7	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01,02
C8	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C9	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C10	CJ1004MD72	1.0 µF 20% 20 V MOLDED TANTALUM	01,02
C11	CT4701JW68	4,700 pF 5% 630 V MET POLYESTER	01,02
C12	CT4701JW68	4,700 pF 5% 630 V MET POLYESTER	01,02
C13	CT4701JW68	4,700 pF 5% 630 V MET POLYESTER	01,02
C14	CT4701JW68	4,700 pF 5% 630 V MET POLYESTER	01,02
C15	CT4701JW68	4,700 pF 5% 630 V MET POLYESTER	01,02
C16	CF4702JL78	0.047 µF 5% 100 V MET POLYCARB	01,02
C17	CF4702JL78	0.047 µF 5% 100 V MET POLYCARB	01,02
C18	CF4702JL78	0.047 µF 5% 100 V MET POLYCARB	01,02
C19	CF4702JL78	0.047 µF 5% 100 V MET POLYCARB	01,02
C20	CF4702JL78	0.047 µF 5% 100 V MET POLYCARB	01,02
CONNECTORS			
JU1	9640A47H01	3 POSITION	01,02
JU2	9640A47H01	3 POSITION	01,02
JU3	9640A47H01	3 POSITION	01,02
JU4	9640A47H01	3 POSITION	01,02
JU6	9640A47H01	3 POSITION	01
JU7	9640A47H01	3 POSITION	01
JU8	9640A47H01	3 POSITION	01
JU9	9640A47H01	3 POSITION	01
JU10	3532A49H06	4 POSITION DOUBLE ROW	01,02
JU11	3532A49H06	4 POSITION DOUBLE ROW	01,02
JU12	3532A49H06	4 POSITION DOUBLE ROW	01,02
JU13	3532A49H06	4 POSITION DOUBLE ROW	01,02
JU14	3532A49H06	4 POSITION DOUBLE ROW	01,02
CUSTOM ICS			
IC3	1500B83G01	***NO ITEM DESCRIPTION***	01,02
DIGITAL ICS			
IC2	3533A86H01	MC14049UBCP HEX INVERTER/BUFFER	01,02
IC4	3535A27H01	MC14504BCP HEX LEVEL-SHIFTER	01,02
DIODES			
D8	836A928H06	1N4148 75 V 0.01 A	01
D9	836A928H06	1N4148 75 V 0.01 A	01

Table 10–3. Keying Module Components (Cont'd).

Location	Style	Description	Group
LINEAR ICs			
IC1	3534A39H02	MC78L05CP POS VOLTREG 5 V 5% 0.1 A	01,02
QN1	3533A64H01	MPQ3904 QUAD NPN ARRAY 40 V 0.2 A	01,02
LEDs			
D1	3508A22H01	RED LED (EDGE MOUNT) 550-0406	01,02
D2	3508A22H01	RED LED (EDGE MOUNT) 550-0406	01,02
D3	3508A22H01	RED LED (EDGE MOUNT) 550-0406	01,02
D4	3508A22H01	RED LED (EDGE MOUNT) 550-0406	01,02
D5	3508A22H01	RED LED (EDGE MOUNT) 550-0406	01,02
IC5	774B936H01	4N35 OPTO-ISO.	01,02
IC6	774B936H01	4N35 OPTO-ISO.	01,02
IC7	774B936H01	4N35 OPTO-ISO.	01,02
IC8	774B936H01	4N35 OPTO-ISO.	01,02
IC9	774B936H01	4N35 OPTO-ISO.	01,02
RELAYS			
K1	1484B33H01	AROMAT TYPE ST1E-DC 12 V	01
K2	1484B33H01	AROMAT TYPE ST1E-DC 12 V	01
RESISTOR NETWORKS			
RN1	3533A81H14	7 COMM TERML 47 KILOHMS 2% SIP	01,02
RN2	3532A91H04	5 INDIVIDUAL 1.5 KILOHMS 2% SIP	01,02
RESISTORS			
R1	RC360AJ1E3	36 OHMS 5% 1 W CARBON COMP	01,02
R2	RM4752FQA9	47.5 KILOHMS 1% 0.25 W METAL FILM	01,02
R3	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01
R4	RM2211FQB0	2.21 KILOHMS 1% 0.25 W METAL FILM	01,02
R5	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01
R6	RM2211FQB0	2.21 KILOHMS 1% 0.25 W METAL FILM	01,02
R7	RM4752FQA9	47.5 KILOHMS 1% 0.25 W METAL FILM	01,02
R8	RM5111FQB0	5.11 KILOHMS 1% 0.25 W METAL FILM	01,02
R9	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R10	RB3900JHL8	390 OHMS 5% 0.5 W CARBON FILM	01
R11	RB3900JHL8	390 OHMS 5% 0.5 W CARBON FILM	01
R12	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R13	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01,02
R14	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R15	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R16	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01,02
R17	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R18	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R19	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01,02
R20	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R21	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02

(Continued on next page.)

Table 10–3. Keying Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS (Cont'd)			
R22	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01,02
R23	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R24	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R25	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01,02
R26	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R27	RM8251FQB0	8.25 KILOHMS 1% 0.25 W METAL FILM	01,02
R28	RM8251FQB0	8.25 KILOHMS 1% 0.25 W METAL FILM	01,02
R29	RM8251FQB0	8.25 KILOHMS 1% 0.25 W METAL FILM	01,02
R30	RM8251FQB0	8.25 KILOHMS 1% 0.25 W METAL FILM	01,02
R31	RM8251FQB0	8.25 KILOHMS 1% 0.25 W METAL FILM	01,02
R32	RC2002J249	20 KILOHMS 5% 2 W CARBON COMP	01,02
R33	RB4300JHL8	430 OHMS 5% 0.5 W CARBON FILM	01,02
R34	RB4300JHL8	430 OHMS 5% 0.5 W CARBON FILM	01,02
R35	RC2002J249	20 KILOHMS 5% 2 W CARBON COMP	01,02
R36	RB4300JHL8	430 OHMS 5% 0.5 W CARBON FILM	01,02
R37	RB4300JHL8	430 OHMS 5% 0.5 W CARBON FILM	01,02
R38	RC2002J249	20 KILOHMS 5% 2 W CARBON COMP	01,02
R39	RB4300JHL8	430 OHMS 5% 0.5 W CARBON FILM	01,02
R40	RB4300JHL8	430 OHMS 5% 0.5 W CARBON FILM	01,02
R41	RC2002J249	20 KILOHMS 5% 2 W CARBON COMP	01,02
R42	RB4300JHL8	430 OHMS 5% 0.5 W CARBON FILM	01,02
R43	RB4300JHL8	430 OHMS 5% 0.5 W CARBON FILM	01,02
R44	RC2002J249	20 KILOHMS 5% 2 W CARBON COMP	01,02
R45	RB4300JHL8	430 OHMS 5% 0.5 W CARBON FILM	01,02
R46	RB4300JHL8	430 OHMS 5% 0.5 W CARBON FILM	01,02
R47	RC2002J249	20 KILOHMS 5% 2 W CARBON COMP	01,02
R48	RC6801J167	6.8 KILOHMS 5% 1 W CARBON COMP	01,02
R49	RC2002J249	20 KILOHMS 5% 2 W CARBON COMP	01,02
R50	RC6801J167	6.8 KILOHMS 5% 1 W CARBON COMP	01,02
R51	RC2002J249	20 KILOHMS 5% 2 W CARBON COMP	01,02
R52	RC6801J167	6.8 KILOHMS 5% 1 W CARBON COMP	01,02
R53	RC2002J249	20 KILOHMS 5% 2 W CARBON COMP	01,02
R54	RC6801J167	6.8 KILOHMS 5% 1 W CARBON COMP	01,02
R55	RC2002J249	20 KILOHMS 5% 2 W CARBON COMP	01,02
R56	RC6801J167	6.8 KILOHMS 5% 1 W CARBON COMP	01,02
SWITCHES			
S1	9646A57H01	SPST PUSH BUTTON	01,02
S2	9646A57H01	SPST PUSH BUTTON	01,02
S3	9646A57H01	SPST PUSH BUTTON	01,02

Table 10–3. Keying Module Components (Cont'd).

Location	Style	Description	Group
ZENERS			
D6	849A515H04	1N4744A 15 V 5% 1 W	01,02
D7	837A398H08	1N747A 3.6 V 5% 0.4 W	01,02
D10	849A487H01	1N4747A 20 V 5% 1 W	01,02
D11	186A797H12	1N752A 5.6 V 5% 0.4 W	01,02
D12	849A487H01	1N4747A 20 V 5% 1 W	01,02
D13	186A797H12	1N752A 5.6 V 5% 0.4 W	01,02
D14	849A487H01	1N4747A 20 V 5% 1 W	01,02
D15	186A797H12	1N752A 5.6 V 5% 0.4 W	01,02
D16	849A487H01	1N4747A 20 V 5% 1 W	01,02
D17	186A797H12	1N752A 5.6 V 5% 0.4 W	01,02
D18	849A487H01	1N4747A 20 V 5% 1 W	01,02
D19	186A797H12	1N752A 5.6 V 5% 0.4 W	01,02

USER NOTES

Chapter 11. Transmitter Module

Schematic	1355D71-8
Parts List	1610C01-11

Table 11–1. 1610C01 Styles and Descriptions.

Group	Description
G01	TRANSMITTER 2- OR 3-FREQUENCY
G02	TRANSMITTER 2- OR 3-FREQUENCY W/Trip Test Unit

11.1 Transmitter Module Description

The function of the TC–10B/TCF–10B Transmitter Module is to provide the RF signal which drives the 10W PA Module. The Transmitter's frequency range is from 30 kHz to 535 kHz, programmable in 0.1 kHz (100 Hz) steps by four rotary switches on the Transmitter. The Transmitter is slaved to a crystal oscillator.

The TC–10B/TCF–10B Transmitter Module operates from keyed inputs (set by jumpers at the Keying Module):

- High-Level Key
- Any Transmitter Key
- Voice Key
- Shift High (TCF–10B only)
- Shift Low (TCF–10B only)

The Transmitter Module also operates with a signal from the Optional Voice Adapter Module:

- AM Voice

The Transmitter Module operates with either no shift or one of three different frequency shifts, selectable by a four-position DIP switch (S5).

11.1.1 Transmitter Control Panel

(This panel is shown in Figure 1-1.)

Operator controls consist of four thumbwheel switches (with indicator windows), representing the frequency range:

- SW1 (x 100 kHz)
- SW2 (x 10 kHz)
- SW3 (x 1 kHz)
- SW4 (x 0.1 kHz)

After pulling the module, use a screw driver to set the thumbwheel switches: CW for higher frequency, CCW for lower frequency.

11.1.2 Transmitter PC Board

(The Transmitter PC Board is shown in Figure 11-1.)

Operator controls are as described below.

Potentiometers

R13	Adjusts high-level (10 W) output
R12	Adjusts low-level (1 W) output
R14	Adjusts voice (4.3 W) output level
R1	Adjusts modulation of transmitter signal (peak-to-valley ratio of signal envelope)

R29 Sets the offset in output amplifier, so that when 0 dBm is generated, R29 is adjusted to minimize the 2nd harmonic distortion

Capacitor

C19 Adjustment for 3.27680 MHz clock oscillator

Switch

S5 Frequency-shift select

Test Point

TP1 Clock Oscillator Output

11.2 TRANSMITTER CIRCUIT DESCRIPTION

The function of the Transmitter Module (see Figure 11-2, Schematic 1355D71) is to provide the RF signal (0 dBm/.001W, 50 ohm balanced), which drives the 10W PA Module. The Transmitters frequency range is from 30 kHz to 535 kHz, programmable in 0.1 kHz (100 Hz) steps by four rotary switches on the Transmitter. The Transmitter Module operates from keyed inputs (set by jumpers at the Keying Module):

- High-Level (10W) Key (pins C/A-8)
- Any Transmitter Key (pin A-10)
- Voice Key (pins C/A-6)
- Shift High (pin C-10) (TCF–10B Only)
- Shift Low (pins A/C 24) (TCF–10B Only)

The Transmitter Module also operates from an audio signal from the Optional Voice Adapter Module: AM Voice (pins C/A-26). Refer to Figure 11-3, Transmitter Block Diagram.

Frequencies are selected using the four BCD (Binary Coded Decimal) switches (SW1 thru SW4); the range is from 30.0 to 535.0 kHz, in 0.1 kHz (100 Hz) steps. The 15-bit output of the BCD switches is converted to a 13-bit binary number by the BCD-to-Binary converter (ROMs I1 and I2).

The 13-bit output of ROMs I1 and I2 provides an input to the Shift and Control Logic (I3), which consists of three parts:

1. A full adder/subtracter which functions under control of:
   - Shift High (Add)
   - Shift Low (Subtract)
2. A frequency-shift, in 50 Hz increments from 0 to 750 Hz, selected by the 4-position DIP switch (S5).
3. A sequencer and multiplexer (MUX) which provides the following outputs to the Numerical Controlled Oscillator (NCO I4):
   - Address select (ADDR)
   - Write (WRN)
   - Load (LDSTB)
   - 2 (8-bit sequential) data bytes

The NCO (I4) generates digital sine functions of very precise frequency, to be used in conjunction with a D/A converter (I5) in analog frequency generation applications. The NCO is designed to interface with and be controlled from an 8-bit bus.

The NCO maintains a record of phase which is accurate to 16 bits. At each clock cycle, the number stored in the 16-bit phase register is added to the previous value of the phase accumulator. The number in the phase accumulator represents the current phase of the synthesized sine function. The number in the Δ-phase register represents the change of phase for each cycle of the clock. This number is directly related to the output frequency by the following:

$$f_0 = \frac{f_C \text{ x } \Delta \text{ - phase}}{2^{16}}$$

where: f_0 is the frequency of the output signal

and: f_C is the clock frequency (3.27680 MHz)

The sine function is generated from the 13 most significant bits of the phase accumulator. The frequency of the NCO is determined by the number stored in the Δ-phase register, which may be programmed by two sequential 8-bit inputs.

The frequency programming capability of the NCO is analogous to sampling a sine wave where the sampling function is the clock.

If the output frequency is very low with respect to the clock (less than f_C / 8096), then the NCO output will sequence through each of the 8096 states of the sine function. As the output frequency is increased with respect to the clock, the sine function will appear to be more discontinuous, because there will be fewer samples in each cycle. At the Nyquist limit, when the output frequency is exactly half the clock, the output waveform reduces to a square wave. The practical upper limit of the NCO output frequency is about 40% of the clock frequency because spurious components created by sampling, which are at a frequency greater than half-the-clock frequency, become difficult to remove by filtering.

The 12-bit output of the NCO is applied to the input of the high-speed Digital-to-Analog Converter (I5), which converts a digital sine wave from the NCO to an analog output. The analog output from I5 is filtered by a 630 kHz Low Pass Filter (C14, C13, L1, L2, C15), producing a 0.512 Vp-p output at the carrier frequency. The carrier frequency is applied to Modulator (I7), where it is modulated by a dc and/or ac signal from a 2 kHz Low Pass Filter (I10, R24, R25, R26, C30, C31, C32). The output of I7 drives the Output Amplifier (I11) and associated components. The output of I11 is coupled through the Output Transformer (T1) to provide a 50 ohm balanced output.

The reference frequency to the NCO is generated by a Crystal-Controlled Clock Oscillator (CCCO), consisting of Y1, CMOS inverter (I6A), R3, R4, C19, C20, and C50, at a frequency of 3.27680 MHz. The CCCO is buffered by I6B, which drives the Shift and Control Logic (I3) and the NCO clocks. The modulator (I7) receives its inputs from the Analog MUX (I9) used for modulation selection, through the Low Pass Filter whose functions are described (in paragraphs 11.2.1, 11.2.2 and 11.2.3) below.

11.2.1 Low-Level Operation

When Transmitter key input voltage (pin A10) is present, it removes the reset from the NCO (I4). If no other input voltage is present (Transmitter key signal only), the voltage divider (R12, R10) supplies the modulating voltage to the modulator (I7), through the selected analog multiplexer (I9) channel. The 1 watt low-level operation is produced when I9 (both A and B) are either "0" or "1", causing I9 to connect inputs X0 and Y0, or X3 and Y3 to the outputs X and Y. Potentiometer R12 controls the low-level output, which is between 0 and 1 mW.

11.2.2 High-Level Operation

When the 10W voltage is keyed, it produces a "1" at the I9 B input, causing channel 2 to be selected. If no other input voltage is present (10 W key signal only), the voltage divider (R10, R13) supplies the modulating voltage to the modulator (I7) through the multiplexer (I9) channel.

The 10 watt high-level operation is produced when I9 A input is "0" and I9 B input is "1", causing I9 to connect inputs X2 and Y2 to the output X and Y. Potentiometer R13 controls the high-level output, which is between 0 and 1 mW.

11.2.3 Voice Operation

When the Voice key input voltage is present, it produces a "1" at I9A input, causing channel 1 to be selected. If no other input voltage is present (Voice key signal only), the voltage divider (R10, R14) supplies the modulating voltage to the modulator (I7), through the selected analog multiplexer (I9) channel. The Voice operation is produced when I9 A input is "1" and I9 B input is "0", causing I9 to connect X1 and Y1 to the outputs X and Y. Potentiometer R14 controls the voice carrier output level of the AM carrier, which is between 0 and 1 mW. In addition, an ac signal from AM Voice Input is added to the dc level (through R8, R11, and C26) to modulate the carrier. The audio modulating level is adjusted (by potentiometer R11) to a maximum of 60% modulation.

On-board voltage regulation is provided by voltage regulators I8 (+5 V), I12 (+15 V), I13 (-15 V) and associated components. The circuitry operates at +15 V, +5 V, or -15 V. All bypassing is to common or PC Board ground. Additional regulated voltages of +4.3 V and -4.3 V are generated by I7 to provide an extremely stable reference for modulating control voltages (provided by R12, R13, and R14).

11.2.4 Frequency-Shift Operation (TCF–10B only)

For TCF–10B operation, circuitry is provided to shift the frequency of the NCO (I4), which supplies the modulator (I7). Shift-low and shift-high commands are fed from the Keying Module to connector pins C/A-24 and C-10, respectively. The NCO can operate on three different frequencies, depending on the combination of shift-high and shift-low inputs to the Shift and Control Logic (I3).

The **shift-low** command causes I3 to select the shift frequency voltage from the Frequency Shift Selector Switch (S5). The NCO (I4) output shifts to a lower frequency and the Transmitter output shifts to a lower frequency (f_C - f_{shift}).

The **shift-high** command causes I3 to select the shift frequency from the Frequency Shift Selector (S5). The NCO (I4) output shifts to a higher frequency and the Transmitter output shifts to a higher frequency (f_c + f_{shift}). The operation of this command is similar to that of the shift-low command, except that the shift is added to (rather than subtracted from) the carrier frequency.

When there is no command to shift low or high, both SL and SH inputs to I3 are logic “1”, and no shift is added to the carrier frequency.

11.3 TRANSMITTER TROUBLESHOOTING

Should a fault occur in this module, place the module on an extender board. Check the RF output (30 to 535 kHz) on pins A/C-28. If there is a Voice Key or AM voice input, use an oscilloscope to examine the modulation envelope. You can check the ac and dc voltages provided on the schematic (Figure 11-2) at the appropriate points, for the conditions on the schematic (10 W, 1 W, and Voice).

You can check all diodes, resistors, chokes and transistors by conventional means.

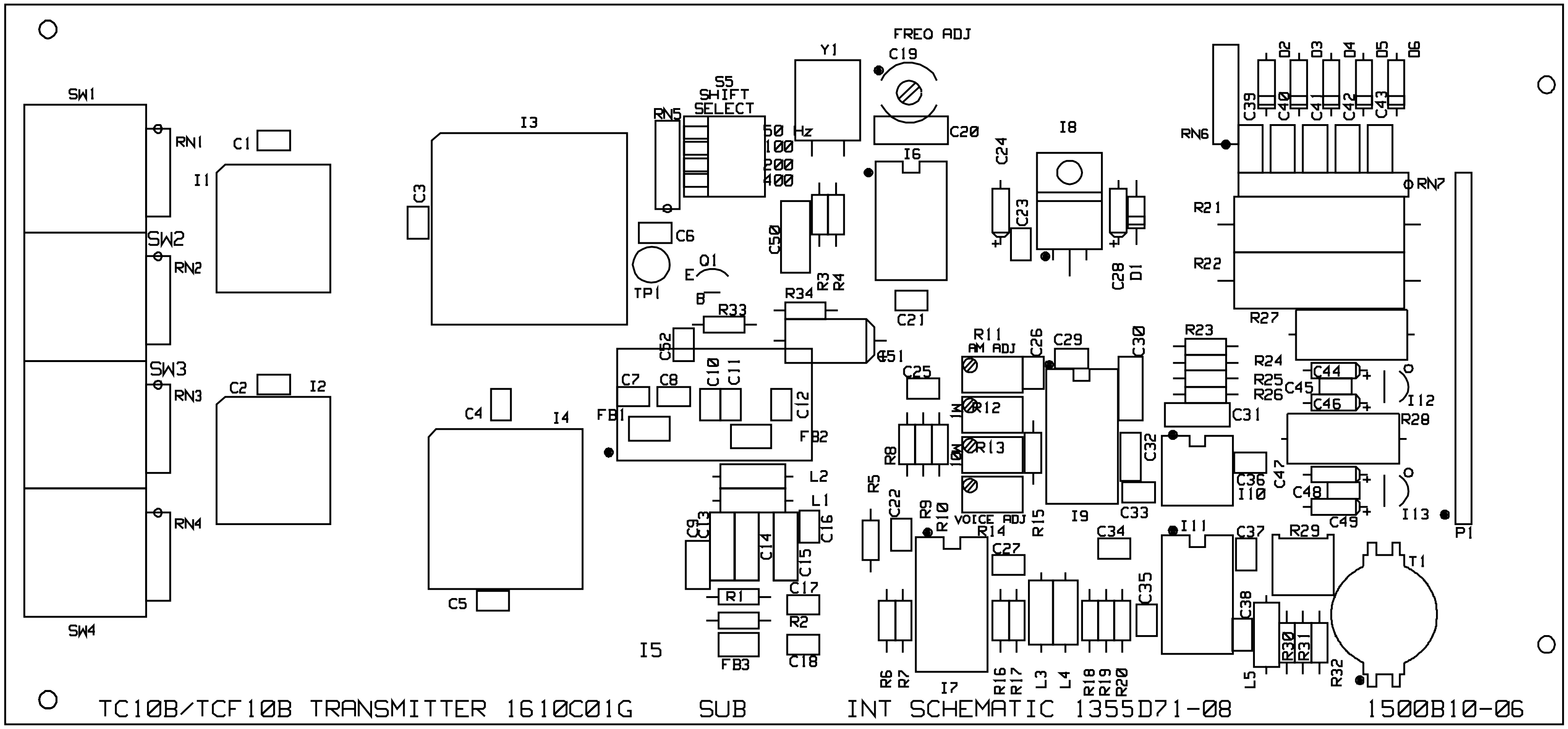

Figure 11–1. TC–10B/TCF–10B Transmitter PC Board (1500B10).

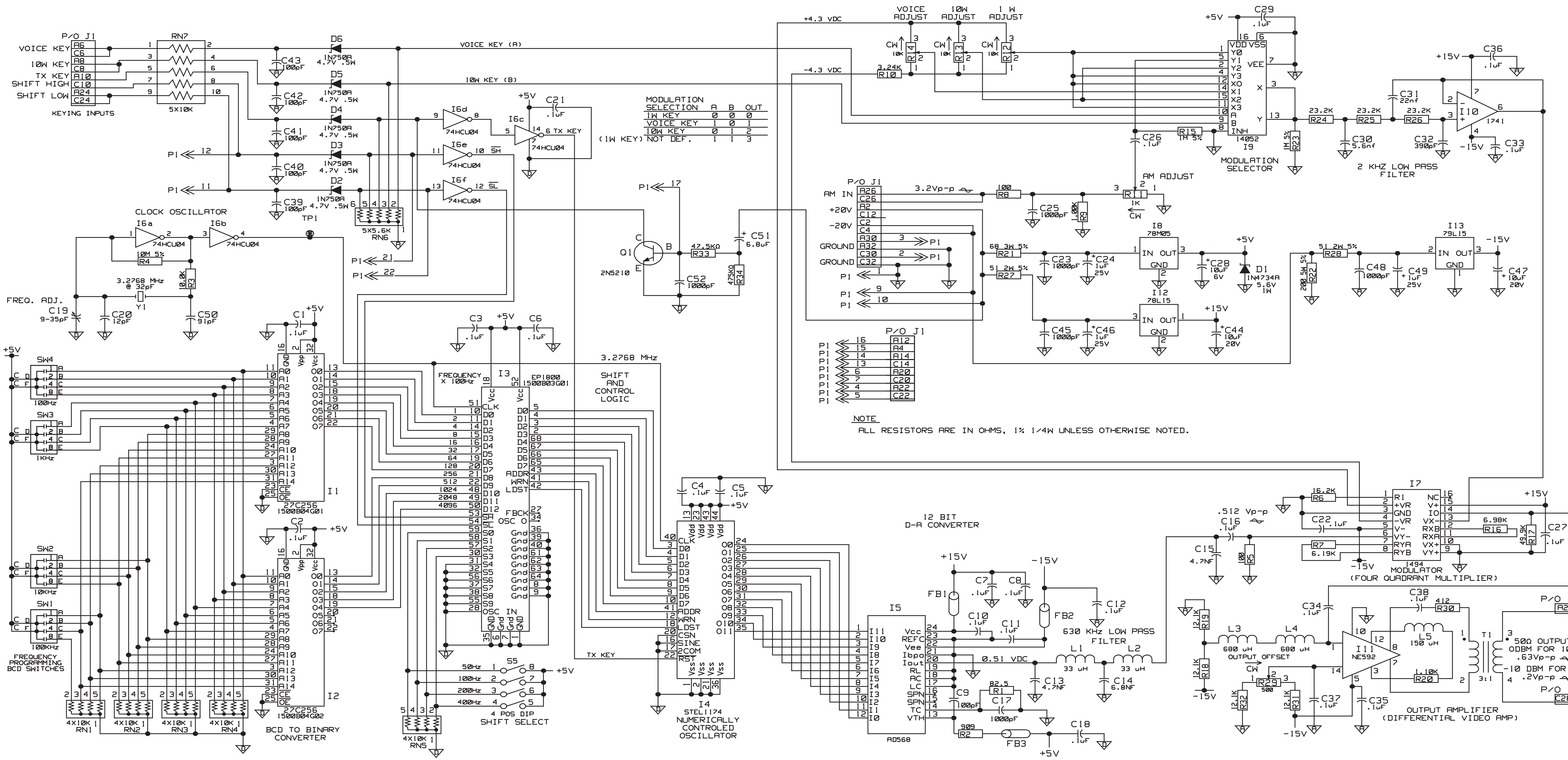

Figure 11–2. TCF–10B Transmitter Schematic (1355D71)

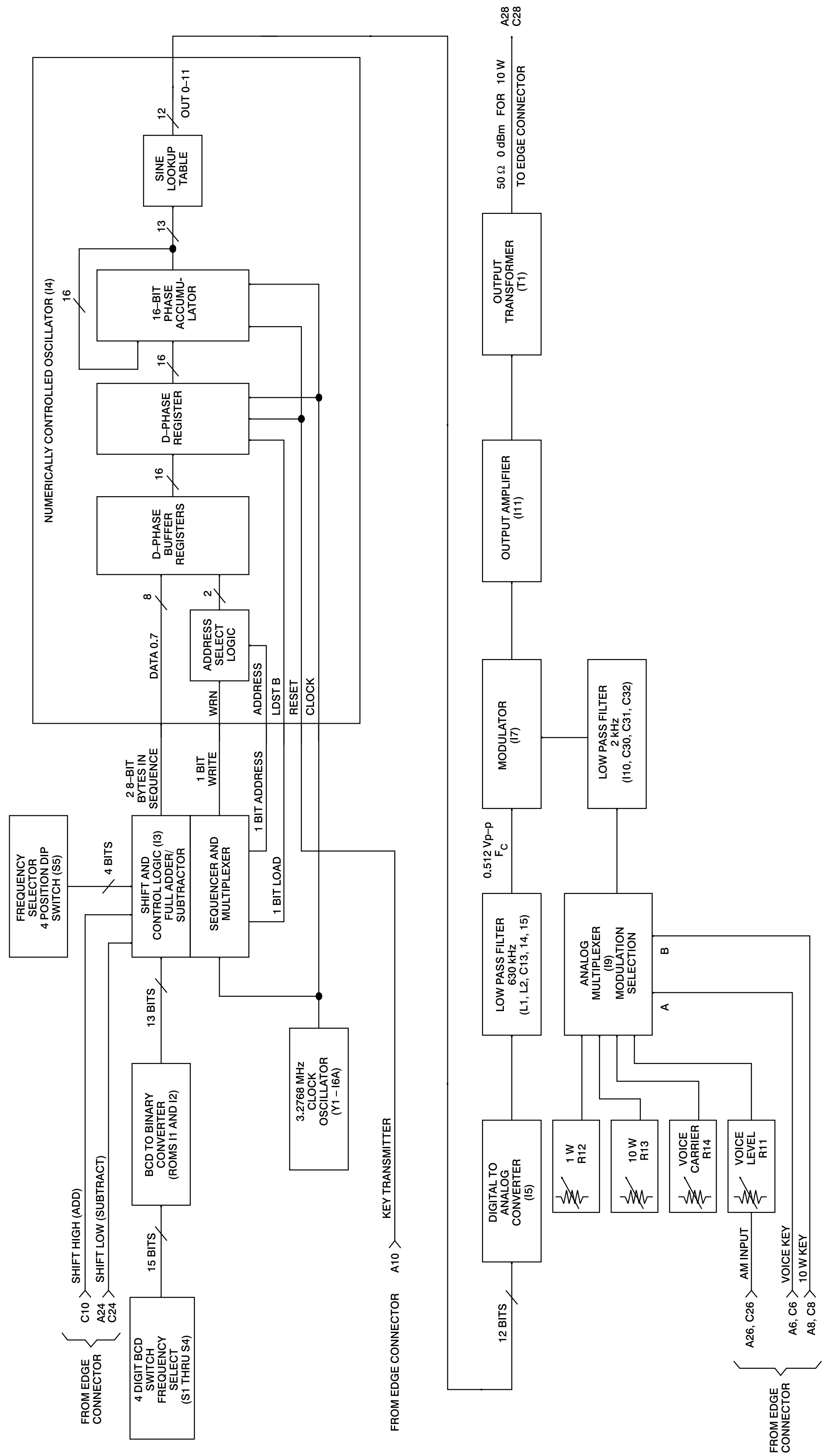

Figure 11–2. TCF–10B Transmitter Block Diagram (1610C09).

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Table 11–2. Transmitter Module Components (1610C01).

Location	Style	Description	Group
BEADS			
FB1	9651A21H01	FERRITE BEADS	01
FB2	9651A21H01	FERRITE BEADS	01
FB3	9651A21H01	FERRITE BEADS	01
CAPACITORS			
C1	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C2	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C3	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C4	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C5	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C6	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C7	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C8	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C9	CP1000KHZZ	100 pF 10% 50 V X7R MONO CERAMIC	01
C10	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C11	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C12	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C13	CT4701JW68	4,700 pF 5% 630 V MET POLYESTER	01
C14	CT6801JW68	6,800 pF 5% 630 V MET POLYESTER	01
C15	CT4701JW68	4,700 pF 5% 630 V MET POLYESTER	01
C17	CP1001ML65	1,000 pF 20% 100 V X7R MONO CERAMIC	01
C20	CR180AGV92	18 pF 2% 500 V DIPPED MICA	01
C23	CP1001ML65	1,000 pF 20% 100 V X7R MONO CERAMIC	01
C24	CJ1004MD72	1.0 µF 20% 20 V MOLDED TANTALUM	01
C25	CP1001ML65	1,000 pF 20% 100 V X7R MONO CERAMIC	01
C28	CJ1005MA72	10 µF 20% 6 V MOLDED TANTALUM	01
C30	CT5601JU74	5,600 pF 5% 400 V MET POLYESTER	01
C31	CT2202JQ74	0.022 µF 5% 250 V MET POLYESTER	01
C32	CR3900JH67	390 pF 5% 50 V DIPPED MICA	01
C39	CP1000KHZZ	100 pF 10% 50 V X7R MONO CERAMIC	01
C40	CP1000KHZZ	100 pF 10% 50 V X7R MONO CERAMIC	01
C41	CP1000KHZZ	100 pF 10% 50 V X7R MONO CERAMIC	01
C42	CP1000KHZZ	100 pF 10% 50 V X7R MONO CERAMIC	01
C43	CP1000KHZZ	100 pF 10% 50 V X7R MONO CERAMIC	01
C44	CJ1005MD72	10 µF 20% 20 V MOLDED TANTALUM	01
C45	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	01
C46	CJ1004MD72	1.0 µF 20% 20 V MOLDED TANTALUM	01
C47	CJ1005MD72	10 µF 20% 20 V MOLDED TANTALUM	01
C48	CP1001ML65	1,000 pF 20% 100 V X7R MONO CERAMIC	01
C49	CJ1004MD72	1.0 µF 20% 20 V MOLDED TANTALUM	01
C50	CR910AGVA6	91 pF 2% 500 V DIPPED MICA	01
C51	CJ6804MG72	6.8 µF 20% 35 V MOLDED TANTALUM	01
C52	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01

Table 11–2. Transmitter Module Components (Cont'd).

Location	Style	Description	Group
CHOKES			
L1	9646A07H31	33.0 µH	01
L2	9646A07H31	33.0 µH	01
L3	9646A07H47	680.0 µH	01
L4	9646A07H47	680.0 µH	01
L5	9646A07H39	150.0 µH	01
DIGITAL ICS			
I9	9646A33H01	MC14052BCP DUAL 4-CHAN ANALOG MUX	01
EPROMS			
I1	1500B04G01	ELECTRICALLY PROGRAMMABLE READ-ONLY MEMORY	01
I2	1500B04G02	ELECTRICALLY PROGRAMMABLE READ- ONLY MEMORY	01
INT CKTS			
I3	1500B03G01	ELECTRICALLY PROGRAMMABLE LOGIC DEVICE	01
I4	9651A22H01	STEL 1174 NCO (44PIN)	01
I5	9651A19H01	AD568 D/A CONVERTER	01
I6	9651A18H01	74HCU04N HEX UNBUF F INV	01
I7	9651A16H01	MC1494L	01
LINEAR ICS			
I10	6277D61H10	MC1741U SINGLE OP-AMP	01
I11	9646A35H01	NE592N WIDEBAND VIDEO AMP	01
I12	9648A02H05	MC78L15ACP POS VOLTREG 15 V 5% 0.1 A	01
I13	9648A82H03	MC79L15ACP NEG VOLTREG 15 V 5% 0.1 A	01
I8	9651A15H01	MC78M05CT	01
POTENTIOMETERS			
R11	3534A25H04	1K 25T TOP ADJ.	01
R12	3534A25H07	10K 25T TOP ADJ	01
R13	3534A25H07	10K 25T TOP ADJ	01
R14	3534A25H07	10K 25T TOP ADJ	01
R29	3502A17H08	500-OHM .5 W 1 TURN CERMET TOP ADJ.	01
RESISTOR NETWORKS			
RN1	3533A81H01	4 COMM TERML 10 KILOHMS 2% SIP	01
RN2	3533A81H01	4 COMM TERML 10 KILOHMS 2% SIP	01
RN3	3533A81H01	4 COMM TERML 10 KILOHMS 2% SIP	01
RN4	3533A81H01	4 COMM TERML 10 KILOHMS 2% SIP	01
RN5	3533A81H01	4 COMM TERML 10 KILOHMS 2% SIP	01

(Continued on next page.)

Table 11–2. Transmitter Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS			
R1	RM825AFQB4	82.5 OHMS 1% 0.25 W METAL FILM	01
R10	RM3241FQB0	3.24 KILOHMS 1% 0.25 W METAL FILM	01
R15	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01
R16	RM6981FQB0	6.98 KILOHMS 1% 0.25 W METAL FILM	01
R17	RM4992FQA9	49.9 KILOHMS 1% 0.25 W METAL FILM	01
R18	RM1212FQA9	12.1 KILOHMS 1% 0.25 W METAL FILM	01
R19	RM1212FQA9	12.1 KILOHMS 1% 0.25 W METAL FILM	01
R2	RM9090FQB1	909 OHMS 1% 0.25 W METAL FILM	01
R20	RM1101FQB0	1.10 KILOHMS 1% 0.25 W METAL FILM	01
R21	RW910AJ5G0	91 OHM 5 W 5% WIRE WOUND	01
R22	RW2000J5G0	200 OHMS 5% 5 W WIREWOUND	01
R23	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01
R24	RM2322FQA9	23.2 KILOHMS 1% 0.25 W METAL FILM	01
R25	RM2322FQA9	23.2 KILOHMS 1% 0.25 W METAL FILM	01
R26	RM2322FQA9	23.2 KILOHMS 1% 0.25 W METAL FILM	01
R27	RC510AJ269	51 OHMS 5% 2 W CARBON COMP	01
R28	RC510AJ269	51 OHMS 5% 2 W CARBON COMP	01
R3	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01
R30	RM4120FQB1	412 OHMS 1% 0.25 W METAL FILM	01
R31	RM1212FQA9	12.1 KILOHMS 1% 0.25 W METAL FILM	01
R32	RM1212FQA9	12.1 KILOHMS 1% 0.25 W METAL FILM	01
R33	RM4752FQA9	47.5 KILOHMS 1% 0.25 W METAL FILM	01
R34	RM4753FQ98	475 KILOHMS 1% 0.25 W METAL FILM	01
R4	RB1005JQB3	10 MEGOHMS 5% 0.25 W CARBON FILM	01
R5	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	01
R6	RM1622FQA9	16.2 KILOHMS 1% 0.25 W METAL FILM	01
R7	RM6191FQB0	6.19 KILOHMS 1% 0.25 W METAL FILM	01
R8	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	01
R9	RM1001FQB0	1.00 KILOHMS 1% 0.25 W METAL FILM	01
CRYSTAL			
Y1	9651A68H01	3.27680 MHz HC18/U 10PPM	01
SWITCHES			
SW1	3533A83H03	THUMBWHEEL BCD 5 POS.	01
SW2	3533A83H02	THUMBWHEEL BCD 10 POS.	01
SW3	3533A83H02	THUMBWHEEL BCD 10 POS.	01
SW4	3533A83H02	THUMBWHEEL BCD 10 POS.	01
SW5	775B517H04	4 POS DIP	01
TRANSFORMERS			
T1	1487B55H01	660-OHM: 75-OHM INTERSTAGE W.B.	01

Table 11–2. Transmitter Module Components (Cont'd).

Location	Style	Description	Group
TRANSISTORS			
Q1	3509A35H12	2N5210 50 V 0.05 A 1.0 W NPN	01
TRIMMERS			
C19	879A834H01	5.5-18 pF TRIMMER	01
ZENERS			
D1	849A515H13	1N4734A 5.6 V 5% 0.4 W	01
D2	837A398H03	1N750A 4.7 V 5% 0.4 W	01
D3	837A398H03	1N750A 4.7 V 5% 0.4 W	01
D4	837A398H03	1N750A 4.7 V 5% 0.4 W	01
D5	837A398H03	1N750A 4.7 V 5% 0.4 W	01
D6	837A398H03	1N750A 4.7 V 5% 0.4 W	01

(Continued on next page.)

USER NOTES

Chapter 12. 10W PA Module

Schematic	1606C33-20
Part List	1606C33-20

Table 12–1. 1606C33 Styles and Descriptions.

Group	Description
G01	WITH POWER ON RELAY
G02	WITHOUT POWER ON RELAY

12.1 10W PA Module Description

The function of the TC-10B/TCF-10B 10 W PA Module is to amplify a 0 dBm (1 mW) input to an output power level of 10 W. You may also adjust the 10W PA for input power levels from 0.5 mW to 2 mW.

The 10W PA Module operates in a 30 to 535 kHz range without tuning. The amplifier has a fixed gain of approximately 49 dB (class A, complementary symmetry push-pull stage). Negative feedback is used to derive a nominal output impedance of 50 ohms.

12.1.1 10W PA Control Panel

(This panel is shown in Figure 1–1.)

Operator controls are as Described below.

Potentiometer (R53) INPUT LEVEL SET

Adjusts power output level to 10 W with 1 mW input.

LED, TRANSMIT, RF Power Indication, Red (D6)

Test Jacks

- INPUT (TJ1)
- COMMON (TJ2)

Optional relay alarm for RF voltage

12.1.2 10W PA PC Board

(The 10W PA PC Board is shown in Figure 12-1.)

Operator controls consist of a Jumper (JU1) for the Alarm Relay (NO/NC), which indicates loss of power condition (less than 1 W).

12.2 10W PA Circuit Description

The function of the 10W PA Module (see Figure 12-2, Schematic 1606C33S) is to amplify a 0 dBm (1 mW) input to an output power level of 10 W. The input from pins C28/A28 passes thru a 700 kHz low pass filter (LPF) consisting of L1 and C1. Potentiometer (R53), labeled “INPUT LEVEL SET” on the front panel, is used to adjust the power level to 10 W output with 1 mW applied at the input.

The 10W PA Module operates in a 30 to 535 kHz range without tuning. The amplifier has a maximum gain of approximately 49 dB (class A, complementary symmetry push-pull stage). Negative feedback is used to derive a nominal output impedance of 50 ohms.

All bypassing is done to common (pins A30/C30, A32/C32). Transistors QN1, QN2 and QN3 are 14 pin DIPs, each containing four individual transistors; QN1 is PNP, while QN2 and QN3 are NPN.

The LPF output drives the amplifier QN1 and QN2. QN1A/QN1B and QN2A/QN2B are configured as a differential amplifier, while QN1C and QN2C are constant current sources. The input signal is applied to the bases of QN1A and QN2A. Negative feedback is applied to the bases of QN1B and QN2B. At the positive side (QN2), the differential output from QN2A and QN2B is amplified by QN2D and Q2. At the negative side (QN1), the differential output from QN1A and QN1B is amplified by QN1D and Q1. The positive side power output transistor (Q6) is driven by Q5; the negative side power output transistor (Q7) is driven by Q4.

The no-load feedback is from transformer (T1) back thru the RC network of R21, C7, C2, C5 and R18 to the junction of R16 and R17, for the purpose of stability. The loaded feedback is derived from a sampling resistor (R33, R35, R36, R37, R38, and R39, all in parallel) and fed back thru C28, C29 and R23. The overall no-load voltage gain is approximately 282. The overall loaded voltage gain is approximately 141. The partial loaded gain, between C28/A28 and the primary of T1, is approximately 38.

The alarm circuit (loss of RF signal condition) consists of QN3, Q8, K1 and associated components. The RF signal is monitored by C22, at T1 pin 1. The signal sample is amplified in QN3A and fed to QN3B and QN3C (QN3B and QN3C are configured as diodes). A voltage doubler is formed from C30, QN3C and QN3B. The output of QN3B drives QN3D, via R44 and R45. QN3D is saturated for an input of 1 W to C22 (with reference to T1 secondary). As QN3D saturates, Q8 conducts, driving the front panel LED (D6, power monitor), causing K1 to energize (or de-energize), indicating loss of signal condition. Jumper JU1 allows the selection of an open circuit or a closed circuit for the loss of signal condition.

The +20 Vdc line (leading to the alarm circuit, etc.) is filtered by C10, C11, L2, L4, C19, C20 and C21. The -20 Vdc (leading to C2/C4) is filtered by C12, C13, L3, C16, C17, C18 and L5.

12.3 10W PA TROUBLESHOOTING

To check individual transistors, e.g., Q1 thru Q8, QN1, QN2 and QN3, remove them first from the PC Board. Ohmmeter measurements of the transistors while in the PC Board are misleading because of other paths on the board.

You may remove the heat sink by unscrewing the four (4) corner screws and the hold-down screws for Q1 thru Q8. The 10W PA Module can operate at no-load conditions without the heat sink for short periods of time while you are troubleshooting.

CAUTION

THE 10W PA IS, BASICALLY, AN OP-AMP PROVIDING VERY HIGH GAIN WITH NEGATIVE FEEDBACK. TRANSISTORS Q1 THROUGH Q5, Q6, AND Q7 ARE THERMALLY CONNECTED, I.E., THEY ARE MOUNTED ON THE SAME PART OF THE HEAT SINK. ANY FAILING TRANSIS-TOR MAY AFFECT OTHER TRANSISTORS. CHECK EACH TRANSISTOR SEPARATELY. IF NO FAULTS ARE FOUND, CHECK OTHER COMPONENTS.

BE CAREFUL NOT TO MISPLACE SCREWS, SPRING WASHER OR INSULATING WASHER USED TO MOUNT Q1 THROUGH Q8. DAMAGED SCREWS OR INSULATORS SHOULD NOT BE USED.

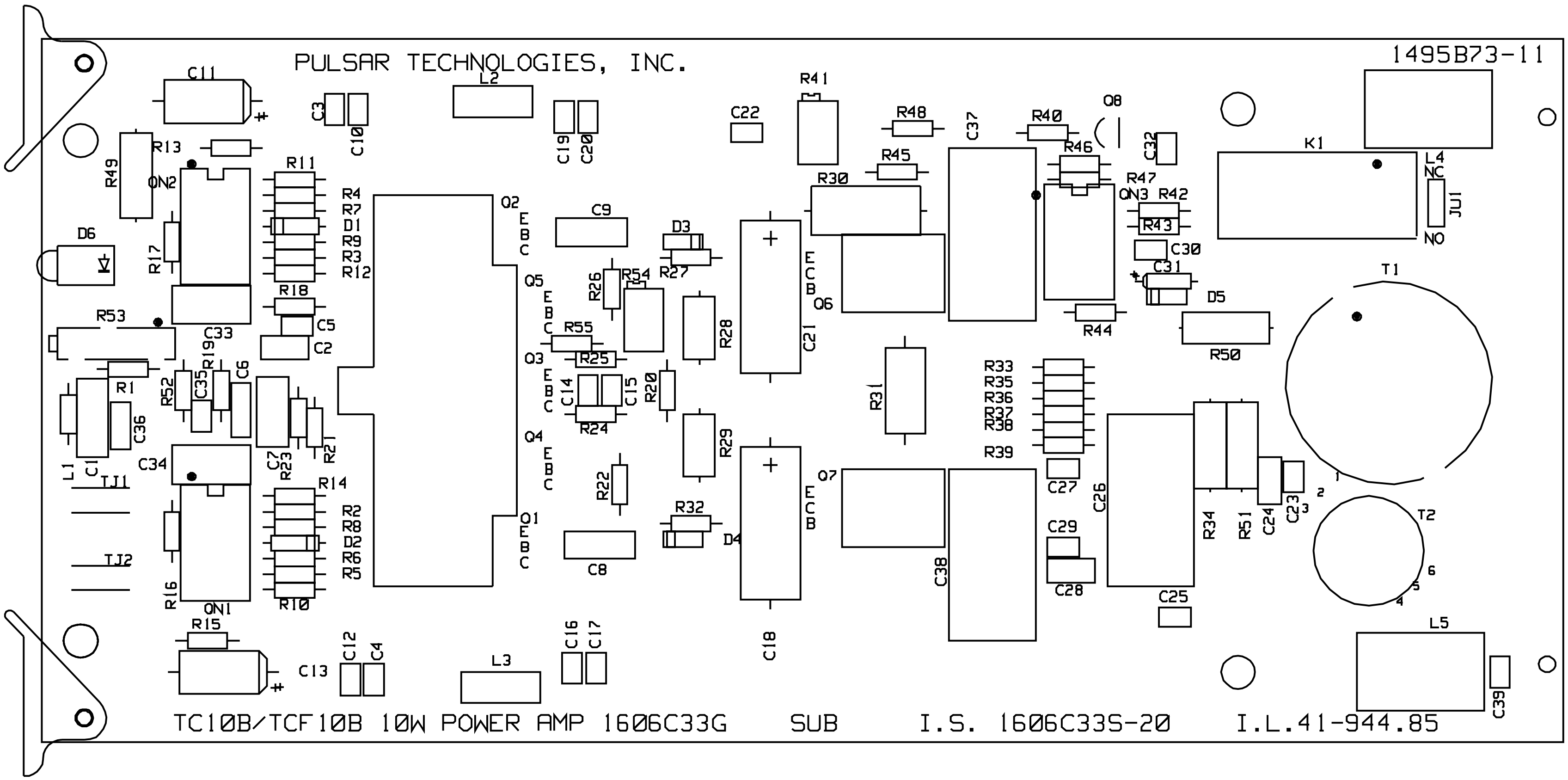

Figure 12–1. TC-10B/TCF-10B 10W PA PC Board (1495B73; Sheet 5 of 7).

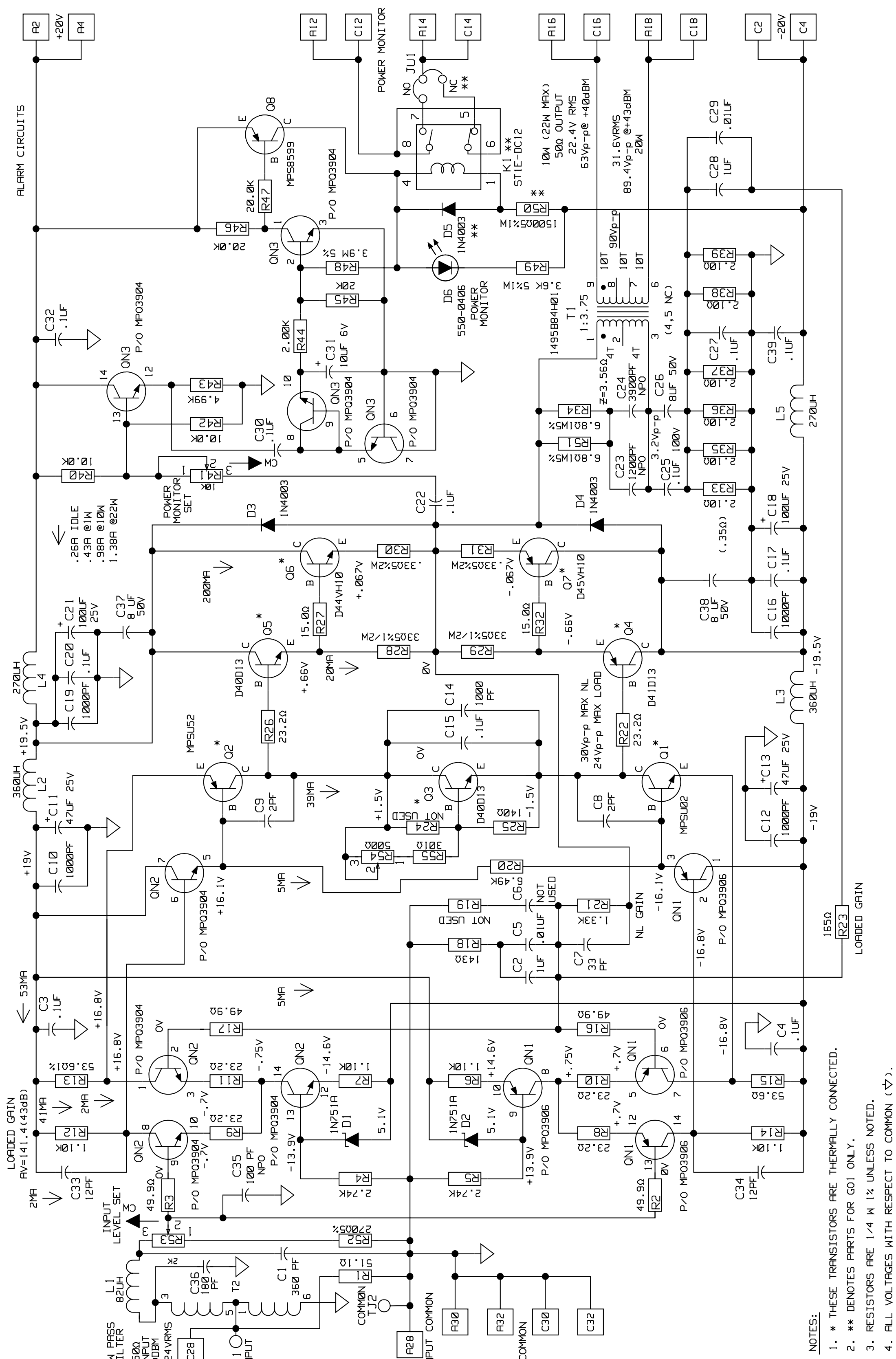

Figure 12–2. 10W PA Schematic (1606C33).

Table 12–2. 10W Power Amplifier Components (1606C33).

Location	Style	Description	Group
CAPACITORS			
C01	CR3900GV91	390 pF 2% 500 V DIPPED MICA	01,02
C02	CP1004MH54	1.0 µF 20% 50 V MONO CERAMIC	01,02
C03	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C04	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C05	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01,02
C07	CR330AGV92	33 pF 2% 500 V DIPPED MICA	01,02
C08	CR200BDV67	2 pF +/-0.5pF 500 V DIPPED MICA	01,02
C09	CR200BDV67	2 pF +/-0.5pF 500 V DIPPED MICA	01,02
C10	CP1001GH65	1,000 pF 2% 50 V C0G MONO CERAMIC	01,02
C11	CJ4705ME72	47 µF 20% 25 V MOLDED TANTALUM	01,02
C12	CP1001GH65	1,000 pF 2% 50 V C0G MONO CERAMIC	01,02
C13	CJ4705ME72	47 µF 20% 25 V MOLDED TANTALUM	01,02
C14	CP1001GH65	1,000 pF 2% 50 V C0G MONO CERAMIC	01,02
C15	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C16	CP1001GH65	1,000 pF 2% 50 V C0G MONO CERAMIC	01,02
C17	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C18	CA10063E12	100 µF +75-10% 25 V ALUMINUM	01,02
C19	CP1001GH65	1,000 pF 2% 50 V C0G MONO CERAMIC	01,02
C20	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C21	CA10063E12	100 µF +75-10% 25 V ALUMINUM	01,02
C22	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C23	CP1201GL65	1,200 pF 2% 100 V C0G MONO CERAMIC	01,02
C24	CP3901GH65	3,900 pF 2% 50 V C0G MONO CERAMIC	01,02
C25	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C26	CE8004JH64	8.0 µF 5% 50 V MET POLYCARBONATE	01,02
C27	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C28	CP1004MH54	1.0 µF 20% 50 V MONO CERAMIC	01,02
C29	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01,02
C30	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C31	CJ1005MA72	10 µF 20% 6 V MOLDED TANTALUM	01,02
C32	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02
C33	CR120AJV67	12 pF 5% 500 V DIPPED MICA	01,02
C34	CR120AJV67	12 pF 5% 500 V DIPPED MICA	01,02
C35	CP1000KH65	100 pF 10% 50 V X7R MONO CERAMIC	01,02
C36	CR3900JH67	390 pF 5% 50 V DIPPED MICA	01,02
C37	CE8004JH64	8.0 µF 5% 50 V MET POLYCARBONATE	01,02
C38	CE8004JH64	8.0 µF 5% 50 V MET POLYCARBONATE	01,02
C39	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02

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(Continued on next page.)

Table 12–2. 10W Power Amplifier Components (Cont'd).

Location	Style	Description	Group
CHOKES			
L01	9646A07H41	220.0 µH	01,02
L04	3532A37H01	3443-58 270 µH .33 OHM 10%	01,02
L05	3532A37H01	3443-58 270 µH .33 OHM 10%	01,02
CONNECTORS			
JU1	9640A47H01	3 POSITION	01
DIODES			
D03	836A928H08	1N4007 1000 V 1 A	01,02
D04	836A928H08	1N4007 1000 V 1 A	01,02
D05	836A928H08	1N4007 1000 V 1 A	01,02
INDUCTORS			
L02	3537A46H34	360 µH	01,02
L03	3537A46H34	360 µH	01,02
LINEAR ICs			
QN1	3533A63H01	MPQ3906 QUAD PNP ARRAY 40 V 0.2 A	01,02
QN2	3533A64H01	MPQ3904 QUAD NPN ARRAY 40 V 0.2 A	01,02
QN3	3533A64H01	MPQ3904 QUAD NPN ARRAY 40 V 0.2 A	01,02
LEDs			
D06	3508A22H01	RED LED (EDGE MOUNT) 550-0406	01,02
POTENTIOMETERS			
R41	3536A55H05	50 K 10%	01,02
R53	3535A32H04	2 K OHM 10%	01,02
R54	3536A55H06	500 OHM 10%	01
RELAYS			
K01	1484B33H01	AROMAT TYPE ST1E-DC 12 V	01
RESISTORS			
R01	RM1241FQB0	1.24 KILOHMS 1% 0.25 W METAL FILM	01,02
R02	RM499AFQB4	49.9 OHMS 1% 0.25 W METAL FILM	01,02
R03	RM499AFQB4	49.9 OHMS 1% 0.25 W METAL FILM	01,02
R04	RM2741FQB0	2.74 KILOHMS 1% 0.25 W METAL FILM	01,02
R05	RM2741FQB0	2.74 KILOHMS 1% 0.25 W METAL FILM	01,02
R06	RM1101FQB0	1.10 KILOHMS 1% 0.25 W METAL FILM	01,02
R07	RM1101FQB0	1.10 KILOHMS 1% 0.25 W METAL FILM	01,02
R08	RM232AFQB4	23.2 OHMS 1% 0.25 W METAL FILM	01,02
R09	RM232AFQB4	23.2 OHMS 1% 0.25 W METAL FILM	01,02
R10	RM232AFQB4	23.2 OHMS 1% 0.25 W METAL FILM	01,02
R11	RM232AFQB4	23.2 OHMS 1% 0.25 W METAL FILM	01,02

Table 12–2. 10W Power Amplifier Components (Cont'd).

Location	Style	Description	Group
RESISTORS (Cont'd)			
R12	RM1101FQB0	1.10 KILOHMS 1% 0.25 W METAL FILM	01,02
R13	RM536AFQB4	53.6 OHMS 1% 0.25 W METAL FILM	01,02
R14	RM1101FQB0	1.10 KILOHMS 1% 0.25 W METAL FILM	01,02
R15	RM536AFQB4	53.6 OHMS 1% 0.25 W METAL FILM	01,02
R16	RM499AFQB4	49.9 OHMS 1% 0.25 W METAL FILM	01,02
R17	RM499AFQB4	49.9 OHMS 1% 0.25 W METAL FILM	01,02
R18	RM1430FQB1	143 OHMS 1% 0.25 W METAL FILM	01,02
R20	RM6491FQB0	6.49 KILOHMS 1% 0.25 W METAL FILM	01,02
R21	RM1331FQB0	1.33 KILOHMS 1% 0.25 W METAL FILM	01,02
R22	RM232AFQB4	23.2 OHMS 1% 0.25 W METAL FILM	01,02
R23	RM1650FQB1	165 OHMS 1% 0.25 W METAL FILM	01,02
R25	RM1400FQB1	140 OHMS 1% 0.25 W METAL FILM	01,02
R26	RM232AFQB4	23.2 OHMS 1% 0.25 W METAL FILM	01,02
R27	RM150AFQB4	15.0 OHMS 1% 0.25 W METAL FILM	01,02
R28	RC330AJH59	33 OHMS 5% 0.5 W CARBON COMP	01,02
R29	RC330AJH59	33 OHMS 5% 0.5 W CARBON COMP	01,02
R30	RW330CJ2A5	0.33 OHMS 5% 2 W WIREWOUND	01,02
R31	RW330CJ2A5	0.33 OHMS 5% 2 W WIREWOUND	01,02
R32	RM150AFQB4	15.0 OHMS 1% 0.25 W METAL FILM	01,02
R33	RM210BFQB7	2.10 OHMS 1% 0.25 W METAL FILM	01,02
R34	RC680BJ1E3	6.8 OHMS 5% 1 W CARBON COMP	01,02
R35	RM210BFQB7	2.10 OHMS 1% 0.25 W METAL FILM	01,02
R36	RM210BFQB7	2.10 OHMS 1% 0.25 W METAL FILM	01,02
R37	RM210BFQB7	2.10 OHMS 1% 0.25 W METAL FILM	01,02
R38	RM210BFQB7	2.10 OHMS 1% 0.25 W METAL FILM	01,02
R39	RM210BFQB7	2.10 OHMS 1% 0.25 W METAL FILM	01,02
R40	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R42	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R43	RM4991FQB0	4.99 KILOHMS 1% 0.25 W METAL FILM	01,02
R44	RM2001FQB0	2.00 KILOHMS 1% 0.25 W METAL FILM	01,02
R45	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R46	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R47	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02
R48	RB3904JQB3	3.9 MEGOHMS 5% 0.25 W CARBON FILM	01,02
R49	RC3601J167	3.6 KILOHMS 5% 1 W CARBON COMP	01,02
R50	RC1501J167	1.5 KILOHMS 5% 1 W CARBON COMP	01
R51	RC680BJ1E3	6.8 OHMS 5% 1 W CARBON COMP	01,02
R52	RB2700JQB2	270 OHMS 5% 0.25 W CARBON FILM	01,02
R55	RM3010FQB1	301 OHMS 1% 0.25 W METAL FILM	01,02

(Continued on next page.)

Table 12–2. 10W Power Amplifier Components (Cont'd).

Location	Style	Description	Group
TIP JACKS			
TJ1	3532A53H09	BLUE	01,02
TJ2	3532A53H03	BLACK PC MOUNT	01,02
TRANSFORMERS			
T01	1495B84G01	1:3.75 OUTPUT	01,02
T02	1498B24G01	1:3 INPUTS	01,02
TRANSISTORS			
Q01	3533A59H01	MPSUO2 40 V 0.8 A 1 W NPN	01,02
Q02	3533A60H01	MPSU52 40 V 1.5 A 1 W PNP	01,02
Q03	3532A45H01	D40D13 75 V 1.0 A 6.2 W NPN	01,02
Q04	3532A45H02	D41D13 75 V 1 A 6.2 W PNP	01,02
Q05	3532A45H01	D40D13 75 V 1.0 A 6.2 W NPN	01,02
Q06	3532A45H19	D44VH10 80 V 15 A 83 W NPN	01,02
Q07	3532A45H20	D45VH10 80 V 15 A 83 W PNP	01,02
Q08	3509A35H09	MPS8599 80 V 0.5 A 0.35 W PNP	01,02
ZENERS			
D01	862A606H06	1N751A 5.1 V 5% 0.4 W	01,02
D02	862A606H06	1N751A 5.1 V 5% 0.4 W	01,02

Chapter 13. RF Interface Module

Schematic	1609C32-8
Parts List	1609C32-8

13.1 RF Interface Module Description

The RF Interface Module, used with the TC–10B/TCF–10B, has several functions:

- Receives RF input from 10W PA Module.
- Matches output impedance at 50, 75, or 100 ohms.
- Low-pass filter covers RF spectrum up to 550 kHz.
- Permits 2- or 4-wire operation.
- Protects against line surges with a gas tube device.

13.1.1 RF Interface Control Panel

(This panel is shown in Figure 1-1.)

Operator controls consist of Test Jacks:

TJ1	Line In
TJ2	Line Common
TJ3	Receiver In
TJ4	Receiver Common

13.1.2 RF Interface PC Board

(The RF Interface PC Board is shown in Figure 13-1.)

Operator controls are as follows:

Matching Impedance Jumpers

JU4	50 ohms
JU3	75 ohms
JU2	100 ohms

2-wire or 4-wire RF Termination

JU1/JU5	"IN"	2-wire
JU1/JU5	"OUT"	4-wire

Attenuator Override Jumper (JU6)

NORM Sensitivity	70 Vrms at 5,000 ohms
HIGH Sensitivity	17 Vrms at 1,000 ohms

13.2 RF Interface Circuit Description

This module receives RF input from the 10W PA Module at pins A16/C16 and A18/C18, and feeds the power through a balanced low-pass filter with a 550 kHz cutoff (L3, L4, L1, L2 and associated components). RF is fed through transformer T1, for matching 50 ohm (JU4), 75 ohm (JU3), or 100 ohm (JU2) resistance to the RF line output (45 Vrms maximum) at pins 12A/12C and 10A/10C, which provide the two-wire UHF (J1) connection on the Rear Panel.

Four-Wire Receiver input is provided at pins 24 A/C and 22 A/C via the 4-wire BNC (J2) connector on the Rear Panel. Jumpers JU1 and JU5 simultaneously connect the four-wire Receiver input to RF line output:

- IN settings for 2-wire operation
- OUT settings for 4-wire operation

Isolation transformer T2, together with series resistor R1, forms an attenuator with 13 dB loss. Receiver input (at pins 28 A/C) is adjusted by jumper JU6:

- When in the NORM position, Receiver maximum input is 70 Vrms at 5,000 ohms
- When in the HIGH position, JU6 overrides the attenuator, providing lower input impedance (Receiver maximum input is 17 Vrms at 1,000 ohms).

13.3 RF Interface Troubleshooting

With the PC Board plugged into the chassis, you can monitor the voltage output to the RF line at TJ1 and TJ2. You can monitor receiver input at TJ3 and TJ4.

Should a fault occur in the RF Interface Module, you can remove the PC board and check the components by conventional means.

13.3.1 Capacitors

Remove from the circuit with jumpers JU2, JU3 and JU4 and check for shorts, dissipation factor, and capacitance. (Perform checks using a signal of 10 kHz or higher.)

13.3.2 Inductors

Check with an ohmmeter.

13.3.3 Transformers

Check for open circuits.

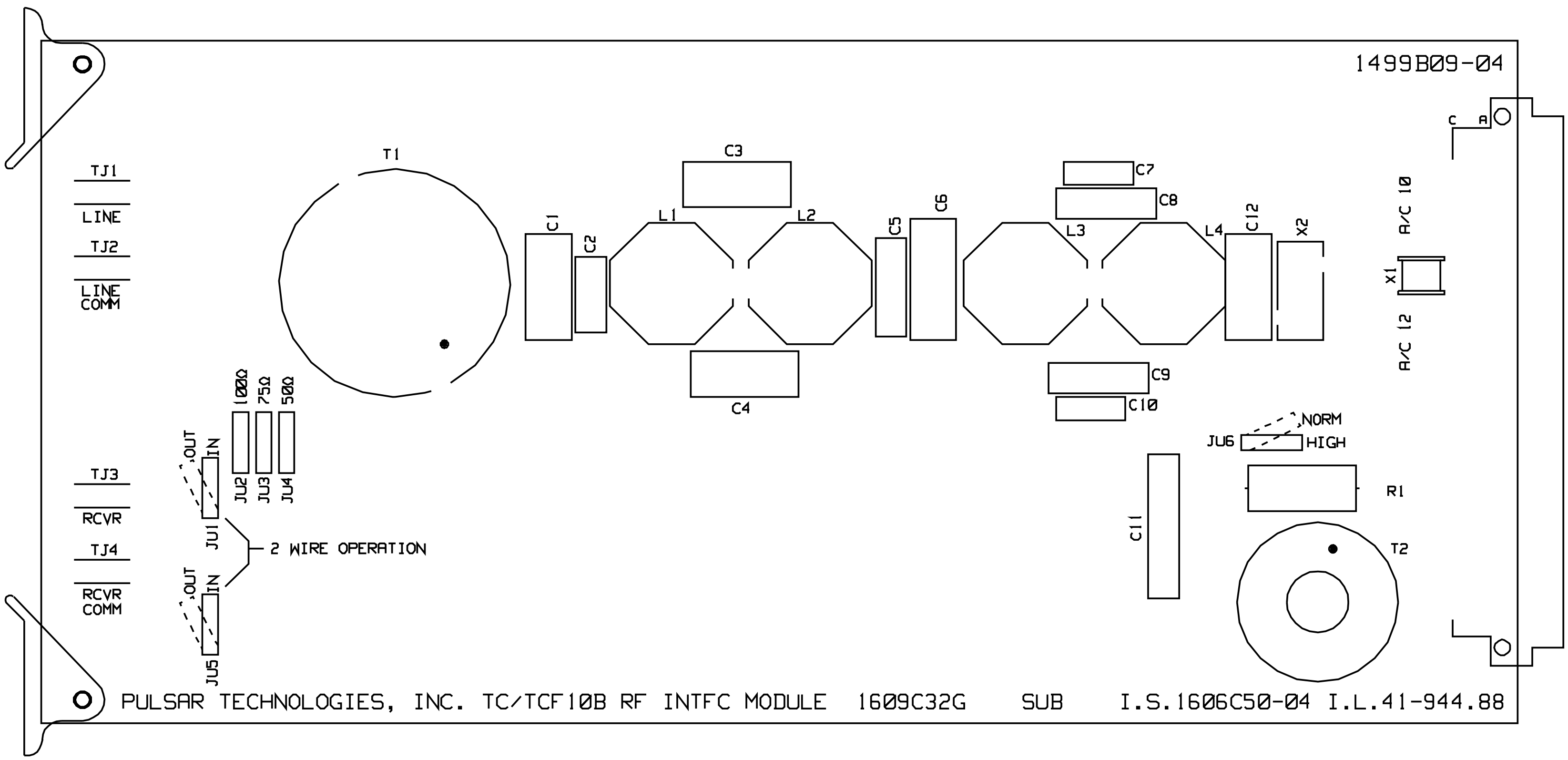

Figure 13–1. TC–10B/TCF–10B RF Interface PC Board (1609C32; Sheet 3 of 3).

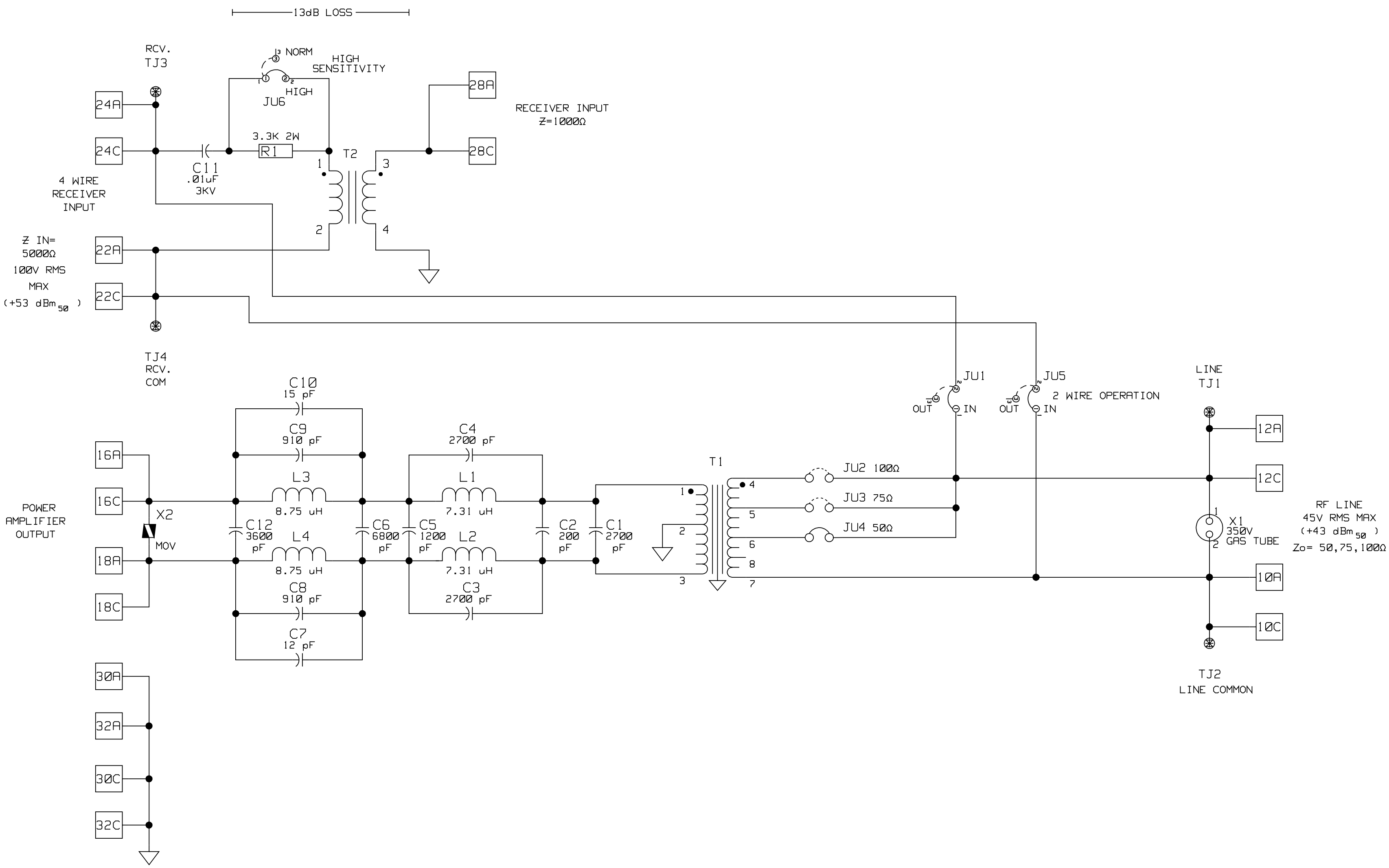

Figure 13–2. TC–10B/TCF–10B RF Interface Schematic (1609C32; Sheet 1 of 3).

Table 13–1. RF Interface Module Components (1609C32).

Location	Style	Description	Group
CAPACITORS			
C1	CR2701GVA6	2700 pF 2% 500 V DIPPED MICA	01
C2	CR2000GV91	200 pF 2% 500 V DIPPED MICA	01
C3	CR2701GVA6	2,700 pF 2% 500 V DIPPED MICA	01
C4	CR2701GVA6	2,700 pF 2% 500 V DIPPED MICA	01
C5	CR1201GVA6	1,200 pF 2% 500 V DIPPED MICA	01
C6	CR6801GV91	6,800 pF 2% 500 V DIPPED MICA	01
C7	CR120AJV67	12 pF 5% 500 V DIPPED MICA	01
C8	CR9100GVA6	910 pF 2% 500 V DIPPED MICA	01
C9	CR9100GVA6	910 pF 2% 500 V DIPPED MICA	01
C10	CR150AJV17	15 pF 5% 500 V DIPPED MICA	01
C11	CQ1002M380	.01 µF 20% 3,000 V Z5U CERAMIC DISC	01
C12	CR3601GVA6	3,600 pF 2% 500 V DIPPED MICA	01
INDUCTORS			
L1	1602C75G09	HYBRID FILTER 7.31 µH	01
L2	1602C75G09	HYBRID FILTER 7.31 µH	01
L3	1602C75G10	HYBRID FILTER 8.75 µH	01
L4	1602C75G10	HYBRID FILTER 8.75 µH	01
JUMPERS			
JU1	3532A54H02	PLUG IN	01
JU2	3532A54H02	PLUG IN	01
JU3	3532A54H02	PLUG IN	01
JU4	3532A54H02	PLUG IN	01
JU5	3532A54H02	PLUG IN	01
JU6	3532A54H02	PLUG IN	01
RESISTORS			
R1	RC3901J249	3.3 KILOHMS 5% 2 W CARBON COMP	01
SURGE PROTECTORS			
X1	3532A90H01	350 V GASTUBE TO8-350B	01
TIP JACKS			
TJ1	3532A53H03	BLACK PC MOUNT	01
TJ2	3532A53H03	BLACK PC MOUNT	01
TJ3	3532A53H03	BLACK PC MOUNT	01
TJ4	3532A53H03	BLACK PC MOUNT	01
TRANSFORMERS			
T1	1493B54G01	RECEIVE	01
T2	714B677G02	1:1 10 K INTERSTAGE	01
VARISTORS			
X2	3509A31H09	V68ZA10	01

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USER NOTES

Chapter 14. Receiver Module & Synthesizer Module

Schematic	1606C32-21
Parts List	1606C32-21

Table 14–1. 1606C32 Styles and Descriptions.

Group	TCF-10B	TC-10B
G01 (1,200 Hz)	Extra Wide Band	Wide Band
G02 (600 Hz)	Medium/ Wide Band	Narrow Band
G03 (300 Hz)	Narrow Band	—

14.1 Receiver Module Description

The TC–10B/TCF–10B Receiver Module passes the RF signal (from the RF Interface Module) through a low-pass filter and attenuator to the first mixer, whose injection is supplied by the frequency synthesizer. The output of the first mixer, at 5.02 MHz, is fed through the first amplifier to a crystal bandpass filter that provides most of the receiver selectivity. The IF signal, after passing through the second and third amplifiers, is mixed (at the second mixer) with the 5 MHz reference from the crystal oscillator, is filtered (bandpass filter) and buffered, providing a 20 kHz output.

The TC–10B has two Receiver bands; the TCF–10B has three Receiver bands for a variety of applications, as shown in Table 14-1 (see the Schematic, Figure 14-3 and Figure 14-4, and Parts List for further detail).

14.1.1 Receiver Control Panel

(This panel is shown in Figure 1-1.)

Operator controls are as follows:

Thumbwheel switches

The Receiver Control Panel's thumbwheel switches have indicator windows showing a frequency range.

Potentiometer

The potentiometer (R3), LEVEL ADJUST attenuator adjusts receiver input (receiver margin sensitivity).

Test Jacks

TJ2	RCV blue
TJ1	INPUT yellow
TJ3	COM green

14.1.2 Receiver PC Board

(The Receiver PC Board is shown in Figure 14-2.)

Operator controls are as follows:

Jumper: JU1 - Disable/Norm

"Disable" allows the Receiver to be turned "OFF" when the Transmitter is keyed. "Norm" has no effect. This jumper is no longer used.

> **CAUTION**
>
> ***SOME TC–10B USERS HAVE INADVERTENTLY PLACED JU1 (ON THE RECEIVER MODULE) IN THE "DISABLE" POSITION, WHEN IT SHOULD HAVE BEEN IN "NORMAL." IF THE RELAY YOU ARE USING WITH THE TC–10B REQUIRES A RECEIVER OUTPUT DURING TRANSMIT, JU1 MUST BE IN "NORMAL."***

Variable Capacitors

C19 Tunes the first mixer injection filter.

C68 Sets the crystal oscillator to 5 MHz

Potentiometers

R67 Voice IF adjustment

R68 IF Gain Control

Test Points

TP1 5 MHz oscillator Reference

TP2 Injection Voltage

TP3 Injection Voltage

TP4 5.02 IF Output from 2nd Mixer

TP5 20 kHz Output

14.2 Receiver Circuit Description

The Receiver Module (see Figure 14-3 and Figure 14-4, Schematic 1606C32S) passes the RF signal (from the RF Interface Module) through a low-pass filter and attenuator to the first mixer, whose injection is supplied by the frequency synthesizer. The output of the first mixer, at 5.02 MHz, is fed through the first amplifier to a crystal bandpass filter that provides most of the receiver selectivity. The IF signal, after passing through the second and third amplifiers, is mixed (at the second mixer) with the 5 MHz reference from the crystal oscillator, is filtered (bandpass filter) and buffered, providing a 20 kHz output.

The RF input of 30 to 535 kHz is fed to connector pin C-28 with the return or common pins A/C-30 and 32. TJ1 and TJ2 are on the front panel for ease in measuring line input and receiver input levels. Zener diodes D1 and D2 provide overload protection for the receiver input circuit. Jumper JU1 allows the receiver to be disabled when transmitting, if desired.

The RF input is fed through a front panel level adjust attenuator (R3) and through a low pass filter to the mixer (I_3). The combination of R4, R5 and R6 provides an attenuator and serves to maintain a 50 ohm termination at the input of the low pass filter (L1, L2, C1, C2 and C3). This attenuator has a 7 dB loss. The attenuator formed by R7, R8 and R9 provides the proper termination for I_3 and also has a 7 dB loss. The low pass filter has a cut-off frequency of 600 kHz.

The synthesizer supplies the second input to the mixer (I_3); this input is always 5.02 MHz plus the channel frequency. (Selection of the receiver channel is done by the front panel thumbwheel switches.) The mixer injection voltage is supplied by the synthesizer to I_1 and I_2 and associated components. I_1 and I_2 are high frequency, low impedance drivers. A low pass filter (L8, L9, L10, L11, C18 and C19) removes harmonics of the injection frequency. R13 through R17 form a matching network for low pass filter termination and mixer matching.

The first mixer (I_3) is a high level type that can withstand large input levels without creating intermodulation products. The oscillator level, injected at pins 7 and 8 of the mixer, is +17 dBm (1.6 Vrms). The 5.02 MHz mixer output, on pins 1 and 2, is fed through a diplexer to the first IF Amplifier (Q1/Q2 and associated components). The diplexer provides 50 ohm termination to all frequencies, but only passes frequencies below 6 MHz. The first IF Amplifier is a high level, low distortion amplifier capable of delivering 100 milliwatts maximum into R24. The amplifier has approximately 14 dB of power gain. A matching attenuator network (R69, R70 and R71) establishes the proper driving impedance for filter FL1. This network has 6 dB loss.

Filter FL1 determines the bandwidth of the receiver. Extra Wide Band (approximately 1.2 kHz), Wide Band (approximately 600 Hz) and Narrow Band (approximately 300 Hz) are available. The stop band attenuation of the filter is greater than 60 dB. FL1 has about 3.5 dB loss. The output of the filter is fed to the 2nd IF amplifier (see Schematic sheet 2, Figure 14-4). A second path from the 1st IF Amplifier is fed to Q3 and Q4 and associated components, which form a buffer amplifier to provide an auxiliary output for the optional voice adapter. This output is brought to connector pins A/C-24. R67 is an adjustment for setting the voice output level.

The combination of I_4, I_5, T2 and associated components form the 5.02 MHz IF amplifier (sheet 2). Amplifier I_5 is resonated by L15 and C42; R68 adjusts the overall gain of the I_4-I_5 combination to present the proper level to the second mixer (I_6). I_4 and I_5 have a combined voltage gain of approximately 54 to 84 dB, depending on the setting of R68. Transformer (T2) has a 16 to 1 impedance ratio and matches the 50 ohm mixer input (pins 1 and 7) to the 800 ohm output of I_5 and R40. There is a voltage loss of 18 dB from I5 pins 7 and 8 to the input of the mixer.

The second mixer (I_6) has a 5.02 MHz input from the IF amplifier and a 5 MHz input from the crystal oscillator. The output from the second mixer, 20 kHz, is fed through a bandpass filter to the output on pin A-28. This mixer has a 5 MHz injection of +7 dBm (.5 Vrms) applied to I_6 pins 2 and 8. The 5.0 MHz reference crystal oscillator is adjusted to 5 MHz by C68, and consists of QN1 (A, B, C and D). Because the input is 5.02 MHz and the injection frequency is 5.00 MHz, the mixer output is 20.0 kHz plus other mixer products. An active bandpass filter is configured from the combination of I_7 and associated components. It is used to drive the receiver output, at connector pin A-28. This filter is tuned to a center frequency of 20 kHz with approximately 4 kHz bandwidth. The bandpass filter has 32 dB voltage gain.

On-board voltage regulation and reverse voltage protection is provided by D3, D4, D5, D6 and associated components. All functional circuit blocks operate from +18.6 and +3.6 or -18.6 and -3.6 to provide +15 Vdc for operation. The synthesizer uses both plus and minus 18.6 and 3.6. The synthesizer plugs onto the PC Board with J1, J2 and J3. You may remove it by unscrewing the three hold down screws and unplugging it.

RF filtering is provided by L6, L7, L12, L13, L18 and L19 (Sheet 1) and by R28, R30, R31 and R34 (Sheet 2) to prevent stray coupling from circuit to circuit. All RF bypassing is to common.

14.3 Receiver Troubleshooting

With the PC Board plugged into the chassis, you can check the following functions:

14.3.1 Input Signal

You can use the following three test points on the control panel to indicate if a signal is getting to the module:

TJ1 Line Input

TJ2 Mixer Input

TJ3 Common

Monitor between TJ1 and TJ3 with a selective Level voltmeter (or equivalent)

Proper input must be:

- (G01) 1,200 Hz bandwidth (> 15 mV rms)
- (G02) 600 Hz bandwidth, > 5 mV rms
- (G03) 300 Hz bandwidth, > 5 mV rms

For normal operation, this input signal should be ≥15 dB above the threshold level.

Monitor between TJ1 and TJ2

Proper input should be:

- (G01) 1,200 Hz bandwidth (72 μV rms)
- (G02) 600 Hz bandwidth (24 mV rms)
- (G03) 300 Hz bandwidth (24 mV rms)

You may adjust this level with the Level Adjust Attenuator (R3).

> **NOTE**
>
> **If the foregoing levels are correct, but the Receiver does not function, place the Receiver Module on an extender board.**

14.3.2 Output Signal

You can check the output signal (20 kHz) at TP5 or pin A-28. When the input threshold voltage is set per the paragraph "Monitor between TJ1 and TJ3 with a selective Level voltmeter (or equivalent)" above, The 20 kHz output should be 63 mV rms. If there is no voltage output at 20 kHz, you can perform the tests described below.

Synthesizer

The 5 MHz crystal oscillator level should be 560 mV rms at pin 12 of the PC Board connector (J1).

Injection

The injection voltage between TP2 and TP3 should be 3.5 Vp-p; the injection frequency should be 5.02 MHz plus the channel frequency. This differential input is measured from TP2 to TJ3 (common) and from TP3 to TJ3 (common). If the injection voltage is low or non-existent, you can remove the Synthesizer to determine if the problem is in the Synthesizer or I_1 and/or I_2.

When removing the Synthesizer, you must be careful to keep the hold-down screws captive. Unscrew the three Synthesizer hold-down screws partially and partially unplug the Synthesizer. Continue this procedure until the Synthesizer is completely unplugged. Do not remove any of the screws completely (about 8 turns should be enough).

You may apply a 5.02 MHz plus the channel frequency signal between Synthesizer connector (J3) pins 2 and 3 to check the operation of I_1, I_2, and the injection filter. Use the variable capacitor (C19) to adjust for maximum output at TP2/TP3.

The 5.02 MHz plus the channel frequency signal should consist of the following:

- Two 5 Vp-p square wave signals, 180 degrees out-of-phase (reference to ground),

or

- With the additional circuitry, as shown in Figure 14-1, one 10 Vp-p square wave signal may be used.

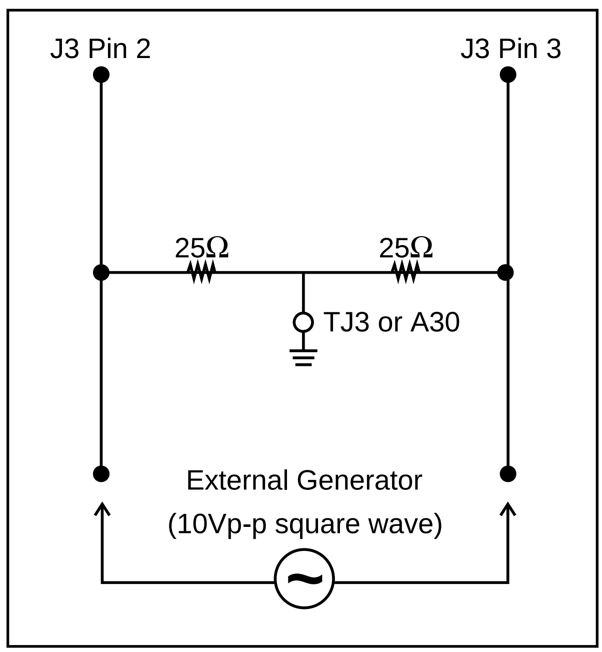

Figure 14–1. Additional Circuitry at Test Jack (TJ3).

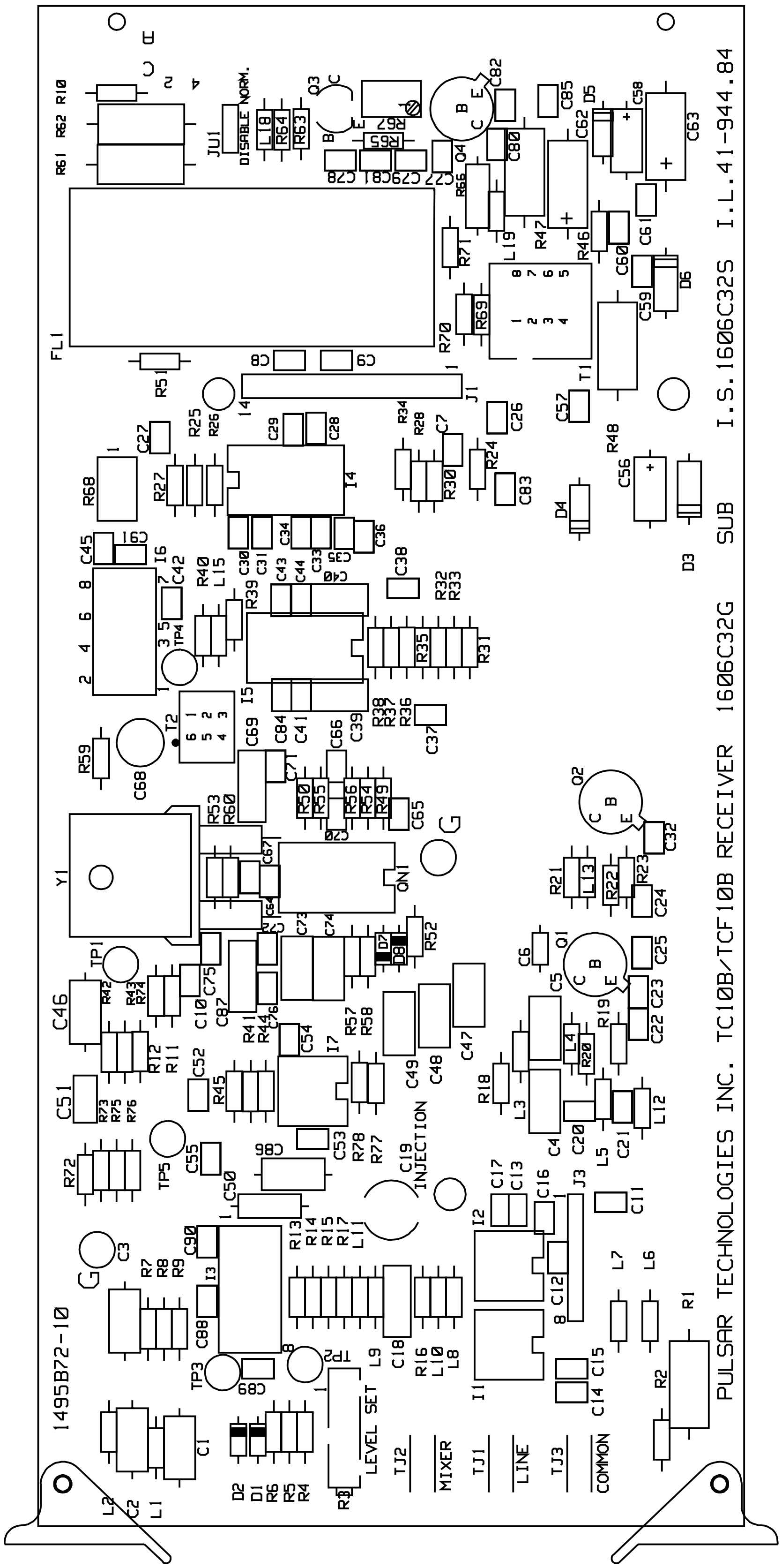

Figure 14–2. TC–10B/TCF–10B Receiver PC Board (1495B72; Sheet 8 of 8).

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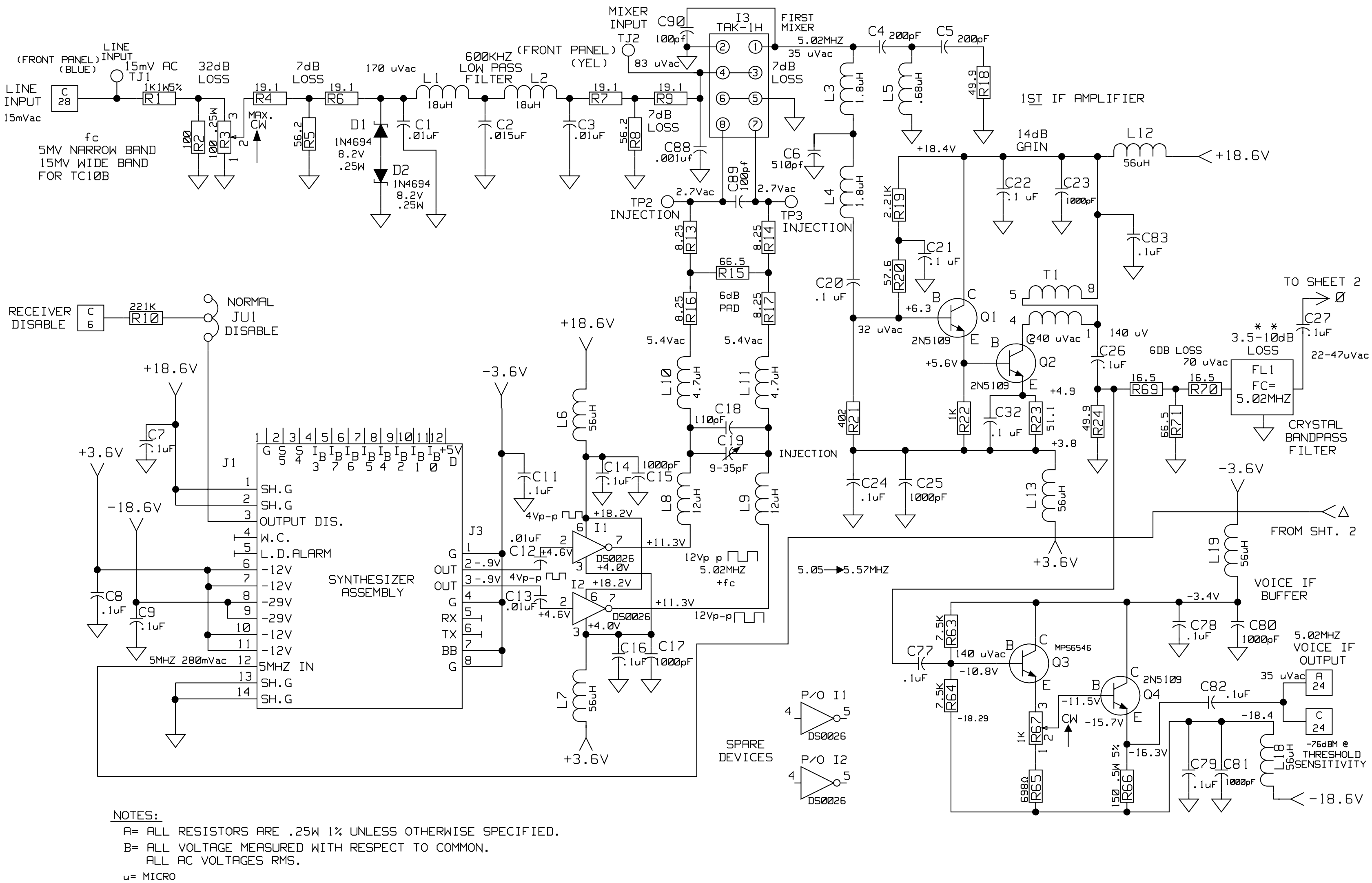


Figure 14–3. TC–10B/TCF–10B Receiver Schematic (1606C32; Sheet 4 of 5).

Pulsar Technologies, Inc.

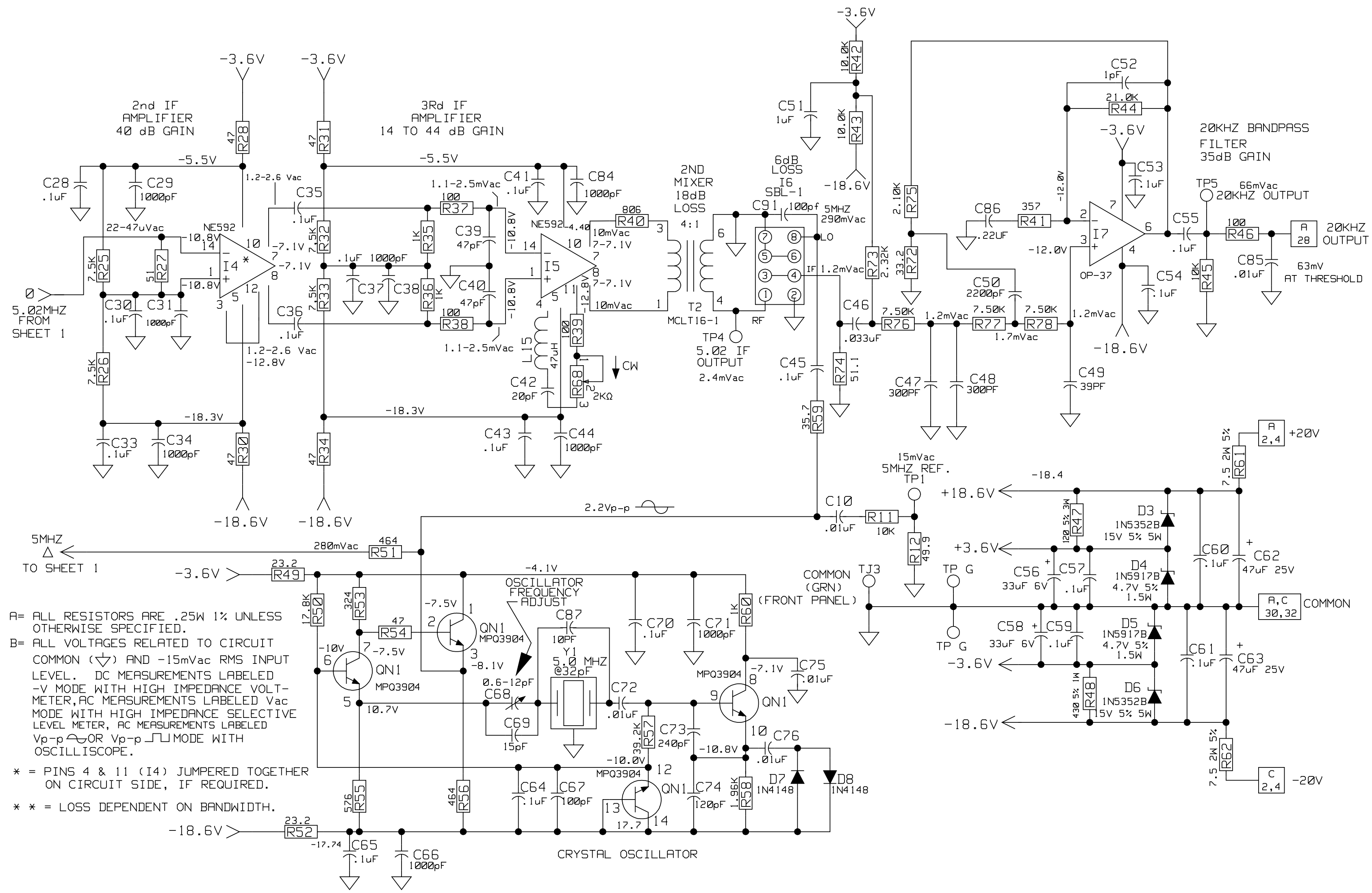
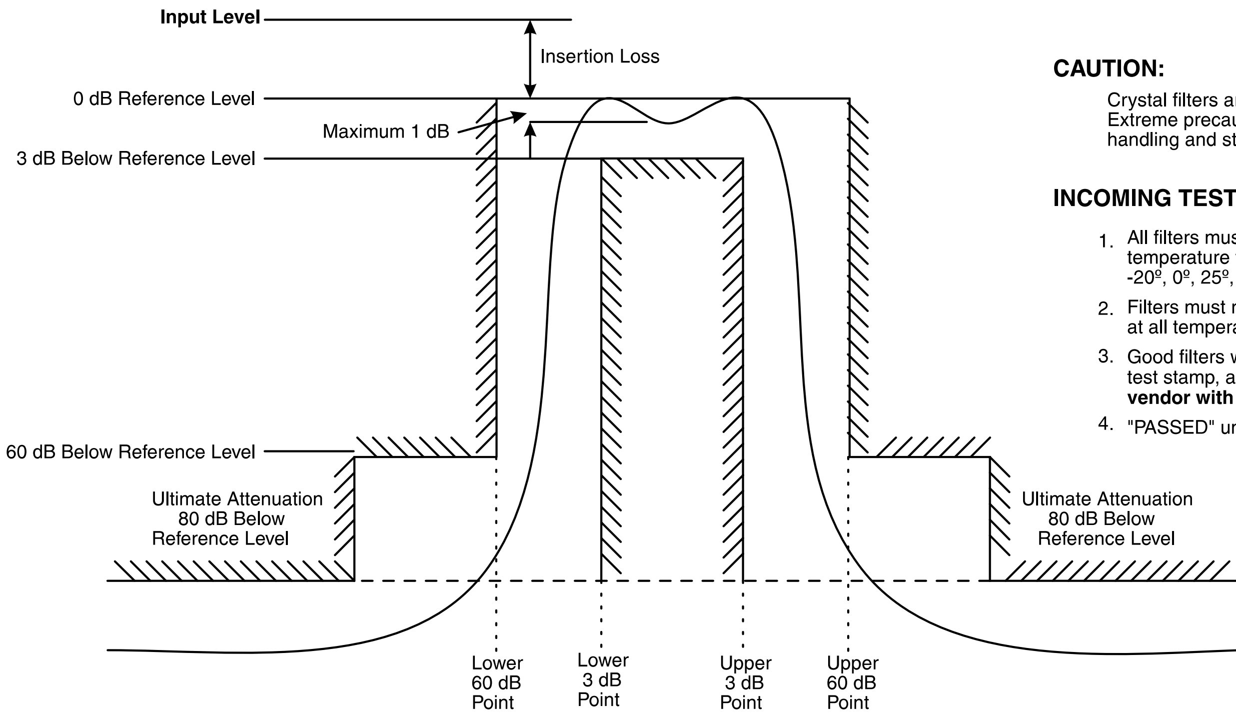


Figure 14–4. TC–10B/TCF–10B Receiver Schematic (1606C32; Sheet 5 of 5).



CAUTION:

Crystal filters are very fragile.
Extreme precautions must be taken during handling and storage to prevent damage.

INCOMING TESTING REQUIREMENTS:

1. All filters must be measured over temperature from -20º C to +60º C using -20º, 0º, 25º, 40º, and 60º C.
2. Filters must remain within their specifications at all temperatures.
3. Good filters will be marked with a "PASSED" test stamp, and **reject units returned to vendor with failure data.**
4. "PASSED" units will then be placed in stock.

STYLE NO. 1353D78H01 NARROW BAND TCF-10B (3 dB BW 300 Hz)

5.02 MHz CRYSTAL BANDPASS FILTER

1. ELECTRICAL SPECIFICATIONS: (See Section 14.3.1). Note that peak response is used for 0dB reference.
1.1 Upper 3 dB point 5.020110 MHz minimum. Lower 3 dB point 5.019890 MHz maximum.
1.2 Lower 60 dB point 5.019500 MHz minimum. Upper 60 dB point 5.020500 MHz maximum.
1.3 Ultimate attenuation ^{3} 80 dB outside frequency range of 5.02 MHz ±10 kHz.
1.4 Passband ripple 1.0 dB peak-to-valley maximum.
1.5 Insertion loss 14.0 dB maximum.
1.6 Terminations 50 ohms resistive input and output.
2.0 ENVIRONMENTAL SPECIFICATIONS
2.1 Operating temperature: The above electrical specifications shall apply over the temperature range -20°C to +70°C.
2.2 Storage temperature: -30°C to +85°C.
2.3 Shock: 30 G 11 ms.
2.4 Vibration: Standard commercial low frequency 0–60 Hz .06 IN displacement.

STYLE NO. 1353D78H02 WIDEBAND/MEDIUM BAND TCF–10B/ NARROW BAND TC-10B (3 dB BW 600 Hz)

5.02 MHz CRYSTAL BANDPASS FILTER

1. ELECTRICAL SPECIFICATIONS: (See Section 14.3.1) Note that peak response is used for 0 dB reference.
1.1 Upper 3 dB point 5.020260 MHz minimum. Lower 3 dB point 5.019740 MHz maximum.
1.2 Lower 60 dB point 5.019000 MHz minimum. Upper 60 dB point 5.021000 MHz maximum.
1.3 Ultimate attenuation ^{3} 80 dB outside frequency range of 5.02 MHz ±20 kHz.
1.4 Passband ripple 1.0 dB peak-to-valley maximum.
1.5 Insertion loss 7.0 dB maximum.
1.6 Terminations 50 ohms resistive input and output.
2.0 ENVIRONMENTAL SPECIFICATIONS
2.1 Operating temperature: The above electrical specifications shall apply over the temperature range -20°C to +70°C.
2.2 Storage temperature: -30°C to +85°C.
2.3 Shock: 30 G 11 ms.
2.4 Vibration: Standard commercial low frequency 0–60 Hz .06 IN displacement.

STYLE NO. 1353D78H03 EXTRA WIDEBAND TCF-10B/ WIDEBAND TC–10B (3 dB BW 1,200 Hz)

5.02 MHz CRYSTAL BANDPASS FILTER

1. ELECTRICAL SPECIFICATIONS: (See Section 14.3.1). Note that peak response is used for 0 dB reference.
1.1 Upper 3 dB point 5.020510 MHz minimum. Lower 3 dB point 5.019490 MHz maximum.
1.2 Lower 60 dB point 5.018000 MHz minimum. Upper 60 dB point 5.022000 MHz maximum.
1.3 Ultimate attenuation ^{3} 80 dB outside frequency range of 5.02 MHz ±40 kHz.
1.4 Passband ripple 1.0 dB peak-to-valley maximum.
1.5 Insertion loss 5.0 dB maximum.
1.6 Terminations 50 ohms resistive input and output.
2.0 ENVIRONMENTAL SPECIFICATIONS
2.1 Operating temperature: The above electrical specification shall apply ove the temperature range -20°C to +70°C.
2.2 Storage temperature: -30°C to +85°C.
2.3 Shock: 30 G 11 ms.
2.4 Vibration: Standard commercial low frequency 0–60 Hz .06 IN displacement.

Figure 14–5. Crystal Filter Characteristics (1353D78; Sheet 2 of 2).

Table 14–2. Receiver Module Components (1606C32).

Location	Style	Description	Group
CAPACITORS			
C01	CF1002JP78	0.01 µF 5% 200 V MET POLYCARB	01,02,03
C02	CF1502GP78	0.015 µF 2% 200 V MET POLYCARB	01,02,03
C03	CF1002JP78	0.01 µF 5% 200 V MET POLYCARB	01,02,03
C04	CR2000JVE0	200 pF 5% 500 V DIPPED MICA	01,02,03
C05	CR2000JVE0	200 pF 5% 500 V DIPPED MICA	01,02,03
C06	CR5100GV67	510 pF 2% 500 V DIPPED MICA	01,02,03
C07	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C08	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C09	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C10	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C11	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C12	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C13	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C14	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C15	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C16	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C17	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C18	CR1100JV67	110 pF 5% 500 V DIPPED MICA	01,02,03
C20	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C21	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C22	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C23	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C24	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C25	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C26	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C27	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C28	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C29	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C30	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C31	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C33	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C34	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C35	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C36	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C37	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C38	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C39	CR470AJV67	47 pF 5% 500 V DIPPED MICA	01,02,03
C40	CR470AJV67	47 pF 5% 500 V DIPPED MICA	01,02,03
C41	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C42	CR200AJR67	20 pF 5% 300 V DIPPED MICA	01,02,03
C43	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C44	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C45	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C46	CF3302JL78	0.033 µF 5% 100 V MET POLYCARB	01,02,03

(Continued on next page.)

Table 14–2. Receiver Module Components (Cont'd).

Location	Style	Description	Group
CAPACITORS (Cont'd)			
C47	CR3300JLE0	330 pF 5% 100 V DIPPED MICA	01,02,03
C48	CR3000JRE0	300 pF 5% 300 V DIPPED MICA	01,02,03
C49	CR390AJVE0	39 pF 5% 500 V DIPPED MICA	01,02,03
C50	CF2201GU70	2200 pF 2% 400 V MET POLYCARB	01,02,03
C51	CP1004MH54	1.0 µF 20% 50 V MONO CERAMIC	01,02,03
C52	CR100BDR67	1 pF +/-0.5 pF 300 V DIPPED MICA	01,02,03
C53	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C54	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C55	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C56	CJ3305MA72	33 µF 20% 6 V MOLDED TANTALUM	01,02,03
C57	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C58	CJ3305MA72	33 µF 20% 6 V MOLDED TANTALUM	01,02,03
C59	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C60	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C61	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C62	CJ4705ME72	47 µF 20% 25 V MOLDED TANTALUM	01,02,03
C63	CJ4705ME72	47 µF 20% 25 V MOLDED TANTALUM	01,02,03
C64	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C65	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C66	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C67	CP1000KH65	100 pF 10% 50 V X7R MONO CERAMIC	01,02,03
C68	863A539H02	0.6-12 pF 50 PPM TRIMMER	01,02,03
C69	CR150AJV17	15 pF 5% 500 V DIPPED MICA	01
C70	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C71	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C72	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C73	CR2400JVE0	240 pF 5% 500 V DIPPED MICA	01,02,03
C74	CR1200JVE0	120 pF 5% 500 V DIPPED MICA	01,02,03
C75	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C76	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C77	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C78	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C79	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C80	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C81	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C82	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C83	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C84	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C85	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01,02,03
C86	CF2203JL78	0.22 µF 5% 100 V MET POLYCARB	01,02,03
C87	CR100AGV92	10 pF 2% 500 V DIPPED MICA	01,02,03
C88	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01,02,03
C89	CP1000KH65	100 pF 10% 50 V X7R MONO CERAMIC	01,02,03
C90	CP1000KH65	100 pF 10% 50 V X7R MONO CERAMIC	01,02,03
C91	CP1000KH65	100 pF 10% 50 V X7R MONO CERAMIC	01,02,03

Table 14–2. Receiver Module Components (Cont'd).

Location	Style	Description	Group
CHOKES			
L01	9646A07H28	18.0 µH	01,02,03
L02	9646A07H28	18.0 µH	01,02,03
L03	9646A07H16	1.80 µH	01,02,03
L04	9646A07H16	1.80 µH	01,02,03
L05	9646A07H11	.68 µH	01,02,03
L06	9646A07H34	56.0 µH	01,02,03
L07	9646A07H34	56.0 µH	01,02,03
L08	9646A07H26	12.0 µH	01,02,03
L09	9646A07H26	12.0 µH	01,02,03
L10	9646A07H21	4.70 µH	01,02,03
L11	9646A07H21	4.70 µH	01,02,03
L12	9646A07H34	56.0 µH	01,02,03
L13	9646A07H34	56.0 µH	01,02,03
L15	9646A07H33	47.0 µH	01,02,03
L18	9646A07H34	56.0 µH	01,02,03
L19	9646A07H34	56.0 µH	01,02,03
CONNECTORS			
J01	3529A12H11	14 PIN SINGLE ROW HEADER	01,02,03
J03	3529A12H09	8 PIN SINGLE ROW HEADER	01,02,03
CRYSTALS			
Y01	1608C06H01	5.0 MHz (32 pF) CRYSTALS	01,02
Y01	1608C06H03	5.0 MHz (32 pF) CRYSTALS	03
DIODES			
D07	836A928H06	1N4148 75 V 0.01 A	01,02,03
D08	836A928H06	1N4148 75 V 0.01 A	01,02,03
FILTERS			
FL1	1353D78H03	XTAL FILTER 5.02 MHz BW 1,200 Hz	01
FL01	1353D78H01	XTAL FILTER 5.02 MHz BW 300 Hz	03
FL01	1353D78H02	XTAL FILTER 5.02 MHz BW 600 Hz	02
JUMPERS			
JU01	3532A54H01	BLUE CLIP JUMPER	01,02,03
LINEAR ICs			
I5	9646A35H01	NE592N WIDEBAND VIDEO AMP	01,02,03
I01	9646A36H01	DS0026 2-PH MOS CLOCK-DRIVER	01,02,03
I02	9646A36H01	DS0026 2-PH MOS CLOCK-DRIVER	01,02,03
I04	9646A35H01	NE592N WIDEBAND VIDEO AMP	01,02,03
I07	3534A38H01	OP37GZ SINGLE OP-AMP (LO NOISE)	01,02,03
QN01	3533A64H01	MPQ3904 QUAD NPN ARRAY 40 V 0.2 A	01,02,03

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(Continued on next page.)

Table 14–2. Receiver Module Components (Cont'd).

Location	Style	Description	Group
MIXERS			
I03	3529A13H03	TAK-1H	01,02,03
I06	3529A13H01	DOUBLE BALANCED SBL-1 I2	01,02,03
POTENTIOMETERS			
R03	3535A32H03	100-OHM 10%	01,02,03
R67	3534A25H04	1 K 25T TOP ADJ.	01,02,03
R68	3534A25H05	2 K-OHM TOP ADJ. VAR.	01,02,03
RESISTORS			
R5	RM562AFQB4	56.2 OHMS 1% 0.25 W METAL FILM	01
R8	RM562AFQB4	56.2 OHMS 1% 0.25 W METAL FILM	01
R01	RC1001J167	1.0 KILOHMS 5% 1 W CARBON COMP	01,02,03
R02	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	01,02,03
R04	RM191AFQB4	19.1 OHMS 1% 0.25 W METAL FILM	01,02,03
R05	RM562AFQB4	56.2 OHMS 1% 0.25 W METAL FILM	02,03
R06	RM191AFQB4	19.1 OHMS 1% 0.25 W METAL FILM	01,02,03
R07	RM191AFQB4	19.1 OHMS 1% 0.25 W METAL FILM	01,02,03
R08	RM562AFQB4	56.2 OHMS 1% 0.25 W METAL FILM	02,03
R09	RM191AFQB4	19.1 OHMS 1% 0.25 W METAL FILM	01,02,03
R10	RM2213FQ98	221 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R11	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R12	RM499AFQB4	49.9 OHMS 1% 0.25 W METAL FILM	01,02,03
R13	RM825BFQB7	8.25 OHMS 1% 0.25 W METAL FILM	01,02,03
R14	RM825BFQB7	8.25 OHMS 1% 0.25 W METAL FILM	01,02,03
R15	RM665AFQB4	66.5 OHMS 1% 0.25 W METAL FILM	01,02,03
R16	RM825BFQB7	8.25 OHMS 1% 0.25 W METAL FILM	01,02,03
R17	RM825BFQB7	8.25 OHMS 1% 0.25 W METAL FILM	01,02,03
R18	RM499AFQB4	49.9 OHMS 1% 0.25 W METAL FILM	01,02,03
R19	RM2211FQB0	2.21 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R20	RM576AFQB4	57.6 OHMS 1% 0.25 W METAL FILM	01,02,03
R21	RM4020FQB1	402 OHMS 1% 0.25 W METAL FILM	01,02,03
R22	RM1001FQB0	1.00 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R23	RM100AFQB4	10.0 OHMS 1% 0.25 W METAL FILM	01,02,03
R24	RM499AFQB4	49.9 OHMS 1% 0.25 W METAL FILM	01,02,03
R25	RM7501FQB0	7.50 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R26	RM7501FQB0	7.50 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R27	RM511AFQB4	51.1 OHMS 1% 0.25 W METAL FILM	01,02,03
R28	RB470AJQB2	47 OHMS 5% 0.25 W CARBON FILM	01,02,03
R30	RB470AJQB2	47 OHMS 5% 0.25 W CARBON FILM	01,02,03
R31	RB470AJQB2	47 OHMS 5% 0.25 W CARBON FILM	01,02,03
R32	RM7501FQB0	7.50 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R33	RM7501FQB0	7.50 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R34	RB470AJQB2	47 OHMS 5% 0.25 W CARBON FILM	01,02,03
R35	RM1001FQB0	1.00 KILOHMS 1% 0.25 W METAL FILM	01,02,03

Table 14–2. Receiver Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS (Cont'd)			
R36	RM1001FQB0	1.00 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R37	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	01,02,03
R38	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	01,02,03
R39	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	01,02,03
R40	RM8060FQB1	806 OHMS 1% 0.25 W METAL FILM	01,02,03
R41	RM3570FQB1	357 OHMS 1% 0.25 W METAL FILM	01,02,03
R42	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R43	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R44	RM2102FQA9	21.0 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R45	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R46	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	01,02,03
R47	RC4300J167	430 OHMS 5% 1 W CARBON COMP	01,02,03
R48	RC6800J167	680 OHMS 5% 1 W CARBON COMP	01,02,03
R49	RM232AFQB4	23.2 OHMS 1% 0.25 W METAL FILM	01,02,03
R50	RM1782FQA9	17.8 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R51	RM4640FQB1	464 OHMS 1% 0.25 W METAL FILM	01,02,03
R52	RM232AFQB4	23.2 OHMS 1% 0.25 W METAL FILM	01,02,03
R53	RM3240FQB1	324 OHMS 1% 0.25 W METAL FILM	01,02,03
R54	RB470AJQB2	47 OHMS 5% 0.25 W CARBON FILM	01,02,03
R55	RM5760FQB1	576 OHMS 1% 0.25 W METAL FILM	01,02,03
R56	RM4640FQB1	464 OHMS 1% 0.25 W METAL FILM	01,02,03
R57	RM3922FQA9	39.2 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R58	RM1961FQB0	1.96 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R59	RM357AFQB4	35.7 OHMS 1% 0.25 W METAL FILM	01,02,03
R60	RM1001FQB0	1.00 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R61	RC750BJ1E3	7.5 OHMS 5% 1 W CARBON COMP	01,02,03
R62	RC750BJ1E3	7.5 OHMS 5% 1 W CARBON COMP	01,02,03
R63	RM7501FQB0	7.50 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R64	RM7501FQB0	7.50 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R65	RM6980FQB1	698 OHMS 1% 0.25 W METAL FILM	01,02,03
R66	RB1500JHL8	150 OHMS 5% 0.5 W CARBON FILM	01,02,03
R69	RM165AFQB4	16.5 OHMS 1% 0.25 W METAL FILM	01,02,03
R70	RM165AFQB4	16.5 OHMS 1% 0.25 W METAL FILM	01,02,03
R71	RM665AFQB4	66.5 OHMS 1% 0.25 W METAL FILM	01,02,03
R72	RM332AFQB4	33.2 OHMS 1% 0.25 W METAL FILM	01,02,03
R73	RM2321FQB0	2.32 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R74	RM511AFQB4	51.1 OHMS 1% 0.25 W METAL FILM	01,02,03
R75	RM2101FQB0	2.10 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R76	RM7501FQB0	7.50 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R77	RM7501FQB0	7.50 KILOHMS 1% 0.25 W METAL FILM	01,02,03
R78	RM7501FQB0	7.50 KILOHMS 1% 0.25 W METAL FILM	01,02,03

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Location	Style	Description	Group
TEST POINTS			
TJ01	3532A53H09	BLUE	01,02,03
TJ02	3532A53H07	YELLOW	01,02,03
TJ03	3532A53H08	GREEN	01,02,03
TRANSFORMERS			
T01	1495B82G01	TRANSFORMER	01,02,03
T02	3537A43H01	WIDE BAND TRANSFORMER	01,02,03
TRANSISTORS			
Q4	3493A90H08	2N5109 20 V 0.44 A 2.5 W NPN	01
Q01	3493A90H08	2N5109 20 V 0.44 A 2.5 W NPN	01,02,03
Q02	3532A45H18	MRF476 18 V 1 A 10 W NPN	01,02,03
Q03	3509A35H08	MPS6546 25 V 0.05 A 0.35 W NPN	01,02,03
Q04	3493A90H08	2N5109 20 V 0.44 A 2.5 W NPN	02,03
TRIMMERS			
C19	879A834H03	9.0-35.0 pF TRIMMER	01,02,03
ZENERS			
D2	837A693H20	1N4694 8.2 V 5% 0.25 W	01
D5	3535A58H05	1N5917B 4.7 V 5% 1.5 W	01
D01	837A693H20	1N4694 8.2 V 5% 0.25 W	01,02,03
D02	837A693H20	1N4694 8.2 V 5% 0.25 W	02,03
D03	862A288H04	1N5352B 15 V 5% 5 W	01,02,03
D04	3535A58H05	1N5917B 4.7 V 5% 1.5 W	01,02,03
D05	3535A58H05	1N5917B 4.7 V 5% 1.5 W	02,03
D06	862A288H04	1N5352B 15 V 5% 5 W	01,02,03

14.4 Synthesizer Module Description

Schematic	1585C56-20
Parts List	1585C56-20

The Synthesizer Module (1585C56G02), for the TC–10B and TCF–10B, is used to derive the injection frequencies from the 5 MHz crystal oscillator reference for the Receiver Module. The voltage-controlled oscillator (VCO), operating in the range of 90 to 114 MHz, is divided by 20 to produce the local oscillator output of 4.5 to 5.7 MHz. The 5 MHz reference is divided by 500 to produce a 20 kHz reference for the phase detector that generates the dc voltage to control the VCO.

14.4.1 Synthesizer Control Panel

The Synthesizer does not have a control panel of its own; its frequencies are displayed through the Receiver control panel.

14.4.2 Synthesizer PC Board

The Synthesizer PC Board does not contain operator controls.

14.5 Synthesizer Circuit Description

The Synthesizer Module (Schematic 1585C56: Figure 14-6, Figure 14-7, and Figure 1-8) is used to derive the injection frequencies from the 5 MHz crystal oscillator reference for the Receiver Module.

The voltage-controlled oscillator (VCO), operating in the range of 90 to 114 MHz, is divided by 20 to produce the local oscillator output of 4.5 to 5.7 MHz. The 5 MHz reference is divided by 500 to produce a 10 kHz reference for the phase detector that generates the dc voltage to control the VCO.

On-board voltage regulation is provided by I4, I14, I15 and I19 (see Figure 14-6).

The phase-locked-loop (PLL) circuitry (see Figure 14-7) includes the frequency synthesizer (I1), integrator (I2), loop filter (I3), VCO (Q3), dual modulus divider, and other circuitry (see Figure 14-7).

The PLL frequency synthesizer chip (I1) is programmed by the microcomputer. The three internal counters (N, A and R reference divider) are programmed for 25 kHz steps, dividing by 9,000 to 11,400 (this includes the 64/65 counter); the VCO is moved in 10 kHz increments. I8 and I9 divide the 90-114 MHz signal by 20 (I8 divides by 10 and I9 divides by 2).

The integrator integrates the + and - pulses coming out of the digital phase detector. The twin “T” notch filter (formed by R12, R13, R14, C39, C40, C41 and C42) is set to 10 kHz. The resulting dc control voltage is fed to the voltage variable capacitance diode (D3) in the voltage controlled oscillator (VCO) circuit.

The phase-detector, divide-by-500-counter, programmable counters, and control logic are all contained in one chip (I1).

Circuitry for the frequency selection switches, multiplexer and microcomputer is shown on the Schematic, Figure 14-8.

Four front panel frequency selection switch outputs are fed to tristate buffers that are used as multiplexers. The input switches provide BCD outputs to I16, I17 and I13. The 100s switch selects 100 kHz; the 10s switch selects 10 kHz; and the 1s switch selects 1 kHz increments. Switch S1 is 0/.5 and selects even kHz or 0.5 kHz. I13, I16 and I17 are TRI-STATE buffers that can have outputs of logic “0”, “1” or “OFF”. Their outputs are paralleled on the bus lines feeding the microcomputer. There are 16 inputs from the BCD switches, but only 8 input lines to the microcomputer. Therefore, data must be stored and sequentially read out into the microcomputer. I13, I16 and I17 function as a multiplexer converting parallel data to serial data.

I11 is the microcomputer and contains built-in RAM, ROM and EPROM. It must be programmed for a specific use. I12 accepts the BCD commands from the microcomputer and six decimal output lines for scanning the microprocessor. These scanning lines are inverted in I18 prior to driving the multiplexer. Q2 provides a logic “0” to pin 5 of J1 to signal an out-of-lock condition.

Other commands — baseband, receive, transmit, wave change, and wave change select — are also fed to the multiplexer. The contents of tristate buffers are scanned by the microprocessor to produce eight (8) command lines for the programmable counter. The lock detector output is also fed to the multiplexer and, if the VCO is not locked, the microprocessor generates an out-of-lock command.

Microcomputer I11 computes the proper divider numbers for I1 and loads them to I1, based on data that is read from the multiplexers (above).

14.6 Synthesizer Troubleshooting

Troubleshooting this module is not recommended. In the event there is a fault, return this module to the PULSAR factory.

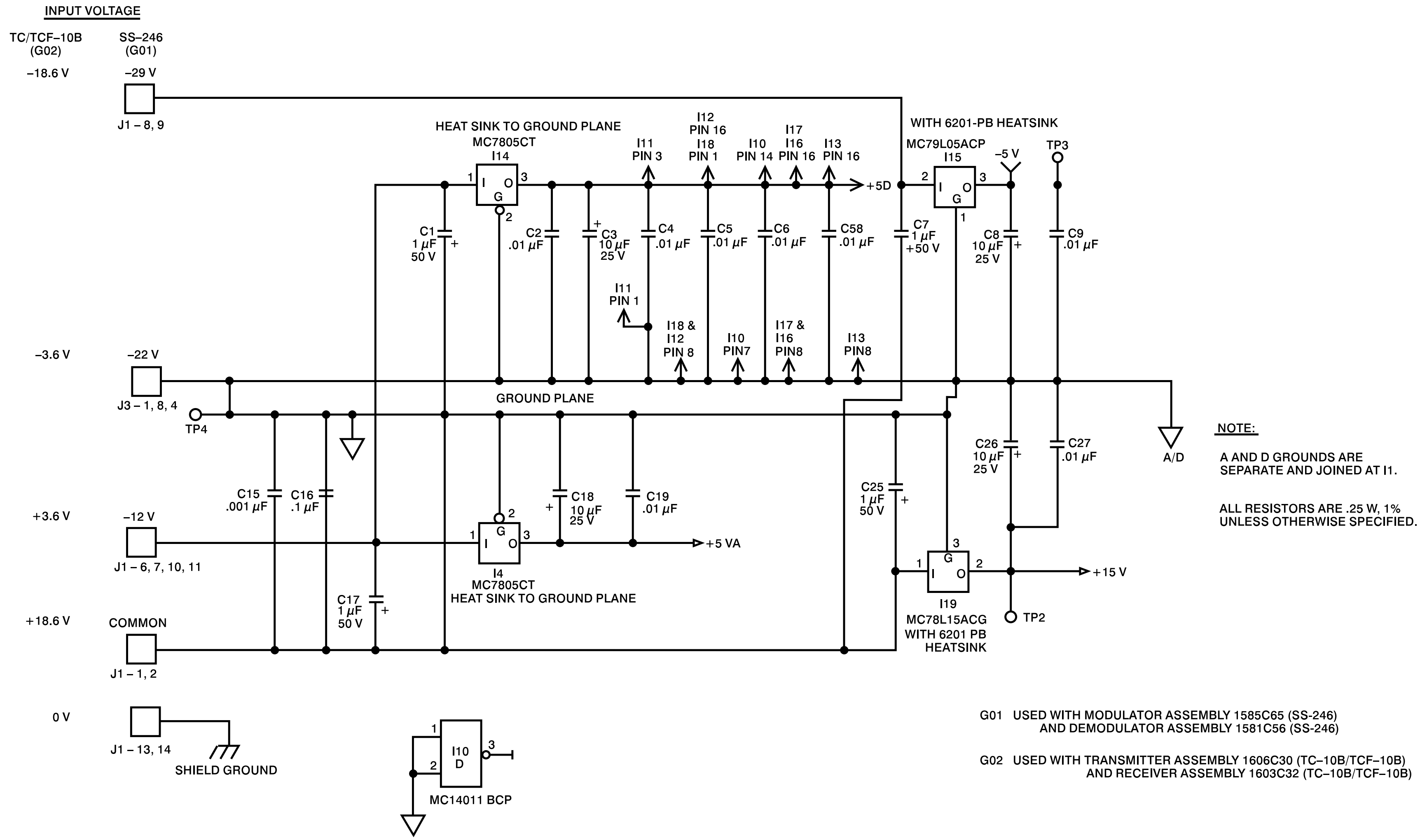

Figure 14–6. TC–10B/TCF–10B Synthesizer Schematic (1585C56S; Sheet 1 of 3).

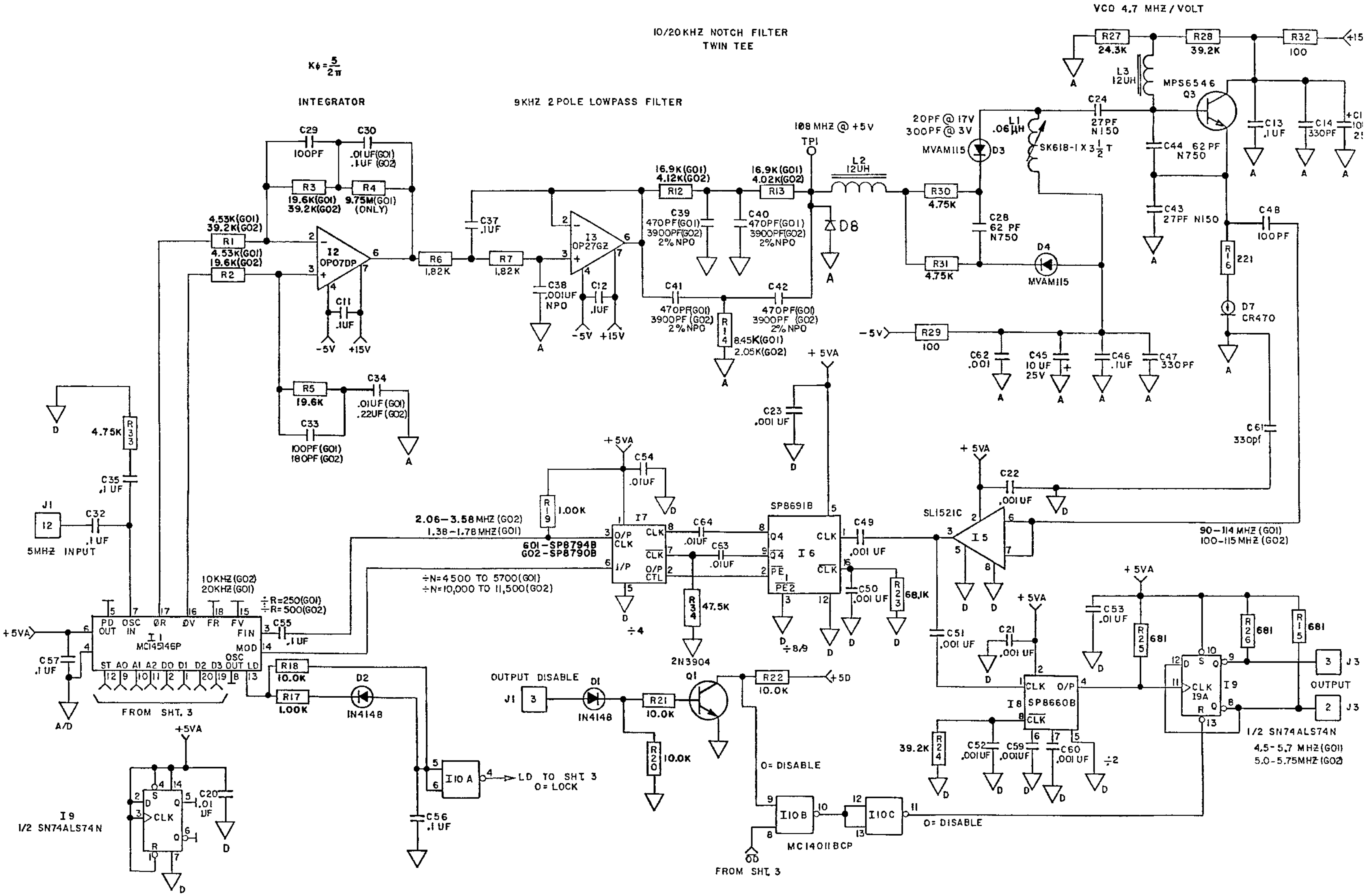

Figure 14–7. TC–10B/TCF–10B Synthesizer Schematic (1585C56S; Sheet 2 of 3).

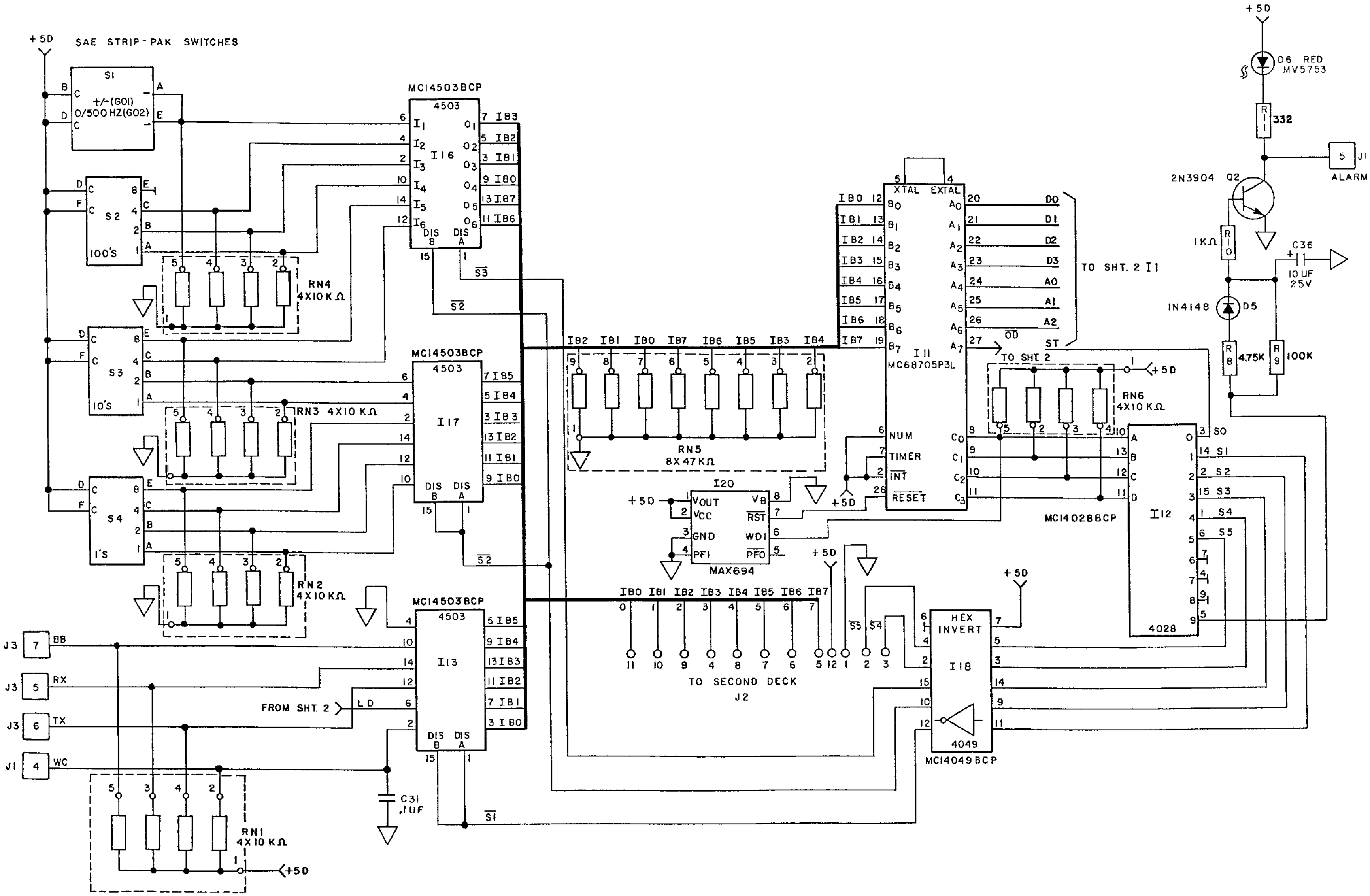

Figure 14–8. TC–10B/TCF–10B Synthesizer Schematic (1585C56S; Sheet 3 of 3).

Table 14–3. Synthesizer Module Components (1585C56).

Location	Style	Description	Group
CAPACITORS			
C1	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	02
C2	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C3	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	02
C4	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C5	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C6	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C7	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	02
C8	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	02
C9	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C10	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	02
C11	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	02
C12	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	02
C13	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	02
C14	CP3300KH65	330 pF 10% 50 V C0G MONO CERAMIC	02
C15	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	02
C16	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	02
C17	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	02
C18	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	02
C19	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C20	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C21	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	02
C22	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	02
C23	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	02
C24	CP270AKL75	27 pF 10% 100 V N150 MONO CERAMIC	02
C25	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	02
C26	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	02
C27	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C28	CP620AKL75	62 pF 10% 100 V N750 MONO CERAMIC	02
C29	CP1000KH65	100 pF 10% 50 V X7R MONO CERAMIC	02
C30	CT1003JLZZ	0.1 µF 5% 100 V MET POLYESTER	02
C32	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	02
C33	CP1800GH65	180 pF 2% 50 V C0G MONO CERAMIC	02
C34	CT2203JJ68	0.22 µF 5% 63 V MET POLYESTER	02
C35	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	02
C36	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	02
C37	CT1003JL68	0.1 µF 5% 100 V MET POLYESTER	02
C38	CP1001GH65	1000 pF 2% 50 V C0G MONO CERAMIC	02
C39	CP3901GH65	3900 pF 2% 50 V C0G MONO CERAMIC	02
C40	CP3901GH65	3900 pF 2% 50 V C0G MONO CERAMIC	02
C41	CP3901GH65	3900 pF 2% 50 V C0G MONO CERAMIC	02
C42	CP3901GH65	3900 pF 2% 50 V C0G MONO CERAMIC	02
C43	CP270AKL75	27 pF 10% 100 V N150 MONO CERAMIC	02
C44	CP620AKL75	62 pF 10% 100 V N750 MONO CERAMIC	02
C45	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	02
C46	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	02

Table 14–3. Synthesizer Module Components (Cont'd).

Location	Style	Description	Group
CAPACITORS (Cont'd)			
C47	CP3300KH65	330 pF 10% 50 V C0G MONO CERAMIC	02
C48	CP1000KH65	100 pF 10% 50 V X7R MONO CERAMIC	02
C49	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	02
C50	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	02
C51	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	02
C52	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	02
C53	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C54	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C55	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	02
C56	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	02
C57	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	02
C58	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C59	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	02
C60	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	02
C61	CP3300KH65	330 pF 10% 50 V C0G MONO CERAMIC	02
C62	CP1001ML65	1000 pF 20% 100 V X7R MONO CERAMIC	02
C63	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
C64	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	02
DIGITAL ICs			
I1	3533A95H01	MC145146P PLL FREQUENCY SYNTHESIZER	02
I6	3534A01H01	SP8691B 2-MODULUS (8/9) DIVDR 200MH	02
I7	9648A89H01	SP8790B DIV-BY-4 MODULUS EXTENDER	02
I8	3533A99H01	SP8660B DIVIDE-BY-10 200 MHz	02
I9	3535A66H01	SN74ALS74N DUAL D FLIP-FLOP	02
I10	3533A84H01	MC14011BCP QUAD 2-INPUT NAND	02
I12	3533A85H01	MC14028BCP BCD-DECIMAL DECODER	02
I13	3535A69H01	MC14503BCP HEX 3-STATE BUFFER	02
I16	3535A69H01	MC14503BCP HEX 3-STATE BUFFER	02
I17	3535A69H01	MC14503BCP HEX 3-STATE BUFFER	02
I18	3533A86H01	MC14049UBCP HEX INVERTER/BUFFER	02
I20	9654A53		
H02	MAX 694 CPA	02	
DIODES			
D1	836A928H06	1N4148 75 V 0.01 A	02
D2	836A928H06	1N4148 75 V 0.01 A	02
D3	3534A27H01	MVAM115 VARICAP 500 pF @ 1 V	02
D4	3534A27H01	MVAM115 VARICAP 500 pF @ 1 V	02
D5	836A928H06	1N4148 75 V 0.01 A	02
D7	3534A06H01	CR470 0.047 A CONSTANT CURRENT	02
INDUCTORS			
L1	3534A44H01	ADJ. 47	02
L2	3533A74H02	12 µH 10%	02
L3	3533A74H02	12 µH 10%	02

(Continued on next page.)

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Table 14–3. Synthesizer Module Components (Cont'd).

Location	Style	Description	Group
LINEAR ICs			
I2	3533A96H01	OP07DP SINGLE OP-AMP (LO VOS)	02
I3	3533A97H01	OP27GZ SINGLE OP-AMP (LO NOISE)	02
I4	3533A90H01	MC7805CT POS VOLTREG 5 V 4% 1 A	02
I5	3533A98H01	SL1521C WIDEBAND AMP	02
I14	3533A90H01	MC7805CT POS VOLTREG 5 V 4% 1 A	02
I15	3533A93H01	MC79L05ACG NEG VOLTREG 5 V 5% 0.1 A	02
I19	3533A92H01	MC78L15ACG POS VOLTREG 15 V 5% 0.1 A	02
MICROPROCSSORS			
I11	1502B04G02	MICROPROCESSOR MC68705P3 (PROGRAMMED OPTOELECTRICS)	02
LEDs			
D6	3532A41H01	MV5753 LED RED	02
RESISTORS			
RN1	3533A81H01	4 COMM TERML 10 KILOHMS 2% SIP	02
RN2	3533A81H01	4 COMM TERML 10 KILOHMS 2% SIP	02
RN3	3533A81H01	4 COMM TERML 10 KILOHMS 2% SIP	02
RN4	3533A81H01	4 COMM TERML 10 KILOHMS 2% SIP	02
RN5	3533A81H02	8 COMM TERML 47 KILOHMS 2% SIP	02
RN6	3533A81H01	4 COMM TERML 10 KILOHMS 2% SIP	02
R1	RM3922FQA9	39.2 KILOHMS 1% 0.25 W METAL FILM	02
R2	RM1962FQA9	19.6 KILOHMS 1% 0.25 W METAL FILM	02
R3	RM3922FQA9	39.2 KILOHMS 1% 0.25 W METAL FILM	02
R5	RM1962FQA9	19.6 KILOHMS 1% 0.25 W METAL FILM	02
R6	RM1821FQB0	1.82 KILOHMS 1% 0.25 W METAL FILM	02
R7	RM1821FQB0	1.82 KILOHMS 1% 0.25 W METAL FILM	02
R8	RM4751FQB0	4.75 KILOHMS 1% 0.25 W METAL FILM	02
R9	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	02
R10	RM1001FQB0	1.00 KILOHMS 1% 0.25 W METAL FILM	02
R11	RM3320FQB1	332 OHMS 1% 0.25 W METAL FILM	02
R12	RM4121FQB0	4.12 KILOHMS 1% 0.25 W METAL FILM	02
R13	RM4021FQB0	4.02 KILOHMS 1% 0.25 W METAL FILM	02
R14	RM2051FQB0	2.05 KILOHMS 1% 0.25 W METAL FILM	02
R15	RM6810FQB1	681 OHMS 1% 0.25 W METAL FILM	02
R16	RM2210FQB1	221 OHMS 1% 0.25 W METAL FILM	02
R17	RM1001FQB0	1.00 KILOHMS 1% 0.25 W METAL FILM	02
R18	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	02
R19	RM1001FQB0	1.00 KILOHMS 1% 0.25 W METAL FILM	02
R20	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	02
R21	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	02
R22	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	02
R23	RM6812FQA9	68.1 KILOHMS 1% 0.25 W METAL FILM	02
R24	RM3922FQA9	39.2 KILOHMS 1% 0.25 W METAL FILM	02
R25	RM6810FQB1	681 OHMS 1% 0.25 W METAL FILM	02

Table 14–3. Synthesizer Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS (Cont'd)			
R26	RM6810FQB1	681 OHMS 1% 0.25 W METAL FILM	02
R27	RM2432FQA9	24.3 KILOHMS 1% 0.25 W METAL FILM	02
R28	RM3922FQA9	39.2 KILOHMS 1% 0.25 W METAL FILM	02
R29	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	02
R30	RM4751FQB0	4.75 KILOHMS 1% 0.25 W METAL FILM	02
R31	RM4751FQB0	4.75 KILOHMS 1% 0.25 W METAL FILM	02
R32	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	02
R33	RM4751FQB0	4.75 KILOHMS 1% 0.25 W METAL FILM	02
R34	RM4752FQA9	47.5 KILOHMS 1% 0.25 W METAL FILM	02
SWITCHES			
S1	3509A52H04	THUMBWHEEL 2 POLE 2 POS.	02
S2	3533A83H03	THUMBWHEEL BCD 5 POS.	02
S3	3533A83H02	THUMBWHEEL BCD 10 POS.	02
S4	3533A83H02	THUMBWHEEL BCD 10 POS.	02
TRANSISTORS			
Q1	3509A35H05	2N3904 40 V 0.2 A 0.625 W NPN	02
Q2	3509A35H05	2N3904 40 V 0.2 A 0.625 W NPN	02
Q3	3509A35H08	MPS6546 25 V 0.05 A 0.35 W NPN	02

USER NOTES

Chapter 15. CLI & Discriminator Module

Table 15–1. 1606C51 Styles and Descriptions.

Group	Description
G01	+/-100 Hz NSHIFT 2F W/INT & EXT CLI
G02	+/-250 Hz WSHIFT 2F W/INT & EXT CLI
G03	+/-500 Hz EWSHIFT 2F W/INT & EXT CLI
G04	+/-250 Hz WSHIFT 3F W/INT & EXT CLI
G05	+/-500 Hz EWSHIFT 3F W/INT & EXT CLI
G06	+/-250 Hz WSHIFT PH-C W/INT & EXT CLI
G07	+/-100 Hz NSHIFT 2F WO/INT & EXT CLI
G08	+/-250 Hz WSHIFT 2F WO/INT & EXT CLI
G09	+/-500 Hz EWSHIFT 2F WO/INT & EXT CLI
G10	+/-250 Hz WSHIFT 3F WO/INT & EXT CLI
G11	+/-500 Hz EWSHIFT 3F WO/INT & EXT CLI
G12	+/-250 Hz WSHIFT PH-C WO/INT & EXT CLI

Schematic	1606C51-10
Parts List	1606C51-10

15.1 CLI & Discriminator Module Description

This module comprises the following TCF–10B circuit functions:

- Rectifies the 20 kHz output from the Receiver Module
- Measures the level of the 20 kHz signal
- Converts to a (0 to +10) Vdc signal, which drives the Internal and External CLI circuits
- Adjusts the Internal and External CLI Meter readings (optional)
- Measures the low-level signal; turns on the low-level relay
- Develops the center frequency (f_C), high frequency (f_H), and low frequency (f_L) and detects noise (as something other than these three frequencies).

15.1.1 CLI and Discriminator Control Panel

(This panel is shown in Figure 1-1.)

Operator controls are as follows:

LEDs

- Noise (Red)
- Low-Level (Red)

Internal and External (Remote) CLI Meters

(Optional.)

15.1.2 CLI and Discriminator PC Board

(The CLI and Discriminator PC Board is shown in Figure 15-1.)

Operator jumpers are as follows:

Jumpers

JU1 Extra Wideband (soldered jumper)

JU2 NO/NC Low-Signal contacts for relay (K1)

Potentiometers

R1 Internal CLI Full-Scale Adjust

R40 Low Level Adjust

R104 External CLI Full-Scale Adjust Factory-adjusted potentiometers

R18 Offset Adjust

R25 AGC Adjust

R37 CLI Zero Adjust

15.2 CLI & Discriminator Circuit Description

The 20 kHz input signal (at connectors A/C-24) passes through an L/C Bandpass Filter (L1, L2 and associated components), enroute to the Current-Controlled Amplifier (I2). The upper half of I2 is used as an AGC amplifier for the input signal. The Buffer Amplifier (I1a) buffers I2. The output of I1a (at TP1) connects the AGC'd input signal of the Limiter (see sheet 2 of the schematic in Figure 15-3). The output of I1a also proceeds through the Full-Wave Rectifier (I1b, I1c), which extracts the amplitude of the signal at I1a. The Full-Wave Rectifier output is compared, at the input of the AGC Integrator (I1d, R28, C10), to the level determined by resistors R25 and R26; the output is a dc level of ±10 V.

AGC voltage is applied to the Logarithmic Current Source (I5a, Q1, lower half of I2). The output of the Log Current Source is applied to I2, pin 1 to complete the AGC loop. The voltage divider (R119, R4, R3) converts the ±10 Vdc AGC signal to a (0 to 10 Vdc) signal that drives the Internal and External CLI circuits. The Internal CLI Full Scale Adjust potentiometer (R1) is used to adjust the Internal CLI Meter reading to +10 dB, with a 20 kHz input of 3.162 Vp-p.

The external CLI drive circuit consists of pulse width modulator (I11), optical isolator (I-14), Q2 and associated components. The output of buffer I5-B is fed to I11. The pulse-width modulator control chip (I11) operates to cause proportional voltages between: I11 pins 2 and 15 and I-14 pins 1 and 2. This is accomplished by integrating the output pulses at I11 pin 10, and using the filtered Vdc as a reference that is fed to I11 pins 1 and 16. Given this condition, the Vdc at pins 1 and 16 will always be the same as the Vdc at pins 2 and 15. Since the output voltage at I11 pin 8 is 180° out-of-phase with the Vdc at I11 pin 10, the average Vdc through the input of I-14 will always be proportional to the Vdc at I11 pins 2 and 15. The clock pulse, determined by I11 (R93 and C29) is approximately 100 Hz. Unlike the classical power supply pulse-width modulator, many pulses can occur between clock pulses because the internal flip-flop is not used. The optical isolator (I-14) has an isolation voltage of 2,500 Vdc and a transistor breakdown of 400 Vdc. I-14, Q2 and associated components form a 100 μA current source that pulses “ON/OFF” through I-14, producing a variable current for the CLI. Temperature compensation for the thermal characteristics of I-14 is provided by RT-1, R116, and R117. You can use the External CLI Full Scale Adjust potentiometer (R110) to adjust the External CLI Meter reading to +10 dB, with a 20 kHz input of 3.162 Vp-p. This meter will operate with 10 to 350 Vdc between pins A/C-12 and A/C-14.

Level Comparator (I5b) determines whether the input level is below the Receiver MARGIN, set by resistor R40. I5b turns “ON” low-level LED (D2). The signal is inverted by Level Comparator (I5c), which operates low-level signal relay (K1).

15.2.1 Digital Discriminator

The 2 Vp-p signal from (TP1) Buffer Amplifier (I1a) is applied to Hysteresis Limiter (I3), converting the 2 Vp-p sign wave to 15 Vp-p square wave (see Schematic, Figure 15-3). The 20 kHz, 15 Vp-p square wave is applied to two mono-stable multi-vibrators (I4a, I4b); with I4b producing 10 μsec pulses from the rising edge of the 15 Vp-p square wave, and I4a producing 10 μsec pulses from the falling edge of the 15 Vp-p square wave. The two 10 μsec wide pulse trains are combined in NOR gate (I6a), producing a 40 kHz square wave train, which is compared against the output of a programmable divider (I9). If the frequency from I9 is higher than the 40 kHz pulse train, the divider number is increased; if the I9 frequency is lower than the pulse train, the divider number is decreased. The circuit (I7a, pin 12) monitors the increase/decrease control line. A square wave is produced (at I12) in which the frequency and duty cycle are proportional to the 40 kHz pulse train, and the divided reference frequency (1 MHz). The output of the frequency pulse train and variable duty cycle is filtered by a third order Low-Pass Filter (I5d and associated components).

The output of the Low-Pass Filter is applied to three window comparators, formed from:

- I8a + I8b (center frequency)
- I8c + I8d (high frequency)
- I10a + I10b (low frequency) and associated components

The outputs of the Window Comparators (WC) are buffered by QN1 (a, b, c) and QN2 (d). The center-frequency WC produces a +15 Vdc output for f_C. The high-frequency WC produces +15 Vdc for f_H, and the low-frequency WC produces -15 Vdc output for f_L (at pin A-28).

15.2.2 Signal-to-Noise Monitor

These WC outputs are OR’d together by diodes (D5, D9 and D12). If the received frequency is not f_C, f_H, or f_L, it is interpreted as noise. This signal is applied to I10c and is inverted; it is filtered by a fast-attack, slow-decay integrator (D15, D16). The output of this stage is compared (by I10d), and a noise alarm is produced. I10d turns “ON” Noise LED (D1).

15.3 CLI & Discriminator Troubleshooting

Should a fault occur in this module, place the module on an extender board.

Signal levels (both ac and dc) are shown on the schematic for an input voltage of -1.0 dBm (562 mVp-p). The TP3 voltages shown in Figure 15-2 are helpful when you are adjusting the discriminator.

Normal signal tracing with an oscilloscope, and/or dc voltmeter, will locate most faults. You may test diodes and other components conventionally with an ohmmeter.

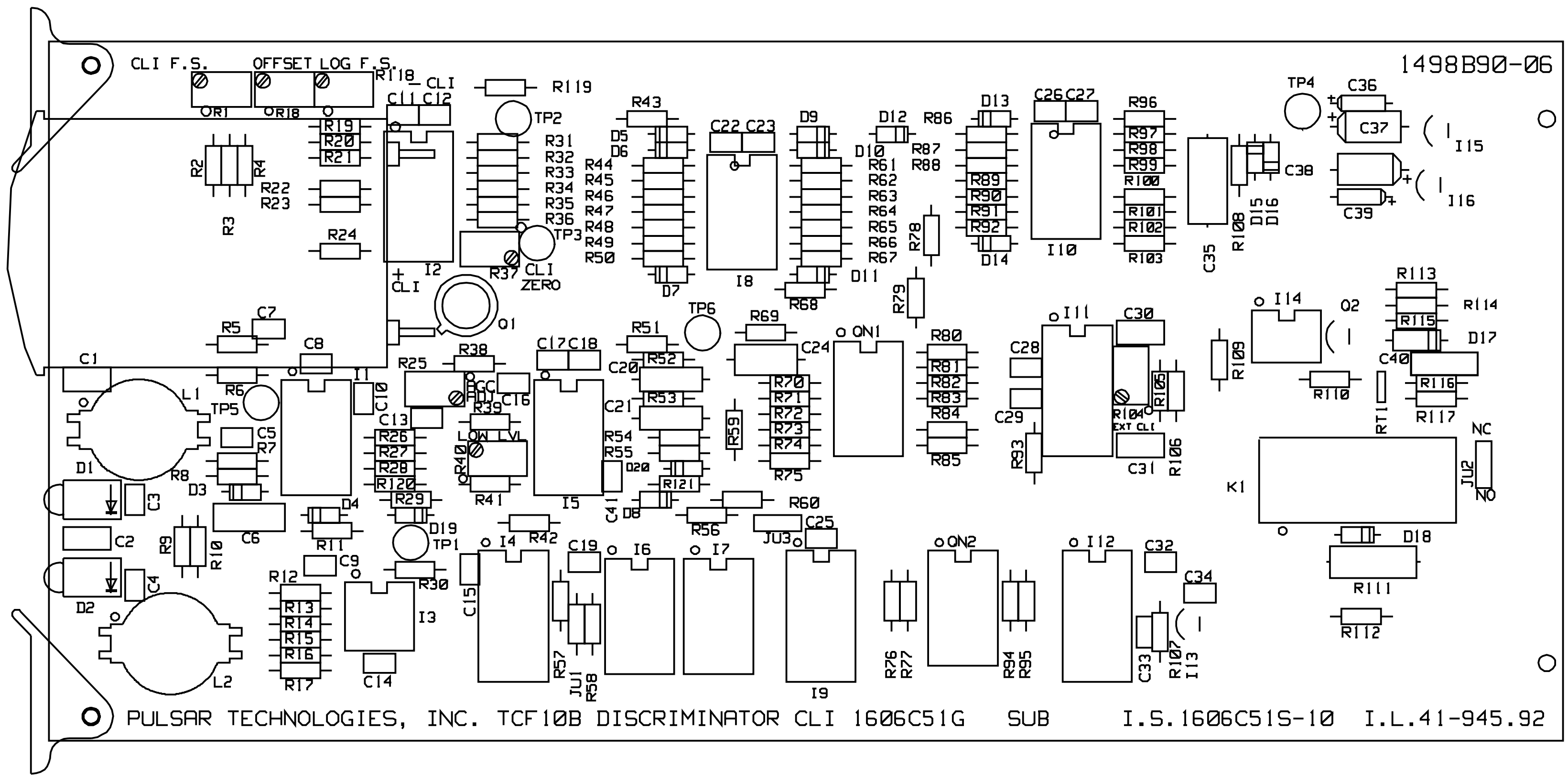
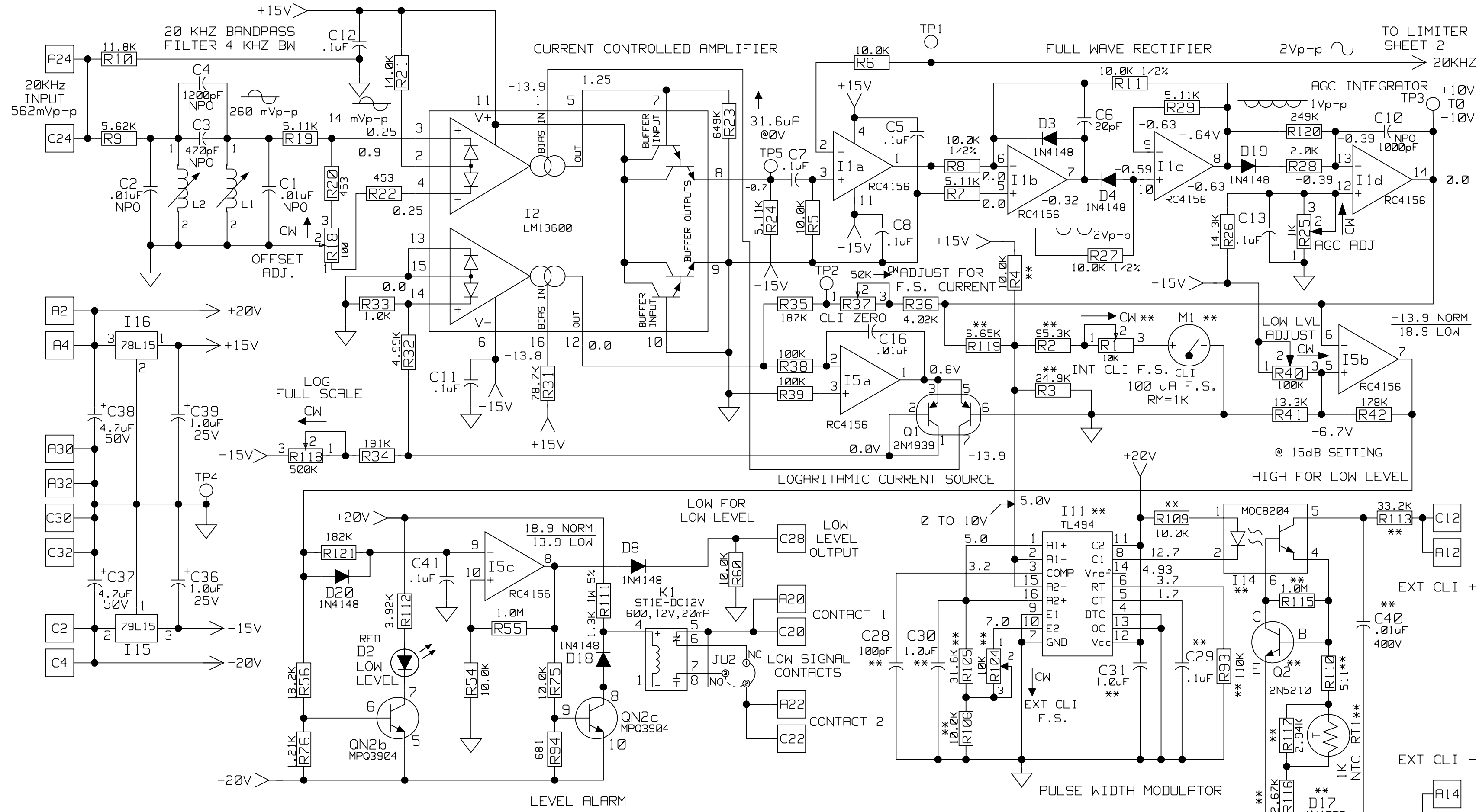


Figure 15–1. TCF–10B CLI and Discriminator PC Board (1495B90).



NOTE:
ALL RESISTORS 1/4 W 1% IN OHMS, UNLESS OTHERWISE NOTED
** PARTS REQUIRED FOR INTERNAL AND EXTERNAL CLI OPTION GROUPS 1,2,3,4,5, AND 6.

INPUT RMS	CLI	INPUT P-P	TP3	REMARKS
1.12V	+10 dB	3.162V	+10V	
630mV	+5 dB	1.778V	+6.67V	
354mV	0 dB	1.000V	+3.33V	15dB MARGIN, NORMAL SIGNAL LEVEL
199mV	-5 dB	.5623V	0V	
112mV	-10 dB	.3162V	-3.33V	
63mV	-15 dB	.1778V	-6.67V	THRESHOLD LOW LEVEL
35.4mV	-20 dB	.1000V	-10.0V	CLI ZERO

Figure 15–2. TCF–10B CLI and Discriminator Schematic (1606C51; Sheet 1 of 7).

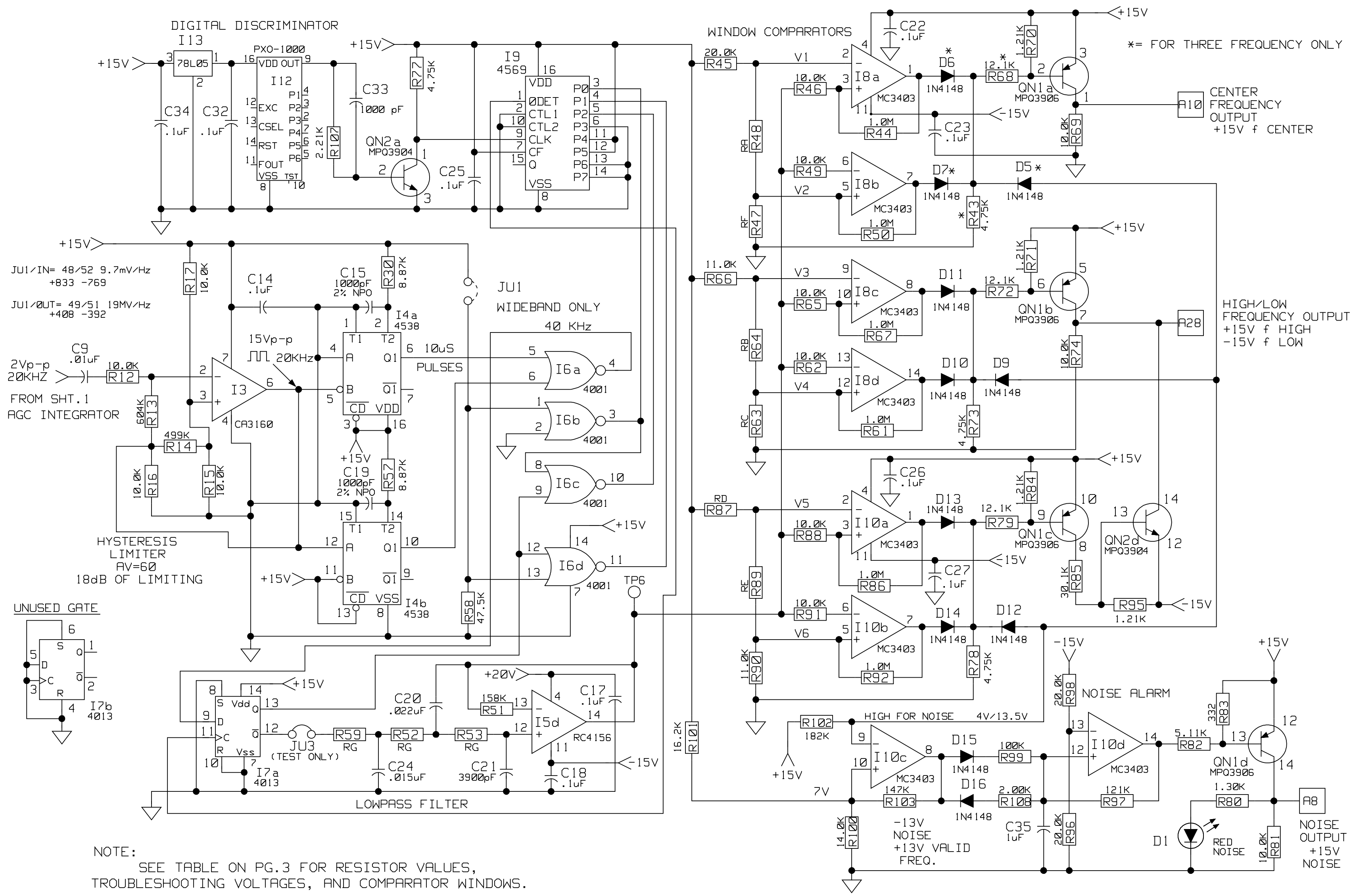


Figure 15–3. TCF–10B CLI and Discriminator Schematic (1606C51; Sheet 2 of 7).

All Resistors 1/4 W 1% IN K-OHMS															
GROUP NUMBER	RA R48	RB R64	RC R63	RD R87	RE R89	RF R47	RG R52,R53,R59 LOWPASS FREQ	V1 (VOLTS)	V2 (VOLTS)	V3 (VOLTS)	V4 (VOLTS)	V5 (VOLTS)	V6 (VOLTS)	WINDOWS (Hz)
GO1 & G07 ± 100 Hz NARROW SHIFT 2 FREQUENCY	0	4.53	21.0	18.7	4.32	20.0	76.8 (136 Hz)	7.5	7.5	10.5	8.59	6.72	4.83	+100 ± 50 -100 ± 50
GO2 & G08 ± 250 Hz WIDE SHIFT 2 FREQUENCY	0	18.2	68.1	54.9	15.0	20.0	38.3 (272 Hz)	7.5	7.5	13.3	10.5	4.83	2.03	+250 +50 -100 -250 -50 +100
GO3 & G09 ± 500 Hz EXTRA WIDE SHIFT 2 FREQUENCY	0	19.1	73.2	51.1	14.3	20.0	19.1 (544 Hz)	7.5	7.5	13.4	10.6	4.98	2.17	+500 +100 -200 -500 -100 +200
GO4 & G10 ± 250 Hz WIDE SHIFT 3 FREQUENCY	5.90	11.8	71.5	60.4	10.2	21.0	38.3 (272 Hz)	8.59	6.72	13.3	11.4	3.90	2.03	0 ± 50 +250 ± 50 -250 ± 50
GO5 & G11 ± 500 Hz EXTRA WIDE SHIFT 3 FREQUENCY	6.04	13.3	78.7	56.2	9.53	21.5	19.1 (544 Hz)	8.71	6.84	13.4	11.5	4.04	2.17	0 ± 100 +500 ± 100 -500 ± 100
GO6 & G12 ± 250 Hz WIDE SHIFT FOR PHASE COMPARISON	0	27.4	59.0	56.2	27.4	20.0	19.1 (544 Hz)	7.5	7.5	13.3	9.06	6.24	2.03	+250 +50 -175 -250 -50 +175

Figure 15–4. TCF–10B CLI and Discriminator Schematic (1606C51; Sheet 3 of 7).

Table 15–2. CLI & Discriminator Module Components (1606C51).

Location	Style	Description	Group
CAPACITORS			
C1	CP1002GH65	0.01 µF 2% 50 V C0G MONO CERAMIC	01 thru 12
C2	CP1002GH65	0.01 µF 2% 50 V C0G MONO CERAMIC	01 thru 12
C3	CP4700GH65	470 pF 2% 50 V C0G MONO CERAMIC	01 thru 12
C4	CP1201GL65	1,200 pF 2% 100 V C0G MONO CERAMIC	01 thru 12
C5	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 12
C6	CR200AGV92	20 pF 2% 500 V DIPPED MICA	01 thru 12
C7	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 12
C8	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 12
C9	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01 thru 12
C10	CP1001GH65	1,000 pF 2% 50 V C0G MONO CERAMIC	01 thru 12
C11	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C12	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C13	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C14	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C15	CP1001GH65	1,000 pF 2% 50 V C0G MONO CERAMIC	01 thru 12
C16	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01 thru 12
C17	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C18	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C19	CP1001GH65	1,000 pF 2% 50 V C0G MONO CERAMIC	01 thru 12
C20	CF2202GL70	0.022 pF 2% 100 V MET POLYCARB	01 thru 12
C21	CF3901GP70	3,900 pF 2% 200 V MET POLYCARB	01 thru 12
C22	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C23	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C24	CF1502GP78	0.015 µF 2% 200 V MET POLYCARB	01 thru 12
C25	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C26	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C27	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C28	CP1000KH65	100 µF 10% 50 V X7R MONO CERAMIC	01,02,03,04,05,06
C29	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01,02,03,04,05,06
C30	CP1004MH54	1.0 µF 20% 50 V MONO CERAMIC	01,02,03,04,05,06
C31	CP1004MH54	1.0 µF 20% 50 V MONO CERAMIC	01,02,03,04,05,06
C32	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C33	CP1001KL65	1,000 pF 10% 100 V X7R MONO CERAMIC	01 thru 12
C34	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12
C35	CF1004JH78	1.0 µF 5% 50 V MET POLYCARB	01 thru 12
C36	CJ1004MD72	1.0 µF 20% 20 V MOLDED TANTALUM	01 thru 12
C37	CJ4704MH72	4.7 µF 20% 50 V MOLDED TANTALUM	01 thru 12
C38	CJ4704MH72	4.7 µF 20% 50 V MOLDED TANTALUM	01 thru 12
C39	CJ1004MD72	1.0 µF 20% 20 V MOLDED TANTALUM	01 thru 12
C40	CT1002JU68	0.01 µF 5% 400 V MET POLYESTER	01,02,03,04,05,06
C41	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01 thru 07,09 thru 12

Table 15–2. CLI & Discriminator Module Components (Cont'd).

Location	Style	Description	Group
CONNECTORS			
JU2	9640A47H01	3 POSITION	01 thru 12
JU3	9640A47H01	3 POSITION	01 thru 12
DIGITAL ICs			
I2	9642A78H01	***NO ITEM DESCRIPTION***	12
I4	3527A09H01	MC14538BAL DUAL MONOSTABLE MULTIVIB	01 thru 12
I6	3536A51H01	MC14001BCP QUAD 2-INPUT NOR	01 thru 12
I7	3535A12H01	MC14013BCP DUAL D FLIP-FLOP	01 thru 12
I9	3536A27H01	MC14569BCP DUAL PROG 4-BIT DWN-CTR	01 thru 12
I12	9642A78H01	***NO ITEM DESCRIPTION***	01 thru 11
DIODES			
D3	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D4	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D5	836A928H06	1N4148 75 V 0.01 A	04,05,10,11
D6	836A928H06	1N4148 75 V 0.01 A	04,05,10,11
D7	836A928H06	1N4148 75 V 0.01 A	04,05,10,11
D8	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D9	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D10	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D11	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D12	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D13	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D14	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D15	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D16	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D17	836A928H08	1N4007 1,000 V 1 A	01,02,03,04,05,06
D18	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D19	836A928H06	1N4148 75 V 0.01 A	01 thru 12
D20	836A928H06	1N4148 75 V 0.01 A	01 thru 12
INDUCTORS			
L1	1495B88G01	INDUCTOR 5.48 MH +/-3%	01 thru 12
L2	1495B88G01	INDUCTOR 5.48 MH +/-3%	01 thru 12
JUMPERS			
JU1	862A478H01	ZERO OHM RESISTOR	05,09,11
JU48	862A478H01	ZERO OHM RESISTOR	09
R1	862A478H01	ZERO OHM RESISTOR	03
R48	862A478H01	ZERO OHM RESISTOR	01,02,03,06,07,08,12

(Continued on next page.)

Table 15–2. CLI & Discriminator Module Components (Cont'd).

Location	Style	Description	Group
LINEAR ICs			
IC15	9648A82H03	MC79L15ACP NEG VOLTREG 15 V 5% 0.1 A	01 thru 12
IC15	9648A82H03	MC79L15ACP NEG VOLTREG 15 V 5% 0.1 A	08
IC16	9648A02H05	MC78L15ACP POS VOLTREG 15 V 5% 0.1 A	04
I1	3534A29H02	RM4156DC QUAD OP-AMP	01 thru 12
I2	9646A34H01	LM13600A DUAL OP TRANSCOND AMP	01 thru 12
I3	3535A16H01	CA3160AE SINGLE OP-AMP	01 thru 12
I5	3534A29H02	RM4156DC QUAD OP-AMP	01 thru 12
I8	3537A40H01	MC3403P QUAD OP-AMP	01 thru 12
I10	3537A40H01	MC3403P QUAD OP-AMP	01 thru 12
I11	9645A92H01	TL494CN PULSE-WIDTH MODULATOR	01,02,03,04,05,06
I13	3534A39H02	MC78L05CP POS VOLTREG 5 V 5% 0.1 A	01 thru 12
I15	9648A82H03	MC79L15ACP NEG VOLTREG 15 V 5% 0.1 A	01,02,03,05,06,07,09,10,11,12
I16	9648A02H05	MC78L15ACP POS VOLTREG 15 V 5% 0.1 A	01,02,03,05 thru 12
QN1	3533A63H01	MPQ3906 QUAD PNP ARRAY 40 V 0.2 A	01 thru 12
QN2	3533A64H01	MPQ3904 QUAD NPN ARRAY 40 V 0.2 A	01 thru 12
METERS			
M1	9646A95H01	100UA F.S. RM=1 K	01,02,03,04,05,06
LEDs			
D1	3508A22H01	RED LED (EDGE MOUNT) 550-0406	01 thru 12
D2	3508A22H01	RED LED (EDGE MOUNT) 550-0406	01 thru 12
I14	774B936H02	MOC8204 OPTICAL ISOLATOR	01,02,03,05,06
IC14	774B936H02	MOC8204 OPTICAL ISOLATOR	04
POTENTIOMETERS			
R1	3534A25H07	10K 25T TOP ADJ	01,02,03,04,05,06
R18	3534A25H03	100 OHMS TOP ADJ. VAR. 25 TURN	01 thru 12
R25	3534A25H04	1K 25T TOP ADJ.	01 thru 12
R37	3534A25H07	10K 25T TOP ADJ	01 thru 12
R40	3534A25H10	100K POT	01 thru 12
R104	3534A25H07	10K 25T TOP ADJ	01,02,03,04,05,06
RELAYS			
K1	1484B33H01	AROMAT TYPE ST1E-DC 12V	01 thru 12

Table 15–2. CLI & Discriminator Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS			
R2	RM9532FQA9	95.3 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R3	RM2492FQA9	24.9 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R4	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R5	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R6	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R7	RM5111FQB0	5.11 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R8	RM1002DQA8	10.0 KILOHMS 0.5% 0.25 W METAL FILM	01 thru 12
R9	RM5621FQB0	5.62 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R10	RM1182FQA9	11.8 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R11	RM1002DQA8	10.0 KILOHMS 0.5% 0.25 W METAL FILM	01 thru 12
R12	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R13	RM6043FQ98	604 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R14	RM4993FQ98	499 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R15	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R16	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R17	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R19	RM5111FQB0	5.11 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R20	RM4530FQB1	453 OHMS 1% 0.25 W METAL FILM	01 thru 12
R21	RM1402FQA9	14.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R22	RM4530FQB1	453 OHMS 1% 0.25 W METAL FILM	01 thru 12
R23	RM6493FQ98	649 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R24	RM5111FQB0	5.11 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R26	RM1432FQA9	14.3 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R27	RM1002DQA8	10.0 KILOHMS 0.5% 0.25 W METAL FILM	01 thru 12
R28	RM2001FQB0	2.00 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R29	RM5111FQB0	5.11 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R30	RM8871FQB0	8.87 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R31	RM7872FQA9	78.7 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R32	RM4991FQB0	4.99 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R33	RM1001FQB0	1.00 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R34	RM1913FQ98	191 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R35	RM1873FQ98	187 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R36	RM4021FQB0	4.02 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R38	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R39	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R41	RM1332FQA9	13.3 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R42	RM1783FQ98	178 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R43	RM4751FQB0	4.75 KILOHMS 1% 0.25 W METAL FILM	04,05,10,11
R44	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01 thru 12
R45	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R46	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R47	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01,02,03,06,07, 08,09,12
R47	RM2102FQA9	21.0 KILOHMS 1% 0.25 W METAL FILM	04,10
R47	RM2152FQA9	21.5 KILOHMS 1% 0.25 W METAL FILM	05,11

(Continued on next page.)

Table 15–2. CLI & Discriminator Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS (Cont'd)			
R48	RM5901FQB0	5.90 KILOHMS 1% 0.25 W METAL FILM	04,10
R48	RM6041FQB0	6.04 KILOHMS 1% 0.25 W METAL FILM	05
R49	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R50	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01 thru 12
R51	RM1583FQ98	158 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R52	RM1912FQA9	19.1 KILOHMS 1% 0.25 W METAL FILM	03,05,06,09,11,12
R52	RM3832FQA9	38.3 KILOHMS 1% 0.25 W METAL FILM	02,04,08,10
R52	RM7682FQA9	76.8 KILOHMS 1% 0.25 W METAL FILM	01,07
R53	RM1912FQA9	19.1 KILOHMS 1% 0.25 W METAL FILM	03,05,06,09,11,12
R53	RM3832FQA9	38.3 KILOHMS 1% 0.25 W METAL FILM	02,04,08,10
R53	RM7682FQA9	76.8 KILOHMS 1% 0.25 W METAL FILM	01,07
R54	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R55	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01 thru 12
R56	RM1822FQA9	18.2 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R57	RM8871FQB0	8.87 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R58	RM4752FQA9	47.5 KILOHMS 1% 0.25 W METAL FILM	01,03 thru 12
R59	RM1912FQA9	19.1 KILOHMS 1% 0.25 W METAL FILM	03,05,06,09,11,12
R59	RM3832FQA9	38.3 KILOHMS 1% 0.25 W METAL FILM	02,04,08,10
R59	RM7682FQA9	76.8 KILOHMS 1% 0.25 W METAL FILM	01,07
R60	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R61	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01 thru 12
R62	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R63	RM2102FQA9	21.0 KILOHMS 1% 0.25 W METAL FILM	01,07
R63	RM5902FQA9	59.0 KILOHMS 1% 0.25 W METAL FILM	06,12
R63	RM6812FQA9	68.1 KILOHMS 1% 0.25 W METAL FILM	02,08
R63	RM7152FQA9	71.5 KILOHMS 1% 0.25 W METAL FILM	04,10
R63	RM7322FQA9	73.2 KILOHMS 1% 0.25 W METAL FILM	03,09
R63	RM7872FQA9	78.7 KILOHMS 1% 0.25 W METAL FILM	05,11
R64	RM1182FQA9	11.8 KILOHMS 1% 0.25 W METAL FILM	04,10
R64	RM1332FQA9	13.3 KILOHMS 1% 0.25 W METAL FILM	05,11
R64	RM1822FQA9	18.2 KILOHMS 1% 0.25 W METAL FILM	02,08
R64	RM1912FQA9	19.1 KILOHMS 1% 0.25 W METAL FILM	03,09
R64	RM2742FQA9	27.4 KILOHMS 1% 0.25 W METAL FILM	06,12
R64	RM4531FQB0	4.53 KILOHMS 1% 0.25 W METAL FILM	01,07
R65	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R66	RM1102FQA9	11.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R67	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01 thru 12
R68	RM1212FQA9	12.1 KILOHMS 1% 0.25 W METAL FILM	04,05,10,11
R69	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R70	RM1211FQB0	1.21 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R71	RM1211FQB0	1.21 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R72	RM1212FQA9	12.1 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R73	RM4751FQB0	4.75 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R74	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R75	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R76	RM1211FQB0	1.21 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R77	RM4751FQB0	4.75 KILOHMS 1% 0.25 W METAL FILM	01 thru 12

Table 15–2. CLI & Discriminator Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS (Cont'd)			
R78	RM4751FQB0	4.75 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R79	RM1212FQA9	12.1 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R80	RM1301FQB0	1.30 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R81	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R82	RM5111FQB0	5.11 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R83	RM3320FQB1	332 OHMS 1% 0.25 W METAL FILM	01 thru 12
R84	RM1211FQB0	1.21 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R85	RM3012FQA9	30.1 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R86	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01 thru 12
R87	RM1872FQA9	18.7 KILOHMS 1% 0.25 W METAL FILM	01,07
R87	RM5112FQA9	51.1 KILOHMS 1% 0.25 W METAL FILM	03,09
R87	RM5492FQA9	54.9 KILOHMS 1% 0.25 W METAL FILM	02,08
R87	RM5622FQA9	56.2 KILOHMS 1% 0.25 W METAL FILM	05,06,11,12
R87	RM6042FQA9	60.4 KILOHMS 1% 0.25 W METAL FILM	04,10
R88	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R89	RM1022FQA9	10.2 KILOHMS 1% 0.25 W METAL FILM	04,10
R89	RM1432FQA9	14.3 KILOHMS 1% 0.25 W METAL FILM	03,09
R89	RM1502FQA9	15.0 KILOHMS 1% 0.25 W METAL FILM	02,08
R89	RM2742FQA9	27.4 KILOHMS 1% 0.25 W METAL FILM	06,12
R89	RM4321FQB0	4.32 KILOHMS 1% 0.25 W METAL FILM	01,07
R89	RM9531FQB0	9.53 KILOHMS 1% 0.25 W METAL FILM	05,11
R90	RM1102FQA9	11.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R91	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R92	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01 thru 12
R93	RM1103FQ98	110 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R94	RM6810FQB1	681 OHMS 1% 0.25 W METAL FILM	01 thru 12
R95	RM1211FQB0	1.21 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R96	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R97	RM1213FQ98	121 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R98	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R99	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R100	RM1402FQA9	14.0 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R101	RM1622FQA9	16.2 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R102	RM1823FQ98	182 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R103	RM1473FQ98	147 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R105	RM3162FQA9	31.6 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R106	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R107	RM2211FQB0	2.21 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R108	RM2001FQB0	2.00 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R109	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R110	RM5110FQB1	511 OHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R111	RC1301J167	1.3 KILOHMS 5% 1 W CARBON COMP	01 thru 12
R112	RM3921FQB0	3.92 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R113	RM3322FQA9	33.2 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R114	RM3322FQA9	33.2 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06

(Continued on next page.)

Table 15–2. CLI & Discriminator Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS (Cont'd)			
R115	RM1004FQ99	1.00 MEGOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R116	RM2671FQB0	2.67 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R117	RM2941FQB0	2.94 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R119	RM6651FQB0	6.65 KILOHMS 1% 0.25 W METAL FILM	01,02,03,04,05,06
R120	RM2493FQ98	249 KILOHMS 1% 0.25 W METAL FILM	01 thru 12
R121	RM1823FQ98	182 KILOHMS 1% 0.25 W METAL FILM	01 thru 10,12
THERMISTORS			
RT1	185A211H14	1,000 OHM NTC	01,02,03,04,05,06
TRANSISTORS			
Q1	9649A24H01	2N4939 DUAL AMP	01 thru 12
Q2	3509A35H12	2N5210 50 V 0.05A 1.0 W NPN	01,02,03,04,05,06

Chapter 16. Receiver Logic Module

Schematic	CF30RXLMN
Parts List	CF40RXLMN

Table 16–1. CF20-RXLMN-00X Styles and Descriptions.

Style	Description
001	2-FREQUENCY UB, PORTT, DTT
003	2-FREQUENCY PHASE COMPARISON
002	3-FREQUENCY DUAL UB, PORTT, DTT

16.1 Module Description

This new version of the Receiver Logic Module — model CF20-RXLMN-00X — replaces the previous version — model 1606C52G0X — in all new TCF–10B carrier sets. The new model is pin-for-pin compatible with the previous version, allowing for easy replacement/upgrading. It provides all of the same functions as the previous version, but with added flexibility.

Instead of just selecting the amount of time for a timer setting (e.g., trip delay, guard hold time, trip hold time), you now have the option of disabling, or not using, it. You can set any of the timers — or other options — for your application using the module's three banks of DIP switches (see "Setting the DIP Switches for Your Application" later in this chapter).

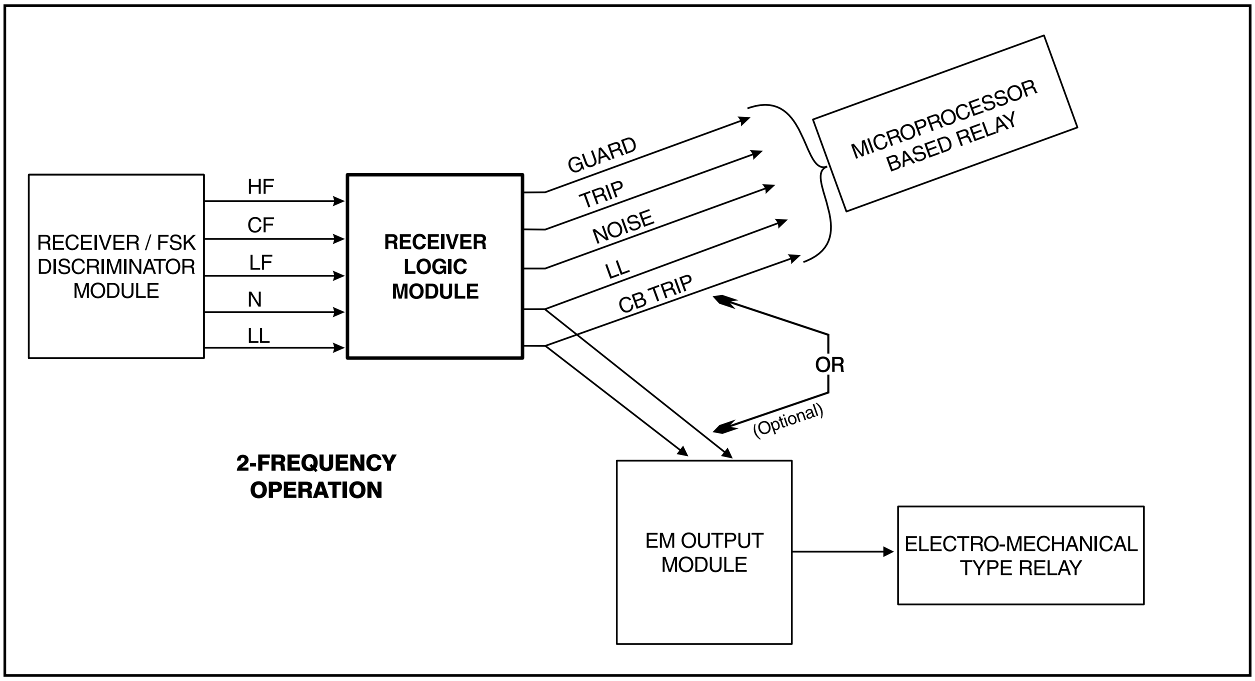


Figure 16–1. Simplified Signal Flow Diagram for 2-Frequency Operation.

The module now uses a programmable logic array, in the form of an EPLD plug-in chip, to control the module's logic functions. The chip that comes with each module is already programmed for the functions used in one of the following types of application:

- 2-Frequency Directional Comparison
- 3-Frequency Directional Comparison
- 2-Frequency Phase Comparison

The Receiver Logic Modules installed in all TCF–10B carrier sets are identical except for the EPLD plug-in chip controlling its logic functions and the front panel, which provides LEDs specific to one of the application types listed above.

Your new TCF–10B Receiver Logic Module is shipped to you already customized for your application. That is, the front panel has the appropriate LEDs for your application and an EPLD chip that is already programmed with the relevant logic and functions. Likewise, the module's DIP switches are preset to the most secure settings for your application. For a complete set of tables showing you the DIP switch settings for the different types of application, as well as the default, or shipped, settings, please see the "Setting the DIP Switches for Your Application" section later in this chapter.

These tables are accompanied by descriptions of each type of setting and explanations of their effect.

Also with this new model, the module's output is no longer limited to a 20 Vdc power source. The new output is a 1 Amp, switched transistor output that you can drive from the station battery using 250, 125 or 48 Vdc. This means that you no longer need the auxiliary power supply (1610C07GXX), unless you are interfacing with a 20 Volt based relay system, such as Uniflex or SKDU/SKBU.

16.1.1 How It Works

During operation, the Receiver Logic Module takes the incoming signal from the Receiver/FSK Discriminator Module and, after determining the proper response, generates the appropriate guard and trip outputs. The module provides both the 1 Amp, optically isolated, transistor switched (solid state) output for microprocessor based relays and, for electro-mechanical relay systems requiring contact outputs, a signal to the EM (Electro-Mechanical) Output Module.

The possible inputs the module receives from the Receiver/FSK Discriminator Module include the high frequency, center frequency, and low

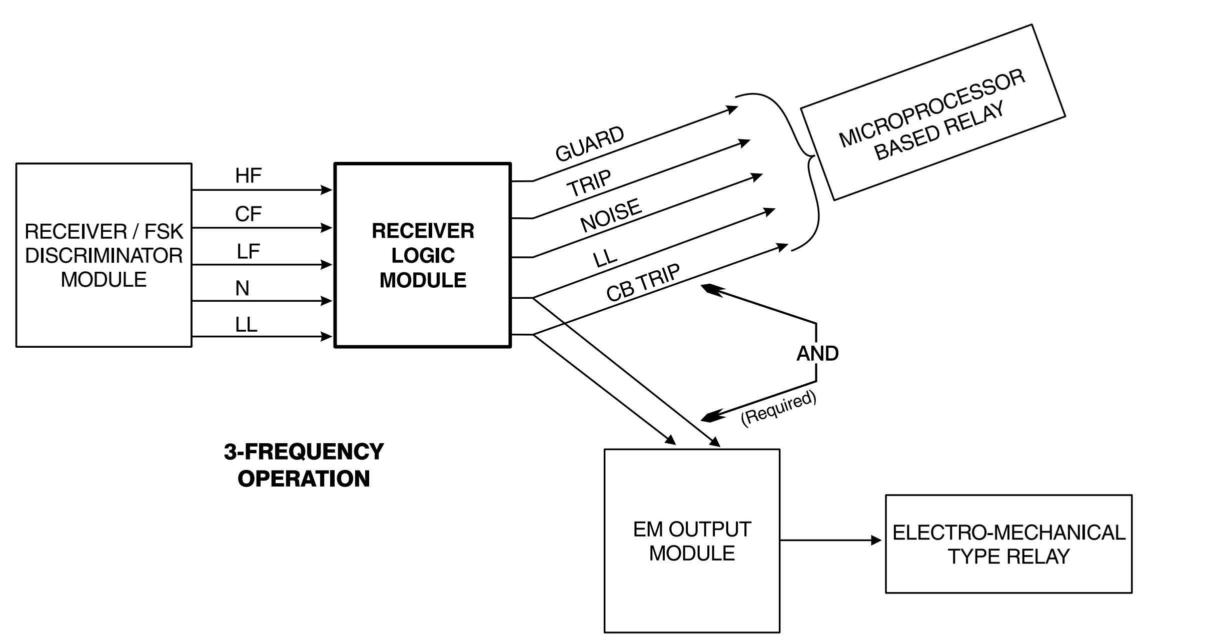


Figure 16–2. Simplified Signal Flow Diagram for 3-Frequency Operation.

frequency signals, as well as (line) noise and low level signals.

The specific outputs the Receiver Logic Module generates are determined by the type of application (see "Receiver Logic Output Signals" below), the conditions of the input signal, and the settings of the module's DIP switches.

16.1.2 Upgrade Information

To make upgrading to the new version (CF20-RXLMN) of the Receiver Logic Module as easy as possible, we have kept it pin-for-pin compatible with the previous version (1606C52G01). We have also kept all the functions of the previous version. This lets you take advantage of the added features and flexibility of the new version without having to reconfigure your system.

Upgrading to the new version of the Receiver Logic Module is as easy as 1–2–3:

1. Remove your old Receiver Logic Module.
2. Verify that the DIP switch settings on the new module are set correctly for your application (see "Setting the DIP Switches for Your Application").
3. Insert your new Receiver Logic Module.

16.1.3 Receiver Logic Output Signals

The module provides output signals for the following types of application:

- 2-Frequency Directional Comparison (CF30-RXLMN-001)
- 3-Frequency Directional Comparison (CF30-RXLMN-002)
- 2-Frequency Phase Comparison (CF30-RXLMN-003)

Functional block diagrams are shown for each of these applications in Figures 16-6 (2-Frequency Directional Comparison), 16-7 (3-Frequency Directional Comparison), and 16-8 (2-Frequency Phase Comparison). The diagrams include the logic, inputs, outputs, DIP switch settings, and external (TCF–10B rear panel) connections for each application.

2-Frequency Phase Comparison Outputs

All 2-Frequency Phase Comparison output signals are 1 A switched transistor (solid state). These four output signals are:

- Trip Positive (Mark)
- Trip Negative (Space)
- Low Level
- Noise

2-Frequency Directional Comparison Outputs

For 2-Frequency Directional Comparison applications, the module provides both 1 A switched transistor (solid state) and electro-mechanical output signals.

The five 1 A, switched transistor (solid state) output signals are:

- UB/POTT (Trip 2)
- Guard
- Low Signal 1
- Checkback Trip 1
- Noise

The two electro-mechanical output signals are:

- Trip 1 (DTT)
- Guard 1

3-Frequency Directional Comparison Outputs

For 3-Frequency Directional Comparison applications, the module provides both 1 A switched transistor (solid state) and electro-mechanical output signals.

The five 1 A switched transistor (solid state) output signals are:

- UB/POTT (Trip 2)
- Guard 2
- Low Signal 2
- Checkback Trip 2
- Noise

The two electro-mechanical output signals are:

- Trip 1/Trip 2
- Guard 1

16.1.4 Receiver Logic Front Panels

The front panel front panel of the TC–10B Receiver Logic Module comes in three variations, one for each of the three application types (2-Frequency Directional Comparison, 3-Frequency Directional Comparison, and 2-Frequency Phase Comparison). Your module comes with front panel that fits your application.

2-F Directional Comparison Front Panel

The front panel for 2-Frequency Directional Comparison applications is shown in Figure 16-3. Its four LEDs provide the following signal indications:

GOOD CHANNEL (this green LED is lit to indicate an absence of noise and low level)

CHECKBACK TRIP (this red LED is lit to indicate a low frequency is received; this will be the only LED lit when a low frequency is received after a loss-of-channel without a guard return)

TRIP (this red LED is lit to indicate a low frequency is received, i.e., the frequency shifts low)

GUARD (this red LED is lit to indicate a high frequency is received, i.e., no frequency shift; the operation is normal)

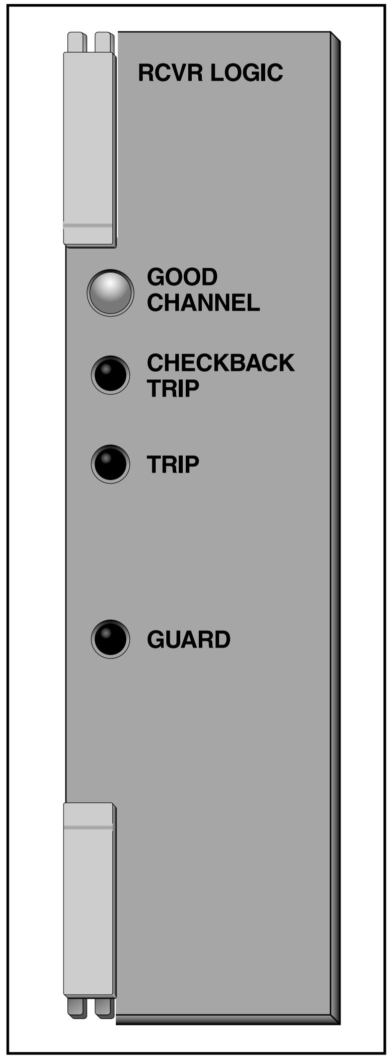


Figure 16–3. Front Panel for 2-Frequency Directional Comparison (Transfer Trip/Unblock) Applications.

3-F Directional Comparison Front Panel

The front panel for 3-Frequency Directional Comparison applications is shown in Figure 16-4. Its five LEDs provide the following signal indications:

GOOD CHANNEL (this green LED is lit to indicate an absence of noise and low level)

CHECKBACK TRIP (this red LED is lit to indicate a low frequency or high frequency is received, depending on the position of SW3-6; this LED will be lit without its corresponding trip LED when the high or low frequency is received following a loss-of-channel without a guard return))

UB/POTT TRIP (this red LED is lit to indicate a high frequency is received, i.e., the frequency shifts high)

DTT TRIP (this red LED is lit to indicate a low frequency is received, i.e., the frequency shifts low, indicating a direct transfer trip)

GUARD (this red LED is lit to indicate the center frequency is received, i.e., no frequency shift; the operation is normal)

2-F Phase Comparison Front Panel

The front panel for 2-Frequency Phase Comparison applications is shown in Figure 16-5. Its three LEDs provide the following signal indications:

GOOD CHANNEL (this green LED is lit to indicate an absence of noise and low level)

TRIP POSITIVE (Mark) (this red LED and the Trip Negative LED alternately flash back and forth very rapidly — approx. 60 times a second each — to indicate normal operation of comparing phases)

TRIP NEGATIVE (Space) (this red LED and the Trip Positive LED alternately flash back and forth very rapidly — approx. 60 times a second each — to indicate normal operation of comparing phases)

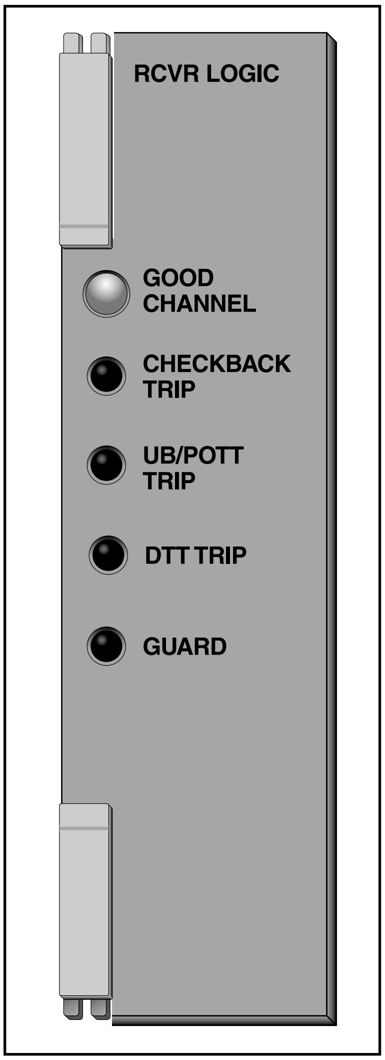


Figure 16–4.
Front Panel for 3-Frequency Directional Comparison (Transfer Trip/Unblock) Applications.

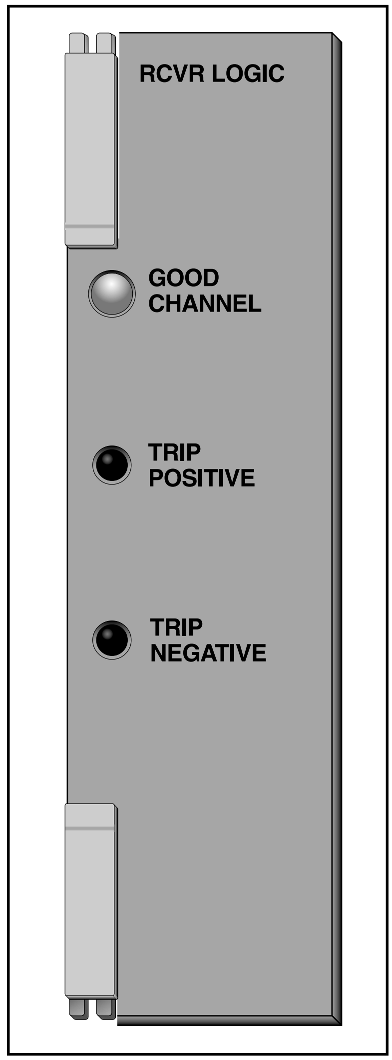


Figure 16–5.
Front Panel for 2-Frequency Phase Comparison Applications.

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16.1.5 Rear Panel Connections

Figure 16-6 shows the connection points for terminal block TB1 on the rear panel of your TCF–10B carrier set. It also shows the function of each position, or connection point. You make all your relay connections for both microprocessor based and electro-mechanical type relays to this terminal block.

For additional diagrams showing all the external (rear panel) connections for your TCF–10B, please refer to Figure 3-4 and Figure 3-5 in Chapter 3 and Figure 7-1 in Chapter 7. For DIN connector pinouts for each application, please see Figure 16-7 (2-F Directional Comparison), Figure 15-8 (3-F Directional Comparison), and Figure 15-9 (2-F Phase Comparison).

16.2 Receiver Logic Signal Paths

The Receiver Logic Module has a different signal flow for each type of application. This is due primarily to the different plug-in EPLD chips used. The input signal (from the Receiver/FSK Discriminator Module) and your DIP switch settings also play a role. Figures 16-7, 16-8, and 16-9 provide functional block diagrams showing the logic and signal path for each application (2-F Directional Comparison, 3-F Directional Comparison, and 2-F Phase Comparison, respectively).

These three figures also show the logic states for the input from the Receiver/FSK Discriminator Module and (for the Directional Comparison applications) the output to the EM Output Module, the DIP switch settings, and the DIN connector pinouts — providing a comprehensive look at the module's signal flow.

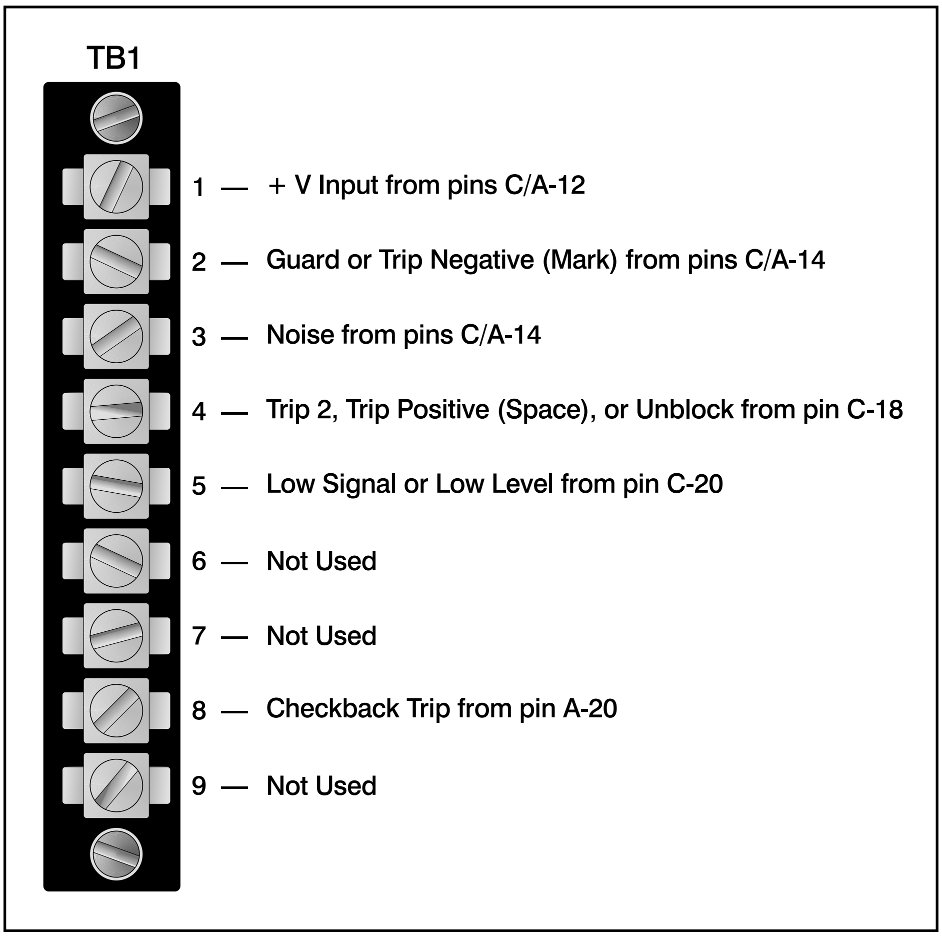

Figure 16–6. Receiver Logic External (Rear Panel) Connections.

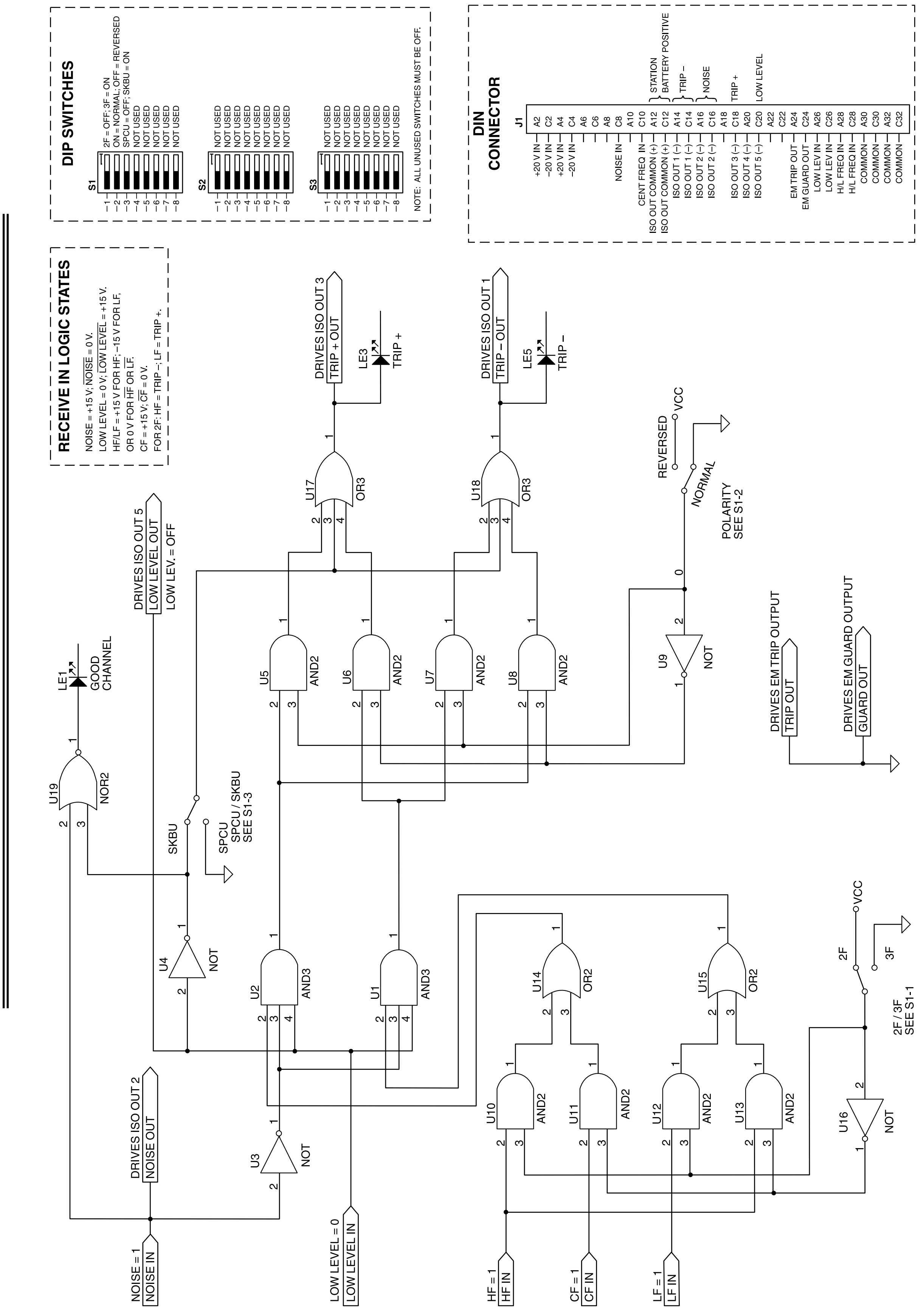

Figure 16–7. Phase Comparison Functional Block Diagram.

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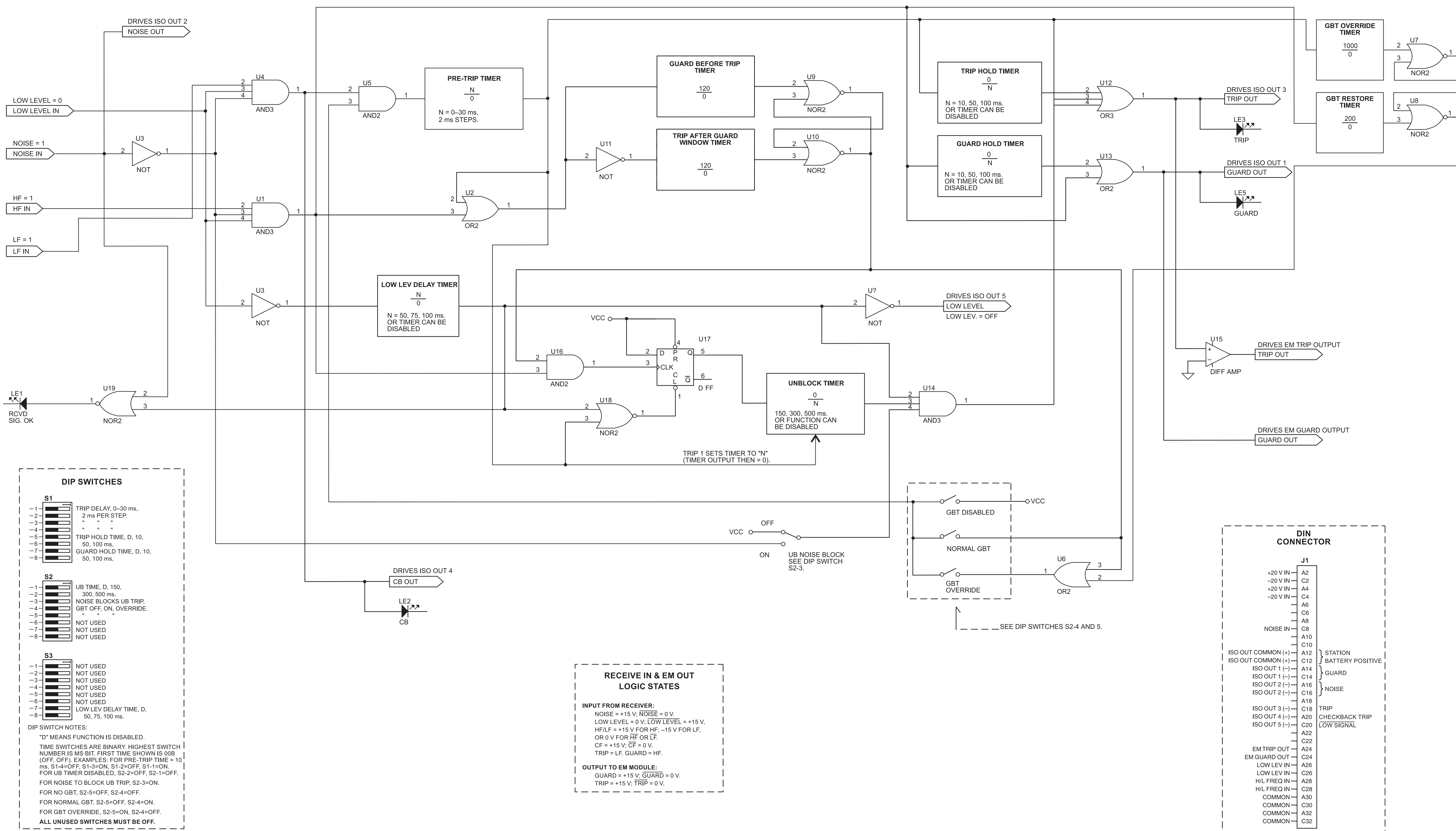

Figure 16–7. 2-Frequency Directional Comparison Functional Block Diagram.

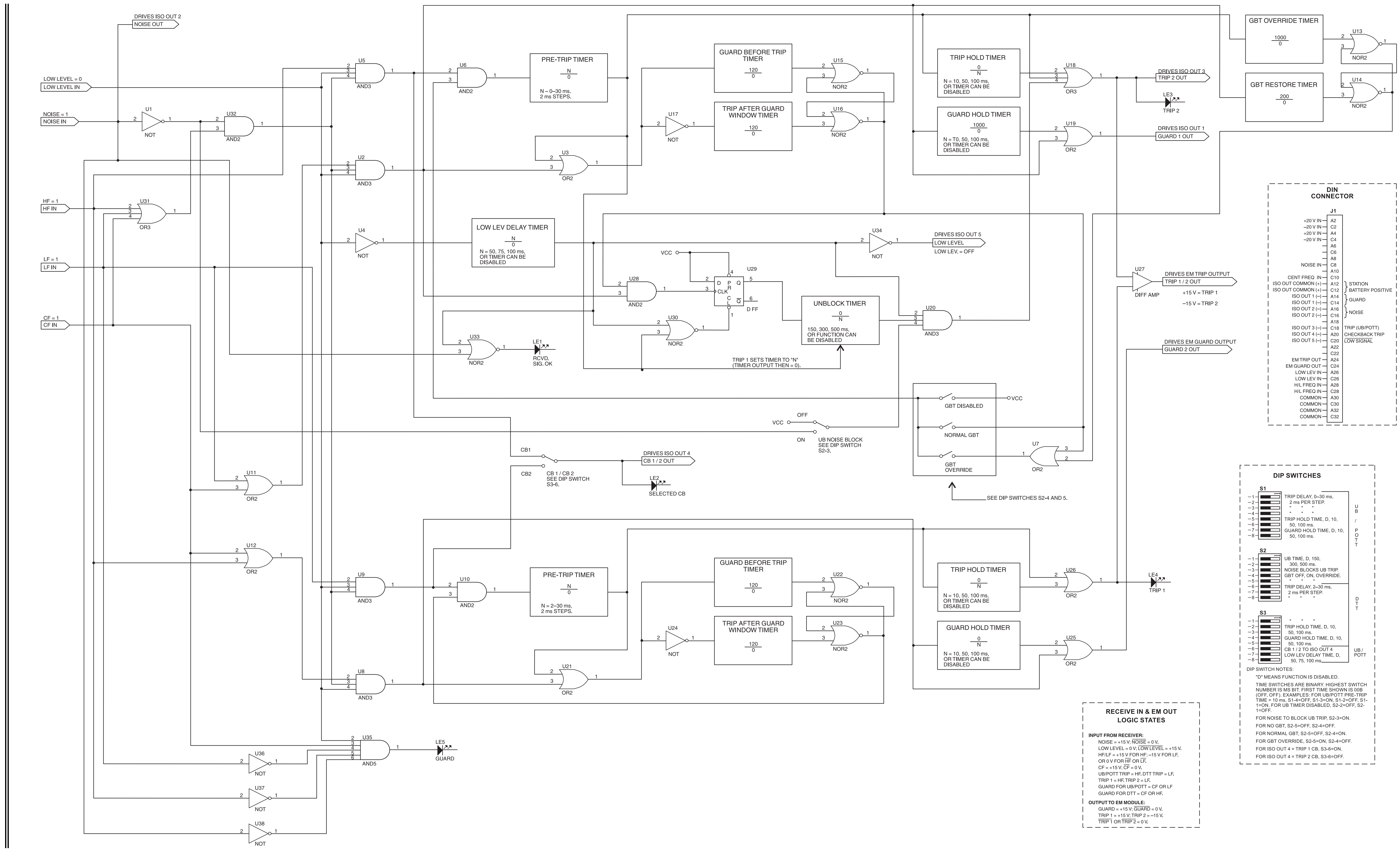

Figure 16–8. 3-Frequency Directional Comparison Functional Block Diagram.

16.3 Setting the DIP Switches for Your Application

As noted earlier, the Receiver Logic Module uses a plug-in EPLD chip to control its logic functions. Your Receiver Logic Module comes to you with the EPLD chip for your type of application already installed. The only adjustments you need to consider are the module's DIP switch settings. Following are three sets of tables showing you all the DIP switch settings that apply to each type of application. The tables also show you the default, or shipped, setting for each switch. These are the most secure settings for your application. Accompanying each table is a description of that switch setting and an explanation of its effect.

16.3.1 Switch Settings for 2-Frequency Directional Comparison (POTT/DTT/UB) Applications

Pre-Trip Timer (POTT/DTT/UB 2F)

The Pre-Trip Timer does not allow tripping until the trip signal has been present for the time you set. You can set this timer from 0 to 30 ms in 2 ms increments. A typical application of this timer in Direct Transfer Trip systems is to set it for the maximum delay possible. Limitations on the critical clearing time of the power system will have a direct impact on this setting. In Directional Comparison Unblock/POTT systems, you set this timer for 0 ms.

The trip delay time switch settings are listed in Table 16-2.

Table 16–2. Trip Delay Switch Settings for POTT/DTT/UB 2F Applications.

TIME IN ms	SW1-1	SW1-2	SW1-3	SW1-4
0	OPEN	OPEN	OPEN	OPEN
2	CLOSED	OPEN	OPEN	OPEN
4	OPEN	CLOSED	OPEN	OPEN
6	CLOSED	CLOSED	OPEN	OPEN
8	OPEN	OPEN	CLOSED	OPEN
10	CLOSED	OPEN	CLOSED	OPEN
12	OPEN	CLOSED	CLOSED	OPEN
14	CLOSED	CLOSED	CLOSED	OPEN
16	OPEN	OPEN	OPEN	CLOSED
18	CLOSED	OPEN	OPEN	CLOSED
20	OPEN	CLOSED	OPEN	CLOSED
22	CLOSED	CLOSED	OPEN	CLOSED
24	OPEN	OPEN	CLOSED	CLOSED
26	CLOSED	OPEN	CLOSED	CLOSED
28	OPEN	CLOSED	CLOSED	CLOSED
30	CLOSED	CLOSED	CLOSED	CLOSED

Position when shipped (30 ms row)

Trip Hold Timer (POTT/DTT/UB 2F)

The Trip Hold Timer lets you stretch the trip output. You can set it for 10, 50, or 100 ms or disable (0 ms) it. We recommend that you use the disabled setting in the Unblock/POTT to avoid problems with transient blocking.

The trip hold time switch settings are listed in Table 16-3.

Table 16–3. Trip Hold Time Switch Settings for POTT/DTT/UB 2F Applications.

TIME IN ms	SW1-5	SW1-6
DISABLED	OPEN	OPEN
10	CLOSED	OPEN
50	OPEN	CLOSED
100	CLOSED	CLOSED

Guard Hold Timer (POTT/DTT/UB 2F)

The Guard Hold Timer stretches the guard output by the amount you set. You can set it for 10, 50, or 100 ms or disable (0 ms) it. The disabled setting is appropriate for most applications.

The guard hold time switch settings are listed in Table 16-4.

Table 16–4. Guard Hold Time Switch Settings for POTT/DTT/UB 2F Applications.

TIME IN ms	SW1-7	SW1-8
DISABLED	OPEN	OPEN
10	CLOSED	OPEN
50	OPEN	CLOSED
100	CLOSED	CLOSED

Position when shipped (arrows point to the DISABLED rows of Tables 16–3, 16–4 and 16–5)

Unblock Timer (POTT/DTT/UB 2F)

The Unblock Timer provides a trip window for the time set on loss of channel, which is defined as low level and loss of guard. You can set it for 150, 300, or 500 ms. The normal setting is 150 ms in the Unblock system and disabled for all other applications. This is what differentiates the Unblock system from the POTT.

The unblock time switch settings are listed in Table 16-5.

Table 16–5. Unblock Time Switch Settings for POTT/DTT/UB 2F Applications.

TIME IN ms	SW2-1	SW2-2
DISABLED	OPEN	OPEN
150	CLOSED	OPEN
300	OPEN	CLOSED
500	CLOSED	CLOSED

Noise Block of Unblock (POTT/DTT/UB 2F)

With this switch (SW2-3) closed, noise will disable the Unblock trip window. Normal application is with this switch opened.

The noise block of unblock switch settings are listed in Table 16-6.

Table 16–6. Noise Block of Unblock Switch Settings for POTT/DTT/UB 2F Applications.

FUNCTION	SW2-3
NOISE ALLOWS UB TRIP	OPEN
NOISE BLOCKS UB TRIP	CLOSED

Guard before Trip (POTT/DTT/UB 2F)

With this function set to “on without override”, the logic requires guard to be received for 120 ms before the system is allowed to trip. With it set to “on with override”, the 120 ms guard return is required except where trip has been received for over 1,000 ms; if there is a loss of channel, then the guard is not required prior to tripping. Typically, you would use this where open breaker keying is required.

The guard before trip time switch settings are listed in Table 16-7.

Table 16–7. Guard Before Trip Switch Settings for POTT/DTT/UB 2F Applications.

FUNCTION	SW2-4	SW2-5
OFF	OPEN	OPEN
ON W/O OVER	CLOSED	OPEN
ON W OVER	OPEN	CLOSED
NOT USED	CLOSED	CLOSED

Position when shipped (arrows point to rows NOISE ALLOWS UB TRIP / OPEN, ON W/O OVER / CLOSED / OPEN, and DISABLED / OPEN / OPEN)

Low Level Delay Timer (POTT/DTT/UB 2F)

The Low Level Delay Timer delays the Unblock timer from initiating a trip window on loss of channel; it also delays the low level output. You can set it for 50, 75, or 100 ms or disable (0 ms) it.

The low level delay time switch settings are listed in Table 16-8.

Table 16–8. Low Level Delay Switch Settings for POTT/DTT/UB 2F Applications.

TIME IN ms	SW3-7	SW3-8
DISABLED	OPEN	OPEN
50	CLOSED	OPEN
75	OPEN	CLOSED
100	CLOSED	CLOSED

NOTE:
SW2-6 through SW2-8 and SW3-1 through SW3-6 are not used in the 2-Frequency Directional Comparison logic program.

16.3.2 Switch Settings for POTT/UB 3F Applications

Pre-Trip Timer (POTT/UB 3F)

The Pre-Trip Timer does not allow tripping until the trip signal has been present for the time you set. You can set this timer from 0 (disabled) to 30 ms in 2 ms increments. A typical application of this timer in Direct Transfer Trip systems is to set it for the maximum delay possible. Limitations on the critical clearing time of the power system will have a direct impact on this setting. In Directional Comparison Unblock/POTT systems, you set this timer for 0 ms.

The trip delay time switch settings are listed in Table 16-9.

Table 16–9. Trip Delay Switch Settings for POTT/UB 3F Applications.

TIME IN ms	SW1-1	SW1-2	SW1-3	SW1-4
0	OPEN	OPEN	OPEN	OPEN
2	CLOSED	OPEN	OPEN	OPEN
4	OPEN	CLOSED	OPEN	OPEN
6	CLOSED	CLOSED	OPEN	OPEN
8	OPEN	OPEN	CLOSED	OPEN
10	CLOSED	OPEN	CLOSED	OPEN
12	OPEN	CLOSED	CLOSED	OPEN
14	CLOSED	CLOSED	CLOSED	OPEN
16	OPEN	OPEN	OPEN	CLOSED
18	CLOSED	OPEN	OPEN	CLOSED
20	OPEN	CLOSED	OPEN	CLOSED
22	CLOSED	CLOSED	OPEN	CLOSED
24	OPEN	OPEN	CLOSED	CLOSED
26	CLOSED	OPEN	CLOSED	CLOSED
28	OPEN	CLOSED	CLOSED	CLOSED
30	CLOSED	CLOSED	CLOSED	CLOSED

Position when shipped (← 30 ms row)

Trip Hold Timer (POTT/UB 3F)

The Trip Hold Timer lets you stretch the trip output. You can set it for 10, 50, or 100 ms or disable (0 ms) it. We recommend that you use the disabled setting in the Unblock/POTT to avoid problems with transient blocking.

The trip hold time switch settings for 3-frequency UB/POTT applications are listed in Table 16-10. The trip hold time switch settings for 3-frequency DTT applications are listed in Table 16-10.

Table 16–10. Trip Hold Time Switch Settings for POTT/UB 3F Applications.

TIME IN ms	SW1-5	SW1-6
DISABLED	OPEN	OPEN
10	CLOSED	OPEN
50	OPEN	CLOSED
100	CLOSED	CLOSED

Guard Hold Timer (POTT/UB 3F)

The Guard Hold Timer stretches the guard output by the amount you set. You can set it for 10, 50, or 100 ms or disable (0 ms) it. The disabled setting is appropriate for most applications.

The guard hold time switch settings for 3-frequency UB/POTT applications are listed in Table 16-12. The guard hold time switch settings for 3-frequency DTT applications are listed in Table 16-11.

Table 16–11. Guard Hold Time Switch Settings for POTT/UB 3F Applications.

TIME IN ms	SW1-7	SW1-8
DISABLED	OPEN	OPEN
10	CLOSED	OPEN
50	OPEN	CLOSED
100	CLOSED	CLOSED

Position when shipped (DISABLED row in Tables 16–10, 16–11 and 16–12)

Unblock Timer (POTT/UB 3F)

The Unblock Timer provides a trip window for the time set on loss of channel, which is defined as low level and loss of guard. You can set it for 150, 300, or 500 ms. The normal setting is 150 ms in the Unblock system and disabled for all other applications. This timer is what differentiates the Unblock system from the POTT.

The unblock time switch settings are listed in Table 16-12.

Table 16–12. Unblock Time Switch Settings for POTT/UB 3F Applications.

TIME IN ms	SW2-1	SW2-2
DISABLED	OPEN	OPEN
150	CLOSED	OPEN
300	OPEN	CLOSED
500	CLOSED	CLOSED

Noise Block of Unblock (POTT/UB 3F)

With this switch (SW2-3) closed, noise will disable the Unblock trip window. Normal application is with this switch opened.

The noise block of unblock switch settings are listed in Table 16-13.

Table 16–13. Noise Block of Unblock Switch Settings for POTT/UB 3F Applications.

FUNCTION	SW2-3
NOISE ALLOWS UB TRIP	OPEN ← Position when shipped
NOISE BLOCKS UB TRIP	CLOSED

Guard before Trip (POTT/UB 3F)

With this function set to "on without override", the logic requires guard to be received for 120 ms before the system is allowed to trip. With it set to "on with override", the 120 ms guard return is required except where trip has been received for over 1,000 ms; if there is a loss of channel, then the guard is not required prior to tripping. Typically, you would use this where open breaker keying is required.

The guard before trip time switch settings are listed in Table 16-14.

Table 16–14. Guard Before Trip Switch Settings for POTT/UB 3F Applications.

TIME IN ms	SW2-4	SW2-5
OFF	OPEN	OPEN
ON W/O OVER	CLOSED	OPEN ← Position when shipped
ON W OVER	OPEN	CLOSED
NOT USED	CLOSED	CLOSED

Low Level Delay Timer (POTT/UB 3F)

The Low Level Delay Timer delays the Unblock timer from initiating a trip window on loss of channel; it also delays the low level output. You can set it for 50, 75, or 100 ms or disable (0 ms) it.

The low level delay time switch settings are listed in Table 16-15.

Table 16–15. Low Level Delay Switch Settings for POTT/UB 3F Applications.

TIME IN ms	SW3-7	SW3-8
DISABLED	OPEN	OPEN ← Position when shipped
50	CLOSED	OPEN
75	OPEN	CLOSED
100	CLOSED	CLOSED

NOTE:

Your Receiver Logic Module is shipped to you with SW3-6 set to the CLOSED position. This is currently the only active setting for this switch, so be sure to *leave it in the CLOSED position.*

16.3.3 Switch Settings for DTT 3F Applications

Pre-Trip Timer (DTT 3F)

The Pre-Trip Timer does not allow tripping until the trip signal has been present for the time you set. You can set this timer from 2 to 30 ms in 2 ms increments. A typical application of this timer in Direct Transfer Trip systems is to set it for the maximum delay possible. Limitations on the critical clearing time of the power system will have a direct impact on this setting.

The trip delay time switch settings are listed in Table 16-16.

Table 16–16. Trip Delay Switch Settings for DTT 3F Applications.

TIME IN ms	SW2-6	SW2-7	SW2-8	SW3-1
2	OPEN	OPEN	OPEN	OPEN
2	CLOSED	OPEN	OPEN	OPEN
4	OPEN	CLOSED	OPEN	OPEN
6	CLOSED	CLOSED	OPEN	OPEN
8	OPEN	OPEN	CLOSED	OPEN
10	CLOSED	OPEN	CLOSED	OPEN
12	OPEN	CLOSED	CLOSED	OPEN
14	CLOSED	CLOSED	CLOSED	OPEN
16	OPEN	OPEN	OPEN	CLOSED
18	CLOSED	OPEN	OPEN	CLOSED
20	OPEN	CLOSED	OPEN	CLOSED
22	CLOSED	CLOSED	OPEN	CLOSED
24	OPEN	OPEN	CLOSED	CLOSED
26	CLOSED	OPEN	CLOSED	CLOSED
28	OPEN	CLOSED	CLOSED	CLOSED
30	CLOSED	CLOSED	CLOSED	CLOSED

Position when shipped (30 ms row)

Trip Hold Timer (DTT 3F)

The Trip Hold Timer lets you stretch the trip output. You can set it for 10, 50, or 100 ms or disable (0 ms) it. We recommend that you use the disabled setting in the Unblock/POTT to avoid problems with transient blocking.

The trip hold time switch settings are listed in Table 16-17.

Table 16–17. Trip Hold Time Switch Settings for DTT 3F Applications.

TIME IN ms	SW3-2	SW3-3
DISABLED	OPEN	OPEN
10	CLOSED	OPEN
50	OPEN	CLOSED
100	CLOSED	CLOSED

Position when shipped

Guard Hold Timer (DTT 3F)

The Guard Hold Timer stretches the guard output by the amount you set. You can set it for 10, 50, or 100 ms or disable (0 ms) it. The disabled setting is appropriate for most applications.

The guard hold time switch settings are listed in Table 16-18.

Table 16–18. Guard Hold Time Switch Settings for DTT 3F Applications.

TIME IN ms	SW3-4	SW3-5
DISABLED	OPEN	OPEN
10	CLOSED	OPEN
50	OPEN	CLOSED
100	CLOSED	CLOSED

16.3.3 Switch Settings for Phase Comparison 2F Applications

Polarity

This switch lets you define the high frequency as trip positive (mark) and the low frequency as trip negative (space). The “NORMAL” setting sets the high frequency as trip negative (space) and the low frequency as trip positive (mark).

The polarity switch settings are listed in Table 16-19.

Table 16–19. Polarity Switch Settings for Phase Comparison Applications.

POLARITY	SW1-2
NORMAL	CLOSED
REVERSED	OPEN

Position when shipped (NORMAL / CLOSED for SW1-2; SKBU / CLOSED for SW1-3)

SPCU/SKBU

This switch lets you define what the logic does for a low level. In the SPCU, a low level or noise clamps trip positive and trip negative to a logical zero. In SKBU, a low level clamps trip positive and trip negative to a logical one.

The SPCU/SKBU switch settings are listed in Table 16-20.

Table 16–20. SPCU/SKBU Switch Settings for Phase Comparison Applications.

PHASE COMPARISON TYPE	SW1-3
SPCU	OPEN
SKBU	CLOSED

NOTE:
Your Receiver Logic Module is shipped to you with SW1-1 set to the OPEN position. This is currently the only active setting for this switch, so be sure to *leave it in the OPEN position.* SW1-4 through SW1-8, SW2-1 through SW2-8 and SW3-1 through SW3-8 are not used in the 2-Frequency Phase Comparison logic programs.

16.4 Troubleshooting

You can use your normal troubleshooting techniques to isolate and check faulty components.

16.5 Drawings

16.5.1 Component Location

The location of each of the components on the Receiver Logic Module PC board is shown in Figure 16-10. There are no jumpers on this board.

16.5.2 Receiver Logic Schematic

The schematic for the Receiver Logic Module is shown in three parts in Figure 16-11, Figure 16-12, and Figure 16-13.

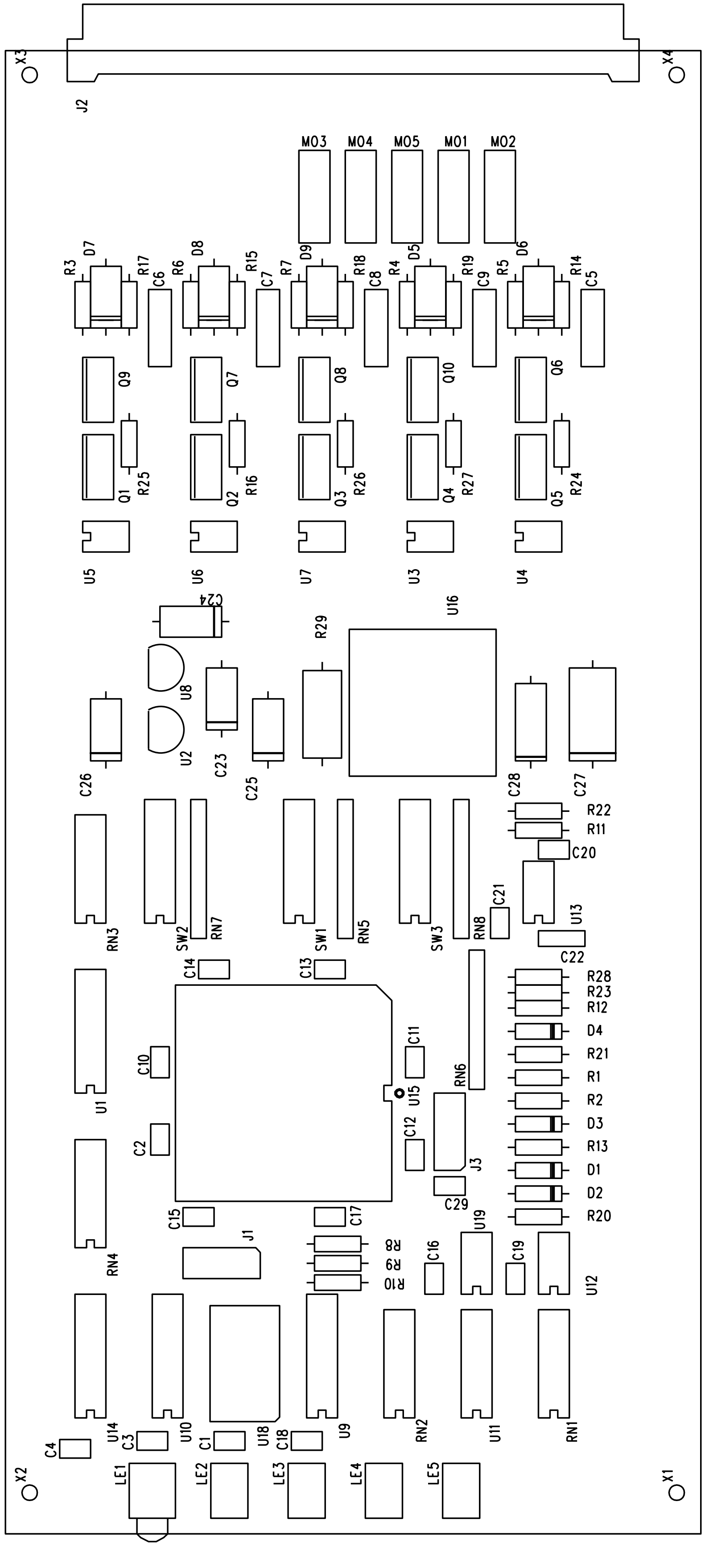

Figure 16–8. TC–10B Receiver Logic PC Board Component Location. (CF50RXLM)

Table 16–21. Receiver Logic Module Components (1606C52).

Location	Style	Description	Group
CAPACITORS			
C1–C4, C10–21, C29	CP1003MH65	.1 µF, 20%, 50 V, X7R mono ceramic radial	1, 2, 3
C5–C9	CE1003JU25	.1 µF, 5%, 400 V, polyester film radial	1, 2, 3
C22	CP1000KHZZ	100 pF, 10%, 50 V, X7R mono ceramic radial	1, 2, 3
C23–C26	CJ1004MG72	1.0 µF, 20%, 35 V tantalum axial	1, 2, 3
C27	CJ4705ME72	47 µF, 20%, 25 V tantalum axial	1, 2, 3
C28	CJ1005KGA8	10 µF, 10%, 35 V tantalum axial	1, 2, 3
CONNECTORS			
J1, J3		10 pos., dual row header (20 pins)	1, 2, 3
J2	9646A11H02	32 pin DIN right angle, rows A & C only	1, 2, 3
DIODES			
D1–D4	836A928H06	1N4148, 75V, 10mA	1, 2, 3
D5–D9	188A342H23	1N5408, 1000V, 3A	1, 2, 3
ICs (DIGITAL)			
U9,U10	9652A49H15	74HCT4020, async binary counter, DIP16	1, 2, 3
U14	01D1-74390-ID0	74HC390N, cmos dual 4 bit counter, DIP16	1, 2, 3
ICs (LINEAR)			
U2	9648A02H05	MC78L15ACP, +15V, 5%, .1A volt.reg.,TO92	1, 2, 3
U8	9648A82H03	MC79L15ACP, -15V, 5%, .1A volt.reg., TO92	1, 2, 3
U12	9656A11H01	LMC6482AIN, Dual OP AMP, DIP8	1, 2, 3
U13	01L3-TL082-CD0	TL082, Dual OP AMP, DIP8	1, 2, 3
CRYSTALS/CLOCKS			
U18	01BA-04096-3I3	4.096MHz crystal oscillator, "14" pin DIP pkg	1, 2, 3
ICs (MIXED)			
U16	01X3-5101A-PT0	PT5101A, 5V, 1A, switching volt reg.	1, 2, 3
U19	9657A17H01	DS1231, power monitor	1, 2, 3
LEDs			
LE1	9657A40H01	550-3505 bi-color (red/grn) LED, edge mount	1, 2, 3
LE2–LE5	3508A22H01	550, red LED, edge mount	1, 2, 3
PROGRAMMED PARTS			
U15	1617C89G02	EPM7128LI84-20, EPLD, PLCL0B (2 freq)	1
U15	01P0-7160E-002	EPM7160LI84-20, EPLD, PLCL0A (3 freq)	2
U15	1617C87G16	EPM7096LI84-20, EPLD, PLCL0C (ph.comp)	3
RELAYS			
U3-7	9656A08H01	AQV254H, photomos relay	1, 2, 3

(Continued on next page.)

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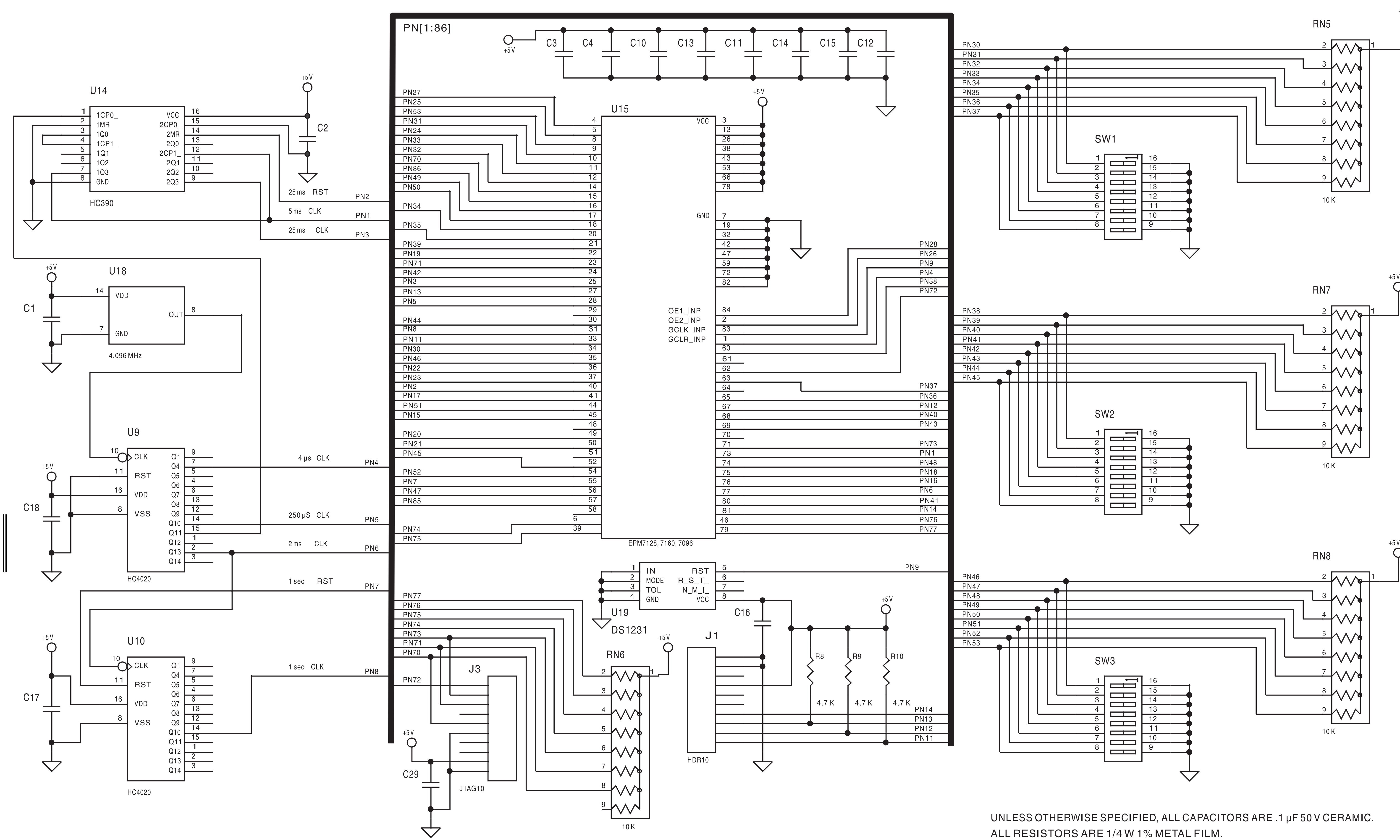
Table 16–21. Receiver Logic Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS			
R1, R2	RM3321FQB0	3.32K ohms, 1%, 1/4W, metal film	1, 2, 3
R3–R7	RM3010FQB1	301 ohms, 1%, 1/4W, metal film	1, 2, 3
R8–R10	RM4751FQB0	4.75K ohms, 1%, 1/4W, metal film	1, 2, 3
R11, R12	RM4991FQB0	4.99K ohms, 1%, 1/4W, metal film	1, 2, 3
R13	RM6651FQB0	6.65K ohms, 1%, 1/4W, metal film	1, 2, 3
R14–R19	RM100AFQB4	10 ohms, 1%, 1/4W, metal film	1, 2, 3
R20, R21	RM1002FQA9	10.0K ohms, 1%, 1/4W, metal film	1, 2, 3
R22, R23	RM2002FQA9	20.0K ohms, 1%, 1/4W, metal film	1, 2, 3
R24–R28	RM1000FQB1	100 ohms, 1%, 1/4W, metal film	1, 2, 3
R29	763A126H49	10 ohms, 5%, 3W, wirewound	1, 2, 3
RN1		6.8K ohms, 2%, 7 individual resistors, DIP14	1, 2, 3
RN2		3.3K ohms, 2%, 7 individual resistors, DIP14	1, 2, 3
RN3		100 ohms, 2%, 7 individual resistors, DIP14	1, 2, 3
RN4	3524A68H07	330 ohms, 2%, 7 individual resistors, DIP14	1, 2, 3
RN5–8	3533A81H04	10K ohms, 2%, 8 resistors w/com, SIP9	1, 2, 3
SWITCHES			
SW1–3	775B517H02	8 SPST, 16 pin DIP	1, 2, 3
TRANSISTORS			
Q1–Q5	3532A45H22	MJE5731, 300V	1, 2, 3
Q6–Q10	3532A45H23	BUL45	1, 2, 3
U1	3533A01H01	ULN2003A, DIP14	1, 2, 3
U11	01T4-2222A-D00	MPQ2222A, Quad NPN, DIP14	1, 2, 3
VARISTORS			
MO1–MO5	3509A31H11	369V MOV	1, 2, 3



UNLESS OTHERWISE SPECIFIED, ALL CAPACITORS ARE .1 µF 50 V CERAMIC.
ALL RESISTORS ARE 1/4 W 1% METAL FILM.

Figure 16–11. TCF–10B Receiver Logic Schematic. (CF30RXLMN; Sheet 1 of 3)

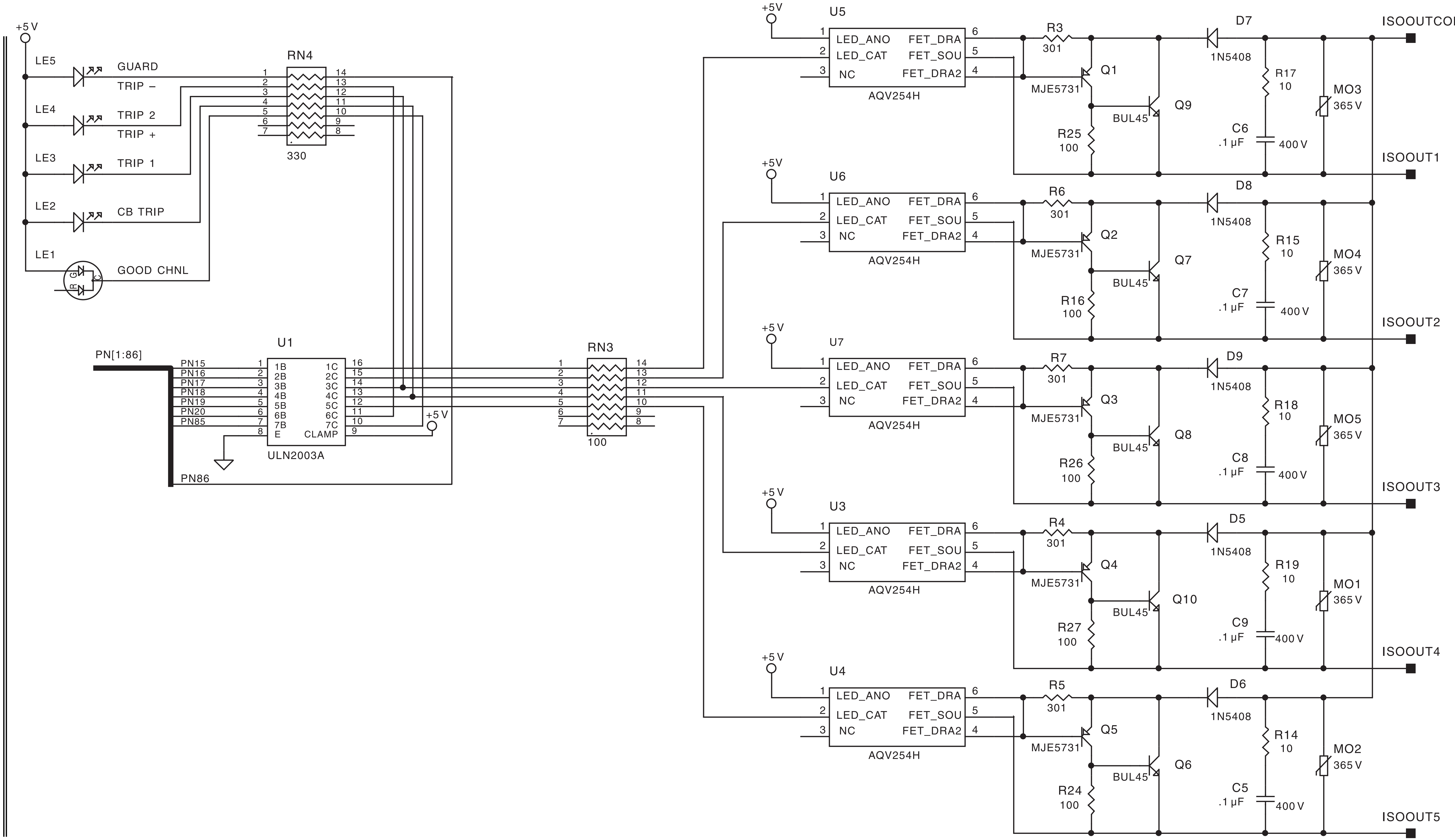


Figure 16–12. TCF–10B Receiver Logic Schematic. (CF30RXLMN; Sheet 2 of 3)

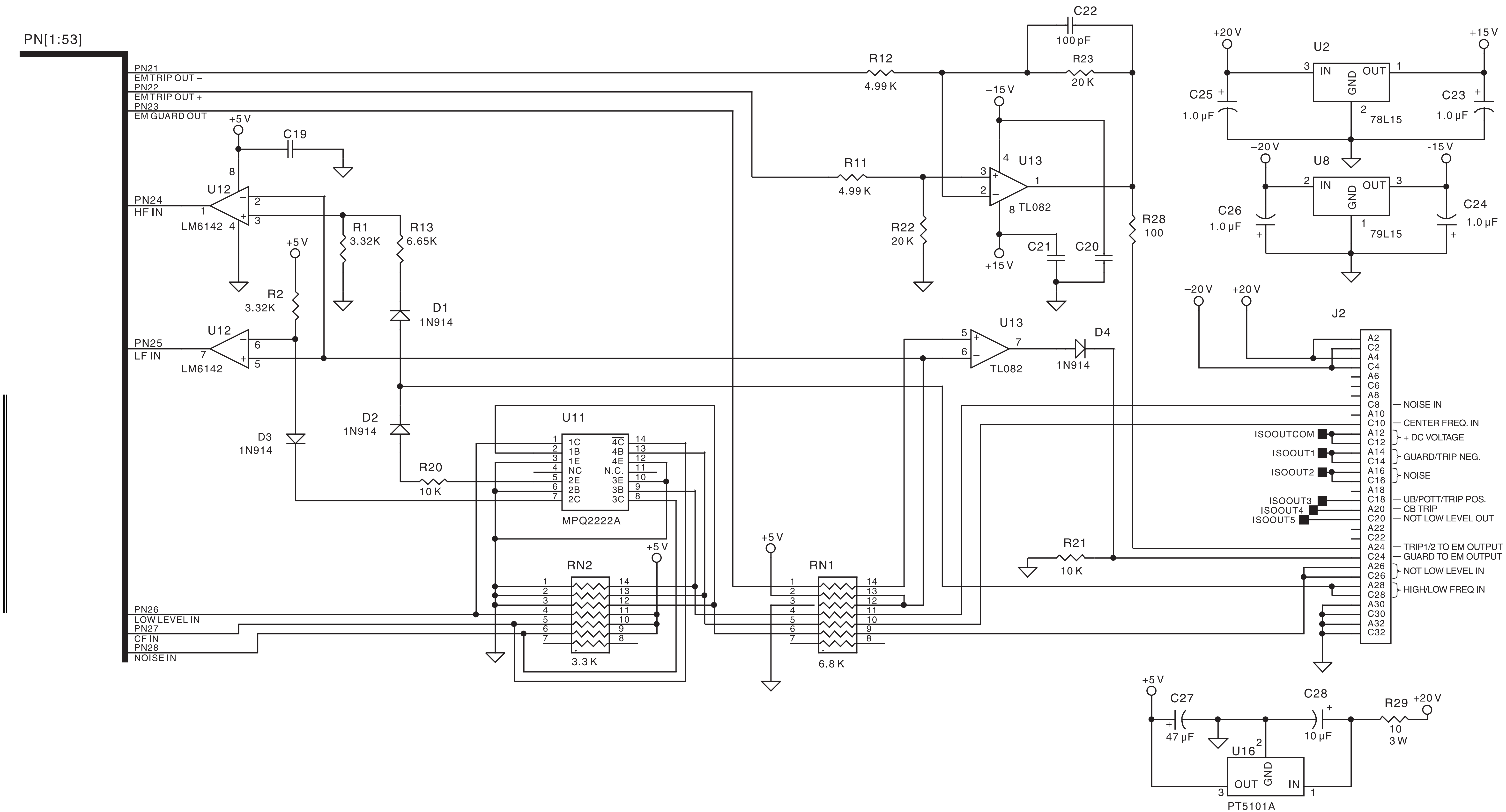


Figure 16–13. TCF–10B Receiver Logic Schematic. (CF30RXLMN; Sheet 3 of 3)

Chapter 17. Optional Electro-Mechanical (EM) Output Module

Schematic	1606C53-6
Parts List	1606C53-6

Table 17–1. 1606C53 Styles and Descriptions.

Group	Description
G01	Without Trip extension
G02	With Trip extension

17.1 EM Output Module Description

This module provides six (6) contact sets, for the TCF–10B, for Trip or Guard output, as follows:

- Trip 1
- Trip 2
- Guard

17.1.1 EM Output Control Panel

(This panel is shown in Figure 1-1.)

The control panel is without operator controls.

17.1.2 EM Output PC Board

(The EM Output PC Board is shown in Figure 17-1.)

Jumpers JU1 through JU6 are used to select Trip 1, Trip 2, or Guard signals. Jumpers JU7 through JU12 set the output relay contacts at either the NO or NC position. The following jumpers and associated components work with each of the six relays:

K1 JU1, JU7, D1, D3, Q1, Q7

K2 JU2, JU8, D4, D6, Q2, Q8

K3 JU3, JU9, D7, D9, Q3, Q9

K4 JU4, JU10, D10, D12, Q4, Q10

K5 JU5, JU11, D13, D15, Q5, Q11

K6 JU6, JU12, D16, D18, Q6, Q12

Jumpers JU13 and JU14 provide selectable “Trip Delays” for Trip 1 and Trip 2.

17.2 EM Output Circuit Description

The EM Output Module provides six (6) relay contacts for trip or guard output (see Figure 17-2). The contacts are rated to make and carry 30 A for 100 ms at 250 Vdc. Continuous switching of 125 Vdc at 0.5 A or 250 Vdc at 0.25 A is provided.

The three-state voltage output from the Receiver Logic Module is as follows:

- Trip 1 (+20 V)
- Trip 2 (-20 V)
- Guard (+20 V)

The trip input (pin C-20) and guard input (pin A-20) is applied to voltage comparators and associated components, as follows:

- Trip 1 (I2b)
- Trip 2 (I2a)
- Guard (I2c)

A trip voltage comparison occurs at 10 Vdc, with 10% hysteresis for noise immunity. The comparator output goes low (-14 Vdc) when the correct voltage is applied.

> **NOTE**
>
> **The following paragraph applies *only* to style G02 modules, *not* to style G01 modules.**

The outputs of I2a and I2b drive I4a and I4b monostable multivibrators (one shots). These "one shots" extend the length of the trip output. The trip extension (not normally used in the U.S., but routinely used in some overseas applications) is selectable from 0 to 400 milliseconds. Typically, you achieve a trip extension of 100 ms by placing JU13 and JU14 in 100–200 ms and adjusting R45 and R46 to the maximum counterclockwise position. If you place JU23 or JU14 in the 0–100 ms position, you should not adjust R45 or R46 to less than 1 K ohms to prevent over dissipating I4a and I4b.

The outputs of I2a and I2b for style G01 modules (or the outputs of I4a and I4b for style G02 modules) turn "ON" the PNP transistor (QN1c for Trip 1 or QN1d for Trip 2), which then supplies a +15 Vdc voltage to jumpers JU1 through JU6. The guard input turns "ON" PNP transistor QN1b, which also supplies a +15 Vdc voltage to jumpers JU1 through JU6.

Jumpers JU1 through JU6 work, basically, the same. Using JU1 as an example, the +15 Vdc voltage flows through resistor R22 to the base of Transistor Q7, turning Q7 "ON". When the current reaches 42 mA at the Q7 emitter, Q1 turns "ON", removing the base drive to Q7. This allows Q7 to operate as a constant current source. The high-speed operation of relay K1 is achieved by operating the 12 V relay at 40 V with this current source.

Diodes D1, D2, and D3 provide snubbing circuits (eliminates spikes and return currents) for relay K1.

17.3 EM Output Troubleshooting

You can use normal troubleshooting techniques to isolate and check faulty components.

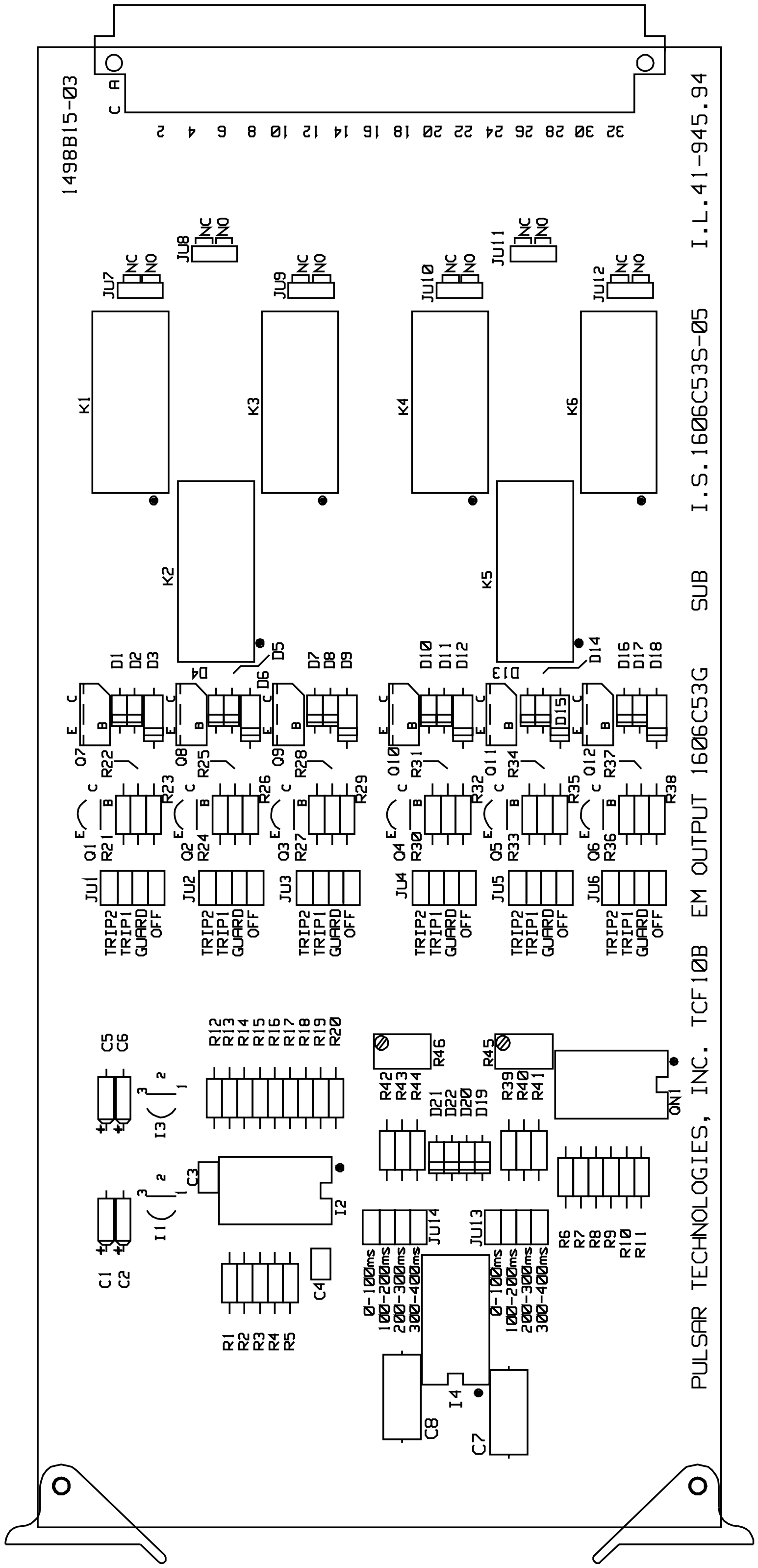


Figure 17–1. TCF–10B EM Output PC Board (1498B15).

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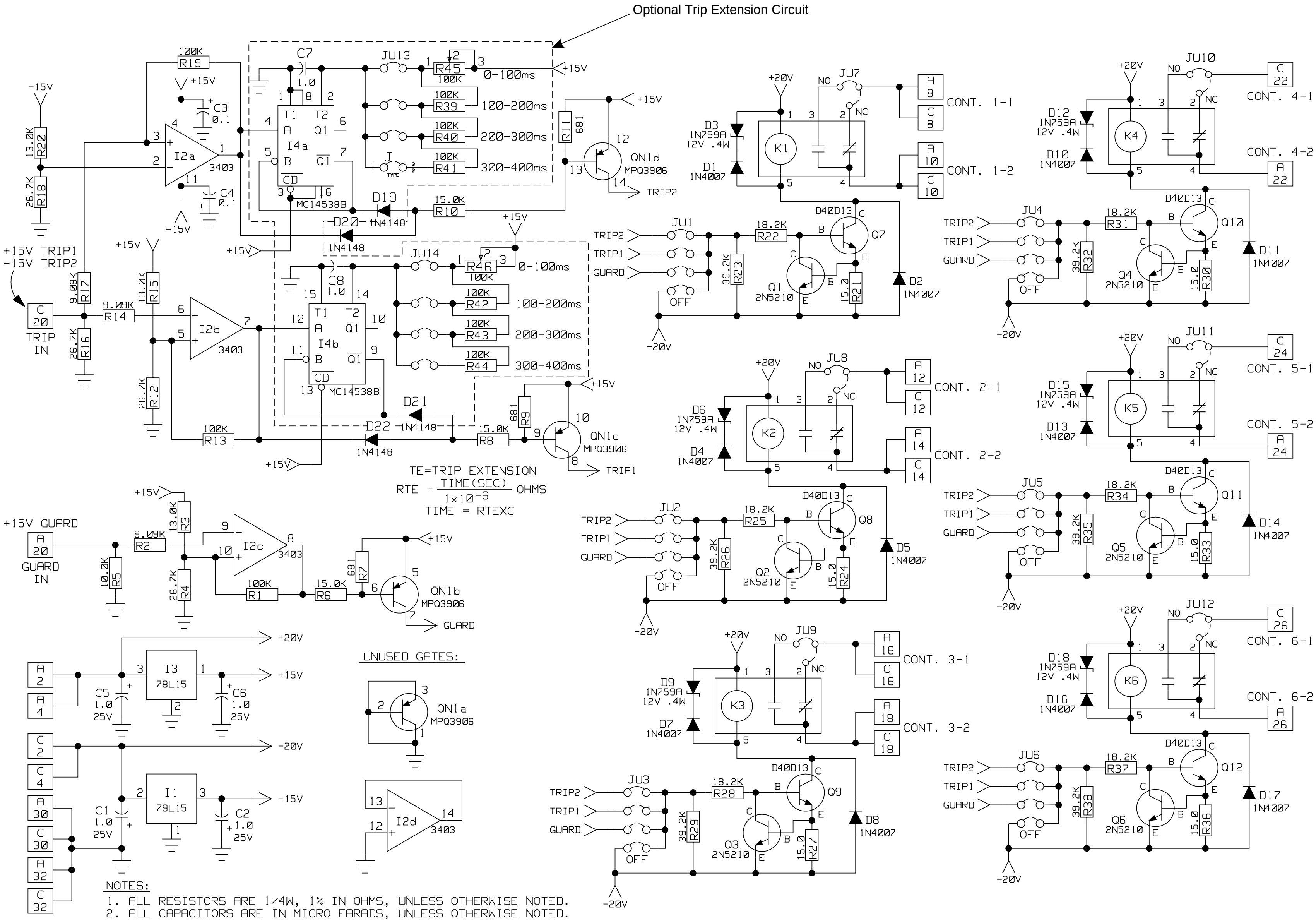

Figure 17–2. TCF–10B EM Output Schematic (1606C53).

Table 17–2. EM Output Module Components (1606C53).

Location	Style	Description	Group
CAPACITORS			
C1	CJ1004MD72	1.0 µF 20% 20 V MOLDED TANTALUM	01
C2	CJ1004MD72	1.0 µF 20% 20 V MOLDED TANTALUM	01
C3	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C4	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C5	CJ1004MD72	1.0 µF 20% 20 V MOLDED TANTALUM	01
C6	CJ1004MD72	1.0 µF 20% 20 V MOLDED TANTALUM	01
C7	CF1004JH78	1.0 µF 5% 50 V METAL POLYCARB	02
C8	CF1004JH78	1.0 µF 5% 50 V METAL POLYCARB	02
CONNECTORS			
JU1	3532A49H06	4 POSITION DOUBLE ROW	01
JU2	3532A49H06	4 POSITION DOUBLE ROW	01
JU3	3532A49H06	4 POSITION DOUBLE ROW	01
JU4	3532A49H06	4 POSITION DOUBLE ROW	01
JU5	3532A49H06	4 POSITION DOUBLE ROW	01
JU6	3532A49H06	4 POSITION DOUBLE ROW	01
JU7 to JU12	9640A47H01	3 PIN 1 ROW	01
JU13	3532A49H06	4 POSITION DOUBLE ROW	02
JU14	3532A49H06	4 POSITION DOUBLE ROW	02
DIODES			
D1	836A928H08	1N4007 1,000 V 1 A	01
D2	836A928H08	1N4007 1,000 V 1 A	01
D4	836A928H08	1N4007 1,000 V 1 A	01
D5	836A928H08	1N4007 1,000 V 1 A	01
D7	836A928H08	1N4007 1,000 V 1 A	01
D8	836A928H08	1N4007 1,000 V 1 A	01
D10	836A928H08	1N4007 1,000 V 1 A	01
D11	836A928H08	1N4007 1,000 V 1 A	01
D13	836A928H08	1N4007 1,000 V 1 A	01
D14	836A928H08	1N4007 1,000 V 1 A	01
D16	836A928H08	1N4007 1,000 V 1 A	01
D17	836A928H08	1N4007 1,000 V 1 A	01
D19	836A928H06	1N4148 75 V .01 A	02
D20	836A928H06	1N4148 75 V .01 A	01, 02
D21	836A928H06	1N4148 75 V .01 A	02
D22	836A928H06	1N4148 75 V .01 A	01, 02
LINEAR ICs			
I1	9648A82H03	MC79L15ACP NEG VOLTREG 15 V 5% 0.1 A	01
I2	3537A40H01	MC3403P QUAD OP-AMP	01
I3	9648A02H05	MC78L15ACP POS VOLTREG 15 V 5% 0.1 A	01
I4	3527A09H01	MC14538BAL DUAL MONOVIBRATOR	02
QN1	3533A63H01	MPQ3906 QUAD PNP ARRAY 40 V 0.2 A	01

(Continued on next page.)

Table 17–2. EM Output Module Components (Cont'd).

Location	Style	Description	Group
POTENTIOMETERS			
R45	3534A25H10	100 K 25 TURN	02
R46	3534A25H10	100 K 25 TURN	02
RELAYS			
K1	9645A10H03	FBR611D012 12 V 285 OHM 10 A 1C	01
K2	9645A10H03	FBR611D012 12 V 285 OHM 10 A 1C	01
K3	9645A10H03	FBR611D012 12 V 285 OHM 10 A 1C	01
K4	9645A10H03	FBR611D012 12 V 285 OHM 10 A 1C	01
K5	9645A10H03	FBR611D012 12 V 285 OHM 10 A 1C	01
K6	9645A10H03	FBR611D012 12 V 285 OHM 10 A 1C	01
RESISTORS			
R1	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	01
R2	RM9091FQB0	9.09 KILOHMS 1% 0.25 W METAL FILM	01
R3	RM1302FQA9	13.0 KILOHMS 1% 0.25 W METAL FILM	01
R4	RM2672FQA9	26.7 KILOHMS 1% 0.25 W METAL FILM	01
R5	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01
R6	RM1502FQA9	15.0 KILOHMS 1% 0.25 W METAL FILM	01
R7	RM6810FQB1	681 OHMS 1% 0.25 W METAL FILM	01
R8	RM1502FQA9	15.0 KILOHMS 1% 0.25 W METAL FILM	01
R9	RM6810FQB1	681 OHMS 1% 0.25 W METAL FILM	01
R10	RM1502FQA9	15.0 KILOHMS 1% 0.25 W METAL FILM	01
R11	RM6810FQB1	681 OHMS 1% 0.25 W METAL FILM	01
R12	RM2672FQA9	26.7 KILOHMS 1% 0.25 W METAL FILM	01
R13	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	01
R14	RM9091FQB0	9.09 KILOHMS 1% 0.25 W METAL FILM	01
R15	RM1302FQA9	13.0 KILOHMS 1% 0.25 W METAL FILM	01
R16	RM2672FQA9	26.7 KILOHMS 1% 0.25 W METAL FILM	01
R17	RM9091FQB0	9.09 KILOHMS 1% 0.25 W METAL FILM	01
R18	RM2672FQA9	26.7 KILOHMS 1% 0.25 W METAL FILM	01
R19	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	01
R20	RM1302FQA9	13.0 KILOHMS 1% 0.25 W METAL FILM	01
R21	RM150AFQB4	15.0 OHMS 1% 0.25 W METAL FILM	01
R22	RM1822FQA9	18.2 KILOHMS 1% 0.25 W METAL FILM	01
R23	RM3922FQA9	39.2 KILOHMS 1% 0.25 W METAL FILM	01
R24	RM150AFQB4	15.0 OHMS 1% 0.25 W METAL FILM	01
R25	RM1822FQA9	18.2 KILOHMS 1% 0.25 W METAL FILM	01
R26	RM3922FQA9	39.2 KILOHMS 1% 0.25 W METAL FILM	01
R27	RM150AFQB4	15.0 OHMS 1% 0.25 W METAL FILM	01
R28	RM1822FQA9	18.2 KILOHMS 1% 0.25 W METAL FILM	01
R29	RM3922FQA9	39.2 KILOHMS 1% 0.25 W METAL FILM	01
R30	RM150AFQB4	15.0 OHMS 1% 0.25 W METAL FILM	01
R31	RM1822FQA9	18.2 KILOHMS 1% 0.25 W METAL FILM	01
R32	RM3922FQA9	39.2 KILOHMS 1% 0.25 W METAL FILM	01
R33	RM150AFQB4	15.0 OHMS 1% 0.25 W METAL FILM	01
R34	RM1822FQA9	18.2 KILOHMS 1% 0.25 W METAL FILM	01

Table 17–2. EM Output Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS (Cont'd)			
R35	RM3922FQA9	39.2 KILOHMS 1% 0.25 W METAL FILM	01
R36	RM150AFQB4	15.0 OHMS 1% 0.25 W METAL FILM	01
R37	RM1822FQA9	18.2 KILOHMS 1% 0.25 W METAL FILM	01
R38	RM3922FQA9	39.2 KILOHMS 1% 0.25 W METAL FILM	01
R39	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	02
R40	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	02
R41	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	02
R42	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	02
R43	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	02
R44	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	02
TRANSISTORS			
Q1	3509A35H12	2N5210 50 V 0.05A 1.0 W NPN	01
Q2	3509A35H12	2N5210 50 V 0.05 A 1.0 W NPN	01
Q3	3509A35H12	2N5210 50 V 0.05 A 1.0 W NPN	01
Q4	3509A35H12	2N5210 50 V 0.05 A 1.0 W NPN	01
Q5	3509A35H12	2N5210 50 V 0.05 A 1.0 W NPN	01
Q6	3509A35H12	2N5210 50 V 0.05 A 1.0 W NPN	01
Q7	3532A45H01	D40D13 75 V 1.0 A 6.2 W NPN	01
Q8	3532A45H01	D40D13 75 V 1.0 A 6.2 W NPN	01
Q9	3532A45H01	D40D13 75 V 1.0 A 6.2 W NPN	01
Q10	3532A45H01	D40D13 75 V 1.0 A 6.2 W NPN	01
Q11	3532A45H01	D40D13 75 V 1.0 A 6.2 W NPN	01
Q12	3532A45H01	D40D13 75 V 1.0 A 6.2 W NPN	01
ZENERS			
D3	837A693H01	1N759A 12 V 5% 0.4 W	01
D6	837A693H01	1N759A 12 V 5% 0.4 W	01
D9	837A693H01	1N759A 12 V 5% 0.4 W	01
D12	837A693H01	1N759A 12 V 5% 0.4 W	01
D15	837A693H01	1N759A 12 V 5% 0.4 W	01
D18	837A693H01	1N759A 12 V 5% 0.4 W	01

USER NOTES

Chapter 18. Optional Voice Adapter Module

Schematic	1606C39-16
Parts List	1606C39-16

18.1 Voice Adapter Module Description

The Voice Adapter Module is designed to provide voice communications between terminals of the TC–10B/TCF–10B carrier systems. This module also provides signaling. Voice communication is provided on a half-duplex basis for the TC–10B, and a full-duplex basis for the TCF–10B.

18.1.1 TC–10B Operation

The Receiver in the TC–10B system outputs 5.02 MHz IF to the Voice Adapter, which is then filtered, AGC amplified, and detected. The detected audio is then amplified and received at the handset. You can connect the handset (with a "push-to-talk" switch) to the TC–10B in three different ways:

1. Plug the handset into the TC–10B Voice Adapter Module at the front panel "HANDSET" jack.
2. Connect the handset remotely, through a jack, to the TC–10B rear panel (terminal TB5).
3. Connect the hookswitch assembly (which supports a handset) remotely to the TC–10B rear panel (terminal TB5).

You initiate signaling by pressing the push-to-talk switch on the handset. You may terminate ringing, at the other end of the system, in four different ways (depending on the configuration you are using):

1. When a handset is plugged into the TC–10B Voice Adapter Module front panel "HANDSET" jack, it activates the alarm cutoff relay.
2. When a handset is connected, remotely, through a jack to the TC–10B rear panel (see Figure 18-4), the remote jack interrupts the alarm circuit.
3. When a handset is removed from its hook-switch; the hookswitch assembly being connected remotely to the TC–10B rear panel (see Figure 18-4), the hookswitch contacts interrupt the alarm circuit.
4. When a handset is used in combination with a hookswitch, lifting the handset and plugging in the handset interrupts the alarm circuit (see Figure 18-4).

When using the TC–10B with voice, refer to Figure 18-5 for the alarm cutoff circuit.

18.1.2 TCF–10B Operation

In the TCF–10B system, the receiver outputs 5.02 MHz IF to the Voice Adapter, which is then filtered, AGC amplified, and detected. The detected audio is then amplified and received at the handset. You can connect the handset to the TCF–10B in the following ways (a hookswitch assembly is required for remote TCF–10B operation):

1. Remote Handset Configuration

   Cradle a handset without a push-to-talk switch on a hookswitch assembly in a location remote from the TCF–10B Voice Adapter Module. Connect the hookswitch assembly in series with the alarm circuit, as well as to the TCF–10B rear panel terminal block TB5 (see Figure 18-4 and Figure 18-5).

   Install a separate calling pushbutton in the remote location, near the handset.

   Initiate signaling at the remote location by lifting the handset from the hookswitch assembly and pressing the calling pushbutton.

2. Local Handset Configuration

   Plug a handset without a push-to-talk switch into the front panel "HANDSET" jack of the Voice Adapter Module.

   Connect the alarm circuit per Figure 18-4 and Figure 18-5.

Initiate signaling by plugging the handset into the module assembly and pressing the calling push-button on the Voice Adapter (see Figure 1-1, "Calling PB").

If a handset with a Push-to-Talk switch is used in either configuration (above), you initiate signalling by lifting the handset from the hook-switch assembly and pressing the Push-to-Talk switch and the Calling pushbutton simultaneously.

18.1.3 Electrical Characteristics

The Voice Adapter Module's electrical characteristics are shown in Table 18-1.

Table 18–1. Voice Adapter Module Electrical Characteristics.

Operating Temp Range	-20° to +60° C (Ambient)
Audio Frequency Response	300 to 2,000 Hz (-3 dB)
Receiver Sensitivity	-74 dBm (50 ohm)
AGC Dynamic Range	40 dB min Audio output ± 0.5. DB for R.F. level change -74 dBm to -34 dBm
Compandor	Jumper selectable (IN/OUT)
TCF Signaling Tone	370 Hz ±50 Hz
TCF Signaling Tone Detector	370 Hz ± 50 Hz
Transmit Audio	3.2 Vp-p (in limit) into 600 ohm
Receive Audio Squelch	When RF input is below -80 dBm (Also jumper selectable to squelch with "push-to-talk" switch)
Powering	Module powered from +20 V, common, and -20 V power supply. Supply current is approximately 50 mA from each supply.
External Handset & Signaling Inputs	Must meet IEEE impulse and IEEE SWC tests (ANS C37.90.1).
Alarm Terminals	Must pass 2,500 Vdc hi-pot for one minute (normal open/normal closed, jumper selectable).

18.2 Voice Adapter Panel Controls

18.2.1 Voice Adapter Control Panel

(This panel is shown in Figure 1-1.)

Operator controls are provided as follows:

Calling Pushbutton ("Calling PB")

Used with TCF–10B only to activate signaling oscillator.

Alarm/Alarm-Cutoff LED ("Alarm/Alarm Cutoff")

Indicates when Alarm/Alarm Cutoff relay is activated.

Receive Audio Level Adjustment ("Receive Audio", R24)

Adjusts the receive audio level.

Microphone Sensitivity Adjustment ("Mic. Sens", R63)

Sets the audio level output to the modulator.

Handset Jack ("Handset", TJ1)

(The handset schematic is shown in Figure 18-8.)

18.2.2 Voice Terminal Block on Rear Panel

(This panel is shown in Figure 3-1.)

Connections are as follows:

- Common
- Signaling input (external calling switch, to be returned to common when signaling).
- Alarm Cutoff signal (2 contacts: NO or NC).
- External receiver output.
- External microphone input.

18.3 Voice Adapter PC Board

(This board is shown in Figure 18-1.)

Operator controls are provided, as follows:

JU1 Receiver Squelch (IN/OUT). When the jumper is "IN", voice keying squelches the receive audio signal.

JU2/JU3 Compandor (IN/OUT) When the jumper is "IN", the audio is compandored; when the jumper is "OUT", the audio is not compandored. We generally recommend that you use companding, as it improves the signal-to-noise performance.

JU4 Signaling (TC/TCF) When jumper is set for "TC", and handset is plugged into handset jack, the alarm cutoff from the handset jack will cause the relay to operate. When jumper is set for "TCF", the presence of a signaling tone will operate the relay.

JU5 Alarm Contacts (NO/NC) When jumper is set in "NO" position, and relay is de-energized, the alarm contacts will be "OPEN". When jumper is in "NC" position, and relay is de-energized, the alarm contacts will be "CLOSED".

18.4 Voice Adapter Circuit Description

18.4.1 Receiver

The RF input to the Voice Adapter is a 5.02-MHz IF signal from the Receiver Module, which is filtered by FL1, amplified by Q1, and input to I1 (an AGC amplifier). The I1 output is filtered by FL2, with Q2 operating as a buffer to drive the AM Detector (I2), which provides a demodulated audio output, plus a dc signal as input to the comparator (I3/1,2,3). Potentiometer R41 provides an adjustable reference and is factory set. The output of I3 controls the gain of the AGC amplifier (I1).

The audio output (from I2) will be squelched by the Audio Squelch circuit (I6) if the RF input (5.02 MHz) is below -85 dBm. This is accomplished by comparator (I3/5,6,7) which monitors the AGC central voltage (see Figure 18-3).

The audio output will also be squelched, with jumper JU1 “IN”, when the transmitter is keyed. The front panel potentiometer RECEIVER AUDIO (R24) provides for field adjustment of the Receive Audio level when you adjust the input level to Audio Output Amplifier (I3/8,9,10). This amplified output is passed through an output protection circuit (R34, Z1) to the HANDSET jack (TJ1), or to a remote handset connected to terminal block (TB5) on the rear panel.

18.4.2 Audio Transmit

The Current Limiter, comprising Q4, Q5, and R72 (see Figure 18-3) provides approximately 22 mA to the handset microphone, when the push-to-talk switch in the handset is pushed. Front panel potentiometer MIC. SENS (R63) provides for adjustment of the level of audio voice signals from the microphone. These signals are input to the 2.2 kHz lowpass filter (I4/1,2,3), which attenuates frequencies above 2200 Hz. The output of I4 is input to the Output Limiter (I4/12,13,14), according to the following conditions:

- If JU2 is “OUT”, input to I4(13) is direct
- If JU2 is “IN”, input to I4(13) is through compressor (I5)

I4 outputs (through pin A-28) provide a maximum signal of 3.2 Vp-p into the 600 ohm input impedance of the Transmitter Module.

18.4.3 TC–10B/TCF–10B Signaling

Jumper JU4 selects either the TC–10B or the TCF–10B signaling operation.

TC–10B Signaling

Set jumper JU4 to the “TC” position. Also set jumper JU5 to “NC”.

Initiate signaling by pressing the push-to-talk switch on the handset. Signals are detected by I7 and Q6, which signal a Voice-Key level to the Keying Module.

You may terminate ringing in two different ways (depending on the configuration used at the other end of the system):

1. By plugging the handset into the front panel “HANDSET” jack of the Voice Adapter Module, Relay K-1 is energized, illuminating the front control panel LED “Alarm/Alarm Cutoff”; the normally-closed contacts are opened and the alarm is interrupted.
2. When using a remotely-connected handset. The alarm contacts from the Voice Adapter (TB5) are wired in series with the Level Detector (TB2) contacts. When a carrier signal is received from a remote system, Level Detector (TB2) contacts close, providing an alarm signal. You can interrupt the alarm in the following ways:
   - By plugging the handset into a jack, which is connected remotely to the TC–10B rear panel (TB5); the jack contacts interrupt the alarm (see Figure 18-4, top scheme)
   - By lifting the handset from the hookswitch assembly, which is connected remotely to TB5; the hookswitch contacts interrupt the alarm (see Figure 18-4, bottom scheme)

TCF–10B Signaling

Set jumper JU4 to the “TCF” position. Also, set jumper JU5 to the “NO” position.

You initiate signaling by pressing the calling pushbutton (see section 18.1.2 TCF–10B Operation for the procedure). The signaling tone oscillator will operate and send a 370 Hz signaling tone to the Transmitter (at the originating end).

At the terminating end of the system, the receiver sends the signaling tone to the Signaling Tone Detector (filtered by I4,8,9,10 and detected by I4/5,6,7), causing relay K1 to operate, closing the alarm contacts.

The normally-open (N.O.) alarm relay contacts are wired in series with the external normally-closed hookswitch contacts (see Figure 18-6). The normally-closed contacts allow alarm signaling to be interrupted when the handset (at the terminating end) is removed from its hookswitch assembly.

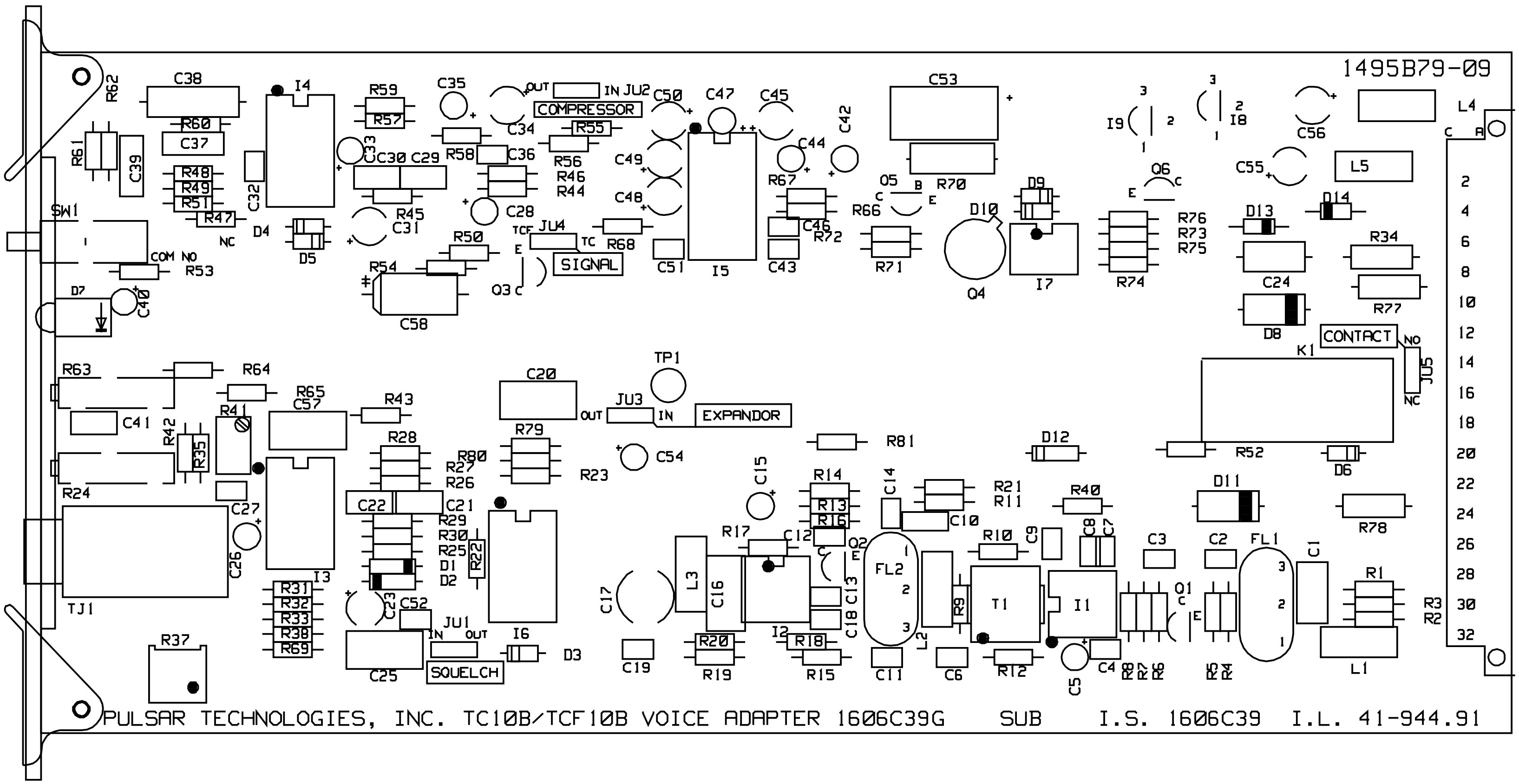

Figure 18–1. TC–10B/TCF–10B Voice Adapter PC Board (1495B79).

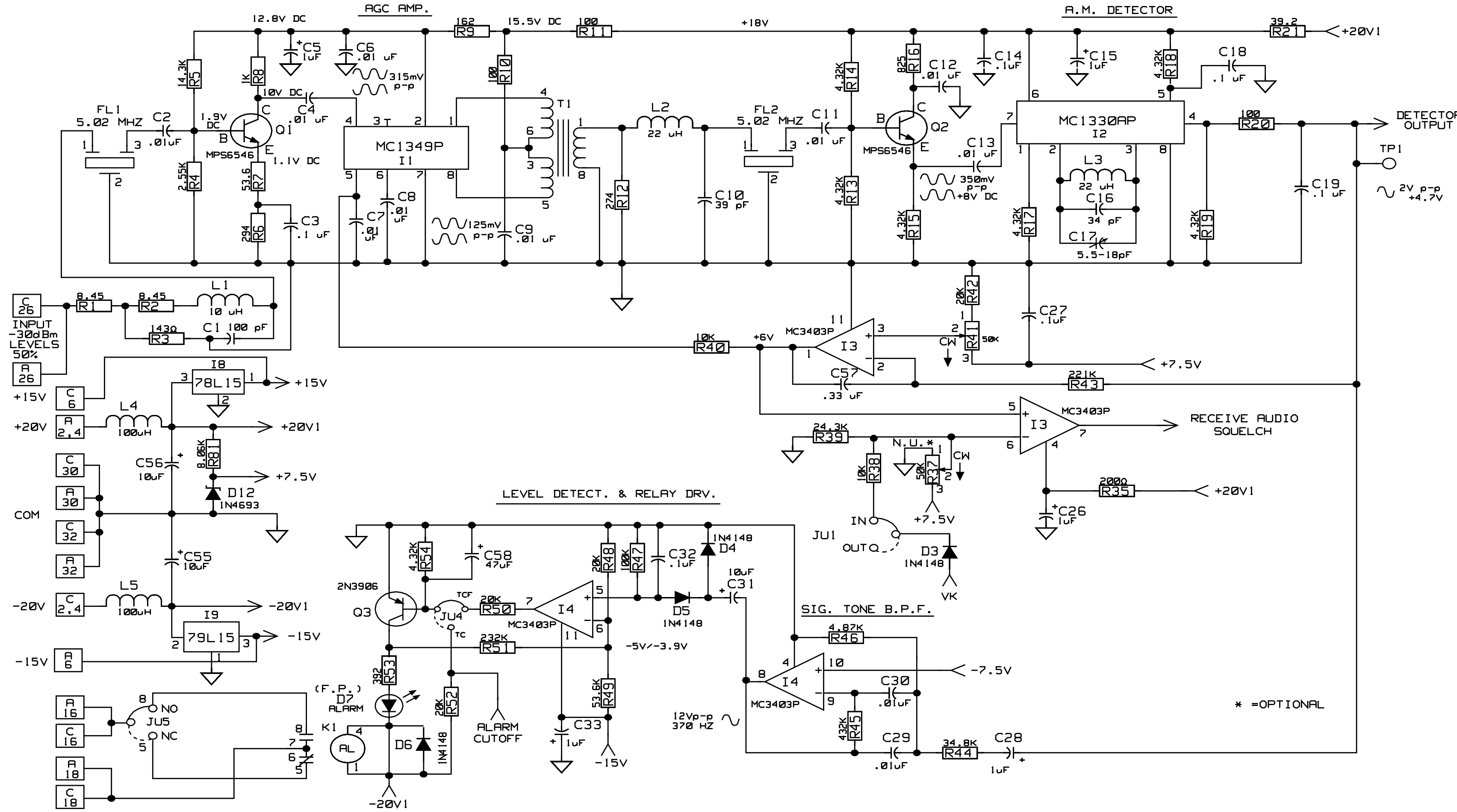

Figure 18–2. TC–10B/TCF–10B Voice Adapter Schematic (1606C39; Sheet 1 of 2).

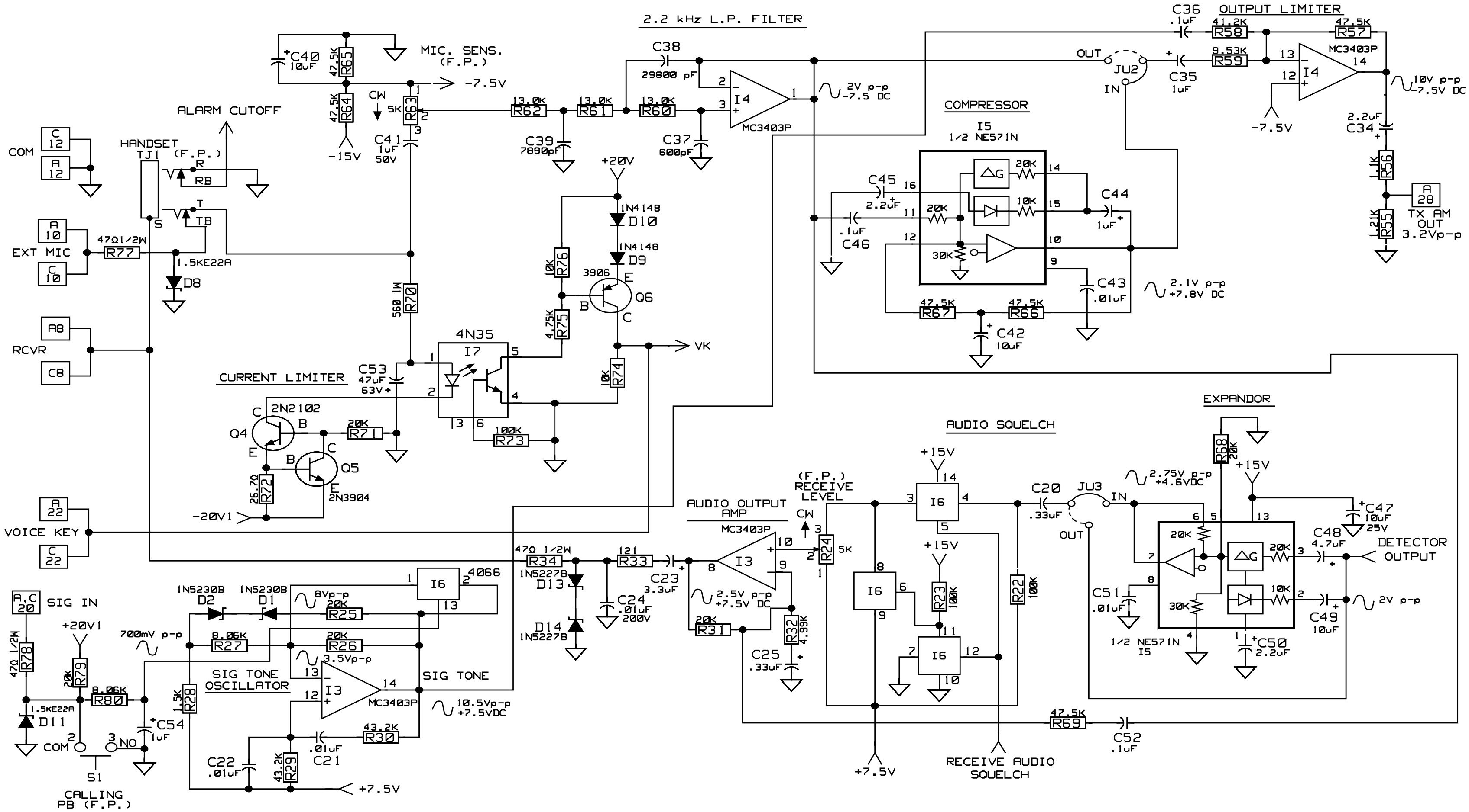

Figure 18–3. TC–10B/TCF–10B Voice Adapter Schematic (1606C39; Sheet 2 of 2).

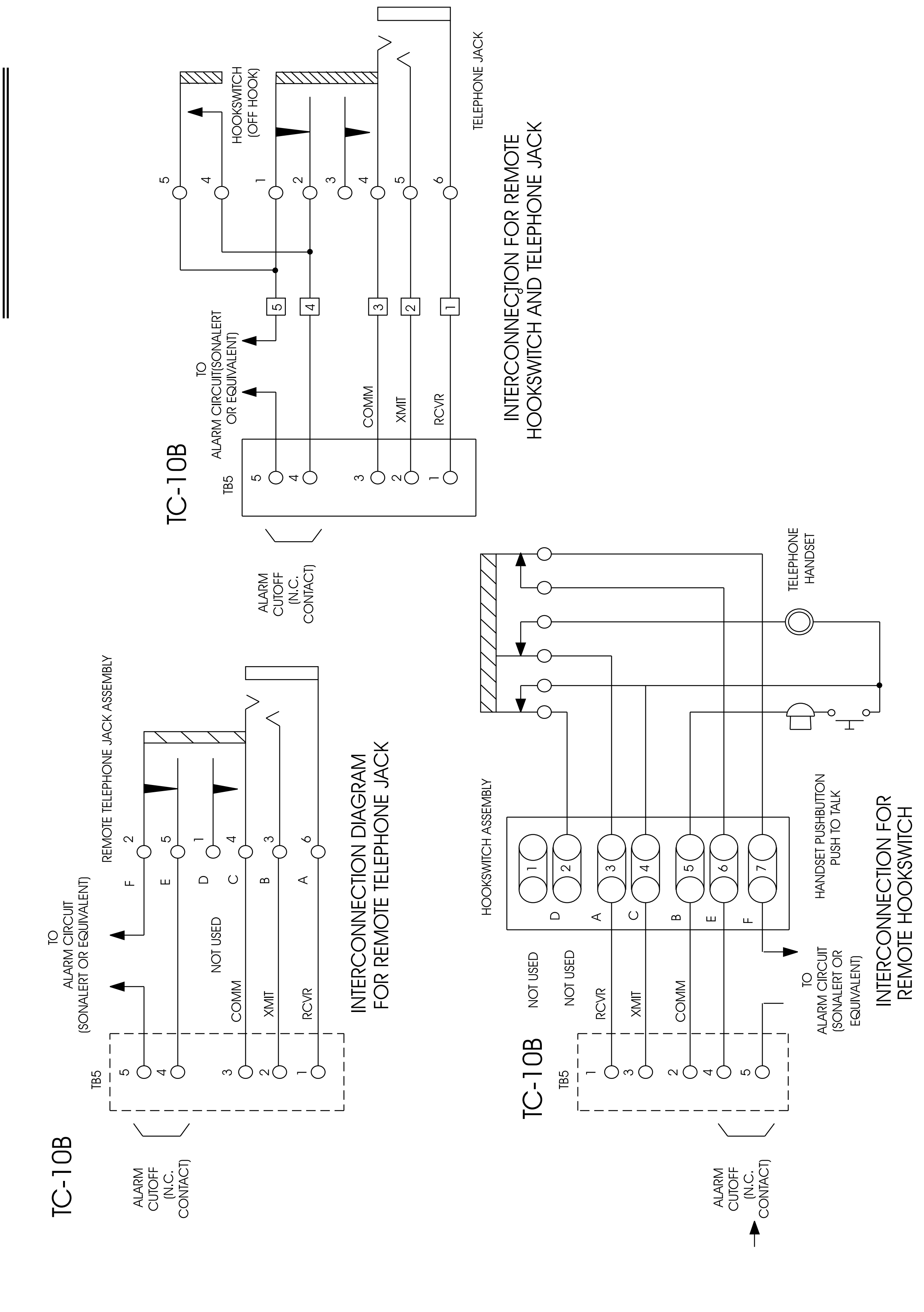

Figure 18–4. TC–10B Interconnecting Diagram (7833C63).

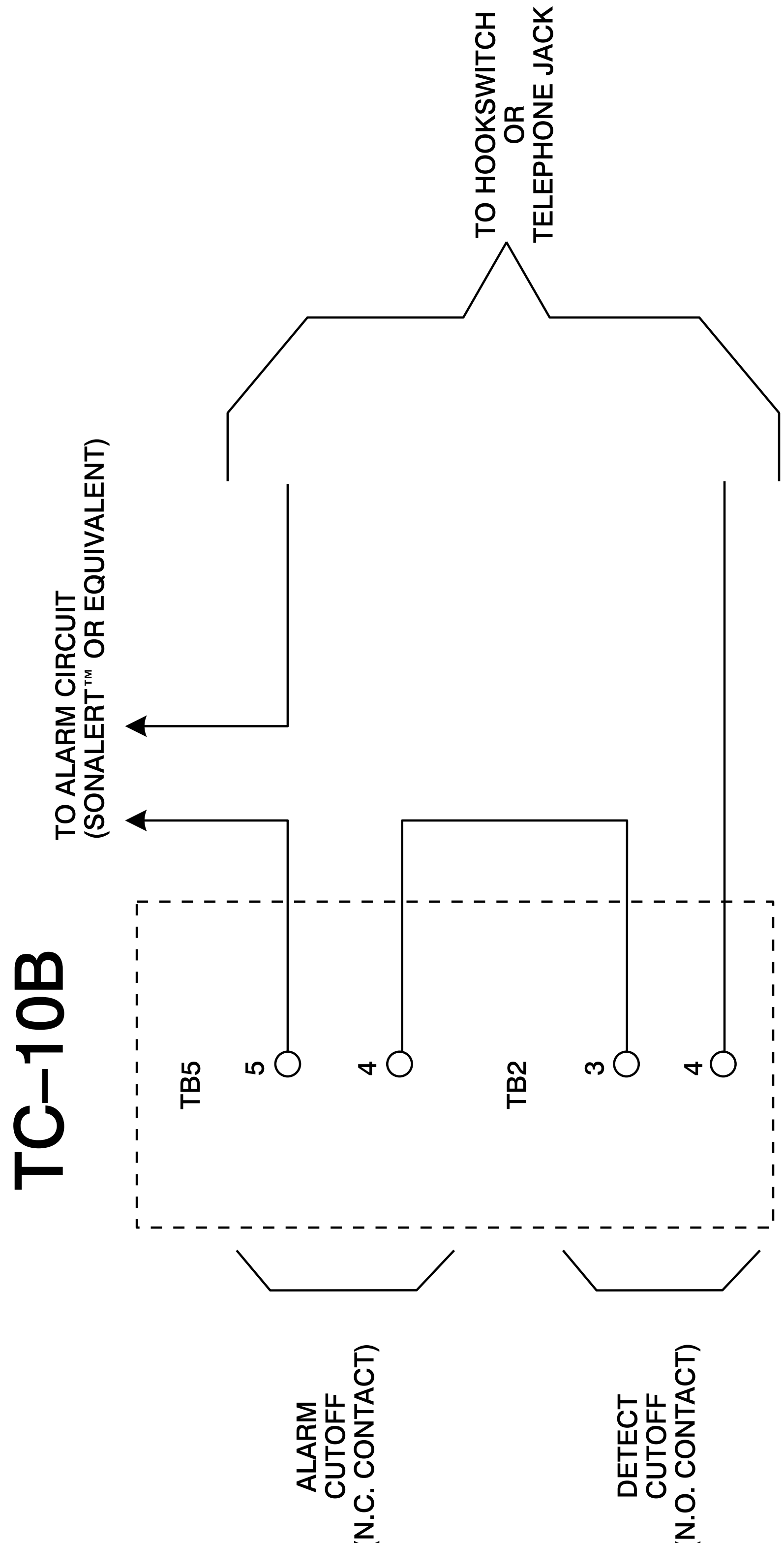

Figure 18–5. TC–10B Connections for Alarm Circuit (7833C63).

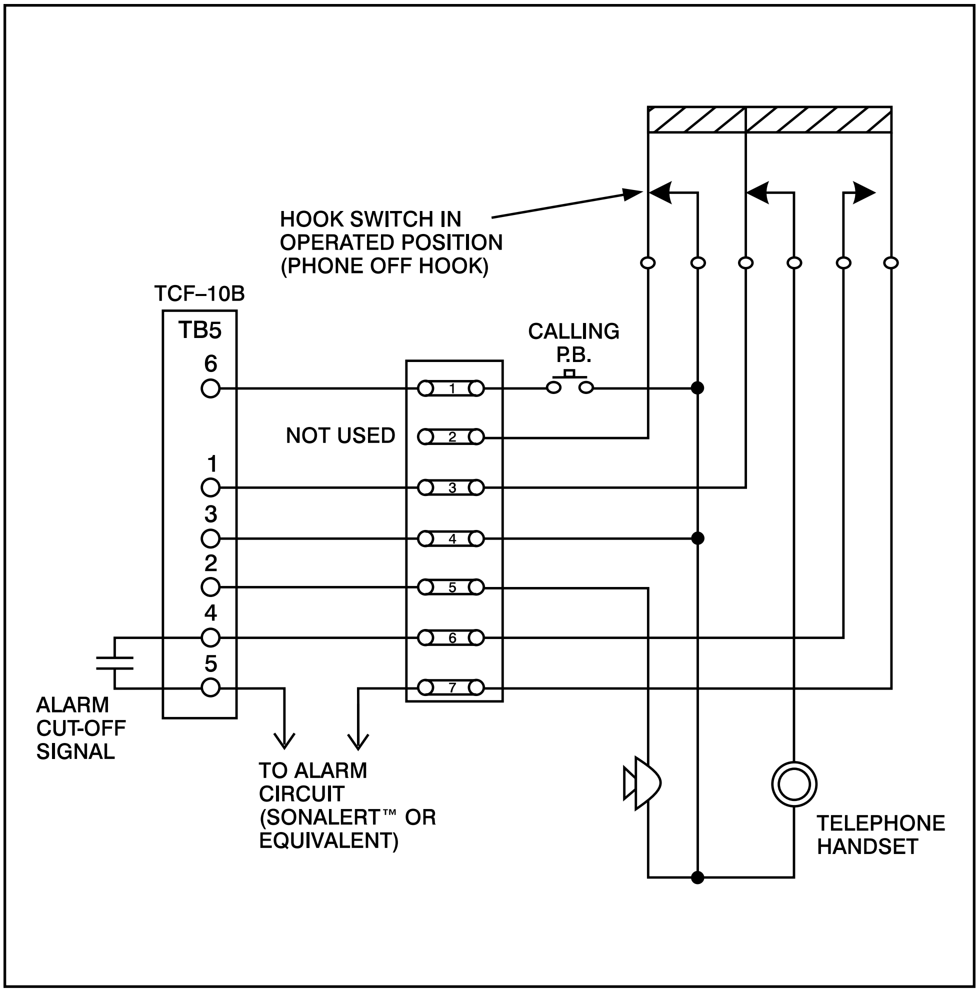

Figure 18–6. TCF–10B Remote Hookswitch Assembly Interconnection Diagram (9651A87).

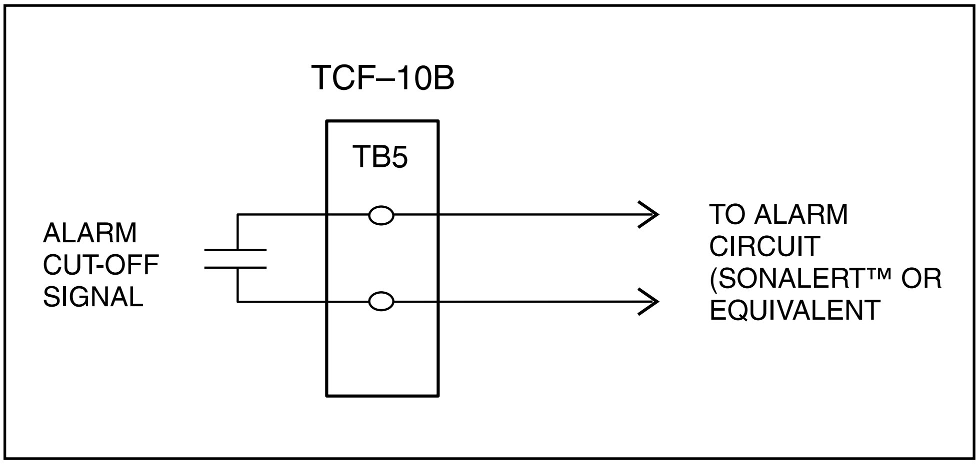

Figure 18–7. TCF–10B Alarm Circuit for Use with Module Jack (9651A88).

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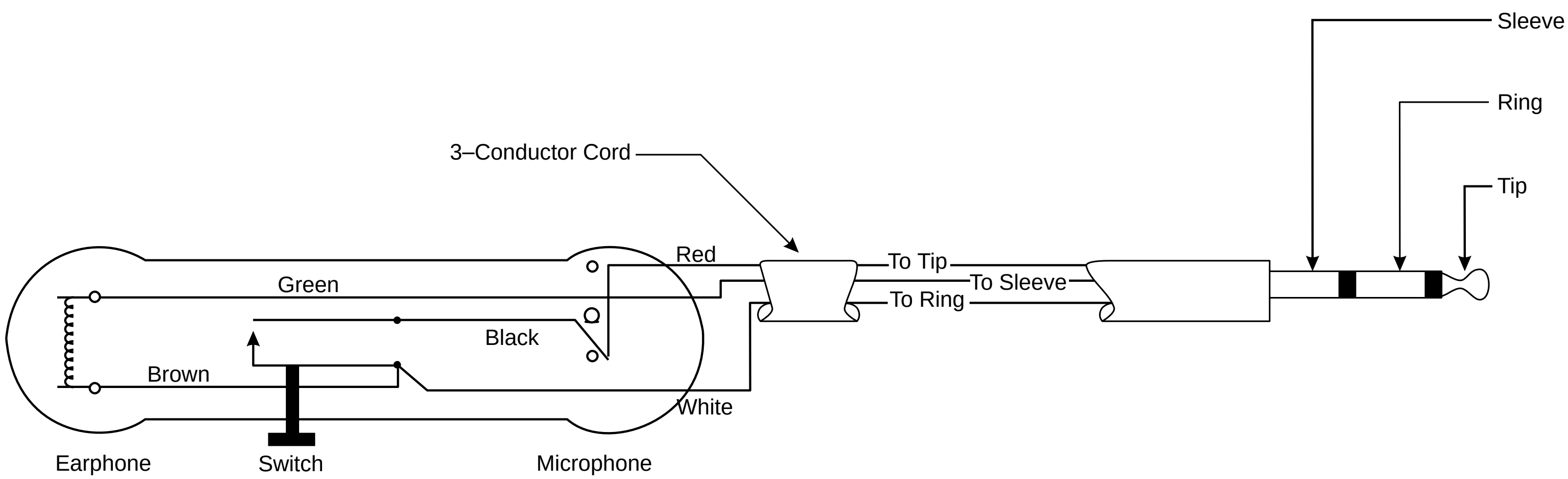

Figure 18–8. TC–10B/TCF–10B Handset Schematic.

Table 18–2. Voice Adapter Module Components (1606C39).

Location	Style	Description	Group
CAPACITORS			
C1	CR1000JV67	100 pF 5% 500 V DIPPED MICA	01
C2	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01
C3	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C4	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01
C5	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	01
C6	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01
C7	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01
C8	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01
C9	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01
C10	CR390AGV92	39 pF 2% 500 V DIPPED MICA	01
C11	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01
C12	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01
C13	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01
C14	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C15	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	01
C16	CR340AGV16	34 pF 2% 500 V DIPPED MICA	01
C18	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C19	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C20	CT3303KL68	0.33 µF 10% 100 V MET POLYESTER	01
C21	CP1002GH65	0.01 µF 2% 50 V C0G MONO CERAMIC	01
C22	CP1002GH65	0.01 µF 2% 50 V C0G MONO CERAMIC	01
C23	CW3304MH76	3.3 µF 20% 50 V DIPPED TANTALUM	01
C24	CF1002JP78	0.01 µF 5% 200 V MET POLYCARB	01
C25	CT3303KL68	0.33 µF 10% 100 V MET POLYESTER	01
C26	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	01
C27	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C28	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	01
C29	CP1002GH65	0.01 µF 2% 50 V C0G MONO CERAMIC	01
C30	CP1002GH65	0.01 µF 2% 50 V C0G MONO CERAMIC	01
C31	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	01
C32	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C33	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	01
C34	CW2204MH76	2.2 µF 20% 50 V DIPPED TANTALUM	01
C35	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	01
C36	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C37	CH6000GH81	600 pF 2% 50 V POLYSTYRENE	01
C38	CH2982GH81	29,800 pF 2% 50 V POLYSTYRENE	01
C39	CH7891GH81	7,890 pF 2% 50 V POLYSTYRENE	01
C40	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	01
C41	CP1004MH54	1.0 µF 20% 50 V MONO CERAMIC	01
C42	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	01

(Continued on next page.)

Table 18–2. Voice Adapter Module Components (Cont'd).

Location	Style	Description	Group
CAPACITORS (Cont'd)			
C43	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01
C44	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	01
C45	CW2204MH76	2.2 µF 20% 50 V DIPPED TANTALUM	01
C46	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C47	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	01
C48	CW4704MH76	4.7 µF 20% 50 V DIPPED TANTALUM	01
C49	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	01
C50	CW2204MH76	2.2 µF 20% 50 V DIPPED TANTALUM	01
C51	CP1002MH65	0.01 µF 20% 50 V X7R MONO CERAMIC	01
C52	CP1003MH65	0.1 µF 20% 50 V X7R MONO CERAMIC	01
C53	CA47054J66	47 µF +100-10% 63 V ALUMINUM	01
C54	CW1004MH76	1 µF 20% 50 V DIPPED TANTALUM	01
C55	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	01
C56	CW1005ME76	10 µF 20% 25 V DIPPED TANTALUM	01
C57	CT3303KL68	0.33 µF 10% 100 V MET POLYESTER	01
TRANSFORMERS			
T1	1497B78G01	TRANSFORMER	01
CONNECTORS			
JU1	9640A47H01	3 POSITION	01
JU2	9640A47H01	3 POSITION	01
JU3	9640A47H01	3 POSITION	01
JU4	9640A47H01	3 POSITION	01
JU5	9640A47H01	3 POSITION	01
DIGITAL ICs			
I6	3534A28H01	MC14066BCP QUAD BILATERAL SWITCH	01
DIODES			
D3	836A928H06	1N4148 75 V 0.01 A	01
D4	836A928H06	1N4148 75 V 0.01 A	01
D5	836A928H06	1N4148 75 V 0.01 A	01
D6	836A928H06	1N4148 75 V 0.01 A	01
D9	836A928H06	1N4148 75 V 0.01 A	01
D10	836A928H06	1N4148 75 V 0.01 A	01
FILTERS			
FL1	1498B46H01	CRYSTAL BANDPASS	01
FL2	1498B46H01	CRYSTAL BANDPASS	01
INDUCTORS			
L1	3533A74H08	10 µH +/-10%	01
L2	3533A74H03	22 µH 10%	01
L3	3533A74H03	22 µH 10%	01
L4	3533A74H01	100 µH 5% 4.5-OHM IR-4	01
L5	3533A74H01	100 µH 5% 4.5-OHM IR-4	01

Table 18–2. Voice Adapter Module Components (Cont'd).

Location	Style	Description	Group
JACKS			
TJ1	3534A18H03	JACK	01
LINEAR ICs			
I1	9640A62H02	MC1350P IF AMPLIFIER	01
I2	9648A83H01	MC1330AP LOW-LEVEL VIDEO DET	01
I3	3537A40H01	MC3403P QUAD OP-AMP	01
I4	3537A40H01	MC3403P QUAD OP-AMP	01
I5	3533A67H02	NE571 COMPANDOR	01
I8	9648A02H05	MC78L15ACP POS VOLTREG 15 V 5% 0.1 A	01
I9	9648A82H03	MC79L15ACP NEG VOLTREG 15 V 5% 0.1 A	01
OPTOELECTRONICS			
D7	3508A22H01	RED LED (EDGE MOUNT) 550-0406	01
I7	774B936H01	4N35 OPTO-ISO.	01
POTENTIOMETERS			
R24	3535A32H05	5 K-OHM 10% 20 TURN	01
R37	3502A17H11	50 K 20 TURN	01
R41	3534A25H06	50 K-OHM .5 W 25 TURN TOP ADJ. CERMET	01
R63	3535A32H05	5 K-OHM 10% 20 TURN	01
RELAYS			
K1	1484B33H01	AROMAT TYPE ST1E-DC 12 V	01
RESISTORS			
R1	RM845BFQB7	8.45 OHMS 1% 0.25 W METAL FILM	01
R2	RM845BFQB7	8.45 OHMS 1% 0.25 W METAL FILM	01
R3	RM1430FQB1	143 OHMS 1% 0.25 W METAL FILM	01
R4	RM2551FQB0	2.55 KILOHMS 1% 0.25 W METAL FILM	01
R5	RM1432FQA9	14.3 KILOHMS 1% 0.25 W METAL FILM	01
R6	RM2940FQB1	294 OHMS 1% 0.25 W METAL FILM	01
R7	RM1100FQB1	110 OHMS 1% 0.25 W METAL FILM	01
R8	RM1001FQB0	1.00 KILOHMS 1% 0.25 W METAL FILM	01
R9	RM1620FQB1	162 OHMS 1% 0.25 W METAL FILM	01
R10	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	01
R11	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	01
R12	RM2740FQB1	274 OHMS 1% 0.25 W METAL FILM	01
R13	RM4321FQB0	4.32 KILOHMS 1% 0.25 W METAL FILM	01
R14	RM4321FQB0	4.32 KILOHMS 1% 0.25 W METAL FILM	01
R15	RM4321FQB0	4.32 KILOHMS 1% 0.25 W METAL FILM	01
R16	RM8250FQB1	825 OHMS 1% 0.25 W METAL FILM	01
R17	RM4321FQB0	4.32 KILOHMS 1% 0.25 W METAL FILM	01
R18	RM4321FQB0	4.32 KILOHMS 1% 0.25 W METAL FILM	01
R19	RM4321FQB0	4.32 KILOHMS 1% 0.25 W METAL FILM	01
R20	RM1000FQB1	100 OHMS 1% 0.25 W METAL FILM	01

(Continued on next page.)

Table 18–2. Voice Adapter Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS (Cont'd)			
R21	RM392AFQB4	39.2 OHMS 1% 0.25 W METAL FILM	01
R22	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	01
R23	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	01
R25	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01
R26	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01
R27	RM8061FQB0	8.06 KILOHMS 1% 0.25 W METAL FILM	01
R28	RM1501FQB0	1.50 KILOHMS 1% 0.25 W METAL FILM	01
R29	RM4322FQA9	43.2 KILOHMS 1% 0.25 W METAL FILM	01
R30	RM4322FQA9	43.2 KILOHMS 1% 0.25 W METAL FILM	01
R31	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01
R32	RM4991FQB0	4.99 KILOHMS 1% 0.25 W METAL FILM	01
R33	RM1210FQB1	121 OHMS 1% 0.25 W METAL FILM	01
R34	RC470AJH59	47 OHMS 5% 0.5 W CARBON COMP	01
R35	RM2000FQB1	200 OHMS 1% 0.25 W METAL FILM	01
R38	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01
R40	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01
R42	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01
R43	RM2213FQ98	221 KILOHMS 1% 0.25 W METAL FILM	01
R44	RM3482FQA9	34.8 KILOHMS 1% 0.25 W METAL FILM	01
R45	RM4323FQ98	432 KILOHMS 1% 0.25 W METAL FILM	01
R46	RM4871FQB0	4.87 KILOHMS 1% 0.25 W METAL FILM	01
R47	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	01
R48	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01
R49	RM5362FQA9	53.6 KILOHMS 1% 0.25 W METAL FILM	01
R50	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01
R51	RM2323FQ98	232 KILOHMS 1% 0.25 W METAL FILM	01
R52	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01
R53	RM3920FQB1	392 OHMS 1% 0.25 W METAL FILM	01
R54	RM4321FQB0	4.32 KILOHMS 1% 0.25 W METAL FILM	01
R55	RM1211FQB0	1.21 KILOHMS 1% 0.25 W METAL FILM	01
R56	RM1101FQB0	1.10 KILOHMS 1% 0.25 W METAL FILM	01
R57	RM4752FQA9	47.5 KILOHMS 1% 0.25 W METAL FILM	01
R58	RM4122FQA9	41.2 KILOHMS 1% 0.25 W METAL FILM	01
R59	RM9531FQB0	9.53 KILOHMS 1% 0.25 W METAL FILM	01
R60	RM1302FQA9	13.0 KILOHMS 1% 0.25 W METAL FILM	01
R61	RM1302FQA9	13.0 KILOHMS 1% 0.25 W METAL FILM	01
R62	RM1302FQA9	13.0 KILOHMS 1% 0.25 W METAL FILM	01
R64	RM4752FQA9	47.5 KILOHMS 1% 0.25 W METAL FILM	01
R65	RM4752FQA9	47.5 KILOHMS 1% 0.25 W METAL FILM	01
R66	RM4752FQA9	47.5 KILOHMS 1% 0.25 W METAL FILM	01
R67	RM4752FQA9	47.5 KILOHMS 1% 0.25 W METAL FILM	01
R68	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01
R69	RM4752FQA9	47.5 KILOHMS 1% 0.25 W METAL FILM	01
R70	RC5600J167	560 OHMS 5% 1 W CARBON COMP	01
R71	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01

Table 18–2. Voice Adapter Module Components (Cont'd).

Location	Style	Description	Group
RESISTORS (Cont'd)			
R72	RM267AFQB4	26.7 OHMS 1% 0.25 W METAL FILM	01
R73	RM1003FQ98	100 KILOHMS 1% 0.25 W METAL FILM	01
R74	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01
R76	RM1002FQA9	10.0 KILOHMS 1% 0.25 W METAL FILM	01
R77	RC470AJH59	47 OHMS 5% 0.5 W CARBON COMP	01
R78	RC470AJH59	47 OHMS 5% 0.5 W CARBON COMP	01
R79	RM2002FQA9	20.0 KILOHMS 1% 0.25 W METAL FILM	01
R80	RM8061FQB0	8.06 KILOHMS 1% 0.25 W METAL FILM	01
R81	RM8061FQB0	8.06 KILOHMS 1% 0.25 W METAL FILM	01
SWITCHES			
S1	9646A94H04	SPDT W/7089 CAP	01
TERMINALS			
TP1	849A242H01	TEST POINT	01
TRANSISTORS			
Q1	3509A35H08	MPS6546 25 V 0.05 A 0.35 W NPN	01
Q2	3509A35H08	MPS6546 25 V 0.05 A 0.35 W NPN	01
Q3	3509A35H06	2N3906 40 V 0.2 A 0.625 W PNP	01
Q4	762A585H09	2N2102 65 V 1 A 1 W NPN	01
Q5	3509A35H05	2N3904 40 V 0.2 A 0.625 W NPN	01
Q6	3509A35H06	2N3906 40 V 0.2 A 0.625 W PNP	01
TRIMMERS			
C17	879A834H01	5.5-18 pF TRIMMER	01
ZENERS			
D1	862A288H30	1N5230B 4.7 V 5% 0.5 W	01
D2	862A288H30	1N5230B 4.7 V 5% 0.5 W	01
D8	878A619H05	1.5KE22A 22 V 5% 5 W 1.5 KW SURGE	01
D11	878A619H05	1.5KE22A 22 V 5% 5 W 1.5 KW SURGE	01
D12	837A693H21	1N4693 7.5 V 5% @ 50 µA 0.25 W	01
D13	862A288H32	1N5227B 3.6 V 5% 0.5 W	01
D14	862A288H32	1N5227B 3.6 V 5% 0.5 W	01

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USER NOTES

Chapter 19. Optional Trip Test Unit (TTU)

Schematic	1614C25-3
Parts List	1614C27-4

19.1 TTU Description

The optional Trip Test Unit is designed to test two-frequency or three-frequency transfer trip units using the TCF–10B. The schematic diagram of the TTU board (daughter board on the Transmitter Module) is shown in Figure 19-1. This board plugs onto the Transmitter board (see Figure 19-4). The backplane PC board for the TC/TCF–10B has been modified to bring out the extra inputs and outputs needed for the TTU operation. Note, however, that backplanes having a sub lower than five (5) cannot be used with the TTU.

The schematic of the backplane is shown in Figure 7-1. The Timing Diagrams for the TTU are shown in Figure 19-8 through Figure 19-13.

Jumpers JU6, JU7, JU8, and JU9 provide two methods of operation:

1) If JU6, JU7, JU8, and JU9 are all in the 2-3 positions, the local transmitter turns off the GUARD frequency for two (2.0) seconds and sends one-half (0.5) seconds of TRIP. This means that the local receiver will be receiving a “real” TRIP, not a checkback trip.

2) If JU6, JU7, JU8, and JU9 are all in the 1-2 positions, the local transmitter will kill GUARD and send a checkback TRIP 1 to the remote. The remote recognizes this and turns off GUARD to the local and sends a checkback TRIP 1 to the local receiver. The local receiver recognizes this and sends a checkback TRIP 2 to the remote, and the remote returns a checkback TRIP 2 to the local receiver. This is used for three-frequency units.

19.1.1 TTU Cycle

Refer to Figure 19-1 and the Timing Diagrams (Figure 19-8 through Figure 19-13) for the following sequence of events describing a TTU cycle. Both the local substation (LS) and the remote substation (RS) are sending GUARD (HIGH) frequency.

19.1.2 Local Substation Transmitter

You initiate a test sequence either by pressing S1 (TT INITIATE) on the front panel or by applying the appropriate voltage to terminals 6 and 7 of TB4 on the backplane. This causes U12 pin 5 to go LOW and initiates the 0/7.0- or 0/3.0-second TTU interval (U9.1 pin 6-TP4). Combining the TT INITIATE and the unkey line P1-17 causes the transmitter to be unkeyed for an interval of two (2) seconds (U9.2 pin 10-TP5). At the end of the two-second “UNKEY” interval, a half-second (0.5-second) or two-second (2.0-second) SHIFT LOW command is generated on TP7. Jumper JU8 in positions 1 to 2 generates a half-second (0.5-second) of TRIP; JU8 in positions 2 to 3 generates two seconds (2.0 seconds) of TRIP.

The originating local substation (LS) has now completed three actions:

1. Generated a seven-second (7.0-second) or three-second (3.0-second) TTU interval.
2. Unkeyed GUARD for two (2) seconds.
3. Sent a half-second (0.5-second) or two-second (2.0-second) interval of TRIP-SHIFT LOW.

19.1.3 Remote Substation Receiver

The remote substation receiver (RS) actions are shown on the timing diagram in Figure 19-9. LOW SIGNAL (P1-13) and NOISE (P1-14) are ANDed together and integrated (1.5 sec/0) in U6.1 and U4.2 to produce an output on TP9. TP9 output generates a one-second (1.0-second) sampling pulse at point C. U6.3 and U6.2 are AND gates. The HIGH input (A) is ANDed with C, and the LO input (B) is ANDed with C. The receiver at RS recognized that it had lost carrier for one-and-a-half (1.5) seconds and is looking for a half-second (0.5-second) or two-second (2.0-second) transmission of LOW (TRIP) or GUARD HIGH.

The TRIP output is on D (U6.2 pin 4), while the GUARD output is on E (U6.3 pin 10).

19.1.4 Remote Substation Transmitter

From the action described in "19.1.1 TTU Cycle" above, a trip has been sent from LS, and thus there is an output from D. LED 1 is illuminated, signalling receipt of a trip from LS. When the signal returns to GUARD, there is an output from E (U6.3 pin 10), and LED 2 is illuminated. This indicates receipt of GUARD. Output D (Y1) saturates QN2.1 and causes a TT INITIATE command in the remote substation (RS). This does not occur if JU6, 7, 8, and 9 are in position 2 to 3. Instead, two seconds of trip are sent to the master unit. QN1.1 (Line C) via JU7 (in positions 2-3) generates two (2) seconds of TRIP.

Refer to the "REMOTE SEND TRIP 1 – TP7" portion of the timing diagram for the REMOTE TRANSMITTER (Figure 19-10).

If Jumpers JU6, JU7, JU8, and JU9 are in the 1-2 positions, the sequence of events in the remote transmitter is the same as in the local substation:

1. Generates a seven-second (7.0-second) TTU interval (U9.1 pin 6).
2. Unkeys GUARD for two (2) seconds (U9.2 pin 10).
3. Sends a half-second (0.5-second) interval of TRIP (TP7 U10.1 pin 6).

19.1.5 Local Substation Receiver

The local substation (LS) receiver responds to the action of the remote substation (RS) transmitter. This is shown on the timing diagram "LOCAL RECEIVER" (Figure 19-12) when jumpers JU6, JU7, JU8, and JU9 are in the 1-2 positions. The GUARD signal is turned off in the remote transmitter, and there is an output from U6.2 or U6.3.

As in the RS, NOISE and LOW SIGNAL are ANDed together and produce a one-second (1.0-second) sampling pulse at the inputs to AND gates U6.3 and U6.2. The half-second (0.5 seconds) of TRIP (low frequency) sent by the RS causes an output from U6.2 pin 4 through Jumper JU6 to QN2.1. U9.1 is already set (7 seconds) and is not changed because of a logic "0" on pin 5. When the remote transmitter returns to GUARD, U6.3 pin 10 has an output and U6.4 pin 11 has an output that drives U10/2 pin 12 via JU9. A two-second (2-second) UNKEY command is sent to the transmitter (see Timing diagram LOCAL XMIT unkey P1-17 U10.2 pin 10 TP8). After the two-second (2-second) UNKEY interval, U7.2 pin 10 shifts the carrier to the HIGH frequency for a half-second (0.5 seconds) and LED 4, "SEND TRIP 2," is illuminated.

When jumpers JU6, JU7, JU8, and JU9 are in the 2-3 positions, the GUARD signal is not turned off in the remote (refer to Figure 19-12). The only signal received is TRIP (U2.1 – pin 1). There is no output from U6.2 or U6.3.

19.1.6 Remote Substation Receiver

The remote substation receiver received two (2) seconds of LOW SIGNAL and NOISE, followed by a half-second (0.5 seconds) of TRIP 2, and LED 2, "RECEIVE TRIP 2," is illuminated. U6.4 pin 11 unkeys the remote transmitter for two (2) seconds and, at the end of this period, sends a half-second (0.5 seconds) of TRIP 2 to the local substation (LS). The LS receives the two (2) seconds of LOW SIGNAL and NOISE, followed by the Trip 2 signal. LED 2, "RECEIVE TRIP 2," is illuminated. The output of U8.4 pin 11 (F) does not produce an output from U6.4 because the seven-second (7.0-second) time interval of the LS has expired.

19.1.7 Timing Diagram

Table 19-1 (in Figure 19-8) Table 19-1a (in Figure 19-8a) list the events that occur at the local substation (LS) and the remote substation (RS). There are nine (9) events for both the LS and the RS. Use Table 19-1 when the TTU jumpers JU6, JU7, JU8, and JU9 are in the 1-2 positions and Table 19-1a when they are in the 2-3 positions.

The timing diagram is divided into four sections:

- LOCAL TRANSMITTER
- REMOTE RECEIVER
- REMOTE TRANSMITTER
- LOCAL RECEIVER

The events shown in Table 19-1 (in Figure 19-7) are shown on the timing diagram, highlighted with circles around the numbers.

19.1.8 Relay K1

Relay K1 operates in conjunction with the RECEIVE TRIP 1 and RECEIVE TRIP 2 LEDS. K1 is energized by the receipt of TRIP 1 or TRIP 2. K2 is energized any time TRIP 1 or TRIP 2 is transmitted. J5 is a voltage selector jumper for the external transfer trip initiate command. J3, the TRIP KILL jumper, is always in the NO position. (The YES position is not used in this application) U11.1 is a power-up reset circuit that prevents a TTU sequence until the circuits have all settled when power is first applied.

19.1.9 Transfer Trip Function

When you use the TTU with a TCF–10B transceiver, the transmitter board (Figure 19-4) is all that is required to provide the transfer trip test function. When you are using only TCF–10B receivers or only TCF–10B transmitters, the Transmitter Module (Figure 19-4) is used in the transmitter only, along with a jumper board plugged into the CLI/discriminator slot. A jumper board is required in the transmitter slot of the receiver only. Use a four-wire shielded cable to interconnect the receiver only and the transmitter only. The jumper boards and the cable are shown in Figure 19-5 and Figure 19-6.

19.1.10 JU6, 7, 8 and 9

Jumpers JU6, 7, 8, and 9 are provided to allow two different types of operation. With JU6, 7, 8, and 9 in the 1 to 2 position, the units send "checkback trips" from one end to the other. In other words, the GUARD signal is turned off before a TRIP is transmitted. (U9.2 drives U10.1.) When the jumpers are in the 2 to 3 position, U10.1 is driven by QN1.1 and D8. Operating in this mode, the TTU operating as a master sends a checkback trip to the remote end. The remote end then sends back a REAL TRIP to the master. P4 is adjusted for TP4 of three (3.0) seconds, instead of the seven (7.0) seconds used for JU6, JU7, JU8, and JU9 in positions 1-2.

⚠ CAUTION

YOU MUST EXERCISE CARE TO DISABLE TRIP FUNCTIONS EXTERNAL TO THE CARRIER SET AT THE MASTER END.

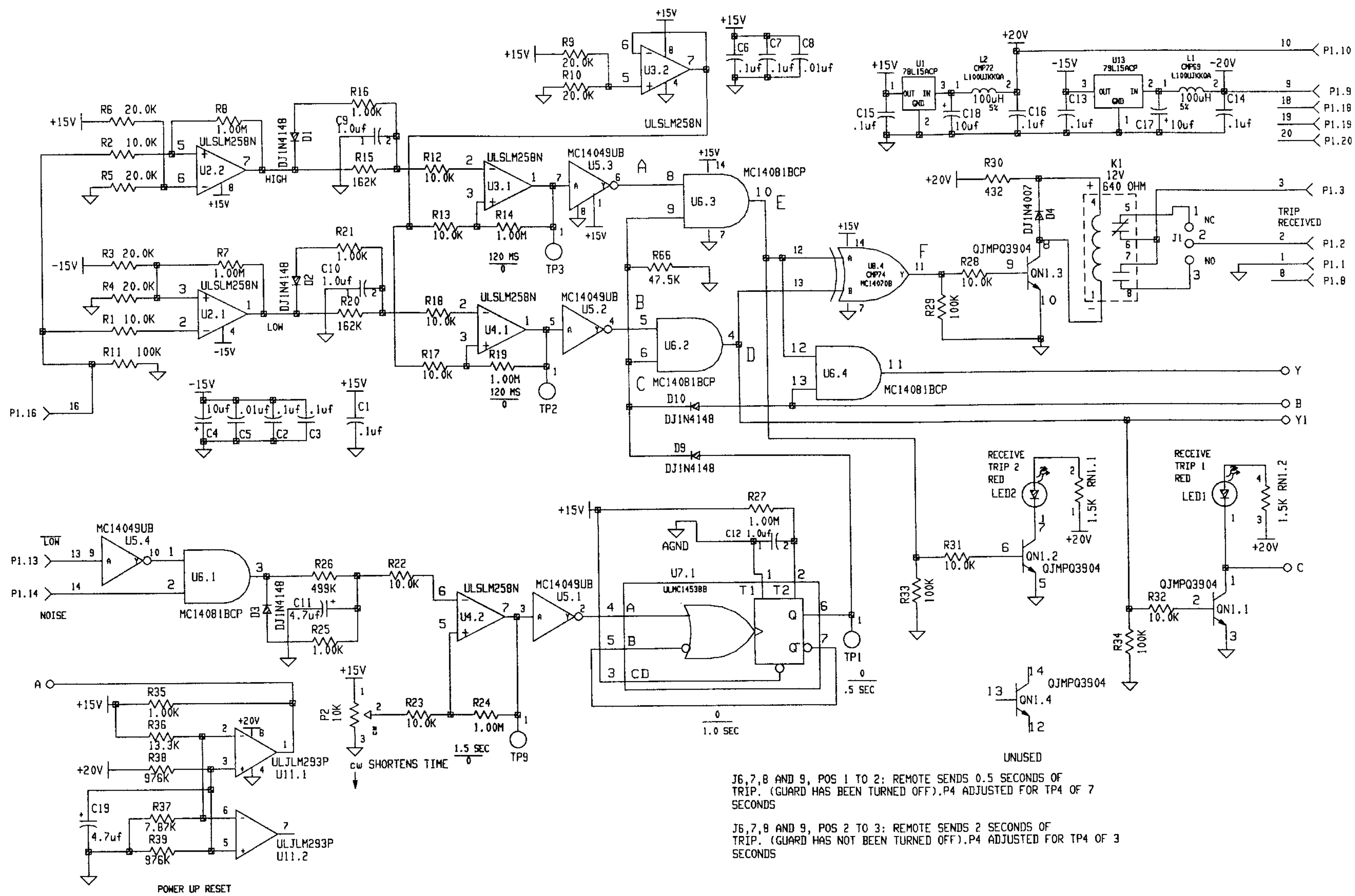

Figure 19–1. Schematic of TTU Daughter Board (1614C25; Sheet 1 of 2).

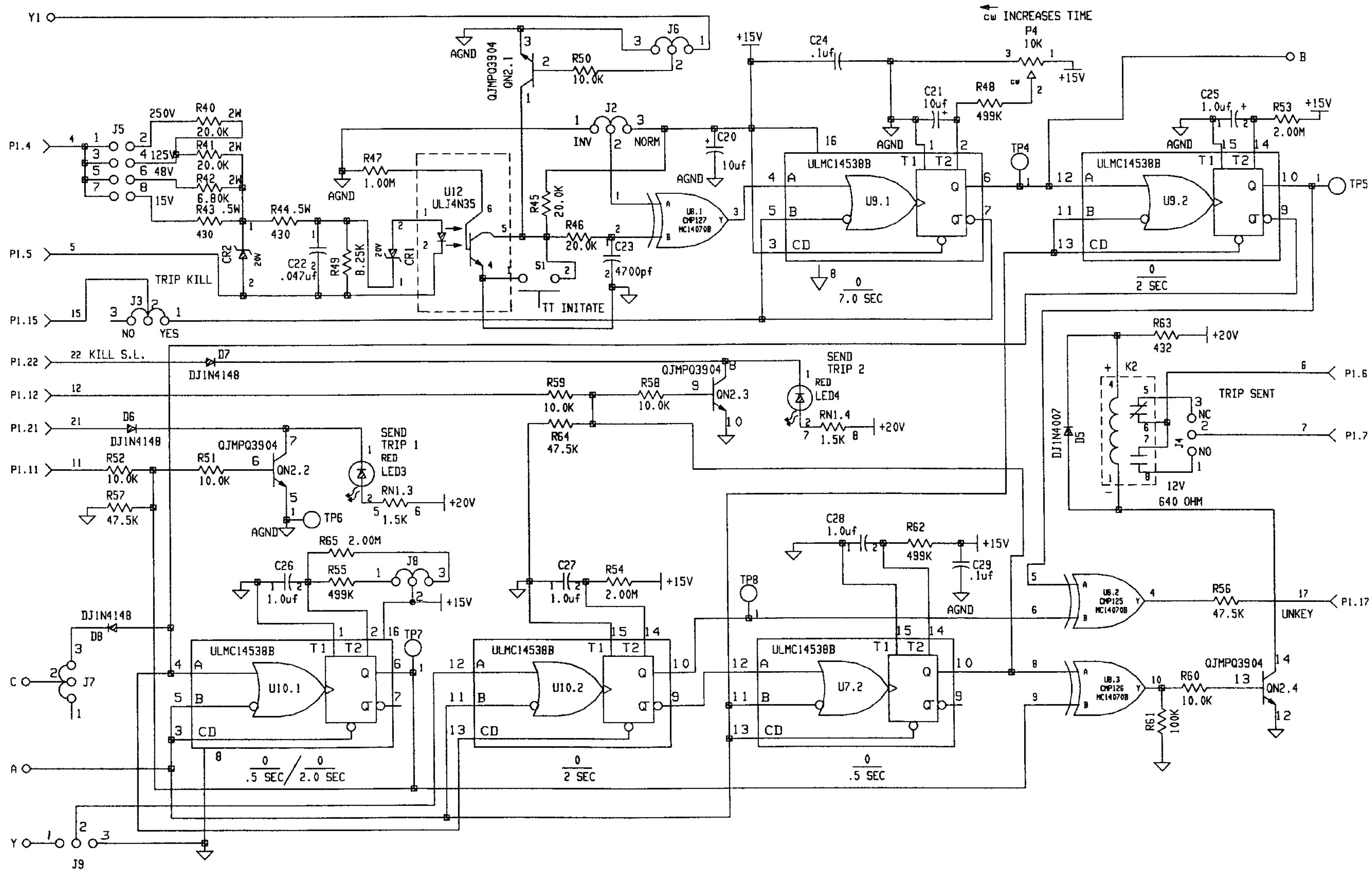

Figure 19–2. Schematic of TTU Daughter Board (1614C25; Sheet 2 of 2).

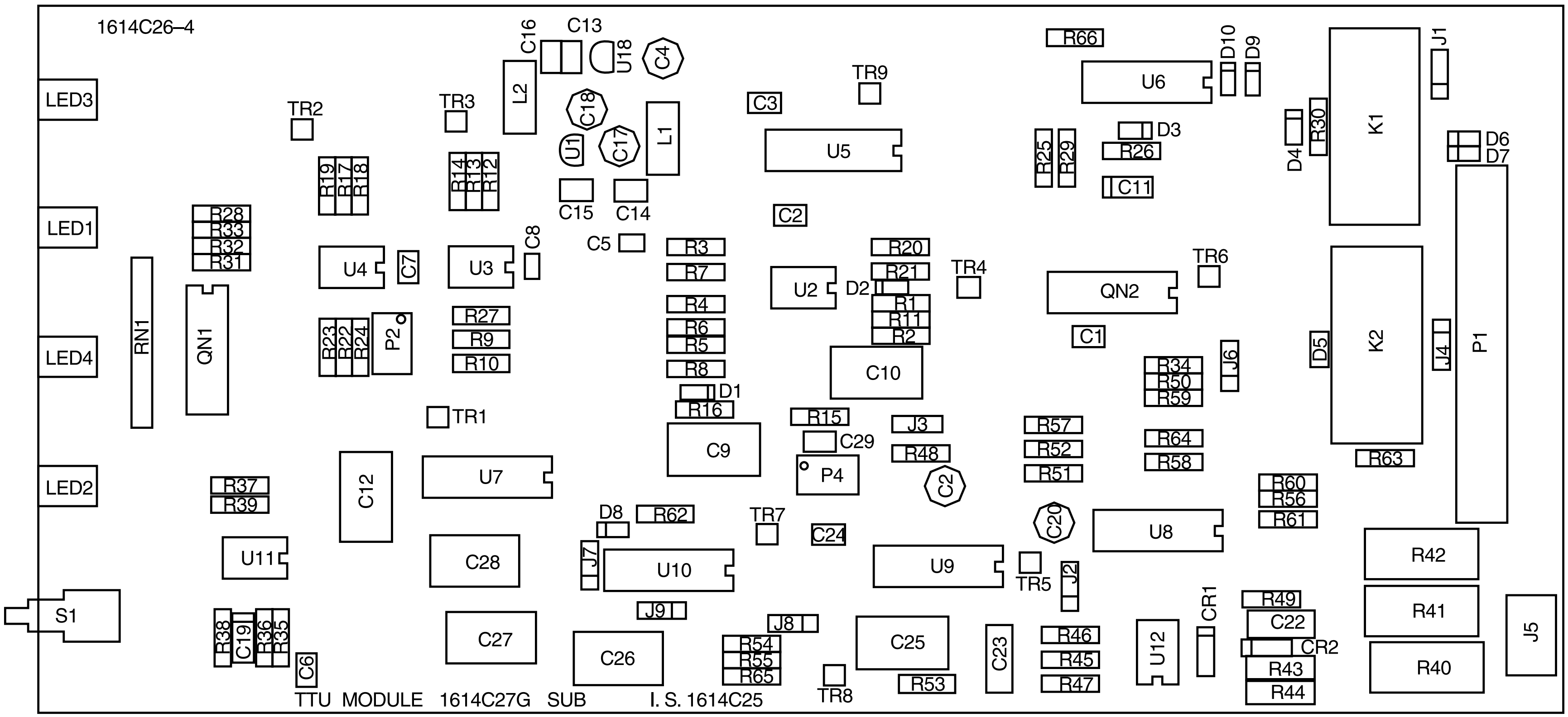

Figure 19–3. Component Layout for TTU Daughter Board (1614C26; Sheet 2 of 2).

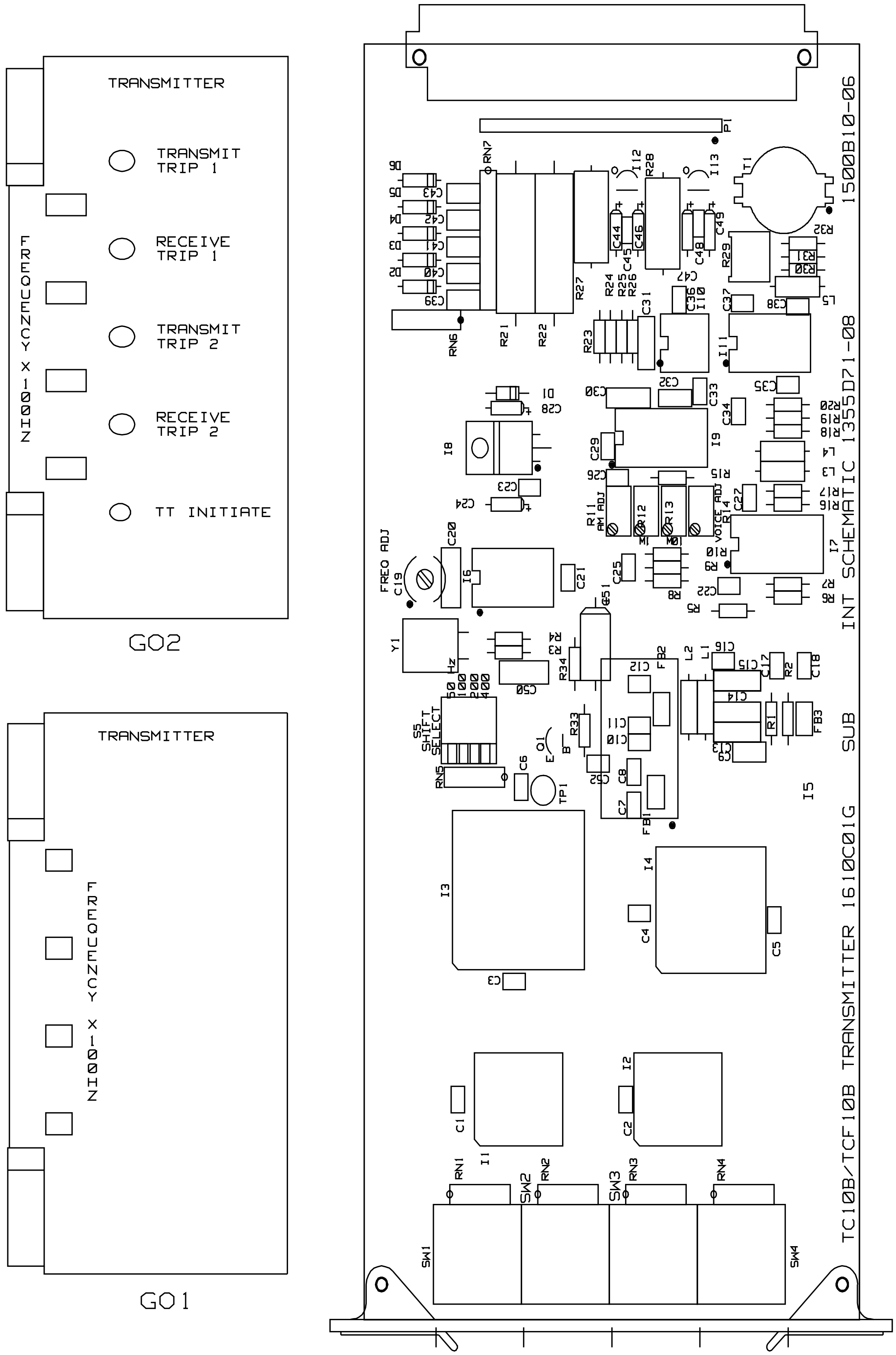

Figure 19–4. Transmitter Board (1610C01).

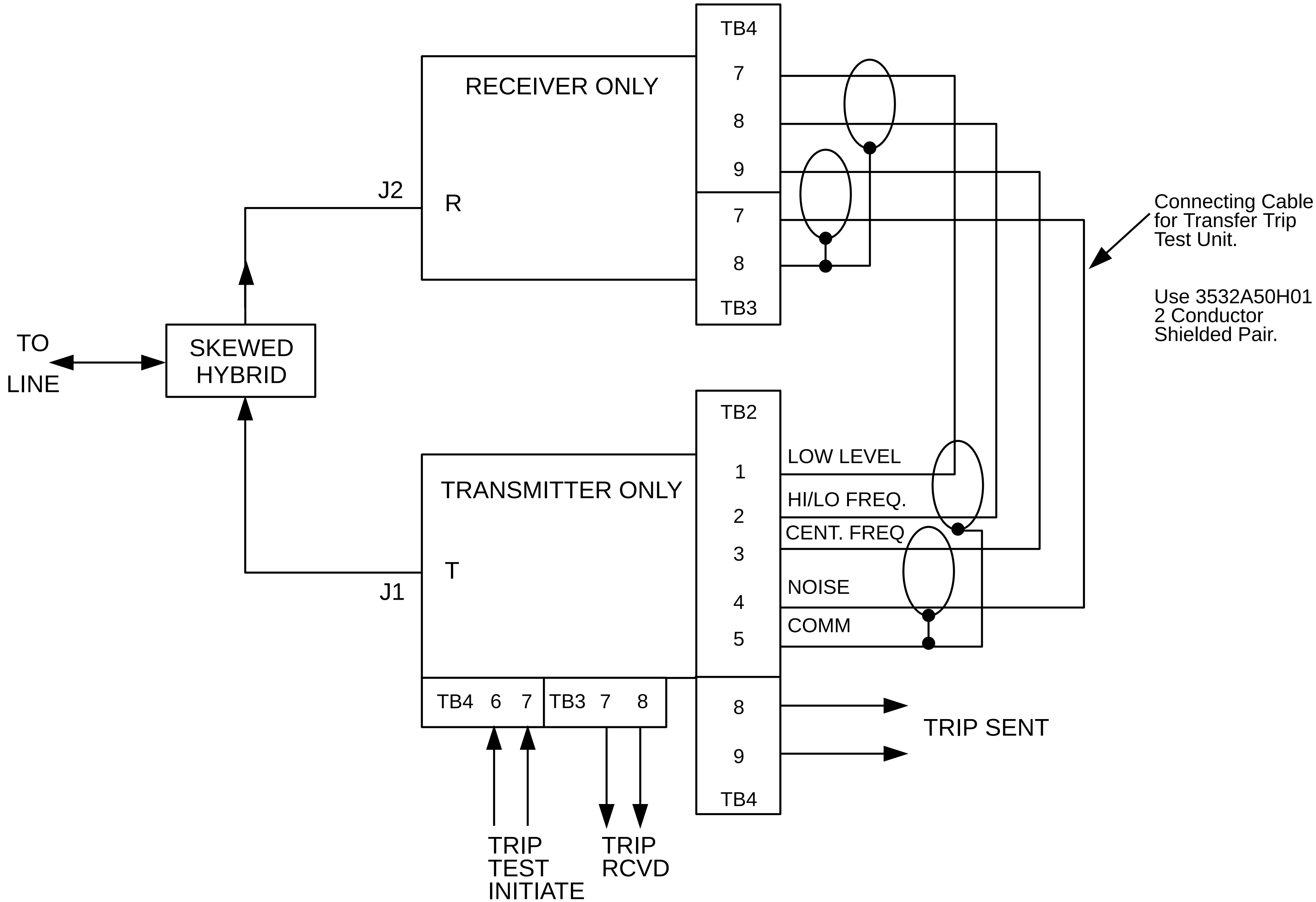

Figure 19–5. Jumper Boards.

For TTU use with

TCF-10B (RCVR Only)
TCF-10B (XMTR Only)

1. TRANSMITTER JUMPER BOARD GOES IN RECEIVER ONLY.

JUMPER	A/C32	to	C30	COMMON	TB3-8
	A14	to	A30	NOISE	TB3-7
	C12	to	C20	CENT. FREQ.	TB4-9
	A12	to	A20	HI/LO FREQ.	TB4-8
	C14	to	A22	LOW LEVEL	TB4-7

2. CLI & DISCRIMINATOR JUMPER BOARD GOES IN TRANSMITTER ONLY.

JUMPER	A/C30	to	C/A20	COMMON	TB2-5
	A8	to	C/A18	NOISE	TB2-4
	A10	to	C/A16	CENT. FREQ.	TB2-3
	A28	to	C/A14	HI/LO FREQ.	TB2-2
	C28	to	C/A12	LOW LEVEL	TB2-1

3. CABLE.

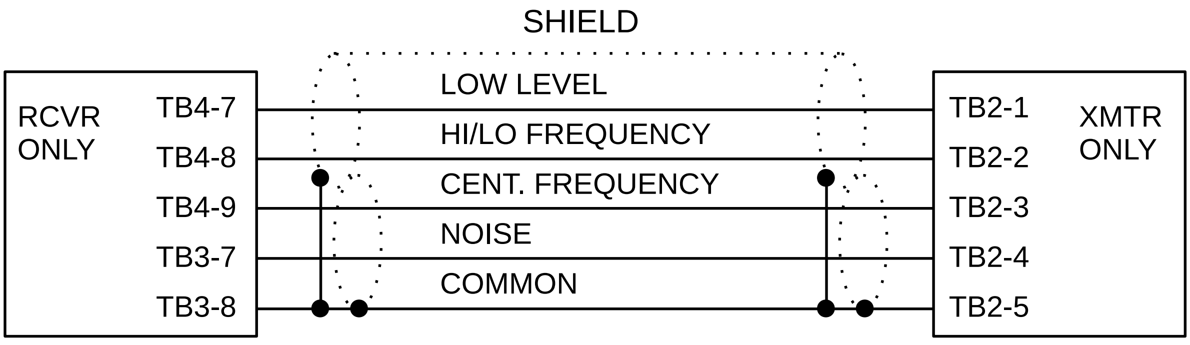

Figure 19–6. Cable Drawing.

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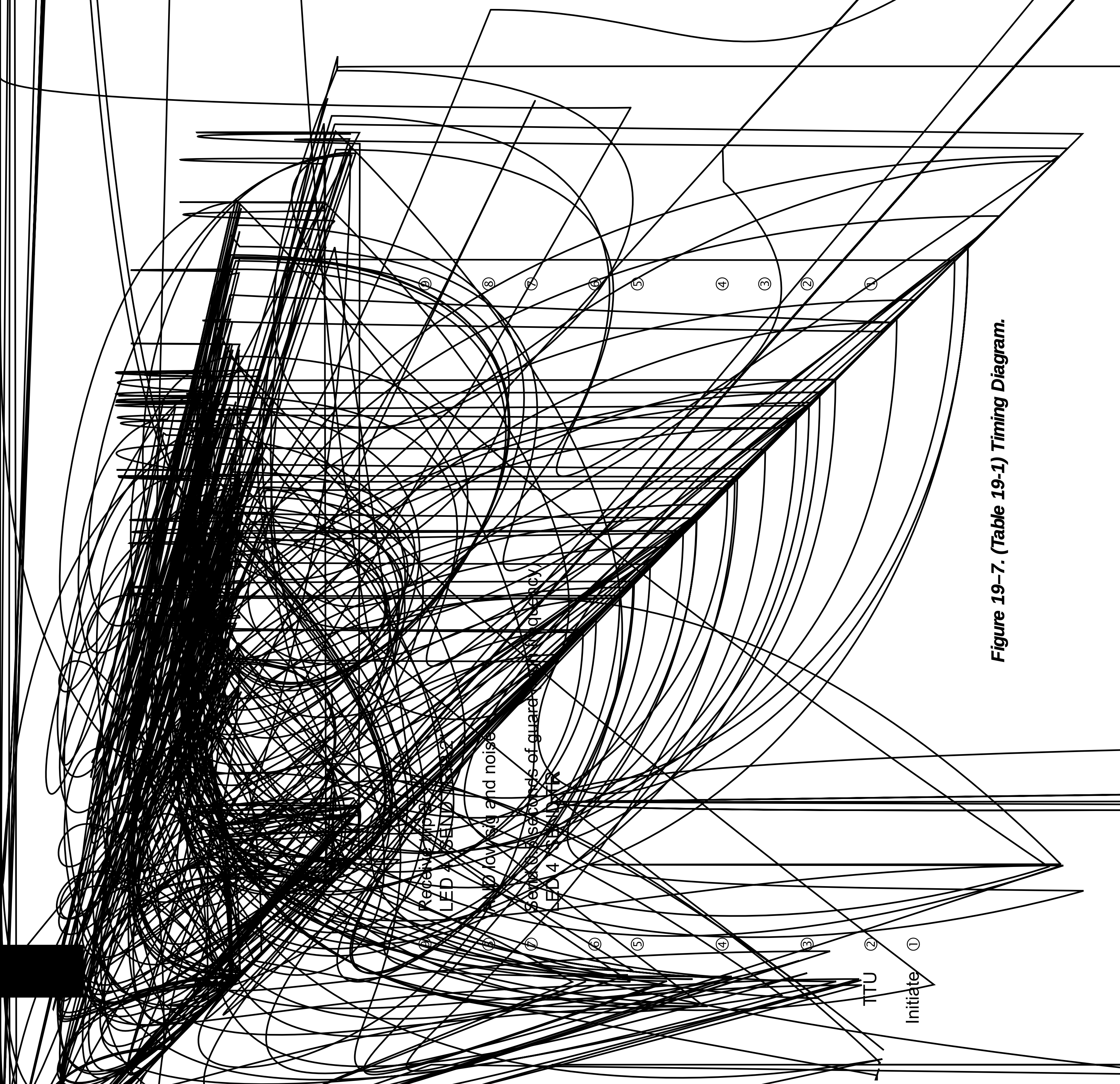

Figure 19–7. (Table 19-1) Timing Diagram.

TABLE 19-1a

Timing Diagram
For Sending Checkback Trip from
Master to Remote and a Full Trip from
Remote to Master
JU6, 7, 8, 9 in 2 to 3

Time ↑		LOCAL SUBSTATION (LS)			REMOTE SUBSTATION (RS)
	⑤	Master receives 2 seconds of TRIP & Checkback TRIP	←	⑤	Send 2 seconds of TRIP to Master
	③	Send 2 seconds of TRIP (low frequency)	→	②	Receive 2.0 seconds of TRIP LED 1 "RECEIVE TRIP 1"
TTU	②	Unkey transmitter for 2 seconds	→	①	AND low sig and noise for 1.5 seconds
Initiate	①	Set up 3.0 second TTU interval			

Figure 19–7a. (Table 19-1a) Timing Diagram.

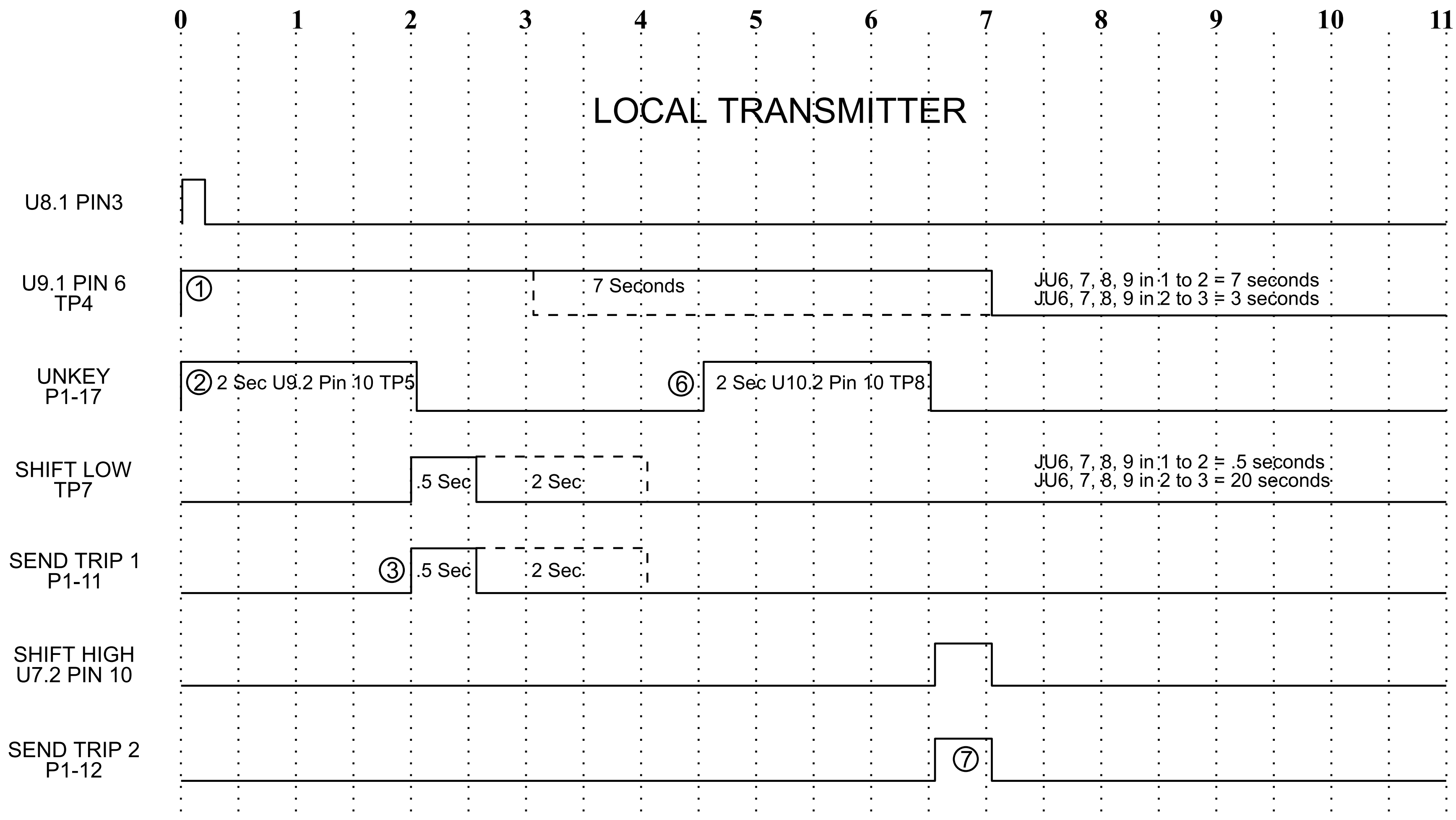

Figure 19–8. TCF–10B Trip Test Unit Timing Diagram (Sheet 1 of 5).

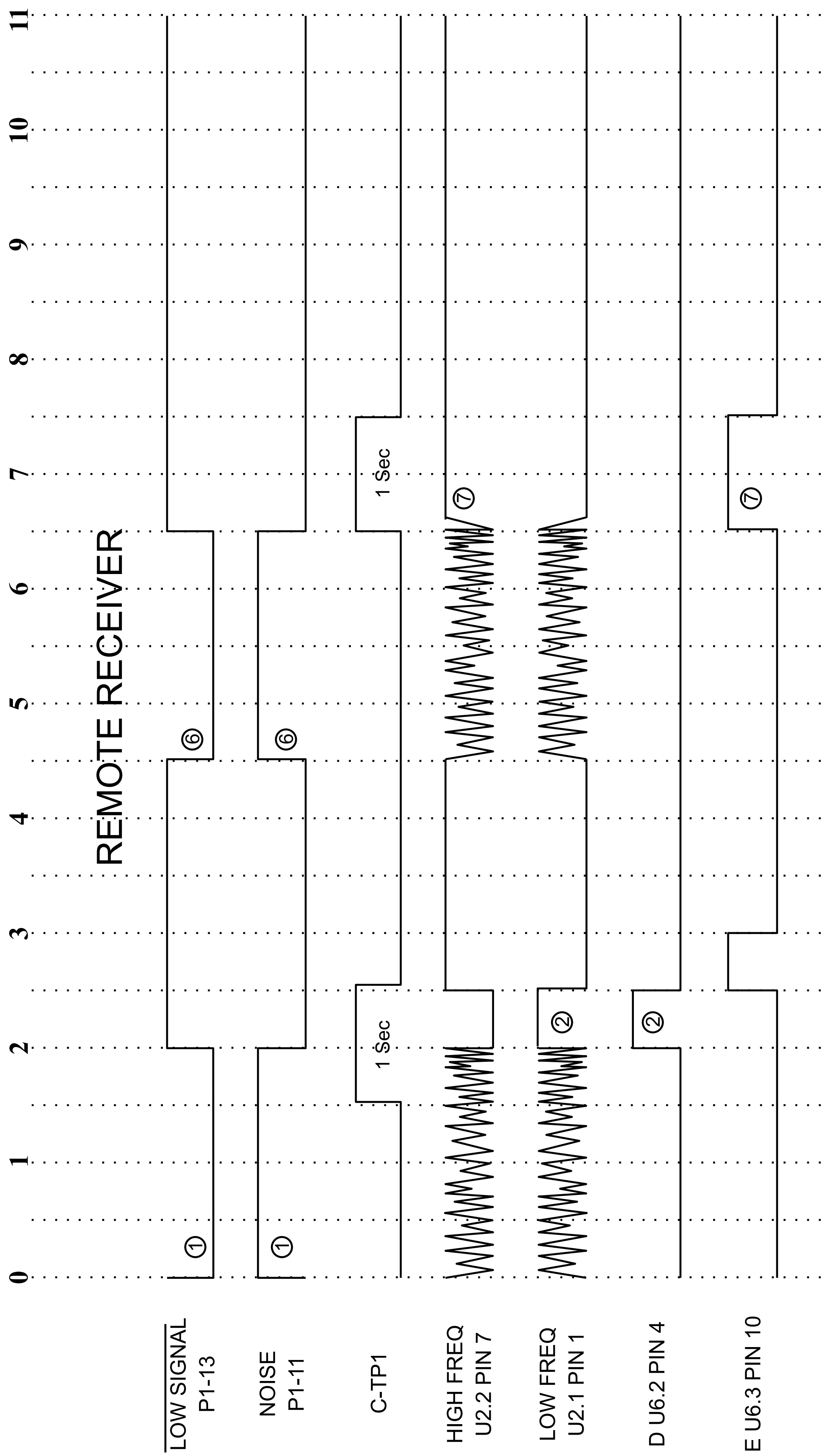

Figure 19–9. TCF–10B Trip Test Unit Timing Diagram (Sheet 2 of 5).

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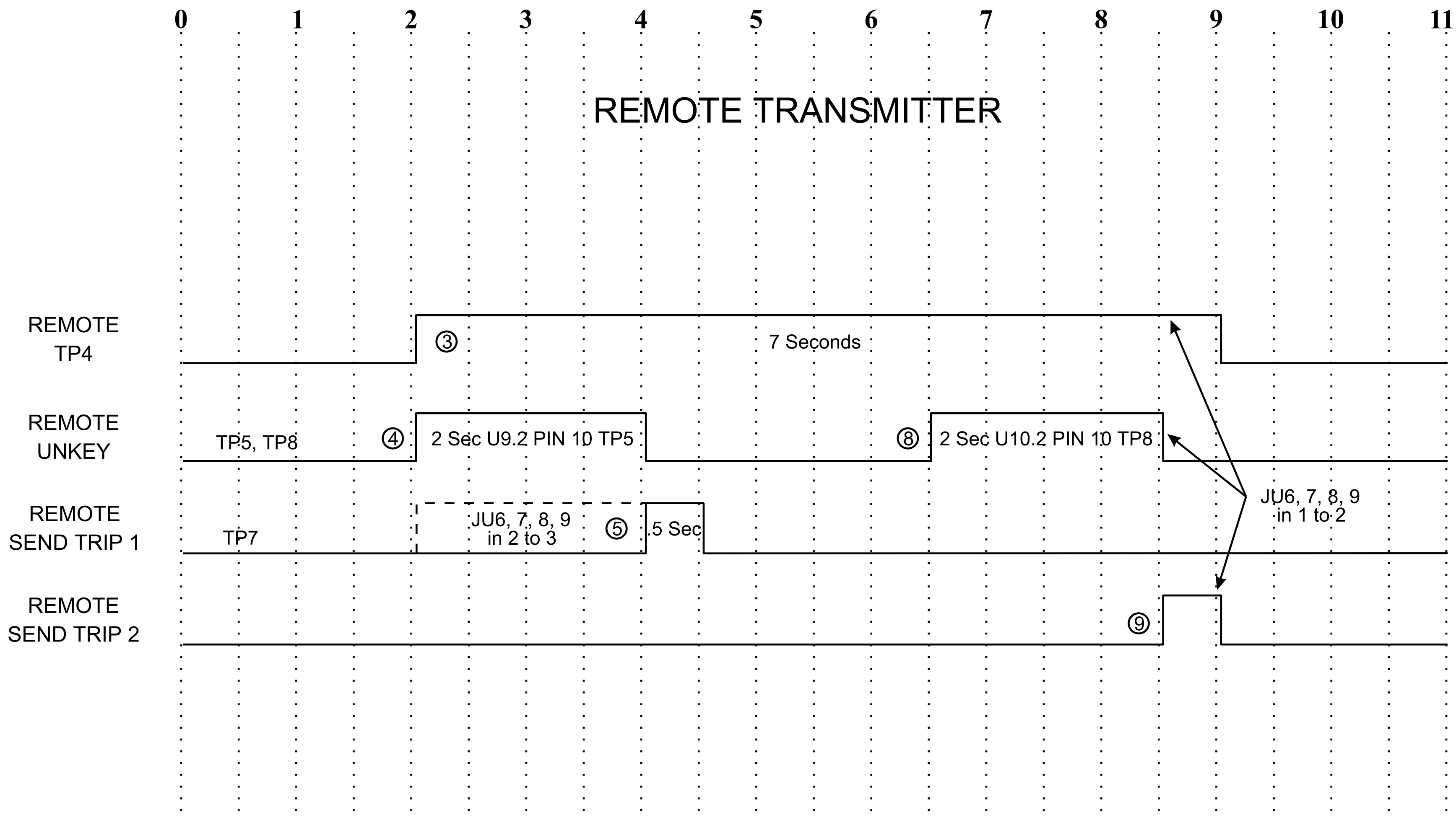

Figure 19–10. TCF–10B Trip Test Unit Timing Diagram (Sheet 3 of 5).

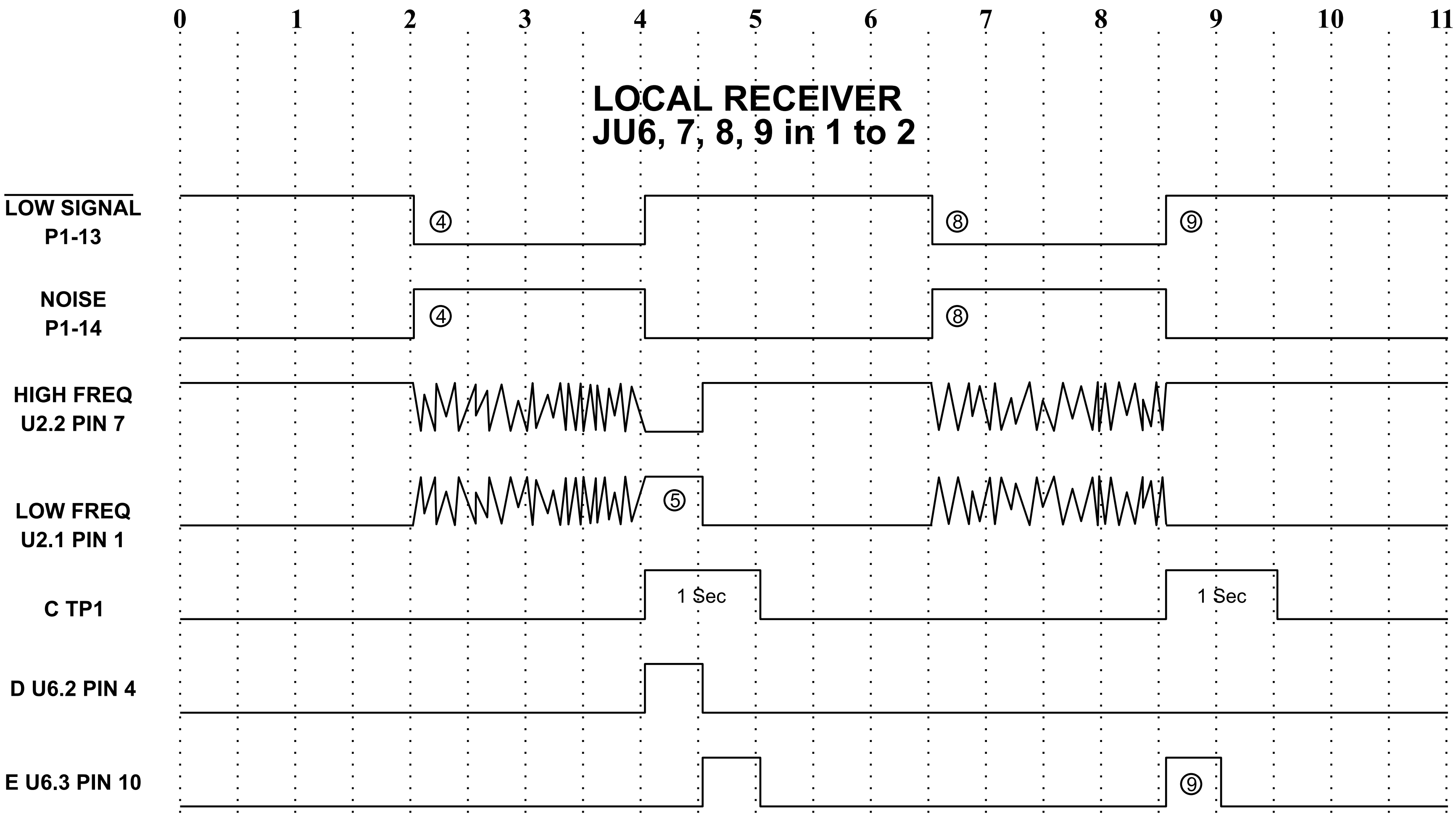

Figure 19–11. TCF–10B Trip Test Unit Timing Diagram (Sheet 4 of 5).

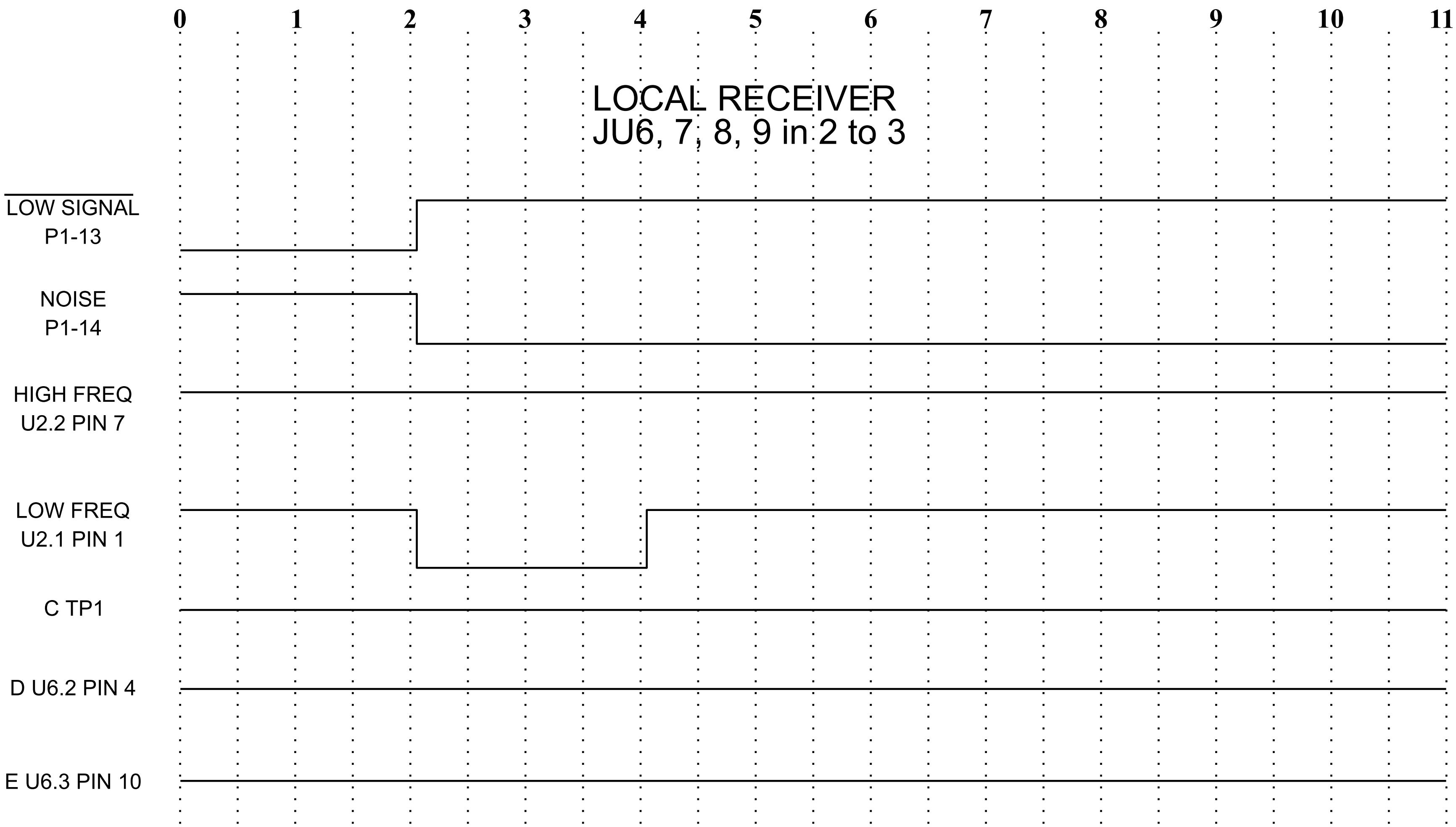

Figure 19–12. TCF–10B Trip Test Unit Timing Diagram (Sheet 5 of 5).

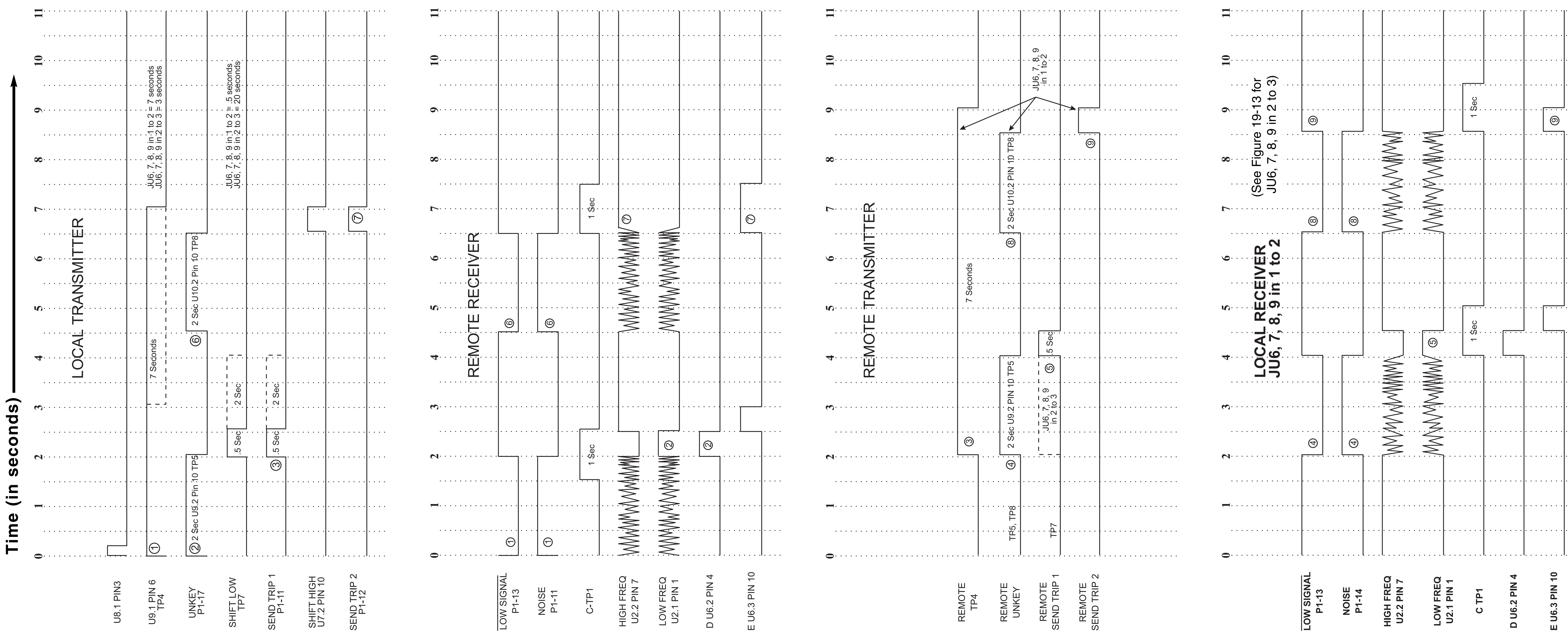

TABLE 19-1

Timing Diagram
For Sending Checkback Trip in Both Directions
JU6, 7, 8, 9 in 1 to 2

		LOCAL SUBSTATION (LS)			REMOTE SUBSTATION (RS)
	⑨	Receive trip 2 LED 4 "SEND TRIP 2"	←	⑨	Send 0.5 seconds of guard (high frequency) LED 4 "SEND TRIP 2"
	⑧	AND low sig and noise	←	⑧	Unkey transmitter for 2 seconds
	⑦	Send 0.5 seconds of guard (high frequency) LED 4 "SEND TRIP 2"	→	⑦	Receive 0.5 seconds of guard LED 2 "RECEIVE TRIP 2"
	⑥	Unkey transmitter for 2 seconds	→	⑥	AND low sig and noise
	⑤	Receive 0.5 seconds trip LED 1 "RECEIVE TRIP 1"	←	⑤	Send 0.5 sec trip (low frequency)
	④	AND low sig and noise for 2 seconds	←	④	Unkey transmitter for 2 seconds
				③	Set up 7.0 second TTU interval
	③	Send 0.5 sec TRIP (low frequency)	→	②	Receive 0.5 seconds trip LED 1 "RECEIVE TRIP 1"
TTU	②	Unkey transmitter for 1.5 seconds	→	①	AND low sig and noise for 1.5 seconds
Initiate	①	Set up 7.0 second TTU interval			

(Time ↑)

TABLE 19-1a

Timing Diagram
For Sending Checkback Trip from
Master to Remote and a Full Trip from
Remote to Master
JU6, 7, 8, 9 in 2 to 3

		LOCAL SUBSTATION (LS)			REMOTE SUBSTATION (RS)
	⑤	Master receives 2 seconds of TRIP & Checkback TRIP	←	⑤	Send 2 seconds of TRIP to Master
	③	Send 2 seconds of TRIP (low frequency)	→	②	Receive 2.0 seconds of TRIP LED 1 "RECEIVE TRIP 1"
TTU	②	Unkey transmitter for 2 seconds	→	①	AND low sig and noise for 1.5 seconds
Initiate	①	Set up 3.0 second TTU interval			

(Time ↑)

Figure 19–13. TCF–10B Trip Test Unit Combined Timing Diagram.