TR-100+

MULTI-FUNCTION RECORDER

Operation Manual

Publication 1079-305
Rev. B

28 November 2006

AMETEK POWER Instruments
255 N. Union Street
Rochester, New York 14605

Tel: (800) 881-4156
Fax: (585) 238-4945
Web: www.ametekpower.com

Please Read This First!

Explanation of Symbols

The following symbols are used with this product and instruction manual for compliance with UL 61010B-1, Electrical Measuring and Test Equipment.

Caution (refer to the product instruction manual for installation and safety information)

IMPORTANT NOTES

THE INSTRUMENT DESCRIBED IN THIS MANUAL REQUIRES A 110V DC OR 110/230V AC POWER SOURCE. THIS MAY BE DERIVED FROM A REMOTE HIGH VOLTAGE BATTERY OR MAINS SUPPLY. THE FIELD CONTACT VOLTAGE MAY BE SELECTED FROM 24/48/125V DC AT TIME OF ORDER

****

ENSURE THAT ALL INSTALLATION/TESTING AND COMMISSIONING IS CARRIED OUT BY TRAINED AND QUALIFIED PERSONNEL TAKING ANY RELEVANT PRECAUTIONS CONCERNING HAZARDOUS VOLTAGES

****

UNAUTHORISED MODIFICATIONS OR REPAIRS WILL INVALIDATE THE AMETEK WARRANTY PLEASE CONTACT THE AMETEK CUSTOMER SERVICES DEPARTMENT BEFORE TAKING SUCH ACTIONS

****

STANDARD DEFAULT SETTINGS ARE INDICATED IN THIS MANUAL TO WHICH TR-100+ RECORDERS WILL BE SET SHOULD NO SPECIFIC CONFIGURATION OR SET UP DETAILS BE SUPPLIED WITH PURCHASE ORDERS

REVISION HISTORY				
Revision	**Date**	**Description**	**Author**	**Approved**
A	6 Aug 03	Layout update	MMcP	
B	Nov 06	Add Digital only input option		

Table of Contents

OVERVIEW

The TR-100+ is a multi-function recorder that includes the features of many separate instruments for monitoring a power system. These include protection operations, system stability, and power quality. The voltages and currents on three phase lines are recorded via standard instrumentation transformers to 16-bit accuracy. The state of protection relays and switchgear can also be monitored via auxiliary switch contacts. Additionally, other transducers can be connected to the TR-100+ for monitoring a wide range of parameters.

By providing a complete range of functions from a single connection to the power network, the TR-100+ is a very cost effective instrument. A range of departments within a utility can use information from the recorder. Recorders can be cross-triggered to extend the amount of data captured for each event. TR-100+s can also be coupled together to provide up to 160 channels of recording.

The TR-100+ can include the functions of any of the systems listed below.

- Transient fault recorder
- Trend monitor
- Generator monitor
- Sequence of events recorder
- Disturbance recorder
- Stability monitor
- Long term logger
- Recording frequency meter
- Recording power meter
- Vector meter
- Power quality analyzer
- Oscilloscope
- Switchgear wear & performance monitor
- Station battery monitor
- Diagnostic & maintenance tool

TRIGGERED RECORDS

When an abnormal event is detected, analog inputs and auxiliary contact data are stored in the TR-100+'s memory. The stored data includes a period of time starting before the event occurs, until after conditions have returned to normal. This data frame constitutes a data record that may be viewed in a graphical form with some initial measurements of the transient event. Both waveform records (transients) and longer-term RMS records (disturbance) are saved.

Loggers

The input voltages and currents to the TR-100+ are recorded as a maximum, minimum and average RMS value every minute. The maximum, minimum and average frequency is also recorded. The TR-100+ is fitted with a large hard drive and this log will save data for 16 weeks before the data is overwritten. Selected blocks of data can be downloaded from the TR-100+ for graphical display. Harmonic data for each channel are also recorded in a separate log. Optionally, the maximum, minimum and average real power and power factor are saved every minute

Power Quality Analyzer

The TR-100+ records the harmonic profile of all voltage and current inputs defined in phase groups continuously. This is used to measure trends with time or compare harmonic distortion at different locations. There are a number of features as part of Display Station that allows harmonic and other power quality data to be viewed.

Voltage dips can be classified by depth and duration to provide a profile of substation performance. This can be used to compare performance at different sites, and show trends with time.

The TR-100+ has a sensitive THD trigger mode that allows very subtle voltage distortions to be recorded, which would otherwise be missed using normal triggering methods. This can indicate progressive faults before they cause a serious problem.

Transducers

The TR-100+ computes a wide range of values from the recorded voltages and currents. External transducers may be connected to the TR-100+ to extend the range of functions. These could include pressure, temperature & tap position etc.

DISPLAY STATION 32

Display Station 32 is a software application that runs on a standard Windows 98/2000/XP based PC. This provides a communication link to all TR-100+, TR-2000, TR-100, PQR and DL8000 monitors via an RS232 port, LAN, dial up modem, or WAN.

All the recorder parameters can be updated remotely, and the analog signals and digital status can be viewed on line. Data records can be downloaded to the user's location, and partial information such as a profile or cameo can be viewed to reduce communications time.

Transient, logger and harmonic data can be displayed, analyzed and printed using a range of functions. An Expert System is used to classify faults into a number of categories for ease of interpretation. Voltage Dip and Breaker Performance Analysis databases are updated for quality and maintenance scheduling.

The supported versions of the Windows Operating System are -

Windows 98 SE
Windows 2000 Professional
Windows XP Professional

TR-100

The TR-100+ is designed to be upgradeable from a TR-100 or DL8000. The connections and input ranges are very similar to allow an easy field upgrade. For more information see Chapter 3. When compared to the TR-100 the TR-100+ offers: -

Higher resolution (16 bits)
Higher accuracy (0.2% FS)
Higher sampling rates (up to 12.8 or 15.36 kHz)
Disturbance (RMS) recording mode
Continuous harmonic recording
Power and power factor recording (optional)
Sequence of events recording
Smaller enclosures (5U, 7U and 9U)
Larger data storage (40Gbytes)
Digital only input modules cards are available

1. INTRODUCTION

The TR-100+ multi-function recorder is designed using leading edge computer hardware and software techniques. The high speed, high resolution recording, flexible triggering modes, and long term recording modes make it ideal for capturing all forms of line transients, protection operations, power quality surveys, real time display of station values, stability monitoring, switchgear maintenance, sequence of events recording, metering, etc.

INPUT CONNECTIONS

In a single chassis a maximum of 32 analog inputs can be connected to standard protection or metering voltage and current transformers. Any input can be configured as a voltage or a current input when the system is ordered. Changing the input range in the field requires a simple link selection. All system inputs are DC coupled with a frequency response up to 3.84kHz (¼ sample rate)

In addition to the 32 analog inputs, there are also 64 digital inputs for reading the state of protection relays and switchgear. The digital inputs require a wetting voltage from a source external to the TR-100+. 4 status relay outputs are available for connection to a SCADA or alarm system. The status relays are high voltage types that need no external supply. The power supply to the recorder can be AC or DC, and must be specified at the time of order.

The TR-100+ can be specified to have 8, 16, 24 or 32 analog inputs with 16, 32, 48 or 64 digital inputs available on the analog modules. Up to 4 additional Digital only input modules consisting of 32 digital inputs may also be specified. Three sizes of chassis may be provided, 5U, 7U and 9U rack-mount cabinet, depending on the number and type of input modules required. If future system expansion is planned the 8, 16 and 24 channel units can be supplied in a 7U or 9U chassis, allowing future addition of Analog or Digital input modules.

RECORDING FUNCTIONS

The TR-100+ provides multiple concurrent power monitoring functions in one system. This gives maximum functionality with minimum installation cost. Each of the recording modes works independently of the others but the transient and disturbance recorders are triggered from the same source. The functions include:

Transient Fault Recorder

All analog and digital inputs are sampled synchronously up to 15,360 times per second (256 samples per cycle). The transient recorder is mostly used for monitoring protection operations. The VT & CT waveforms and auxiliary protection contacts are recorded before, during, and after the fault clearance. The optional Expert System software can be used to analyze this data and report on any abnormalities. Other information can be extracted for Power Quality and system maintenance.

Disturbance recorder

The Disturbance recorder monitors longer-term events. RMS and phasor information is stored twice per cycle per channel, and these are used to compute a variety of power system quantities. This function is used for recording re-closer sequences and system stability events. It can also be used to extend the pre- and post-fault times of a Transient record.

Long-term (trend) logger

The input and computed quantities are logged as maximum, minimum and average quantities every minute. A 16-week log of data is saved by the system. This data can be retrieved at reduced sampling rates for trending and power quality analysis.

Power Quality monitor

The parameters that define Power Quality are recorded by the TR-100+, and then processed and viewed by applications running on a PC. These include:

Voltage & frequency profiles
Voltage dips
Loss of supply
Harmonic content

Flexible display options allow this information to be shown in a wide range of styles. Refer to the Display Station manual for setup information.

Sequence of Events Recorder

All transitions on the digital inputs of the TR-100+ are recorded and can be displayed with a disturbance record. The time resolution is 1 ms. Input point and time filtering are available to limit the number of events displayed. Digital data is also available with transient records.

Real Time Monitoring

As well as triggering and logging instruments, the TR-100+ includes the ability to view analog and digital inputs and computed values in near real time. Measured values and waveforms can be seen locally or remotely. These can replace or act as back-up systems for:

Waveform oscilloscope
Panel meters
Annunciation panel
Vector displays

Fault Locator

Based on the information in a transient record of a line fault and a model of the transmission line impedance, the distance-to-fault can be calculated. Source and remote end impedances, remote end in-feed and mutual coupling are used to compute a more accurate distance.

The source, remote and line impedances may be entered in sequence component, per phase or per unit (PU) form. The fault distance is computed several times during the period of the fault and the results averaged. The fault impedance is also returned. The fault impedance can be used with a complex impedance model to locate the source of a fault in a distribution network. Distribution fault location is not currently part of the Display Station data analysis suite.

On-line Switchgear & Battery Monitor

Because the TR-100+ is attached to strategic protection equipment, it can be used for condition monitoring. Circuit breaker operations are recorded and analyzed by an Expert System. The measurements from each operation are stored in a database and these are used in a number of programmable contact wear formulae.
The accumulated number of operations, arcing current and arcing time all contribute to wear of the main contacts. By selecting one of the three standard formulae, the service period for each piece of switchgear can be determined.

The TR-100+ can also monitor the breaker coil currents and battery voltage. This provides more information on the state of the switchgear and the state of the battery under load.

Power Logger (optional)

The real power and power factor values from the logger are used to plot the load profile and the amount of reactive load. The Power Factor is displayed with unity power factor (1) at the center of the band, lagging pf above and leading pf below.

Plant Commissioning Diagnostic Tool

The extensive sets of functions within Display Station Analysis (DSA) allow it to be used for the installation and commissioning of a power plant. Test records can be taken either manually or automatically and analyzed with DSA to check for correct operation of switchgear, transformers, etc. These records can be archived and used for comparison during future diagnostic checks.

HARD DISK STORAGE

The TR-100+ is fitted with a hard disk drive. This provides a large non-volatile data storage capacity for transient and disturbance fault records. It also stores the long-term logger data. The long-term logger saves the maximum, minimum and average voltages, currents and frequency every minute. It also records certain power usage and power quality data. This log is 16 weeks long and requires approximately 8 Mbytes of storage for every 8 input channels.

NETWORK CAPABILITY

The TR-100+ can be configured as part of an integrated monitoring network with multiple recorders at sub-stations within a region. Display Station can be located at the regional control center or headquarters. Communications between Display Station and the TR-100+s may be by dial-up modem on an internal or external phone system, or by a TCP/IP network connection on a company wide area network (WAN).

EVENT LOG

The TR-100+ maintains a log of event and error messages that may be read by Display Station. If an internal error is detected during a self-test, a message is placed in the event log. The red 'Attention' LED and relay are then activated until Display Station reads the message.

TIME SYNC

The TR-100+ can accept a number of sources for time synchronization. The ‘Remote comms’ connector on the rear panel can be programmed to accept a serial time code from an external clock. There is also an option to include an IRIG-B receiver that is available as a BNC socket on the rear panel.

2. HARDWARE DESCRIPTION

Depending on the number of Analog/Digital and Digital only input modules required the TR-100+ chassis are supplied in a 5U, 7U or 9U. The front panel of the chassis may be released by unscrewing the two screws at the top of the panel. When the panel is opened the internal architecture of the TR-100+ may be seen. The system is based on a number of horizontal steel trays that slide into tracks in two high-density polyethylene side plates, making service and maintenance of the TR-100+ very easy. The trays are locked in place with brackets that are screwed to the side plates.

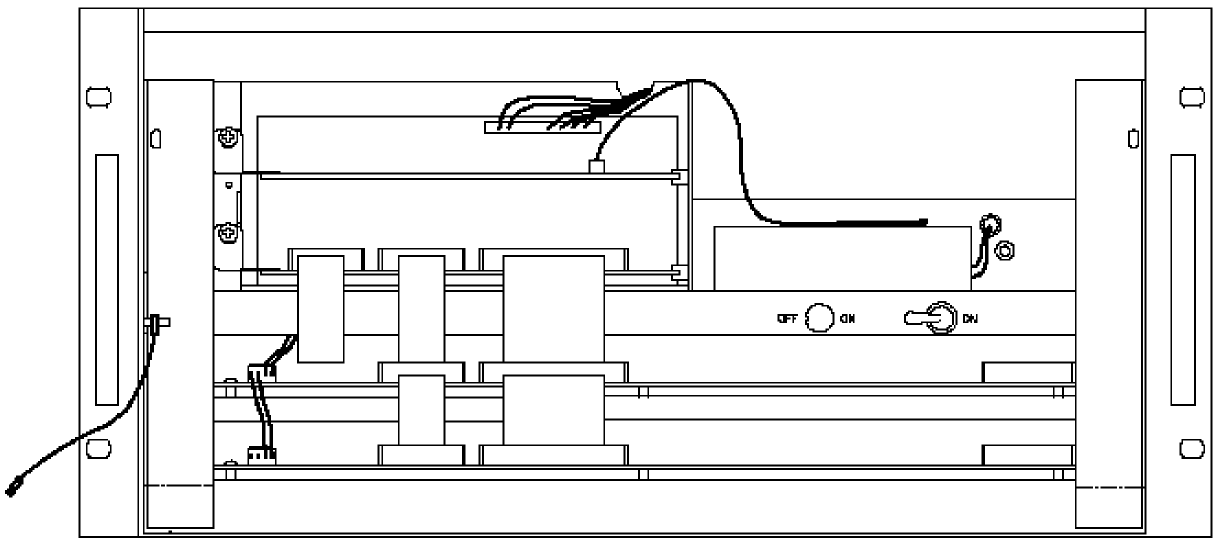


Figure 1 TR-108+ 16 channel internal layout

The top tray houses the processor and acquisition boards, the disk drive and the power supply, while the bottom tray(s) holds the input conditioning board(s).

TOP TRAY

On the top (or processor) tray, the top board is the Pentium processor board and the bottom board is the acquisition board. These boards are plugged into a three-slot backplane and secured by a bracket at the left side of each board. A card guide supports the right side of each board. The spare slot in the backplane is assigned for options such as a data modem or network board.

When the unit is powered up there are three red LEDs at the top of the backplane to indicate that the supply voltages are on (+5V, +12V & -12V). Note there is no –5V in a TR-100+ and so the equivalent LED is not illuminated.

The power supply is fitted at the rear of the tray with the power, communications and auxiliary connectors mounted on the back flange of the tray. The main power switch is fitted to the front flange of the tray at the right hand side.

BOTTOM TRAY

The bottom tray(s) hold the input boards, which contain the signal conditioning components for the analog/digital input channels and the status relay outputs, as well as the Digital only input modules. It is connected to the acquisition board by two ribbon cables. The large central one is for the analog and digital data signals, the smaller left hand one is for the status outputs.

The top-most input board must be maintained in this position. This board contains the status output circuitry, and cannot be moved to any other position in the enclosure.

At the right rear of each input board is a strip of spring metal fingers. These slide against a bracket on the rear panel to make a connection for the protective earth ground. It is important to ensure that these contacts are kept clean. The signal input connectors are mounted directly on the rear of the input board with no interposing cables or boards. The actual configuration of voltage and current inputs is detailed in the Project Summary supplied with the unit. If the input configuration is changed this should be documented in the Project Summary at the rear of this manual.

CHASSIS SIZES

The TR-100+ systems fit inside 5U, 7U or 9U rack mount or wall mount cabinets. The top tray (processor tray) is the same for all models. There are up to 6 extra input trays at the bottom of the enclosure to accommodate the various number of Analog/digital or Digital only input modules. The internal chassis connection to the extra boards is identical to the input modules in a 16-channel system. Connections are made in the same way at the rear of the cabinet with extra rows of screw terminals. The actual configuration of voltage and current inputs as well as the number of digital inputs is detailed in the Project Summary supplied with the unit. Reference Table 1 Recorder Models and Input Modules

Table 1 Recorder Models and Input Modules

Model	Analog Boards	Digital Boards	Available Analog Channels	Available Digital Channels	Chassis Size
TR-108+	1	0	8	16	5U
TR-108+D1	1	1	8	48	7U
TR-108+D2	1	2	8	80	7U
TR-108+D3	1	3	8	112	9U
TR-108+D4	1	4	8	144	9U
TR-116+	2	0	16	32	5U
TR-116+D1	2	1	16	64	7U
TR-116+D2	2	2	16	96	7U
TR-116+D3	2	3	16	128	9U
TR-116+D4	2	4	16	160	9U
TR-124+	3	0	24	48	7U
TR-124+D1	3	1	24	80	9U
TR-124+D2	3	2	24	112	9U
TR-132+	4	0	32	64	7U
TR-132+D1	4	1	32	96	9U
TR-132+D2	4	2	32	128	9U

FRONT PANEL

Inside the front panel is a board that carries the status LEDs and test button. It is connected to the acquisition board via a 14-conductor IDC cable. To the right of this board is the serial port connector (used with Display Station), which is linked to the processor board via a 9-conductor cable.

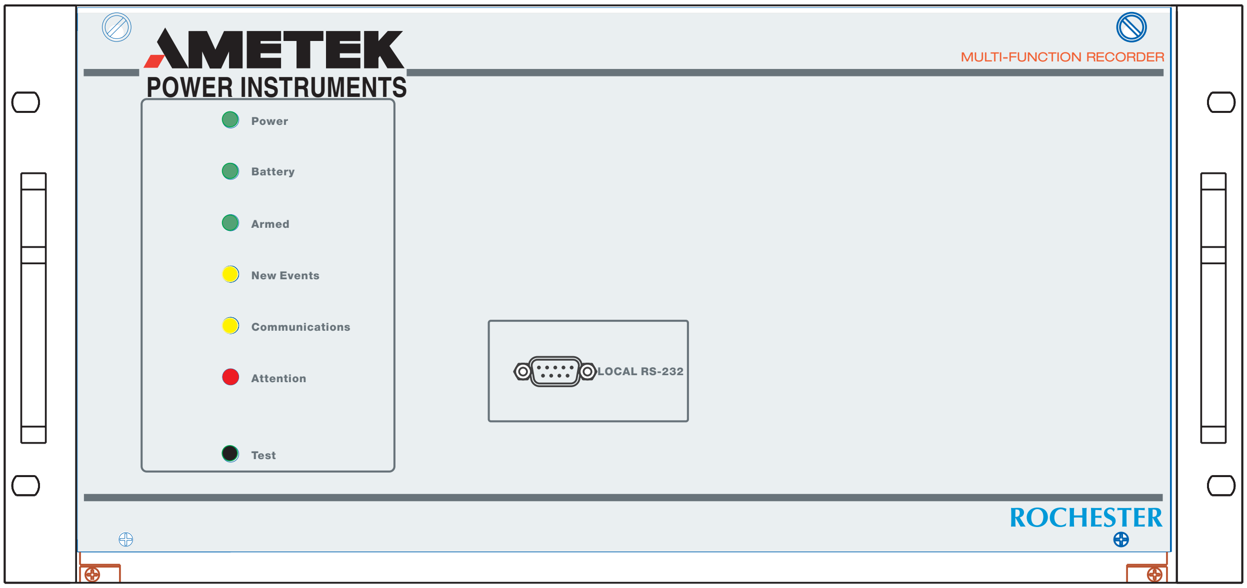


Figure 2 TR-108+ front panel

Status LEDs

There are six indicators on the front panel that display the system status. Four of these functions are also available as relay outputs on the rear panel. The six LEDs have the following functions:

Power

This green LED is illuminated when the external power supply is present. The LED is connected to the internal +5V supply.

Battery

This option is not currently used.

Armed

At power on, this green LED will remain off until the TR-100+ has completed its internal self-tests. If everything is satisfactory, the light will turn on and will stay on as long as the TR-100+ is acquiring data. To put the system off line, see ‘Disarm System’ below.

New Events

This amber LED shows that the TR-100+ has triggered and that one or more data records are available for downloading. After Display Station reads the directory with the new records, this LED will be switched off.

The TR-100+ is fitted with a hard disk drive and this LED will flicker as data is being written to or read from the drive.

Communications

During either local or remote communications, this amber LED is lit. A local operator may use this to indicate that a remote connection is active. Only one communications channel to Display Station can be active at any one time.

Attention

If the TR-100+ detects a problem during any of its regular internal self-tests, it will illuminate this red LED. If this is seen, Display Station should be connected to read the TR-100+'s event log and find the source of the problem (see Display Station 32 manual).

Test Button

The 'Test' button on the front panel may be used at any time to check that the TR-100+ is operating correctly. When the button is pressed, a series of internal tests are made and a manual trigger is performed. This record may be recovered and viewed by Display Station Analysis to check the integrity of the signal inputs. Alternatively, Display Station can be connected to view the inputs in near real time. If the TR-100+ detects a fault during these tests, it will switch on the 'Attention' indicator. The cause of the problem can be found by reading the event log with Display Station.

Disarm System

The 'Test' button may also be used to disarm all recording within the TR-100+. This may be required if maintenance is being performed on the monitored lines or transformers when extraneous triggering could occur. By pushing the 'Test' button for 5 seconds, the 'On Line' LED will go out, indicating that all recording is disarmed. There is also a tone that changes from a low to high pitch when the system disarms.

To rearm the recorder, press the 'Test' button again briefly. Since the recorder is not yet armed, no test record will be generated. The Disarm function is also available in the Recorder Configuration window of Display Station. Messages are placed in the alarm log that indicates the time and date the system was disarmed and re-armed.

N.B. No triggering or logging functions operate while the system is disarmed.

STATUS OUTPUTS

The four solid-state status relay outputs are situated on the left of the top input board. These are specified as normally open contacts. The power relay is held on by the system logic. The others are software controlled and switched on to indicate the designated function.

The four defined functions are as follows:

Power

Duplicates the function of the front panel LED. This relay will be closed when power is applied to the recorder.

Armed/Ready

Duplicates the function of the front panel 'Armed' LED. This relay will be closed when the recorder is acquiring data.

Triggered

The relay is activated while the TR-100+ is triggered with a minimum on-time of 500 ms. this relay has a slightly different function if the recorder cross triggering is enabled (see Section 4).

Attention

Duplicates the function of the front panel LED. This relay will normally be open and will close when the red 'attention' LED on the front panel is on.

TRANSIENT AND DISTURBANCE RECORDING

For transient recording, all the inputs are sampled at up to 256 samples per cycle (12,800 samples per second at 50 Hz or 15,360 at 60 Hz) and stored in a circular memory buffer. The input levels are compared with defined values to check for an abnormal condition (e.g. an under voltage or an over current). If one is detected, the TR-100+ triggers and starts storing the sampled data in a separate post-fault buffer. After a fixed time, or after the inputs have returned to normal, the TR-100+ will stop saving data to the post-fault buffer and start a new circular buffer.

The data in the first circular buffer and the post-fault buffer form a data record that has saved data from the analog and digital inputs before, during, and after the time the trigger condition was seen. This record may send to Display Station for display and analysis.

Disturbance recording works in a similar way except that the RMS and phasor information is saved twice per cycle (100 samples per second at 50 Hz, or 120 samples at 60 Hz). The recording times for a disturbance record may be several minutes. The triggering mode is linked to the transient record and these are aimed at longer-term events such as system stability and some power quality parameters.

The transient and disturbance recorders are cross-triggered so that the disturbance record can act as extended pre- and post-fault data for the transient record. Both these record types have dynamic post-fault. This means that if a trigger condition continues longer than the minimum post-fault time the record will extend up to the maximum length set. If a trigger extends beyond the maximum transient record length it will be captured by the disturbance recorder function. If it extends beyond the minimum disturbance post-fault time the length of the disturbance record will increase. For both record types the TR-100+ will continue to capture data until:-

The minimum post-fault time is reached if the trigger duration is short
There are no triggers active for the ‘safety window’ time.
The maximum record length is reached if the trigger duration is long.

To set the triggering conditions and read the data records, simply plug a portable computer running Display Station software into the program port on the front of the TR-100+. One computer can be used for many TR-100+s, thereby reducing costs and making the parameter and record data more secure. All the functions available from the local RS232 port are also available remotely via a modem or data network.

The selectable sample rates for transient recording are: -

SPC	**50Hz**	**60Hz**
64	3.2kHz	3.84kHz
128	6.4kHz	7.68kHz
256	12.8kHz	15.36kHz

3. INSTALLATION

The TR-100+ is available in a 5U, 7U, or 9U 19” rack mounting enclosure. All main supply, input and output connections are via screw terminals at the rear of the case. Communications and other auxiliary connectors are also on the rear panel. The only exception is the program plug, which is for temporary use and is on the front panel.

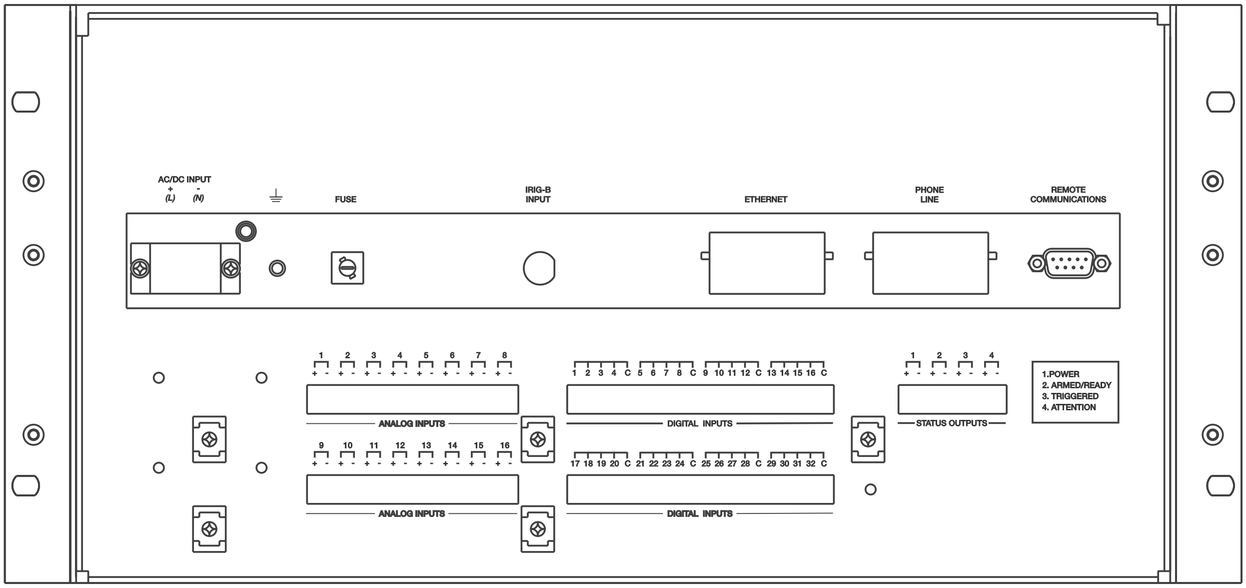


Figure 3-16-channel TR-116+ rear panel connection details

The TR-100+ is available in a wide range of configurations with a number of options. To check the actual specification of a particular system, consult the System Drawings in Appendix IV of this manual. Please confirm that the Serial number matches that on the specification.

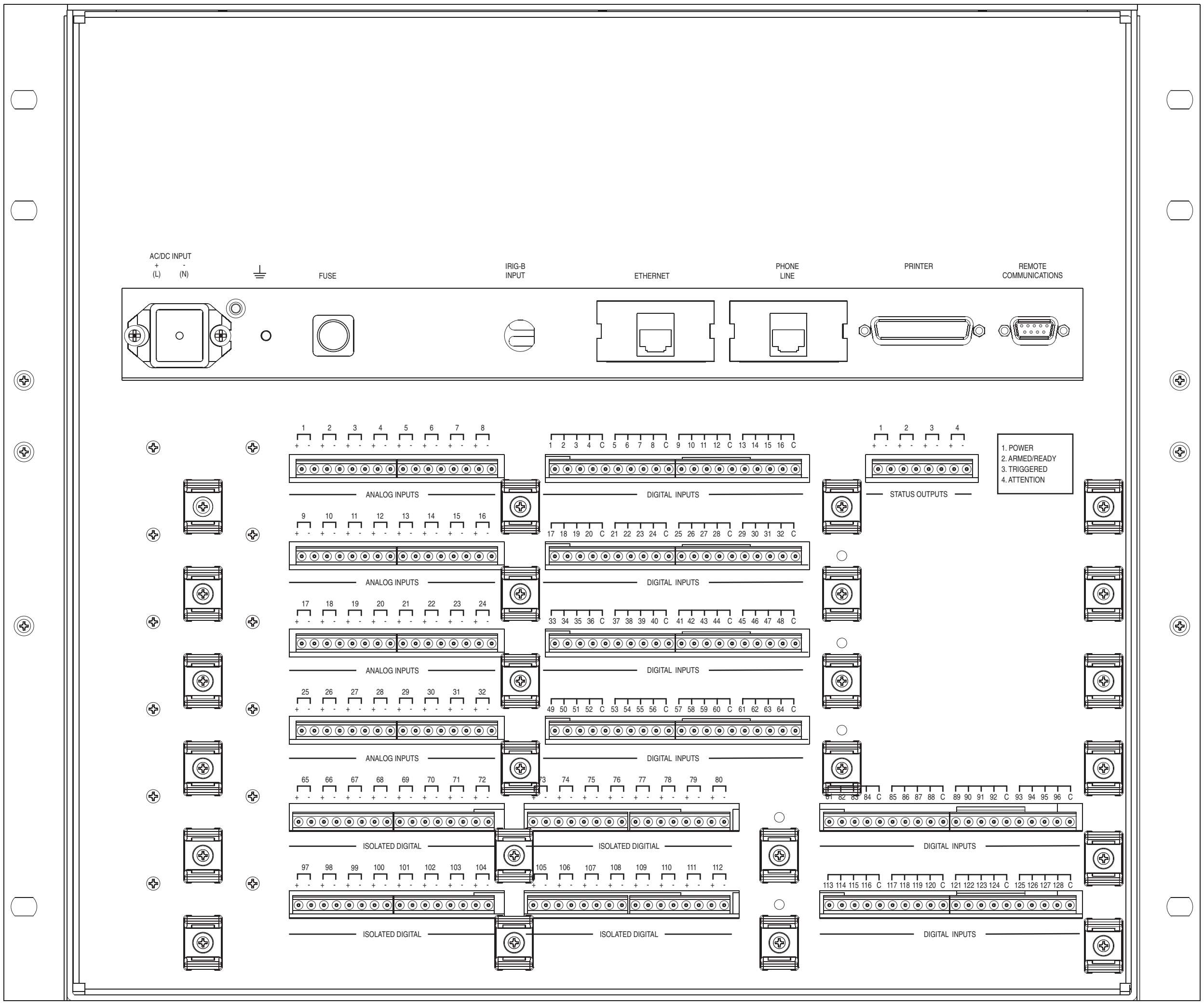


Figure 4 TR-132+ D2 32 Analog channels 126 digital channels in a 9U chassis.

POWER SUPPLY CONNECTION

The main power supply is connected to the terminal block at the center left of the rear panel. If a DC supply is being used, the polarity must be observed. The actual voltage specified will be indicated in the System Drawings located in Appendix IV of this manual. The specified voltage must be used, and damage may occur if an incorrect voltage is applied. The maximum wire size that the terminals will accept is 4 mm^2 (12 AWG).

There is an earth stud at the rear of the TR-100+ that must be connected to a main system earth with a suitable braided ground cable. This is required to ensure the safe operation of the TR-100+.

ANALOG & DIGITAL INPUT CONNECTIONS

The analog input cables are connected to the strip connectors at the rear of the TR-100+. The sequence of voltage and current transformer inputs must follow the User Specification sheet. The maximum wire size for all analog and digital inputs is 1.5 mm^2 (14 AWG). Smaller wire sizes can be accommodated using crimp terminations.

Voltage Inputs

The voltage inputs are connected directly to the standard 57 – 120V secondary windings of protection or metering VTs. The primary nominal and full-scale voltages are given in the System Drawings in Appendix IV.
Since all inputs are isolated from each other, either phase-to-phase or phase-to-neutral windings can be connected.

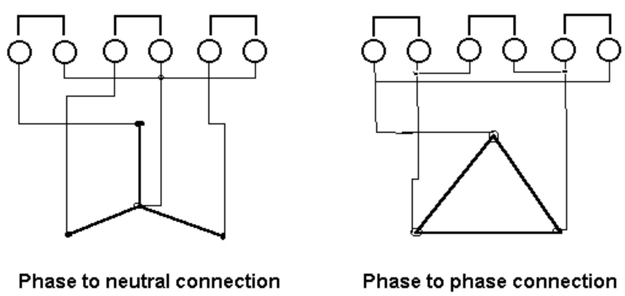


Figure 5 VT wiring option

Current Inputs

The current inputs are derived from either a shunt resistor or an interposing CT connected in series with the 1 Amp or 5 Amp secondary winding of a protection CT. In the latter case, a burden resistor is fitted either inside the TR-100+ or on the CT module. The CT ratio and burden resistor value are chosen to suit the maximum short circuit current level and protection CT ratio. The primary nominal and full-scale values are given in the User Specification.

There are a number of options available for interposing CTs. The most common is the toroidal or 'wedding ring' type. Four of these are normally fitted to a DIN rail mounting assembly. This type requires either shorting (disconnect) switches or a line outage, so that the protection CT secondary can be wired to the interposing CT module. External high power, low resistance shunts may be installed in a similar fashion.

The split-core and clamp-on CTs do not require an outage and are very simple to fit. These are most popular on portable systems. Clamp types are available with sensitivities down to 1.4 A full scale.

Special Analog Inputs

By special arrangement, other input ranges can be set to suit transducers and other sources. This ensures that the correct scaling and triggering values are used. To set special inputs, a component change may be required on the input board, along with recalibration of the unit.

Some examples of other inputs that have been used are:

+/- 10 V industrial transducers
400 V for mains supply monitoring *
600 V for measuring rise in ground potential *
50 V – 150 V for recording tripping battery voltage
2V for Hall effect CT for monitoring battery current

* High voltage ranges require use of an external Voltage Divider Box, available from AMETEK.

For non-sinusoidal signals, a DC input can be specified in the Display Station configuration.

Digital Inputs

There can be between 16 and 160 digital inputs. These are normally used for monitoring the operation of protection relays and switchgear via auxiliary contacts.

The digital inputs must have a DC power supply connected externally and the voltage must be as specified in the System Drawings. When the contact being monitored is closed, approximately 3 mA DC will flow through the contact.

On the Analog/digital input modules, there are twice as many digital inputs as analog inputs. These are normally used for monitoring the operation of protection relays and switchgear via auxiliary contacts. Each group of 4 inputs is isolated from every other group and has a common connection (marked C) for the field control voltage (FCV). This common connection may be wired to either the battery positive or negative terminal. On the digital-only cards there are 16 inputs arranged in isolated groups of 4, and there are 16 inputs individually isolated. The normal state of the input is defined in the recorder configuration in Display Station. The signal is displayed as being in the “Normal” or “Alarm” state.

STATUS OUTPUT CONNECTIONS

The four status relay output circuits are available on the 8 terminal strip connector at the right of the rear panel. The relay outputs are normally open, dry solid-state contacts in the unpowered state. The functions of these relays are described in the previous chapter.

AUXILIARY CONNECTIONS

RS232 Serial Ports

If an external modem has been specified, it is connected to the 9-pin D connector marked ‘Remote comms’ at the right of the rear panel. The connectors conform to the PC format for RS232 serial ports. There is also a front mounted 9-pin RS232 port available for a direct serial connection to a PC running Display Station. The baud rate for this connection (Com 1) is set by a configuration switch on the acquisition board and is selectable as 9600 or 57,600 baud (default). The serial cable supplied should be used for this. Both the front and rear RS232 communications ports have the following pin configurations:

Pin	Use
1	DCD
2	Rx
3	Tx
4	DTR
5	Gnd
6	DSR
7	RTS
8	CTS
9	RI

The data format is:

Baud rate	57,600*
Parity	None
Data bits	8
Stop bits	1
Handshake	Hardware

* The actual baud rate for Com2 (external modem or serial time code) is settable within Display Station. Use the *Configuration* option then select *Peripherals* then *Modem.*

Modem port

If an internal modem has been specified the phone connection is available as a standard RJ11 connection on the rear panel. An internal modem will be assigned Com3 that leaves the rear serial port (Remote comms) available for a serial time code connection. The modem parameters may be set up using Display Station 32. A direct serial connection is required to do this.

IRIG-B and Serial Time Code Ports

When a recorder is synchronized to an external, serial time source it is connected to the rear serial port. The baud rate and code type are set up using Display Station 32. If an IRIG-B signal is being used it is connected to the BNC connector near the center of the rear panel. An optional receiver board is used to demodulate the time code and send it to the Com 2 connector inside the recorder. If IRIG-B is in use the rear serial connector is not available.

Network port

If network support has been specified a UTP connection is available as a standard RJ45 socket at the rear of the recorder. The network may also be supplied as a co-ax connection on a BNC socket. The network may also be supplied on an optical port close to the BNC socket on the rear panel. The optical connectors are ST types and 62.5/125μm fiber is recommended. The upper connector is for transmit and the lower for receive. The configuration of the network parameters is made using Display Station 32. A direct serial connection to the 'Program' plug must be used to do this.

The TR-100+ will support both a modem and a network. Only one connection can be made to the recorder at any one time. To support this the modem must be an external type.

APPLYING POWER TO THE TR-100+

When all the relevant connections have been made, the system is switched on by first opening the front panel to expose the power switch. This is the toggle switch at the center right of the enclosure. It is moved to the right to turn on the TR-100+.

When the TR-100+ is switched on, it performs a series of internal self-tests to check the processor, the memory and the acquisition system. This takes about 30 seconds after which, if no fault is found, the TR-100+ will illuminate the green 'On line' lamp and start acquiring data.

The sampling rate, channel labels, scaling and other parameters may have been set at the factory. If these are to be changed, Display Station must be connected to the 'Program' plug on the front panel. Other parameters may also be changed over the remote connection. See the Display Station 32 manual for details on programming the TR-100+.

Real Time Display

The real time display function in Display Station may be used to check that the signal levels reported by the TR-100+ are correct. The phase relationships of the voltages and currents may also be seen. The status of all the digital inputs is also shown. For more information on this, see the Display Station 32 manual.

Test Record

A test record may be generated to verify the input connections to the recorder. Press the ‘Test’ button on the front panel momentarily to generate the record. After several seconds the ‘Data available’ LED will be illuminated to indicate that a new record is available. Use Display Station 32 to recover and display the record. This will be a permanent document of the state of the inputs to the TR-100+. Transient or disturbance records of this type are given the trigger type ‘Manual’.

TR-100 UPGRADE

The connections and input ranges of the TR-100+ are designed to be very similar to the TR-100 recorder to allow a simple field upgrade. The power and communications cables can swap easily to the new chassis. The analog plug will also change over provided the arrangement of voltage and current are the same. The digital inputs require a small change where the common connections for each group of four inputs are connected together in the TR-100+. The field contact voltage (FCV) must be the same for the TR-100 and TR-100+. The status relay connections are also very similar. The external relay supply used with the TR-100 is not required for the TR-100+.

4. HARDWARE CONFIGURATION

The TR-100+ is available in many configurations with various user-defined options. The values set for this machine at time of delivery may be found on the User Specification sheet and the System Drawings.

The TR-100+ is available with either Analog/digital inputs only or Analog/digital and Digital only input modules. The various TR-100+ model numbers, the number and type(s) of input modules and the necessary chassis sizes are listed below.

Table 2 Models and Input Modules

Model	Analog Boards	Digital Boards	Available Analog Channels	Available Digital Channels	Chassis Size
TR-108+	1	0	8	16	5U
TR-108+D1	1	1	8	48	7U
TR-108+D2	1	2	8	80	7U
TR-108+D3	1	3	8	112	9U
TR-108+D4	1	4	8	144	9U
TR-116+	2	0	16	32	5U
TR-116+D1	2	1	16	64	7U
TR-116+D2	2	2	16	96	7U
TR-116+D3	2	3	16	128	9U
TR-116+D4	2	4	16	160	9U
TR-124+	3	0	24	48	7U
TR-124+D1	3	1	24	80	9U
TR-124+D2	3	2	24	112	9U
TR-132+	4	0	32	64	7U
TR-132+D1	4	1	32	96	9U
TR-132+D2	4	2	32	128	9U

CROSS TRIGGERING

Any number of TR-100+ recorders may be coupled together to form a system with any number of inputs (in multiples of 8, 16, 24, or 32 analog inputs). This system uses the 'Triggered' status relay outputs and digital input 15 of each recorder. They are connected as follows:

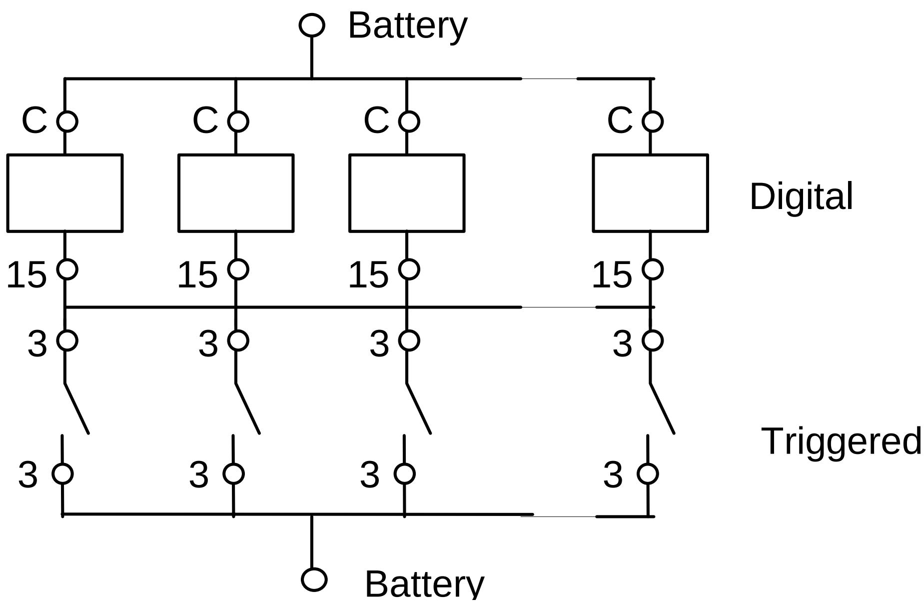


Figure 6 Cross-triggering wiring

Switch 3 on SW1 on the acquisition board must be ON for every machine connected together in this way. When this is done and the systems are switched on the channel labels for digital input 15 will become 'Cross-trigger'. The triggering for these channels must be enabled manually but are automatically set as level sensitive with profiling off.

Pseudo Machine

Up to 5 x 32 channel recorders may be connected together in the above way to create a ‘Pseudo Machine’. This may be configured in Display Station 32 to be viewed as a 160-channel recorder. A combined configuration and data records make this an easy way to create a large recorder. Display Station will automatically combine the configurations and records from the component recorders. For more information on this see the Display Station 32 manual.

Operation

When any of the connected recorders is triggered, its 'Triggered' status output relay will pulse immediately. This will cause digital input 15 on all recorders (including the one originating the trigger) to go into the alarm state. When this happens, the other recorders will trigger, but their status relays will not be activated. If a valid trigger is detected on a recorder other than that which started the process, its status relay will activate, thus extending the post fault period of all recorders if necessary. The originating recorder will have a normal cause of trigger, but the others will show 'Cross-trigger' to identify the source of the original trigger.

When the fault records are downloaded to Display Station, they may be viewed and printed individually. The records can be aligned using the *normal* to *alarm* transition on each digital input 15 as a common time reference. The time, date, and cause of the composite record will be that of the recorder which started the process. Because the status relays have a switching time of up to 2ms, the effective pre-fault period will be shorter than specified. Increasing the pre-fault length by one cycle on all the connected recorders will compensate this for.

If cross triggering is enabled, a manual trigger (caused by pressing the 'Test' button or by selecting 'Manual trigger' from Display Station) will not cause the 'Triggered' relay to operate.

INPUT BOARDS

The TR-100+ may have from 1 to 4 Analog input boards and 0 to 4 additional Digital only input boards. These boards are located below the processor tray and are connected via two ribbon cables to the acquisition board. There are two jumpers located between and behind these connectors that determine the address of each board. The boards are ordered from 1 to 6, top to bottom. The links are set as per the following table: -

Acquisition Board Configuration Switches

Set-up the acquisition board configuration switches as shown below. Reference the System Drawings for number of channels and options that are enabled.

BANK 1

Switch	**Default setting**	*Function*	*Off*	*On*
1	See Bank 1 table below	No. of inputs - 1	0	1
2	See Bank 1 table below	No. of inputs - 2	0	1
3	Off	Cross triggering	Off	On
4	On	Com1 baud rate	9600	57600
5	Off	Modem - Com3	No Modem	Modem
6	Off	Serial clock - Com2	No Clock	Clock
7	Off	Default config	Normal Operation	Force Defaults
8	On	System frequency	50Hz	60Hz

BANK 1 Switch 1 and 2 Number of Analog modules

Switch 1	**Switch 2**	**Inputs (A/D)**
0	0	8/16
1	0	16/32
0	1	24/48
1	1	32/64

BANK 2

Switch	*Default Setting*	*Function*	*Off*	*On*
1		*IRIGB _TYPE*	*AC*	*DC*
2	*OFF*	*IRQ_SELECT*	*IRQ7*	*IRQ3*[1]
3	*OFF*	*Digital Cards*	*No digital cards*	*Digital card(s) present*
4	*OFF*	*No. of inputs - 1*	*See Bank 2 table below*	
5	*OFF*	*No. of inputs - 2*		

BANK 2 Switch 4 and 5 Number of Digital Only modules

SW ITC H 4	**Switch 5**	**Digital inputs**
OFF	OFF	1 CARD
ON	OFF	2 CARDS
OFF	ON	3 CARDS
ON	ON	4 CARDS

[1] Selecting IRQ3 for IRIGB will disable COM2 See BIOS setup.

Digital Input Board Resistor Table

If necessary, the Digital Inputs can be changed to accept a different voltage level. Reference the Input Module schematic for resistor locations and change the value of Rx51 to match the Digital input voltage.

Input VDC (Nominal)	**Rx51**	**Description**
12 V	3.6K	Carbon Composition Resistor (1W)
24 V	6.8K	Carbon Composition Resistor (1W)
48 V	15K	Carbon Composition Resistor (1W)
125V	39K	Carbon Composition Resistor (1W)
250 V	82K	Carbon Composition Resistor (2W)

Input Board Analog Input Range Selection Table

Set the Input Board range selection jumpers per the table below. The jumpers are located at the back and center right of the board. The channels are ordered from right to left and the odd numbers are at the rear and the evens at the front.

Input Range	**Jumper (Jx)**	**Resistor Selected**
0-2 Vpk (Current)	**None**	**None**
0-300 Vpk (Voltage)	**JP0**	**R1**
0-10 Vpk (Transducer)	**JP1**	**R2**
TBD	**JP2**	**R3**

Analog Input Board Jumper Locations

Set the Analog Input Board configuration jumpers per the table below. The jumpers are located behind and between the two ribbon cables at the front of the board.

Board #	Channels	BRD_SEL_0	BRD_SEL_1
1	1-8	On	On
2	9-16	Off	On
3	17-24	On	Off
4	18-32	Off	Off

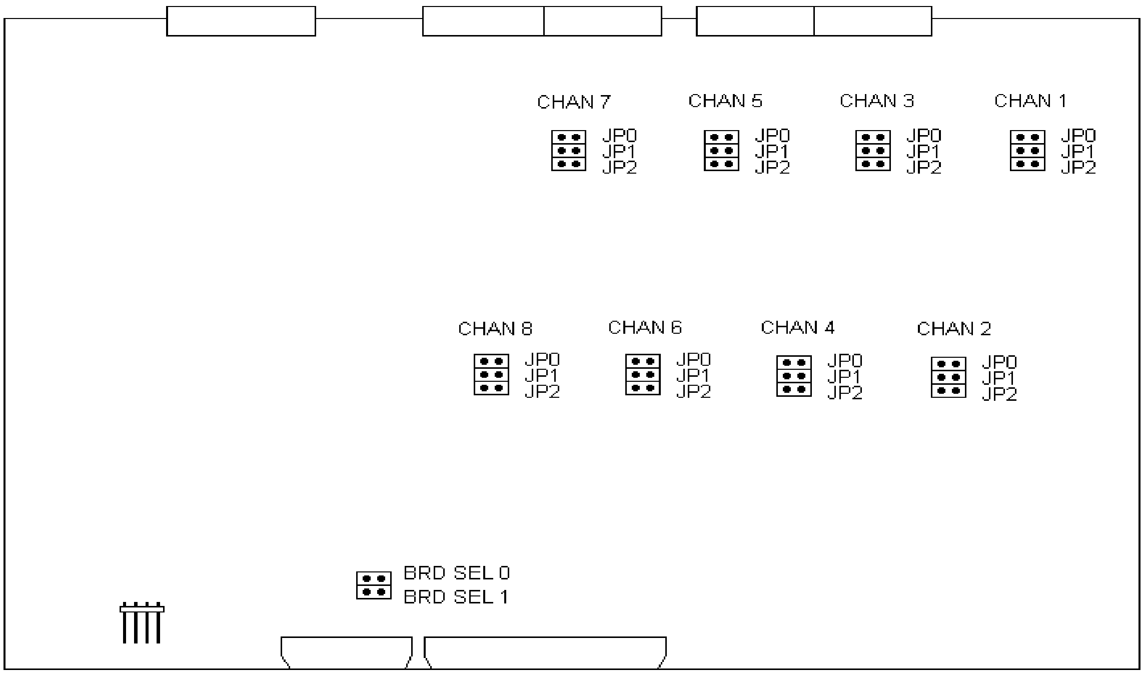


Figure 7 Analog Input Board Jumpers

Digital Only Input Board Jumper Locations

Set the Digital-Only Input Board configuration jumpers per the table below. The jumpers are located behind and between the two ribbon cables at the front of the board. Actual channel number will vary depending on the number of digital channels available on the analog cards.

Board #	Channels	BRD_SEL_0	BRD_SEL_1
1	1-32	On	On
2	33-64	Off	On
3	65-96	On	Off
4	97-128	Off	Off

Channel numbers as reported in Display Station will depend on the number of analog boards fitted.

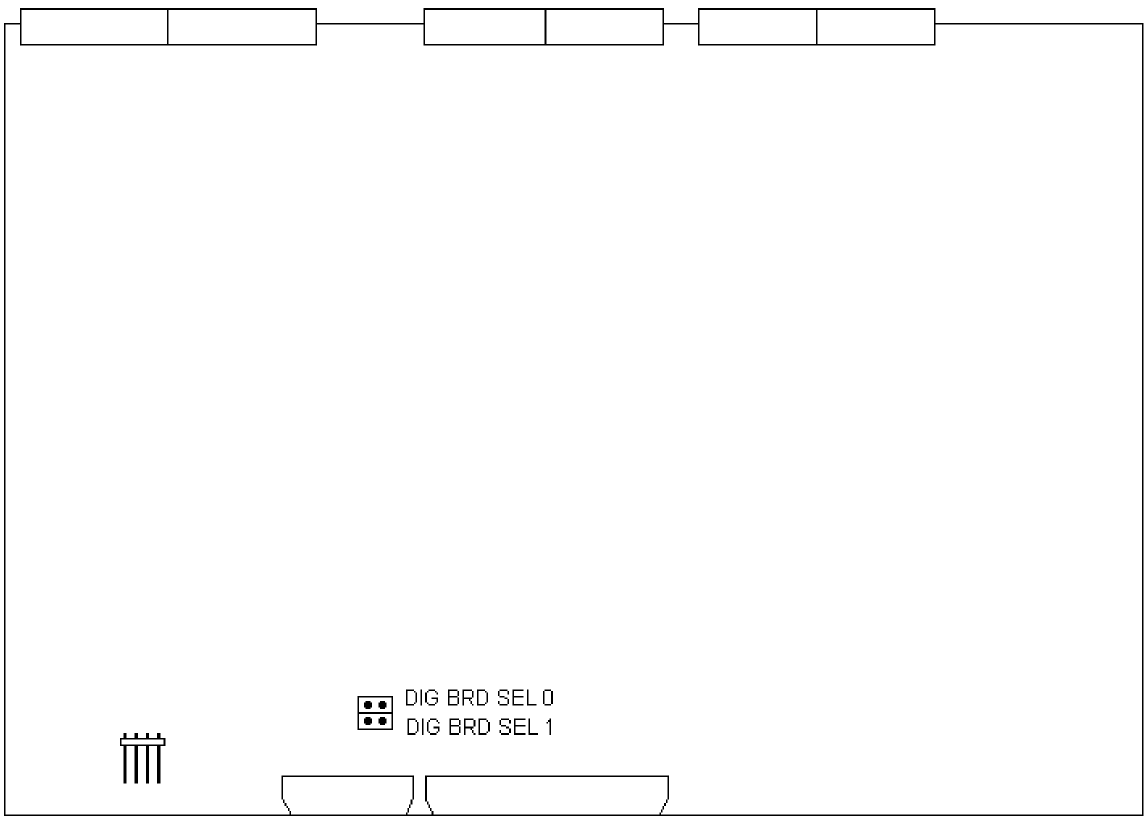


Figure 8 Digital-only Input Board Jumpers

5. MAINTENANCE

The TR-100+ is designed for the rigors of an industrial environment, however the unit requires a minimal amount of regular and preventative maintenance. It is recommended that the calibration be checked annually. For information on system calibration please see the TR-100+ Maintenance Manual

BATTERIES

The standard TR-100+ has 2 lithium batteries that have a life of ten years without any external power applied. The first maintains the real time clock on the processor board and the second is the parameter and profiles memory on the acquisition board which is an M4Z32-BR00SH1 at location U6. The latter includes a yellow ‘Snap-Hat’ battery that may be replaced easily if required.

To prevent problems it is recommended that these batteries be replaced 7 years after receipt of the equipment.

APPENDIX I - TR-100+ SPECIFICATIONS

INPUTS

No. of channels using Analog only modules	8, 16, 24 or 32 Analog, with 16, 32, 48 or 64 Digital Up to 160 channels by cross triggering systems
No. of channels using both Analog and Digital Only inputs	8, 16, 24 or 32 Analog, with 16, 32, 48, 64 Digitals 80, 96, 112, 128, 144 additional Digital channels
Voltage inputs	57-120V RMS typical 212.13V RMS max. Other options available
Current inputs	1A or 5A RMS typical Inputs via shunts or CTs CT phase lag correction
Current over range	Selectable for current (x1 – x20) CT phase shift correction
Input burden	0.06 VA (voltage) <0.014 VA (current)
Transducer inputs	0 – 12V or +/- 12V max for monitoring AC or DC quantities
Frequency response	DC – 1/4 sampling rate, +0dB, -3dB.
Accuracy	Better than 0.2% of full scale
Digital inputs	24 / 48 / 125 / 250 Vdc external wetting supply Contacts settable as normally open or closed
Digital debounce	1 – 10ms in 1ms increments (used for triggering only)

RECORDING (TRANSIENT)

Recording resolution	16 bits (65536 levels)
Dynamic range	96.3 dB
Recording accuracy	+/- 1 LSB
Sample rate	64, 128 & 256 samples per cycle Up to 12,800 per sec. at 50 Hz Up to 15,360 per sec. at 60 Hz
Pre-fault time	2 - 300 cycles
Post-fault time	Fault length will extend as long as a trigger condition exists. Minimum is 8 - 100 cycles
Safety window	Recording time after trigger: 0 - 16 cycle
Maximum record length	1 - 30 sec. (This prevents memory filling with a continuous trigger)
Synchronization	All analog channels sampled together. No data skew
Programmable Features	Sample rates Pre, max & min post fault times Safety window Maximum record length Trigger level and polarity Trigger enable Time and date Channel labels
Configuration Switches	Number of analog & digital channels System frequency (50/60Hz) Modem connected Cross trigger enabled IRIG-B enabled

FAULT PROFILE (TRANSIENT)

Measured Values	Fault duration, triggered channel Pre, during and post fault values per channel Maximum & minimum values per channel Selected digital channel timing

RECORDING (DISTURBANCE)

Sample rate	2 x supply frequency (100/120 Hz)
Pre-fault	2 sec. - 600 sec.
Post-fault time	Fault length will extend as long as a trigger condition exists. Minimum value is 4 sec. – 600 sec.
Safety window	Recording time after fault 2 sec. – 120 sec.
Maximum record length	1 - 20 min.
Recorded values	Fundamental voltages / currents (amplitude and angle) RMS voltages and currents, Frequency Digital data in SER format
Computed values (in DSA)	Apparent, real & reactive power Phase angle & power factor Positive, negative & zero sequence components Imbalance Phasors Load impedance, X/R ratio

RECORDING (LOGGING)

Storage interval	1 minute - Data can be recovered at up to 60 min intervals.
Record length	16 weeks (circulating buffer)
Recorded values	Maximum, minimum & average RMS voltages & currents, frequency. Digital data in SER format
Harmonic log	Average amplitude per channel up to 63^{rd} harmonic, every 10 mins (IEC 61000-4-7)
Power log (optional)	Maximum, minimum & average import or export real power and power factor per line group, every 1 minute.

TRIGGERING

Analog channels	Over & under RMS level (or DC) with hysteresis Rate of change of level, THD Positive, negative & zero phase sequence Frequency & rate of change of frequency (ROCOF)
Accuracy	Better than 0.5%
Digital channels	Normal to alarm state and return to normal state Edge or level sensitive
Programmability	Triggering on any number of analog or digital channels.
Cross trigger	Allows unlimited number of recorder channels with precise time sync.

SYSTEM TIMING

Time source	Internal battery backed real time clock
Oscillator source	Conditioned 32.768kHz oscillator
Accuracy	Normally better than 1 sec per day
Range	Time and date (including leap year and day of the year)
Time setting	Manual or via optional serial time code or IRIG-B

COMMUNICATIONS

Serial ports	Up to 3 RS232 types
Default setting	57600 baud, 8 bits, 1 stop, no parity
Serial port 1 (front)	Uses: Local programming Data retrieval Real time data display Software updates
Serial port 2 (rear)	Uses: Serial time signal and IRIG-B Remote programming Data retrieval from remote computer systems Real time data display
Serial port 3 (Optional modem)	Uses: Remote programming Data retrieval from remote computer systems Real time data display Software updates
Modem	Hayes compatible type internal (ISA) or external, fax compatible. Non plug and play type (fixed Com & IQR)
Phone line sharing (Optional)	External unit to share a single phone line with a station phone and multiple recorders or IEDs
Network connection (Optional)	10BaseT (twisted pair & RJ45), 10Base2 (co-ax and BNC) or 10BaseFL (multi-mode optical fiber & ST)
Network protocol	TCP/IP

DATA STORAGE

Buffer storage	64 Mbytes DRAM
Program storage	8 Mbytes flash ROM
Permanent storage medium	3.5” Hard disk 40 Gbytes

FRONT PANEL DISPLAY

LED indicators	Power OK (Green) Battery OK (Green) – not used Armer/Ready (Green) Data available (Amber) Comms in progress (Amber) Attention (Red)

STATUS RELAYS

Type	Solid State
Number of outputs	4
Contact rating	1 Amp max 400 V dc / 280 Vac max Power & on line are N/C Attention & triggered are N/O
Indication	Power OK System on line Attention System Triggered
Isolation	Input to output - 2500 V ac Contact to contact - 600 V dc

POWER SUPPLY

Input voltage options	85 - 300 V dc, 85 - 264 V ac Start up > 104 V dc. 24 / 48 V dc optional
Power requirement	45 W Max.
Backup batteries	Internal batteries for real-time clock and parameter memory

VOLTAGE WITHSTAND

Isolation	2.5 kV RMS for 1 minute, Channel to channel, channel to ground. (per IEC 255-5) 2.15 kV dc for Power Supply
Impulse voltage withstand	Impulse voltage withstand 5 kV, 1.2/50 µs. 0.5 Joule (per IEC 255-5)
Surge withstand	2.5 kV, 1 MHz damped sine wave (per IEC 255-22-1; IEEE/ANSI C37.90.1-1989)
RFI	80MHz – 1GHz @ 10V/m (per IEC 801-3 & IEC 801-6 & IEEE/ANSI C37.90.2)
ESD	8kV contact, 15kV air discharge (per IEC 801-2)

ENCLOSURE

Cabinet	19" rack mounting cabinet
Rack mount size	480 mm wide (including flanges) 223 mm high (5U) 313 mm high (7U) 400 mm high (9U) 350 mm deep (including handles) 5U – 18.9"W x 8.8"H x 13.8"D 7U – 18.9"W x 12.3"H x 13.8"D 9U – 18.9"W x 15.75"H x 13.8"D
Rack mount weight	13.7 Kg. (30.2 lbs)5U 18.0 Kg. (39.7 lbs)7U 22.3 Kg. (49.2 lbs)9U

ENVIRONMENT

Operating temperature	-10 to 55 °C 14 to 131 °F
Relative humidity	10 - 97% non condensing

AMETEK reserve the right to change this specification without notice

APPENDIX II – PARAMETER CALCULATIONS

Introduction

The Multi Function Recorder (TR-100+) is a high performance monitoring instrument that can implement the functions of over 10 different systems concurrently. These can be configured and interrogated locally or remotely over a dial up modem or corporate WAN.

Inputs are connected to standard VT and CT secondaries as well as relay and switchgear auxiliary contacts. For the CT signals, an interposing shunt resistor, 'wedding ring' or clamp type CT can be used. Derived quantities (frequency, sequence components, power etc.) are computed internally and no external transducers are required. External transducers can be used for other, non derived, quantities such as temperature, pressure, generator rotor angle, etc.

Up to 32 analog inputs are synchronously sampled at regular intervals up to 15,360 samples per second, at 16 bits per sample. The sample clock is locked to the incoming supply frequency to ensure that there is exactly the same number of samples in every supply cycle. This maximizes the accuracy of RMS, vector and harmonic calculations.

Conventions

The TR-100+ uses mostly fundamental calculations due to the differing techniques for computing derived quantities (especially power), and the lack of world wide accepted standards (such as parameters computed from the current and voltage vectors at the present system frequency).

Reactive power into an inductive load (current lagging voltage) is treated as positive. Power factor measurements in the power logger are appended with 'L' for lagging and 'C' for leading.

Exported real power (voltage and current in phase) is treated as positive.

Phase to neutral vectors are shown pointing outwards from the neutral point. Phase to phase vector Vab is shown pointing from a to b; i.e. It is the resultant vector of Vb - Va.

Three voltage or current channels can be defined as a phase group. These are listed in positive sequence order and the first channel is the reference phase. One voltage and one current phase group can be defined as a line group. These groups are used when defining the sources for sequence component, power & impedance calculations, etc.

Time Measurement

The TR-100+ uses an internal real time clock to mark the time of triggered records and log files. This clock can be synchronized to a PC when connected to the recorder using Display Station 32. The recorder can also be connected to serial time code source or an IRIG-B signal via a BNC connector on the real panel.

Frequency Measurement

The TR-100+ has a frequency channel that is calculated from a defined voltage channel. It is recommended that a voltage channel with at least 25% full-scale signal be used. The TR-100+ uses the zero crossing method for extracting frequency. The signal is first filtered with a recursive IIR filter to remove non 50 Hz or 60 Hz components. The exact position of each zero crossing is found using similar triangles to determine the sub-sample position. Both positive and negative crossings are measured. The four period measurements over two cycles are averaged. The inverse is taken to yield the frequency. Any measurements that fall outside the fundamental frequency +/- 5 Hz are ignored. If the source voltage falls below 10% of the full scale value a frequency value is not computed.

Vector Measurement

The Cartesian vectors for every channel are generated twice per cycle. The angle is corrected for 180° inversion. This form can be converted into the polar notation for calculation of the derived parameters.

The data for one cycle are multiplied by sine and cosine tables to give the Cartesian co-ordinates. Since the sample clock is locked to the supply frequency the derived vector angle is not related to absolute time. The reported angle is that at the start of the data window. The magnitudes are divided by $\sqrt{2}$ to give the equivalent RMS value.

RMS Measurement

The true RMS value for every channel is generated twice per cycle. The data samples for one cycle are squared and summed. The square root is taken of this value divided by the number of samples per cycle. The number of samples per cycle will vary with the sample rate.

$$V_{rms} = \sqrt{\frac{\sum_{n=1}^{256} V_n^2}{256}}$$

Frequency Correction

Because the system frequency varies by small but finite amounts during normal operation, uncorrected RMS and vector measurements will have an error that is a function of frequency deviation. Since the TR-100+ is locked to the system frequency, it corrects for these errors.

Calculation of Derived Parameters

A range of fundamental quantities may be computed from the fundamental voltage and current vectors.

Sequence components

$$3\bar{V}_{+1} = \bar{V}_a + a\bar{V}_b + a^2\bar{V}_c$$ Positive

$$3\bar{V}_0 = \bar{V}_a + \bar{V}_b + \bar{V}_c$$ Zero

$$3\bar{V}_{-1} = \bar{V}_a + a^2\bar{V}_b + a\bar{V}_c$$ Negative

$\bar{V}_a$ represents the vector form of the a phase voltage

(operator **a** rotates the vector by 120°)

Power (fundamental)

Apparent

$$S_f = V_f * I_f$$

Real

$$P_f = V_f * I_f * Cos\Phi$$

Reactive

$$Q_f = V_f * I_f * Sin\Phi$$

For delta VTs real power is computed using the two wattmeter method.

Displacement power factor

$$PF = Cos\Phi$$

Harmonic Measurement

A single cycle window is used to calculate the harmonic content of voltages and currents. A standard Fast Fourier Transform (FFT) technique is used to calculate the amplitude of each component. A minimum of 4 samples per cycle is required to extract a harmonic component accurately. A number of samples are taken over the integrating interval (10 mins for EN50160) and averaged. The actual number will depend on the input channels and sampling rate.

The average amplitude is stored every 10 minutes. Data for the fundamental and up to the 63rd harmonic are recorded. THD, thd, TDD and K factor are computed on the host PC.

Real Power

True power is computed by multiplying individual current and voltage samples and then averaging over one cycle. The actual number of samples per cycle will vary with the sample rate.

$$P = \frac{1}{256}\sum_{n=1}^{256} V_n * I_n$$

Real power for a circuit with a delta wound VT is derived using the two wattmeter method. This makes two power measurements using two of the line currents. It can be proved that the sum of the two powers is same as the total circuit power:

$$P = V_a I_a + V_b I_b + V_c I_c \qquad \text{Total circuit power}$$

$$I_a + I_b + I_c = 0 \qquad \text{Currents sum to 0}$$

Substituting the second equation into the first and collecting terms yields:

$$P = (V_a - V_b) I_a + (V_c - V_b) I_c$$

The total circuit power can be measured using two wattmeters on the phase-to-phase voltages. Note that the phasing of the VTs is important. This value is recorded in the optional power logger.

Apparent Power

Apparent power is computed from the RMS voltage and current.

$$S = V_{rms} * I_{rms}$$

Power Factor

True power factor is the ratio of real to apparent power. This is used in the pf logger.

$$PF_{True} = \frac{P}{S}$$

To remove the confusion about the sign of power factor the value is suffixed with a 'C' to indicate leading and 'L' to show lagging in the power logger.

Total Harmonic Distortion (THD)

The THD for an input is derived from the RMS and vector magnitude (V)

$$\%THD = \frac{\sqrt{RMS^2 - V^2}}{V} x100$$

This is the IEEE form of THD. In DSA32, the calculation of THD can be selected from either the IEEE or ANSI standard. Refer to the DSA help file for a complete explanation of the differences.

APPENDIX III – TROUBLESHOOTING

The first indication that a TR-100+ is not functioning correctly is normally that it will not make a remote connection. Before going on site, it is worth checking the phone line by ringing the TR-100+'s number and listening for the phone to be answered by the modem, followed by a series of tones. If these are heard, then the phone line and modem are OK and there is power to the TR-100+. If a data switch or DTMF switch is being used, then the phone may be answered but no tones will be heard.

If this is successful, contact the TR-100+ using a terminal package such as Hyperterminal™ in Windows™. After the modem has issued a 'CONNECT' message, press <Enter> 3 or 4 times. The TR-100+ should return with a list of configuration parameters. If this is successful, the fault may be with the Comms Manager set up of Display Station. To disconnect from the TR-100+ using a terminal, type "quit" then press <Enter>.

Off-Site Checks

Problem:	Modem doesn't answer.
Things to check:	Correct phone number?
	Telecom wiring at substation?
	If a data switch is used is it powered up?
	Is TR-100+ powered up? (see below)
	Is initialization string at TR-100+ correct? (S0=1)

Problem:	Modem answers but is unable to communicate with TR-100+.
Things to check:	Are initialization strings at Display Station & TR-100+ correct?
	Is TR-100+ active? (see below)

Recommended initialization string for US Robotics modems:

AT&F1^M~~~~ATS0=1&G2&W^M

All Hayes compatible commands must begin with 'AT'. The ^M symbols are interpreted as if the <Enter> key has been pressed. The ~ symbol is interpreted as a short delay.

On-Site Checks

Start with test 1). Follow the test numbers depending on the result of each test. After a change is made start with test 1) again.

1) Is the green 'Power' light on? Yes 2) No 5)

2) Press the 'Test' button for 1 second. Does the buzzer sound and the yellow 'Data available' light come on after a number of seconds?
Yes 3) No 4)

3) The TR-100+ is working correctly. The fault is with the modem, data switch or phone line. Is the internal modem board seated correctly? (This is the short board near the top of the unit with the gray phone connection.)
Yes 8) No 11)

4) Are the three red lights above the processor board on. (This is the board at the top of the TR-100+)
Yes 7) No 11)

5) Is the power switch on? This is the toggle switch found at the right of the upper tray behind the front panel. Yes 10) No 6)

6) Switch system on 1)

7) Restart the TR-100+ by switching off the supply waiting a few seconds then switching it on again. The processor should 'beep' several times as it checks its memory. After this there is short delay then the 'On line' light will be illuminated. The red 'Attention' light will also come on which is normal. This may be cleared by pressing the 'Test' button. This, in turn, will cause the 'Data available' light to be illuminated since a test record has been generated. Did this work correctly?
Yes 8) No 14)

8) Contact the person with Display Station and ask them to contact the TR-100+. The phone should ring once then the modem should answer. If line share device is being used then an 'M' should be displayed on its front panel. The modem will respond with a number of tones followed by a 'hash' sound (like an AM radio not tuned to a station). This should end and a few seconds later the TR-100+ 'Communications' light will come on. This indicates a valid connection. Was the connection completed? Yes 17) No 13)

9) Connect a laptop computer running Display Station to the front of the TR-100+. Check the 'Comms Manager' settings. The port should be COM1 or COM2 and the speed should be 57600. The actual values will depend on the computer in use and the speed set on the internal DIP switches in the TR-100+. Make a 'Direct' connection. Is the connection successful?
Yes 3) No 15)

10) There is no power to the TR-100+. Check the incoming supply and the fuse at the rear of the unit. There is also a fuse inside the power supply that is at the left rear of the processor tray. Was everything correct?

Yes 12) No 16)

11) Check that all the boards on the processor tray are seated correctly and all the ribbon cables are in place. If boards need to be re-seated switch the system off first.

7)

12) There is a fault in the power supply or supply wiring. Replace and re-test .

1)

13) If the modem did not answer, the fault may be with the initialization string (see above). If this is correct there is a fault with the modem. Replace it and re-test.

1)

14) There is a fault with the processor board. Replace it and re-test.

1)

15) There is a fault with the wiring to the front port. Check that the ribbon cable is plugged into the processor board.

1)

16) Replace fuse, etc. and re-test.

1)

17) The TR-100+ is OK.

Check for Intermittent Resetting

The voltages may also be checked at the power connector located above the SBC to the right. The wire colors indicate the voltage :-

Red	+5V
Black	0V
Yellow	+12V
Blue	-12V

The value between the red and black wires should be 5.0 +/- 0.1 volts.

If the voltage is low the fault may be with the power supply, connectors or wiring.

APPENDIX IV – ORDERING INFORMATION

Transient Recorders TR-100+ Ordering Information

Code	Base unit
TR108+	8-channel TR-100+ in a 5U chassis
TR108E+	8-channel TR-100+ in a 7U chassis
TR116+	16-channel TR-100+ in a 5U chassis
TR116E+	16-channel TR-100+ in a 7U chassis
TR124+	24-channel TR-100+ in a 7 chassis
TR132+	32-channel TR-100+ in a 7U chassis

Code	Prime Power
P1	88 - 370 VDC/85 - 264 VDC
P2	48 VDC
P3	24 VDC

Code	Field Contact Voltage
F1	250VDC
F2	125 VDC
F3	48 VDC
F4	24 VDC

Code	Recording Options
RO	None (base unit includes harmonics and RMS/Hz logging)
R1	Power Package

Code	Time source
T1	Internal Clock Only
T3	IRIG-B

Code	Communications
C1	Standard - RS232
C2	Hayes compatible modem
C3A	Ethernet - 10BaseT
C3B	Ethernet - 10Base2
C3C	Ethernet - Fiber Optic

Code	Communications
H50	50 Hz operation
H60	60 Hz operation

TR132+	P1	F1	R0	T1	C1	H60

<--Typical Model Number

Options	Description
Shunts	Required for current channels (1 per current - 0.5, 1, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, or 12.5Arms nominal)
CICTs	Can be used in lieu of shunts (1, 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10, or 12.5Arms nominal)
Prn Shelf	slide-out shelf for above printer - includes paper source and take-up trays
LAN Modem	Consult factory for application details - 4 ports

APPENDIX V – RETURNS PROCEDURE

PROCEDURES FOR FACTORY REPAIR AND RETURN

A. Obtain a Returned Material Authorization (RMA) number by calling the AMETEK Repair Department and giving the following information:

1. ***Model*** and ***Serial Number*** of the equipment.
2. Failure Symptom - **Be Specific**
3. Approximate date of installation.
4. The site name and address of the failed equipment.
5. Complete shipping information for the return of the equipment if other than the operating site.
6. Name and telephone number of person to contact if questions arise.

B. Enclose the information with the equipment and pack in a commercially accepted shipping container with sufficient packing material to insure that no shipping damage will occur. Mark the outside of the container with the RMA number.
Ship to the appropriate location:

Attention: Repair Department

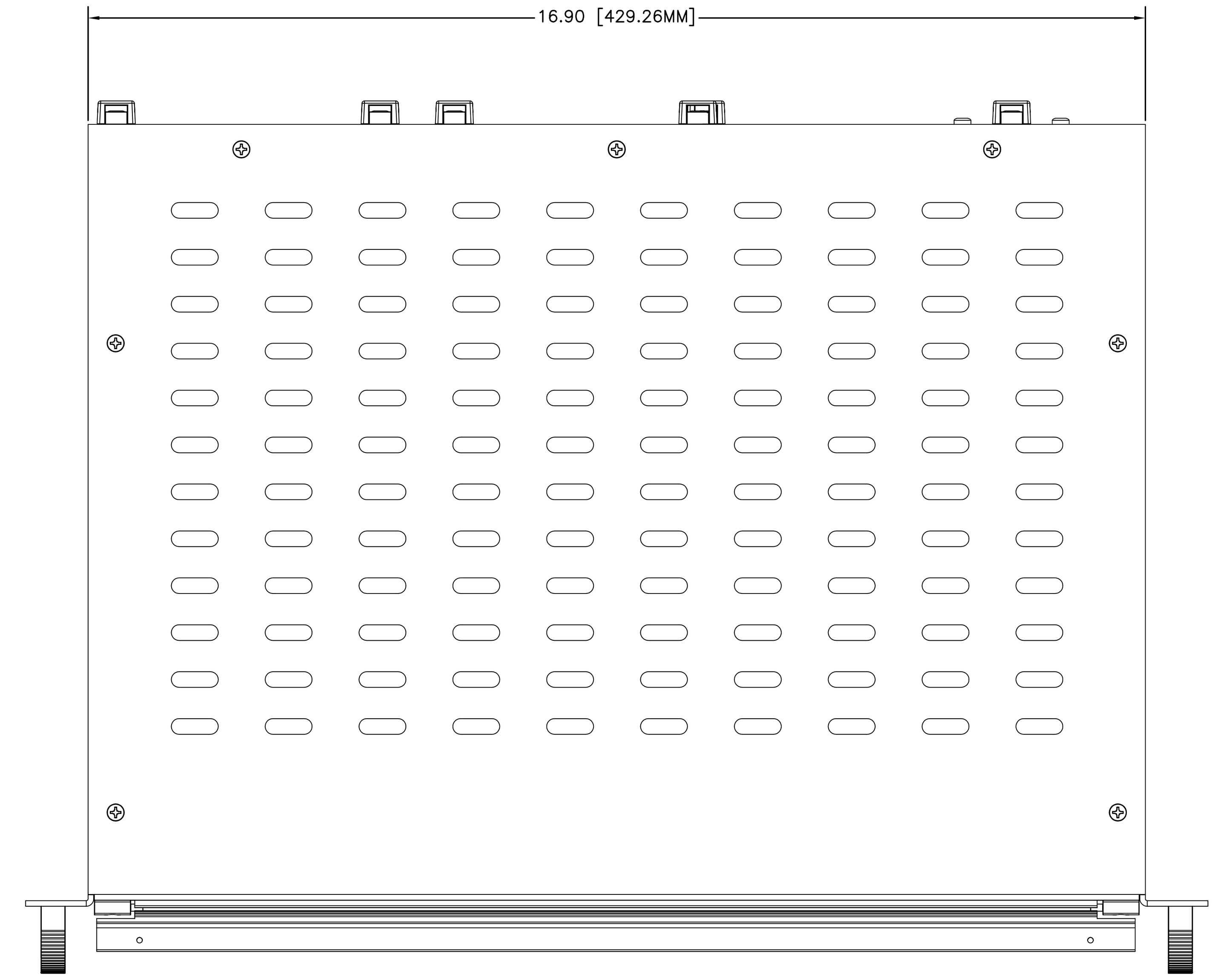
AMETEK, INC.
255 North Union Street
Rochester, New York 14605 USA
Telephone: (888) 222-6282
Fax: (585) 238-4097

C. Your equipment will be tested, repaired, and inspected at the factory. Normal factory turn-around is ten working days or less (excluding shipping time).

D. For emergency service or repair status information, please contact the Repair Department at (585) 238-4993.

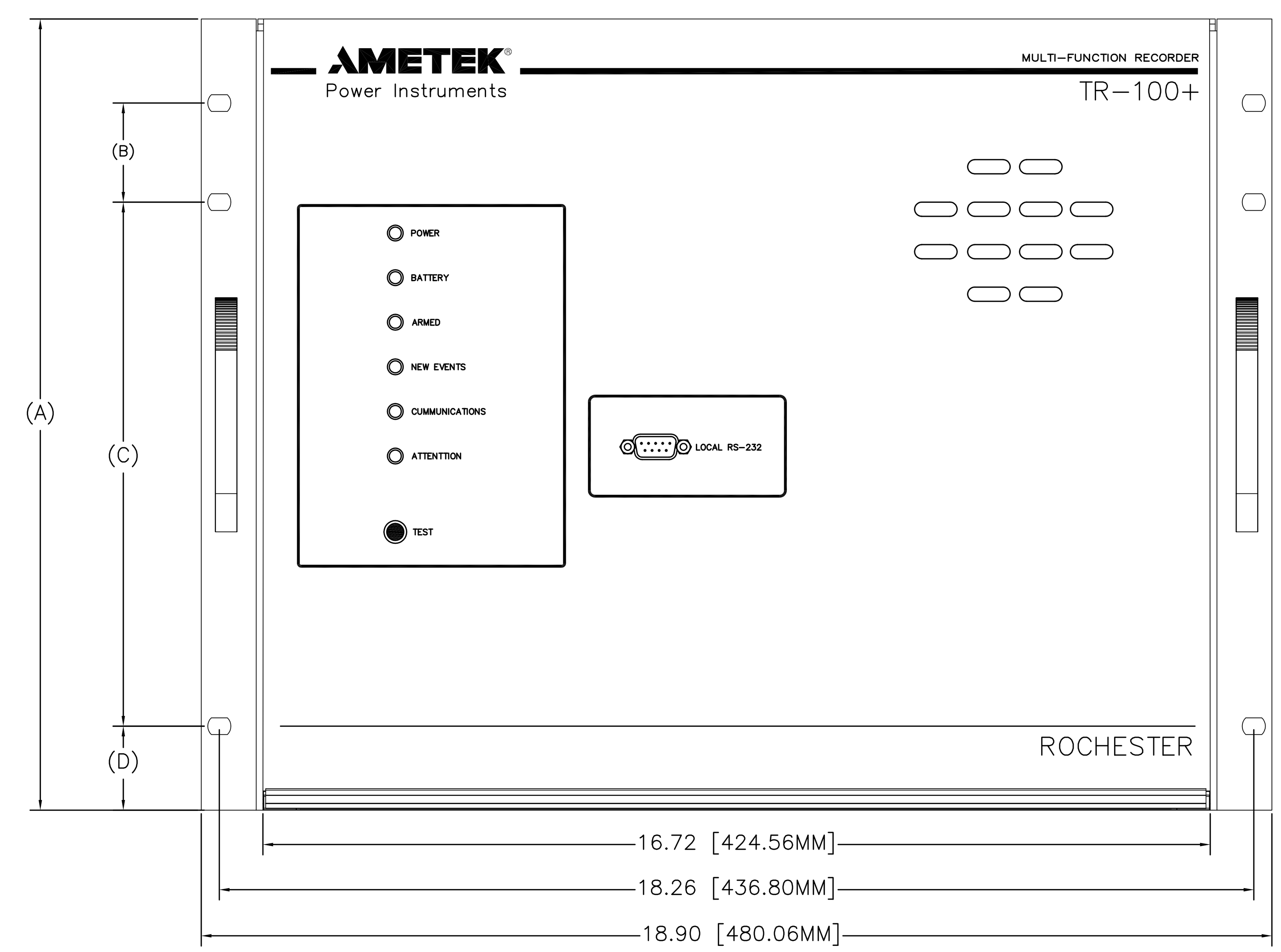
WARRANTY — Ametek Power Instruments warrants equipment of its own manufacture to be free from defects in material and workmanship, under normal conditions of use and service. Ametek Power Instruments will replace any component found to be defective, upon its return, transportation charges prepaid, within one year of its original purchase. Ametek Power Instruments will extend the same warranty protection on accessories, which is extended to Rochester Instrument Systems by the original manufacturer. Ametek Power Instruments assumes no responsibility, expressed or implied, beyond its obligation to replace any component involved. Such warranty is in lieu of all other warranties expressed or implied.

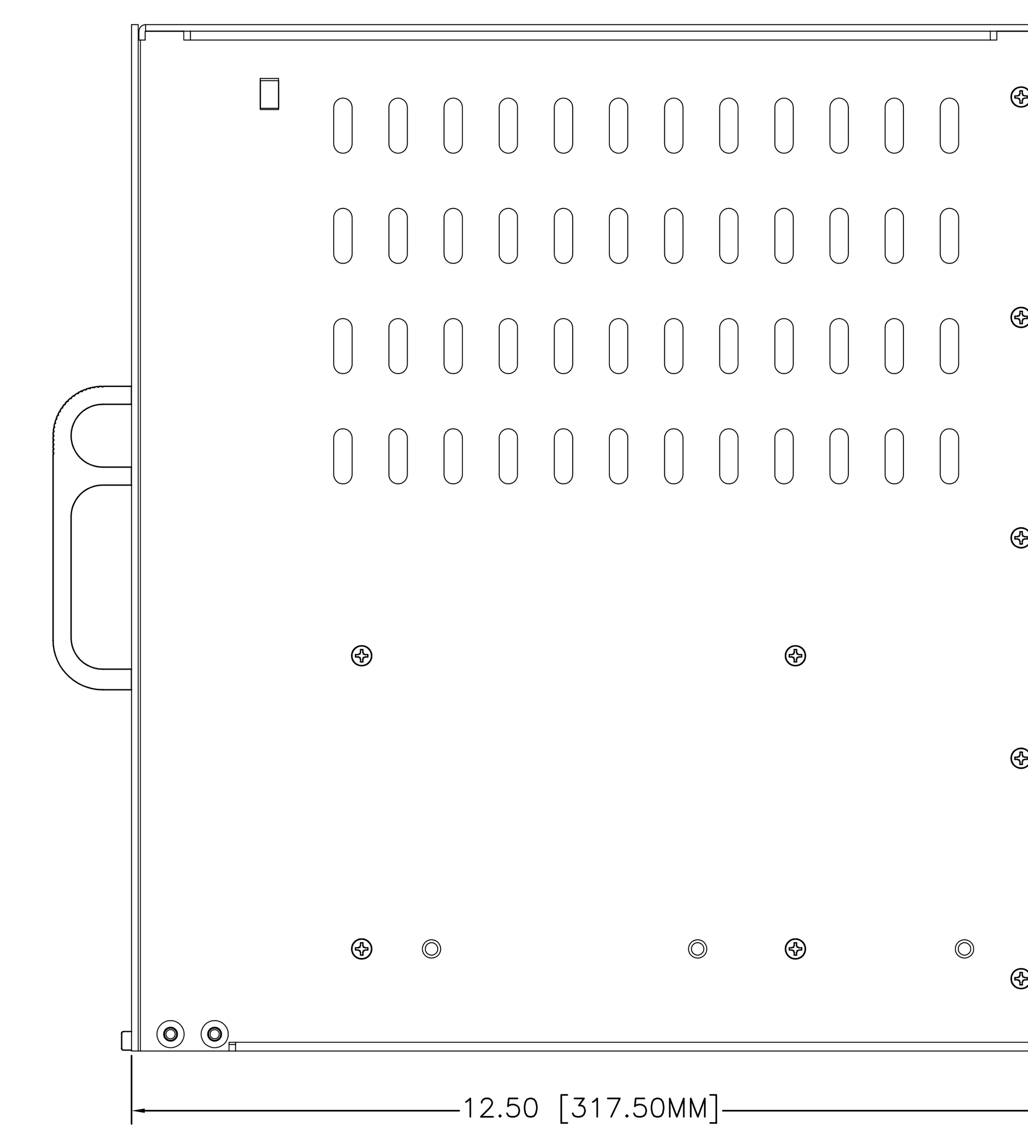
PROPRIETARY



NOTES:
1. TRANSIENT RECORDER DIMENSIONS WILL VARY DEPENDING ON OPTIONS CHOSEN. SEE CHART FOR CHASSIS SIZES.
2. FOR REAR PANEL CONNECTIONS, SEE PAGE 2 & 3.
3. FOR MODEL CODES AND DESCRIPTIONS SEE PAGE 4.

TR MODEL	DIMENSION					ANALOG CHANNELS	DIGITAL CHANNELS
	U-SIZE	(A)	(B)	(C)	(D)		
TR-108+	5	8.72 [221.5mm]	----	5.75 [146.1mm]	1.48 [37.6mm]	8	16
TR-108+E	7	12.20 [309.9mm]	----	9.34 [237.2mm]	1.48 [37.6mm]	8	16
TR-108+-D1	7	12.20 [309.9mm]	----	9.34 [237.2mm]	1.48 [37.6mm]	8	48
TR-108+-D2	7	12.20 [309.9mm]	----	9.34 [237.2mm]	1.48 [37.6mm]	8	80
TR-108+-D3	9	15.72 [399.2mm]	1.75 [44.5mm]	11.0 [279.4mm]	1.48 [37.6mm]	8	112
TR-108+-D4	9	15.72 [399.2mm]	1.75 [44.5mm]	11.0 [279.4mm]	1.48 [37.6mm]	8	144
TR-116+	5	8.72 [221.5mm]	----	5.75 [146.1mm]	1.48 [37.6mm]	16	32
TR-116+E	7	12.20 [309.9mm]	----	9.34 [237.2mm]	1.48 [37.6mm]	16	32
TR-116+-D1	7	12.20 [309.9mm]	----	9.34 [237.2mm]	1.48 [37.6mm]	16	64
TR-116+-D2	7	12.20 [309.9mm]	----	9.34 [237.2mm]	1.48 [37.6mm]	16	96
TR-116+-D3	9	15.72 [399.2mm]	1.75 [44.5mm]	11.0 [279.4mm]	1.48 [37.6mm]	16	128
TR-116+-D4	9	15.72 [399.2mm]	1.75 [44.5mm]	11.0 [279.4mm]	1.48 [37.6mm]	16	160
TR-124+	7	12.20 [309.9mm]	----	9.34 [237.2mm]	1.48 [37.6mm]	24	48
TR-124+E	9	15.72 [399.2mm]	1.75 [44.5mm]	11.0 [279.4mm]	1.48 [37.6mm]	24	48
TR-124+-D1	9	15.72 [399.2mm]	1.75 [44.5mm]	11.0 [279.4mm]	1.48 [37.6mm]	24	80
TR-124+-D2	9	15.72 [399.2mm]	1.75 [44.5mm]	11.0 [279.4mm]	1.48 [37.6mm]	24	112
TR-132+	7	12.20 [309.9mm]	----	9.34 [237.2mm]	1.48 [37.6mm]	32	64
TR-132+E	9	15.72 [399.2mm]	1.75 [44.5mm]	11.0 [279.4mm]	1.48 [37.6mm]	32	64
TR-132+-D1	9	15.72 [399.2mm]	1.75 [44.5mm]	11.0 [279.4mm]	1.48 [37.6mm]	32	96
TR-132+-D2	9	15.72 [399.2mm]	1.75 [44.5mm]	11.0 [279.4mm]	1.48 [37.6mm]	32	128





EXPANDABLE OPTION

ORIGINAL	MAY BE EXPANDED TO:				
TR-108+E	TR-116+	TR-124+	TR-132+	X	X
TR-116+E	X	TR-124+	TR-132+	X	X
TR-124+E	X	X	TR-132+	TR-132+-D1	TR-132+-D2
TR-132+E	X	X	X	TR-132+-D1	TR-132+-D2

OTHER EXPANDABLE OPTIONS FOR EXPANDED DIGITIALS REQUIRING REAR PANEL CHANGES ARE AVAILABLE CONSULT FACTORY FOR ADDITIONAL INFORMATION.

REV	DESCRIPTION	DATE	APPROVAL
A	NEW RELEASE		

REVISIONS

PROPRIETARY

UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
[] ARE IN MILLIMETERS
TOLERANCES ON:
2 PL DECIMALS ± 0.02
3 PL DECIMALS ± 0.005
ANGLES ± 1°

MATERIAL

FINISH

SIGNATURES		DATE
DRAWN	BAM	4/26/07
CHECK		

THIRD ANGLE PROJECTION
CAGE CODE 32582
SOFTWARE: 2005
AUTOCAD VER.
RIS ROCHESTER SCIENTIFIC COLUMBUS

AMETEK
Power Instruments
255 North Union Street, Rochester NY 14605 USA

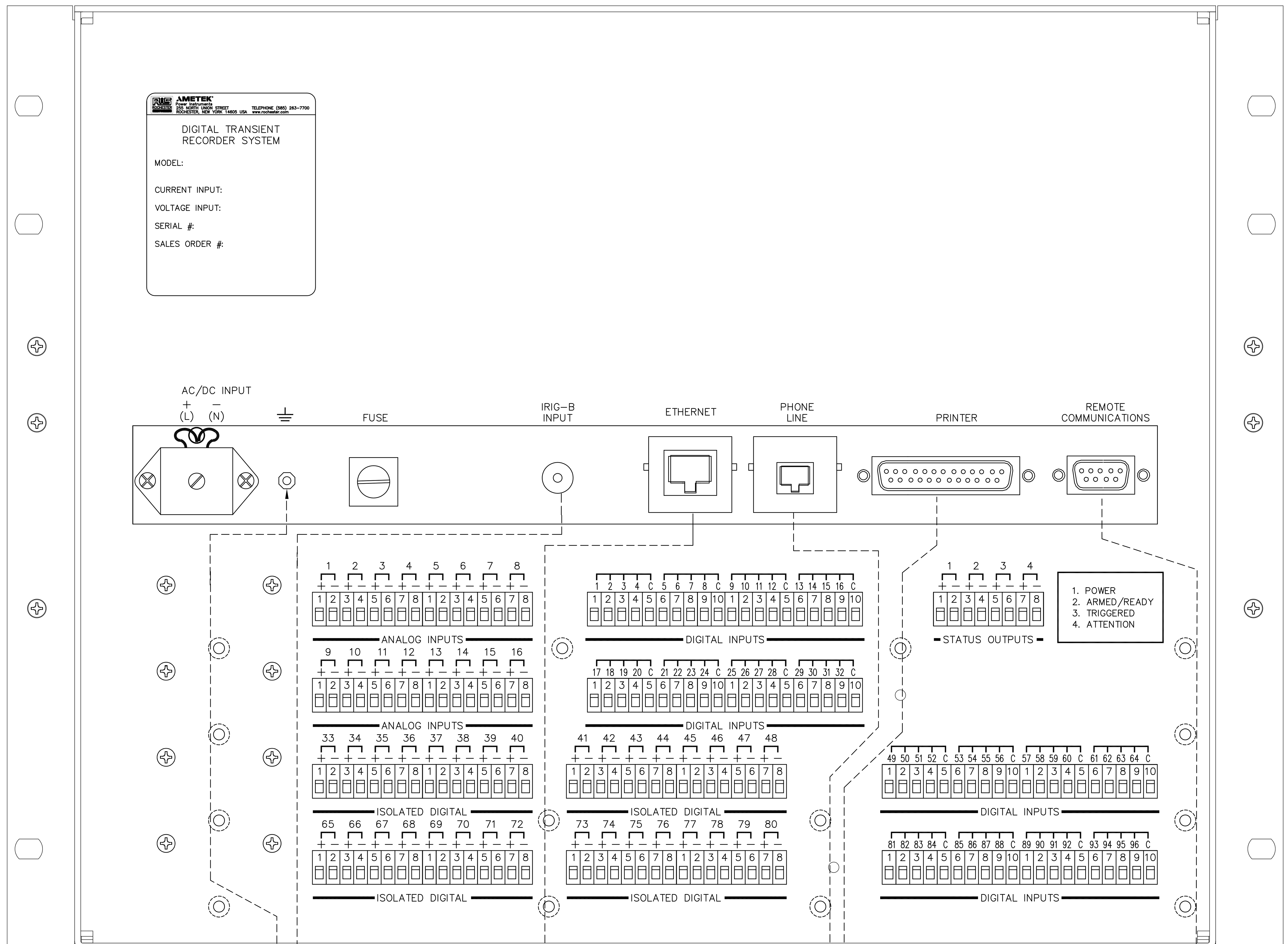
TITLE TR-100+ DETAIL DRAWING UNIT SIZES
TR

SIZE D | DWG NO 1086-939 | REV A

SCALE NONE | FILE NAME 1086-939.dwg | SHEET 1 OF 4

PROPRIETARY

TR-108+-D2 SHOWN



AMETEK RECOMMENDS THE USE OF A HIGH FREQUENCY GROUND BRAIDED WIRE FOR CONNECTION TO SUBSTATION GROUND

IRIG-B INPUT
(REFER TO MODEL #, SHEET 4)

TO CUSTOMER SUPPLIED NETWORK
(REFER TO MODEL #, SHEET 4)

TO LOCAL PRINTER

TO TELEPHONE LINE
(REFER TO MODEL #, SHEET 4)

SEE NOTE 5 FOR EXTERNAL MODEM OPTION.
SEE NOTE 7 FOR ADDED COMMUNICATIONS OPTION.

INSTALLATION NOTES:

1. CUSTOMER WIRING SHOWN DASHED
   AMETEK FACTORY WIRING SHOWN SOLID
2. FIELD CONTACT VOLTAGE IS SUPPLIED BY CUSTOMER. (FOR PROPER FCV REFER TO MODEL #, SHEET 3).

SERVICE NOTES:

1. FOR ANALOG CHANNEL ASSIGNMENTS REFER TO SERIAL TAG LOCATED AT THE REAR SIDE OF THE TR-100+.
   TO CHANGE A CHANNEL FROM CURRENT TO VOLTAGE OR VOLTAGE TO CURRENT CHANGE THE JUMPER ON THE INPUT MODULE AND RE-CALIBRATE THE MODULE. (REFER TO TR-100+ INSTRUCTION MANUAL)
2. STATUS VISUAL INDICATORS ARE ON THE FRONT PANEL. CONTACT OUTPUTS FOR POWER ON, ARMED/READY, ATTENTION AND TRIGGERED ARE AVAILABLE AT THE REAR OF THE TR-100+ CHASSIS. THE RELAYS ARE RATED 1.0A AC/DC, 280VAC/400VDC MAXIMUM VALUES.
3. POWER WIRING AND INPUT WIRING SHOULD BE ROUTED SEPARATELY FOR NOISE IMMUNITY. CONTACT INPUTS SHOULD ALSO BE ROUTED SEPARATELY.
4. DIGITAL CHANNEL 15 IS USED TO CROSS-TRIGGER MULTIPLE RECORDERS. THE STATUS RELAY "TRIGGERED" OUTPUT IS WETTED AND FED INTO THE DIGITAL CHANNEL 15. THERE IS A HARDWARE SWITCH WHICH IS SET TO CONFIGURE THE CHANNEL AS A CROSS TRIGGER CHANNEL.
5. WHEN AN INTERNAL MODEM IS USED, SWITCH 1 POSITION 5 ON ACQUISITION CARD IS SET "ON", AND REMOTE COMMUNICATIONS PORT IS USED FOR ADDED COMMUNICATIONS OPTIONS (Q1 & Q2, REFER TO NOTE 7).
   WHEN SWITCH 1 POSITION 5 IS IN THE "OFF" POSITION, REMOTE COMMUNICATIONS PORT CAN BE USED FOR DIRECT COMMUNICATION TO A PC.
6. WHEN THE POWER IS APPLIED TO THE TR-100+ THEN UNDER NORMAL CONDITIONS:
   POWER & ON LINE RELAYS ARE ENERGIZED (NORMALLY CLOSED).
   TRIGGERED & ATTENTION RELAYS ARE DE-ENERGIZED (NORMALLY OPEN).
7. REMOTE COMMUNICATIONS PORT IS USED FOR ADDED COMMUNICATIONS OPTIONS (Q1 & Q2, REFER TO PAGE 4).

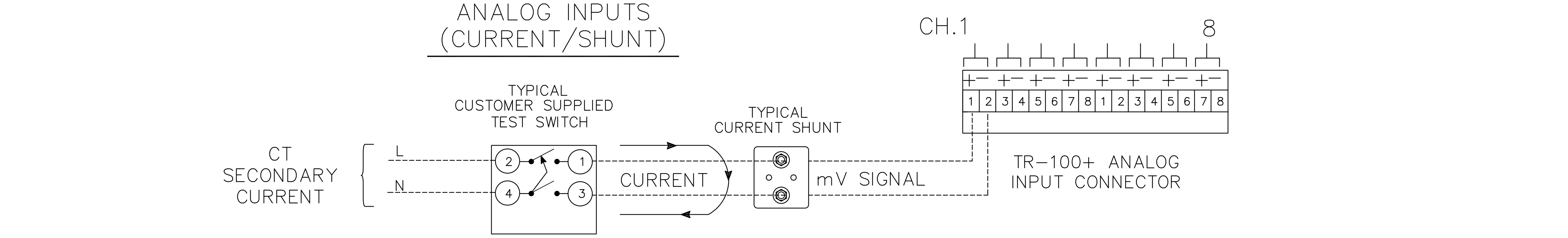
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES [] ARE IN MILLIMETERS TOLERANCES ON: 2 PL DECIMALS ± 0.02 3 PL DECIMALS ± 0.005 ANGLES ± 1°	AMETEK Power Instruments 255 North Union Street, Rochester NY 14605 USA	
	TITLE: TR100+ DETAIL DRAWING REAR PANEL CONNECTIONS TR	
MATERIAL FINISH	SIZE: D	DWG NO: 1086-939 — REV: A
	SCALE: NONE	FILE NAME: 1086-939.dwg — SHEET 2 OF 4

PROPRIETARY

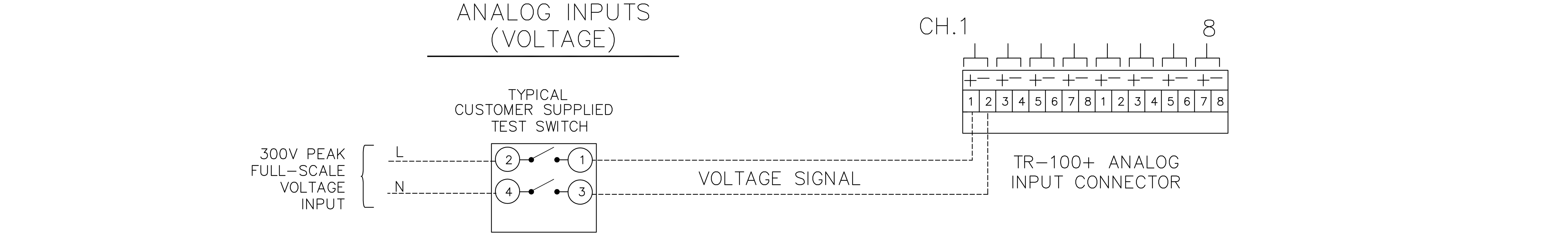
TYPICAL INPUT CONNECTIONS

ANALOG INPUTS (CURRENT/CICT)

ANALOG INPUTS (CURRENT/SHUNT)



ANALOG INPUTS (VOLTAGE)

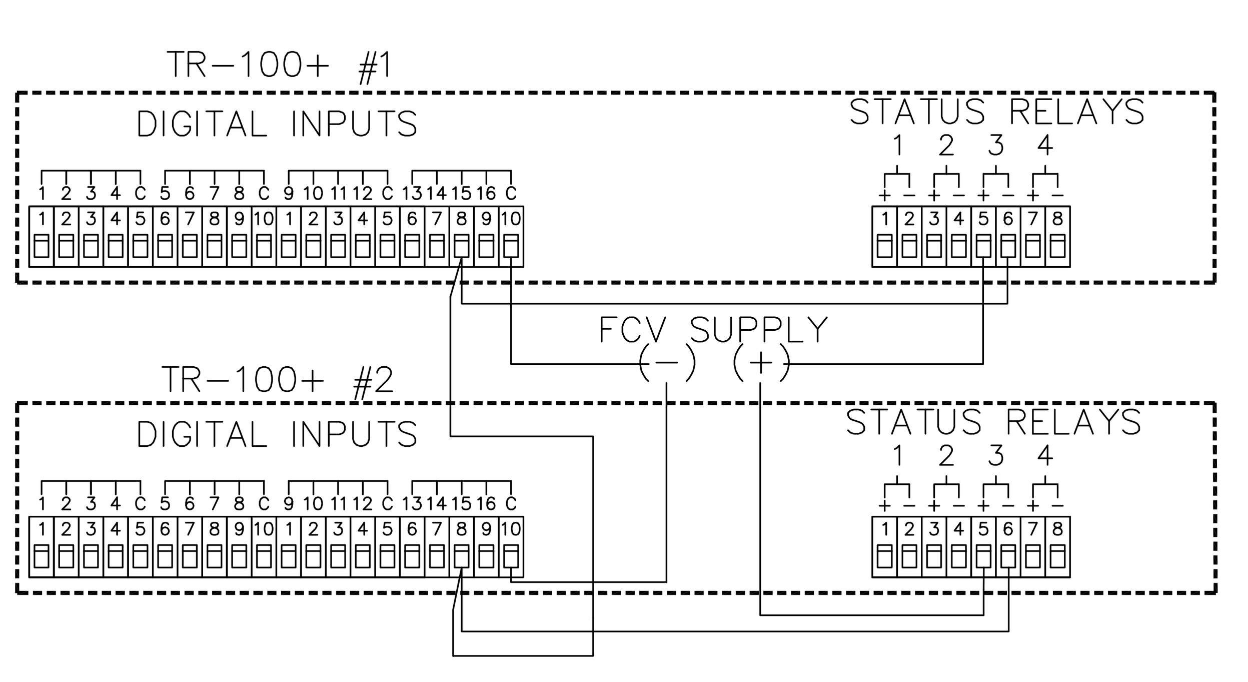


MULTIPLE SYSTEM CROSS TRIGGER SYNCHRONIZATION

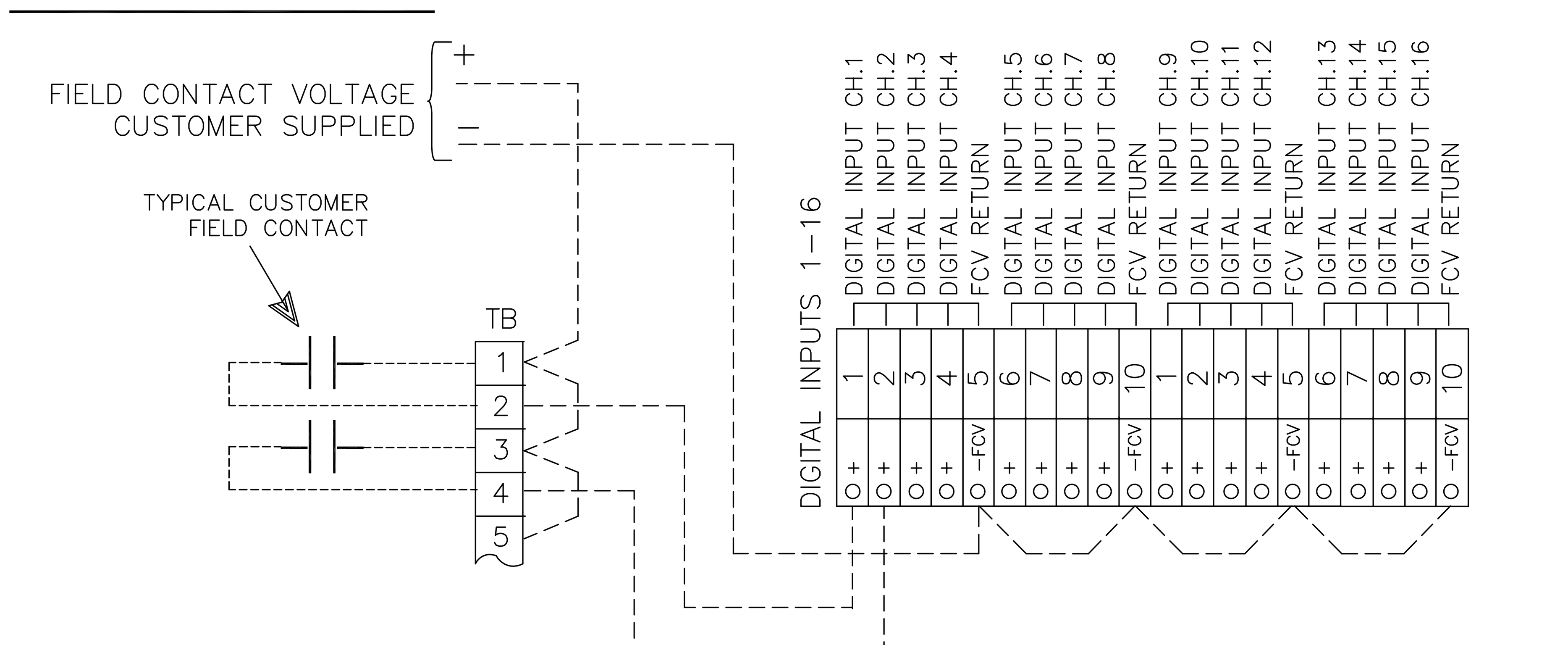
(TWO UNITS SHOWN)

STATUS RELAYS:

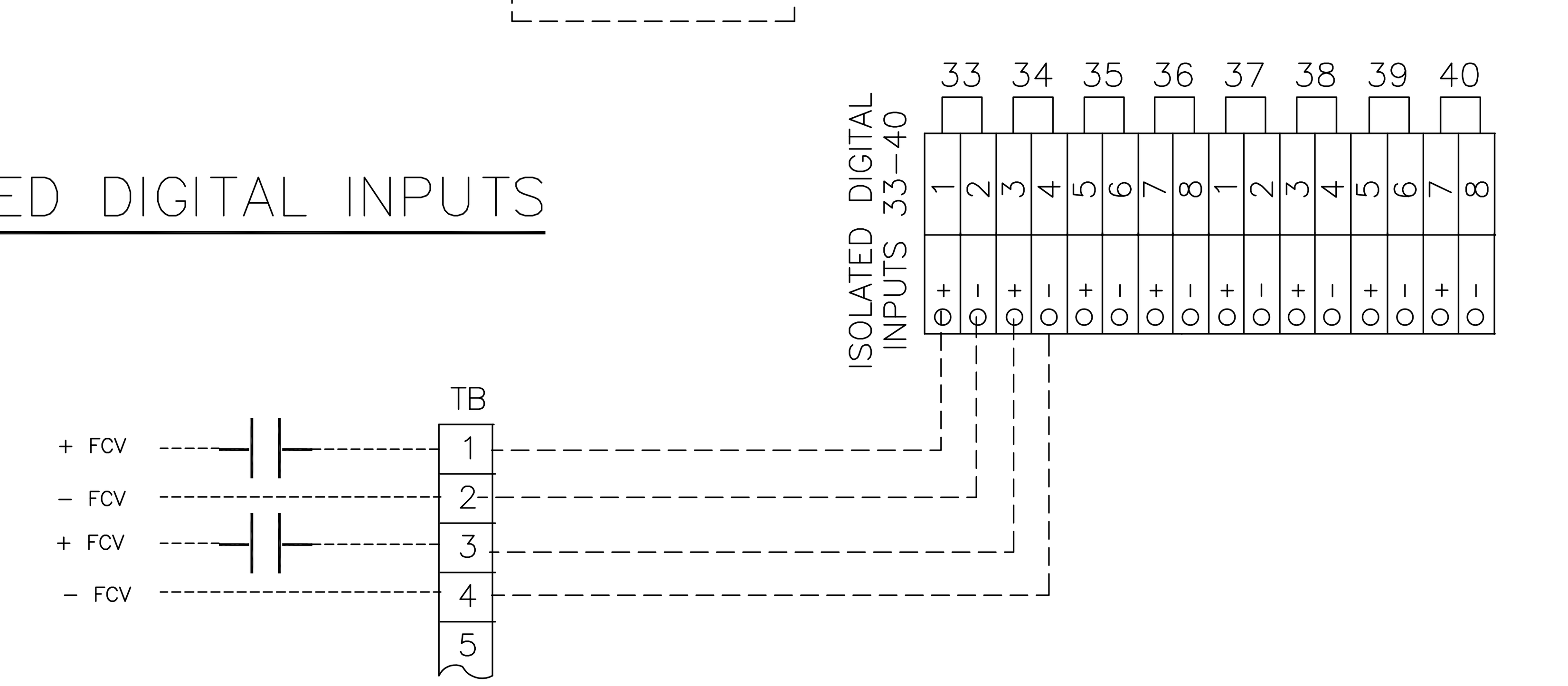
1. POWER
2. ON LINE
3. TRIGGERED
4. ATTENTIION



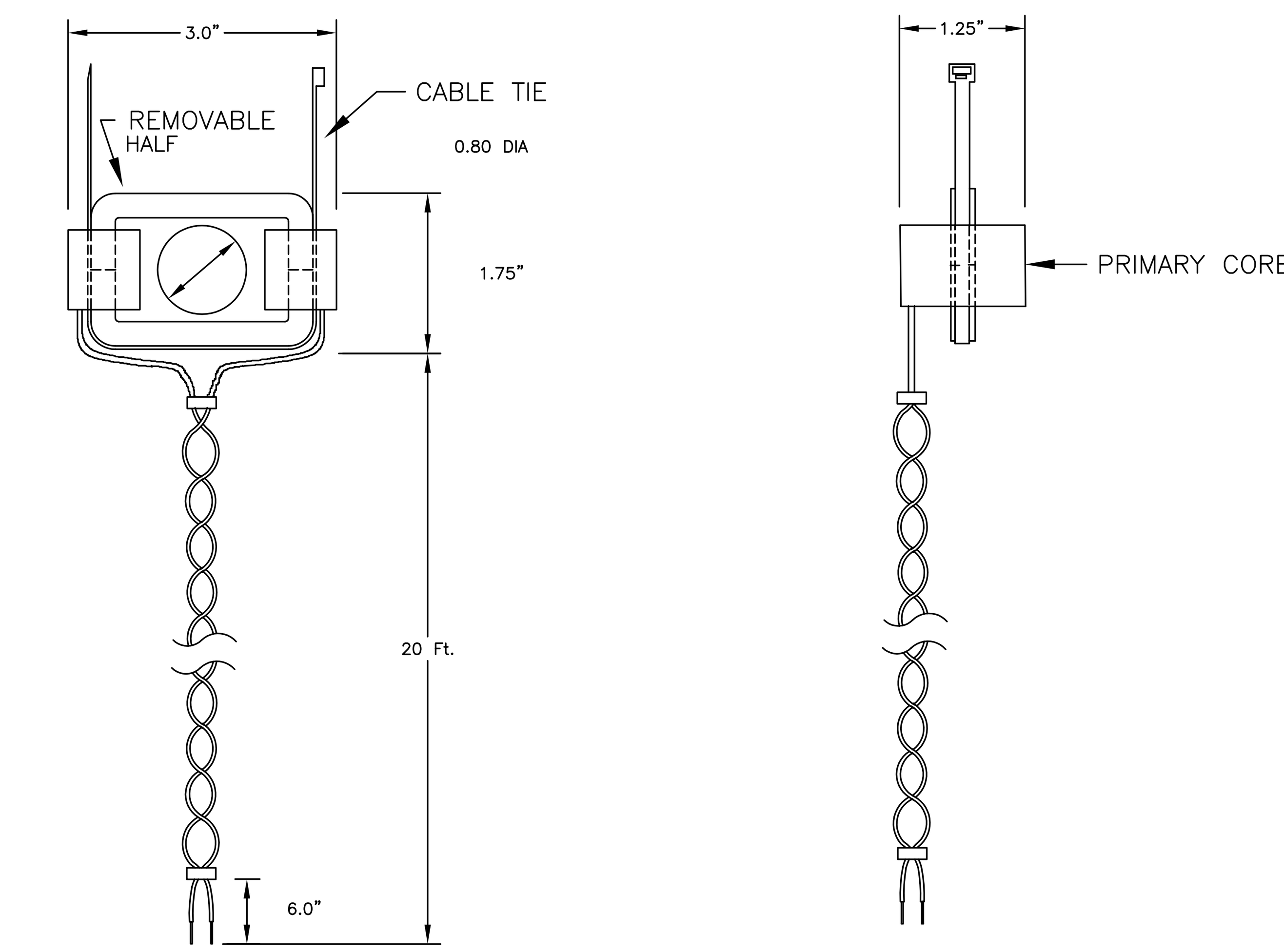
DIGITAL INPUTS



ISOLATED DIGITAL INPUTS



SPLIT CORE Current Isolation Current Transformer (CICT) OUTLINE DRAWING

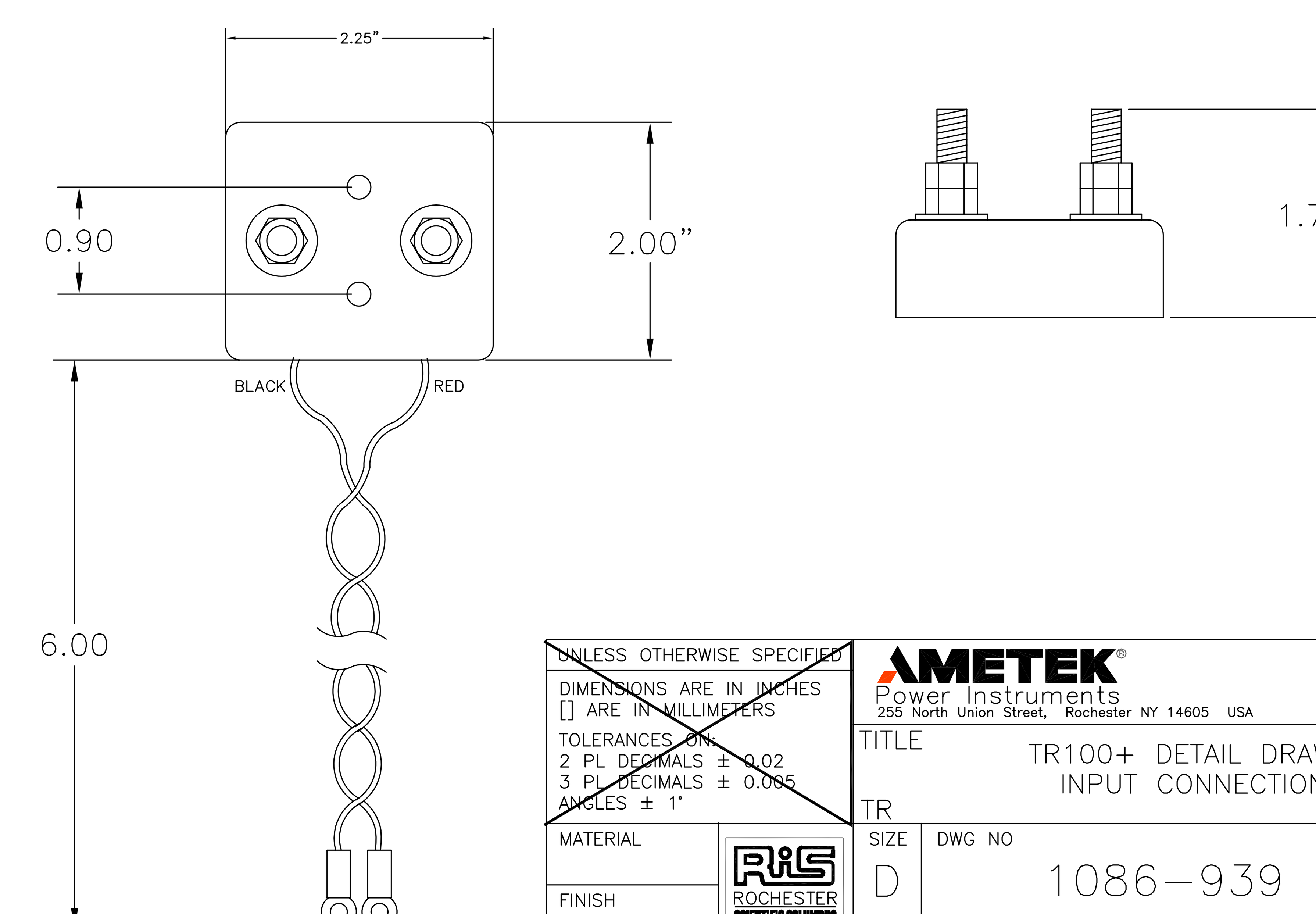


Notes:

1. Appropriate AMETEK P/N and Nominal current will be put on transformer in bold white letters. Markings will be on start side of transformer core (non-removable half) to indicate start of single turn (user-supplied) primary winding.

2. Top half of core is completely removable to allow customer insertion of primary wire (single turn) through core window. A cable tie is provided to secure both halves together for semi permanent mounting.

TRANSIENT RECORDER CURRENT SHUNT OUTLINE



UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
[] ARE IN MILLIMETERS
TOLERANCES ON:
2 PL DECIMALS ± 0.02
3 PL DECIMALS ± 0.005
ANGLES ± 1°

MATERIAL

FINISH

AMETEK® Power Instruments
255 North Union Street, Rochester NY 14605 USA

ROCHESTER SCIENTIFIC COLUMBUS

TITLE: TR100+ DETAIL DRAWING INPUT CONNECTIONS

TR

SIZE: D | DWG NO: 1086-939 | REV: A

SCALE: NONE | FILE NAME: 1086-939.dwg | SHEET 3 OF 4

PROPRIETARY

MODEL NUMBER: TR– XXX – XX – XX – XX – XX – XX – XX – XX – XX – XX – XX

MASS STORAGE
- MS1 (HARD DISK DRIVE)

EXPANDED DIGITALS
- D0 (NO ADDED DIGITAL INPUTS)
- D1 (32 ADDED DIGITAL INPUTS)
- D2 (64 ADDED DIGITAL INPUTS)
- D3 (96 ADDED DIGITAL INPUTS)
- D4 (128 ADDED DIGITAL INPUTS)

LANGUAGE ON CHASSIS
- E (ENGLISH ONLY)
- C (CHINESE AND ENGLISH)
- F (FRENCH AND ENGLISH)
- G (GERMAN AND ENGLISH)
- S (SPANISH AND ENGLISH)

FREQUENCY
- F50 (50 Hz OPERATION)
- F60 (60 Hz OPERATION)

ADDED COMMUNICATIONS
- Q0 (NONE)
- Q1 (DNP; NO IRIG–B)
- Q2 (DNP WITH IRIG–B)

COMMUNICATION OPTIONS
- C1 (STANDARD RS–232)
- C2 (HAYES COMPATIBLE INTERNAL MODEM)
- C3B (ETHERNET, 10BASE T)

TIME SOURCE
- T1 (INTERNAL CLOCK ONLY)
- T3 (IRIG–B, NO GPS)

RECORDING OPTIONS
- R0 (NONE)
- R1 (POWER PACKAGE)

FIELD CONTACT VOLTAGE
- F1 (250VDC)
- F2 (125VDC)
- F3 (48VDC)
- F4 (24VDC)

PRIME POWER
- P1 (88–300VDC OR 85–264VAC)
- P2 (48VDC)
- P3 (24VDC)

BASE UNIT
- 108+ (8 ANALOG/16 DIGITAL CHANNELS)
- 108+E (8 ANALOG/16 DIGITAL CHANNELS)*
- 116+ (16 ANALOG/32 DIGITAL CHANNELS)
- 116+E (16 ANALOG/32 DIGITAL CHANNELS)**
- 124+ (24 ANALOG/48 DIGITAL CHANNELS)
- 124+E (24 ANALOG/48 DIGITAL CHANNELS)
- 132+ (32 ANALOG/64 DIGITAL CHANNELS)
- 132+E (32 ANALOG/64 DIGITAL CHANNELS)

TRANSIENT RECORDER

TRANSIENT RECORDER E OPTIONS

* TR–108+E IS AN 8A/16D CHANNEL UNIT WITH A CHASSIS EXPANDABLE TO 32A/64D (TR–132+)

** TR–116+E IS A 16A/32 CHANNEL UNIT WITH A CHASSIS EXPANDABLE TO 32A/64D (TR–132+)

UNLESS OTHERWISE SPECIFIED	AMETEK® Power Instruments 255 North Union Street, Rochester NY 14605 USA
DIMENSIONS ARE IN INCHES [] ARE IN MILLIMETERS TOLERANCES ON: 2 PL DECIMALS ± 0.02 3 PL DECIMALS ± 0.005 ANGLES ± 1°	TITLE TR100+ DETAIL DRAWING MODEL CODES TR
MATERIAL	SIZE D
FINISH	DWG NO 1086–939
ROCHESTER SCIENTIFIC COLUMBUS	REV A
	SCALE NONE
	FILE NAME 1086–939.dwg
	SHEET 4 OF 4

APPENDIX VI – CONTACT INFORMATION

TELEPHONE / FAX NUMBER LIST

This sheet provides an easy-to-use reference for all major departments. Use these numbers for ordering equipment, application assistance, technical support, and scheduling field service

Please Note: Your instruction manual may contain other phone and fax numbers; this list will take precedence.

MAIN OFFICE

AMETEK Power Instruments – Rochester
255 North Union St., Rochester, NY 14605

DEPARTMENT/PRODUCT LINE	TELEPHONE	FAX
MAIN PHONE	585-263-7700	585-262-4777
FIELD SERVICE	800-374-4835	585-238-4945
REPAIRS/RETURNS	888-222-6282	585-238-4945
SALES SUPPORT	800-950-6676	585-454-7805

FAR EAST OFFICE

AMETEK Power Instruments
10 Ang Mo Kio Street 65
#05-12 Techpoint
Singapore 569059
Tel: 65 484.2388
Fax: 65.481.6588

EUROPEAN HEADQUARTERS

AMETEK Power Instruments
Unit 20, Ridgeway
Donibristle Industrial Estate
Dunfermline, UK
Tel: 01383.825630
Fax: 01383.825715
sales@ametekuk.com