MTS-1010

MULTI-FUNCTION POWERMETER

OPERATION AND REFERENCE MANUAL

Third Edition

November 1997

MANTA™

TEST SYSTEMS

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MTS-1010 Multi-Function Powermeter, Operation and Reference Manual

The information and specifications contained within from Manat Test Systems is believed to be accurate and reliable at the time of printing. However, because of the nature of this product, specifications shown in this manual are subject to change without notice.

The features and capabilities described herein reflect those available in MTS-1010 firmware version 14.5.

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INTRODUCTION

1.1 DISTINCTIVE CHARACTERISTICS

- Ten simultaneous measurements
- Compact and lightweight
- Flexible computer interface allows programmability
- True RMS and full autoranging
- Optimized for relay testing work
- Two wire pulse timing mode
- High speed measurement mode output for all readings
- Easy-to-use ergonomic design

1.2 GENERAL DESCRIPTION

The MTS-1010 Powermeter is a compact microprocessor enhanced metering system, specifically designed for ease of use. It is optimized for protective relay test and calibration work, by the inclusion of such features as audible/visual relay operation sensors, two-wire pulse timing trigger inputs, and a high-speed measuring plus reading freeze mode.

Ergonomic design, including display function annunciators, colour coding, status lamps, autoranging and physical layout separating input leads from controls and displays minimize the familiarization time required for operation.

The standard RS-232C serial computer interface offers the potential for significant productivity gains especially where large amounts of data must be recorded, numerically processed, and plotted. The interface provides the capability for usage in a partially or fully automated test system.

1.3 APPLICATIONS

- Test and calibration of virtually any relay including:

Synchrocheck	Under/overvoltage
Differential	Directional restrained overcurrent
Impedance	Voltage restrained overcurrent
Reverse power	Timed overcurrent
DC Timer	Pilot wire
Volts per Hertz	Under/overfrequency

- Verification of metering installations for accuracy, polarity, and potential transformer and current transformer ratios
- Monitor outputs of unmetered electronic test systems
- Automated data logging, power factor surveys, load profiles, etc.

1.4 IMPORTANT SAFETY PRECAUTIONS

HIGH VOLTAGE CAN BE LETHAL!!

This instrument can be used to measure high levels of voltage and current. Incorrect usage may cause injury to the instrument or to the user. The user ***must*** be qualified to work safely in the intended application environment of the instrument. Failure to adhere to the following minimum requirements constitutes misuse of the instrument, and the manufacturer accepts no liability for damages arising from such misuse.

1. The instrument case must always be effectively grounded. The rear panel grounding stud must be connected via 12 gauge wire to a known secure ground to supplement the power supply cord ground.

2. Voltage signals to the instrument must be supplied via high rupture capacity leads. Retractable shroud safety leads such as the pair supplied with the instrument are available from the distributor.

3. Current signals to the instrument must be supplied via minimum 14 gauge unfused leads securely fastened with C-hook terminals, when in-service current measurements are being taken. This is also recommended as a minimum when is measurements are being performed.

4. ***Never*** exceed maximum instrument ratings, namely:

   (a) 500 VRMS to ground/600 VRMS differential to Channel A & B voltage inputs.

   (b) 50 amps for one minute/125 amps for five seconds to Channel A & B current inputs.

   (c) 300 VDC to ground or differential to trigger inputs.

Always employ good safety practices, such as last made/first broken connections to energy sources, verifying integrity of leads before taking measurements, and keeping the leads and instrument in good condition.

1.5 LIMITED PRODUCT WARRANTIES

1.5.1 Hardware

Manta Test Systems warrants that its hardware products and the hardware components of its products shall be free from defects in materials and workmanship under normal use and service for a period of one year from the date such products are shipped from Manta Test Systems. Provided that Manta Test Systems receives notice of any defects in materials or workmanship of its hardware products or hardware components of its products within such one-year period, Manta Test Systems shall at its option, either repair or replace the defective hardware product or hardware component, if proven to be defective.

1.5.2 Software & Firmware

Manta Test Systems warrants that its software products and the software and firmware components of its products shall not to fail to execute their programming instructions under normal use and service, due to defects in materials and workmanship if properly installed on intended hardware, for a period of one year from the date such products are shipped from Manta Test Systems. Provided Manta Test Systems receives notice of such defects within the warranty period, it shall at its option, either repair or replace the software or firmware media if proven to be defective.

1.5.3 Separate Extended Warranty for Hardware Products

Aside from the standard warranty set forth above, Manta Test Systems offers a separate extended warranty plan for all hardware products (excluding cables, batteries and accessories) which may be purchased and extends the standard warranty by one additional year. The extended warranty is issued under the same terms, conditions and exclusions as the standard warranty set forth herein. Pricing is based on the cost of the product and the average cost of servicing and calibration. Refer to the Manta Test Systems price list available from your local representative or Manta Test Systems for extended warranty pricing for specific products. The extended warranty must be purchased and paid for within 3 months from the date the product is shipped from Manta Test Systems.

EXCLUSION OF OTHER WARRANTIES AND LIMITATION OF REMEDIES

1.5.4 Exclusion of Other Warranties

THE FOREGOING WARRANTIES ARE EXCLUSIVE, AND ARE IN LIEU OF ANY AND ALL OTHER WARRANTIES (WHETHER WRITTEN, ORAL OR IMPLIED), INCLUDING BUT NOT LIMITED TO WARRANTY OF MERCHANTABILITY IN OTHER RESPECTS THAN AS SET FORTH ABOVE AND WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE.

Limitation of Liability and Remedies

IT IS UNDERSTOOD AND AGREED THAT MANTA TEST SYSTEMS'S LIABILITY AND PURCHASER'S SOLE REMEDY, WHETHER IN CONTRACT, UNDER ANY WARRANTY, IN TORT (INCLUDING NEGLIGENCE), STRICT LIABILITY OR OTHERWISE SHALL NOT EXCEED THE COST OF REPAIR OR REPLACEMENT OF MANTA TEST SYSTEMS'S PRODUCTS, AS SET FORTH ABOVE, AND UNDER NO CIRCUMSTANCES SHALL MANTA TEST SYSTEMS BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, INCLUDING BUT NOT LIMITED TO, PERSONAL INJURY, PROPERTY DAMAGE, DAMAGE TO OR LOSS OF EQUIPMENT, LOST PROFITS OR REVENUE, COSTS OF RENTING REPLACEMENTS AND OTHER ADDITIONAL EXPENSES. FURTHERMORE, IT IS UNDERSTOOD AND AGREED THAT MANTA TEST SYSTEMS SHALL NOT BE LIABLE FOR ANY DAMAGES, LOSSES OR EXPENSES AS A RESULT OF THE PURCHASER'S OR ANYONE ELSE'S

i. NEGLIGENCE (WHETHER DEEMED ACTIVE OR PASSIVE),

ii. MISUSE, ABUSE, OR MODIFICATION OF MANTA TEST SYSTEMS'S PRODUCTS,

iii USE OR OPERATION OF PRODUCTS NOT IN CONFORMITY WITH THE SPECIFICATIONS AND INSTRUCTIONS FURNISHED BY MANTA TEST SYSTEMS FOR ITS PRODCTS,

iv REPAIR OR MAINTENANCE OF MANTA TEST SYSTEMS'S PRODUCTS BY PERSONS OR ENTITIES WHO ARE NOT AUTHORIZED BY MANTA TEST SYSTEMS, OR

v DAMAGE TO OR DESTRUCTION OF PRODUCTS DURING DELIVERY TO MANTA TEST SYSTEMS FOR ANY REASON.

Limitation of Warranty Regarding Software

Manta Test Systems does not warrant that the operation of the software, firmware or hardware shall be uninterrupted or error free.

1.5.5 Extension of Warranty

At the discretion of Manta Test Systems, the warranty may be extended for a product which has been returned for service shortly after its warranty period has expired.

SECTION 2
SPECIFICATIONS

Two independent input channels are employed, to each of which a current and a voltage signal may be simultaneously connected. All other electrical parameters are derived from these inputs and shown when selected in the upper display.

2.1 FREQUENCY MEASUREMENT

Resolution:	0.001 Hz for 8.000-9.999 Hz input 0.01 Hz for 10.00-99.99 Hz input ±0.1 Hz for 100.0-650.0 Hz input
Accuracy:	±0.01 Hz (low frequency scale) 0.1 Hz (high frequency scale)
Range:	8.0-99.99 Hz (low frequency scale) 8.0-500.0 Hz (high frequency scale)
Speed:	Measurement speed is dependent on input frequency For 60 Hz inputs: 2 readings/sec 7.5 readings/sec in START state For 50 Hz inputs: 1.6 readings/sec 6.3 readings/sec in START state
Annunciation:	Annunciator shows Hz Second annunciator shows FLTR OUT in high frequency scale

2.2 TIME MEASUREMENT

2.2.1 Time (Seconds) Mode

Resolution:	0.1 milliseconds
Accuracy:	±0.5 milliseconds
Range:	0.0 ms - 9999 sec, autoranging at the end of each decade

2.2.2 Time (Hertz) Mode

Resolution:	0.1 Hz of frequency of Channel A input
Accuracy:	±0.1 Hz of frequency of Channel A input
Range:	0.0 Hz - 9999 Hz, autoranging at 999.9 Hz

2.3 PHASE MEASUREMENT

Display Modes:	0 - 360° mode, default 0 - ±180° mode, user selectable
Resolution:	0.01° for readings 0.0° - 99.99° 0.1° for readings 100.0° - 359.9° 0.01° for readings -9.99° to -0.01°, (in 180° mode only)
Accuracy:	±0.5° for inputs between 10% and 100% of scale
Range:	0.0° - 360.0°
Speed:	Measurement speed is dependent on input frequency For 60 Hz inputs: 2 readings/sec 7.5 rdgs/sec in START state For 50 Hz inputs: 1.6 readings/sec 6.3 readings/sec in START state
Polarity:	Phase of channel A (volts or amps) leads phase of channel B (volts or amps).

2.4 VOLTAGE MEASUREMENT

Available on channel A and/or B. True RMS, DC coupled.

Accuracy:	±0.5% of reading and ±0.2% of scale
Range:	Autoranging at 19.99 V/199.9 V Auto ranging always occurs on over-range. Down-ranging occurs only if input level is below 9% scale of selected range and RANGE switch is engaged.
Maximum input:	600 VAC sustained input
Input impedance:	2 megohms
Speed:	3 readings/sec, 30 readings/sec in START state

2.5 CURRENT MEASUREMENT

Available on channel A and/or B. True RMS AC coupled via low-burden current transformers.

Accuracy:	±0.5% of reading and ±0.2% of scale Range:Auto-ranging at 1.999A/19.99A Auto ranging always occurs on over-range. Down-ranging occurs only if input level is below 9% of full scale of selected range and RANGE switch is engaged.
Maximum input:	35 amps sustained, 125 amps for 5 seconds Higher current rated input posts are available.
Speed:	3 readings/sec, 30 readings/sec in START state

2.6 POWER MEASUREMENTS

Power measurements are calculated by the internal microprocessor from the current, voltage and phase angle measurements.

2.6.1 Kilowatts

Resolution:	0.001 kW
Accuracy:	±1.5% of VA
Range:	63.0 to +63.00 kW

2.6.2 Kilovars

Resolution:	0.001 kVAR
Accuracy:	±1.5% of kVAR
Range:	-63.0 to +63.00 kVAR

2.6.3 Kilovoltamperes

Resolution:	0.001 kVA
Accuracy:	±1.0% of kVA
Range:	0.0 - 63.00 kVA

2.6.4 Power Factor

Resolution:	0.001
Accuracy:	±.004 of power factor
Range:	-1.000 to 1.000

2.7 EXTERNAL TRIGGER

- Floating three terminal inputs for START and STOP triggers
- Change of state detection for contact or AC/DC voltage (30-300V).
- Contact inputs protected to 300V AC/DC
- Input impedance 60 kohm minimum

2.8 POWER SUPPLY

- 120 VAC/60 Hz version:
  Input range: 100-130 VAC at 50-70 Hz
- 240 VAC/50/60 Hz version:
  Input range: 220-260 VAC at 47-70 Hz
- 12 VDC version:
  Snap-on 12VDC battery pack or automotive cigarette lighter plug input.
  Standard 120 VAC/60 Hz operation for non-field use also recharges the battery pack.

2.9 RS-232C SERIAL COMMUNICATIONS PORT

Connector:	Standard 25-pin female DB-25, DCE configuration
Data Format:	8 bits, no parity, 1 start bit, 1 stop bit
Speed:	Standard rates from 110 to 9600 baud

- Facilitates communication with printers, terminals computers and other RS-232C devices
- Permits automated output and recording of all measurements
- Permits control of all meter functions for fully automated or semi-automated testing

2.10 PHYSICAL CHARACTERISTICS

- Aluminum case and frame
- Moulded ABS plastic front/rear covers
- Integrated carry handle/tilt stand
- Large rear feet allow vertical operation
- Size: 10" W x 6" H x 10.5" D (254mm W x 152mm H x 267mm D)
- Weight: 12 lbs (5.5 kg)
- Recessed voltage/contact input terminals accept shrouded safety plugs or standard banana plugs. All on 3/4" centres.
- Current binding posts accept banana plugs, hook terminals or bare wires. All on standard 3/4" centres
- Separate safety grounding post on rear panel

2.11 OPTIONS

- 01: **Cordura carry case**
  Padded case with shoulder strap and pockets for leads and manuals.
- 02: **Snap-on lead case**
  Attractive, Cordura case snaps onto the top of the meter to carry leads, cords and accessories.

- 03: **Impedance measurement.**
  Direct display of impedance, based on Z=V/I, Z=V/21, or Z=V/I.7321. Replaces kVAR, kVA and P.F. display.
- 05: **High current measurement version**
  High current measurement version. High current binding posts for applications requiring greater than 20 Amps. (Included FREE with all new orders).
- 06: **IEEE-488 interface**
- 08: **W, VAR, VA display**
  Replaces kW, kVAR, kVA display with W, VAR, VA readings. Only display resolution is improved, not accuracy.
- 09: **Ratio measurement**
  Replaces kVAR display with Channel 1/Channel 2 ratio measurement. This allows measurement of impedance (V/I), admittance (I/V), voltage ratio (V/V) and current ratio (I/I). The V/V and I/I measurements are useful for measuring turns ratio and gain.
- 10: **Slip frequency**
  Measures the difference in frequency between the Channel A & B inputs with up to 0.001Hz resolution. Useful for synchrocheck relay applications.
- 11: **Analog outputs**
  Provides up to 2 low level analog outputs proportional to any measured quantity (eg. voltage, current, frequency, phase, power). Useful for an external recording or monitoring device. Contact Manta Test Systems for complete details.
- 12: **High Intensity display**
  High intensity red LED front panel displays for outdoor use in high ambient light conditions. (Included FREE with new MTS-1010 orders).
- 14: **Synchrocheck**
  Provides an extra high speed phase measurement mode for checking phase angle when testing synchrocheck and synchronizing relays. The maximum reading speed is one reading per cycle, for 20 - 60 Hz inputs.
- 15: **Wh measurement**
  Replaces kVA display with Wh measurement for testing watthour meters.
- 17: **Signal processing**
  Adds three measurement capabilities;
  1) Low pass filter for Channel A, inserts 5th order Low Pass filter in signal path to attenuate signals above 60 Hz at 30 db/octave.
     Eliminates all higher order harmonics from signal.
  2) Average response AC measurement on Channel A. Useful alternative to True RMS response, for such tests as second harmonic restraint and current transformer excitation.
  3) Peak responding measurement for Channels A and B. Captures and holds positive or negative peak signal with 1 millisecond response time. Can be calibrated for peak value or RMS equivalent. Extremely fast response useful for transient tests such as inrush measurement.
     (NOTE: Call Manta Test systems for compatibility with other options)
- 18: **Extended low level phase measurement**
  Extends 0.5 degree measurement accuracy for phase angle down to 4.5% of scale (0.9V or 0.09A minimum).
- 20: **Hard-shell shipping case**
- 21: **10V Triggers**
  Reduced trigger voltage threshold to 10V (Standard is 30V).

- 22: **0-20 amp input**
  Replaces high current input capability with 20A for improved accuracy of current measurement down to 20mA.
- 23: **240V, 50Hz Input**
- 24: **Extra Manual**
- 25: **1 Year Extended Warranty**
  Additional year for a total of 2 years.

2.12 OTHER MANTA TEST SYSTEMS PRODUCTS

- MTS-1200: 3-Channel AC/DC Current Voltage Source
- MTS-1300: Three Phase Voltage/Phase/Frequency Source
- MTS-1700: Series Advanced Universal Protective Relay Test System
- MTS-1400: Transducer Test System

Specifications are available upon request from Manta Test Systems Inc.

Note: All features and specifications subject to future change.

SECTION 3
BASIC OPERATION

3.1 PRINCIPLE OF OPERATION

The MTS-1010 Powermeter is a dual-channel voltmeter/ammeter integrated with start/stop trigger circuitry for performing timing measurements. The meter also measures frequency, phase, kilowatts, kilovars, kilovoltamperes, and power factor from the dual voltage/current inputs.

3.1.1 Trigger States

The start and stop trigger inputs allow the meter to be operated in three different modes. These modes are illustrated in the state diagram below:

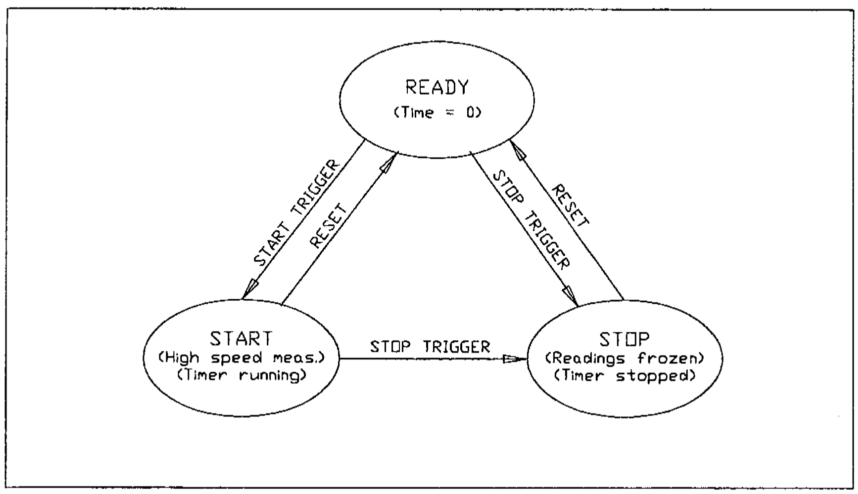

Figure 3-1. Trigger States

The MTS-1010 begins in the READY state. Any start trigger will start the timer and switch all measurements into the START or triggered state, in which measurements are updated at high speeds. This START state is typically used for measurement during a simulated fault condition.

Any subsequent stop trigger will cause the STOP state to be entered. This will stop the timer and freeze all readings at their current values. The stop trigger inputs are typically connected to the relay contacts allowing the values of all parameters to be captured at the time of relay pick-up.

Operating the reset switch in any state will return the meter to the READY state and reset the timer.

3.1.2 Applications of Trigger States

The trigger states do more than facilitate timing measurement. They may be used in many ways which enhance everyday measurement work. Typical applications of the trigger states are listed below.

State	Applications
READY	Normal high-accuracy measurement Data logging or monitoring
START	Measure/capture rapidly changing signals Track signals during manual adjustment of some parameter (eg. voltage, current, frequency, phase) Timing measurement
STOP	Capture values of all measurements at the time of relay operation (ie. stop trigger) Freeze readings for manual or automatic recording

3.2 MAKING BASIC MEASUREMENTS

This section briefly describe how to make most basic measurements. For detailed information, see section 4.

3.2.1 AC/DC Voltage Measurement

- Apply the signal to be measured to the [CHANNEL A VOLTAGE] or [CHANNEL B VOLTAGE] input as desired.
- Select V on the [CHANNEL A I/V SWITCH] or [CHANNEL B I/V SWITCH] as applicable.
- For stable, accurate measurements, engage the [RESET/RANGE] switch in the lower, RANGE position.
- AC Current Measurement
- Apply the current to be measured to the [CHANNEL A CURRENT] or [CHANNEL B CURRENT] input as desired.
- Select I on the [CHANNEL A I/V SWITCH] or [CHANNEL B I/V SWITCH] as applicable.
- For stable, accurate measurements, engage the [RESET/RANGE] switch in the lower, RANGE position.

CHANNEL A or CHANNEL B can accept both a voltage and current simultaneously. This feature allows for the measurement of two voltages and two currents simultaneously.

3.2.2 Frequency Measurement

- Apply the signal to be measured to the [CHANNEL A VOLTAGE] or [CHANNEL A CURRENT] input as appropriate and select I or V using the [CHANNEL A I/V SWITCH].

- Press the [FREQ/KW] pushbutton once or twice, as required, to display HZ in the [FTP display].
- For stable, accurate measurements, engage the [RESET/RANGE] switch in the lower, RANGE position.

3.2.3 Phase Measurement

- Apply the signals of interest to the channel A and B inputs. The meter will measure the phase by which channel A leads B.
- Select the desired signals on channels A and B using the [CHANNEL A I/V SWITCH] and [CHANNEL B I/V SWITCH].
- Press the [PHASE/PF] pushbutton once or twice, as required to display DEG in the [FTP display].
- The reading is the angle by which the Channel A signal leads the Channel B signal.
- For stable, accurate measurements, engage the [RESET/RANGE] switch in the lower, RANGE position.

3.2.3.1 ±180° DISPLAY MODE. Phase angle can be displayed in ±180° mode. This may make measurements near 0 degrees easier. It also displays phase to 0.01 degree resolution for angles between -9.99 and -0.01 degrees. To display phase in ±180° mode: When selecting phase to be displayed, continue to press and hold the [PHASE] button for 3 seconds. The phase display will flip to ±180° mode. To return to 0°-360° mode, repeat the above steps.

3.2.3.2 LOW INPUT BLANKING. A blanking feature for phase readings when channel inputs are too low to obtain meaningful phase readings. When either the channel A or channel B input falls below 1% of scale, a small "o.o" is displayed as the phase reading. This is visibly different from a display of "0.0", indicating in phase signal inputs.

Remember that rated 0.5 degree accuracy is only maintained for signal inputs between 10% and 100% of scale. Reduced accuracy readings are obtainable for signal inputs between 1% and 10% of scale (typically 1 to 5 degrees). Therefore, for accurate phase measurements, always engage the range switch in order to use the lowest possible scale.

3.2.4 Power Measurements

3.2.4.1 BASIC USAGE.

- Apply the voltage to channel A input and the current to channel B input or vice versa.
- Select channel A to read the desired current or voltage using the [CHANNEL A I/V SWITCH] and select the opposite quantity on channel B
- For KW measurement, press the [FREQ/KW] button once or twice, as required to display KW in the [FTP Display].
- For reactive power, press the [TIME (SEC)/KX] button once or twice, required, to display KX in the [FTP Display].
- For apparent power, press the [TIME (HZ)/KVA] button once or twice, as required, to display KVA in the [FTP Display].
- For power factor, press the [PHASE/PF] button once or twice, as required, to display PF in the [FTP Display].

3.2.5 Timing Measurements

- Connect any signals to be measured to channel A and/or B.
- Connect a start trigger signal to the [START TRIGGER INPUTS].
- Connect a stop trigger signal to the [STOP TRIGGER INPUTS].
- Momentarily engage the [RESET/RANGE] switch to the RESET position to reset all timers and trigger circuit
- Vary the relay inputs (usually to a fault condition). This should cause a start trigger, and a relay operation should generally cause a stop trigger.
- After the stop trigger all readings are frozen (including time in Hz or seconds) and may be recalled on the [FTP Display] or channel A & B displays.

3.2.5.1 OVERCURRENT RELAY TIMING EXAMPLE. An example of timing measurement with a simple overcurrent relay is illustrated here. The current to the relay is stepped from zero to the fault value using a switched output from the resistance load source. At the same time, auxiliary contact outputs on the source are closed, activating the start trigger on the meter. When the relay operates, the contact closure causes a stop trigger, stopping the timers and freezing the current reading at the time of operation.

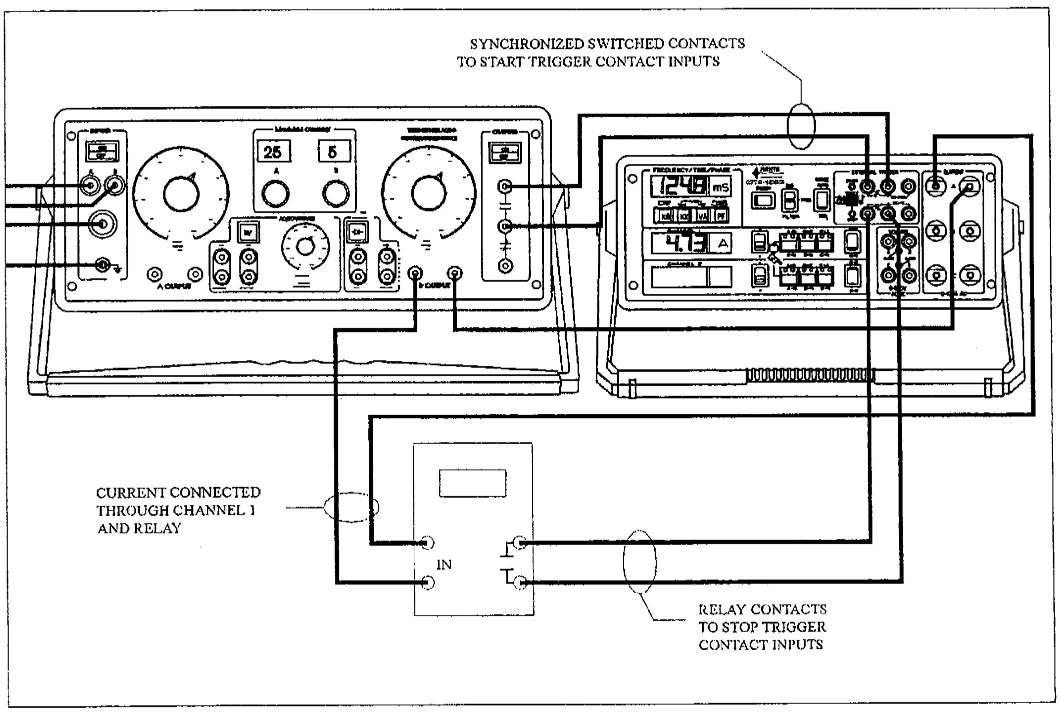

Figure 3-2. Timing Measurement for Overcurrent Relays

SECTION 4
DETAILED OPERATION

4.1 FRONT PANEL FEATURES

4.1.1 Front Panel Layout

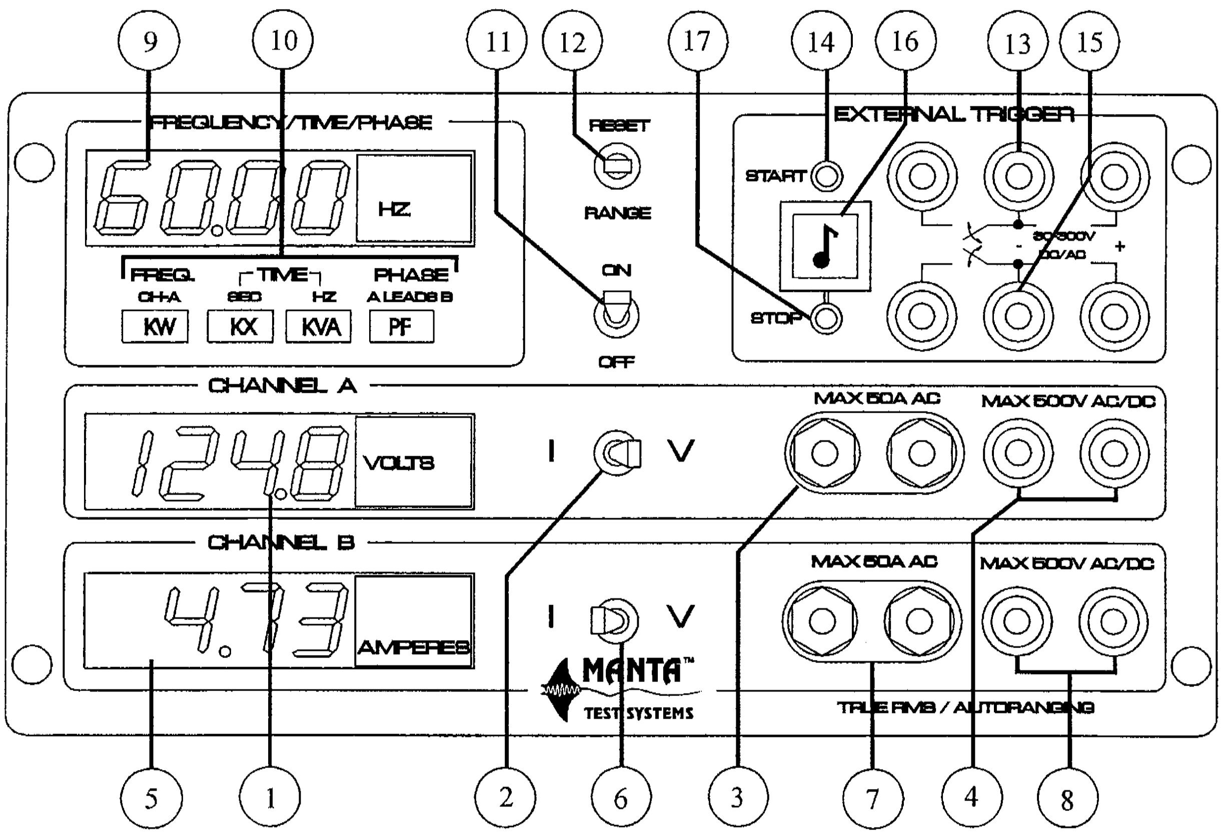

Figure 4-1. Front Panel Layout

1. CHANNEL A DISPLAY
2. CHANNEL A I/V SWITCH
3. CHANNEL A CURRENT INPUT
4. CHANNEL A VOLTAGE INPUT
5. CHANNEL B DISPLAY
6. CHANNEL B I/V SWITCH
7. CHANNEL B CURRENT INPUT
8. CHANNEL B VOLTAGE INPUT
9. FTP DISPLAY
10. FTP DISPLAY SELECT PUSHBUTTONS
11. ON/OFF SWITCH
12. RESET/RANGE SWITCH
13. START TRIGGER INPUTS
14. START LED
15. STOP TRIGGER INPUTS
16. TONE SWITCH
17. STOP LED

4.1.2 Channel A & B Displays

These display current or voltage, as selected by the I/V selector switch for the channel. An internal annunciator reads AMPERES or VOLTS as selected by the I/V sector switch except when under remote control of external computer. Current and voltage inputs may be connected simultaneously and alternately displayed via the switch. However, in the STOP mode, ([STOP LED] lit) only the quantity selected at moment of stop trigger is valid (see Appendix A).

4.1.3 Channel A & B I/V Switches

Selects current or voltage input to channel for display, when the meter is in local control mode.

4.1.4 Channel A & B Current Input

These current inputs are AC coupled, unfused, low burden current transformer inputs. Maximum continuous current input is limited by the rating of binding posts and 12 gauge internal wiring to 35 amperes. Short-term inputs in excess of 100 amperes are acceptable (the current rating of externally connected relay coils are typically the limiting factor). Higher current rated binding posts available via special order.

4.1.5 Channel A & B Voltage Input

These inputs are DC coupled, 2Mohm impedance, and internally fused. The internal fuses are not user replaceable, as their failure may indicate an internal problem which must be rectified by the instrument's distributor. The maximum sustained input voltage is limited by input terminal ratings of 500Vrms to ground. The maximum voltage between terminals must not exceed 600Vrms.

CAUTION: Whenever measuring voltages in excess of 250VACrms/300VDC the supplied fused prods or equivalent must be used.

True RMS response ensures accurate measurement of distorted waveforms. The voltage input is DC coupled, allowing measurement of DC voltages which are frequently encountered in relay systems.

4.1.6 FTP Display

This displays frequency, time, phase, or power quantities, as selected by the pushbuttons. Annunciators show function currently selected. After a stop trigger, ([STOP LED] lit) each of the measurements present at the moment of the trigger may be displayed by appropriate operation of the pushbuttons. Voltage and/or current inputs must have been present for a minimum amount of time to obtain correct displayed values of frequency phase and power (see section 4.1.7).

4.1.7 FTP Display Select Pushbuttons

These are used to call up one of the eight functions on the FTP display either before or after a stop trigger. These are disabled in remote control mode.

4.1.7.1 FREQUENCY. This button selects display of frequency of the current or voltage present on the Channel A inputs. The standard range is 20.00 to 99.99Hz allowing tests to be made on low frequency telemetry systems, as well as power frequencies. The range is extended to 500.0 Hz if DIP SWITCH #1 is closed prior to power up. A few seconds may be required to reliably lock onto the input frequency. For accurate readings therefore ensure the signal is present long enough prior to a stop trigger. The annunciator reads HZ in this mode.

4.1.7.2 KILOWATTS. Once frequency has been selected, the second press of the frequency push button will cause kilowatts derived from V and I inputs of Channel A and B to be displayed. There must be a voltage and a current selected on channel A & B to obtain a reading. Two currents or two voltages result in blanking of the display. The annunciator reads KW in this mode.

4.1.7.3 TIME SEC. This button selects time in seconds on the FTP display. Relay contact or voltage signals to the START and STOP trigger inputs control the starting and stopping respectively, of the timer. The timer starts at 0.0 msec with autoranging up to lockout at 9999 seconds. The annunciator reads mSEC or SEC in this mode.

4.1.7.4 KILOVARS. When time in seconds is selected, a second operation of the pushbutton causes Kilovars derived from Aand B channel Vand I inputs to be displayed. The annunciator reads KX in this mode. A current and a voltage must be selected to obtain a reading.

4.1.7.5 TIME HZ. This button selects time reading in cycles of the frequency present on channel A inputs on the FTP display. As with frequency measurements, an input signal must be present for a few seconds before starting a timing sequence, to allow locking of the frequency multiplier. This timer function autoranges to 9999 Hz. The annunciator reads HZ in this mode.

4.1.7.6 KILOVOLTAMPERES. When time in HZ is selected, a second operation of the pushbutton causes KVA derived from channel A and B voltage and current inputs to be displayed. The annunciator shows KVA in this mode. A current and a voltage must be selected to obtain a reading.

4.1.7.7 PHASE. This button selects the phase angle between selected AC signals on channels A and B, to be displayed on the FTP display. The reading is in degrees, from 0.0 to 360.0, with the channel A signal defined as leading channel B signal. The annunciator shows DEG in this mode. A valid signal must be present a few seconds prior to freeze action, to obtain an accurate reading.

4.1.7.8 OBTAINING ACCURATE PHASE READINGS. Rated accuracy is only maintained for signals in the 10%-100% range of the current of voltage inputs. Therefore, if 0.5 deg accuracy is required, ensure the RANGE switch is engaged before recording the reading.

A quick accuracy check may be done by applying 120 VAC to both channels, and reversing polarity to one channel. The reading should be 180.0± 0.5. The same quantity applied in-phase to both channels will usually give a reading of 360.0. but since the reading rolls over to 0.0 at this point, any slight fluctuation may be enough to cause a reading varying between 0.0 and 360.0.

Digital filters with a very steep cutoff at 100Hz are used to virtually eliminate the effect of harmonics on accuracy. This also allows shifting of the cutoff frequency for higher frequency measurements. A byproduct of it's action is a small ripple in the output waveform which may cause some variation in the least significant digit of the display, especially at low input levels. KVA readings are unaffected however and other readings stabilize beyond about 0.5 degrees from true in phase.

4.1.7.9 POWER FACTOR. When phase angle has been selected, a second operation of the pushbutton causes power factor derived from channel A and B V and I inputs to be displayed. The annunciator shows P.F. in this mode.

4.1.8 On/Off Switch

This switch turns on the instrument, when it is connected to the 120VAC/60Hz or 240VAC/50/60Hz power supply via the supplied power cord, battery or car adaptor.

4.1.9 Reset/Range Switch

This is a dual-purpose centre-off switch. The upper momentary [RESET] position is used to return to READY mode, from either the START or the STOP mode. Timer functions always reset to zero on operation of switch. The lower, [RANGE] position enables auto down-ranging of channel Aand B if the respective reading is less than 9% of the normal range at that time. Placing the switch in the mid OFF position disables down-ranging, to permit rapid capture of currents or voltages which may be present only momentarily at the A and B inputs.

More than one second is required for each auto up-range and subsequent reading stabilization, which would make it impossible to record short duration signals if the meter always returned to the most sensitive range on removal of the input signals. Blocking downranging via the RANGE switch means the meter stays in the range currently in use. It can also mean however that the level-sensitive frequency and phase circuits may not always be in their optimum range, so where accuracy of these quantities are important, always engage the [RANGE] position before recording the reading.

4.1.10 External Trigger Start Terminals

These three input terminals allow external contacts or voltage signals to start the second and cycle timers, and engage the high-speed mode of other circuitry. The left and center terminals detect impedance change-of-state, such as contact closure or low-impedance voltage source appearance. The right and center terminals detect voltage change-of-state.

In either case, the initial appearance of a signal activates the START state, illuminating the [START LED]. Once triggered, operation of the [RESET] switch, turns off the [START LED] and arms the circuits to detect the next change of state. This could be the disappearance of the signal, thus enabling trigger action from contact opening/voltage disappearance, as well as the more conventional contact closure/voltage appearance.

The recommended mode is to use voltage sensing whenever possible, since these terminals do not inject a voltage of their own into the circuit under test. The voltage output from the impedance terminals, although of very high source impedance, may in some cases be sufficient to alter observed operation time of sensitive electronic relays.

Up to 300 VDC may be applied to any of the three terminals without damage. AC voltage should be avoided due to the inherent poor accuracy caused by it's continuous reversals. Input impedance of either pair is greater than 60kohms. Complete galvanic isolation is ensured by use of optical coupling and independent power supplies for the sensing circuits. The inputs are polarity sensitive, so if expected action is not achieved, roll the input leads.

In the START state, channels A and B begin to update at 30 times/second rather than the normal 3 times/second. Independent A/D converters in each channel ensure accurate synchronizing of the displayed data. This system optimizes speed, at the expense of only freezing one V or I reading per channel. The frequency/time/phase/power readings derived from channels A and B are processed simultaneously by the internal microprocessor, and therefore may all be frozen and recalled. The update rate of these readings are also increased by the START trigger.

4.1.11 Start LED

When lit, indicates that the START state is active, and that timers have been started and are running. START state is exited by the [RESET] switch or by operation of STOP trigger.

4.1.12 External Trigger Stop Terminals

The sensing action, impedance characteristics, and floating status of these inputs are identical to those of the START inputs described above. Activation is indicated by lighting of the [STOP LED].

They control the START state, ie when the [STOP LED] is illuminated all displayed readings will be frozen at the value they had at the moment of STOP trigger, whether the normal or high-speed modes were active at the time.

The STOP trigger can also be overridden by the [TONE SWITCH], described in section 4.1.13.

4.1.12.1 TWO WIRE PULSE TIMING. By paralleling the START and STOP inputs, pulse type operations may be timed using only a single pair of sensing leads. The rising edge of a voltage pulse, for example would cause a start trigger, and the falling edge would cause a stop trigger. This allows measurement of the duration of a voltage pulse.

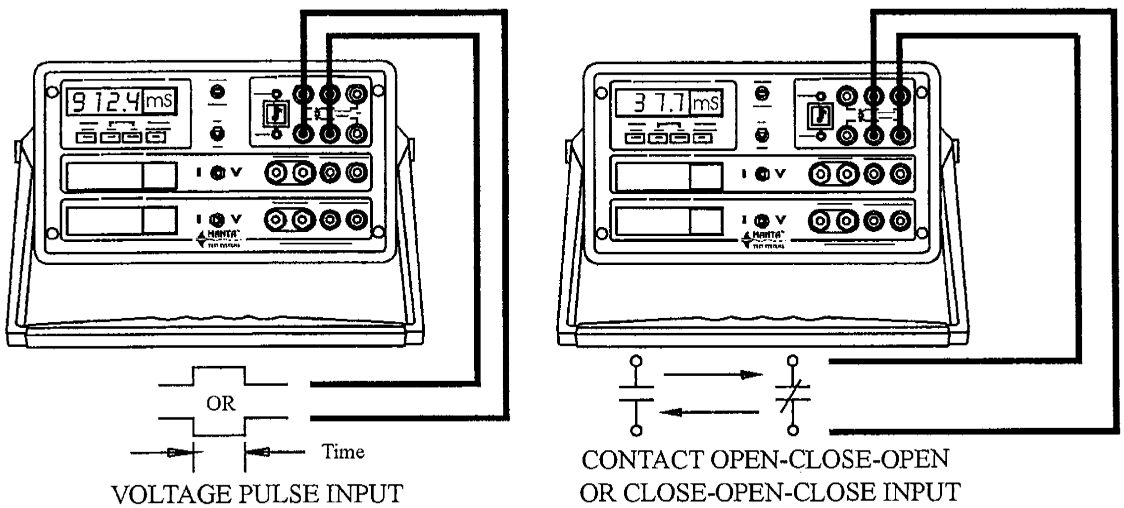

Figure 4-2. Two Wire Timing Setup

4.1.13 Tone Switch

This internally illuminated pushbutton controls audible annunciation plus 'pick-up mode' and is intended to facilitate detection of external relay operation.

An output contact of the relay under test or voltage controlled by same, are connected to the appropriate [STOP TRIGGER INPUTS]. Contact closure, or voltage appearance, will then be indicated by illumination of the switch and by an audible tone if the switch is latched in. Latching in the switch also engages the 'pick-up mode'.

During tests such as minimum pickup level for current relays, an operating signal such as AC current will typically be passed several times through the operate point to check for consistent operation. Normally each STOP operation would freeze the meter readings, necessitating continual manual resetting. Engaging the tone however defeats the freeze action of the STOP trigger. To restore normal operation of the STOP trigger for high-speed timed measurements, push the switch to the OFF (out) position.

'Pick-up mode' without tone operation can be achieved by shorting the [EXT RESET] inputs on the back panel.

4.1.14 Stop LED

When lit, indicates that STOP state is active and all timers have been stopped and all readings are frozen. To restore normal operation, operate [RESET] switch.

4.2 REAR PANEL FEATURES

4.2.1 Rear Panel Layout

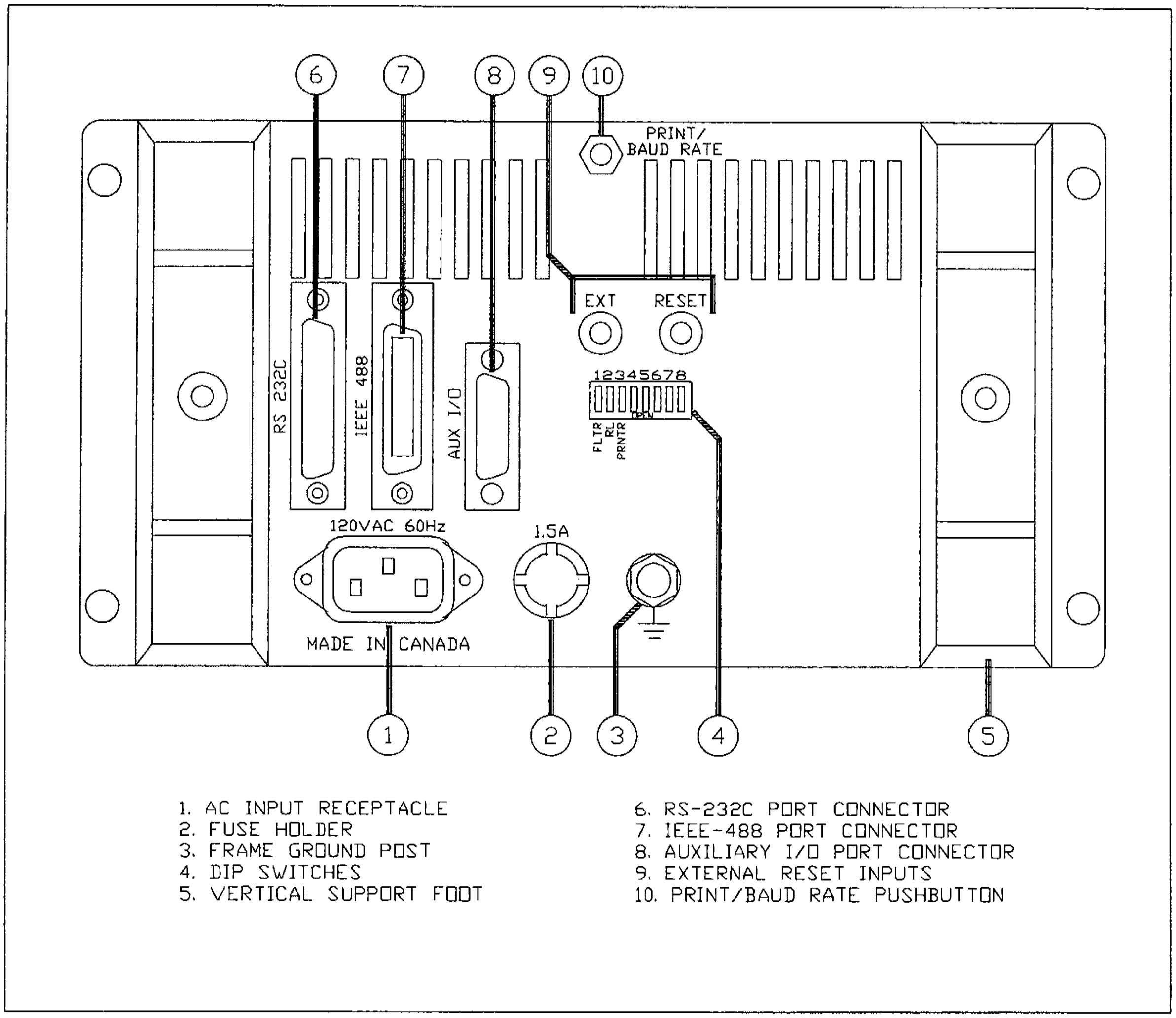

Figure 4-3. Rear Panel Layout

4.2.2 External Reset Terminals

This pair of jacks located on the rear panel are intended to be connected to the [EXT RESET] output terminals of the MTS-1710, Universal Protective Relay Test System, allowing single-button reset of both the MTS-1710 and the meter. However any external dry contact or opto-isolated signal can be used for the same purpose.

CAUTION: Do not apply a voltage signal to these terminals!

4.2.3 DIP Switches

4.2.3.1 DIP SWITCH #1. This switch is labelled FLTR, and controls the cutoff point of the digital filters for phase angle and frequency measurement. If set to the top (closed) position prior to power up of the meter, it selects the high frequency measurement mode, by raising the cutoff point of the digital filters above 500Hz. Simultaneously the frequency display shifts it's decimal point to permit a full range 500.0Hz reading and illuminates the FLTR OUT annunciator.

This will of course impair the accuracy of phase angle measurements whenever noise or harmonic distortion are present, therefore use only for high frequency checks. Normal filter action is restored by returning the switch to OPEN and turning the meter off, then back on.

4.2.3.2 DIP SWITCH #2. This switch is labelled R/L and configures the meter to process control signals to the MTS-1200 via the AUX I/O connector.

4.2.3.3 DIP SWITCH #3. This switch enables the special printer mode, whereby a serial interface printer may be directly connected to the RS-232C port. (See section 5.5)

4.2.3.4 DIP SWITCHES #4-8. These remaining switches are for options including IEEE-488 programming.

4.2.4 AUX I/O Connector

This rear panel connector is an auxiliary output allowing commands sent to the meter via an external computer to be processed and sent via the connector to control a third device. Applications available include a Three Phase Voltage Selector module, and digitally controlled, resistance loaded current/voltage source.

This port provides an 8 bit TTL level output. The connector pinout is given below. See section 5.3.2 for operation.

Pin #	Function	Pin #	Function
1	NC	9	NC
2	NC	10	NC
3	NC	11	Ground
4	+5V supply	12	Output bit 4
5	Output bit 3	13	Output bit 5
6	Output bit 2	14	Output bit 6
7	Output bit 7	15	Output bit 1
8	Output bit 0		

4.2.5 RS-232C Connector

This standard 25-pin female connector allows the meter to be connected to the serial port of an external computer. Its use is covered in detail in section 5.

4.2.6 Print/Baud Rate Pushbutton

This rear panel pushbutton is used to program the baud rate of serial data transfer, by depressing it during power-up and releasing when the desired baud rate is displayed. Operation after power-up transmits a set of readings over the serial port.

4.2.7 IEEE-488 Connector

This connector is present for systems with the IEEE-488 interface option. The RS-232C port remains fully functional with this option installed.

SECTION 5
RS-232C INTERFACE

5.1 INTRODUCTION

The MTS-1010 Powermeter's RS-232C interface enables a remote system to perform the following:

1. Control all display selections
2. Control the RESET and RANGE controls
3. Interrogate and output all readings over the interface in a desired format
4. Access the AUX I/O port to control another digitally controllable device (eg. 3-phase voltage selector)
5. Select high/low frequency scales
6. Perform data acquisition
7. Allow for semi and fully automated testing

The extensive output control capabilities of the meter allow for data logging applications. Measurement results can be directly input into personal computers or microcomputers, and processed by users' application programs. Any combination of meter readings can be output in a tabular form, separated by commas or spaces. All numbers are output in ASCII format. This allows data to be directly input into BASIC programs or applications packages such as Lotus 1-2-3 or dBASE III, while remaining directly readable to the user. In addition, a special program mode can be selected, which simplifies the processing that is done when the meter is under the control of an external computer. As with the meter's hardware features, significant design effort has gone into software to ensure maximum ease in setting up computer application programs.

The meter's full range of computer-accessible features uniquely make possible computer-aided testing using only conventional test equipment. Relay operation sensing, and the associated freezing of meter readings, allow an external computer to automate the documenting of test procedures. For testing such as impedance relays, where many test point values must be recorded, processed, and graphically analyzed, substantial productivity gains are possible. Computers from the wide range of powerful, inexpensive PC-compatible laptops coupled with commercial software as above are in use with the meter now. Talk to your distributor for current information on computer-aided testing using only the conventional equipment you now possess. Most of the information in this section also pertains to the IEEE-488 interface.

5.2 RS-232C CONNECTIONS

The RS-232C connector is a standard DB-25 female connector, wired as a DCE (Data Communications Equipment). Since many computers ignore the handshake signals, pins 2, 3 and 7 may be the only lines that have to be connected to obtain a functional interface. Due to the potential complexities involved, contact your computer dealer regarding cabling requirements for your specific computer, terminal or printer. The following data will assist you in setting up an operational interface:

RS-232C CONNECTOR PIN ASSIGNMENTS

PinNumber	Signal	Direction
1	Frame Ground	NA
2	Transmit Data	To MTS-1010 Powermeter
3	Receive Data	From MTS-1010 Powermeter
4	Request to Send	To MTS-1010 Powermeter
5	Clear to Send	From MTS-1010 Powermeter
6	Data Set Ready	From MTS-1010 Powermeter
7	Signal Ground	NA
8	Data Carrier Detect	From MTS-1010 Powermeter
20	Data Terminal Ready	To MTS-1010 Powermeter

Data format: 8 bits + 1 stop bit + 1 start bit, no parity

Data speed: 10 user selectable standard baud rates: 110, 300, 600, 1200, 1800, 2400, 3600, 4800, 7200, and 9600 baud (Other non-standard baud rates available on request)

Protocol: The RS-232C output now has XON/XOFF capability to prevent data loss when used with computers and devices with XON/XOFF capability. CONTROL-S (ASCII 19) and CONTROL-Q (ASCII 17) characters are used to pause and resume data output from the MTS-1010. These may be used manually, if desired, to pause the display.

For those who are using Lotus Symphony or Lotus 1-2-3 + Measure on the IBM PC, enable Outbound handshaking (XON/XOFF) in order to prevent data loss.

On power-up the meter assumes a data rate of 9600 baud (from software version 13.0 and up, earlier versions are 600 baud). To select a different baud rate, depress and hold the Baud Rate pushbutton while turning on the meter. The available baud rates will be sequentially displayed on the MTS-1010 display. Release the button when the desired rate is displayed. The selected rate is retained as long as the meter is not turned off.

Once successful communication has been established, a message similar to the following will be sent by the meter:

```
MTS-1010 Powermeter
Serial #14.1, 00, 0895
Type HLP for help.
Ready
```

5.3 COMMAND DESCRIPTIONS

All functions are accessible via the RS-232C and the IEEE-488 interfaces. A simple 3 letter code is used to select any particular function. For RS-232C interfaces, simply type this code followed by the RETURN key, from the computer or terminal connected to the MTS-1010 powermeter. For IEEE-488 interfaces, the code should be terminated by an EOI command. To see the list of available commands, use the HLP (help) command. All commands may be typed in any combination of upper and lower case, although key command letters are denoted here in upper case for clarity.

The Drr, Prr, -rr, and +rr commands use common suffixes, denoted by 'rr'. Examples of valid commands are: DFR, DPH, PPH, +KW and -FR. The valid suffixes and their meaning are given in the following table:

FR	frequency
TS	time (seconds)
TH	time (Hertz)
PH	phase
KW	average power
KX	reactive power (kVAR)
VA	apparent power (kVA)
PF	power factor
CA	channel A
CB	channel B

5.3.1 Function Control Commands

REM The REM command places the meter in remote control mode. This disables most front panel controls, and enables control via the communications interface. This mode is indicated by the 'REMOTE' annunciator on the channel A display. The meter must be in remote mode in order to operate the following commands: RES, RNG, RSL, RGL, CAV, CAI, CBV, CBI, DFR, DTS, DTH, DPH, DKW, DKX, DVA and DPF. When remote mode is entered, the MTS-1010 display selection and channel A & B selections remain the same as previously selected.

LOC The LOC command is the opposite of the REM command and places the meter in local control mode. Front panel controls are re-enabled and the 'REMOTE' annunciator is turned off.

RES The RES command resets the triggering logic. This provides the same function as operating the Reset switch.

RNG The RNG command resets the autorange circuit. This provides the same function as momentarily operating the Range switch.

RSL The RSL command latches the reset control in the on position. It has the same effect as permanently engaging the reset switch, which disables the start and stop triggers. The RES command may be used to release this control to the off position. Note that if RSL was executed and then the meter was returned to local control, the reset control would still be in the ON mode, regardless of the front panel switch position. The RES command is the only way to release the control to the off mode.

RGL The RGL command latches the downrange control in the on position. It has the same effect as engaging the range switch, allowing automatic downranging. The RNG command may be used to release this control to the off position. Note that if RSL was executed, and then the meter was returned to local control, the down range control would still be in the ON mode, regardless of the front panel switch position. The RNG command is the only way to release the control to the off mode.

CAV The CAV command selects voltage measurement on channel A.

CAI The CAI command selects current measurement on channel A.

CBV The CBV command selects voltage measurement on channel B.

CBI The CBI command selects current measurement on channel B.

LFS The LFS command selects the low scale for frequency measurement (20 - 99.99 Hz). (NOTE: The LFS and HFS commands override the rear panel switch setting)

HFS The HFS command selects the high scale for frequency measurement (0-500.0 Hz). This scale is indicated by the 'FLTR OUT' annunciator. The digital filter is not actually taken out of the circuit in this mode, its cutoff frequency is simply raised to approximately 500 Hz.

Drr The Drr command selects reading denoted by 'rr' to be displayed on the MTS-1010 display. (eg. DPH displays phase)

5.3.2 Auxiliary Port Control

The auxiliary port is special output port on the rear panel of the MTS-1010 Powermeter. It is used for digital control of other related devices along with the meter, such as a programmable resistance load or the Digiswitch voltage selector module. It is basically an 8 bit TTL level output channel. The outputs can be placed in a high impedance state (referred to here as the 'off' state). Control of this port is accessible via the following two commands:

AUX The AUX command toggles the auxiliary port on and off. After executed, the meter will send the message 'Auxiliary port on' or 'Auxiliary port off', to inform the user or computer of the new state. This is a sample execution of the AUX command:

```
Ready >aux
Auxiliary port on
Ready >
```

A### The A### command sends the 8 bit code (given by to the auxiliary port. Any decimal value from 0 to 255 is valid. For example, the command A67 sends the binary word 01000011 to the port. This code is only output if the port is in the 'on' state.

5.3.3 Output Commands

Prr The Prr commands print the current value of the reading specified by 'rr'. For example, PPH prints the phase reading. The appropriate units are also printed if the meter is in Terminal mode. This is a sample execution of the Prr command:

```
Ready >pph
40.4 deg.
Readypfr
59.98 Hz
Ready >
```

HLP The HLP command prints a summary list and description of all available commands.

REP The REP command prints a formatted report of measurements, all trigger status. Proper decimal point placement and units are maintained throughout. This command has the same function as pushing the rear panel Baud/Print pushbutton during normal operation. The rear panel pushbutton is provided for convenience, or applications in which only a printer is connected to the RS-232C port. This is a sample execution of the REP command:

```
Ready >rep
Report:
Freq: 60.08 Hz Chan. A:0127V
Time: 131.2 sec Chan. B:1.098A
Phase: 240.5deg
Power: -.5406kW Stat:Triggered
Ready >
```

STA The STA command prints the current trigger status. The three possible responses returned by the meter are "Ready", "Triggered" and "Stop". This is a sample execution of the STA command:

```
Ready >sta
Triggered
```

PSP The PSP command causes the meter to print "Stop" on the next transition to stop mode. Only the first transition to stop mode will cause "Stop" to be printed. The command must be re-issued to detect further transitions.

This command may be used to sense relay operation if the relay contacts are connected to the stop trigger inputs. When the relay contacts change state (open/close) the stop trigger is activated, changing the meter trigger status to 'stop'. If the PSP command had previously been sent, the meter will send "Stop" to the host computer, informing it that the relay has operated and to proceed in the test.

LFT The LFT command toggles the line feed option on and off. In the 'on' state, a line feed code is sent at the end of every line output by the meter. So terminals and printers require this code in order to print output on successive lines.

SER The SER command toggles the suppressing of error messages on or off. The initial value is off. When toggled on, error messages are not output over the RS-232C interface. This command is intended for use in multidrop control configurations in which two or more instruments are controlled via a single RS-232C port, (eg. MTS-1010 and PS-3E).

CW0 The CW0 command turns off the 50ms delay after each transmission of a return (ASCII 13). This allows maximum RS-232C output rates to be achieved for high speed data acquisition applications.

CW1 The CW1 command turns on the 50ms delay after each transmission of a carriage return (ASCII 13). The meter defaults to this mode on power up. This delay accommodates use of the meter with computers or devices with unbuffered RS-232C interfaces or slow displays.

5.3.4 Tabular Output

The TTL, TBL, -rr, +rr, DLS, and DLC commands control tabular output of readings. On power-up the meter defaults to outputting all 10 measurements in the table. Selected measurements can be deleted from the table using the -rr commands (eg. -KW to delete the kilowatts reading).

Selected readings can be added to the table using the +rr commands. However, the order in which the readings appear, cannot be changed. A title line for the table can be output, using the TTL command. The title line is aligned to the table of readings, and includes the appropriate units. The TBL command prints out all of the selected readings on a single line separated by tabs. Comma separators can be selected by using the DLC command. This feature is mainly for direct input into applications programs.

5.3.4.1 EXAMPLE USAGE. The following is an example of a typical command sequence using tabular output commands:

-PH	
-KX	This sequence produces a labelled
-TH	table of seven columns by 4 rows,
PGM	for direct input into a spreadsheet
TTL	program.
TBL	
TBL	
TBL	
TBL	
DLC	
TBL	

The meter output resulting from this sequence is shown below:

```
Ready >-ph
Ready >-kx
Ready >-th
Ready >pgm
```

Freq. [Hz]	Time [sec.]	Power [kW]	App Pwr [kVA]	Power Factor	Chan. A [Volts]	Chan. B [Volts]
60.01	85.24	0.0	0.0	0.0	0128	0.78
60.00	87.57	0.0	0.0	0.0	0128	10.78
60.00	89.78	0.0	0.0	0.0	0128	0.82
59.99	98.12	0.0	0.0	0.0	0128	10.80
59.99	103.6	0.0	0.0	0.0	0128	10.79

The PGM command sets the program mode on, in order to suppress the prompt and user input. The TRM command returns the meter to terminal mode. This mode is the default mode, and is useful for simple tests and demonstrations of control capabilities. The TTL and TBL commands produce a neat tabular output on the terminal.

Note that each reading is allocated eight columns in the output line, so that all ten measurements can be displayed in one line on an eighty column screen. All output commands are available in both local and remote control modes.

5.3.4.2 DESCRIPTION TABULAR OUTPUT COMMANDS.

TTL The TTL command prints out a title line of all selected readings in orderer tabular outputs. A second line of all relevant units is also printed.

TBL The TBL command prints out all of the selected readings on a single line. The readings are kept in close alignment to the title line if the TTL command was used. The readings are always printed in the same order, independent of which readings were chosen by the -rr and +rr commands.

This is a sample execution of the TTL and TBL commands:

```
Ready >ttl
                                                  Reac     App
Freq      Time      Time      Phase     Power     Pwr      Pw       Power    Chan A
[Hz]      [sec.]    [Hz]      [deg.]    [kW]      [kVAR]   [kVA]    Factor   [Volts]
Ready >tbl
59.90     31.99     1924.     240.9     0.0       0.0      0.0      0.0      0128
```

-rr The -rr commands delete the specified reading from tabular output. For example, -TS deletes the time in seconds reading from the table.

+rr The +rr commands add the specified reading to the table. For example, +PF adds the power factor reading to the table.

DLS The DLS command chooses a space as a delimiter for tabular output. A space is then used to separate readings when the TBL command is executed.

DLC The DLC command chooses a comma as a delimiter for tabular output. A comma is then used to separate readings when the TBL command is executed. This feature is useful when using BASIC's INPUT command to read a list of readings from the meter. The BASIC language requires that numerical input be separated by commas when using the INPUT command.

5.3.5 Program/Terminal Modes

The meter can communicate in 2 conversational modes, Program mode or Terminal mode. The mode is controlled by the following two commands:

PGM The PGM command sets the meter in Program mode. This mode is used for direct computer control of the meter. In this mode, characters sent to the meter as commands are not echoed back to the terminal or computer. Communication on the interface is effectively limited to one direction at a time. Also, the user prompt is not sent, and units such as Hz and kW are not printed in response to Prr commands. All of these features help to simplify applications programs.

TRM The TRM command is the opposite of the PGM command and places the meter in the user-friendly Terminal mode. This mode is used for simple tests, demonstrations, and very simple control applications.

5.4 COMMAND SUMMARY

5.4.1 Meter function control commands

Mnemonic	Meaning	Remarks
REM	Remote	Take remote control
LOC	Local	Return control to front panel
RES	Reset	Reset triggering logic
RNG	Range	Reset autorange circuitry
RSL	Reset latched	Latch reset control on
RGL	Range latched	Latch range control on (autorange)
CAV	Channel A Volts	Meter selection
CBV	Channel B Volts	Meter selection
CAI	Channel A Amps	Meter selection
CBI	Channel B Amps	Meter selection
HFS	High frequency scale	
LFS	Low frequency scale	
DFR	Display Frequency	Front panel display selection
DTS	Display time (seconds)	Front panel display selection
DTH	Display time (Hertz)	Front panel display selection
DPH	Display phase	Front panel display selection
DKW	Display power (kilowatts)	Front panel display selection
DKX	Display power (kVar)	Front panel display selection
DVA	Display power (kVA)	Front panel display selection
DPF	Display power factor	Front panel display selection
AUX	Toggle auxiliary port on/off	
A###	Send code ### to auxiliary port	

5.4.2 Output related commands

Mnemonic	Meaning	Remarks
LFT	Line feed toggle	Toggle auto line feed ON/OFF
REP	Report	Print report of readings
PGM	Program mode	Set Program mode
TRM	Terminal mode	Set Terminal mode
TTL	Title	Print title line of table
TBL	Table report	Print report of readings in tabular form
+rr	add reading	Add a reading to the table (eg. +KW)
-rr	delete reading	Delete a reading from the table (eg. -PF)
DLS	delimiter space	Set delimiter to a space
DLC	delimiter comma	Set delimiter to a comma
Prr	Print reading	Print only one specified reading (eg. PFR)
STA	Status	Print trigger status
PSP	Print stop trigger	Print "Stop" when STOP mode entered
HLP	Help	Print out a summary list of available commands
SER	Suppress error	Suppress printing of error messages
CW0	CR wait off	Turn carriage return wait off
CW1	CR wait on	Turn carriage return wait on

5.5 DEFAULT PARAMETERS

Due to the many operating modes and variables which are maintained by the meter, an external computer may need to know the initial state of the meter after power-up. This is especially true when the meter is used in applications requiring little or no human intervention. Therefore, the following list of default parameters have been provided. This list gives the value of various parameters which the meter assumes after power-up (software version 13.0 & up).

Control mode:	Local
Trigger status:	Ready
MP-10 display:	Time in seconds
Channel A:	as per front panel switch
Channel B:	as per front panel switch
Frequency scale:	as per rear panel switch
Terminal mode:	On
Auto line feed:	On (line feed sent after each CR)
Carriage return wait:	On
Error message output:	On
Baud rate:	9600
Tabular output:	All 10 readings output
Tabular output delimiter:	space
Auxiliary port:	off
Auxiliary port data:	0

Note when the special serial printer mode is selected, (via the rear panel DIP switch #3) the auto line feed parameter default is off. In addition, extra long delays are placed after every character and carriage return to accommodate slow printers.

SECTION 6
MTS-1010 OPTIONS

6.1 OPTION -03 IMPEDANCE MEASUREMENT

With this option, the three new parameters measured, designated Z1, Z2 and Z3, are calculated based on the following formulae:

$Z1 = V/I$	(ohms)
$Z2 = V/2I$	(ohms)
$Z3 = V/\sqrt{3}\,I$	(ohms)

Where V is the voltage reading, and I is the current reading.

Calculation of these quantities, is enabled as soon as one of the meter's channels is measuring voltage and the other current.

6.1.1 Reading Accuracy

The accuracy of the Z1, Z2, and Z3 measurements depend almost entirely on the accuracy of the voltage and current meaurements. Therefore, a maximum of 4 digit precision can be obtained. The accuracy of the calculation is 50% of the least signifigant digit. The accuracy of the channel A and B readings must be added to this to obtain the actual reading accuracy.

6.1.2 Front Panel Display

The standard display of secondary KX, KVA and P.F. quantities are substituted with Z1, Z2, and Z3 respectively. The top LED display annunciators will read V/I, V/2I, or $V/\sqrt{3}I$ when impedance quantities are selected. The KX, KVA, and P.F. readings will no longer be displayable via front panel selection. However, they may be displayed without annunciation of units on the upper LED display by using the DKX, DVA, and DPF commands, via the RS-232C interface.

Division by zero conditions (current = 0.0A) will be reported to the display by a series os dashes, '----'. Values greater than 9999 ohms will also be reported the same way. The actual reading can be obtained from the RS-232C interface. Values less then 1.000 ohm will show less than 4 significant digits on the LED display. However, all 4 significant digits can be obtained from the RS-232C interface. Values less than 0.001 ohms will be displayed as 0.0.

6.1.3 New RS-232C Commands

The following new RS-232C commands are an extension of the standard command set. Operation of these commands are the same as the other Drr, Prr, +rr, and -rr commands, and should be self-explanatory from an understanding of the standard set.

Mnemonic	Meaning
DZ1	Display Z1 on upper LED display
DZ2	Display Z2 on upper LED display
DZ3	Display Z3 on upper LED display
PZ1	Print value of Z1
PZ2	Print value of Z2
PZ3	Print value of Z3
+Z1	Add Z1 to tabular output
+Z2	Add Z2 to tabular output
+Z3	Add Z3 to tabular output
-Z1	Remove Z1 from tabular output
-Z2	Remove Z2 from tabular output
-Z3	Remove Z3 from tabular output

Note that division by zero errors (current = 0.0A) will be output as -9999 ohms when using these commands. This allows application programs which require numerical input, to detect this error condition.

6.1.4 Tabular Output

After power-up the meter will default to printout the following readings in tabular output:

Freq.	(Hz)
Time	(sec.)
Time	(Hz)
Phase	(deg.)
Power	(kW)
V/I	(ohms)
V/2I	(ohms)
V/1.73I	(ohms)
Chan. A	(Volts) or (Amps)
Chan. B	(Volts) or (Amps)

The KX, VA and P.F. readings can be added to the table by using the standard +KX, +VA and +PF commands.

6.2 MTS-1010 OPTION -04: 12VDC OPERATION/BATTERY PACK

6.2.1 Description

The battery pack option allows the meter to be used in portable applications, where AC power is not readily available. When fully charged, the pack gives approximately 7.5 hours of continuous operation, or longer when used intermittently. The battery supply cord is terminated in a standard cigarette lighter-style plug, allowing operation from the 12V system of most vehicles.

6.2.2 Option Contents

The 12V battery pack option includes the following:

Modified MTS-1010 meter, with special power supply and 12V input jack

- 1 12-volt supply/adapter cable.
- 1 Battery pack with snap on case.
- 1 Wall mount 12V charger

6.2.3 Instructions for Use

When using the battery pack for the first time, charge it for a few hours before use.

Snap the battery pack on the top of the meter, and plug it in via the supplied adapter cable. The adapter cord is plugged in to the female socket of the battery pack and to the input jack mounted on the plate of the IEEE-488 slot on the rear panel of the meter.

Whenever the battery pack is connected and AC power is also supplied to the MP-10, the batteries will also be recharged. More rapid recharging is available from the wall mount charger, however and this is the preferred recharge method.

CAUTION: Fully discharging the batteries will end their service life.

6.2.4 Functional Differences

Full rated accuracy of the meter is available when running on battery power. For units shipped before 1993, there is one significant functional difference however, in the trigger circuits. With AC power, each trigger circuit has it's own fully isolated power supply. On battery power the START and STOP trigger circuit power supply lines are paralleled and supplied directly from the battery, so are no longer floating with respect to each other. If DC voltage signals are required to be used for triggering, the black trigger input terminals should be jumpered together. This will help ensure signals of the same polarity will be applied to the inputs.

6.3 MTS-1010 OPTION -07: DIGISWITCH - 3Φ VOLTAGE SELECTOR

6.3.1 Introduction

The Digiswitch, Three Phase Voltage Selector, provides the following advantages:

- Extends the MTS-1010 Powermeter's measurement capabilities to 3-Φ voltage measurement.
- Computer controllable voltage selection, to allow automation of tests such as crossed wattmeter readings.
- Eliminates tedious and hazardous wire swapping for polyphase voltage measurements.

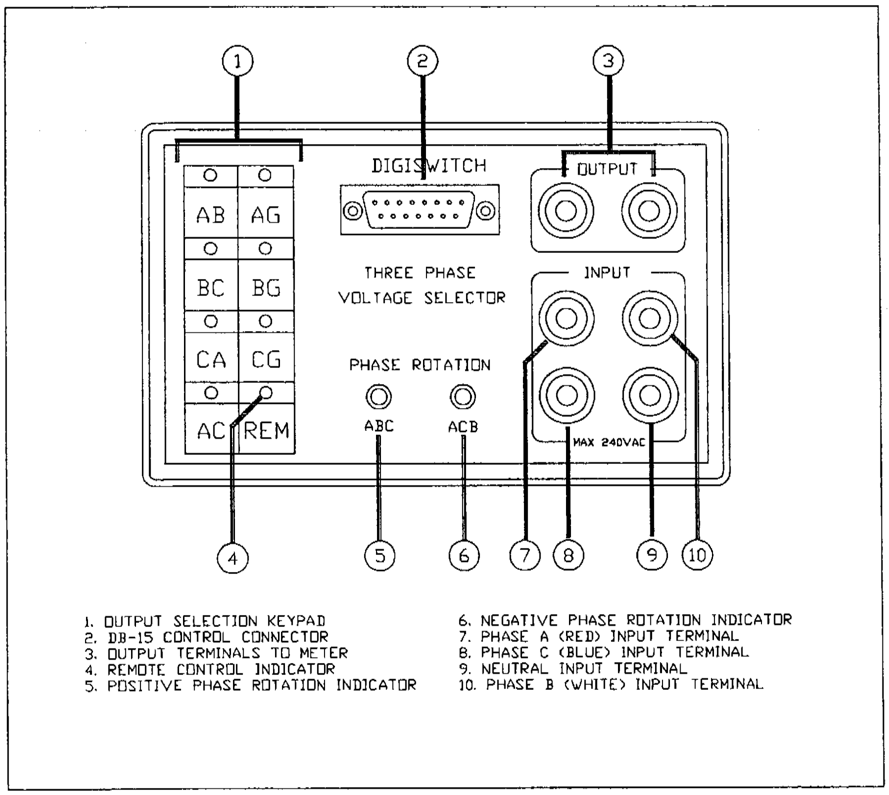

Figure 6-1

6.3.2 Specifications

Power supply:	+5V supply via DB-15 control connector 300 mA maximum supply current
Inputs:	240 VAC phase-to-phase maximum Voltage inputs are fuse protected and current limited via resistors.
Voltage selections:	7 manually or remotely selectable outputs AB, BC, CA, AC, AN, BN, CN

Indicators: LED indicators for all voltage selections
LED indicators for ABC (positive) phase rotation and ACB (negative) phase rotation.
REM indicator for remote control.

Options: Accessory pack containing four colour-coded fused voltage leads and carry case.

CAUTION: This voltage selector is intended to switch voltage to high impedance meter inputs (greater than 2 Mohms). It is NOT intended to switch voltage to a low impedance load such as a relay.

Use of fused leads such as available in the accessory pack is highly recommended for the safety of the user. Always connect the input leads to the Digiswitch before connecting to a voltage source, and remove from the source before removing from the Digiswitch.

6.3.3 Operation

6.3.3.1 BASIC MANUAL OPERATION.

1. Connect the control/power supply input to the MTS-1010 Powermeter's 'AUX I/O port' via the supplied DB-15 connector cable.

2. Connect the three-phase voltage to be measured to the 4 input terminals on the Digiswitch. The Red, White, Blue and Yellow-green terminals are phases A, B, C, and Neutral respectively.

3. Connect the meter voltage inputs to the Digiswitch output terminals.

4. Select the desired voltage to be measured on the Digiswitch keypad. The selected voltage is switched to the meter with the correct polarity, provided that the inputs and outputs have been wired correctly.

6.3.3.2 PHASE ROTATION INDICATORS. These LEDs indicate ABC (positive) phase rotation or ACB negative phase rotation. Approximately 60V AC phase-to-neutral must be present on the inputs before they are activated.

6.3.4 Remote Control

6.3.4.1 INTRODUCTION. Remote computer control of the 3- voltage selector is accessible via the DB-15 connector on the Digiswitch. This connector is intended to interface directly to the MTS-1010 Powermeter's 'AUX I/O' port.

Note: A standard male - female cable is used (ie. pin 1-male connected to pin 1-female, pin 2-male connected to pin 2-female, etc.).

The simple readable commands that control this port can be generated by an automatic test program. Applications of this include automation of crossed wattmeter or 3- phase angle measurements.

6.3.4.2 TAKING REMOTE CONTROL. The Digiswitch is operated in remote control via the A### and AUX commands on the MTS-1010 Powermeter. To place the Digiswitch under remote control, the following command sequence should be sent to the meter from a computer or terminal:

A135
AUX

This is a sample execution of this sequence as seen via the remote computer:

Ready >A135
Ready >AUX
Auxiliary port on
Ready >

The A135 command deselects all voltages and sets the remote line high. This code is stored internally by the meter and is not presented to the voltage selector until the AUX command is sent. Actually, any code between 128 and 135 may be used for the first command, however 135 will select no output to appear initially on the voltage selector outputs.

A command between A128 and A135 should be sent before issuing the AUX command to properly initialize the port.

6.3.4.3 VOLTAGE SELECTION. After taking remote control, the REM light on the module should be on, and the pushbutton control should be disabled. To select individual voltages, the following commands should be sent to the MTS-1010 Powermeter:

COMMAND	SELECTION
A128	AB voltage
A129	BC voltage
A130	CA voltage
A131	AC voltage
A132	AN voltage
A133	BN voltage
A134	CN voltage
A135	none

6.3.4.4 RESTORING MANUAL CONTROL. Manual keypad control of the module may be restored by issuing the AUX command again, toggling to auxiliary port output off. This is a sample execution of this function:

Ready >AUX Auxiliary port off
Ready >

Manual control should now be restored.

6.3.5 Connector Pinout

For those wishing to operate the Digiswitch independent of the MTS-1010 Powermeter, the following pinout chart for the control connector is supplied. The Digiswitch must be supplied with a +5VDC, 300mA power supply.

DB-15 pin#	Function
1	NC
2	NC
3	NC
4	+5V supply
5	Control bit 3
6	Control bit 2
7	*REM (pull to GND for remote mode) (this pin wired as control bit 7)
8	Control bit 0
9	NC
10	NC
11	GND
12	NC
13	NC
14	NC
15	Control bit 1

6.4 MTS-1010 OPTION -09: RATIO A/B MEASUREMENT OPTION

6.4.1 Operation

The second press of the [TIME SEC.] button will select the ratio A/B measurement. This replaces the kVAR reading on standard meters. The kVAR reading can still be interrogated or displayed by using the PKX or DKX commands of the RS-232C interface.

By selecting the appropriate V/I quantities on channels A and B, four different quantities can be measured, as shown below.

Channel A Selection	Channel B Selection	A/B Quantity	Units
Volts	Amps	Impedance	ohms
Amps	Volts	Admittance	mhos
Volts	Volts	Voltage ratio	-
Amps	Amps	Current ratio	-

The V/V and I/I measurements are useful for measuring transformer turns ratio and gain.

6.4.2 Specifications

Resolution:	Full 4 digit resolution, autoranging
Range:	0.0 to 9999 Overflow values are displayed as '----', but actual values may be read via the RS-232C interface.
Accuracy:	(1% + 0.2% of channel A scale + 0.2% of channel B scale)
Speed:	3 readings/sec, 30 readings/sec in START state

6.4.3 New RS-232C Commands

The following new RS-232C commands are available with this option:

DRA - Display ratio
- displays ratio A/B on upper LED display

PRA - Print ratio
- Print the current value of ratio A/B

These commands are extensions of the Prr and Drr commands detailed in sections 5.3.1 and 5.3.3 of the manual.

6.5 MTS-1010 OPTION-10: FREQUENCY DIFFERENCE MEASUREMENT OPTION

6.5.1 Operation

To display frequency difference (fA-fB), press and hold the [FREQ] button for 3 seconds. The display will flip to fA-fB and the HZ annunciator will flash to indicate this mode. To return to channel A frequency display, repeat the above, while frequency difference is displayed.

The fA-fB display will display both positive and negative differences in frequency between the channel A & B inputs, with up to 0.001 Hz resolution. This is useful for synchrocheck relay testing applications.

6.5.2 Specifications

Resolution:	up to 0.001 Hz, depending on sign and magnitude
Range:	-500 to +500 Hz (high frequency scale) -100 to +100 Hz (low frequency scale)
Accuracy	±0.01 Hz
Speed:	Measurement speed is dependent on A & B input frequencies For 60 Hz inputs: 1.5 readings/second or 3.75 readings/sec in START state

6.5.3 New RS-232C Commands

The following new RS-232C commands are available with this option:

DFD	- display frequency difference - selects fA-fB for display on the upper LED display
PFD	- print frequency difference - prints the current value of fA-fB
+FD	- add frequency difference to tabular output
-FD	- remove frequency difference from tabular output

These commands are extensions of the Drr, Prr, +rr, and -rr commands detailed in section 5.3 of the manual.

6.5.4 Affects on Reading Speed

Frequency and phase measurement speeds may be up to 50% slower than the normal rate with the fA-fB measurement active. Triggering the meter into the START state will increase the reading speed, as on regular meters.

If still higher speeds are required, disable the fA-fB measurement by holding in the [FREQ] button while turning on the [ON/OFF] switch. This disables the option, and allows for full frequency and phase measurement speed, as on standard meters.

6.6 MTS-1010 OPTION -11: PROPORTIONAL ANALOG OUTPUT OPTION

6.6.1 Introduction

This option provides up to two low level analog outputs proportional to any measured or computed quantity (eg. voltage, current, frequency, phase, power). This is useful for an external recording or monitoring device.

6.6.2 Specifications

Output resolution:	12 bits
Output range:	0 - 10V (unipolar output) or 0 - ±10V bipolar output
Accuracy:	Limited by measurement accuracy, see section 2 of this manual
Output impedance:	200 ohm typical, outputs are short circuit protected

6.6.3 Typical Customer Specific Data

Customer: XXX

The analog outputs are connected to the AUX I/O connector on the rear panel.

AUX I/O Connector Pin#	Signal
1	Proportional 0-6V: ±180 deg phase output
9	Ground
2	Proportional 0-6V: ±0.25 HZ output
10	Ground

Contact Powertec Industries for your specific requirements.

6.7 MTS-1010 OPTION -14: SYNCHROCHECK OPTION

6.7.1 Introduction

The synchrocheck option provides an extra high speed phase measurement mode for checking phase angle when testing synchrocheck and synchronizing relays. The maximum reading speed obtainable is one reading per cycle, for 20 - 65 Hz inputs.

It is recommended that OPTION -10 (Frequency difference measurement) also be used in conjunction with this option, as a perfect combination for testing synchrocheck and synchronizing relays.

6.7.2 Operation

6.7.2.1 ENABLING/DISABLING THE SYNCHROCHECK OPTION.

1. To enable the high speed phase measurement:

   (a) Turn off the MTS-1010.

   (b) Turn on (close) DIP switch #4 on the rear panel of the MTS-1010.

   (c) Turn on the MTS-1010.

   (d) Press the [PHASE] pushbutton to display phase.

   (e) Apply an external start trigger to put the MTS-1010 into high speed phase measurement mode.

2. To disable the high speed phase measurement:

   (a) Turn off the MTS-1010.

   (b) Turn off (open) DIP switch #4 on the rear panel of the MTS-1010.

   (c) Turn on the MTS-1010. Phase measurement speeds will now be returned to normal as on standard meters (For 60Hz inputs: 2 rdgs/sec in "Ready" mode, 7.5 rdgs/sec in "Triggered" mode)

6.7.2.2 PHASE MEASUREMENT IN "READY" MODE. When neither the START or STOP triggers have been activated, the MTS-1010 is in the "Ready" mode or state. In this mode, the phase measurement speed is normal (For 60Hz inputs: 2 rdgs/sec).

6.7.2.3 FROZEN MEASUREMENT ON STOP TRIGGER. When an external STOP trigger is sensed, the phase reading is frozen at the value measured in the last complete cycle.

6.7.2.4 DUAL MODE PHASE DISPLAY. The 180 mode phase display can be enabled/disabled by pressing and holding the [PHASE] button for 3 seconds, when phase is being displayed. This is a standard MTS-1010 feature.

6.7.3 Specifications

The following specifications apply to the phase angle measurement when the synchrocheck option is enabled (DIP switch #4 on) and the MTS-1010 is in the "Triggered" state (START LED on).

Recommended maximum frequency difference (Δf):	0.5 Hz (Δf= freq. difference between channel A & B inputs)

Nominal input frequency (f) : 25 - 65 Hz
Nominal measurement speed: 1 reading per cycle

The measurement error is a combination of a fixed absolute error, and an aperture error. The aperture error is caused by the frequency difference between the channel A & B inputs. This error is larger for MTS-1010's which have the frequency difference measurement active. To improve the accuracy, disable the frequency difference measurement by holding in the [FREQ] pushbutton while turning on the MTS-1010.

1. For MTS-1010 with frequency difference measurement enabled & installed:

   Aperture error = $\pm(1080 \times \Delta f) / f$ degrees

   Total error = $\pm(1080 \times \Delta f) / f \pm 0.7$ degrees

f [HZ]	Δf [HZ]	Error [degrees]
60.0	0.05	±1.6
60.0	0.10	±2.5
60.0	0.25	±5.2
60.0	0.50	±9.7

2. For MTS-1010 with frequency difference measurement disabled or MTS-1010 without frequency difference measurement option:

   Aperture error = $\pm(360 \times \Delta f) / f$ degrees

   Total error = $\pm(360 \times \Delta f) / f \pm 0.7$ degrees

f [HZ]	Δf [HZ]	Error [degrees]
60.0	0.05	±1.0
60.0	0.10	±1.3
60.0	0.25	±2.2
60.0	0.50	±3.7

6.7.4 Use with the RS-232C PPH Command

The PPH command is used to interrogate the phase angle measurement via the RS-232C interface. This command will always return the value that would be displayed in the upper LED display. When the extra high speed measurement mode is active the PPH command returns the high speed measured value. In the STOP state, the frozen value is returned. In the READY state, the averaged value is returned.

6.7.5 Compatibility with Other Options

The synchrocheck option is fully compatible with other MTS-1010 options, such as frequency difference measurement (Option -10) and analog outputs (Option -11) and ratio A/B measurement (Option -09). All of these options can be installed with minimal effect on performance.

6.8 MTS-1010 OPTION -15: WATTHOUR MEASUREMENT OPTION

6.8.1 Description

This option replaces the kVA reading on standard meters with a computed watthour measurement. The kVA reading can still be interrogated or displayed by using the PVA or DVA commands of the RS-232C interface.

6.8.2 Operation

6.8.2.1 MEASURING WATTHOURS.

- Select Channel A voltage and Channel B current or vice versa. The second press of the [TIME HZ.] button will select the watthour measurement on the upper display. If the display is blank, this indicates that proper selections have not been made on channels A and B.
- Provide a start trigger to begin the integrating watthour measurement.
- At the end of the measurement period, provide a stop trigger to stop the watthour measurement. The frozen watthour value is the measured energy between the start and stop triggers.

6.8.2.2 LIMITATIONS.

- The measurement accuracy is limited by the 0.5% accuracy of current and voltage measurements and the 0.5 degree accuracy of phase measurements. A best accuracy of 1.5% can be expected. The watthour measurement is a computed value based on the current, voltage and phase angle measurements, using 36ms integration steps.
- The range of displayable values is +9999 Wh to -999 Wh, with a best resolution of 0.001 Wh. Overflow is indicated by "----" on the display.
- If during the watthour measurement, the channel A or B I/V selector switches are changed, this disturbs the watthour measurement, and will invalidate the reading. When this occurs, the watthour display will be blanked until the MTS-1010 is reset back to the READY state.

6.8.3 RS-232 Control

The following new RS-232 commands are available for use with this option.

PWH	The PWH command prints the present watthour value.
DWH	The DWH command selects watthours to be displayed on the upper display.

6.9 MTS-1010 OPTION-16: THREE-PHASE CURRENT MEASUREMENT OPTION

6.9.1 Description

This option has a converted channel B which allows measurement of both the channel B current and a third channel of current (Channel C) on the channel B display. This allows 3 phases of current to be connected to the MTS-1010 at once. Similar to channel A on the MTS-1010, only one quantity at a time is measured and displayed on channel B. Remote control and interrogation of all 3 current channels is provided.

6.9.2 Operation

6.9.2.1 MEASURING CHANNEL B CURRENT.

- Connect the current to be measured to the [CHANNEL B CURRENT] input.
- Select IB on the [CHANNEL B I/V SWITCH] (left position). The channel B current will be displayed on the channel B display. "CHAN. B AMPERES" will be displayed in the "annunciator window"

6.9.2.2 MEASURING CHANNEL C CURRENT.

- Connect the current to be measured to the channel C current input on the rear panel.
- Select IC on the [CHANNEL B I/V SWITCH] (center position). The channel C current will be displayed on the channel B display. "CHAN. C AMPERES" will be displayed in the "annunciator window"

6.9.2.3 PHASE AND ANGLE POWER MEASUREMENTS. Note that whatever quantity is measured/displayed on channel B (IB, IC or Volts B) is the reference signal for the phase measurement, and is used for power measurements.

6.9.3 RS-232 Control

The following RS-232 commands control the channel B selection. These commands can only be executed in remote mode. The only new command added with this option is CBC.

CBC	The CBC command selects IC to be measured/displayed on channel B.
CBI	The CBI command selects IB to be measured/displayed on channel B.
CBV	The CBV command selects voltage measurement on channel B.

Example: Interrogate all current readings, selecting appropriate channels

Ready >CAI	<- select channel A current
Ready >CBI	<- select channel B current
Ready >PCA	<- print channel A current
4.97A	
Ready >PCB	<- print channel B current
12.92A	
Ready >CB	<- select channel C current on B display
Ready >PCB	<- print channel C current
3.07A	(ie. the value on the channel B display)
Ready >	

6.10 MTS-1010 OPTION -17: SIGNAL PROCESSING

6.10.1 Description

This option adds 3 capabilities to the standard MTS-1010 meter.

1. Low pass filter for Channel A, inserts 5th order LP filter in signal path to attenuate signals above 60 Hz at 30 db/octave. Eliminates all higher order harmonics from signal.

2. Average response for AC measurements on Channel A. Offers alternative to True RMS response, for such tests as second harmonic restraint and current transformer excitation.

3. Peak responding measurement for Channels A and B. Captures and holds positive or negative peak signal with 1 millisecond response time. Displayed reading can be calibrated for either peak value or RMS equivalent of peak value. Extremely fast response useful for transient tests such as inrush measurement.

Note: This option is incompatible with meters fitted with any of the following options;

-06 IEEE-488 interface
-15 Kwhr measurement
-16 Three phase current measurement

6.10.2 Operation

6.10.2.1 LOW PASS FILTER. To engage this feature, select the FLTR switch of the rear panel DIP switches to On. This will illuminate the FLTR annunciator in Channel A display, and place the steep cutoff filter directly in the current/voltage amplitude measurement path of Channel A. Channel B continues to perform unfiltered measurements, so it is possible to observe the effects of the filtering action by supplying the same signal to both channels. Because the filter is by design very frequency sensitive, it is recommended that the feature only be selected when this characteristic is desired, and the filter be switched off for normal measurements.

6.10.2.2 AVERAGE RESPONSE. To engage this feature, select the AVG switch of the rear panel DIP switches to on. This will illuminate the AVG ChA annunciator in Channel B display, and place an average responding rather than True RMS responding circuit directly in the current/voltage amplitude measurement path of Channel A. Channel B continues to perform TRMS measurements, allowing a signal to be simultaneously measured both ways. It is recommended that the default TRMS measurement be left selected on Channel A except when Average response is specifically required. TRMS response provides more accurate measurement of the energy content of distorted signals.

6.10.2.3 PEAK RESPONSE. To engage this feature, select the PEAK switch of the rear panel DIP switches to On. This will illuminate the PEAK annunciator in Channel B display, and place a peak responding circuit directly in the current/voltage amplitude measurement path of both Channels A and B. This feature has an extremely fast response time, on the order of 1 millisecond, to allow the capture of very fast transient signals such as inrush currents. The reading will capture and hold the highest value of such transients. By default it is calibrated to display a reading equal to the RMS value of a sine wave, assuming that the captured value is the peak value of that sine wave. If desired, it can be recalibrated to display the actual peak value.

To ensure that very brief signals are captured correctly, it is necessary to ensure the meter is selected to the correct range. This is done simply by applying a signal of the expected magnitude to the meter with autoranging selected to On, which will automatically select the correct range, and then selecting autoranging to Off, which will lock it in that range, <u>before</u> the signal is removed. See section 4.1.9 Reset/Range Switch for further details of autoranging.

Once a signal has been captured, the operator should make note of the reading as soon as possible. The reading slowly decreases over a period of several minutes. Once it has been recorded, the reading can be reset by operating the Reset switch.

Because of the high input impedance of the voltage measurement circuits and the rapid response time of the peak reading feature, transient voltage measurements may show some variation between tests due to switching noise. If this occurs, average several readings. Current measurements because of their lower impedance, are less likely to be affected this way.

Peak measurement should only be engaged when specifically required. It could cause operator confusion when trying to measure varying signals.

SECTION 7
IEEE-488 INTERFACE

7.1 INTRODUCTION

The MTS-1010 Powermeter has an optional IEEE-488 interface which complies with the IEEE-488 1978 Interface standard. The IEEE-488 (GPIB) interface for the MTS-1010 allows control of the MTS-1010 from a suitable controller. The MTS-1010 can be controlled, and interrogated for readings using the same command set as for the RS-232C interface.

This addendum will only cover IEEE-488 details as they apply to the MTS-1010 Powermeter. For complete information on IEEE-488, we suggest that you refer to one or more of the following:

1. **488.1-1987** IEEE Standard Digital Interface for Programmable Instrumentation (ANSI), available from the IEEE.

2. Tutorial Description of the Hewlett-Packard Interface Bus, available from the Hewlett-Packard Company.

3. TMS9914A GPIB Controller User's Guide. Publication No. SPPU013, available from Texas Instruments Incorporated.

7.2 IEEE-488 CONNECTOR PINOUT

Connection to the GPIB is made using the IEEE-488 connector on the rear panel.

Pin connections

Pin #	Signal	Pin #	Signal
1	DIO1	13	DIO5
2	DIO2	14	DIO6
3	DIO3	15	DIO7
4	DIO4	16	DIO8
5	EOI	17	REN
6	DAV	18	0V(GND)
7	NRFD	19	0V(GND)
8	NDAC	20	0V(GND)
9	IFC	21	0V(GND)
10	SRQ	22	0V(GND)
11	ATN	23	0V(GND)
12	Shield (0V)	24	0V(GND)

7.3 IEEE-488 Address DIP Switch

The IEEE-488 address must be set on the rear panel DIP switch of the MTS-1010 prior to turning the instrument on. The bit assignments for the address are shown in the following diagram:

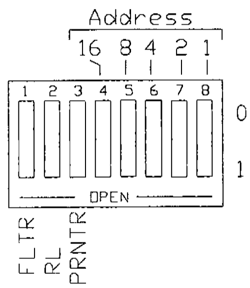

Figure 7-1

7.4 IEEE-488 SUB-SET IMPLEMENTATION

The following sub-sets of the IEEE-488 Standard are implemented by the MTS-1010 Powermeter.

SH1	Source Handshake
AH1	Acceptor Handshake
T6	Basic Talker, serial poll, unaddresses if MLA
TE0	Extended Talker, no capability
L4	Basic Listener, unaddressed if MTA
LE0	Extended Listener, no capability
SR1	Service Request
RL1	Remote/Local
DC1	Device Clear
PP0	Parallel Poll, no capability
DT0	Device Trigger, no capability
E2	Tristate drivers
C0	Not a controller

7.5 INTERFACE COMMANDS AND MTS-1010 SPECIFIC COMMANDS

Use of the IEEE-488 interface for the MTS-1010 involves both interface commands (commands used to manage the interface) and MTS-1010 specific commands (commands understood only by the MTS-1010, for purposes of controlling it).

7.5.1 Interface Commands

Interface commands are sent by the controller to manage the interface. The following table shows the interface commands which are applicable to controlling the MTS-1010.

Summary of IEEE-488 Interface Commands			
Mnemonic	Type*	Command	Description
ATN	U	Attention	Indicates interface message.
DCL	M	Device Clear	Set all device to initial state.
END	U	End	Indecate end of message.
GTL	A	Go to local	Resume front panel operation/control.
IFC	U	Interface Clear	Terminate all bus activity. Reset the interface.
MLA	L	My Listen Address	Indicate next listener. Returns talk to idle.
MTA	L	My Talk Address	Indicate next talker. Returns listener to idle.
REN	U	Remote Enable	Enable control of devices via the bus.
SDC	A	Selected Device Clear	Resets selected instrument to initial state.
SPD	M	Serial Poll Disable	Disables a serial poll.
SPE	M	Serial Poll Enable	Enables a serial poll.
SQR	U	Service Request	Informs controller of a request for service.
UNL	M	Unlisten	All devices stop receiving data
UNT	M	Untale	Current talker stops sending data.

*Type:
U: Uni-line command. Asserts a single bus management line
L: Local command refers to controller only
M: Multi-line command
A: Addressed command

7.5.2 MTS-1010 Specific Commands

The MTS-1010 specific commands are used to control or interrogate the MTS-1010. These are the same commands as used by the RS-232 interface (described in section 5), plus some additional commands as described in section 7.6.9.

7.6 MTS-1010 IEEE-488 PROGRAMMING

This section provides specific information on programming the MTS-1010 via the IEEE-488 interface.

7.6.1 Annunciators

Three annunciators on the MTS-1010 indicate its IEEE-488 addressed status. When the MTS-1010 is under IEEE-488 remote control (REN asserted), the "REMOTE" annunciator in the channel A display will be activated. When the MTS-1010 is addressed to listen, the "LISTEN" annunciator in the channel B display will be activated. When the MTS-1010 is addressed to talk, the "TALK" annunciator in the channel B display will be activated.

7.6.2 Sending Commands to the MTS-1010

The same command set as used for the RS-232C interface is used by the IEEE-488 interface. Commands should be terminated by a carriage return (ASCII 13) character, or an END signal. Terminating a command with both a CR and END is also acceptable. An END signal is given by asserting the EOI (End or Identify) command line in conjunction with the last byte in the message.

7.6.3 Receiving Data from the MTS-1010

The MTS-1010 sends data in ASCII format, (identical to the RS-232C interface). Each reply line is terminated by a CR (ASCII 13) plus an optional LF character (ASCII 10). Each reply message can also be terminated by a programmable sequence (via the ODL# command). Whenever a new command is sent to the MTS-1010, any unread output that a previous command may have generated will be discarded.

MTS-1010 commands which reply with multiple lines of data, such as REP or HLP, are also available using the IEEE-488 interface. Each line is terminated by an CR plus an optional LF character. The entire message may be terminated by any combination of an ETX character and an END command (as specified by the ODL# command).

7.6.4 Examples

Example 1: The following example initializes the interface, puts the MTS-1010 into remote control mode, selects desired channels and displays on the MTS-1010, and interrogates several readings.

Note: This example assumes that the controller has a device address of 21, and the MTS-1010 has a device address of 15.

<CR> indicates a carriage return (ASCII 13) character.

(END) indicated the IEEE-488 bus END signal.

The IEEE-488 commands and MTS-1010 commands are sent by the controller.

IEEE-488 Command	MTS-1010 Command	MTS-1010 Response	Comment
IFC			Clear the interface
REN			Enable remote control
UNT			Turn off all talkers
UNL			Turn off all listeners
MTA 21			Setup controller as talker
MLA 15			Setup MTS-1010 as listener
	LF0<CR>		Turn auto linefeed off
	CAV<CR>		Select channel A voltage
	CBI<CR>		Select channel B current
	DPH<CR>		Select phase display
	PGM<CR>		Print values without units
	PPH<CR>		Print phase
MLA 21			Setup controller as listener
MTA 15			Setup MTS-1010 as talker
		102.5<CR>	Phase reading from MTS-1010
MTA 21			Setup controller as talker
MLA 15			Setup MTS-1010 as listener
	ODL2<CR>		Configure MTS-1010 to send (END) signal after message
	PCA<CR>		Print channel A reading
MLA 21			Setup controller as listener
MTA 15			Setup MTS-1010 as talker
		68.4<CR>(END)	Channel A reading
UNT			Turn off all talkers
UNL			Turn off all listeners

Example 2: The following example initializes the interface, puts the MTS-1010 into remote control mode, and interrogates the MTS-1010 twice for all readings except the time in Hz and kVAR readings.

IEEE-488 Command	MTS-1010 Command	MTS-1010 Response	Comment
IFC			Clear the interface
REN			Enable remote control
UNT			Turn off all talkers
UNL			Turn off all listeners
MTA 21			Setup controller as talker
MLA 15			Setup MTS-1010 as listener
	LF0<CR>		Turn auto linefeed off
	-TH<CR>		Omit time in Hz reading from table
	-KX<CR>		Omit kVar reading
	DLC<CR>		Put commas between tabular values
	TTL<CR>		Print table title lines
MLA 21			Setup controller as listener
MTA 15			Setup MTS-1010 as talker
		Freq. Time Phase Power App.Pwr Power Chan. A Chan. B<CR> [Hz] [sec] [deg] [kW] [kVA] Factor [Volts] [Volts]<CR><CR>	
MTA 21			Setup controller as talker
MLA 15			Setup MTS-1010 as listener
	TBL<CR>		Print tabular readings

MLA 21		Setup controller as listener
MTA 15		Setup MTS-1010 as talker
	60.00, 5.677, 120.0, 0.0, 0.0, -.500, 70.0, 82.3<CR>	
MTA 21		Setup controller as talker
MLA 15		Setup MTS-1010 as listener
	TBL<CR>	Print tabular readings
MLA 21		Setup controller as listener
MTA 15		Setup MTS-1010 as talker
	60.00, 7.023, 120.1, 0.0, 0.0, -.5015, 69.9, 82.3<CR>	
UNT		Turn off all talkers
UNL		Turn off all listeners

7.6.5 Service Request

A service request can be generated by the MTS-1010 under three conditions (the occurrence of a start trigger, stop trigger or an error). The MTS-1010 can be configured to cause a service request under one or more of these events using the SRQ# command. When an SRQ has been sent, the controller can request the status of the MTS-1010 using a serial poll.

7.6.6 Serial Polling

All devices capable of generating an SRQ contain a status register which holds information on the current status of the device. The device status register is read by the controller during a serial poll to determine which device is requesting service, and the type of service required. The status register on the 7150 contains eight bits and is used as the serial poll byte. The contents of the register is shown below:

8	7	6	5	4	3	2	1	<- DIO lines
7	6	5	4	3	2	1	0	<- Register bits
0								

Bit 7:	Always zero
Bit 6:	1 = MTS-1010 requesting service
	0 = MTS-1010 not requesting service
Bit 5:	1 = MTS-1010 in remote control
	0 = MTS-1010 in local control
Bit 4:	0 = Channel B voltage selected
	1 = Channel B current selected
Bit 3:	0 = Channel A voltage selected
	1 = Channel A current selected
Bit 2:	0 = No error
	1 = An error has occurred
Bits1,0	0,0 = Trigger status = Ready
	0,1 = Trigger status = Stop
	1,0 = Trigger status = Triggered

7.6.7 Device Clear Function

The IEEE-488 device clear command (DCL) will set the MTS-1010 status as follows:

Channel A set to voltage
Channel B set to voltage
Trigger status set to ready (timer reset)
Auxiliary port state set to off
Auxiliary port data = 0
Frequency scale set to low
Table data delimiter = space
Disable service request (SRQ) functions
Output delimiter set to CR only
Auto linefeed after CR enabled

The MTS-1010 also supports the selected device clear command (SDC).

7.6.8 Modified Operation of RS-232 Commands

The use of the following commands from the IEEE-488 interface differ from the RS-232 interface.

Command	Description
REM	Remote Control This command cannot be used on the IEEE-488 interface. Use the IEEE-488 REN command instead.
LOC	Local Control This command cannot be used on the IEEE-488 interface. Use the IEEE-488 GTL command instead.
TRM	Terminal Mode Enable printing units after Prr (print reading) commands. For example, PCA will return "120.1V" instead of just "120.1" if terminal mode is set on. Note that the other features of the MTS-1010 "Terminal mode" is not applicable to the IEEE-488 interface. The MTS-1010 will not echo characters sent by the controller, nor will it send a "Ready" prompt.
PGM	Program Mode Disable printing of units after Prr (print reading) commands.

7.6.9 New Commands

In order to simplify programming via the IEEE-488 interface, the following new commands have been added. Note that these commands can also be sent via the RS-232 interface. Note that SRQ# and ODL# commands are specifically for the IEEE-488 option.

Command	Description
SRQ#	Service request configuration This command configures the MTS-1010 to generate a service request when a certain condition(s) occurs. The MTS-1010 can be configured to generate a service request on a start trigger, stop trigger, or an error.

Valid values are 0-7

	Service Request on:		
Value	Error	Start Trigger	Stop Trigger
0	Disabled	Disabled	Disabled
1	Disabled	Disabled	Enabled
2	Disabled	Enabled	Disabled
3	Disabled	Enabled	Enabled
4	Enabled	Disabled	Disabled
5	Enabled	Disabled	Enabled
6	Enabled	Enabled	Disabled
7	Enabled	Enabled	Enabled

ERQ
Error message request
This command requests the MTS-1010 to send the description of the last encountered error.

AUX#
Auxiliary port on/off
This is an extension of the AUX command. Instead of toggling the auxiliary port on or off, this command allows directly turning the port on or off.
Valid values are 0 - 1.
- 0 - Turn auxiliary port off (default)
- 1 - Turn auxiliary port on

The "Auxiliary port on" and "Auxiliary port off" messages are not sent by the MTS-1010 when AUX1 or AUX0 is used.

LF1
Auto line feed on
This command enables automatic transmission of LF (line feed, ASCII 10) characters after each CR character the MTS-1010 sends.
This is the default setting

LF0
Auto line feed off
This command disables automatic transmission of LF (line feed, ASCII 10) characters after each CR character the MTS-1010 sends.

ODL#
Output delimiter configuration
This command specifies how the MTS-1010 will terminate messages which it transmits on the bus.
Valid values are 0 - 3
- 0 - messages are terminated by a CR (default)
- 1 - messages are terminated by CR, ETX
- 2 - messages are terminated by CR, (END)
- 3 - messages are terminated by CR, ETX, (END)

Examples:

Set the output delimiter to CR only:
ODL0
LF0

Set the output delimiter to CR, LF, (END)
ODL2
LF1

Example: The following example initializes the interface, puts the MTS-1010 into remote control mode, configures the MTS-1010 to initiate a service request when a stop trigger has been sensed. When the service request occurs, the controller performs a serial poll to read the status of the MTS-1010, then interrogates the time reading and resets the meter.

IEEE-488 MTS-1010

Command	Command	MTS-1010 Response	Comment
IFC			Clear the interface
REN			Enable remote control
UNT			Turn off all talkers
UNL			Turn off all listeners
MTA 21			Setup controller as talker
MLA 15			Setup MTS-1010 as listener
	SRQ1 <CR>		Enable SRQ on stop trigger
			Here the controller waits until a service request occurs
ATN			When service request occurs take control of the bus
SPE			Send serial poll enable
MTA 15			Setup MTS-1010 as talker
MLA 21			Setup controller to listen
		97	MTS-1010's serial poll status byte
SPD			End serial poll
MTA 21			Setup controller as talker
MLA 15			Setup MTS-1010 as listener
	PTS <CR>		Print time in seconds command
MLA 21			Setup controller as listener
MTA 15			Setup MTS-1010 as talker
		3.902 sec. <CR>	Timer reading response
MTA 21			Setup controller as talker
MLA 15			Setup MTS-1010 as listener
	RES <CR>		Reset MTS-1010 trigger status
UNT			Turn off all talkers
UNL			Turn off all listeners

7.7 SIMULTANEOUS USE OF IEEE-488 AND RS-232C INTERFACES

The IEEE-488 and RS-232C interfaces on the MTS-1010 can be used simultaneously. The IEEE-488 interface is assigned priority over the RS-232. If the RS-232 has remote control, it may be taken away by the IEEE-488 controller.

While the IEEE-488 interface has remote control, the RS-232 host cannot take away control using the REM or LOC commands. In addition, the RS-232 interface is limited to using only non-remote control commands, such as interrogation commands. Remote control commands such as CAV, CAI, RES, can only be executed by the controlling interface. An error message will be returned to the RS-232 host if it attempts to use remote control commands while the IEEE-488 controller has remote control.

The input and output buffers for the two interfaces are completely independent, therefore no interaction between the two will occur.

SECTION 8
SERVICING

8.1 TROUBLESHOOTING

The only user-serviceable part is the AC power fuse located on the rear panel near the AC inputs. Replace the fuse if required with an ABC 1.5amp/250 volt part.

The voltage input fuses are not user replaceable, as failure may indicate an internal problem which must be repaired by the distributor. Note that failure of only one of the fuses may still allow a voltage reading to be obtained, due to the configuration of the input circuitry. The voltage reading however will normally be incorrect and the phase angle/frequency dependent readings may also be affected. Measuring the same voltage on Channel Aand B by paralleling voltage inputs will quickly verify this condition.

Internal servicing should be limited to a quick check that all printed circuit cards are securely engaged in their receptacle, and that all interwiring connectors are securely seated and screw terminals tight. The modular construction of the case and circuitry has been designed to ensure rapid servicing turn around if required and socketed IC's minimize board repair time. The complex nature of the circuitry however requires qualified technical personnel to ensure rated performance is maintained.

8.2 CALIBRATION PROCEDURE

The need for calibration adjustments has been minimized by the use of precision components. There are only five adjustments to be made for all functions. The location of the trimpots are shown in the diagram below. They are accessible after removing the four screws securing the top half of the instrument case.

CAUTION: Calibration should only be attempted by qualified personnel, using good safety practices and accurate instrumentation. Dangerous voltage are accessible with the instrument cover removed. Calibration should only be done when an independent measurement with a 0.1% or better accuracy, true RMS responding instrument, shows significant drift has occurred. Understand the significance of "±0.5% of reading ±0.2% of scale" specification to ensure calibrations actually required.

8.2.1 Setup Requirements

A stable variable voltage source of minimum 0-300 volts AC, a stable variable current source of minimum 0-30 amps AC, an accurate frequency counter, and a 0.1% or better, TRMS responding AC voltmeter and ammeter are required. The current source must be verified to have an output which is exactly in phase with the voltage source. All instruments should have been powered on for at least 30 minutes.

8.2.2 Procedure

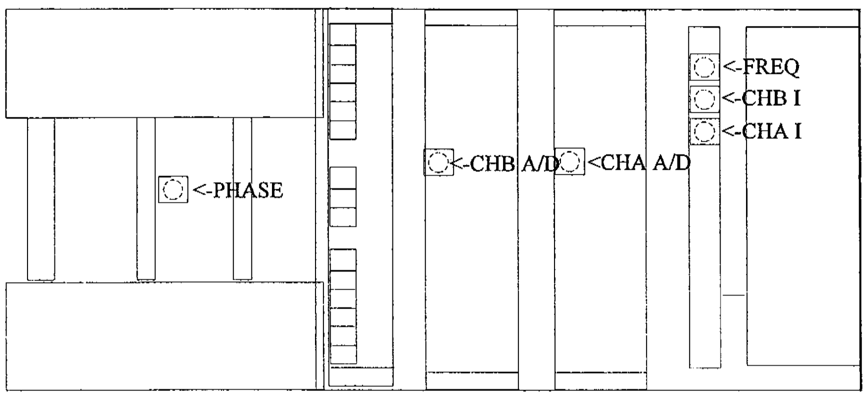

Figure 8-1

1. Connect the frequency counter to the frequency test jacks, and adjust the frequency trimpot to get 120.0kHz. This maximizes the ability of the instrument to reject 60 Hz noise. (If the main power system is 50Hz, the frequency should be adjusted to 100kHz).

2. Remove the frequency counter. Using short jumper cords, connect the red Channel A voltage input to the black channel B voltage input. Likewise jumper the two remaining terminals, then connect the A or B voltage inputs to the variable voltage source. Keep fingers and test prods well clear of front panel terminals, power supplies and printed circuit conductors.

3. Adjust the voltage source to obtain approximately 180 volts. Adjust the A/D reference voltage via the channel A A/D PCB trimpot, to obtain exactly the same reading as the reference voltmeter. In a similar manner adjust the channel B reading.

4. Now check and record the readings of all three voltage displays while varying the voltage signal from 2.00 volts to 500 volts, engaging the RANGE switch to ensure maximum resolution is always obtained. The readings should agree within stated accuracy limits. If voltages in the 2.00 to 20.00, or 200 to 500 range are out of specification, the associated precision gain resistors must be replaced.

5. Power down the voltage test source. Use a jumper to connect the black channel A current input to the red channel B current input. Connect the test current source, in series with the reference ammeter, in channel A red and out channel B black.

6. Power on the test source, select A and B for Amperes, and adjust for 18-19 amps current. As quickly as possible, adjust the channel A and channel B current trimpots to obtain exactly the same reading as the reference ammeter.

7. Check and record all readings at a series of points this time from 200mA to 50amps. Any additional error factors from the recorded voltage readings should be due to current transformer non-linearity,

since the same gain and A/D circuits are used.

8. Now power on the voltage source again, and adjust to approximately 100 volts. Adjust the current source to approximately 10 amps. Select Channel A to volts, Channel B to current, and the MTS-1010 display to phase angle. If necessary roll the leads from one of the test sources to obtain a reading of roughly 180 degrees. Now adjust the phase angle trim pot to obtain exactly 180.0 degrees.

9. Finally, check the other phase readings, by first selecting Channel B to volts, then both channels to current. In each case the reading should be 180 ± 0.5 degrees.

10. Power down the test sources before removing wiring. Note that low current or voltage readings especially in the high speed mode may be displayed even though no signals are connected to the inputs. These are 'noise floor' readings, switching noise from the multiplexed LED displays, caused by the close coupling inherent in a meter of such small dimensions. Whenever a legitimate signal source is present at the inputs however, an in-spec reading should be obtained down to below 5% of the most sensitive scale. Note also that the very high 2 Mohm input impedance of the voltmeter circuits, may allow a reading to be present from lead pickup when not connected to a low-impedance voltage source.

8.3 EPROM REPLACEMENT PROCEDURE

The performance of many of the features of the meter are controlled by programs stored in Erasable Programmable Read Only Memory (EPROM). When significant program (software) changes have been made, or it is desired to incorporate custom changes, it will be necessary to exchange the resident EPROM for one containing the new programs. This is a very straight forward procedure which can be done in the field in less than 10 minutes, using a small slot screwdriver and posidrive #2 screwdriver.

8.3.1 Procedure

1. Ensure the AC power cord and all signal inputs have been removed from the meter. Ground the meter case by connecting from the rear panel ground stud to secure ground, and discharge any static buildup by touching tools and hands to the case.

2. Remove the four screws securing the top half of the case and lift the top off, exposing the interior. The printed circuit card to be removed is connected to the BAUD switch on the rear panel by a twisted pair of yellow wires. Remove these wires from the board by pulling their connector perpendicular to the card. The small screwdriver used to remove the screws can be used to gently ease these off.

3. Remove the four screws from the corners of the rear panel, and swing it back and up, swiveling about the lower left corner, to expose the back end of the card to be removed, (card in the middle slot of the left cardcage). Pull straight back on the connector board or cable on the end of the card cage, removing it. Remove the center PC board, holding it by it's edges only. Lay the card, component side up, on a static-free surface such as a slightly damp cloth, or section of aluminum foil.

4. The EPROM is a large 28-pin ceramic device with a label on it stating the current software revision- it will be similar in appearance to the new component to be inserted. Note the polarity of the component. The small semi-circular notch in one end (identifying pin #1) should be next to the bottom edge of the board. The new component must be inserted with exactly the same orientation.

5. Gently remove the EPROM from it's socket by sliding the small screwdriver under one end and lifting. Remove it holding it by the ends (avoid touching the pins) and set on the non-static surface.

6. Remove the new EPROM from it's protective foam after touching a grounded surface. Hold the EPROM by the ends and plug it into the socket, observing correct orientation as above. When all pins have begun to correctly enter the socket, firmly push into place so it seats fully on both sides.

7. This completes installation. Reassemble the case by reversing the instructions above. Make sure the card is reinserted correctly (component side facing same direction as others, and the phase angle potentiometer and baud switch connector on top). Double check that the connectors have been replaced before restoring the top cover. A quick functional check should be made to verify correct installation.

APPENDIX A
HIGH SPEED MEASUREMENTS

This MTS-1010 Powermeter is designed to facilitate high-speed measurements but there are limitations to it's capabilities in this area that the user should be aware of.

The limiting factor in making AC measurements is the speed of the true RMS conversion circuit. Unless complex computer-based computation techniques are used, several cycles are required to generate an equivalent RMS output for the A/D converter.

This meter uses a TRMS converter for each channel, with filter constants chosen to give an accurate result in about 45 msec, or 3 cycles. The A/D converters in high-speed mode update 30 times/second, ie 33ms per reading, and depending on what portion of their cycle they were in when set to this mode, may require at least one cycle to stabilize.

Frequently the action that triggers the high speed circuits, such as switching on or off AC/DC voltage/current will produce a burst of transient voltages which will be superimposed on the measured quantity, producing one or more erroneous readings, especially on the high-impedance voltage inputs. As with most A/D systems, higher speed means greater susceptability to noise, since it inherently tracks noise signals faster. The result of all these conditions is that reliable frozen reading of current and voltage cannot be achieved in less than 50 milliseconds, and significantly longer may be required for a large step change.

As mentioned previously the frequency multipliers for channel A signal, used to derive quantities for time in Hz, require more than one second to lock on the input frequency, so if high-speed measurements are required of this quantity there should be a signal present prior to the start of the measurement cycle.

Time in seconds is easily the most common used feature for triggered measurements, and is affected by none of the above restraints, since it employs an internal crystal reference oscillator as it's measurement source. The only timing restriction is the 3 msec minimum interval, set by the reset action of the trigger to allow 2-wire pulse timing.

Finally, it is of course necessary to have current and voltage ranges set correctly prior to a high-speed measurement, since each automatic up-ranging can takes nearly one second. This will be done automatically by the meter if similar values are checked prior to the high-speed test, and the RANGE switch is then left in the OFF (center) position.