OPERATOR MANUAL

For The

Model 7810

Transconductance Amplifier

www.guildline.com

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1. INTRODUCTION

1.1. SCOPE

This manual contains operation procedures, technical specifications, design descriptions, maintenance instructions, and setup diagrams for the Guildline Instruments Model 7810 Transconductance Amplifier.

1.2. GENERAL DESCRIPTION

The Model 7810 Transconductance Amplifier is a low uncertainty / high accuracy transconductance amplifier with excellent long term and short term stability. The 7810 provides calibrated currents up to 100 A over a specified range from DC to 100 kHz, and uncalibrated currents up to 200 kHz. The input accepts voltages in the range of 0 to 5 V RMS. Six output current ranges source currents from 5 mA to 100 A full scale with a 7.5 Vrms compliance voltage

The 7810 is manually controllable through an integrated colour touch screen or may be automatically controlled via integrated IEEE 488.2 and USB interfaces except for the main power ON/OFF switch. The 7810 operates on line power with voltages from 110, 115, 120, 220, or 240 VAC ± 10 %; and at 50 Hz or 60 Hz ± 5 %.

Figure 1-1 : Model 7810

1.3. WARRANTY

Each Model 7810 Transconductance Amplifier provided includes a two (2) year warranty in which Guildline Instruments warrants that the unit is free from defects in material, workmanship, manufacturing, and design and will perform to or exceed specifications, if operated properly, for the duration of the two (2) year warranty coverage. This warranty only extends to the intended original purchaser.

Guildline will repair or replace any failed unit under warranty within a reasonable length of time at no additional cost to the customer. The repair action will correct any deficiencies so units shall meet all specifications. If a replacement unit is provided, the replacement unit will assume the balance of the warranty of the replaced unit. The unit will be calibrated with standards traceable to a NMI source.

Guildline will be responsible for returning warranty standards to the owner and will bear transportation costs from the repair centre back to the user. It will be the customer's responsibility for transportation costs for equipment returned to Guildline for repair or replacement. Warranty repairs will be provided in Canada, but Guildline maintains a US address for warranty shipments for US Customers.

Guildline does not provide warranty service or file claims due to shipping damage. Customers are responsible for properly packaging instruments and insuring instruments, to account for the possibility of shipping damage.

These warranties will not, in any way, be voided by any customer performed routine maintenance accomplished in accordance with Guildline's service procedures (e.g. replace fuses, adjust instrument in accordance with calibration instructions, cleaning, etc.).

1.4. TO OBTAIN WARRANTY SERVICE

Before returning any warranty equipment to Guildline Service Center, a Return Authorization Number (RMA) and shipping instructions from Guildline Instruments is required. Guildline Service Center information is as follows:

The phone number in the USA and Canada to obtain Product Support, Calibration Service or Replacement Parts is (800) 310-8104.

To Contact Guildline Instruments, the following information is provided.

USA and Canada Telephone: (613) 283-3000
USA and Canada Fax: 1-613-283-6082
Outside US and Canada Telephone: + [0] [1] 613 283-3000
Outside US and Canada Fax: + [0] [1] 613 283-6082

You can also contact Guildline Instruments Limited via their Email or Website.

Email is: sales@guildline.com
Website is: www.guildline.com

Any 7810 Transconductance Amplifier delivered that has a product/design or safety defect which prevents the unit from meeting contract specification requirements will be modified by Guildline to eliminate the defect and ensure all specifications are met. All modifications including parts and labour will be done at no cost to the customer.

1.5. SPECIFICATIONS

1.5.1. Output Current Ranges

Current Range (Full Scale)	Output Current (0 % to 100 % of Full Scale)	Transconductance (Siemens)
5 mA	0 to 5 mA	1 m
50 mA	0 to 50 mA	10 m
500 mA	0 to 500 mA	100 m
5 A	0 to 5 A	1
50 A	0 to 50 A	10
100 A	0 to 100 A	100

1.5.2. Stability Over 10 Minute Interval

Frequency (Hz)	± % of Reading + % of Range (0 % to 100 % of Full Scale)	± % of Reading (100 % to 200 % of Full Scale)
DC	0.002 + 0.0015	0.004
10 to 10 k	0.005 + 0.004	0.01
10 k to 100 k	0.01 + 0.008	0.02
100 k to 2 M	Unspecified	Unspecified

1.5.3. Accuracy Over 1 Year, 95 % Uncertainty

Accuracy (12 Months) ± (% of Reading + % of Range) 1 Hour Warm-up			
Selected Range ➲	**100 A**	**50 A**	**5A**
Output Currents ➲	**50 A to 100 A**	**5 A to 50 A**	**0.5 A to 5 A**
DC	± (0.02 + 0.015)	± (0.02 + 0.015)	± (0.02 + 0.015)
10 Hz – 10 kHz	± (0.05 + 0.04)	± (0.05 + 0.04)	±(0.05 + 0.04)
10 kHz – 30 kHz	± (0.10 + 0.08)	± (0.10 + 0.08)	± (0.10 + 0.08)
30 kHz – 50 kHz	± (0.15 + 0.12)	± (0.15 + 0.12)	± (0.15 + 0.12)
50 kHz – 100 kHz	± (0.30 + 0.24)	± (0.30 + 0.24)	±(0.30 + 0.24)

Accuracy (12 Months) ± (% of Reading + % of Range) 1 Hour Warm-up			
Selected Range ➲	**500 mA**	**50 mA**	**5 mA**
Output Currents ➲	**5 mA to 500 mA**	**5 mA to 50 mA**	**0.5 mA to 5 mA**
DC	± (0.02 + 0.015)	± (0.02 + 0.015)	± (0.02 + 0.015)
10 Hz – 10 kHz	± (0.05 + 0.04)	± (0.05 + 0.04)	± (0.05 + 0.04)
10 kHz – 30 kHz	± (0.10 + 0.08)	± (0.10 + 0.08)	± (0.10 + 0.08)
30 kHz – 50 kHz	± (0.15 + 0.12)	± (0.15 + 0.12)	± (0.15 + 0.12)
50 kHz – 100 kHz	± (0.30 + 0.24)	± (0.30 + 0.24)	± (0.30 + 0.24)

1.5.4. General Specifications

Compliance Voltage	Maximum 9 Vrms, 9 VDC	
Noise	± 0.05 % of Current Range in a Band from DC to 100 kHz Unspecified from 100 kHz to 200 kHz	
Manual Operation	Color Touch Screen	
Remote Operation	IEEE 488.2	SCPI Based Instructions
Dimensions (H x W x D)	15" x 20.7" x 30"	381 mm x 526 mm x 762
Weight	75 lbs. (34.1 kg)	
Operating Temperature Range	22.8 °C ± 3.3 °C	73.0 °F ± 5.9 °F
Operating Humidity Range	20 % to 50 % RH	
Storage Temperature Range	-20 °C to +60 °C	-4 °F to +140 °F
Storage Humidity Range	15 % to 80 % RH	
Warm Up Time	1 Hour	
Output Connectors	5 - 100 A (LC Female)	0 - 5 A (Type N Female)
Power Supply Requirements	110, 115, 120, 220, or 240 VAC ± 10 %	50 Hz or 60 Hz ± 5 %
Mounting Provisions	Rack Mountable or Bench Top	

2. INSTALLATION

2.1. INITIAL INSPECTION

This instrument was carefully inspected both mechanically and electrically before shipment. It should be free of marks and scratches and in perfect electrical order upon receipt.

Unpack the instrument and retain the shipping container until the instrument has been inspected for damage in shipment. If in-shipment damage is observed, notify the carrier and obtain authorization for repairs before returning the instrument to the factory.

The 7810 is shipped with the following accessories and spare parts:

- Technical Manual (TM7810)
- 110 to 230 Volt, 15 A detachable line cord
- Rack Mounting Kit
- Calibration Certificate

2.2. POWER REQUIREMENTS

The instrument is shipped with a three wire 15 A, 110 to 230 Volt North American line cord. The 7810 is designed for use with AC power sources between 110 to 250 Volts rated at 15 A. The detachable line cord is equipped with a NEMA 6-15 end for connection to the power source.

Where the supplied line cord does not match the power outlet receptacle, the plug may be removed from the line cord and replaced with a grounded plug of the correct type. The plug should be wired as shown in Table 2-1.

Cord Wire Colour	Potential Voltage
Brown	Line
Blue	Neutral
Green/Yellow	Ground (Earth)

Table 2-1 : Line Cord Wiring

2.3. PRELIMINARY SETUP POCEDURE

Upon completion of inspection the instrument should be placed on a solid bench top capable of holding the weight of the instrument.

2.4. WARNING:

BEFORE SWITCHING ON THIS INSTRUMENT, THE PROTECTIVE TERMINAL OF THIS INSTRUMENT MUST BE CONNECTED TO A PROTECTIVE EARTH CONTACT. THE POWER LINE CORD SUPPLIED WILL PROVIDE THE PROTECTIVE GROUNDING WHEN INSERTED INTO A SOCKET OUTLET PROVIDED WITH AN EARTH CONTACT.

THE PROTECTIVE ACTION MUST NOT BE NEGATED BY THE USE OF AN EXTENSION CORD OR ADAPTOR WITHOUT A PROTECTIVE GROUNDING CONDUCTOR.

3. MANUAL OPERATION

3.1. FRONT PANEL

Figure 3-1 : Front Panel Guildline 7810

3.1.1. Touch Screen

The touch screen is used for configuration of the 7810 ranges, control of output current and monitoring purposes. Refer to section 3.3. for touch screen displays and functions.

3.1.2. USB Interface Bus

The Type A connector is used to connect the 7810 to external devices such as memory sticks, computer mice/keyboard or USB communication adapters.

3.1.3. Input

The input consists of: a four terminal voltage input to drive the 7810, an active guard that can be used to drive the input connection cable shields and a circuit common connection. NOTE that connecting a device with an active guard to the 7810 guard will damage the 7810.

Figure 3-2 : Input Terminals

V+ Input - the V+ Input terminal provides the connection for source input voltage "V+" connection.

V- Input - the V- Input terminal provides the connection for the source input voltage "V-" connection.

HI Input - the HI Input terminal provides the connection for the source input voltage "Sense +".

LO Input - the LO Input terminal provides the connection for the source input voltage "Sense -".

Guard – this Guard input terminal provides a buffered output voltage signal that has the same magnitude and phase as the input source voltage. The Guard input terminal can be used to drive the guard or shield conductor in the interconnect cable from the input voltage source.

NOTE: If using this Guard, the shield must not be attached at the input voltage source and/or the connected device must not have an active Guard or the 7810 can be damaged.

Ground – the Ground symbol terminal provides a connection to the internal input circuit common or ground and is isolated from instrument safety ground.

3.1.4. 0 - 5 A Output

The 0 – 5 A output is a Type N female coaxial connector which provides the means for connecting the current ranges up to 5 A to the device under test. A driven guard terminal located on the lower right of the Front Panel is provided that supplies a signal that can be used to guard an output cable shield. If this Guard is used, only the 7810 side of the output cable shield should be connected.

3.1.5. 5 - 100 A Output

The 5 – 100 A output is an LC female coaxial connector which provides the means for connecting the current ranges above 5 A to the device under test. A driven guard terminal is provided that supplies a signal that can be used to guard an output cable shield.

3.1.6. Guard

This Guard output terminal provides a buffered output voltage signal that has the same magnitude and phase as the output current "+" signal. The Guard output terminal can be used to drive the guard or shield conductor in the interconnect cable from the output of the 7810.

NOTE that the connected device must not have an active Guard or the 7810 can be damaged.

3.2. REAR PANEL

Figure 3-3 : Rear Panel Guildline 7810

3.2.1. Power Entry

The power entry provides the means to connect the 7810 to a power source as well as a means of turning the power to the 7810 on and off. Protection against excessive drain on input power is provided by the integrated 15 A circuit breaker.

3.2.2. GPIB Interface Bus

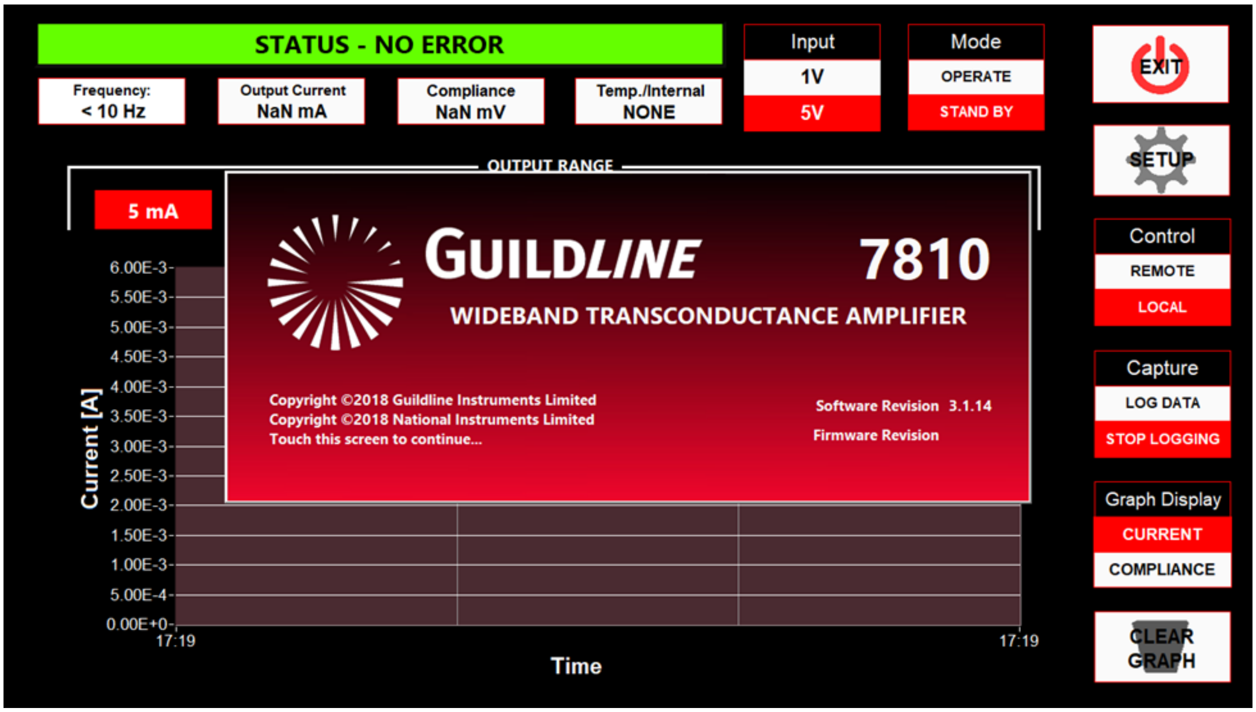
The GPIB IEEE-488.2 connector is used to connect the 7810 to an external controller.

3.2.3. USB Interface Bus

The Type A connector is used to connect the 7810 to external devices such as memory sticks, computer mice/keyboard or USB communication adapters.

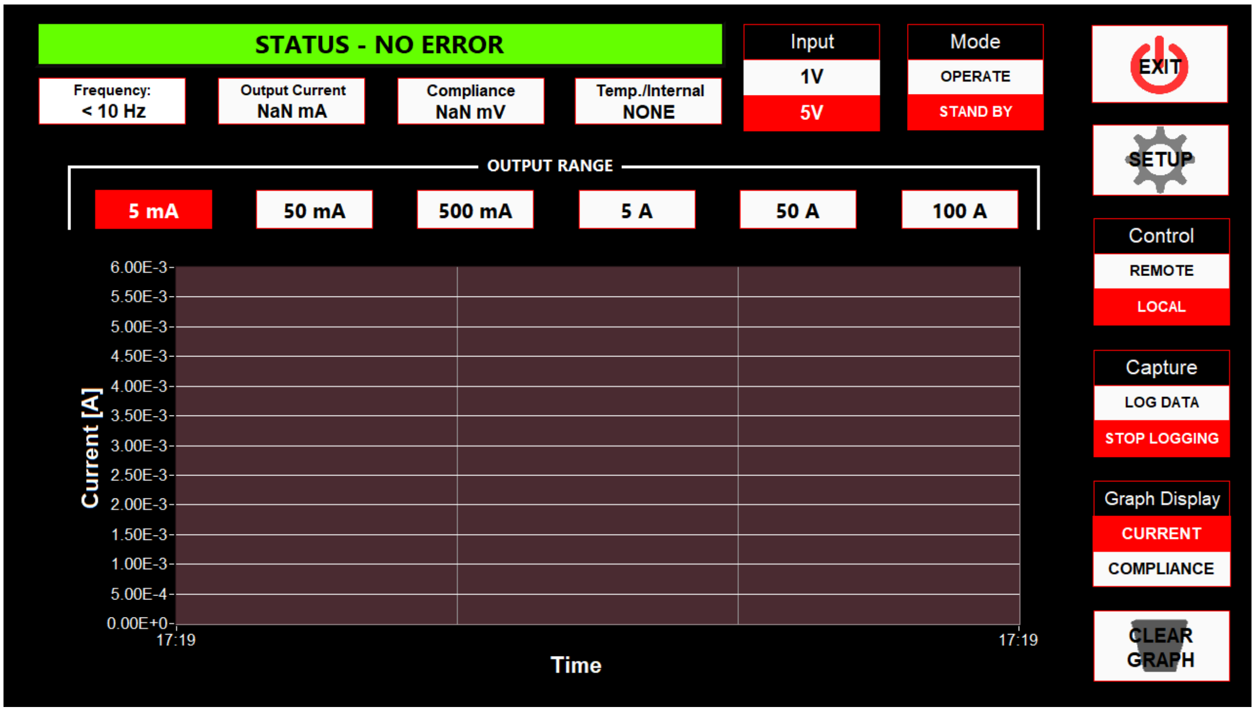
3.3. FRONT PANEL TOUCH SCREEN OPERATION

The 7810 Graphical User Interface (or GUI) is provided on a Windows Embedded PC which is built into the instrument. The interface utilizes the touch screen interface with on screen keyboard for user control and entry. The user interface software utilizes the full screen as a "Metro" style application common to Windows 8 and newer. Note that this interface runs on Professional (x86 and x64) versions of windows and is not supported in RT versions. The following screen is displayed upon startup. Touch the red 'Guildline 7810' screen to continue to the main GUI screen.



3.4. MAIN SCREEN

The main screen, as shown below, is where you have access to all user features of the 7810 Transconductance Amplifier. The screen has operator functions available mainly to the right hand side of the screen with statistics in the middle of the screen and graph to the left. The graph will automatically adjust the scale such that all data will be visible up to a maximum length of hours as defined in the Setup GUI screen. If data is being logged all data is still available in the stored file.



The main screen is used to display the status of the 7810 including output current and compliance voltage when in operation.

The Input voltage range (i.e. 1 V or 5 V) can be selected by touching the appropriate tab, as can the Output Range for current. You can select any of the displayed output ranges for current from 5 mA to 100 A. To use this screen simply touch the desired range and press “OK” to accept. Click on “Cancel” if you do not want to change the range. The selected Input voltage range and Output Range for current are highlighted in red.

Once the Input voltage and Output current ranges are selected the OPERATE tab is selected and the 7810 will generate the requested output current. To stop generating output current select the STAND BY tab and the 7810 will be placed into standby mode.

Note that all selections on the main GUI screen are highlighted in red.

Note that all selections on the main GUI screen are highlighted in red.

The tabs on the right of the screen are described below.

SETUP to set communication parameters.

Control for LOCAL operation using the front panel of the 7810, or REMOTE operation for use with a connected computer. The "Enable Remote" button disables all interactive features of the GUI and allows the 7810 Transconductance Amplifier to be controlled by another computer via GPIB (included/default), or RS-232C (optional). Any one of these options can be used at any time. While remote is enabled the GUI will still display the graph, statistics and readings.

Capture to log data. The LOG DATA tab will begin to store the data to a standard comma separated values format file. This file is stored in "C:\Results\YYYY\YYYY-MM\TransCond_DataLog_YYYYMMDD_0001.csv". This path and name is generated automatically where "YYYY" is the year, "MM" is the month, and "DD" is the day. To keep file sizes reasonable and to ensure there are no filename conflicts the name is also given a 4 digit incremental number as well. To stop logging data hit the STOP LOGGING tab.

Graph Display to display either CURRENT or COMPLIANCE voltage on the screen;

CLEAR GRAPH to clear the data that is displayed on the screen. Note that clearing the graph does not remove the data from the stored data if "Log Data" is enabled. Also note that the statistics will be cleared as well. These statistics reflect all the present data in the graph.

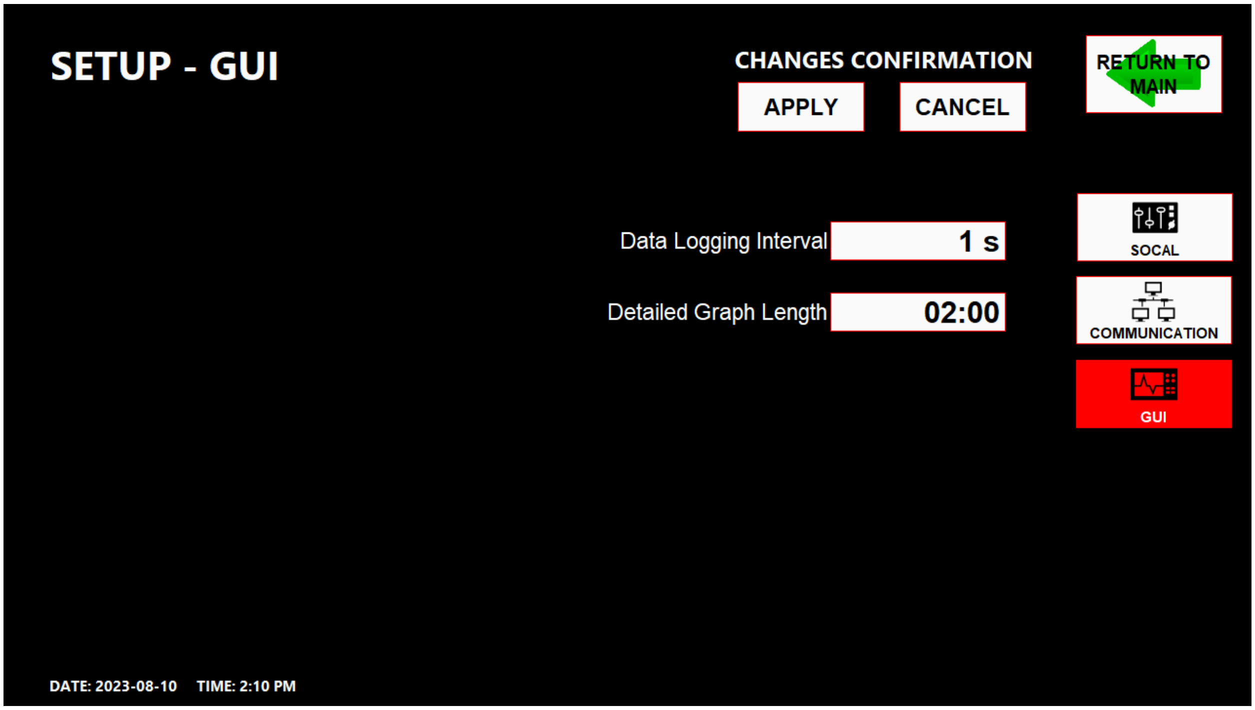
The "Exit" button simply exits the 7810 Transconductance Amplifier Graphical User Interface. The 7810 will continue to maintain the settings of the last configuration even if the GUI is not running.

As shown above all screens can be easily accessed starting from the main screen, with the exception of the screens which affect the calibration of 7810. These screens are password protected. The default password for these screens is "7810" and can be altered by changing the stored password in the "TransCond7810.ini" file stored in the program directory under the key "Password".

Also note that this interface can be installed and run on any computer running Windows 7 or newer and can run as a standard desktop app "Windowed", rather than full screen "Metro" mode by changing the "TabletPC" from true to false in the "TransCond7810.ini" file.

Note that to edit this file you will need administrative privileges in Windows.

3.5. SETUP SCREEN



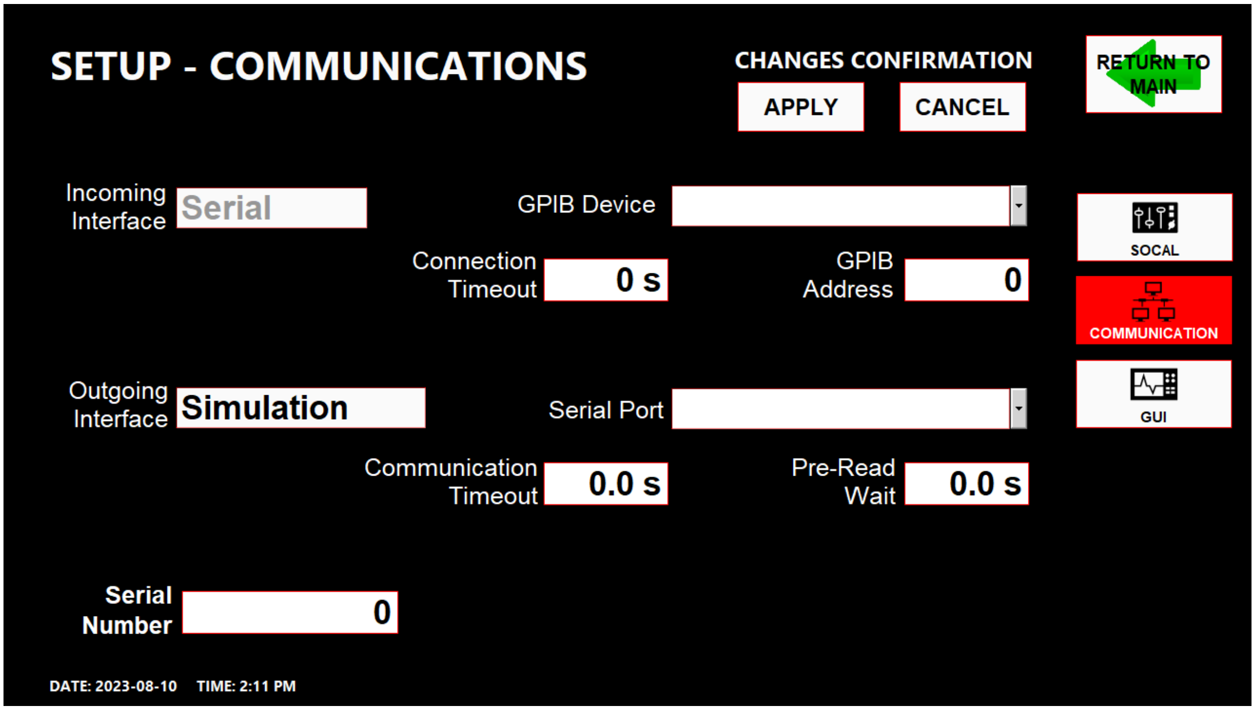
The "Data Logging Interval" field is where the operator can set the rate in which the 7810 updates the graph and statistics. The rate is expressed in seconds.

The "Detailed Graph Length" field is where the operator can set the length in time that the graph will display and for which statistics are calculated.

The "Apply" button will implement the parameters as displayed on the screen.

The "Cancel" button will close the Setup screen without making any changes to the parameters.

3.6. SETUP COMMUNICATIONS SCREEN



The Setup Communications screen sets the Remote and Internal Communication parameters. Provided on the right of the screen are buttons to navigate to the other Setup screens.

The “Incoming Interface” field is a drop menu listing all the available interfaces for connecting the 7810 Transconductance Amplifier to an external computer for remote control. More detail on how to remotely control the 7810 Transconductance Amplifier is outlined in the Remote Control Section of this manual. You can select the desired interface option based on the installed available option. These can be GPIB (included/default), or RS-232C (optional).

The “Connection Timeout” field allows the operator to set the time the GUI will wait for a connection from a remote PC before closing the active connection.

The “Outgoing Interface” field is a drop menu listing all the available interfaces for connecting the 7810 Transconductance Amplifier hardware to the internal computer for internal control. You can select the desired interface option based on the installed available option. These can be RS-232C (included/default), or GPIB (optional). There is also a “Simulation” option which emulates a connection to the 7810 Transconductance Amplifier hardware.

The “GPIB Address” field (sometimes called “Serial Port”) is a drop menu listing of all the available ports/addresses for connecting to the 7810 Transconductance Amplifier hardware. Note that one of these fields will also appear next to the “Incoming Interface” depending on what interface is chosen.

The “Communication Timeout” field allows the operator to set the time the GUI will wait for a response from the 7810 Transconductance Amplifier hardware before reporting a connection error.

The “Apply” button will implement the parameters as displayed on the screen.

The “Cancel” button will close the Setup screen without making any changes to the parameters.

3.7. RECOMMENDED PRACTICE

The 7810 has protection circuitry on its inputs and outputs, and is therefore quite robust. However, the following practice is recommended to reduce the likelihood of damaging the instrument.

Reduce the input voltage to zero (i.e. disable output current) before doing the following:

- powering the instrument ON or OFF
- changing or setting output current range or output frequency
- removing or attaching a load to the output

If frequencies greater than 100 kHz are being used it is recommended to start with a lower output current (e.g. 1 A) to ensure that the 7810 will not overheat. If the 7810 is stable at higher frequencies (i.e. > 100 kHz), then gradually increase the output current until the required output current is reached. If the 7810 starts to overheat or enters a voltage over-compliance state it will automatically shut down.

Note that inductive loads require particular care in that any change in current (i.e. removing an inductive load under power) creates a back EMF (i.e. inductive kick-back) which may negatively affect the 7810 or other instruments attached to the setup. Similarly, a discontinuous inductive load, such as applying a clamp on current meter or changing ranges on an inductive meter, will create a back EMF. If the back EMF is too large the 7810 will automatically shut down.

3.8. CAUTIONS

3.8.1. Link To Common

The Lo input terminal of the 7810 may be linked directly to the Common terminal. With no link installed between input Lo and the Common terminal, the sum of the common mode voltage (the voltage between the Lo input terminal and the Ground terminal) and the normal mode voltage (the voltage between the Hi input terminal and the Lo input terminal) must not exceed 10 V.

3.8.2. Circuit Common Connection To Output

The potential at the circuit Common terminal is directly connected with the return connections of the two front panel current output connectors. It is therefore important to consider the grounding of the source connected to the 7810 input, and the load connected to the 7810 output. If more than one of these components connects to the safety ground of the 7810 a ground loop will be created. This can adversely affect the measurement system and should be avoided. A single connection to safety ground at any one of the inputs, or outputs, should not adversely affect the measurement system. The Common terminal must not be floated beyond ± 50 V from safety ground to prevent damage to the 7810 circuit.

3.8.3. Input and Output Guard Strategy

A signal guard is used to reduce the distortion in the input and/or the output (analog) signals. The 7810 uses an active guard. An Active Guard is a voltage level of the input/output signals that is buffered with a very fast amplifier to minimize latency. It is important that the Guard NOT be connected to another instrument that has an active guard as damage may result. The active guard should only be connected at one place in a measurement circuit to avoid circulating currents within a measurement setup.
When this buffered voltage is applied to the shield around the circuit it protects the signal from distortion in two ways

1) External signals are prevented from affecting the desired signal from interference.

2) Any leakage current from parasitic capacitance is supplied from the Guard signal rather than the actual signal. The Guard is in effect a sacrificial current source at the same voltage level as the measurement signal. With an Active Guard at the same voltage level, there is very little capacitance between the Guard and the signal being protected.

The 7810 Transconductance Amplifier (i.e. TCA) has both an Active Input Guard and an Active Output Guard. Either, or both of these Guards, may be used depending on the configuration selected by the user.

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Input Signals, Including Input Guard

The 7810 Front Panel contains the following input signals, including an Input Guard:

V**+** - should be used for the high side of the input signal.

HI - should be used for the +ve sense line of the input signal.

V- - should be used for the low side of the input signal.

LO - should be used for the –ve sense line of the input signal.

GROUND – this is tied to the 7810 internal ground of the input circuit. It can be used as a passive shield for the input, or it can be tied to the external Guard of the input signal generator. This is NOT an earth ground.

GUARD – This is an active Input Guard which is produced from the V+ input voltage. It can be attached to the input signal shield as long as the source input shield is not connected to a Guard or GND already.

Output Signals, Including Output Guard

There are two different output ranges / terminals on the 7810 TCA. Only one of these outputs is active at a time.

One output terminal is for low current ranges, up to 5 A. This uses an N-Type connector and is located on the center bottom of the 7810 front panel.

The other output terminal is an LC-Connector located at the center of the 7810 front panel above the 5 A output. The LC Connector is used for 5 A to 100 A output currents.

The Output Guard is located on the right of the 7810 front panel and is an active replica of the output voltage as seen at either the output of the N-Type connector or the LC connector, depending on which is active. This can be used as an active guard on the output signal. As always, precautions must be taken when using any active guard. Specifically, before using the 7810 Output Guard, verify it will not be tied to another Active Guard or Ground shield.

Like a grounded shield it is important that the Guard be only connected at one place in the measurement to avoid circulating currents.

3.8.4. Power-Down of the 7810

Since the 7810 is controlled by a Windows computer, it must be shut down gracefully or the operating system may be damaged. These are the steps needed to power down the 7810:

1) Stop current output, reduce the output range to the lowest level (5mA).

2) Close the 7810 program and use the PC shutdown control to power down the PC, wait until the screen goes black and the computer shuts down.

3) Shut the 7810 power down by using the switch in the upper right corner of the back panel.

4. THEORY OF OPERATION

4.1. INTRODUCTION

The 7810 Transconductance Amplifier is an instrument that supplies a stable source of current which has an amplitude directly proportional to a voltage supplied at the input terminals. The 7810 has an operational calibrated range from DC to a frequency of 100 kHz. Although the 7810 will respond to frequencies up to 200 kHz there is no specification of the performance above 100 kHz. The 7810 has a wide range of output current from a minimum of 1 mA to a maximum of 100 A in 6 ranges. The instrument consists of various interconnected circuits to transform input voltages from 0 to 5 volts into stable output currents up to 100 A as described in this section.

4.2. OVERVIEW

The 7810 Transconductance Amplifier is a device that produces an output current that is proportional to the input voltage. The 7810 Transconductance, (Iout/Vin) varies from 1 milli-Siemen at the lowest range to 100 Siemens at the highest range.

The 7810 has a patented modular design that makes use of high stability 5 A transconductance cells that are combined in a unique way to provide a total output current capability of 100 A with a calibrated frequency range from DC to 100 kHz, and an operating range up to 200 kHz. The design optimizes the frequency linearity and stability as well as reducing voltage compliance losses and thermal dissipation within the instrument.

The ranges below 5 A output utilize a single 5 A cell which is connected to a separate Type N connector on the front panel. The higher ranges (5A to 100A) are connected through an LC type connector.

Two wide band voltage to current converters convert the voltage on the input terminals to nominal full scale current outputs of 5 mA RMS which drives either the 5 A single cell for the lower ranges or the 20 combined cells for the higher current ranges up to 100 A. Figure 4-1 illustrates the main sub-sections of the 7810 Transconductance Amplifier.

4.3. INSTRUMENT CONTROL

The 7810 is controlled by an internal micro-processor through a front panel colour touch screen or through either the GPIB or the USB back panel digital interfaces. A back panel circuit breaker provides for connecting and disconnecting the 7810 from the source of line power.

The micro-processor also monitors a number of internal circuits to ensure safe operation of the instrument and displays the current status of the instrument.

4.4. VOLTAGE INPUT CIRCUIT

The 7810 has a four terminal input arrangement so that the effects of input lead length can be automatically compensated. This ensures that the full accuracy of the transconductance can be realized regardless of lead length and input frequency.

A buffered voltage is also generated and connected to the input Guard terminal which may be used to guard the shield of the input leads as may be applicable. A circuit Common connection is also provided which may be used as an external monitoring reference point or as a passive guard for the shield of the input leads. To prevent possible damage only one side of the input voltage shield should be connected.

4.5. COMPLIANCE VOLTAGE DISPLAY

The compliance voltage at the output connectors is continuously monitored and displayed on the touch screen. A warning is displayed when the monitored voltage reaches the limit of 7.5 Volts DC or 7.5 V ACrms and if the voltage is too high the 7810 will automatically shut down.

4.6. SIGNAL FREQUENCY and INPUT VOLTAGE DISPLAY

The RMS voltage and frequency of the input is monitored continuously and displayed on the main GUI screen.

4.7. OVERLOAD DETECTION and PROTECTION

The micro-processor continuously monitors the input voltage and frequency, the output compliance voltage, and the EMF feedback. The micro-processor will disconnect the drive to the current cell array whenever the 7810 exceeds any of its operating limits in terms of input voltage, output compliance voltage, EMF feedback or internal heat. The status of the 7810 is displayed on the touch screen and provided through remote interface.

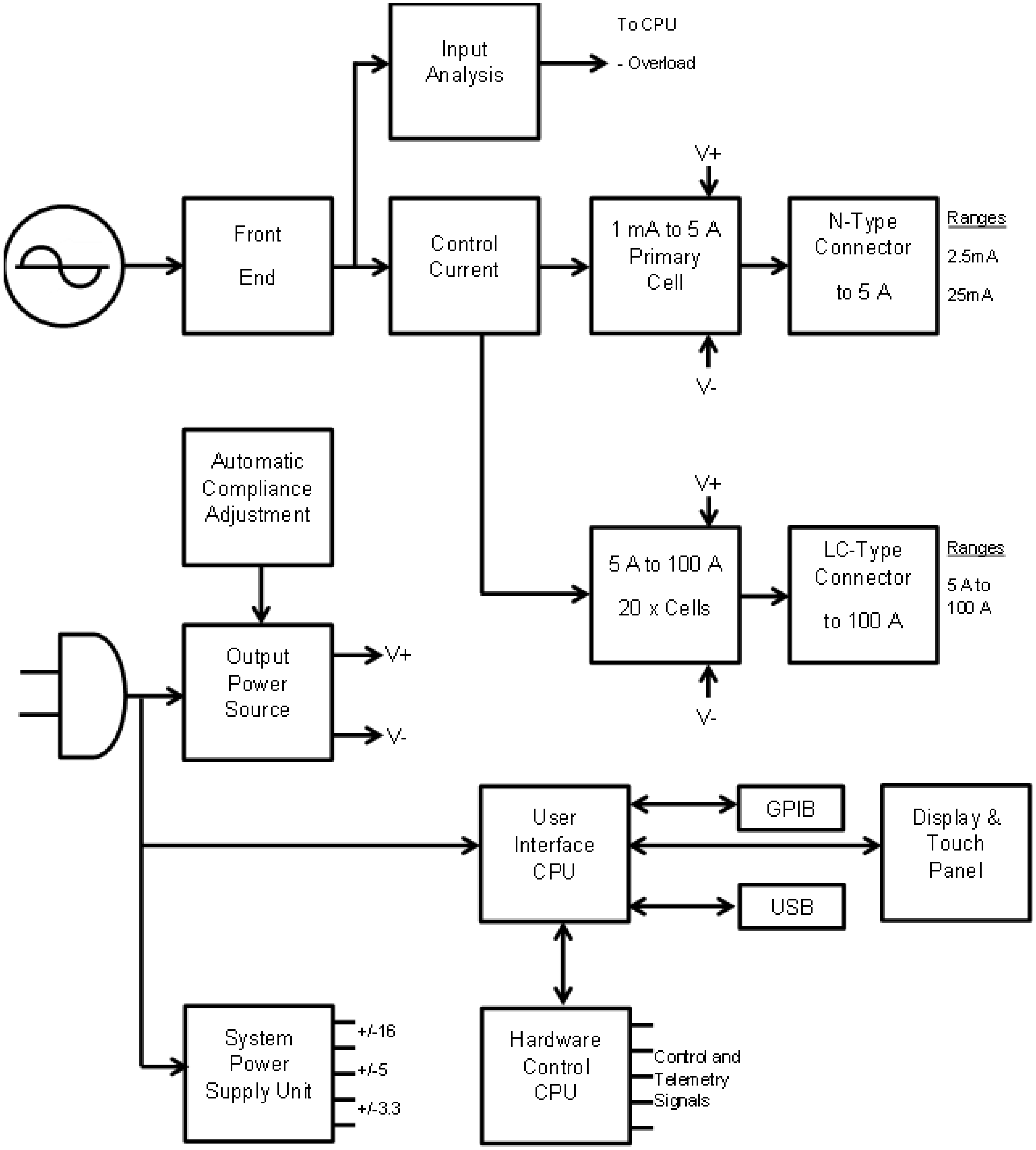

Figure 4-1 : Model 7810 Block Diagram

5. MAINTENANCE AND TROUBLESHOOTING

5.1. PERIODIC MAINTENANCE

Periodic maintenance should be performed annually by completing the following:

1 - Checking that cooling fans are operating and that air screens are clean of accumulated dust.

2 - Verification that output current meets specifications as per section 5.3. below.

5.2. TROUBLESHOOTING

The following table outlines various problems which may occur and possible causes.

Symptom	Possible Cause	Possible Solution
No display	Instrument not plugged in or switched on or power supply failure.	Check instrument is plugged into a live power source and turned on.
Display on but not responding	Display locked out by remote controller.	Remove remote controller.
Overload warning on display	Improper setup, no load connected or load connected to wrong output. Too high an input voltage. Too high an inductive load.	Check setup and that proper load is connected to correct output and that any cable used is not damaged. Check that input voltage is within required limits. Check that the load connected to the 7810 is not creating too large of an inductive feedback.
GPIB or USB bus not responding	Incorrect bus address or bus cable not connected correctly.	Check GPIB bus address is correct, and that communications cable is connected correctly and is not damaged.

Table 5-1 : Troubleshooting Guide

5.3. PERFORMANCE VERIFICATION AND CALIBRATION

Performance may be verified and calibration may be accomplished using the procedure described in this section.

5.3.1. Test Equipment Required

Test equipment of equivalent performance may be substituted from the list provided.

Description	Model
AC/DC Voltage Calibrator	Fluke 5700A
AC/DC Current Shunts with traceable calibration	Guildline 7340
Digital Voltmeter	Agilent 3458A
Various interconnection cables and adapters	

5.3.2. DC Accuracy And Stability Verification and Calibration

Connect the voltage calibrator, 7810, the reference shunt and DVM as illustrated in Figure 5-1.

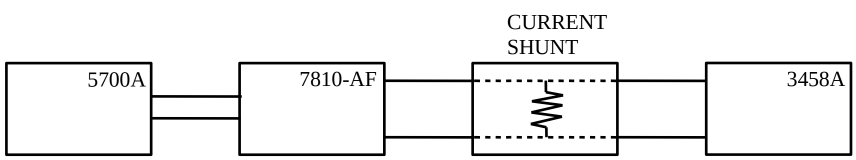

Figure 5-1 : Verification Test Set-up

Note: For proper calibration results the input must be configured in the "4-wire" mode. All four terminals must be taken independently to the calibrator such that the potential sense leads are a shielded pair and the source leads are a shielded pair. Both lead shields should be connected to the calibrator ground terminal.

Figure 5-2: Input Terminals

Refer to Table 5-2 for the reference shunt to be used for specific ranges of the 7810.

7810 Range	Reference Current Shunt (Ohms)
5 mA	7340-0.01A (100)
50 mA	7340-0.1A (10)
500 mA	7340-1A (1)
5 A	7340-10A (0.1)
50 A	7340-50A (0.01)
100 A	7340-100A (0.004)

Table 5-2 : Reference Current Shunt Selection

5.3.3. Procedural Steps For DC Current Verification

1 - Turn on the voltage calibrator, DVM and 7810 and allow the system to warm up for a minimum of 30 minutes before proceeding. Set the calibrator output range to “Locked” at the 11 V range (or the closest range higher than 5 V) so the range does not automatically switch while measurements are being taken.

2 - Attach the shunt for the 5 mA range, select 0.0 V output on the voltage calibrator and after a minimum 2 minute time interval for the system and DVM to settle, zero the display of the DVM.

3 - Select + 5 V output on the voltage calibrator and record a series of 50 samples of DVM readings over a 10 minute period allowing a few minutes for the readings to stabilize.

4 - Repeat step 3 with a selection of – 5 V for the voltage calibrator.

5 - Repeat steps 1 to 4 for each other range from 50 mA to 100 A.

6 - Enter the results onto Tables 5-3 and 5-4 taking into account specific reference shunt DC resistance values and uncertainties for the positive and negative output currents.

Note that the tolerances listed in the table include a margin for uncertainty contributions of the voltage calibrator output, the DVM measurements, and the reference shunt.

The mean test current and stability are derived from the following formulae:

Imean = Vdvm / Rcal

Istab = 2 x Vdev

Where; Vdvm is the mean of the series of 50 samples of the DVM readings.

Rcal is the DC calibrated value of the reference shunt in ohms.

Vdev is the standard deviation of the mean of the series of 50 samples of the DVM readings.

Range	Shunt DC Resistance	Mean of DVM Readings	Std. Dev. of DVM Readings	Mean Test Current	Mean Test Current Error	Test Current Stability	Test Current Error Tolerance	Current Stability Tolerance
(mA, A)	(Ohms)	(Volts)	(%)	(mA, A)	(%)	(%)	(%)	(%)
5 mA	100						0.0382	0.0035
50 mA	10						0.0382	0.0035
500 mA	1						0.0382	0.0035
5 A	0.1						0.0382	0.0035
50 A	0.01						0.0381	0.0035
100 A	0.004						0.0379	0.0035

Table 5-3 : Positive DC Verification Values

Range	Shunt DC Resistance	Mean of DVM Readings	Std. Dev. of DVM Readings	Mean Test Current	Mean Test Current Error	Test Current Stability	Test Current Error Tolerance	Current Stability Tolerance
(mA, A)	(Ohms)	(Volts)	(%)	(mA, A)	(%)	(%)	(%)	(%)
5 mA	100						0.0382	0.0035
50 mA	10						0.0382	0.0035
500 mA	1						0.0382	0.0035
5 A	0.1						0.0382	0.0035
50 A	0.01						0.0381	0.0035
100 A	0.004						0.0379	0.0035

Table 5-4 : Negative DC Verification Values

5.3.4. Procedural Steps For AC Current Verification

1 - Turn on the voltage calibrator, DVM and 7810 and allow the system to warm up for a minimum of 30 minutes before proceeding. Set the calibrator output range to "Locked" at the 11 V range (or a range higher than 5 V) so the range does not automatically switch while measurements are being taken.

2 - Attach the shunt for the 5 mA range, select 0.0 V output on the voltage calibrator and wait a minimum 2 minute time interval for the system and DVM to settle to a minimum on the display of the DVM.

3 - Select 5 Vac, 100 Hz output on the voltage calibrator and record a series of 50 samples of DVM readings over a 10 minute period allowing a few minutes for the initial readings to stabilize.

4 - Repeat step 3 with a selection of 5 Vac and frequencies of 1 kHz, 10 kHz, 50 kHz and 100 kHz for the voltage calibrator.

5 - Repeat steps 1 to 4 for each other range from 50 mA to 100.

6 - Enter the results onto Tables 5-5 to 5-8 taking into account specific reference shunt DC resistance values, AC-DC differences and uncertainties for each output current frequency point.

Note that the tolerances listed in the table include a margin for uncertainty contributions of the voltage calibrator output, the uncertainty of the DVM measurements, the uncertainty of the reference shunt calibrated values and system level uncertainties as presented in section 9.

The mean test current and stability are derived from the following formulae:

Imean = {Vdvm / Rcal} x {1 + AC-DCdiff/1,000,000}

Istab = 2 x Vdev

Where; Vdvm is the mean of the series of 50 samples of the DVM readings.

Rcal is the DC calibrated value of the reference shunt in ohms.

AC-DCdiff is the reference shunt calibrated value of the AC-DC Difference in ppm at the specified frequency.

Vdev is the standard deviation of the mean of the series of 50 samples of the DVM readings.

Range	Shunt DC Resistance	Mean of DVM Readings	Std. Dev. of DVM Readings	Mean Test Current	Mean Test Current Error	Test Current Stability	Test Current Error Tolerance	Current Stability Tolerance
(mA, A)	(Ohms)	(Volts)	(%)	(mA, A)	(%)	(%)	(%)	(%)
5 mA	100						0.075	0.009
50 mA	10						0.08	0.009
500 mA	1						0.08	0.009
5 A	0.1						0.08	0.009
50 A	0.01						0.08	0.009
100 A	0.004						0.079	0.009

Table 5-5 : 100 kHz AC Verification Values

Range	Shunt DC Resistance	Mean of DVM Readings	Std. Dev. of DVM Readings	Mean Test Current	Mean Test Current Error	Test Current Stability	Test Current Error Tolerance	Current Stability Tolerance
(mA, A)	(Ohms)	(Volts)	(%)	(mA, A)	(%)	(%)	(%)	(%)
5 mA	100						0.075	0.009
50 mA	10						0.08	0.009
500 mA	1						0.08	0.009
5 A	0.1						0.08	0.009
50 A	0.01						0.08	0.009
100 A	0.004						0.079	0.009

Table 5-6 : 1 kHz AC Verification Values

Range	Shunt DC Resistance	Mean of DVM Readings	Std. Dev. of DVM Readings	Mean Test Current	Mean Test Current Error	Test Current Stability	Test Current Error Tolerance	Current Stability Tolerance
(mA, A)	(Ohms)	(Volts)	(%)	(mA, A)	(%)	(%)	(%)	(%)
5 mA	100						0.075	0.009
50 mA	10						0.08	0.009
500 mA	1						0.08	0.009
5 A	0.1						0.08	0.009
50 A	0.01						0.08	0.009
100 A	0.004						0.079	0.009

Table 5-7 : 10 kHz AC Verification Values

Range	Shunt DC Resistance	Mean of DVM Readings	Std. Dev. of DVM Readings	Mean Test Current	Mean Test Current Error	Test Current Stability	Test Current Error Tolerance	Current Stability Tolerance
(mA, A)	(Ohms)	(Volts)	(%)	(mA, A)	(%)	(%)	(%)	(%)
5 mA	100						0.175	0.018
50 mA	10						0.18	0.018
500 mA	1						0.18	0.018
5 A	0.1						0.18	0.018
50 A	0.01						0.18	0.018
100 A	0.004						0.179	0.018

Table 5-8 : 30 kHz AC Verification Values

Range	Shunt DC Resistance	Mean of DVM Readings	Std. Dev. of DVM Readings	Mean Test Current	Mean Test Current Error	Test Current Stability	Test Current Error Tolerance	Current Stability Tolerance
(mA, A)	(Ohms)	(Volts)	(%)	(mA, A)	(%)	(%)	(%)	(%)
5 mA	100						0.501	0.018
50 mA	10						0.506	0.018
500 mA	1						0.506	0.018
5 A	0.1						0.506	0.018
50 A	0.01						0.506	0.018
100 A	0.004						0.507	0.018

Table 5-9 : 100 kHz AC Verification Values

6. REMOTE CONTROL

The 7810 Transconductance Amplifier operates directly from the user interface or under remote control of an external instrument controller, computer or terminal. Remote control can be interactive, with the user controlling each step from a terminal, or under the control of a computer running the 7810 in an automated system.

This chapter describes the interfaces and the commands to which the 7810 will respond.

6.1. INTERFACES

The model 7810 has two external interfacing standards available through the use of the remote pass through on the tablet PC:

A parallel interface conforming to IEEE-488.2 (included/default).
A USB interface.

The IEEE-488 is implemented through connecting a USB/GPIB adapter to the embedded PC.

The RS-232C is implemented through connecting a USB/RS-232C adapter to the embedded PC.

The 7810 can only be operated via one of the interfaces at a time.

6.2. IEEE-488 (GPIB) INTERFACE

The 7810 is fully programmable for use on the IEEE standard 488.1 interface bus (also known as the General Purpose Interface Bus (GPIB)). The interface is also designed in compliance with the supplemental standard IEEE-488.2. Devices connected to the bus in a system are designated as talkers, listeners, talker/listeners, or controllers. The 7810 can be operated on the IEEE-488 bus as a talker or under the control of an instrument controller as a talker/listener.

This manual assumes that the user is familiar with the basics of the IEEE-488 interface bus.

The IEEE-488 interfacing standard applies to the interface of instrumentation systems or portions of them, in which:

1. The data exchanged among the interconnected apparatus is digital.
2. The number of devices that may be interconnected by one contiguous bus does not exceed 15.
3. The total transmission path lengths over the interconnecting cables does not exceed the lesser of either 20 meters or 2 meters times the number of devices on the bus.
4. The data rate across the interface on any signal line does not exceed 1 megabit per second.

6.2.1. Controller

There can be only one designated controller in charge on the IEEE-488 bus. This device exercises overall bus control and is capable of both receiving and sending data. The rest of the devices can be designated as listener, talker or talker/listener.

The controller can address other devices and command them to listen, address one device to talk and wait till the data is sent. Data routes are set by the controller but it needs not take part in the data interchange.

All controller query and command sequences should be terminated with the line-feed character (0x0A) and/or optionally, the controller should assert the EOI data byte control signal.

6.2.2. IEEE-488 Responses

The reply to any IEEE-488 query command will be a sequence of ASCII characters followed by a line-feed character (0x0A). The line-feed character may also be expressed as 0A16 or 1010 or 128 or Ctrl-J. Throughout this manual we will use the "C" programming language notation for expressing numbers in base 16, specifically 0x0A indicates that 0A is to be interpreted in base 16 (hex).

6.2.3. Interconnecting Cable And IEEE-488 Connector

The interconnecting cable of IEEE-488 1978 consists of 24 conductors, 16 conductors are for carrying signals and 8 for grounding. An individual cable assembly may be up to 4 meters long and should have both a plug and a receptacle connector type at each end of the cable. Each connector assembly is fitted with a pair of captive locking screws.

6.2.4. Typical System

Data Input/Output Lines - The 8 data I/O lines form the data bus over which data between the various devices is transmitted under the supervision of the controller. The message bytes are carried on Data I/O signal lines in a bit parallel byte serial form, asynchronously and generally in a bi-directional manner.

Handshake or Data Byte Control - The three interface signals are used to effect the transfer of each byte of data on the DIO signal lines from a talker or controller or one or more listeners.

1. DAV (DATA VALID) is used to indicate the condition of (availability and validity) information on the DIO signal lines.
2. NDAC (NOT DATA ACCEPTED)
3. NRFD (NOT READY FOR DATA) is used to indicate the condition of readiness of devices to accept data.

4. SRQ (SERVICE REQUEST) is used by a device to indicate the need for attention and to request an interruption of the current sequence of events.
5. REN (REMOTE ENABLE) is used (by a controller) in conjunction with other messages to select between two alternate sources of device programming data.
6. EOI (END OR INDENTIFY) is used (by a talker) to indicate the end of a multiple byte transfer sequence or in conjunction with ATN (by a controller) to execute a polling sequence.
7. ATN (ATTENTION)
8. IFC (INTERFACE CLEAR)

6.2.5. Address And Talk/Listen Selection

The IEEE-488 Address and Talk/Listen status can be set using the front panel controls as directed by the operator menu system.

If there is no controller and the 7810 is hooked up to a printer for hard copy, then Talk Only mode should be selected as the preferred mode of operation.

6.2.6. IEEE-488 Electrical Interface

The 7810 meets the subsets of the IEEE-488 interface specification IEEE-488.1 shown in Table 6-1. The pin connections on the IEEE-488 interface connector are shown in Table 6-2.

Source Handshake	SH1	complete source handshake capabilities.
Acceptor Handshake	AH1	complete acceptor handshake capabilities.
Talker	T5	has a talker capability with a single primary address in the range 0 to 30. Extended addressing is not implemented. Talk only.
Listener	L4	supports basic listener with unaddressed if MTA(My Talk Address) is received. The talk and listen addresses will always be the same. Does not support extended listen addresses. Does not support Listen Only.
Service Request	SR1	complete service request generation capabilities.
Remote Local	RL1	all functions on the front panel can be locked out by the IEEE-488 controller.
Parallel Poll	PP0	no parallel poll capabilities.
Device Clear	DC1	full device clear capabilities.
Device Trigger	DT0	no device trigger capabilities.
Controller	C0	can never become the bus controller.
Electrical Interface	E2	all required electrical interface capability.

Table 6-1 : IEEE-488 Device Capabilities

PIN	NAME	DESCRIPTION
1	DIO1	Data Input Output Line 1
2	DIO2	Data Input Output Line 2
3	DIO3	Data Input Output Line 3
4	DIO4	Data Input Output Line 4
5	EIO	End or Identify
6	DAV	Data Valid
7	NRFD	Not Ready for Data
8	NDAC	Not Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	Screening on Cable (connected to safety ground)
13	DIO5	Data Input Output Line 5
14	DIO6	Data Input Output Line 6
15	DIO7	Data Input Output Line 7
16	DIO8	Data Input Output Line 8
17	REN	Remote Enable
18	GND6	Ground wire of twisted pair with DAV
19	GND7	Ground wire of twisted pair with NRFD
20	GND8	Ground wire of twisted pair with NDAC
21	GND9	Ground wire of twisted pair with IFC
22	GND10	Ground wire of twisted pair with SRQ
23	GND11	Ground wire of twisted pair with ATN
24	GND	Logic Ground

Table 6-2 : IEEE-488 Pin Designations

6.2.7. IEEE-488 Input Buffering

The IEEE-488 input buffer is 256 bytes long. The input full bit is set when the buffer is above 75 % full (64 bytes remaining), hence if the programmer limits messages sent to the 7810 to 32 bytes and checks the IFL bit in the status register before sending each message, then under normal operating conditions the buffer should never overflow. If the buffer is full and the programmer sends more data, the 7810 will perform the necessary handshaking as per usual, but the data will be lost. This is done for two reasons:

If the buffer is full, the fault must have originated with the controller, since the 7810 interprets most commands in fewer than 15 milliseconds. This also prevents the 7810 from locking up the IEEE-488 bus.

6.2.8. IEEE-488 Output Buffering

Output from query commands are placed into a 256 byte output buffer. When the controller reads data from the 7810 the responses will come from the output buffer in first-in first-out order. If for some reason the controller does not read the responses from its query commands the output buffer will overflow, in this case the first data into the buffer will still be valid and the later data will be lost. When output data is lost the query error bit in the status register will be set. When the output buffer is not empty then the message available (MAV) bit will be set in the status register.

6.2.9. IEEE-488 Deadlock

If the controller demands a byte of data from the 7810 and the buffer is empty, the 7810 will set the Query Error flag in the Event Status Register.

6.3. RS-232C INTERFACE

The 7810 can optionally have an RS-232C interface which can be connected to a controller or to a simple printer. The controller (which can be almost any computer with an RS-232C interface) can control the 7810 through a variety of commands which allow setting the instrument’s operating parameters, and analysing the measurements made by the 7810. The simple printer interface can be used to log any or all of the measurements taken by the 7810 during normal operation.

When using the RS-232C port to remotely control the 7810, either interactively with a terminal or under computer control, operation is the same as using an IEEE-488 controller connected to the IEEE-488 port for control, with the following exceptions:

1. The program message terminator is Carriage Return (0x0D).
2. There is no SRQ capability when using serial remote control. The status registers still behave as described in this chapter, but the 7810 serial interface does not have a way to perform the SRQ function.
3. There is no direct way to perform IEEE-488 hardware interface functions such as DCL (Device Clear) or SDC (Selected Device Clear).

Pin		Function	Direction
1	CHG	Chassis Ground	IN/OUT
2	TxD	Transmit Data	IN
3	RxD	Receive Data	OUT
4	RTS	Request To Send	IN
5	CTS	Clear To Send	OUT
6	DSR	Data Set Ready	OUT
7	GND	Signal Ground	IN/OUT
8	DCD	Data Carrier Detect	OUT
20	DTR	Data Terminal Ready	IN
All other pins not used or connected			

Table 6-3 : RS232 Pin Designations

The 7810 Transconductance Amplifier is a data communication equipment (DCE) so TxD is an input (the data which the modem is to transmit).

6.3.1. RS-232C Responses

The reply to any RS-232C query command will be a sequence of ASCII characters followed by a Carriage-Return character (0x0D) and then a Line-Feed character (0x0A). The Line-Feed character may also be expressed as 0A16 or 1010 or 128 or Ctrl-J. Throughout this document we will use the "C" programming language notation for expressing numbers in base 16, specifically 0x0A indicates that 0A is to be interpreted in base 16 (hex).

6.4. COMMAND LANGUAGE

The commands for IEEE-488 and RS-232C mainly correspond to the labels assigned to the front panel menus. Throughout this document when examples are given they apply to commands through the RS-232C interface or through the IEEE-488 interface. The examples will not show the termination characters since these differ for each of the interfaces (See sections 0. and 0.).

6.4.1. General Syntax For Commands

The 7810 uses a sophisticated command parser which can usually determine which command was desired, even if the command is entered incorrectly. Some care should be taken when sending commands such as SYSTem:VERBose and SYSTem:VERSion? since the parser may not be able to decide which command was desired in the event of a gross misspelling (such as using VERBion instead of VERSion).

No command used in the 7810 has an embedded space in its name, spaces (0x20) are used only to separate command names from their parameters.

The comma "," must delimit all multiple arguments used in a command sequence.

Throughout this manual some of the command names will have an UPPER case portion and a lower case portion. The command may be shortened such that only the portion of the command name which was presented in UPPER case characters is present. The command parser of the 7810 is case insensitive (i.e. the letter case of commands sent to the 7810 does not matter), both UPPER case letters and lower case letters may be used.

6.4.2. General Syntax For Numbers

Numeric parameters may have up to 30 characters, and although the 7810 will accept numeric parameters in the range ±2.2E-308 through ±1.8E308, the useful range of numbers is between ±1.0E-8 and ±1.0E5.

The portion of the command parser which interprets numeric input will correctly recognize most common forms of numeric input, for example the following are all valid methods of expressing the number 123.4:

123.4
123.4e00
0.1234E3
1234e-1
0000123.4

The following are examples of invalid forms of expressing a number:

123.4 e00	space between mantissa and exponent letter
1234D-1	exponent not e or E
n123.4	letter in front of the first digit
e34	missing mantissa

Multipliers (such a µ, m, k, and M) are not permitted on commands, all numbers must be entered in the base units, for example 100 mV can be expressed as 100e-3 or 0.100. Expressions (for example 7 + 20 X 3) are not allowed as parameters.

6.5. REMOTE AND LOCAL OPERATION

The 7810 can be operated using the front panel keys or it can be operated remotely using a remote controller. In addition, the 7810 can be placed in a local lockout condition at any time by a command from the controller. When combined, the local, remote, and lockout conditions yield four possible operating states:

6.5.1. Local

The 7810 responds to local and remote commands. This is also called "Front Panel Operation". Only remote commands that do not affect the state of the 7810 are allowed to execute. (For example, the command Voltage? is allowed to operate but the command Range 50.0 which would change the instrument state is not allowed.) If the controller sends a command which would affect the instrument's state while in local, the command will be ignored, and no error indication will be given.

6.5.2. Local With Lockout

Local with lockout is identical to Local except that the 7810 will go into remote with lockout instead of the remote state when the 7810 receives a remote command. The local with lockout state is entered by sending an IEEE-488 LLO+REN command from the controller, or by sending the RS232 LOCKOUT command to the 7810.

6.5.3. Remote

When the Remote Enable (REN) line is asserted and the controller addresses the 7810 as a listener, the 7810 enters the remote state.

Front panel operation is restricted to the use of the <Escape> key. Pressing the <Escape> key or sending the GTL (Go To Local) interface message returns the 7810 to the local state.

6.5.4. Remote With Lockout

The remote with lockout state can be entered from remote or local with lockout, but not directly from local. Remote with lockout is similar to the remote state but restricted: the <Escape> key will not return to the local state. To return the 7810 to the local with lockout state the controller must send a GTL interface command. To return the 7810 to the local state the controller must un-assert the REN control line. Table 6-4 summarizes the possible Remote/Local state transitions.

From	To	IEEE-488 Interface Command	RS-232C Interface Command
Local	Remote	MLA + REN	REMOTE
	Local / Lockout	LLO + REN	LOCKOUT
Remote	Local	GTL	LOCAL
	Remote / Lockout	LLO + REN	LOCKOUT
Local / Lockout	Remote / Lockout	MLA + REN	REMOTE
Remote / Lockout	Local	Not (REN)	LOCAL
	Local / Lockout	GTL	None

Table 6-4 : Remote/Local State Transitions

6.6. PROGRAMMING COMMAND SUMMARY

A brief description of each of the possible remote RS232 and IEEE-488 commands and their syntax in BNF (Backus Naur Form) follows:

words inside angle brackets (i.e. <digit>) are defined items

:== means "is defined to be"

{|} means "or"

words inside square brackets (i.e. [+]) means optional

Required letters are shown in upper case but may be upper or lower case.

```
<d>        :== {0|1|2|3|4|5|6|7|8|9}
<l>        :== {A|B|C|...|Z|a|b|c|...|z}
<s>        :== {<l> | <l><s>}
<b>        :== {0|1}
<u>        :== {<d> | <d><u>}
<n>        :== [{+|-}]<u>
<f>        :== <n>[.[<u>]][E<n>]
<?>        :== {<l> | <d>}
<*>        :== {<?> | <?><*>}       (not to be confused with  *)
<DD>       :== <u>                  (limited to range 1...31)
<MM>       :== <u>                  (limited to range 1...12)
<YYYY>     :== <u>                  (limited to ranges 0...38, 70...99 and 1970...2038)
<hh>       :== <u>                  (limited to range 0...23)
<mm>       :== <u>                  (limited to range 0...59)
<ss>       :== <u>                  (limited to range 0...59)
```

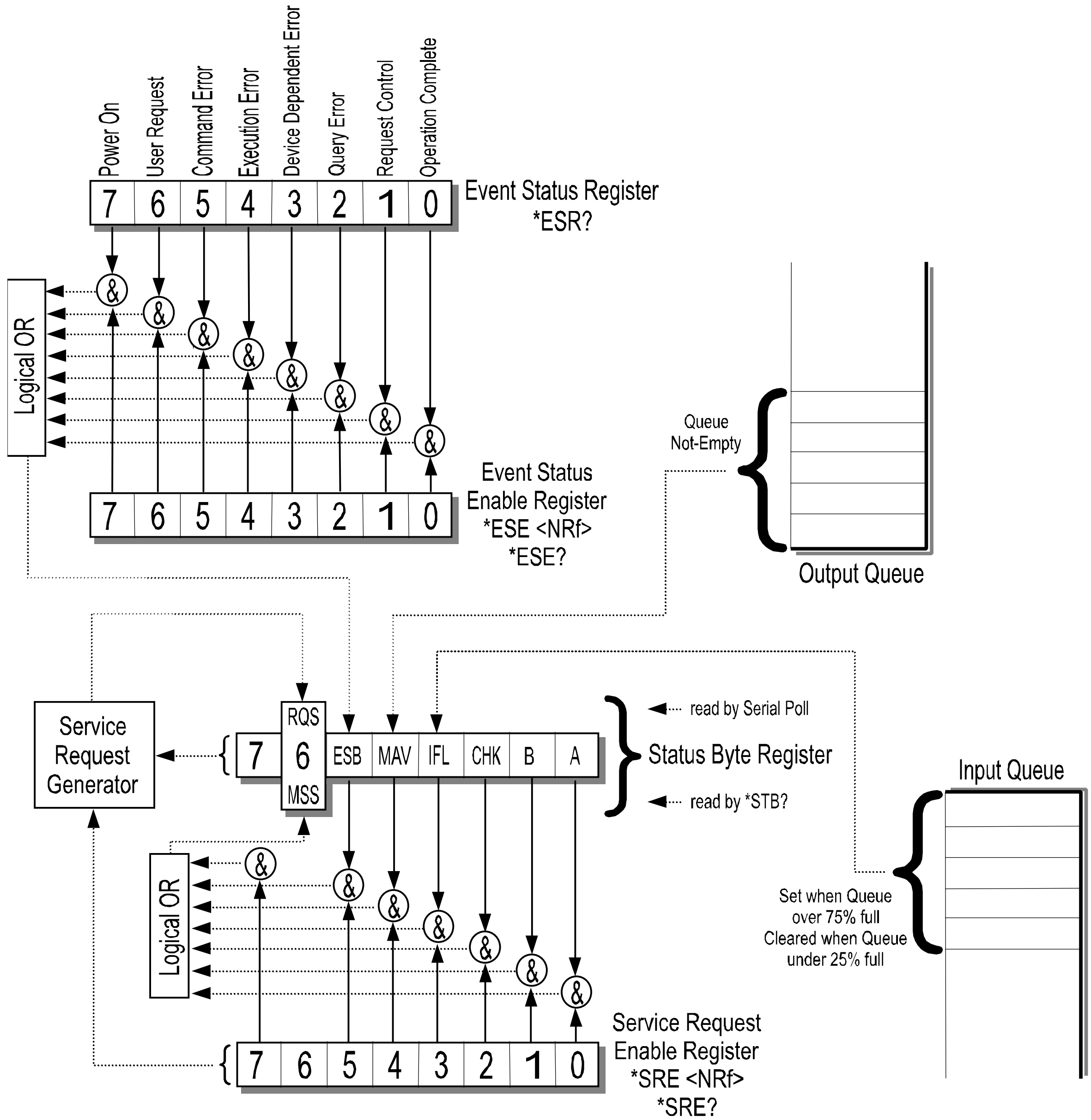

Figure 6-1 : Event Status Bit Operation

6.7. REMOTE COMMANDS

This section details all the valid commands which may be sent over either the IEEE-488 or the RS-232C interface port. The responses listed below are the verbose response.

If the numeric parameter to the command is missing or unrecognizable the CME (CoMmand Error) bit in the Event Status Register (see Figure 6-1) will be set. If the unrecognizable command was sent over the RS-232C interface, the 7810 will respond with “Unrecognized Command”.

If the numeric value is out of range then the EXE (EXecution Error) bit will be set for a program data element out of range error. If the out of range value was sent over the RS-232C interface, the 7810 will respond with “Invalid Parameter”.

Unless otherwise indicated, the terse response is that portion of the response printed in bold.

6.7.1. *CLS - Clear Status Command

This command clears all Event Status Registers summarized in the status byte register. All queues, except the Output Queue, that are summarized in the status byte register are emptied. The 7810 is forced into the Operation Complete Idle State and the Operation Complete Query Idle state.

6.7.2. *ESE <u> - Set Event Status Enable Register

This command sets the standard event status enable register bits. When the bits in the Event Status Enable (ESE) register are "ANDed" with the bits in the Event Status Register (ESR) if the result is non-zero then the Event Status Bit (ESB) in the Status Byte (STB) register is set.

The values accepted for the *ESE command are between 0 and 255, all other values are considered to be an error. The default value for the Event Status Enable (ESE) register at power on is zero (0).

6.7.3. *ESE? - Event Status Enable Query

This command reports the current value of the Event Status Enable Register. The value returned will be between 0 and 255.

6.7.4. *ESR? - Event Status Register Query

This query allows the programmer to determine the current contents of the event status register. Reading the Event Status Register clears it.

BIT LOCATION		NAME	DESCRIPTION
0	LSB	OPC	OPeration Complete - This event bit is generated in response to the *OPC or *OPC? command. It indicates that the 7810 has completed any pending operations and that the parser is ready to accept more program messages.
1		RQC	ReQuest Control - This event bit indicates to the GPIB controller that the 7810 is requesting permission to become the controller in charge. The 7810 will NEVER set this bit.
2		QYE	QuerY Error - This bit indicates that an attempt is being made to read data from the output queue when no output is either present or pending, or that data in the output queue has been lost (queue overflow). See also GPIB Deadlock.
3		DDE	Device Dependent Error - Not used.
4		EXE	EXecutive Error - Set when 1) a program data element is evaluated to be outside the legal input range or is inconsistent with the 7810's capabilities; 2) a valid program message could not be properly processed.
5		CME	CoMmand Error - Set when 1) a syntax error has been detected by the parser; 2) a semantic error has occurred indicating that an unrecognized header has been received; 3) a Group Execute Trigger was entered into the input buffer inside of a program message.
6		URG	User Request - Set when any key is depressed on the 7810 keyboard.
7	MSB	PON	Power On - This bit is set after the 7810 is powered up.

Table 6-5 : Event Status Register

BIT LOCATION		NAME	DESCRIPTION
0	LSB	TIME	System Time has Changed - This bit is set once each second as the real time clock ticks, and is cleared by the execution of the TIme? command.
1		OLD	OverLoaD - This bit is set when operation of the unit is attempted outside its limits.
2		CHK	Checksum Computation Complete - This bit is set once, after instrument power on and the completion of the computation of the ROM checksum and is cleared by the RomChecksum? command.
3		IFL	Input full - This bit is set when the input queue is over 75 % full and cleared when the queue drops below 25 % full.
4		MAV	Message AVailable - This bit is set when the output queue is not empty.
5		ESB	Event Status Bit - This bit is set when the result of a bitwise AND of the Event Status Register and the Event Status Enable Register is not zero.
6		RQS	Request for Service - This bit is set when the result of a bitwise and of the Status Byte Register and the Service Request Enable Register is not zero.
7	MSB	Spare	reserved for future expansion.

Table 6-6 : Status Byte Register

6.7.5. *IDN? - Identification Query

This command causes the 7810 to reply with an identification string. The identification string is built up of four (4) fields delimited by commas (,). The first field is the manufacturer (i.e. Guildline Instruments), the second field is the model (i.e. 7810), the third field is the serial number (i.e. 72065), and the final field is the firmware revision (i.e. A). A typical response might read:

Guildline Instruments, 7810, 72065, A

The reply string will be shorter than 73 characters.

6.7.6. *OPC - Operation Complete

This command will cause the 7810 to set the Operation Complete bit (bit 0) in the Event Status Register. Since the 7810 processes all commands sequentially, the operation complete bit will be set as soon as the command is parsed.

6.7.7. *OPC? - Operation Complete Query

This query will place a numeric 1 in the output buffer indicating that all pending operations are complete.

6.7.8. *OPT? - Report Available Options

This query command reports the presence or absence of various options. The format of the reply is a series of arbitrary ASCII response fields separated by commas. The 7810 will always report the value 0.

6.7.9. *RST - Device Reset

This command is intended to return the 7810 to a known state, specifically a return to terse mode. This command will not affect the following:

1. The output queue.
2. The state of the IEEE-488 interface.
3. The selected address of the 7810.
4. The *SRE setting.
5. The *ESE setting.

The *RST command will perform the following actions:

Clear the key-press buffer.

Make remote responses terse.

Set the 5 mA current output range.

*RST is a MANDATORY IEEE-488.2 command.

6.7.10. *SRE <u> - Service Request Enable Command

The service request enable command allows the 7810 to generate a service request on the IEEE-488 interface under a limited set of conditions. The limitations on the conditions are defined by the numeric parameter following the *SRE command. The numeric parameter is a decimal integer in the range 0-255. The numeric parameter when expressed in base 2 (binary) represents the bit values of the Service Request Enable Register. For all bits (except bit 6) a bit value of one (1) indicates an enabled condition and a bit value of zero (0) represents a disabled condition. *SRE? is the companion query command.

6.7.11. *SRE? - Service Request Enable Query

This command allows a programmer to determine the current contents of the Service Request Enable Register. A decimal number between 0 and 63 or between 128 and 191 will be returned.

6.7.12. *STB? - Status Byte Query

This command allows the programmer to read the status byte and master summary bits (shown in Table 6-6.).

The response from this command is a decimal integer in the range 0-255. This decimal integer when expressed in base 2 (binary) represents the bit values in the Status Byte Register. Note that the Master Summary Status bit and Not RSQ is reported in bit 6.

The Status Byte Register can also be read with the Read Serial Poll hardware command on the IEEE-488 interface.

This Register can be read by Serial Poll or by the *STB? command.

6.7.13. *TST? - Query Results Of Self Test

This command is intended to report the status of any self-tests performed by the 7810. If the 7810 passes all of its self-tests then the reply will be 0.

The possible failure codes are the sum of:

1 Non-volatile memory failure

2 ROM checksum failure

4 Power supply failure

6.7.14. *TRG - Group Execute Trigger

This command performs the same action as a group execute trigger on the GPIB interface. Since the 7810 is not capable of starting any action on command, this command will set the execution error bit in the event status register (bit 4).

6.7.15. Date? - Display The 7810 Internal Date

This command will report the date maintained in the system real time clock in the terse format:

YYYY/MM/DD

or if verbose mode is enabled:

Date YYYY/MM/DD

where YYYY, MM and DD are the year, month and day respectively.

6.7.16. DER? - Device Error Register

This command will report the status of the Device Error Register. The meanings of the bits in the Device Error Register are shown in Table 6-7.

In verbose mode the response will be:

Device Error Register 2

and in terse mode the response will be:

2

where the number (2) will change to reflect the actual contents of the Device Error Register.

BIT LOCATION		NAME	DESCRIPTION
0	LSB	ALO	AnaLogue Overload - This bit is set to indicate that the 7810 has detected an analogue overload condition (Input voltage >100 % fsc).
1		COV	Compliance Over Voltage - This bit is set when the amplifier compliance voltage capability has been exceeded.
2		OLB	OverLoad Bypass - This bit is set when the overload bypass switch is engaged by the operator of the 7810.
3		OLR	OverLoad Relay - This bit is set when the overload relay is engaged by the 7810 when either: (Input voltage >100 % fsc and OLB is not set) or (Input voltage >200 % fsc)
4		Spare	reserved for future expansion.
5		Spare	reserved for future expansion.
6		Spare	reserved for future expansion.
7	MSB	Spare	reserved for future expansion.

Table 6-7 : Device Error Register

6.7.17. Operate – Set The Operation State

This command changes the active state of operation. For example, the command:

Operate 1

will enable output current range based on the input voltage and sensitivity selection.

Only a value of 0 or 1 may be specified:

(0, 1)

Where 0 disables operation, and 1 enables operation.

If the numeric parameter to the command is missing or not recognized, the CME (CoMmand Error) bit in the Event Status Register will be set. If the numeric value is not 1 or 0 (i.e. > 2) then the EXE (EXecution Error) error bit will be set for a program data element out of range.

6.7.18. Operate? - Display The Current Operation State

This query command displays the value of the current operation state. In verbose mode the reply will be:

Operate 1

or in terse mode the reply will be:

1

where the value 1 is dependent upon the current operation state.

6.7.19. Range - Select Output Current Range

This command changes the currently selected output range. For example, the command:

Range 100A

will select the 100A output current range where the value 100 is dependent on the range desired.

Any value from the list below can be specified, as the instrument has only a limited set of ranges available:

(5 mA, 50 mA, 500 mA, 5 A, 50 A, 100 A)

After a Range command has been executed care should be taken to ensure that the range desired has actually been selected.

If the numeric parameter to the command is missing or not one of the above values, the CME (CoMmand Error) bit in the Event Status Register will be set. If the numeric value is out of range (i.e. > 100A) then the EXE (EXecution Error) error bit will be set for a program data element out of range.

6.7.20. Range? - Display The Currently Selected Range

This query command displays the value of the currently selected range. In verbose mode the reply will be:

Range 50A

or in terse mode the reply will be:

50A

where the value 50A is dependent upon the current range selected.

6.7.21. SInce? - Display The Time The 7810 Was Last Reset

This query command will display the date and time at which the 7810 was last powered up (or reset). The verbose reply will be:

SInce Thurs June 2, 10:55:22 1988

or in terse mode:

Thurs June 2, 10:55:22 1988

where the date displayed will depend upon the startup date. Under normal conditions the 7810 should be able to operate for months or years without a reset, therefore this command reflects when the last power failure occurred.

6.7.22. Serial Number - Set The 7810 Serial Number

This command accepts an integer in the range 0 to +200 000. This number will be reported in the serial number field of the *IDN? command.

6.7.23. TErse - Turn Off Verbose Mode

This is the default mode for the 7810 after reset. Typically query commands will return very little extraneous information in terse mode.

For example, the command:

TErse

will place the 7810 into terse mode.

6.7.24. UPtime? - Display How Long The 7810 Has Been Running

This query command will reply with the number of seconds since the last power failure (or reset). In verbose mode the response will be:

UPTIME 234 61 SECONDS

and in the terse mode the response will be:

234 61

where the number 234 61 will change to reflect the actual up time. Note: The number of seconds can get quite large, as large as 231 - 1 = 214 748 364 7, however the number of seconds in a year is only 31,557,600 hence it will take nearly 70 years to overflow this number.

6.7.25. VErbose - Set Verbose Mode

The VErbose command causes the output of all subsequent commands to contain additional information. This mode should be used for determining problems with programs and when the instrument is being used interactively.

For example, the command:

VErbose

will place the 7810 into verbose mode.

6.7.26. Volt - Select The Input Voltage Range

This command changes the currently selected input voltage range. For example the command:

Volt 5V

will select the 5V input range where the value 5 is dependent on the range desired. Only 1V or 5V values can be specified as the instrument has only a limited set of ranges available.

After a Volt command has been executed care should be taken to ensure that the range desired has actually been selected.

If the numeric parameter to the command is missing or not recognized, the CME (CoMmand Error) bit in the Event Status Register will be set. If the numeric value is out of range (i.e. > 55 V) then the EXE (EXecution Error) error bit will be set for a program data element out of range error.

6.7.27. Volt? - Display The Current Input Voltage Range

The Volt? command will report the currently selected voltage range. In verbose mode the response will be:

5V

and in the terse mode the response will be:

5

where the number will change to reflect the actual input voltage range.

6.7.28. Programming Hints

In general, a simple way to get this instrument to respond is to select a voltage range, or to set an output range, by using the KEY command (see Section 6.7.18.) and sending the same keystrokes that would be used from the front panel. This technique allows the system operator to easily try out the command sequences from the front panel before coding the necessary controller routines.