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# 71M6543

Polyphase Energy Meter IC  
DEMO BOARD REV 4.0 and 5.0

## USER'S MANUAL

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# 1 GETTING STARTED

## 1.1 GENERAL

The Teridian™ 71M6543 REV 4.0 and REV 5.0 Demo Boards are demonstration boards for evaluating the 71M6543F device for polyphase electronic power metering applications in conjunction with the Remote Sensor Interface or CT sensors. The Demo Boards allow the evaluation of the 71M6543F energy meter chip for measurement accuracy and overall system use.

The 71M6543 REV 4.0 Demo Board incorporates a 71M6543F integrated circuit, three 71M6103 or 71M6203 Remote Interface ICs, peripheral circuitry such as a serial EEPROM, emulator port, and on-board power supply, as well as a USB interface for serial communication with a PC.

The 71M6543 REV 5.0 Demo Board is optimized and prepared for the connection of external CTs and is otherwise identical to the REV 4.0 Demo Board.

All Demo Boards are pre-programmed with a Demo Program (Demo Code) in the FLASH memory of the 71M6543F IC. This embedded application is developed to exercise all low-level function calls to directly manage the peripherals, flash programming, and CPU (clock, timing, power savings, etc.).

The 71M6543F IC on the REV 4.0 Demo Board is pre-programmed and pre-calibrated for the 50  $\mu\Omega$  or 120  $\mu\Omega$  shunts shipped with the board. The Demo Board may also be used for operation with a CT after hardware modifications that can be performed by the user. This configuration will require a different version of the Demo Code and different settings. It should be noted that the 71M6543 performs better with CTs when used with the 71M6543 REV 5.0 Demo Board.

## 1.2 SAFETY AND ESD NOTES

Connecting live voltages to the demo board system will result in potentially hazardous voltages on the demo board.



**THE DEMO SYSTEM IS ESD SENSITIVE! ESD PRECAUTIONS SHOULD BE TAKEN WHEN HANDLING THE DEMO BOARD!**



**EXTREME CAUTION SHOULD BE TAKEN WHEN HANDLING THE DEMO BOARD ONCE IT IS CONNECTED TO LIVE VOLTAGES! BOARD GROUND IS CLOSE TO LIVE VOLTAGE!**

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## 1.3 DEMO KIT CONTENTS

- 71M6543 Demo Board REV 4.0 with three 71M6203 or 71M6103 ICs and one 71M6543F IC with pre-loaded demo program, or 71M6543 Demo Board REV 5.0 with inputs configured for CTs.
- 5VDC/1,000mA universal wall transformer with 2.5mm plug (Switchcraft 712A compatible)
- USB Interface Module (USB/Serial Adapter)
- USB cable
- ANSI base with three 50  $\mu\Omega$  shunt resistors, Oswell P/N EBSB20050H-92-19-73-6.4-V1 (optional, for ANSI kits only)
- Three 120  $\mu\Omega$  shunt resistors, Oswell P/N EBSA15120-32-14.8-21-6.2-V1 (optional, for IEC kits)

## 1.4 DEMO BOARD VERSIONS

The following versions of the Demo Board are or have been available:

- 71M6543 Demo Board Rev 1.0 (CTs only) - **discontinued**
- 71M6543 Demo Board Rev 2.0 (CTs or 71M6103 Remote Sensor Interface ICs on daughter boards) - **discontinued**
- 71M6543 Demo Board Rev 3.0 (71M6103 Remote Sensor Interface ICs) - **discontinued**
- 71M6543 Demo Board Rev 4.0 (71M6103 Remote Sensor Interface ICs)
- 71M6543 Demo Board Rev 5.0 (CTs or 71M6103 Remote Sensor Interface ICs)

This manual applies to **71M6543 Rev 4.0 and Rev 5.0** only. For the earlier Demo Board revisions please see their respective manuals.

## 1.5 COMPATIBILITY

This manual applies to the following hardware and software revisions:

- 71M6543F IC revision B02.
- Demo Code revision 5.4F or later
- 71M6543 Demo Board Rev 4.0 or Rev. 5.0

## 1.6 SUGGESTED EQUIPMENT NOT INCLUDED

For functional demonstration:

PC with Microsoft Windows<sup>®</sup> versions Windows XP<sup>®</sup>, ME, or 2000, equipped with RS-232 port (COM port) via DB9 connector

For software development (MPU code):

Signum ICE (In Circuit Emulator): ADM-51

[www.signum.com](http://www.signum.com)

Signum WEMU51 version 3.11.09 or later should be used. Using a USB isolator between PC and the Signum ADM-51 is strongly recommended

Keil 8051 "C" Compiler kit: CA51

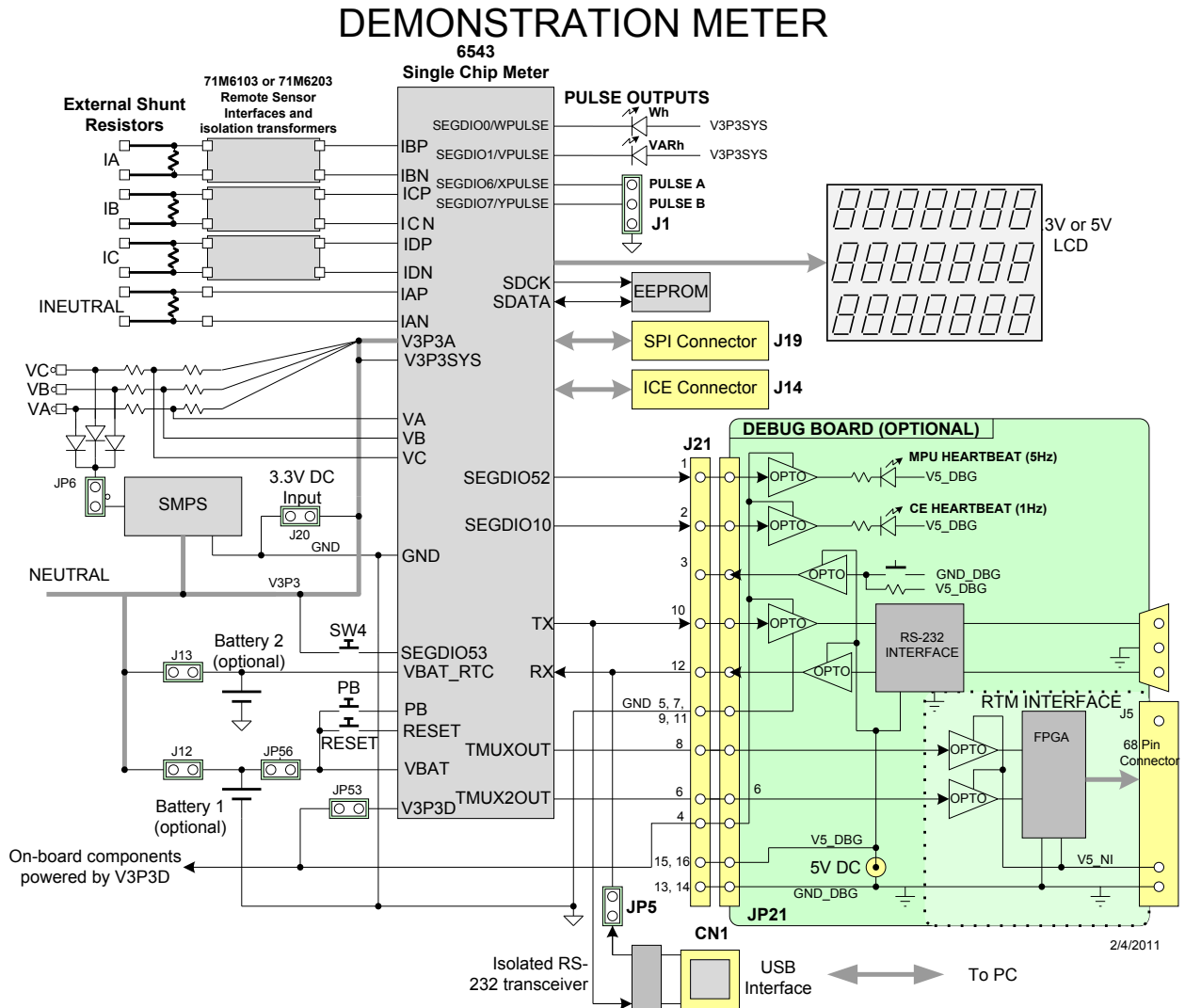
[www.keil.com/c51/ca51kit.htm](http://www.keil.com/c51/ca51kit.htm), [www.keil.com/product/sales.htm](http://www.keil.com/product/sales.htm)

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## 1.7 DEMO BOARD TEST SETUP

Figure 1-1 shows the basic connections of the Demo Board REV 4.0 plus optional Debug Board with the external equipment. The PC should be connected via the USB Interface (CN1). Communication can also be established via the optional Debug Board, but this board is not part of the Demo Kit.

For stand-alone testing (without AC voltage) the Demo Board maybe powered via the 5.0 VDC input (J20). The optional Debug Board must be powered with its own 5 VDC power supply.



**Figure 1-1: Teridian 71M6543 REV4.0 Demo Board with Debug Board: Basic Connections**

The Demo Board contains all circuits necessary for operation as a meter, including display, calibration LEDs, and internal power supply. The optional Debug Board uses a separate power supply, and is optically isolated from the Demo Board. It interfaces to a PC through a 9 pin serial port connector.



**It is recommended to set up the demo board with no live AC voltage connected, and to connect live AC voltages only after the user is familiar with the demo system.**



**All input signals are referenced to the V3P3A (3.3V power supply to the chip).**

## 1.7.1 POWER SUPPLY SETUP

There are several choices for the meter power supply:

- Internal (using the AC line voltage). The internal power supply is only suitable when the voltage exceeds 100V RMS. To enable the internal supply, a jumper needs to be installed across JP6 on the top of the board.
- External 5.0 VDC connector (JP20) on the Demo Board.

## 1.7.2 CABLES FOR SERIAL COMMUNICATION

**It is recommended to use the USB connection to communicate with the Demo Code.** The optional Debug Board is not normally shipped with the Demo Kit and requires a serial port (DB9) on the PC along with a separate power supply.

### 1.7.2.1 USB Connection

A standard USB cable can be used to connect the Demo Board to a PC running HyperTerminal or a similar serial interface program. A suitable driver, e.g. the FTDI CDM Driver Package, must be installed on the PC to enable the USB port to be mapped as a virtual COM port. The driver can be found on the FTDI web site (<http://www.ftdichip.com/Drivers/D2XX.htm>).

See Table 3-1 for correct placement of jumper JP5 depending on whether the USB connection or the serial connection via the optional Debug Board is used.

### 1.7.2.2 Serial Connection (Optional)

For connection of the DB9 serial port of the Debug Board to a PC serial port (COM port), either a straight or a so-called "null-modem" cable may be used. JP1 and JP2 are plugged in for the straight cable, and JP3/JP4 are empty. The jumper configuration is reversed for the null-modem cable, as shown in Table 1-1.

Cable Configuration	Mode	Jumpers on Debug Board			
		JP1	JP2	JP3	JP4
Straight Cable	Default	Installed	Installed	--	--
Null-Modem Cable	Alternative	--	--	Installed	Installed

**Table 1-1: Jumper Settings on Debug Board**

JP1 through JP4 can also be used to alter the connection when the PC is not configured as a DCE device. Table 1-2 shows the connections necessary for the straight DB9 cable and the pin definitions.

PC Pin	Function	Demo Board Pin
2	TX	2
3	RX	3
5	Signal Ground	5

**Table 1-2: Straight Cable Connections**

Table 1-3 shows the connections necessary for the null-modem DB9 cable and the pin definitions.

PC Pin	Function	Demo Board Pin
2	TX	3
3	RX	2
5	Signal Ground	5

**Table 1-3: Null-modem Cable Connections**

See Table 3-1 for correct placement of jumper JP5 on the Demo Board depending on whether the USB connection or the serial connection via the Debug Board is used.

### 1.7.3 CHECKING OPERATION

A few seconds after power up, the LCD display on the Demo Board should display a brief greeting in the top row and the demo code revision in the bottom row:

H	E	L	L	O			
5.	4	F					

The "HELLO" message should be followed by the display of accumulated energy:

					0.	0	0
	0	3					

Wh	SYS

The "SYS" symbol will be blinking, indicating activity of the MPU inside the 71M6543.

In general, the fields of the LCD are used as shown below:

			Measured value			
	Command number					
					(Phase)	

Unit

### 1.7.4 SERIAL CONNECTION SETUP

After connecting the USB cable from the Demo Board to the PC, or after connecting the serial cable from the optional Debug Board to the PC, start the HyperTerminal application and create a session using the following parameters:

**Port Speed: 9600 bd**

**Data Bits: 8**

**Parity: None**

**Stop Bits: 1**

**Flow Control: XON/XOFF**

When using the USB connection, you may have to define a new port in HyperTerminal after selecting File → Properties and then clicking on the "Connect Using" dialog box. If the USB-to-serial driver is installed (see section 1.7.2.1) a port with a number not corresponding to an actual serial port, e.g. COM27, will appear in the dialog box. This port should be selected for the USB connection.

HyperTerminal can be found by selecting Programs → Accessories → Communications from the Windows® start menu. The connection parameters are configured by selecting File → Properties and then by pressing the Configure button. Port speed and flow control are configured under the General tab (Figure 1-3, left), bit settings are configured by pressing the Configure button (Figure 1-3, right), as shown below. A setup file (file name "Demo Board Connection.ht") for HyperTerminal that can be loaded with File → Open is also provided with the tools and utilities.

In Windows 7®, HyperTerminal is not available, but can be installed from various resources on the Internet.



**Port parameters can only be adjusted when the connection is not active. The disconnect button, as shown in Figure 1-2 must be clicked in order to disconnect the port.**

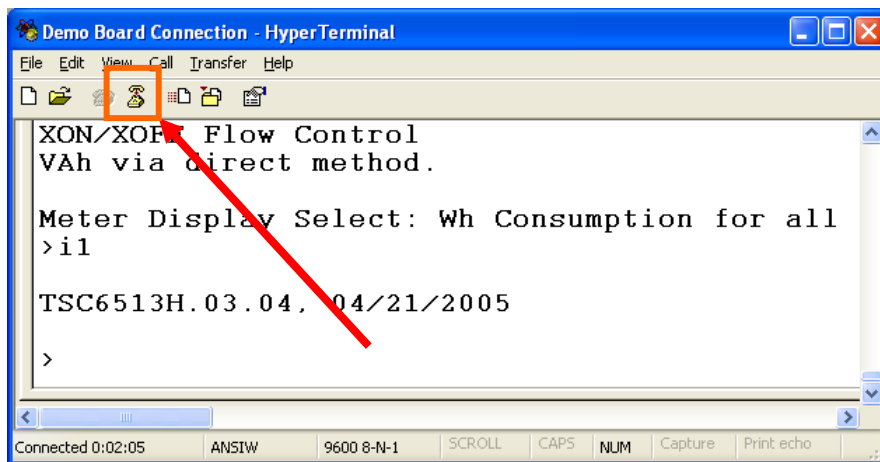


Figure 1-2: HyperTerminal Sample Window with Disconnect Button (Arrow)

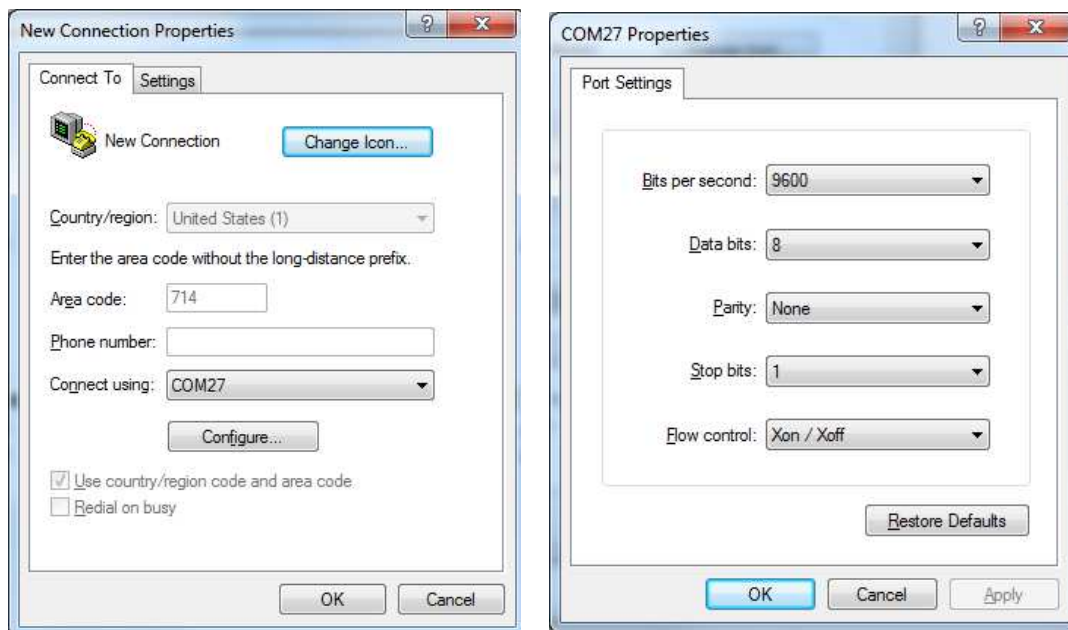


Figure 1-3: Port Setup (left) and Port Speed and Handshake Setup (right)

Once, the connection to the demo board is established, press <CR> and the command prompt, >, should appear. Type >? to see the **Demo Code** help menu. Type >i to verify the demo code revision.

## 1.8 USING THE DEMO BOARD

The 71M6543 Demo Board is a ready-to-use meter prepared for use with external shunt resistors.

Demo Code versions for polyphase operation (EQU 5) are available on the Maxim web site ([www.maxim-ic.com](http://www.maxim-ic.com)) and the 71M6543F is pre-programmed with Demo Code that supports polyphase metering.

Using the Demo Board involves communicating with the Demo Code via the command line interface (CLI). The CLI allows all sorts of manipulations to the metering parameters, access to the EEPROM, selection of the displayed parameters, changing calibration factors and many more operations.

Before evaluating the 71M6543F on the Demo Board, users should get familiar with the commands and responses of the CLI. A complete description of the CLI is provided in section 1.8.1.

## 1.8.1 SERIAL COMMAND LANGUAGE

The Demo Code residing in the flash memory of the 71M6543F provides a convenient way of examining and modifying key meter parameters via its command line interface (CLI).

The tables in this chapter describe the commands in detail.

### Commands for CE Data Access:

]	CE DATA ACCESS	Comment
<b>Description:</b>	Allows user to read from and write to CE data space.	
<b>Usage:</b>	] [Starting CE Data Address] [option]...[option]	
<b>Command combinations:</b>	]A???	Read consecutive 16-bit words in Decimal, starting at address A
	]A\$\$\$	Read consecutive 16-bit words in Hex, starting at address A
	]A=n=n	Write consecutive memory values, starting at address A
	]U	Update default version of CE Data in flash memory
<b>Example:</b>	]40\$\$\$	Reads CE data words 0x40, 0x41 and 0x42.
	]7E=12345678=9876ABCD	Writes two words starting @ 0x7E

All CE data words are in 4-byte (32-bit) format. Typing ]A? will access the 32-bit word located at the byte address  $0x0000 + 4 * A = 0x1028$ .

### Commands for MPU/XDATA Access:

)	MPU DATA ACCESS	Comment
<b>Description:</b>	Allows user to read from and write to MPU data space.	
<b>Usage:</b>	) [Starting MPU Data Address] [option]...[option]	
<b>Command combinations:</b>	)A???	Read three consecutive 32-bit words in Decimal, starting at address A
	)A\$\$\$	Read three consecutive 32-bit words in Hex, starting at address A
	)A=n=m	Write the values n and m to two consecutive addresses starting at address A
	?)	Display useful RAM addresses.
<b>Example:</b>	)08\$\$\$\$	Reads data words 0x08, 0x0C, 0x10, 0x14
	)04=12345678=9876ABCD	Writes two words starting @ 0x04

MPU or XDATA space is the address range for the MPU XRAM (0x0000 to 0xFFFF). All MPU data words are in 4-byte (32-bit) format. Typing ]A? will access the 32-bit word located at the byte address  $4 * A = 0x28$ . The energy accumulation registers of the Demo Code can be accessed by typing two Dollar signs (“\$\$\$”), typing question marks will display negative decimal values if the most significant bit is set.

**Commands for DIO RAM (Configuration RAM) and SFR Control:**

R	DIO AND SFR CONTROL	Comment
<b>Description:</b>	Allows the user to read from and write to DIO RAM and special function registers (SFRs).	
<b>Usage:</b>	R [option] [register] ... [option]	
<b>Command combinations:</b>	RIx...	Select I/O RAM location x (0x2000 offset is automatically added)
	Rx...	Select internal SFR at address x
	Ra???...	Read consecutive SFR registers in Decimal, starting at address a
	Ra\$\$\$...	Read consecutive registers in Hex, starting at address a
	Ra=n=m...	Set values of consecutive registers to n and m starting at address a
<b>Example:</b>	RI2\$\$\$	Read DIO RAM registers 2, 3, and 4 in Hex.

The SFRs (special function registers) are located in internal RAM of the 80515 core, starting at address 0x80.

**Commands for EEPROM Control:**

EE	EEPROM CONTROL	Comment
<b>Description:</b>	Allows user to enable read from and write to EEPROM.	
<b>Usage:</b>	EE [option] [arguments]	
<b>Command combinations:</b>	EECn	EEPROM Access (1 → Enable, 0 → Disable)
	EERa.b	Read EEPROM at address 'a' for 'b' bytes.
	EESabc..xyz	Write characters to buffer (sets Write length)
	EETa	Transmit buffer to EEPROM at address 'a'.
	EEWa.b...z	Write values to buffer
	CLS	Saves calibration to EEPROM
<b>Example:</b>	EEShello EET\$0210	Writes 'hello' to buffer, then transmits buffer to EEPROM starting at address 0x210.



Due to buffer size restrictions, the maximum number of bytes handled by the EEPROM command is 0x40.

**Commands for Flash Memory Control:**

F	FLASH CONTROL	Comment
<b>Description:</b>	Allows user to enable read from and write to Flash memory.	
<b>Usage:</b>	F [option] [arguments]	
<b>Command combinations:</b>	FRa.b	Read Flash at address 'a' for 'b' bytes.
	FSabc..xyz	Write characters to buffer (sets Write length)
	FTa	Transmit buffer to Flash memory at address 'a'.
	FWa.b...z	Write string of bytes to buffer
<b>Example:</b>	FShello FT\$FE10	Writes 'hello' to buffer, then transmits buffer to EEPROM starting at address 0xFE10.

**Auxiliary Commands:**

Typing a comma (",") repeats the command issued from the previous command line. This is very helpful when examining the value at a certain address over time, such as the CE DRAM address for the temperature (0x40).

The slash ("/") is useful to separate comments from commands when sending macro text files via the serial interface. All characters in a line after the slash are ignored.

**Commands controlling the CE, TMUX and the RTM:**

<b>C</b>	<b>COMPUTE ENGINE, MEMORY, AND CALIBRATION CONTROL</b>	<b>Comment</b>
<b>Description:</b>	Allows the user to enable and configure the compute engine, store and recall configurations, and initiate calibration.	
<b>Usage:</b>	C [option] [argument]	
<b>Command combinations:</b>	CEn	Compute Engine Enable (1 → Enable, 0 → Disable)
	CTn.m	Selects the signal for the TMUX output pins (n = 1 for TMUXOUT, n = 2 for TMUX2OUT). M is interpreted as a hex number.
	CREn	RTM output control (1 → Enable, 0 → Disable)
	CRSa.b.c.d	Selects CE addresses for RTM output
	CLS	Stores calibration and other settings to EEPROM.
	CLR	Restores calibration and other settings from EEPROM.
	CLD	Restores calibration and other settings to defaults.
	CLB	Start auto-calibration based on voltage (MPU address 0x0C, current (MPU 0x0D), and duration (MPU 0x0E) in seconds.
	CLC	Apply machine-readable calibration control (Intel Hex-Records).
	CPA	Start the accumulating periodic pulse counters.
	CPC	Clear the pulse counters
	CPDn	Activate pulse counters for n seconds
<b>Example:</b>	CE0	Disables CE, ("SYS will stop blinking on the LCD).
	CT1.12	Selects the VBIAS signal for the TMUXOUT pin

**Commands for Identification and Information:**

<b>I</b>	<b>INFORMATION MESSAGES</b>	<b>Comment</b>
<b>Description:</b>	Allows the user to read information messages.	
<b>Usage:</b>	I	Sends complete demo code version information on serial interface.
	M0	Displays meter ID on LCD.

The I command is mainly used to identify the revisions of Demo Code and the contained CE code.



**Commands for Battery Mode Control and Battery Test:**

B	INFORMATION MESSAGES	Comment
<b>Description:</b>	Allows the user to control battery modes and to test the battery.	
<b>Usage:</b>	BL	Enters LCD mode when in brownout mode (B> prompt).
	BS	Enters sleep mode when in brownout mode (B> prompt).
	BT	Starts a battery test – when in mission mode (> prompt).
	BWSn	Set wake timer to n seconds for automatic return to brownout mode.
	BWMn	Set wake timer to n minutes for automatic return to brownout mode.

**Commands for Controlling the RTC:**

RT	REAL TIME CLOCK CONTROL	Comment
<b>Description:</b>	Allows the user to read and set the real time clock.	
<b>Usage:</b>	RT [option] [value] ... [value]	
<b>Command combinations:</b>	RTDy.m.d.w: Day of week	(Year, month, day, weekday [1 = Sunday]). If the weekday is omitted it is set automatically.
	RTR	Read Real Time Clock.
	RTTh.m.s	Time of day: (hr, min, sec).
	RTAs.t	Real Time Adjust: (start, trim). Allows trimming of the RTC. If s > 0, the speed of the clock will be adjusted by 't' parts per billion (PPB). If the CE is on, the value entered with 't' will be changing with temperature, based on Y_CAL, Y_CALC and Y_CALC2.
	>	Access look-up table for RTC compensation.
<b>Example:</b>	RTD05.03.17.5	Programs the RTC to Thursday, 3/17/2005
	RTA1.+1234	Speeds up the RTC by 1234 PPB.
	>0????	Read the first four bytes in the look-up table.



The "Military Time Format" is used for the RTC, i.e. 15:00 is 3:00 PM.

**Commands for Accessing the Trim Control Registers:**

T	TRIM CONTROL	Comment
<b>Description:</b>	Allows user to read trim and fuse values.	
<b>Usage:</b>	T [option]	
<b>Command combinations:</b>	T4	Read fuse 4 (TRIMM).
	T5	Read fuse 5 (TRIMBGA)
	T6	Read fuse 6 (TRIMBGB).
<b>Example:</b>	T4	Reads the TRIMM fuse.



These commands are only accessible for the 71M6543H (0.1%) parts. When used on a 71M6543F (0.5%) part, the results will be displayed as zero.

**Reset Commands:**

W	RESET	Comment
<b>Description:</b>	Watchdog control	
<b>Usage:</b>	W	Halts the Demo Code program, thus suppressing the triggering of the hardware watchdog timer. This will cause a reset, if the watchdog timer is enabled.

**Commands for the 71M6x0x Remote Sensor Interface:**

6	71M6x0x Interface	Comment
<b>Description:</b>	Commands for control of the Remote Sensor Interface IC.	
<b>Usage:</b>	6En	Remote sensor Enable (1 → Enable, 0 → Disable)
	6Ra.b	Read Remote Sensor IC number a with command b.
	6Ca.b	Write command b to Remote Sensor IC number a.
	6Ta.b	Send command b to Remote Sensor IC number a in a loop forever.
	6T	Send temp command to 6000 number 2 in a loop forever.
	6R1.20	Reads the temperature from Remote Sensor IC number 1. See section 1.10.7 for information on how to interpret the temperature data.

**Commands for Controlling the Metering Values Shown on the LCD Display:**

Step	Text or Numerical Display	CLI command	Displayed Parameter(s)
0	10000 00	M0	Meter ID
1	24.5 °C 01	M1	Temperature difference from calibration temperature. Displayed in 0.1°C
2	59.9 02	M2	Frequency at the VA_IN input [Hz]
3	3.27 Wh 03	M3	Accumulated imported real energy [Wh]. The default display setting after power-up or reset.
4	1.04 Wh 04	M4	Accumulated exported real energy [Wh].
5	2.21 VARh 05	M5	Accumulated reactive energy [VARh].
6	0.95 VARh 06	M6	Accumulated exported reactive energy [VARh].
7	4.11 VAh 07	M7	Accumulated apparent energy [VAh].
8	0.7 h 08	M8	Elapsed time since last reset or power up.
9	01:43:59 09	M9	Time of day (hh.mm.ss)
10	01.01.01 10	M10	Date (yy.mm.dd)
11	0.62 11 1	M11.P	Power factor (P = phase)
12	0	M12	Not used in the 71M6543
13	120 13	M13	Zero crossings of the mains voltage
14	48 14	M14	Duration of sag or neutral current [s]
15	29.98 A 29.91 A 30.02 A	M15	RMS current (P = phase). "M15.4" displays the neutral current.
16	240.27 V 239.43 V 240.04 V	M16	RMS voltage
17	3.34 V 17	M17	Battery voltage
18	241.34 W 240.92 W 241.01 W	M18	Momentary power in W (P = phase)
19	50400 W 19	M19	Demand
20	88.88.88 88.88.88 88.88.88	M20	LCD Test



Displays for total consumption wrap around at 999.999Wh (or VARh, VAh) due to the limited number of available display digits. Internal registers (counters) of the Demo Code are 64 bits wide and do not wrap around.

## 1.8.2 USING THE DEMO BOARD FOR ENERGY MEASUREMENTS

The 71M6543 Demo Board was designed for use with shunt resistors connected via the Remote Sensor Interfaces and it is shipped in this configuration.

The Demo Board may immediately be used with 50  $\mu\Omega$  shunt resistors (ANSI version) or 120  $\mu\Omega$  shunt resistors (IEC version). It is programmed for a Kh factor of 3.2 (see Section 1.8.4 for adjusting the Demo Board for shunts with different resistance).

Once, voltage is applied and load current is flowing, the red LED D5 will flash each time an energy sum of 3.2 Wh is collected. The LCD display will show the accumulated energy in Wh when set to display mode 3 (command >M3 via the serial interface).

Similarly, the red LED D6 will flash each time an energy sum of 3.2 VARh is collected. The LCD display will show the accumulated energy in VARh when set to display mode 5 (command >M5 via the serial interface).

## 1.8.3 ADJUSTING THE KH FACTOR FOR THE DEMO BOARD

The 71M6543 Demo Board is shipped with a pre-programmed scaling factor Kh of 3.2, i.e. 3.2 Wh per pulse. In order to be used with a calibrated load or a meter calibration system, the board should be connected to the AC power source using the spade terminals on the bottom of the board. On the revision REV 4.0 of the Demo Board, the shunt resistor wires are terminated directly to the dual-pin headers J22, J23, and J24 on the board.

The Kh value can be derived by reading the values for *IMAX* and *VMAX* (i.e. the RMS current and voltage values that correspond to the 250mV maximum input signal to the IC), and inserting them in the following equation for Kh:

$$Kh = 54.5793 * VMAX * IMAX / (SUM\_SAMPS * WRATE * X),$$

See the explanation in section 1.10.5 for an exact definition of the constants and variables involved in the equation above.

## 1.8.4 ADJUSTING THE DEMO BOARDS TO DIFFERENT SHUNT RESISTORS

The Demo Board REV 4.0 is prepared for use with 120  $\mu\Omega$  or 50  $\mu\Omega$  (ANSI option) shunt resistors in all current channels. A certain current flowing through the 120  $\mu\Omega$  shunt resistors will result in the maximum voltage drop at the ADC of the 71M6103 Remote Sensor ICs. This current is defined as *IMAX* and can be adjusted at MPU location 0x03 (see section 1.10.3).

*IMAX* will need to be changed when different values are used for the shunt resistor(s) which will require that *WRATE* has to be updated as shown in section 1.10.5.

The scaling of the neutral current measurement is controlled by the *i\_max2* variable at MPU location 0x01C.

## 1.8.5 USING THE PRE-AMPLIFIER

In its default setting, the 71M6543F applies a gain of 1 to the current input for the neutral current inputs (IAP/IAN pins). This gain is controlled with the *PRE\_E* bit in I/O RAM (see the Data Sheet). The command line interface (RI command) can be used to set or reset this bit. It is recommended to maintain the gain of setting of 1 (RI2704=0x90).

## 1.8.6 USING CURRENT TRANSFORMERS (CTS)

All phases of the 71M6543 REV 5.0 Demo Board are equipped with connectors for external CTs. CTs should be connected to the headers J5, J7, and J10. A burden resistor of 1.7  $\Omega$  is installed at the R26, R27, and R31 (and corresponding resistors for phases B and C) locations. With a 2000:1 ratio CT, the maximum current will be 208 A.

For the CT configuration, a shunt resistor of 50  $\mu\Omega$  should be installed to measure the neutral current. Different values can be accommodated by changing the value of *i\_max2* at MPU location 0x1C (see section 1.10.3).

**Note: The CT configuration requires a different version of the Demo Code than is used for the shunt configuration.**

## 1.8.7 ADJUSTING THE DEMO BOARDS TO DIFFERENT VOLTAGE DIVIDERS

The 71M6543 Demo Board comes equipped with its own network of resistor dividers for voltage measurement mounted on the PCB. The resistor values (for the 71M6543 REV 2.0 Demo Board) are 2.5477M $\Omega$  (R66, R64, R47, R39 combined) and 750 $\Omega$  (R32, R52, R72), resulting in a ratio of 1:3,393.933. This means that *VMAX* equals 176.78mV\*3,393.933 = 600V. A large value for *VMAX* has been selected in order to have headroom for

over-voltages. This choice need not be of concern, since the ADC in the 71M6543F has enough resolution, even when operating at 120 Vrms or 240 Vrms.

If a **different set of voltage dividers** or an external voltage transformer (potential transformer) is to be used, scaling techniques should be used.

In the following example we assume that the line voltage is not applied to the resistor divider for VA formed by R66, R64, R47, R39, and R32, but to a voltage transformer with a ratio N of 20:1, followed by a simple resistor divider. We also assume that we want to maintain the value for  $V_{MAX}$  at 600V to provide headroom for large voltage excursions.

When applying  $V_{MAX}$  at the primary side of the transformer, the secondary voltage  $V_s$  is:

$$V_s = V_{MAX} / N$$

$V_s$  is scaled by the resistor divider ratio  $R_R$ . When the input voltage to the voltage channel of the 71M6543 is the desired 177mV,  $V_s$  is then given by:

$$V_s = R_R * 176.8 \text{ mV}$$

Resolving for  $R_R$ , we get:

$$R_R = (V_{MAX} / N) / 176.8 \text{ mV} = (600V / 30) / 176.8 \text{ mV} = 170.45$$

This divider ratio can be implemented, for example, with a combination of one 16.95 k $\Omega$  and one 100  $\Omega$  resistor.

If potential transformers (PTs) are used instead of resistor dividers, phase shifts will be introduced that will require negative phase angle compensation. Teridian Demo Code accepts negative calibration factors for phase.

## 1.9 CALIBRATION PARAMETERS

### 1.9.1 GENERAL CALIBRATION PROCEDURE

Any calibration method can be used with the 71M6543F ICs. This Demo Board User's Manual presents calibration methods with three or five measurements as recommended methods, because they work with most manual calibration systems based on counting "pulses" (emitted by LEDs on the meter).

Naturally, a meter in mass production will be equipped with special calibration code offering capabilities beyond those of the 71M6543 Demo Code. It is basically possible to calibrate using voltage and current readings, with or without pulses involved. For this purpose, the MPU Demo Code should be modified to display averaged voltage and current values (as opposed to momentary values). Also, automated calibration equipment can communicate with the Demo Boards via the serial interface and extract voltage and current readings. This is possible even with the unmodified Demo Code.

Complete calibration procedures are given in section 2.2 of this manual.

Regardless of the calibration procedure used, parameters (calibration factors) will result that will have to be applied to the 71M6543F IC in order to make the chip apply the modified gains and phase shifts necessary for accurate operation. Table 1-4 shows the names of the calibration factors, their function, and their location in the CE RAM.

Again, the command line interface can be used to store the calibration factors in their respective CE RAM addresses. For example, the command

```
>]10=+16302
```

stores the decimal value 16302 in the CE RAM location controlling the gain of the current channel ( $CAL\_IA$ ).

The command

```
>]11=4005
```

stores the hexadecimal value 0x4005 (decimal 16389) in the CE RAM location controlling the gain of the voltage channel ( $CAL\_VA$ ).

Table 1-4: CE RAM Locations for Calibration Constants

Coefficient	CE Address (hex)	Description
<i>CAL_VA</i> <i>CAL_VB</i> <i>CAL_VC</i>	0x11 0x14 0x17	Adjusts the gain of the voltage channels. +16384 is the typical value. The gain is directly proportional to the CAL parameter. Allowed range is 0 to 32767. If the gain is 1% slow, CAL should be increased by 1%.
<i>CAL_IA</i> <i>CAL_IB</i> <i>CAL_IC</i>	0x10 0x13 0x16	Adjusts the gain of the current channels. +16384 is the typical value. The gain is directly proportional to the CAL parameter. Allowed range is 0 to 32767. If the gain is 1% slow, CAL should be increased by 1%.
<i>LCOMP2_A</i> <i>LCOMP2_B</i> <i>LCOMP2_C</i>	0x12 0x15 0x18	This constant controls the phase compensation. No compensation occurs when <i>LCOMP2_n</i> =16384. As <i>LCOMP2_n</i> is increased, more compensation is introduced.  CE codes for CT configuration do not use delay adjustment. These codes use phase adjustment ( <i>PHADJ_n</i> ).

### 1.9.2 CALIBRATION MACRO FILE

The macro file in Figure 1-4 contains a sequence of the serial interface commands. It is a simple text file and can be created with Notepad or an equivalent ASCII editor program. The file is executed with HyperTerminal's *Transfer->Send Text File* command.

```
CE0          /disable CE
]10=+16022   /CAL_IA (gain=CAL_IA/16384)
]11=+16381   /CAL_VA (gain=CAL_VA/16384)
]12=+17229   /LCOMP2_A (default 16384)
CE1          /enable CE
```

Figure 1-4: Typical Calibration Macro File

It is possible to send the calibration macro file to the 71M6543F for “temporary” calibration. This will temporarily change the CE data values. Upon power up, these values are refreshed back to the default values stored in flash memory. Thus, until the flash memory is updated, the macro file must be loaded each time the part is powered up. The macro file is run by sending it with the *transfer → send text file* procedure of HyperTerminal.



**Use the *Transfer → Send Text File* command!**

### 1.9.3 UPDATING THE DEMO CODE (HEX FILE)

The *d\_merge* program updates the hex file (for example *6543eq5\_6103\_5p3c\_01nov10.hex*, or similar) with the values contained in the macro file. This program is executed from a DOS command line window. Executing the *d\_merge* program with no arguments will display the syntax description. To merge *macro.txt* and *old\_6543\_demo.hex* into *new\_6543\_demo.hex*, use the command:

```
d_merge old_6543_demo.hex macro.txt new_6543_demo.hex
```

The new hex file can be written to the 71M6543F/71M6543H through the ICE port using the ADM51 in-circuit emulator or the TFP-2 flash programmer.

### 1.9.4 UPDATING CALIBRATION DATA IN FLASH OR EEPROM

It is possible to make data permanent that had been entered temporarily into the CE RAM. The transfer to EEPROM memory is done using the following serial interface command:

```
>]CLS
```

Thus, after transferring calibration data with manual serial interface commands or with a macro file, all that has to be done is invoking the U command.

Similarly, calibration data can be restored to default values using the CLD command.



**After reset, calibration data is copied from the EEPROM, if present. Otherwise, calibration data is copied from the flash memory. Writing 0xFF into the first few bytes of the EEPROM deactivates any calibration data previously stored to the EEPROM.**

## 1.9.5 LOADING THE CODE FOR THE 71M6543F INTO THE DEMO BOARD

**Hardware Interface for Programming:** The 71M6543F IC provides an interface for loading code into the internal flash memory. This interface consists of the following signals:

E\_RXTX (data), E\_TCLK (clock), E\_RST (reset), ICE\_E (ICE enable)

These signals, along with V3P3D and GND are available on the emulator headers J14.

Programming of the flash memory requires a specific in-circuit emulator, the ADM51 by Signum Systems or the Flash Programmer (TFP-2) provided by Maxim.

Chips may also be programmed before they are soldered to the board. Gang programmers suitable for high-volume production are available from BPM Microsystems.

**In-Circuit Emulator:** If firmware exists in the 71M6543F flash memory; it has to be erased before loading a new file into memory. Figure 1-5 and Figure 1-6 show the emulator software active. In order to erase the flash memory, the RESET button of the emulator software has to be clicked followed by the ERASE button.

**To successfully erase the flash memory, the following steps have to be taken:**

- 1) Disable the CE by writing 0x00 to address 0x2000
- 2) Write 0x20 to address 0x2702 (*FLSH\_UNLOCK[]* register in I/O RAM)
- 3) Reset the demo board (RESET button or power cycle)
- 4) Activate the ERASE button in the WEMU51 user interface
- 5) Now, new code can be loaded into the flash memory

Once the flash memory is erased, the new file can be loaded using the commands File followed by Load. The dialog box shown in Figure 1-6 will then appear making it possible to select the file to be loaded by clicking the Browse button. Once the file is selected, pressing the OK button will load the file into the flash memory of the 71M6543F IC. At this point, the emulator probe (cable) can be removed. Once the 71M6543F IC is reset using the reset button on the Demo Board, the new code starts executing.

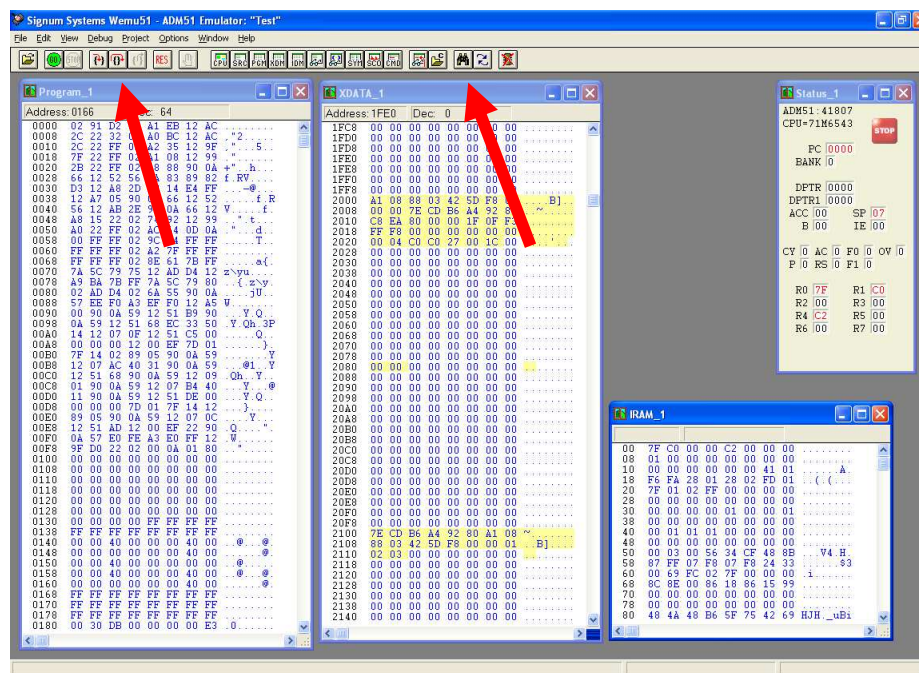


Figure 1-5: Emulator Window Showing Reset and Erase Buttons (see Arrows)

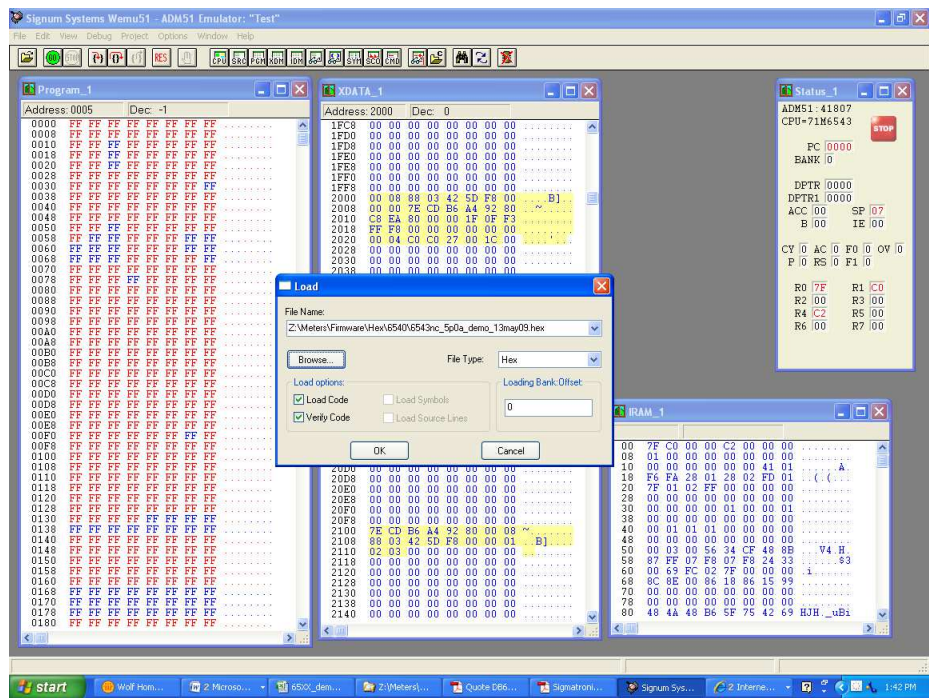


Figure 1-6: Emulator Window Showing Erased Flash Memory and File Load Menu

**Flash Programmer Module (TFP-2):** The operational firmware of the TFP2 will have to be upgraded to revision 1.53. Follow the instructions given in the User Manual for the TFP-2.

### 1.9.6 THE PROGRAMMING INTERFACE OF THE 71M6543F

#### Flash Downloader/ICE Interface Signals

The signals listed in Table 1-5 are necessary for communication between the TFP2 Flash Downloader or ICE and the 71M6543F.

Signal	Direction	Function
ICE_E	Input to the 71M6543F	ICE interface is enabled when ICE_E is pulled high
E_TCLK	Output from 71M6543F	Data clock
E_RXTX	Bi-directional	Data input/output
E_RST	Bi-directional	Flash Downloader Reset (active low)

Table 1-5: Flash Programming Interface Signals



The E\_RST signal should only be driven by the Flash Downloader when enabling these interface signals. The Flash Downloader must release E\_RST at all other times.



## 1.10 DEMO CODE

### 1.10.1 DEMO CODE DESCRIPTION

The Demo Board is shipped preloaded with Demo Code in the 71M6543F chip. The code revision can easily be verified by entering the command `>i` via the serial interface (see section 1.8.1). Check with your local Maxim representative/FAE or for the latest revision, or obtain the latest revision from the Maxim web site.

The Demo Code offers the following features:

- It provides basic metering functions such as pulse generation, display of accumulated energy, frequency, date/time, and enables the user to evaluate the parameters of the metering IC such as accuracy, harmonic performance, etc.
- It maintains and provides access to basic household functions such as the real-time clock (RTC).
- It provides access to control and display functions via the serial interface, enabling the user to view and modify a variety of meter parameters such as Kh, calibration coefficients, temperature compensation etc.
- It provides libraries for access of low-level IC functions to serve as building blocks for code development.

A detailed description of the Demo Code can be found in the Software User's Guide (SUG). In addition, the comments contained in the library provided with the Demo Kit can serve as useful documentation.

The Software User's Guide contains the following information:

- Design guide
- Design reference for routines
- Tool Installation Guide
- List of library functions
- 80515 MPU Reference (hardware, instruction set, memory, registers)

### 1.10.2 DEMO CODE VERSIONS

Each sensor configuration has its own Demo Codes version. Using the wrong type of Demo Code will result in malfunction. Table 1-6 shows the available Demo Code versions and their application.

**Table 1-6: Demo Code Versions**

File Name	Supported Configuration	Supported Demo Board
6543equ5_6103_5p3d_14feb11.hex	3 x 71M6103 with shunts	71M6543 DB REV4-0
6543equ5_6113_5p3d_14feb11.hex	3 x 71M6113 with shunts	71M6543 DB REV4-0
6543equ5_6203_5p3d_14feb11.hex	3 x 71M6203 with shunts	71M6543 DB REV4-0
6543equ5_6603_5p3d_14feb11.hex	3 x 71M6603 with shunts	71M6543 DB REV4-0
6543equ5_ct_5p3d_14feb11.hex	CT	71M6543 DB REV5-0

### 1.10.3 IMPORTANT MPU ADDRESSES

In the Demo Code, certain MPU XRAM parameters have been given addresses in order to permit easy external access. These variables can be read via the command line interface (if available), with the `)n$` command and written with the `)n=xx` command where `n` is the word address. Note that accumulation variables are 64 bits long and are accessed with `)n$$` (read) and `)n=hh=ll` (write) in the case of accumulation variables.

The first part of the table, the addresses `)00..)1F`, contains adjustments, i.e. numbers that may need adjustment in a demonstration meter, and so are part of the calibration for demo code. In a reference meter, these may be in an unchanging table in code space.

The second part, `)20..)2F`, pertains to calibration, i.e. variables that are likely to need individual adjustments for quality production meters.

The third part, `)30...`, pertains to measurements, i.e. variables and registers that may need to be read in a demonstration meter.

Table 1-7: MPU XRAM Locations

Name	Purpose	LSB	Default	)?	Signed?	Bits
i_min	Metering element enters creep mode if current is below this value. If 0, creep logic is disabled. In creep mode, on each metering element, Wh, VARh, i0sqsum, and other items are zeroed.	Same units as CE's i0sqsum.	0.08A	)0	signed	32
cfg	Configure meter operation on the fly.	bit0: 1=Display KWh. bit1: 1=clear accumulators, errors, etc. (e.g. ")1=2") bit2: 1=Reset demand. (e.g. ")1=4") bit3: 1=CE Raw mode. MPU does not change CE values with creep or small current calculations. bit5: 1= Send a message once per second for IEC 62056-217 Mode D on UART 1, at 2400 BAUD, even parity. The meter's serial number and current Wh display are sent as data. UART 1 is routed to an IR LED if possible. Mode D data fields are prefaced with OBIS codes in legacy format. <sup>7,1</sup> bit6: 1=Auto calibration mode <sup>1</sup> bit7: 1=Enable Tamper Detect <sup>2,1</sup>	0  Do nothing special.	)1	N/A	8
v_min	error if below. Also creep.* Below this, low voltage seconds are counted. Voltage, Wh, VARh, Frequency, and other voltage-dependent items are zeroed.	Same units as CE's v0sqsum.	40V	)2	signed	32
i_max	Scaling Maximum Amps for standard sensor.	0.1A	110.5 for 200 $\mu$ Ohm shunt with 8x preamp. 884.0 A for 200 $\mu$ Ohm shunt, 442.0A for 400 $\mu$ Ohm shunt.	)3	signed	16
v_max	Scaling Maximum Volts for PCB	0.1V	600 V, for the Demo Board.	)4	signed	16
i_limit	Error if exceeded.	Same units as CE's i0sqsum.	50.9A = $30A \cdot \sqrt{2}$ *120%	)5	signed	32
v_limit	Error if exceeded.*	Same units as CE's v0sqsum.	407.3V = $240V \cdot \sqrt{2}$ *120%	)6	signed	32