Simplifying System Integration™

6612_OMU_S2_URT_V1_13
Firmware Description Document

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1 Introduction

This document describes the firmware 6612_OMU_S2_URT_V1_13, which can be used with the Teridian 78M6612 dual outlet power and energy measurement IC. This firmware is designed for single phase measurement systems using current shunts as the current sensors, but current transformer sensors may also be used if desired.

Applicability of this firmware is with the Teridian 78M6612 OMU Demo Unit and the Teridian 78M6612 AC-PMON Demo Board. The demo vehicles are calibrated and the user can immediately access measurement data such as Watts, Voltage, Current, accumulated Energy and line frequency. RTC (real time clock) is not supported by this firmware.

All measurement calculations are computed by the 78M6612 and this information is communicated to the host processor. All communication between the 78M6612 and the host processor occurs over a serial interface (UART0) on the TX and RX pins of the 78M6612 device. The following sections detail the commands to be sent by the host to configure the 78M6612 and for accessing measurement information.

2 Description of Basic Measurement Equations

The Teridian 78M6612 with firmware 6612_OMU_S2_URT_1_13 provides the user with two types of continuously updating measurement data (on 1 second increments by default). One is defined as "Narrowband" (NB) and the other is defined as "Wideband" (WB).

Narrowband measurements are typically used by utilities where the measured waveforms are assumed to be sinusoidal.

Wideband measurements are generally of interest when measuring nonlinear systems such as switched mode power supplies that tend to have non-sinusoidal waveforms.

Table 1 lists the basic measurement equations for the Narrowband and the Wideband methods.

Table 1: Measurement Equations Definitions

Symbol	Parameter	Narrowband Equation	Wideband Equation
V	RMS Voltage	$V = \sqrt{\sum v(t)^2}$	$V = \sqrt{\sum v(t)^2}$
I	RMS Current	I = S/V	$I = \sqrt{\sum i(t)^2}$
P	Active Power	$P = \sum (i(t) * v(t))$	$P = \sum (i(t) * v(t))$
Q	Reactive Power	$Q = \sum (i(t) * v(t)\text{shift } 90^\circ)$	$Q = \sqrt{(S^2 - P^2)}$
S	Apparent Power	$S = \sqrt{(P^2 + Q^2)}$	S = V * I
PF	Power Factor	P/S	P/S
PA	Phase Angle	ATAN (Q/P)	ATAN (Q/P)

Both types of measurement outputs are continuously available to the user. To obtain measurement outputs, the serial UART interface between the 78M6612 and the host processor must be set up and is described in the next section.

3 Serial Communication

The serial communication with the 78M6612 takes place over a UART (UART0) interface. The default settings for the UART of the 78M6612 are given below:

Baud Rate: 38400bps
Data Bits: 8
Parity: None
Stop Bits: 1
Flow Control: Xon/Xoff

The host's serial interface port is required to implement these settings on its UART. To verify communication between the host and the 78M6612, the host must send a <CR> (carriage return) to the 78M6612. Communication is verified when the 78M6612 returns a > (greater than sign) known as the command prompt. An example is given below:

The host sends the following to the 78M6612:

<CR>

The 78M6612 sends the following back to the host:

>

Commands the host may send to the 78M6612 in order for the host to configure the 78M6612 or to receive the measurement data are given in the next section.

4 Command Line Interface

Firmware 6612_OMU_S2_URT_V1_13 contains an instruction set called the Command Line Interface (CLI), which facilitates communication via UART between the 78M6612 and the host processor. The CLI provides a set of commands which are used by the host to configure and to obtain information from the 78M6612.

4.1 Identification and Information Commands

The **I** command is used to identify the revisions of Demo Code and the contained CE code. The host sends the **I** command to the 78M6612 as follows:

>**I**<CR>

The 78M6612 will send back to the host the following:

TSC 78M6612 OMU S2 URT v1.13, July 20 2009(c)2008 Teridian Semiconductor Corp.
All Rights Reserved
CE6612_OMU_S2_A01_V1_2
>

4.2 Reset Commands

A soft reset of the 78M6612 can be performed by using the Z command. The soft reset restarts code execution at addr 0000 but does not alter flash contents. To issue a soft reset to the 78M6612, the host sends the following:

>Z<CR>

The W command acts like a hardware reset. The energy accumulators in XRAM will retain their values.

Z	**Reset**	
Description:	Allows the user to cause soft resets.	
Usage:	Z	Soft reset.
	W	Simulates watchdog reset.

4.3 MPU Data Access Command

The most pertinent is the MPU data access command. All the measurement calculations are stored in the MPU data addresses of the 78M6612. The host requests measurement information using the MPU data access command which is a right parenthesis

)

To request information, the host sends the MPU data access command, the address (in hex) which is requested, the format in which the data is desired (Hex or Decimal) and a carriage return. The contents of the addresses that would be requested by the host are contained in Section 5.

4.3.1 Individual Address Read

The host can request the information in hex or decimal format. $ requests information in hex, and ? requests information in decimal. When requesting information in decimal, the data is preceded by a + or a -. The exception is)AB? which returns a string (see page 39).

An example of a command requesting the measured power in Watts from Outlet 1 (located at address 0x08) in decimal is as follows:

>)08?<CR>

An example of a command requesting the measured power in Watts from Outlet 1 (located at address 0x08) in hex is as follows:

>)08$<CR>

4.3.2 Consecutive Read

The host can request information from consecutive addresses by adding additional ? for decimal or additional $ for hex.

An example of requests for the contents in decimal of ten consecutive addresses starting with 0x12 is:

>)12??????????<CR>

An example of requests for the contents in hex of ten consecutive addresses starting with 0x12 would be:

>)12$$$$$$$$$$<CR>

Note: The number of characters per line is limited to no more than 60.

4.3.3 Block Reads

The block read command can also be used to read consecutive registers:)saddr:eaddr? For decimal format or)saddr:eaddr$ for hex format where saddr is the start address and eaddr is the final address.

The following block read command requests the Outlet 1 wideband information contained in Table 4 in decimal format:

>)20:3D?<CR>

4.3.4 Concatenated Reads

Multiple commands can also be added on a single line. Requesting information in decimal from two locations and the block command from above are given below:

>)12?)15?)20:3D?<CR>

Note: The number of characters per line is limited to no more than 60.

4.3.5 MPU/XDATA Access Commands

)	**MPU Data Access**	
Description:	Allows user to read from and write to MPU data space.	
Usage:	) {Starting MPU Data Address} {option}…{option}<CR>	
Command Combinations:	)saddr? <CR>	Read the register in decimal.
	)saddr?? <CR>	Read two consecutive registers in decimal.
	)saddr???<CR>	Read three consecutive registers in decimal.
	)saddr:eaddr?	Block read command in decimal format. Read consecutive registers starting with starting address saddr and ending with address eaddr. Results given in decimal.
	)saddr$<CR>	Read the register word in hex.
	)saddr$$ <CR>	Read two consecutive register words in hex.
	)saddr$$$<CR>	Read three consecutive register words in hex.
	)saddr:eaddr$	Block read command in hex format. Read consecutive registers starting with starting address saddr and ending with address eaddr. Results given in hex.
	)saddr=n<CR>	Write the value n to address saddr in hex format.
	)saddr=n=m<CR>	Write the values n and m to two consecutive addresses starting at saddr in hex format.
	)saddr=+n<CR>	Write the value n to address saddr in decimal format.
	)saddr=+n=+m<CR>	Write the values n and m to two consecutive addresses starting at saddr in decimal format.

Examples:	)08$<CR>	Reads data word 0x08 in hex format.
	)08$$<CR>	Reads data words 0x08, 0x09 in hex format.
	)08$$$<CR>	Reads data words 0x08, 0x09, 0x0A in hex format.
	)28:4D$	Read Outlet 1 narrowband data words in hex.
	)08?<CR>	Reads data word 0x08 in decimal format.
	)08??<CR>	Reads data words 0x08, 0x09 in decimal format.
	)08???<CR>	Reads data words 0x08, 0x09, 0x0A in decimal format.
	)28:4D?	Read Outlet 1 narrowband data words in decimal.
	)04=12345678<CR>	Writes word @ 0x04 in hex format.
	)04=12345678=9876ABCD<CR>	Writes two words starting @ 0x04 in hex format.
	)04=+123<CR>	Writes two words starting @ 0x04 in decimal format.
	)04=+123=+334<CR>	Writes two words starting @ 0x04 in decimal format.

MPU or XDATA space is the address range for the MPU XRAM (0x00 to 0x7F). Addresses from 0x80 to FF wrap to 0x00 to 0x7F. The MPU registers differ in size, LSBs and format.

4.4 Auxiliary Commands

4.4.1 Repeat Command

The repeat command can be useful for monitoring measurements and is efficient in demands from the host.

If the host requests line frequency, alarm status, Irms nb overcurrent event count, Vrms SAG event count, Vrms overvoltage event count, voltage, power, and accumulated energy measurements for Outlet 1 with the following command string:

>)01????????<CR>

If the host then desires this same request without issuing another command, the repeat command can be used:

>, (no carriage return needed for the repeat command)

The host only needs to send one character rather than an entire string.

	Auxiliary	
Description:	Various	
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.
	/	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.

4.5 Calibration Commands

Using the precision source method, the user provides a precision voltage and precision current load is provided to the device for calibration. The 6612_OMU_S2_URT_V1_13 firmware provides commands to calibrate the measurement units. For linear current sensors, such as current shunt, no phase calibration is necessary.

There are two types of calibration commands. The first type provides complete calibration. The second group, called atomic calibration commands, provides calibration for individual portions of the IC.

4.5.1 Complete Calibration Command (“Single Command Calibration”)

There are two calibration commands in this first group: CAL and CALW. **Only one of these commands is needed to calibrate the System/Unit.**

To use these commands, a precision voltage source and a precision current source are required

4.5.1.1 CAL Command

To use the CAL command, enter the following:

>CAL<CR>

The response is:

TCal OK
VCal OK
ICal 0 OK
>

The device would calibrate the temperature (reads CE register 71, enters it into MPU register C0, and saves to flash), calibrate the voltage (adjusts CAL VA and CAL VB registers and saves them to flash), and finally calibrate the current (adjusts CAL IA register and saves to flash).

4.5.1.2 CALW Command

To use the CALW command, enter the following:

>CALW<CR>

The response is:

TCal OK
VCal OK
WCal 0 OK
>

The device will calibrate the temperature, calibrate the voltage, and finally calibrate the power and save all values to flash.

The commands are summarized in the table below:

CALx	**Complete Calibration Commands**	
Description:	Allows the user to Calibrate the IC.	
Usage:	CAL	Calibrates temperature, then voltage, and finally current for Outlet 1.
	CAL2	Calibrates temperature, then voltage, and finally current for Outlet 2.
	CAL3	Calibrates temperature, then voltage, and finally current for both Outlet1 and Outlet 2.
	CALW	Calibrates temperature, then voltage, and finally power for Outlet 1.
	CALW2	Calibrates temperature, then voltage, and finally power for Outlet 2.
	CALW3	Calibrates temperature, then voltage, and finally power for both Outlet1 and Outlet 2.

4.5.2 Atomic Calibration Commands

The atomic calibration commands provide individual calibration of voltage, current, temperature, watts and a sequence of these results in providing full calibration for the unit.

4.5.2.1 CLV Command

An example of an atomic calibration command would be to calibrate voltage with the CLV command. The CLV command calibrates voltage to the target value and tolerance and saves the coefficients to flash. The CLV command example is given below:

>CLV<CR>

The response is:

VCal OK
>

4.5.2.2 CLI Command

The user can then calibrate the current on Outlet 1 using the CLI1 command. The CLI1 command calibrates the current on Outlet 1 to the target value and tolerance and saves the coefficients to flash. The CLI1 command example is given below:

>CLI1<CR>

The response is:

ICal 0 OK
>

4.5.2.3 CLT Command

The CLT command is used for the temperature calibration. With this command, the contents of CE register 71 are read and entered into MPU register C0 and the contents are saved to flash. The CLT command example is given below::

>CLT<CR>

The response is:

TCal OK
>

A summary of the atomic calibration commands are given in the table below:

CLxx	**Atomic Calibration Commands**	
Description:	Allows the user to Calibrate individual sections of the IC.	
Usage:	CLV	Calibrates voltage only.
	CLI1	Calibrate current on Outlet 1 only.
	CLI2	Calibrate current on Outlet 2 only.
	CLI3	Calibrate for current on both Outlet 1 and Outlet 2 only.
	CLW1	Calibrate for power on Outlet 1 only.
	CLW2	Calibrate for power on Outlet 2 only.
	CLW3	Calibrate for power on Outlet 1 and Outlet 2 only.
	CLT	Calibrate temperature only.

The commands that follow are mainly for advanced users and are included for reference only. These commands are not needed to operate the 78M6612 OMU or AC-PMON demo kits.

4.6 CE Data Access Commands

The CE is the main signal processing unit in the 78M6612. The user writes to the CE data space are mainly for calibration purposes.

The 78M6612 OMU demo units and 78M6612 AC-PMON demo units come pre-calibrated. No user writes to the CE data space are necessary.

For the advanced user, details of CE data access commands are given. The commands similar to the MPU access except that] is used for the CE data access command.

The host requests access to information from the CE data space using the CE data access command which is a right bracket:

]

To request information, the host sends the CE data access command, the address (in hex) which is requested, the format in which the data is desired (hex or decimal) and a carriage return. The contents of the addresses that would be requested by the host are contained in Section 5.

The host can request the information in hex or decimal format. $ requests information in hex and ? requests information in decimal.

4.6.1 Single Register CE Access

An example of a command requesting the calibration constant for current on Outlet 1 (located at address 0x08) in decimal is as follows:

>]08?<CR>

An example of a command requesting the calibration constant for current on Outlet 1 (located at address 0x08) in hex is as follows:

>]08$<CR>

4.6.2 Consecutive CE Reads

The host can request information form consecutive addresses by adding additional ? for decimal or additional $ for hex.

An example of requests for the contents in decimal of ten consecutive addresses starting with 0x08 would be:

>]08??????????<CR>

An example of requests for the contents in hex of ten consecutive addresses starting with 0x08 would be:

>]08$$$$$$$$$$<CR>

Note: The number of characters per line is limited to no more than 60.

4.6.3 U Command

The U command is used for updating default values of the CE Data in flash. The description is given in the CE control Command section.

Additional examples are provided in the table that follows:

]	**CE Data Access**	
Description:	Allows user to read from and write to CE data space.	
Usage:	] {Starting CE Data Address}{option}…{option}<CR>	
Command Combinations:	]saddr?<CR>	Read 32-bit word in decimal.
	]saddr??<CR>	Read two consecutive 32-bit words in decimal.
	]saddr???<CR>	Read three consecutive 32-bit words in decimal.
	]saddr$<CR>	Read 32-bit words in hex.
	]saddr$$<CR>	Read two consecutive 32-bit words in hex.
	]saddr$$$<CR>	Read three consecutive 32-bit words in hex.
	]U<CR>	Update default version of CE Data in FLASH. **Important: The CE must be stopped (CE0) before issuing this command! Also, remember to restart by executing the CE1 command prior to attempting measurements.**
Examples:	]40$<CR>	Reads CE data word 0x40 in hex.
	]40$$<CR>	Reads CE data words 0x40 and 0x41 in hex.
	]40$$$<CR>	Reads CE data words 0x40, 0x41 and 0x42 in hex.
	]40?<CR>	Reads CE data words 0x40 in decimal.
	]40??<CR>	Reads CE data words 0x40 and 0x41 in decimal.
	]40???<CR>	Reads CE data words 0x40, 0x41 and 0x42 in decimal.
	]7E=12345678=9876ABCD<CR>	Writes word at 0x7E (hex format).
	]7E=12345678=9876ABCD<CR>	Writes two words starting at 0x7E (hex format).
	]7E=+2255<CR>	Write the value 2255 in decimal to location 0x7E.
	]7E=+2255=+456<CR>	Write the value 2255 in decimal to location 0x7E and the value 456 in decimal to location 0x8E.

CE data space is the address range for the CE DRAM (0x1000 to 0x13FF). All CE data words are in 4-byte (32-bit) format. The offset of 0x1000 does not have to be entered when using the] command, thus typing]A? will access the 32-bit word located at the byte address 0x1000 + 4 * A = 0x1028.

4.7 CE Control Commands

The most pertinent command is the enable command, CEn. It is mainly used to turn the CE on or off such that the CE data contents can be updated in flash using the U command. The CE is normally on but in order to update the CE data entry, the CE must first be turned off using the CE0.

4.7.1 CE Data Write

If the cal coefficient for the IA current input is changed:

>]08=FFFFC9B0<CR>

4.7.2 Turn Off CE Command

For this value to be the default value, the U command is used. The CE must first be turned off using the CE0 command:

>CE0<CR>

4.7.3 U Command

The U command is now issued to change the default value set above as follows:

>]U<CR>

4.7.4 Turn On CE Command

The CE must then be turned on using the CE1 command:

>CE1<CR>

The default value for the CAL IA coefficient is now changed in the CE Data space and is updated in Flash.

The CE Control Commands are highlighted in the table below:

C	**Compute Engine Control**	
Description:	Allows the user to enable and configure the compute engine.	
Usage:	C {option} {argument}<CR>	
Command Combinations:	CEn<CR>	Compute Engine Enable (1 → Enable, 0 → Disable)
	CTn<CR>	Select input n for TMUX output pin. Enter n in hex notation.
	CREn<CR>	RTM output control (1 → Enable, 0 → Disable)
	CRSa.b.c.d<CR>	Selects CE addresses for RTM output. (maximum of four).
Examples:	CE0<CR>	Disables the CE.
	CE1<CR>	Enables the CE.
	CT1E<CR>	Selects the CE_BUSY signal for the TMUX output pin.

4.8 I/O RAM (Configuration RAM) Command

The RI command is used for altering the I/O RAM contents. This is usually not necessary as the FW defaults these settings appropriately.

One case where the RI command could be used would be to speed up the accumulation interval for energy measurements. If the accumulation interval is to be reduced by half from its default value, the following command is entered:

>RI1=+30<30>

More details on the accumulation interval are given in Section 5.

R	**DIO and SFR Control**	
Description:	Allows the user to read from and write to I/O RAM..	
Usage:	RI {option} {register} … {option} <CR>	
Command Combinations:	RIx…<CR>	Select I/O RAM location x (0x2000 offset is automatically added).
Example:	RI60$$$$<CR>	Read all four RTM probe registers.

Configuration RAM space is the address range 0x2000 to 0x20FF. This RAM contains registers used for configuring basic hardware and functional properties of the 78M6612 and is organized in bytes (8 bits). The 0x2000 offset is automatically added when the command RI is typed.

5 MPU Measurement Outputs

This section describes the measurement outputs that can be obtained. Energy outputs are accumulated numbers. The default accumulation interval is 1 second (999.75 ms). The host accessing the measurement information from the 78M6612 more frequently will not result in any update in the information. The accumulation interval is set by the following:

0.01666 * *SUM_CYCLES[5:0]* (in seconds) where *SUM_CYCLE[5:0]* are register bits in the I/O RAM that can be between 15d and 63d (default is 60d). *SUM_CYCLES* must never be set below 15 (0.250 seconds).

The user can reduce the accumulation cycle with the RI command. To reduce the accumulation interval to 0.5 seconds, enter the following via the UART:

RI1=+30<CR>

A)U command will preserve the new accumulation value across power resets, by writing them to flash.

Table 2 lists the Narrowband outputs for Outlet 1.

Table 2: Outlet 1 MPU Outputs for Narrowband Method

Output	Location (hex)	LSB	Comment	Example
Delta Temperature	00	0.1 °C	Temperature difference from 22 °C.	If external temperature is 32 °C)00?<CR> Returns: +10.0
Line Frequency	01	0.1 Hz	Line Frequency.	If the line frequency is 60 Hz:)01?<CR> Returns: +60.0
Alarm Status	02		**Definition for Status Register** Bit 0 – Minimum Temperature Alarm. Bit 1 – Maximum Temperature Alarm. Bit 2 – Minimum Frequency Alarm. Bit 3 – Maximum Frequency Alarm. Bit 4 - SAG Voltage Alarm. Bit 5 – MINVA – under minimum voltage on VA input. Bit 6 – MAXVA – over maximum voltage on VA input. Bit 7 – MAXIA_NB – maximum narrowband current exceeded on Outlet 1. Bit 8 – MAXIA_WB – maximum wideband current exceeded on Outlet 1. Bit 9 – PFA_NB negative – Narrowband Power Factor Negative Threshold Alarm for Outlet 1. Bit 10 – PFA_NB positive – Narrowband Power Factor Positive Threshold Alarm for Outlet 1. Bit 11 – PFA_WB negative - Wideband Power Factor Negative Threshold Alarm for Outlet 1.	Alarms become "1" when thresholds exceeded. Note: Additional Status Alert is Located at addr 0xBD (see Table 8) Note: When AC voltage input is less than or equal to 10 V_{RMS}, • Only MINVA alarm is active. • All measurements are forced to 0 except power factor, which is forced to 1. Note: The frequency measurement is forced to 0 as long as the SAG voltage alarm is active.

Output	Location (hex)	LSB	Comment	Example
			Bit 12 – PFA_WB positive – Wideband Power Factor Positive Threshold Alarm for Outlet 1. Bit 13 – MAXIB_NB – maximum narrowband current exceeded on Outlet 2. Bit 14 – MAXIB_WB – maximum wideband current exceeded on Outlet 2. Bit 15 – PFB_NB negative – Narrowband Power Factor Negative Threshold Alarm for Outlet 2. Bit 16 – PFB_NB positive – Narrowband Power Factor Positive Threshold Alarm for Outlet 2. Bit 17 – PFB_WB negative – Wideband Power Factor Negative Threshold Alarm for Outlet 2. Bit 18– PFB_WB positive – Wideband Power Factor Positive Threshold Alarm for Outlet 2. Bit 19 – MAXIT_WB – maximum total wideband current exceeded on both Outlet 1 and Outlet 2. Bit 20 – MAXIT_NB – maximum total narrowband current exceeded on both Outlet 1 and Outlet 2. Bit 21 – CREEP A Alert – Creep Alert on Outlet 1. Bit 22 – CREEP B Alert – Creep Alert on Outlet 2. Bit 23 – Line/Neutral Reversal detected. Bit 24 – Reserved. Bit 25 – Reserved. Bit 26 – Unexpected Reset. Bits 27-31 – Reserved.	
Irms_nb A Overcurrent Event Count	03	1	Counter increments on each edge event.	If four narrowband over current events have occurred on Outlet 1:)03?<CR> Returns: +4
Vrms Under Voltage Event Count	04	1	Counter increments on each edge event.	If four under voltage events have occurred:)04?<CR> Returns: +4
Vrms Over Voltage Event Count	05	1	Counter increments on each edge event.	If four over voltage events have occurred:)05?<CR> Returns: +4
Vrms A	06	mVrms	Vrms voltage.	If the line voltage is 120 V)06?<CR> Returns: +120.000

Output	Location (hex)	LSB	Comment	Example
Watts A	07	mW	Outlet 1 active power measurement (per second).	If 120 Watts are measured on Outlet 1)07?<CR> Returns: +120.000
Wh A	08	mWh	Outlet 1 active accumulated energy measurement (per hour).	If 120 Wh are measured on Outlet 1)08?<CR> Returns: +120.000
Total Cost A	09	mUnits	Outlet 1 cost of Wh A.	If the cost is 102.536 units on Outlet 1)09?<CR> +102.536
Irms_nb A	0A	mArms	Outlet 1 narrowband rms current measurement.	If narrowband current measured on Outlet 1 is 12 Amps)0A?<CR> Returns: +12.000
VARs_nb A	0B	mW	Outlet 1 narrowband reactive power measurement (per second).	If narrowband 120 VARs are measured on Outlet 1)0B?<CR> Returns: +120.000
VAs_nb A	0C	mW	Outlet 1 narrowband apparent power measurement (per second).	If narrowband 120 VAs are measured on Outlet 1)0C?<CR> Returns: +120.000
Power Factor_nb A	0D	–	Outlet 1 narrowband power factor. The output will be between -0.950 and 1.000. Positive power factor is defined as current lagging voltage (inductive). Negative power factor is defined as voltage lagging current (capacitive).	If the narrowband power factor on Outlet 1 is 0.95)0D?<CR> Returns: +0.950
Phase Angle_nb A	0E	–	Outlet 1 narrowband phase angle. The output will be between 180.000 and -180.000.	If the narrowband phase angle measured on Outlet 1 is 60 degrees)0E?<CR> Returns: +60.000
Reserved	0F	–	Reserved	Reserved
Vrms A Min	10	mV	Minimum Vrms measured.	If the minimum line voltage measured was 105 V)10<CR> Returns: +15.000
Vrms A Max	11	mV	Maximum Vrms measured.	If the maximum line voltage measured was 130 V)11<CR> Returns: +130.000

Output	Location (hex)	LSB	Comment	Example
Watts A Min	12	mW	Minimum Outlet 1 active power measured (per second).	If the minimum power measured on Outlet 1 is 80 Watts)12?<CR> Returns: +80.000
Watts A Max	13	mW	Maximum Outlet 1 active power measured (per second).	If the maximum power measured on Outlet 1 is 200 Watts)13?<CR> Returns: +200.000
Irms_nb A Min	14	mArms	Outlet 1 minimum narrowband rms current measured.	If the smallest narrowband current measured on Outlet 1 is 1 Amp)14?<CR> Returns: +1.000
Irms_nb A Max	15	mArms	Outlet 1 maximum narrowband rms current measured.	If the largest narrowband current measured on Outlet 1 is 30 Amps)15?<CR> Returns: +30.000
VARs_nb A Min	16	mW	Outlet 1 minimum narrowband reactive power measured (per second).	If the largest VARs measured on Outlet 1 is 80 VARs)16?<CR> Returns: +80.000
VARs_nb A Max	17	mWs	Outlet 1 maximum narrowband reactive power measured (per second).	If the largest narrowband VARs measured on Outlet 1 is 300VARs)17?<CR> Returns: +300.000
VAs_nb A Min	18	mW	Outlet 1 minimum narrowband apparent power measured (per second).	If the smallest narrowband VAs measured on Outlet 1 is 80 VARs)18?<CR> Returns: +80.000
VAs_nb A Max	19	mWs	Outlet 1 maximum narrowband apparent power measured (per second).	If the largest narrowband VAs measured on Outlet 1 is 300VARs)19?<CR> Returns: +300.000
Power Factor_nb A Min	1A	–	Outlet 1 minimum narrowband power factor measured. Minimum is defined as the most negative or least positive number.	If minimum narrowband power factor measured on Outlet 1 is -0.6)1A?<CR> Returns: -0.600
Power Factor_nb A Max	1B	–	Outlet 1 maximum narrowband power factor measured. Maximum is defined as the most positive or least negative number.	If maximum narrowband power factor measured on Outlet 1 is 0.9)1B?<CR> Returns: +0.900
Phase Angle_nb A Min	1C	–	Outlet 1 minimum narrowband phase angle measured.	If the minimum narrowband phase angle measured on Outlet 1 is 10 degrees)1C?<CR> Returns: +10.000

Output	Location (hex)	LSB	Comment	Example
Phase Angle_nb A Max	1D	–	Outlet 1 maximum narrowband phase angle measured.	If the maximum narrowband phase angle measured on Outlet 1 is 70 degrees)1D?<CR> Returns: +70.000
Reserved	1E	–	Reserved	Reserved
Reserved	1F	–	Reserved	Reserved

Table 3 lists the wideband measurement outputs for Outlet 1.

Table 3: Outlet 1 MPU Outputs for Wideband Method

Output	Location (hex)	LSB	Comment	Example
Delta Temperature	20	0.1 °C	Temperature difference from 22° C. Note: Duplicate of address 0x00 (see Table 2)	If external temperature is 32 °C)20?<CR> Returns: +10.0
Line Frequency	21	0.1 Hz	Line Frequency Note: Duplicate of address 0x01 (see Table 2)	If the line frequency is 60 Hz:)21?<CR> Returns: +60.0
Alarm Status	22		**Definition for Status Register** Bit 0 – Minimum Temperature Alarm. Bit 1 – Maximum Temperature Alarm. Bit 2 – Minimum Frequency Alarm. Bit 3 – Maximum Frequency Alarm. Bit 4 - SAG Voltage Alarm. Bit 5 – MINVA – under minimum voltage on VA input. Bit 6 – MAXVA – over maximum voltage on VA input. Bit 7 – MAXIA_NB – maximum narrowband current exceeded on Outlet 1. Bit 8 – MAXIA_WB – maximum wideband current exceeded on Outlet 1. Bit 9 – PFA_NB negative – Narrowband Power Factor Negative Threshold Alarm for Outlet 1. Bit 10 – PFA_NB positive – Narrowband Power Factor Positive Threshold Alarm for Outlet 1. Bit 11 – PFA_WB negative - Wideband Power Factor Negative Threshold Alarm for Outlet 1. Bit 12 – PFA_WB positive – Wideband Power Factor Positive Threshold Alarm for Outlet 1. Bit 13 – MAXIB_NB – maximum narrowband current exceeded on Outlet 2.	Alarms become “1” when thresholds exceeded. Note: Additional Status Alert is Located at addr 0xBD (see Table 8) Note: When AC voltage input is less than or equal to 10 V_{RMS}, • Only MINVA alarm is active. • All measurements are forced to 0 except power factor, which is forced to 1. Note: The frequency measurement is forced to 0 as long as the SAG voltage alarm is active.

Output	Location (hex)	LSB	Comment	Example
			Bit 14 – MAXIB_WB – maximum wideband current exceeded on Outlet 2. Bit 15 – PFB_NB negative – Narrowband Power Factor Negative Threshold Alarm for Outlet 2. Bit 16 – PFB_NB positive – Narrowband Power Factor Positive Threshold Alarm for Outlet 2. Bit 17 – PFB_WB negative – Wideband Power Factor Negative Threshold Alarm for Outlet 2. Bit 18– PFB_WB positive – Wideband Power Factor Positive Threshold Alarm for Outlet 2. Bit 19 – MAXIT_WB – maximum total wideband current exceeded on both Outlet 1 and Outlet 2. Bit 20 – MAXIT_NB – maximum total narrowband current exceeded on both Outlet 1 and Outlet 2. Bit 21 – CREEP A Alert – Creep Alert on Outlet 1. Bit 22 – CREEP B Alert – Creep Alert on Outlet 2. Bit 23 – Line/Neutral Reversal detected. Bit 24 – Reserved. Bit 25 – Reserved. Bit 26 – Unexpected Reset. Bits 27-31 – Reserved. Note: Duplicate of address 0x02 (see Table 2)	
Irms_wb A Overcurrent Event Count	23		Counter increments on each edge event.	If four wideband over current events have occurred on Outlet 1:)23?<CR> Returns: +4
Vrms Under Voltage Event Count	24		Counter increments on each edge event. Note: Duplicate of address 0x04 (see Table 2).	If four under voltage events have occurred:)24?<CR> Returns: +4
Vrms Over Voltage Event Count	25		Counter increments on each edge event. Note: Duplicate of address 0x06 (see Table 2).	If four over voltage events have occurred:)25?<CR> Returns: +4
Vrms A	26	mV	Vrms voltage Note: Duplicate of address 0x06 (see Table 2).	If the line voltage is 120 V)26?<CR> Returns: +120.000
Watts A	27	mW	Outlet 1 active power measurement (per second). Note: Duplicate of address 0x07 (see Table 2).	If 120 Watts are measured on Outlet 1)27?<CR> Returns: +120.000

Output	Location (hex)	LSB	Comment	Example
Wh A	28	mWh	Outlet 1 active accumulated energy measurement (per hour). Note: Duplicate of address 0x08 (see Table 2).	If 120 Wh are measured on Outlet 1)28?<CR> Returns: +120.000
Total Cost A	29	mUnits	Outlet 1 cost of Wh A. Note: Duplicate of address 0x09 (see Table 2).	If the cost is 102.536 units on Outlet 1)29?<CR> +102.536
Irms_wb A	2A	mA	Outlet 1 wideband rms current measurement.	If narrowband current measured on Outlet 1 is 12 Amps)2A?<CR> Returns: +12.000
VARs_wb A	2B	mW	Outlet 1 wideband reactive power measurement (per second).	If narrowband 120 VARs are measured on Outlet 1)2B?<CR> Returns: +120.000
VAs_wb A	2C	mW	Outlet 1 wideband apparent power measurement (per second).	If narrowband 120 VAs are measured on Outlet 1)2C?<CR> Returns: +120.000
Power Factor_wb A	2D	–	Outlet 1 wideband power factor. The output will be between -0.950 and 1.000. Positive power factor is defined as current lagging voltage (inductive). Negative power factor is defined as voltage lagging current (capacitive).	If the narrowband power factor on Outlet 1 is 0.95)2D?<CR> Returns: +0.950
Phase Angle_wb A	2E	–	Outlet 1 wideband phase angle. The output will be between 180.000 and -180.000.	If the narrowband phase angle measured on Outlet 1 is 60 degrees)2E?<CR> Returns: +60.000
Reserved	2F	–	Reserved	Reserved
Vrms A Min	30	mV	Minimum Vrms measured Note: Duplicate of address 0x10 (see Table 2).	If the minimum line voltage measured was 105 V)30<CR> Returns: +15.000
Vrms A Max	31	mV	Maximum Vrms measured Note: Duplicate of address 0x11 (see Table 2).	If the maximum line voltage measured was 130 V)31<CR> Returns: +130.000
Watts A Min	32	mW	Minimum Outlet 1 active power measured (per second) Note: Duplicate of address 0x12 (see Table 2)	If the minimum power measured on Outlet 1 is 80 Watts)32?<CR> Returns: +80.000

Output	Location (hex)	LSB	Comment	Example
Watts A Max	33	mW	Maximum Outlet 1 active power measured (per second) Note: Duplicate of address 0x13 (see Table 2).	If the maximum power measured on Outlet 1 is 200 Watts)33?<CR> Returns: +200.000
Irms_wb A Min	34	mArms	Outlet 1 minimum wideband rms current measured.	If the smallest narrowband current measured on Outlet 1 is 1 Amp)34?<CR> Returns: +1.000
Irms_wb A Max	35	mArms	Outlet 1 maximum wideband rms current measured.	If the largest narrowband current measured on Outlet 1 is 30 Amps)35?<CR> Returns: +30.000
VARs_wb A Min	36	mW	Outlet 1 minimum wideband reactive power measured (per second).	If the largest VARs measured on Outlet 1 is 80 VARs)36?<CR> Returns: +80.000
VARs_wb A Max	37	mW	Outlet 1 maximum wideband reactive power measured (per second).	If the largest VARs measured on Outlet 1 is 300 VARs)37?<CR> Returns: +300.000
VAs_wb A Min	38	mW	Outlet 1 minimum wideband apparent power measured (per second).	If the smallest VAs measured on Outlet 1 is 80 VARs)38?<CR> Returns: +80.000
VAs_wb A Max	39	mW	Outlet 1 maximum wideband apparent power measured (per second).	If the largest VAs measured on Outlet 1 is 300 VARs)39?<CR> Returns: +300.000
Power Factor_wb A Min	3A	–	Outlet 1 minimum wideband power factor measured. Minimum is defined as the most negative or least positive number.	If minimum narrowband power factor measured on Outlet 1 is –0.6)3A?<CR> Returns: -0.600
Power Factor_wb A Max	3B	–	Outlet 1 maximum wideband power factor measured. Maximum is defined as the most positive or least negative number.	If maximum narrowband power factor measured on Outlet 1 is 0.9)3B?<CR> Returns: +0.900
Phase Angle_wb A Min	3C	–	Outlet 1 minimum wideband phase angle measured.	If the minimum narrowband phase angle measured on Outlet 1 is 10 degrees)3C?<CR> Returns: +10.000
Phase Angle_wb A Max	3D	–	Outlet 1 maximum wideband phase angle measured.	If the maximum narrowband phase angle measured on Outlet 1 is 70 degrees)3D?<CR> Returns: +70.000
Reserved	3E	–	Reserved	Reserved

Output	Location (hex)	LSB	Comment	Example
Reserved	3F	–	Reserved	Reserved

Table 4 lists the narrowband measurement outputs for Outlet 2.

Table 4: Outlet 2 MPU Outputs for Narrowband Method

Output	Location (hex)	LSB	Comment	Example
Delta Temperature	40	0.1 °C	Temperature difference from 22° C. Note: Duplicate of address 0x00 (see Table 2).	If external temperature is 32 °C)40?<CR> Returns: +10.0
Line Frequency	41	0.1 Hz	Line Frequency Note: Duplicate of address 0x01 (see Table 2).	If the line frequency is 60 Hz:)41?<CR> Returns: +60.0
Alarm Status	42		**Definition for Status Register** Bit 0 – Minimum Temperature Alarm. Bit 1 – Maximum Temperature Alarm. Bit 2 – Minimum Frequency Alarm. Bit 3 – Maximum Frequency Alarm. Bit 4 – SAG Voltage Alarm. Bit 5 – MINVA – under minimum voltage on VA input. Bit 6 – MAXVA – over maximum voltage on VA input. Bit 7 – MAXIA_NB – maximum narrowband current exceeded on Outlet 1. Bit 8 – MAXIA_WB – maximum wideband current exceeded on Outlet 1. Bit 9 – PFA_NB negative – Narrowband Power Factor Negative Threshold Alarm for Outlet 1. Bit 10 – PFA_NB positive – Narrowband Power Factor Positive Threshold Alarm for Outlet 1. Bit 11 – PFA_WB negative – Wideband Power Factor Negative Threshold Alarm for Outlet 1. Bit 12 – PFA_WB positive – Wideband Power Factor Positive Threshold Alarm for Outlet 1. Bit 13 – MAXIB_NB – maximum narrowband current exceeded on Outlet 2. Bit 14 – MAXIB_WB – maximum wideband current exceeded on Outlet 2.	Alarms become “1” when thresholds exceeded. Note: Additional Status Alert is Located at addr 0xBD (see Table 8). Note: When AC voltage input is less than or equal to 10 V_{RMS}, • Only MINVA alarm is active. • All measurements are forced to 0 except power factor, which is forced to 1. Note: The frequency measurement is forced to 0 as long as the SAG voltage alarm is active.

Output	Location (hex)	LSB	Comment	Example
			Bit 15 – PFB_NB negative – Narrowband Power Factor Negative Threshold Alarm for Outlet 2. Bit 16 – PFB_NB positive – Narrowband Power Factor Positive Threshold Alarm for Outlet 2. Bit 17 – PFB_WB negative – Wideband Power Factor Negative Threshold Alarm for Outlet 2. Bit 18– PFB_WB positive – Wideband Power Factor Positive Threshold Alarm for Outlet 2. Bit 19 – MAXIT_WB – maximum total wideband current exceeded on both Outlet 1 and Outlet 2. Bit 20 – MAXIT_NB – maximum total narrowband current exceeded on both Outlet 1 and Outlet 2. Bit 21 – CREEP A Alert – Creep Alert on Outlet 1. Bit 22 – CREEP B Alert – Creep Alert on Outlet 2. Bit 23 – Line/Neutral Reversal detected. Bit 24 – Reserved. Bit 25 – Reserved. Bit 26 – Unexpected Reset. Bits 27-31 – Reserved. Note: Duplicate of address 0x02 (see Table 2).	
Irms_nb B Overcurrent Event Count	43		Counter increments on each edge event.	If four narrowband over current events have occurred on Outlet 2:)43?<CR> Returns: +4
Vrms Under Voltage Event Count	44		Counter increments on each edge event. Note: Duplicate of address 0x04 (see Table 2).	If four under voltage events have occurred:)44?<CR> Returns: +4
Vrms Over Voltage Event Count	45		Counter increments on each edge event. Note: Duplicate of address 0x06 (see Table 2).	If 4 over voltage events have occurred:)45?<CR> Returns: +4
Vrms A	46	mV	Vrms voltage Note: Duplicate of address 0x06 (see Table 2).	If the line voltage is 120 V)46?<CR> Returns: +120.000
Watts B	47	mW	Outlet 2 active power measurement (per second).	If 120 Watts are measured on Outlet 2)47?<CR> Returns: +120.000

Output	Location (hex)	LSB	Comment	Example
Wh B	48	mWh	Outlet 2 active accumulated energy measurement (per hour).	If 120 Wh are measured on Outlet 2)48?<CR> Returns: +120.000
Total Cost B	49	mUnits	Outlet 2 cost of Wh B.	If the total cost is 102.536 units on Outlet 2)49?<CR> +102.536
Irms_nb B	4A	mArms	Outlet 2 narrowband rms current measurement.	If narrowband current measured on Outlet 2 is 12 Amps)4A?<CR> Returns: +12.000
VARs_nb B	4B	mW	Outlet 2 narrowband reactive power measurement (per second).	If narrowband 120 VARs are measured on Outlet 2)4B?<CR> Returns: +120.000
VAs_nb B	4C	mW	Outlet 2 narrowband apparent power measurement (per second).	If narrowband 120 VAs are measured on Outlet 2)4C?<CR> Returns: +120.000
Power Factor_nb B	4D	–	Outlet 2 narrowband power factor. The output will be between -0.950 and 1.000. Positive power factor is defined as current lagging voltage (inductive). Negative power factor is defined as voltage lagging current (capacitive).	If the narrowband power factor on Outlet 2 is 0.95)4D?<CR> Returns: +0.950
Phase Angle_nb B	4E	–	Outlet 2 narrowband phase angle. The output will be between 180.000 and -180.000.	If the narrowband phase angle measured on Outlet 2 is 60 degrees)4E?<CR> Returns: +60.000
Reserved	4F	–	Reserved	Reserved
Vrms A Min	50	mV	Minimum Vrms measured Note: Duplicate of address 0x10 (see Table 2).	If the minimum line voltage measured was 105 V)50<CR> Returns: +15.000
Vrms A Max	51	mV	Maximum Vrms measured Note: Duplicate of address 0x11 (see Table 2).	If the maximum line voltage measured was 130 V)51<CR> Returns: +130.000
Watts B Min	52	mW	Minimum Outlet 2 active power measured (per second).	If the minimum power measured on Outlet 2 is 80 Watts)52?<CR> Returns: +80.000

Output	Location (hex)	LSB	Comment	Example
Watts B Max	53	mW	Maximum Outlet 2 active power measured (per second).	If the maximum power measured on Outlet 2 is 200 Watts)53?<CR> Returns: +200.000
Irms_nb B Min	54	mArms	Outlet 2 minimum narrowband rms current measured.	If the smallest narrowband current measured on Outlet 2 is 1 Amp)54?<CR> Returns: +1.000
Irms_nb B Max	55	mArms	Outlet 2 maximum narrowband rms current measured.	If the largest narrowband current measured on Outlet 2 is 30 Amps)55?<CR> Returns: +30.000
VARs_nb B Min	56	mW	Outlet 2 minimum narrowband reactive power measured (per second).	If the largest VARs measured on Outlet 2 is 80 VARs)56?<CR> Returns: +80.000
VARs_nb B Max	57	mW	Outlet 2 maximum narrowband reactive power measured (per second).	If the largest narrowband VARs measured on Outlet 2 is 300 VARs)57?<CR> Returns: +300.000
VAs_nb B Min	58	mW	Outlet 2 minimum narrowband apparent power measured (per second)	If the smallest narrowband VAs measured on Outlet 2 is 80 VARs)58?<CR> Returns: +80.000
VAs_nb B Max	59	mW	Outlet 2 maximum narrowband apparent power measured (per second).	If the largest narrowband VAs measured on Outlet 2 is 300 VARs)59?<CR> Returns: +300.000
Power Factor_nb B Min	5A	–	Outlet 2 minimum narrowband power factor measured. Minimum is defined as the most negative or least positive number.	If minimum narrowband power factor measured on Outlet 2 is -0.6)5A?<CR> Returns: -0.600
Power Factor_nb B Max	5B	–	Outlet 2 maximum narrowband power factor measured. Maximum is defined as the most positive or least negative number.	If maximum narrowband power factor measured on Outlet 2 is 0.9)5B?<CR> Returns: +0.900
Phase Angle_nb B Min	5C	–	Outlet 2 minimum narrowband phase angle measured.	If the minimum narrowband phase angle measured on Outlet 2 is 10 degrees)5C?<CR> Returns: +10.000

Output	Location (hex)	LSB	Comment	Example
Phase Angle_nb B Max	5D	–	Outlet 2 maximum narrowband phase angle measured.	If the maximum narrowband phase angle measured on Outlet 2 is 70 degrees)5D?<CR> Returns: +70.000
Reserved	5E	–	Reserved	Reserved
Reserved	5F	–	Reserved	Reserved

Table 5 lists the wideband measurement outputs for Outlet 2.

Table 5: Outlet 2 MPU Outputs for Wideband Method

Output	Location (hex)	LSB	Comment	Example
Delta Temperature	60	0.1 °C	Temperature difference from 22° C. Note: Duplicate of address 0x00 (see Table 2).	If external temperature is 32 °C)60?<CR> Returns: +10.0
Line Frequency	61	0.1 Hz	Line Frequency Note: Duplicate of address 0x01 (see Table 2).	If the line frequency is 60 Hz:)61?<CR> Returns: +60.0
Alarm Status	62		**Definition for Status Register** Bit 0 – Minimum Temperature Alarm. Bit 1 – Maximum Temperature Alarm. Bit 2 – Minimum Frequency Alarm. Bit 3 – Maximum Frequency Alarm. Bit 4 - SAG Voltage Alarm. Bit 5 – MINVA – under minimum voltage on VA input. Bit 6 – MAXVA – over maximum voltage on VA input. Bit 7 – MAXIA_NB – maximum narrowband current exceeded on Outlet 1. Bit 8 – MAXIA_WB – maximum wideband current exceeded on Outlet 1. Bit 9 – PFA_NB negative – Narrowband Power Factor Negative Threshold Alarm for Outlet 1. Bit 10 – PFA_NB positive – Narrowband Power Factor Positive Threshold Alarm for Outlet 1. Bit 11 – PFA_WB negative - Wideband Power Factor Negative Threshold Alarm for Outlet 1. Bit 12 – PFA_WB positive – Wideband Power Factor Positive Threshold Alarm for Outlet 1. Bit 13 – MAXIB_NB – maximum narrowband current exceeded on Outlet 2. Bit 14 – MAXIB_WB – maximum wideband current exceeded on Outlet 2. Bit 15 – PFB_NB negative – Narrowband Power Factor Negative Threshold Alarm for Outlet 2. Bit 16 – PFB_NB positive – Narrowband Power Factor Positive Threshold Alarm for Outlet 2.	Alarms become "1" when thresholds exceeded. Note: Additional Status Alert is Located at addr 0xBD (see Table 8). Note: When AC voltage input is less than or equal to 10 V_{RMS}, • Only MINVA alarm is active. • All measurements are forced to 0 except power factor, which is forced to 1. Note: The frequency measurement is forced to 0 as long as the SAG voltage alarm is active.

Output	Location (hex)	LSB	Comment	Example
			Bit 17 – PFB_WB negative – Wideband Power Factor Negative Threshold Alarm for Outlet 2. Bit 18– PFB_WB positive – Wideband Power Factor Positive Threshold Alarm for Outlet 2. Bit 19 – MAXIT_WB – maximum total wideband current exceeded on both Outlet 1 and Outlet 2. Bit 20 – MAXIT_NB – maximum total narrowband current exceeded on both Outlet 1 and Outlet 2. Bit 21 – CREEP A Alert – Creep Alert on Outlet 1. Bit 22 – CREEP B Alert – Creep Alert on Outlet 2. Bit 23 – Line/Neutral Reversal detected. Bit 24 – Reserved. Bit 25 – Reserved. Bit 26 – Unexpected Reset. Bits 27-31 – Reserved. Note: Duplicate of address 0x02 (see Table 2)	
Irms_wb B Overcurrent Event Count	63		Counter increments on each edge event.	If four wideband over current events have occurred on Outlet 2:)63?<CR> Returns: +4
Vrms Under Voltage Event Count	64		Counter increments on each edge event. Note: Duplicate of address 0x04 (see Table 2).	If 4 under voltage events have occurred:)64?<CR> Returns: +4
Vrms Over Voltage Event Count	65		Counter increments on each edge event. Note: Duplicate of address 0x06 (see Table 2).	If 4 over voltage events have occurred:)65?<CR> Returns: +4
Vrms A	66	mV	Vrms voltage Note: Duplicate of address 0x06 (see Table 2).	If the line voltage is 120 V)66?<CR> Returns: +120.000
Watts B	67	mW	Outlet 2 active power measurement (per second) Note: Duplicate of address 0x47 (see Table 4).	If 120 Watts are measured on Outlet 2)67?<CR> Returns: +120.000
Wh B	68	mWh	Outlet 2 active accumulated energy measurement (per hour) Note: Duplicate of address 0x48 (see Table 4).	If 120 Wh are measured on Outlet 2)68?<CR> Returns: +120.000
Total Cost B	69	mUnits	Outlet 2 cost of Wh B Note: Duplicate of address 0x49 (see Table 4).	If the total cost is 102.536 units on Outlet 2)69?<CR> +102.536

Output	Location (hex)	LSB	Comment	Example
Irms_wb B	6A	mArms	Outlet 2 wideband rms current measurement.	If wideband current measured on Outlet 2 is 12 Amps)6A?<CR> Returns: +12.000
VARs_wb B	6B	mW	Outlet 2 wideband reactive power measurement (per second).	If wideband 120 VARs are measured on Outlet 2)6B?<CR> Returns: +120.000
VAs_wb B	6C	mW	Outlet 2 wideband apparent power measurement (per second).	If wideband 120 VAs are measured on Outlet 2)6C?<CR> Returns: +120.000
Power Factor_wb B	6D	–	Outlet 2 wideband power factor. The output will be between -0.950 and 1.000. Positive power factor is defined as current lagging voltage (inductive). Negative power factor is defined as voltage lagging current (capacitive).	If the wideband power factor on Outlet 2 is 0.95)6D?<CR> Returns: +0.950
Phase Angle_wb B	6E	mDegrees	Outlet 2 wideband phase angle. The output will be between 180.000 and -180.000.	If the wideband phase angle measured on Outlet 2 is 60 degrees)6E?<CR> Returns: +60.000
Reserved	6F	–	Reserved	Reserved
Vrms A Min	70	mV	Minimum Vrms measured Note: Duplicate of address 0x10 (see Table 2).	If the minimum line voltage measured was 105 V)70<CR> Returns: +15.000
Vrms A Max	71	mV	Maximum Vrms measured Note: Duplicate of address 0x11 (see Table 2).	If the maximum line voltage measured was 130 V)71<CR> Returns: +130.000
Watts B Min	72	mW	Minimum Outlet 2 active power measured (per second) Note: Duplicate of address 0x52 (see Table 4).	If the minimum power measured on Outlet 2 is 80 Watts)72?<CR> Returns: +80.000
Watts B Max	73	mW	Maximum Outlet 2 active power measured (per second) Note: Duplicate of address 0x53 (see Table 4).	If the maximum power measured on Outlet 2 is 200 Watts)73?<CR> Returns: +200.000
Irms_wb B Min	74	mArms	Outlet 2 minimum wideband rms current measured.	If the smallest wideband current measured on Outlet 2 is 1 Amp)74?<CR> Returns: +1.000

Output	Location (hex)	LSB	Comment	Example
Irms_wb B Max	75	mArms	Outlet 2 maximum wideband rms current measured.	If the largest wideband current measured on Outlet 2 is 30 Amps)75?<CR> Returns: +30.000
VARs_wb B Min	76	mW	Outlet 2 minimum wideband reactive power measured (per second).	If the largest VARs measured on Outlet 2 is 80 VARs)76?<CR> Returns: +80.000
VARs_wb B Max	77	mW	Outlet 2 maximum wideband reactive power measured (per second).	If the largest VARs measured on Outlet 2 is 300 VARs)77?<CR> Returns: +300.000
VAs_wb B Min	78	mW	Outlet 2 minimum wideband apparent power measured (per second).	If the smallest VAs measured on Outlet 2 is 80 VARs)78?<CR> Returns: +80.000
VAs_wb B Max	79	mW	Outlet 2 maximum wideband apparent power measured (per second).	If the largest VAs measured on Outlet 2 is 300 VARs)79?<CR> Returns: +300.000
Power Factor_wb B Min	7A		Outlet 2 minimum wideband power factor measured. Minimum is defined as the most negative or least positive number.	If minimum wideband power factor measured on Outlet 2 is –0.6)7A?<CR> Returns: -0.600
Power Factor_wb B Max	7B	–	Outlet 2 maximum wideband power factor measured. Maximum is defined as the most positive or least negative number.	If maximum wideband power factor measured on Outlet 2 is 0.9)7B?<CR> Returns: +0.900
Phase Angle_wb B Min	7C	mDegrees	Outlet 2 minimum wideband phase angle measured.	If the minimum wideband phase angle measured on Outlet 2 is 10 degrees)7C?<CR> Returns: +10.000
Phase Angle_wb B Max	7D	mDegree	Outlet 2 maximum wideband phase angle measured.	If the maximum wideband phase angle measured on Outlet 2 is 70 degrees)7D?<CR> Returns: +70.000
Reserved	7E	–	Reserved	Reserved
Reserved	7F	–	Reserved	Reserved

Table 6 lists the narrowband measurement outputs for both outlets combined (Outlet 1 + Outlet 2).

Table 6: Combined Outlets MPU Outputs for Narrowband Method

Output	Location (hex)	LSB	Comment	Example
Watts T	80	mW	Active power measurement (per second) on both outlets.	If 120 Watts are measured on both outlets)80?<CR> Returns: +120.000
Wh T	81	mWh	Active accumulated energy measurement (per hour) on both outlets.	If 120 Wh are measured on Outlet 2)81?<CR> Returns: +120.000
Total Cost T	82	mUnits	Total Cost of Wh for both outlets.	If the total cost is 102.536 units on both outlets)82?<CR> +102.536
Irms_nb T	83	mArms	Combined outlet narrowband rms current measurement.	If narrowband current measured on both outlets is 12 Amps)83?<CR> Returns: +12.000
VARs_nb T	84	mW	Combined outlet narrowband reactive power measurement (per second).	If narrowband 120 VARs are measured on both outlets)84?<CR> Returns: +120.000
VAs_nb T	85	mW	Combined outlet narrowband apparent power measurement (per second).	If narrowband 120 VAs are measured on both outlets)85?<CR> Returns: +120.000
Irms_nb T Overcurrent Event Count	86		Counter increments on each edge event.	If four narrowband over current events have occurred on Outlet 1 and Outlet 2:)86?<CR> Returns: +4
Reserved	87	–	Reserved	Reserved
Watts T Min	88	mW	Minimum combined outlet active power measured (per second).	If the minimum power measured on both outlets is 80 Watts)88?<CR> Returns: +80.000
Watts T Max	89	mW	Maximum combined active power measured (per second).	If the maximum power measured on both outlets is 200 Watts)89?<CR> Returns: +200.000
Irms_nb T Min	8A	mArms	Minimum combined outlet narrowband rms current measured.	If the smallest narrowband current measured on both outlets is 1 Amp)8A?<CR> Returns: +1.000

Output	Location (hex)	LSB	Comment	Example
Irms_nb T Max	8B	mArms	Maximum combined outlet narrowband rms current measured.	If the largest narrowband current measured on both outlets is 30 Amps)8B?<CR> Returns: +30.000
VARs_nb T Min	8C	mW	Minimum combined outlet narrowband reactive power measured (per second).	If the largest narrowband VARs measured on both outlets is 80 VARs)8C?<CR> Returns: +80.000
VARs_nb T Max	8D	mW	Maximum combined outlet narrowband reactive power measured (per second).	If the largest narrowband VARs measured on both outlets is 300 VARs)8D?<CR> Returns: +300.000
VAs_nb T Min	8E	mW	Minimum combined outlet narrowband apparent power measured (per second).	If the smallest narrowband VAs measured on both outlets is 80 VARs)8E?<CR> Returns: +80.000
VAs_nb T Max	8F	mW	Maximum combined outlet narrowband apparent power measured (per second).	If the largest narrowband VAs measured on both outlets is 300 VARs)8F?<CR> Returns: +300.000

Table 7 lists the wideband measurement outputs for both outlets combined (Outlet 1 + Outlet 2).

Table 7: Combined Outlets MPU Outputs for Wideband Method

Output	Location (hex)	LSB	Comment	Example
Watts T	90	mW	Active power measurement (per second) on both outlets. Note: Duplicate of address 0x80 (see Table 6).	If 120 Watts are measured on both outlets)90?<CR> Returns: +120.000
Wh T	91	mWh	Active accumulated energy measurement (per hour) on both outlets. Note: Duplicate of address 0x81 (see Table 6).	If 120 Wh are measured on Outlet 2)91?<CR> Returns: +120.000
Total Cost T	92	mUnits	Total Cost of Wh for both outlets. Note: Duplicate of address 0x82 (see Table 6).	If the total cost is 102.536 units on both outlets)92?<CR> +102.536
Irms_wb T	93	mArms	Combined outlet wideband rms current measurement.	If wideband current measured on both outlets is 12 Amps)93?<CR> Returns: +12.000
VARs_wb T	94	mW	Combined outlet wideband reactive power measurement (per second).	If wideband 120 VARs are measured on both outlets)94?<CR> Returns: +120.000
VAs_wb T	95	mW	Combined outlet wideband apparent power measurement (per second).	If wideband 120 VAs are measured on both outlets)95?<CR> Returns: +120.000
Irms_wb T Overcurrent Event Count	96		Counter increments on each edge event.	If four wideband over current events have occurred on Outlet 1 and Outlet 2:)96?<CR> Returns: +4
Reserved	97	–	Reserved	Reserved
Watts T Min	98	mW	Minimum combined outlet active power measured (per second) Note: Duplicate of address 0x88 (see Table 6).	If the minimum power measured on both outlets is 80 Watts)98?<CR> Returns: +80.000
Watts T Max	99	mW	Maximum combined outlet active power measured (per second) Note: Duplicate of address 0x89 (see Table 6).	If the maximum power measured on both outlets is 200 Watts)99?<CR> Returns: +200.000
Irms_wb T Min	9A	mArms	Minimum combined outlet wideband rms current measured.	If the smallest wideband current measured on both outlets is 1 Amp)9A?<CR> Returns: +1.000

Output	Location (hex)	LSB	Comment	Example
Irms_wb T Max	9B	mArms	Maximum combined outlet wideband rms current measured.	If the largest wideband current measured on both outlets is 30 Amps)9B?<CR> Returns: +30.000
VARs_wb T Min	9C	mW	Minimum combined outlet wideband reactive power measured (per second).	If the largest VARs measured on both outlets is 80 VARs)9C?<CR> Returns: +80.000
VARs_wb T Max	9D	mW	Maximum combined outlet wideband reactive power measured (per second).	If the largest VARs measured on both outlets is 300 VARs)9D?<CR> Returns: +300.000
VAs_wb T Min	9E	mW	Minimum combined outlet wideband apparent power measured (per second).	If the smallest VAs measured on both outlets is 80 VARs)9E?<CR> Returns: +80.000
VAs_wb T Max	9F	mW	Maximum combined outlet wideband apparent power measured (per second).	If the largest VAs measured on both outlets is 300 VARs)9F?<CR> Returns: +300.000

6 Configuration Parameter Entry

6.1 MPU Parameters

Table 8 lists the MPU parameters that the Firmware 6612_OMU_S2_URT_V1_13 has configured. The user does not need to alter any of these parameters while using the demo unit.

Table 8: MPU Parameters

MPU Parameter	Location (hex)	LSB	Default	Comment	Example
VMAX A	A0	mVrms	+600.000	External rms voltage corresponding to 250 mVpk at the VA input of the 78M6612. It must be set high enough to account for overvoltages. Usually set to 600 V (600.000d).	VMAX on channel A is 600V for headroom. For added margin, VMAX could be set as follows: VMAX = (Vpk/√2)(2E06+75)/750 = 478.581)A0=+471.581<CR>
Starting IA	A1	mArms	+0.007	Minimum current value to be measured on the IA input. Currents below this value will be ignored. Also known as CREEP IA.	Default setting is 7 mA. If start current on channel A desired is 10 mA:)A1=+0.010<CR>
IMAX A	A2	mArms	+52.000	External rms current corresponding to 250 mVpk at the IA input of the 78M6612.	The default is set to 52 Amps for overhead. For added margin, in a system using current shunts IMAX could be changed as follows: IMAX= (Vpk/√2)/R_{shunt} For a 4 mΩ current shunt IMAX=44.19 Amps To set IMAX A:)A2=+44.190<CR>
Starting IB	A3	mArms	+0.007	Minimum current value to be measured on the IB input. Currents below this value will be ignored. Also known as CREEP IB	Default setting is 7 mA. If start current on channel B desired is 10 mA:)A3=+0.010<CR>
IMAX B	A4	mArms	+52.000	External rms current corresponding to 250 mVpk at the IB input of the 78M6612.	The default is set to 52 Amps for overhead. For added margin, in a system using current shunts IMAX could be changed as follows: IMAX= (Vpk/√2)/R_{shunt} For a 4 mΩ current shunt IMAX=44.19 Amps)A4=+44.190<CR>
Unused	A5	–	–		

MPU Parameter	Location (hex)	LSB	Default	Comment	Example
Temperature Nominal	A6	–	+0	Temp_raw_x reading at 22 °C. Needed to enable temperature compensation.	Temp _raw_x is obtained from the CE:]71?<CR> This value is then entered here:)A6=+value in decimal Also, the command: >CLT<CR> Will do the same as the steps above.
Reserved	A7	–		Reserved	
PPMC	A8	ppm/°C	-668	ppm per °C.	Do not change the default setting.
$PPMC^2$	A9	ppm/°C^2	-341	ADC temperature compensation ppm per °C^2.	Do not change the default setting.
Cost/kWh	AA	mUnits	+0.150	Cost per kWh (kilowatt hour) in milliunits.	If the cost per kWh is to be 10 units:)AD=+10.000<CR>
Units of Cost	AB	N/A	USD	4-byte string describing unit of cost (e.g. USD, EURO etc.). There must be 4 characters. If entering US dollars, USD, there needs to be a space after the D to make it a four character string.	To enter US Dollars:)AB="USD "<CR> To enter Euros:)AB="EURO"<CR>
Relay Configuration	AC	–	0	Bit 1 (Relay Polarity) 0 = Normal Polarity 1 = Inverted Polarity Bit 0 (Relay Type) 0 = non-latched 1 = latched	
Sequence Delay	AD	0.1s	+0.1	Time delay between relays.	If the user desires a 1 second delay between the closing of the first and second relays and also a one second delay between the opening of the first and second relays, then enter the following: >)AD=+1<CR>
Energize Delay	AE	ms	+0.000	Parameter given in relay manufacturer's data sheet is entered here. The amount of delay will be 1 ms plus the value entered in)AE.	If the user desires 8 ms of delay then enter the following: >)AE=+0.007<CR>

MPU Parameter	Location (hex)	LSB	Default	Comment	Example
De-Energize Delay	AF	ms	+0.000	Parameter given in relay manufacturer's data sheet is entered here. The amount of delay will be 1 ms plus the value entered in)AF.	If the user desires 8 ms of delay then enter the following: >)AF=+0.007<CR>
Reserved	B0 - BC	ppb	0	Reserved	Reserved
Additional Status	BD	–	1	Bit 0 – Reserved. Bit 1 – WPULSE Disable. Bit 2 – VCal Failure. Bit 3 – ICal1 Failure. Bit 4 – WCal1 Failure. Bit 5 – ICal2 Failure Bit 6 – WCal2 Failure	
Unused	BE	–			
Unused	BF	–			
Reserved	C0	–	0	Reserved	Reserved
Calibration Voltage	C1	mVrms	+120.000	Target line voltage (rms) used for calibration.	If the target line voltage for calibration is 220V, enter the following: >)C1=+220<CR>
Calibration Current	C2	mArms	+1.000	Target load current (rms) used for calibration.	If the target load current for calibration is 2A, enter the following: >)C2=+2<CR>
Calibration Phase	C3	0.1°	+0	Target Phase (voltage to current). Normally set to zero.	
Tolerance on Voltage	C4	mVrms	+0.010	Measured value to fall within this set tolerance of the target value (Calibration Voltage entry) for the calibration to be complete.	If the tolerance to the target voltage is desired to be more coarse, to within 0.1V, the user can enter the following: >)C4=+0.100<CR>
Tolerance on Current	C5	mArms	+0.010	Measured value to fall within this set tolerance of the target value (Calibration Current entry) for the calibration to be complete.	If the tolerance to the target current is desired to be more coarse, to within 0.1A, the user can enter the following: >)C5=+0.100<CR>
Average Count for Voltage	C6	1	+3	Number of voltage measurements taken and averaged to be compared to the target value (Calibration Voltage entry).	If the amount of averaging for the voltage measurement is desired to increase to 10 enter the following: >)C6=+10<CR>

MPU Parameter	Location (hex)	LSB	Default	Comment	Example
Average Count for Current	C7	1	+3	Number of current measurements taken and averaged to be compared to the target value (Calibration Current entry).	If the amount of averaging for the current measurement is desired to increase to 10 enter the following: >)C7=+10<CR>
Max Iteration for Voltage	C8	1	+10	Number of attempts to reach the target value (Calibration Voltage entry) within the programmed tolerance.	If maximum number of iterations to be tried for obtaining the target value of voltage within the set tolerance (at C4) is to be reduced to 5, then enter: >)C8=+5<CR>
Max Iteration for Current	C9	1	+10	Number of attempts to reach the target value (Calibration Voltage entry) within the programmed tolerance.	If maximum number of iterations to be tried for obtaining the target value of power within the set tolerance (at C5) is to be reduced to 5, then enter: >)C9=+5<CR>
Tolerance on Watts	CA	mW	+0.010	Measured value to fall within this set tolerance of the target value (Calibration Voltage multiplied by the calibration current entries) for the calibration to be complete.	If the tolerance to the target power is desired to be more coarse, to within 0.1W, the user can enter the following: >)CA=+0.100<CR>
Average Count for Watts	CB	1	+3	Measured value to fall within this set tolerance of the target value (Calibration Voltage multiplied by the calibration current entries) for the calibration to be complete.	If the amount of averaging for the power measurement is desired to increase to 10 enter the following: >)CB=+10<CR>
Max Iteration for Watts	CC	1	+10	Number of attempts to reach the target value (Calibration Voltage multiplied by the calibration current entries) within the programmed tolerance.	If maximum number of iterations to be tried for obtaining the target value of power within the set tolerance (at CA) is to be reduced to 5, then enter: >)CC=+5<CR>
Calibration WRATE	CD	1	+4860	Entry for WRATE during the calibration step only. After calibration, WRATE returns to the value entered in]0F.	
Calibration Temperature	CE	0.1°C	+22.0	Target nominal temperature for calibration.	If the user desires the target nominal temperature to be 25°C, then set as follows: >)CE=+25.0<CR>

MPU Parameter	Location (hex)	LSB	Default	Comment	Example
Unused	CF	–		Unused	
Temp Alarm Min Threshold	D0	0.1°C	+0.0°C	Minimum Temperature Alarm Threshold. A temperature below this threshold will set the alarm (bit 0 of the Alarm Status Register).	If the minimum temperature threshold is to be change to 10°C then set as follows: >)D0=+10.0
Temp Alarm Max Threshold	D1	0.1°C	+70°C	Maximum Temperature Alarm Threshold. A temperature above this threshold will set the alarm (bit 1 of the Alarm Status Register).	If the maximum temperature threshold is to be change to 50°C then set as follows: >)D1=+50.0
Frequency Minimum Threshold	D2	0.1Hz	+59.0	Minimum Frequency Alarm Threshold. A frequency below this threshold will set the alarm (bit 2 of the Alarm Status Register).	If the minimum frequency threshold is to be changed to 59.5 Hz then enter the following: >)D2=+59.5
Frequency Maximum Threshold	D3	0.1Hz	+61.0	Maximum Frequency Alarm Threshold. A frequency above this threshold will set the alarm (bit 3 of the Alarm Status Register).	If the maximum frequency threshold is to be changed to 60.5 Hz then enter the following: >)D2=+60.5
SAG Voltage Alarm Threshold	D4	mVpk	+80.0	Sets an alarm (bit 4 of the Alarm Status Register) if voltage drops below the SAG threshold.	
Min Voltage Alarm Threshold	D5	mVrms	+100.000	Minimum voltage level selected to flag user (bit 5 of the Alarm Status Register).	To change the minimum voltage threshold from the 40 Volt default to 80 Volts:)D5=+80.000<CR>
Peak Voltage Alarm Threshold	D6	mVrms	+140.000	Peak voltage setting that user wishes to flag (bit 6 of the Alarm Status Register).	To change the peak voltage threshold from the default 407.3 Volts to 280 Volts:)D6=+280.000<CR>
Unused	D7	–			
Peak IA_nb Alarm Threshold	D8	mArms	+15.000	Maximum Narrowband Current measured on the IA channel above which a flag must set (bit 7 of the Alarm Status Register).	If the peak narrowband current threshold on Outlet 1 is to be changed from the default value of 15 Amps to 30 Amps then set as follows:)D8=+30.000<CR>

MPU Parameter	Location (hex)	LSB	Default	Comment	Example
Peak IA_wb Alarm Threshold	D9	mArms	+15.000	Maximum Wideband Current measured on the IA channel above which a flag must set (bit 8 of the Alarm Status Register).	If the peak wideband current threshold on Outlet 1 is to be changed from the default value of 15 Amps to 30 Amps then set as follows:)D9=+30.000<CR>
PFA_nb_Neg Threshold	DA	–	-0.700	Narrowband Power Factor Negative Threshold for Outlet 1. A less negative narrowband power factor than this threshold will set an alarm (bit 9 of the Alarm Status Register).	If the negative narrowband power factor threshold on Outlet 1 is to be changed from the default to -0.6 then set as follows:)DA=-0.600<CR>
PFA_nb_Pos Threshold	DB	–	+0.700	Narrowband Power Factor Positive Threshold for Outlet 1. A narrowband power factor less than this threshold will set an alarm (bit 10 of the Alarm Status Register).	If the positive narrowband power factor threshold on Outlet 1 is to be changed from the default to +0.600 then set as follows:)DB=+0.600<CR>
PFA_wb_Neg Threshold	DC	–	-0.700	Wideband Power Factor Negative Threshold for Outlet 1. A less negative wideband power factor than this threshold will set an alarm (bit 11 of the Alarm Status Register).	If the negative wideband power factor threshold on Outlet 1 is to be changed from the default to -0.6 then set as follows:)DC=-0.600<CR>
PFA_wb_Pos Threshold	DD	–	+0.700	Wideband Power Factor Positive Threshold for Outlet 1. A positive wideband power factor less than this threshold will set an alarm (bit 12 of the Alarm Status Register).	If the positive wideband power factor threshold on Outlet 1 is to be changed from the default to +0.6 then set as follows:)DD=+0.600<CR>
Peak IB_nb Alarm Threshold	DE	mArms	+15.000	Maximum Narrowband Current measured on the IB channel above which a flag must set (bit 13 of the Alarm Status Register).	If the peak narrowband current threshold on Outlet 2 is to be changed from the default value of 15 Amps to 30 Amps then set as follows:)DE=+30.000<CR>

MPU Parameter	Location (hex)	LSB	Default	Comment	Example
Peak IB_wb Alarm Threshold	DF	mArms	+15.000	Maximum Wideband Current measured on the IB channel above which a flag must set (bit 14 of the Alarm Status Register).	If the peak wideband current threshold on Outlet 2 is to be changed from the default value of 15 Amps to 30 Amps then set as follows:)DF=+30.000<CR>
PFB_nb_Neg Threshold	E0	–	-0.700	Narrowband Power Factor Negative Threshold for Outlet 2. A less negative narrowband power factor than this threshold will set an alarm (bit 15 of the Alarm Status Register).	If the negative narrowband power factor threshold on Outlet 2 is to be changed from the default to -0.6 then set as follows:)E0=-0.600<CR>
PFB_nb_Pos Threshold	E1	–	+0.700	Narrowband Power Factor Positive Threshold for Outlet 2. A narrowband power factor less than this threshold will set an alarm (bit 16 of the Alarm Status Register).	If the positive narrowband power factor threshold on Outlet 2 is to be changed from the default to +0.600 then set as follows:)E1=+0.600<CR>
PFB_wb_Neg Threshold	E2	–	-0.700	Wideband Power Factor Negative Threshold for Outlet 2. A less negative wideband power factor than this threshold will set an alarm (bit 17 of the Alarm Status Register).	If the negative wideband power factor threshold on Outlet 2 is to be changed from the default to -0.6 then set as follows:)E2=-0.600<CR>
PFB_wb_Pos Threshold	E3	–	+0.700	Wideband Power Factor Positive Threshold for Outlet 2. A positive wideband power factor less than this threshold will set an alarm (bit 18 of the Alarm Status Register).	If the positive wideband power factor threshold on Outlet 2 is to be changed from the default to +0.6 then set as follows:)E3=+0.600<CR>
Peak I Total_nb Alarm Threshold	E4	mArms	+20.000	Maximum Narrowband Current measured on Outlet 1 plus Outlet 2 above which a flag must be set (bit 19 of the Alarm Status Register).	If the narrowband peak current threshold on Outlet 1 plus Outlet 2 is to be changed from the default value of 20 Amps to 30 Amps then set as follows:)E4=+30.000<CR>

MPU Parameter	Location (hex)	LSB	Default	Comment	Example
Peak I Total_wb Alarm Threshold	E5	mArms	+20.000	Maximum Wideband Current measured on Outlet 1 plus Outlet 2 above which a flag must be set (bit 20 of the Alarm Status Register).	If the wideband peak current threshold on Outlet 1 plus Outlet 2 is to be changed from the default value of 20 Amps to 30 Amps then set as follows:)E5=+30.000<CR>
Alarm Mask_Reg	E6	–	00801FFF	Alarm mask for bits in the Alarm Status register. A "0" masks the bit.	If bits 0 and 1 are to be masked then set as follows: >)E6=FFFFFFFC
Alarm Mask_DIO	E7	–	00801FFF		
Control Relay	F0	–	0	Bit 1 (Relay for Outlet 2) 0 = DIO19 = 0 1 = DIO19 =1 Bit 0 (Relay for Outlet 1) 0 = DIO7 = 0 1 = DIO7 = 1 Note: AC[1] = 1 inverts the bits above.	
Min/Max Control	F1	–	0	BIT1 – 1 Start/Stop MIN/MAX recording. 1 = Start 0 = Stop BIT0 – 1 Reset MIN/MAX registers. Bit autoclears.	Starts MIN/MAX recording.)AC=10<CR>)AC=01<CR> Resets the MIN/MAX registers.
Clear Control	F2	–	0	Clear Control Register: Bit1 – Clears Counts Bit 0 – Clears Accumulators.	

6.2 CE Parameters

Table 9 lists the CE parameters that the Firmware 6612_OMU_S2_URT_V1_13 has set. The user does not need to alter any of these parameters.

Table 9: CE Parameters

CE Parameter	Location (hex)	LSB	Default	Comment	Example
CAL IA	08	16384 is the default and is a gain of 1. 32767 is max giving a gain of 2.	+13873	Gain constant for IA input.	If current on channel A is low by 1% scale the nominal number, 16384 by 1/(1-0.01). Number to be entered would be 16549:]08=+16549<CR> If current on channel A is high by 1% scale the nominal number, 16384 by 1/(1+0.01). Number to be entered would be 16222:]08=+16222<CR>
CAL IB	09	16384 is the default and is a gain of 1. 32767 is max giving a gain of 2.	+13873	Gain constant for IB input.	If current on channel B is low by 1% scale the nominal number, 16384 by 1/(1-0.01). Number to be entered would be 16549:]09=+16549<CR> If current on channel A is high by 1% scale the nominal number, 16384 by 1/(1+0.01). Number to be entered would be 16222:]09=+16222<CR>
CAL VA	0A	16384 is the default and is a gain of 1. 32767 is max giving a gain of 2.	+13024	Gain constant for VA input.	If voltage on channel A is low by 1% scale the nominal number, 16384 by 1/(1-0.01). Number to be entered would be 16549:]0A=+16549<CR> If current on channel A is high by 1% scale the nominal number, 16384 by 1/(1+0.01). Number to be entered would be 16222:]0A=+16222<CR>
CAL VB	0B	16384 is the default and is a gain of 1. 32767 is max giving a gain of 2.	+13024	Gain constant for VB input.	If voltage on channel B is low by 1% scale the nominal number, 16384 by 1/(1-0.01). Number to be entered would be 16549:]0B=+16549<CR> If current on channel A is high by 1% scale the nominal number, 16384 by 1/(1+0.01). Number to be entered would be 16222:]0B=+16222<CR>
PHASE_ ADJ_IA	0C	-16384 ≤ PHASE_ ADJ_IA ≤ +16384	0	Outlet 1 Phase adjustment =15 * PHASE_ADJ_IA * 2^{-14} (degrees)	No adjustment should be necessary when using current shunts.

CE Parameter	Location (hex)	LSB	Default	Comment	Example
PHASE_ ADJ_IB	0D	-16384 ≤ PHASE_ ADJ_IB ≤ +16384	0	Outlet 2 Phase adjustment =15 * PHASE_ADJ_IB * 2^{-14} (degrees)	No adjustment should be necessary when using current shunts.
CESTATE	0E		5005h	SAG CNT Bits 15:8 – determines the consecutive voltage samples below SAG_Threshold before a sag alarm is declared. 255 is the maximum value. Pulse Selection (PULSEL) Bit 4 0 – chooses Outlet 1 (IA input) for pulse generation 1 – chooses Outlet 2 (IB input) for pulse generation. Current sensor selection Bits 3 and 2 00 – selects CT 11 – selects shunt. Pulse gain factor Bits 1 and 0 00 – 6x 01 – (6/64)x 10 – 96x 11 – 1.5x	]0E=5005 Selects at least 80 (50h) consecutive voltage samples below SAG_Threshold before SAG alarm. Select Outlet 1 as pulse source. Selects Current Shunts as the sensor for both Outlet 1 and Outlet 2 Selects Pulse Gain Factor equal to 6/64
WRATE	0F	Kh = VMAX A * IMAX A / (WRATE * X) 1.6826E+ 01 WattSec	+4860	Controls the number of pulses that are generated per measured Wh and VARh measurements.	]0F=+4860 Kh = 0.32 * Wh / pulse with X = 6/64, VMAX =600 V and IMAX = 52 A
Reserved	10			Reserved	

CE Parameter	Location (hex)	LSB	Default	Comment	Example
SAG Threshold	11	VMAX A *4.2551E-07 (Vpk)	+313350	The voltage threshold for SAG warnings. The default value is 80 Vpk if VMAX = 600 V.	)11=+313350 80 Vpk SAG Threshold.
QUANTA	12	VMAX A * IMAX A * 1.8541E-10 (Watt)	0	Compensation added to the Watt calculation for Outlet 1. Used for compensation at low current levels. Keep below 10000d.	
QUANTB	13	VMAX A * IMAX B * 1.8541E-10 (Watt)	0	Compensation added to the Watt calculation for Outlet 2. Used for compensation at low current levels. Keep below 10000d.	
QUANT VAR A	14	VMAX A * IMAX A * 1.8541E-10 (Watt)	0	Compensation added to the VAR calculation for Outlet 1. Used for compensation at low current levels. Keep below 10000d.	
QUANT VAR B	15	VMAX A * IMAX B * 1.8541E-10 (Watt)	0	Compensation added to the VAR calculation for Outlet 2. Used for compensation at low current levels. Keep below 10000d.	
QUANT IA	16	(IMAX A)^2 * 4.6351E-11 (A^2)	0	IA input compensation added for input noise and truncation in the squaring calculation for I^2. Used for compensation at low current levels. Keep below 10000d.	

CE Parameter	Location (hex)	LSB	Default	Comment	Example
QUANT IB	17	$(IMAX\ B)^2$ * 4.6351E-11 (A^2)	0	IA input compensation added for input noise and truncation in the squaring calculation for I^2. Used for compensation at low current levels. Keep below 10000d.	
Reserved	18	–	–	Reserved	Reserved
Gain Adjust	19	16384 is the default and is a gain of 1.	+16384	32767 is max giving a gain of 2.	To increase all channels equally by 1% scale the nominal number, 16384 by 1/(1-0.01). Number to be entered would be 16549:]19=+16549<CR> To decrease all channels 1% scale the nominal number, 16384 by 1/(1+0.01). Number to be entered would be 16222:]19=+16222<CR>
Reserved	1A	–	–	Reserved	Reserved
Reserved	1B	–	–	Reserved	Reserved

7 Address Content Summary

If the color shading is the same, the information in the table cells is the same between narrowband and wideband measurements. Note that Outlet 1 = channel A and Outlet 2 = channel B.

Table 10: MPU Output Summary Chart

Outlet 1	Address	Narrowband	Address	Wideband
Common Data	00	Delta Temp	20	Delta Temp
	01	Line Frequency	21	Line Frequency
	02	Alarm Status	22	Alarm Status
	03	Over Current Event Count	23	Over Current Event Count
	04	Under Voltage Event Count	24	Under Voltage Event Count
	05	Over Voltage Event Count	25	Over Voltage Event Count
	06	Volts	26	Volts
Common, Outlet 1 Specific Data	07	Watts (A)	27	Watts (A)
	08	Energy (A)	28	Energy (A)
	09	Cost (A)	29	Cost (A)
Tier 1, Outlet 1 Specific Data	0A	Current (A)	2A	Current (A)
	0B	VAR (A)	2B	VAR (A)
	0C	VA (A)	2C	VA (A)
	0D	Power Factor (A)	2D	Power Factor (A)
	0E	Phase (A)	2E	Phase (A)
	0F	(Reserved for Future)	2F	(Reserved for Future)
Tier 2, Outlet 1 Specific Max/Min Data	10	Vrms Min	30	Vrms Min
	11	Vrms Max	31	Vrms Max
	12	Watts Min (A)	32	Watts Min (A)
	13	Watts Max (A)	33	Watts Max (A)
	14	Current Min (A)	34	Current Min (A)
	15	Current Max (A)	35	Current Max (A)
	16	VAR Min (A)	36	VAR Min (A)
	17	VAR Max (A)	37	VAR Max (A)
	18	VA Min (A)	38	VA Min (A)
	19	VA Max (A)	39	VA Max (A)
	1A	Power Factor Min (A)	3A	Power Factor Min (A)
	1B	Power Factor Max (A)	3B	Power Factor Max (A)
	1C	Phase Min (A)	3C	Phase Min (A)
	1D	Phase Max(A)	3D	Phase Max(A)
	1E	(Reserved for Future)	3E	(Reserved for Future)
	1F	(Reserved for Future)	3F	(Reserved for Future)

Outlet 2		Narrowband		Wideband
Common Data	40	Delta Temp	60	Delta Temp
	41	Frequency	61	Frequency
	42	Alarm Status	62	Alarm Status
	43	Over Current Event Count	63	Over Current Event Count
	44	Voltage SAG Event Count	64	Voltage SAG Event Count
	45	Over Voltage Event Count	65	Over Voltage Event Count
	46	Volts	66	Volts
Common, Outlet 2 Specific Data	47	Watts (B)	67	Watts (B)
	48	Energy (B)	68	Energy (B)
	49	Cost (B)	69	Cost (B)
Tier 1, Outlet 2 Specific Data	4A	Current (B)	6A	Current (B)
	4B	VAR (B)	6B	VAR (B)
	4C	VA (B)	6C	VA (B)
	4D	Power Factor (B)	6D	Power Factor (B)
	4E	Phase (B)	6E	Phase (B)
	4F	(Reserved for Future)	6F	(Reserved for Future)
Tier 2, Outlet 2 Specific Max/Min Data	50	Vrms Min	70	Vrms Min
	51	Vrms Max	71	Vrms Max
	52	Watts Min (B)	72	Watts Min (B)
	53	Watts Max (B)	73	Watts Max (B)
	54	Current Min (B)	74	Current Min (B)
	55	Current Max (B)	75	Current Max (B)
	56	VAR Min (B)	76	VAR Min (B)
	57	VAR Max (B)	77	VAR Max (B)
	58	VA Min (B)	78	VA Min (B)
	59	VA Max (B)	79	VA Max (B)
	5A	Power Factor Min (B)	7A	Power Factor Min (B)
	5B	Power Factor Max (B)	7B	Power Factor Max (B)
	5C	Phase Min (B)	7C	Phase Min (B)
	5D	Phase Max (B)	7D	Phase Max (B)
	5E	(Reserved for Future)	7E	(Reserved for Future)
	5F	(Reserved for Future)	7F	(Reserved for Future)

Totals of Multiple Outlets		**Narrowband**		**Wideband**
Common Total Data	80	Total Watts	90	Total Watts
	81	Total Energy	91	Total Energy
	82	Total Cost	92	Total Cost
Bandwidth Specific Totals	83	Total Current	93	Total Current
	84	Total VARs	94	Total VARs
	85	Total VA's	95	Total VA's
	86	Total Over Current Count	96	Total Over Current Count
	87	(Reserved for Future)	97	(Reserved for Future)
Common Total Max/Min Data	88	Total Watts Min	98	Total Watts Min
	89	Total Watts Max	99	Total Watts Max
Bandwidth Specific Total Max/Min Data	8A	Total Current Min	9A	Total Current Min
	8B	Total Current Max	9B	Total Current Max
	8C	Total VAR Min	9C	Total VAR Min
	8D	Total VAR Max	9D	Total VAR Max
	8E	Total VA Min	9E	Total VA Min
	8F	Total VA Max	9F	Total VA Max

Table 11: MPU Input Summary Chart

Voltage	A0	Vmax
Current - Outlet 1	A1	Imin (Creep A) - Outlet1
	A2	Imax (A) - Outlet1
Current - Outlet 2	A3	Imin (Creep B) - Outlet2
	A4	Imax (B) - Outlet2
Unused	A5	Unused
Temperature	A6	TEMPERATURE NOMINAL
	A7	Reserved
	A8	PPMC
	A9	PPMC2
Cost	AA	Cost per KWh
	AB	Cost Unit string
Relay Configuration	AC	Polarity, Latch type
	AD	Sequence Delay
	AE	Energize Delay
	AF	Denergize Delay
	B0 -BC	Unused
Misc. Config	BD	Configuration
Unused	BE	Unused
	BF	Unused
Quick Calibration Parameters	C0	Calibration Type
	C1	Calibration Voltage (Target)
	C2	Calibration Current (Target)
	C3	Calibration Phase
	C4	Tolerance on Voltage Calibration
	C5	Tolerance on Current Calibration
	C6	Average Count for Voltage
	C7	Average Count for Current
	C8	Max Iterations for Voltage
	C9	Max Iterations for Current
	CA	Tolerance on Watts Calibration
	CB	Average Count for Watts
	CC	Max Iterations for Watts
	CD	Calibration WRATE
	CE	Calibration Temperature
	CF	Unused
Temperature	D0	Min Temperature Alarm Threshold
	D1	Max Temperature Alarm Threshold
Frequency	D2	Min Frequency Alarm Threshold
	D3	Max Frequency Alarm Threshold

Voltage	D4	SAG Voltage Alarm Threshold
	D5	Min Voltage Alarm Threshold
	D6	Max Voltage Alarm Threshold
Unused	D7	Unused
Current - Outlet 1	D8	Max Current Alarm Threshold (NB)
	D9	Max Current Alarm Threshold (WB)
Power Factor - Outlet 1	DA	Power Factor Alarm - Threshold (NB)
	DB	Power Factor Alarm + Threshold (NB)
	DC	Power Factor Alarm - Threshold (WB)
	DD	Power Factor Alarm + Threshold (WB)
Current - Outlet 2	DE	Max Current Alarm Threshold (NB)
	DF	Max Current Alarm Threshold (WB)
Power Factor - Outlet 2	E0	Power Factor Alarm - Threshold (NB)
	E1	Power Factor Alarm + Threshold (NB)
	E2	Power Factor Alarm - Threshold (WB)
	E3	Power Factor Alarm + Threshold (WB)
Total Current	E4	Max Current Alarm Threshold (NB)
	E5	Max Current Alarm Threshold (WB)
Alarm Mask for Status Regs	E6	Alarm Mask for Status
Alarm Mask for Alarm DI/O	E7	Alarm Mask for Alarm DI/O
Relay Controls	F0	Relay On/Off Control
Min/Max Controls	F1	Min/Max Controls
Clear Control	F2	Accumulator and Counter Clear

Table 12: CE Input Summary Chart

Calibration	08	Calibration Gain IA
	09	Calibration Gain IB
	0A	Calibration Gain VA
	0B	Calibration Gain VB
Phase Compensation	0C	Phase Adjust IA
	0D	Phase Adjust IB
CE Configuration	0E	CE State
Pulse Rate	0F	Wrate
	10	Reserved
SAG Threshold	11	SAG Threshold
Quantization Corrections	12	Quantization offset Watts A
	13	Quantization offset Watts B
	14	Quantization offset VAR A
	15	Quantization offset VAR B
	16	Quantization offset IA
	17	Quantization offset IB
	18	Reserved
Gain Adjust	19	Temperature Gain Adjust

8 Contact Information

For more information about Teridian Semiconductor products or to check the availability of the 78M6612, contact us at: http://www.teridian.com/contact-us/

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Revision History

Revision	Date	Description
1.0	7/29/2009	First publication.
1.1	12/21/2009	In Section 1, deleted "The OMU demo units are typically pre-loaded with the "H" version, but both versions are provided in the demo kit's CDs." In Table 1, corrected the Narrowband Equation and the Wideband Equation for Symbol P. In Section 4.3.1, added "When requesting information in decimal, the data is preceded by a + or a -. The exception is)AB? which returns a string (see page 39)." In Section 4.8, deleted all references to "SFR". Throughout the document, inserted "+" in front of decimal numbers.