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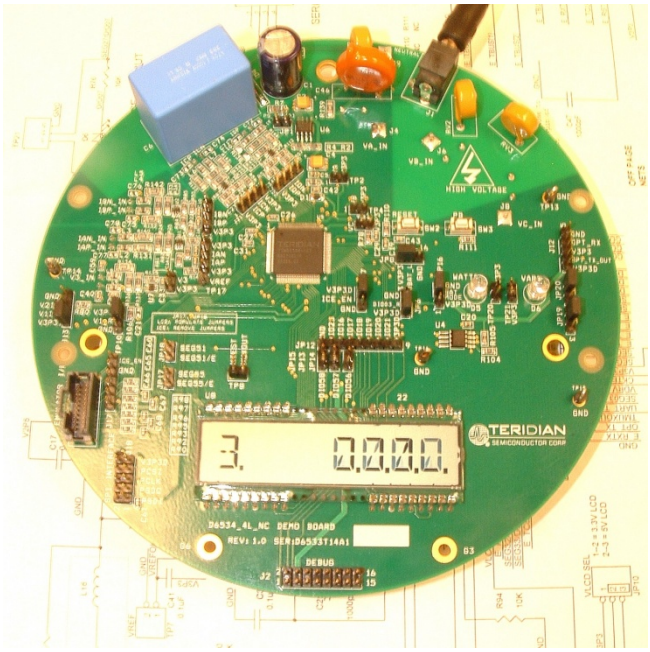
71M6534H Demo Board

USER'S MANUAL



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71M6534H

3-Phase Energy Meter IC

DEMO BOARD

USER'S MANUAL

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1 GETTING STARTED

1.1 GENERAL

The TERIDIAN Semiconductor Corporation (TSC) 71M6534H Demo Board is a demonstration board for evaluating the 71M6534H device for 3-phase electronic power metering applications. It incorporates a 71M6534 or 71M6534H integrated circuit, peripheral circuitry such as a serial EEPROM, emulator port, and on board power supply as well as a companion Debug Board that allows a connection to a PC through a RS232 port. The demo board allows the evaluation of the 71M6534 or 71M6534H energy meter chip for measurement accuracy and overall system use.

The board is pre-programmed with a Demo Program in the FLASH memory of the 71M6534/6534H 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 71M6534/6534H IC on the Demo Board is pre-programmed with default calibration factors.

1.2 SAFETY AND ESD PRECAUTIONS

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!

1.3 DEMO KIT CONTENTS

- Demo Board D6534T14A2 with 71M6534H IC and pre-loaded demo program:
- Debug Board
- Two 5VDC/1,000mA universal wall transformers with 2.5mm plug (Switchcraft 712A compatible)
- Serial cable, DB9, Male/Female, 2m length (Digi-Key AE1020-ND)
- CD-ROM containing documentation (data sheet, board schematics, BOM, layout), Demo Code (sources and executable), and utilities

The CD-ROM contains a file named **readme.txt** that describes all files found on the CD-ROM.

1.4 DEMO BOARD VERSIONS

At printing time of this document only the following version of the Demo Board is available:

- Demo Board D6534T14A2 (standard)

1.5 COMPATIBILITY

This manual applies to the following hardware and software revisions:

- 71M6534 or 71M6534H chip revision A03
- Demo Kit firmware revision 4p6q
- Demo Boards D6534T14A2

1.6 SUGGESTED EQUIPMENT NOT INCLUDED

For functional demonstration:

- PC w/ MS-Windows® versions XP, ME, or 2000, equipped with RS232 port (COM port) via DB9 connector

For software development (MPU code):

- Signum ICE (In Circuit Emulator): ADM-51 – **see update information in section 1.11**
  http://www.signum.com

- Keil 8051 "C" Compiler kit: CA51
  http://www.keil.com/c51/ca51kit.htm, http://www.keil.com/product/sales.htm

1.7 DEMO BOARD TEST SETUP

Figure 1-1 shows the basic connections of the Demo Board plus Debug Board with the external equipment for desktop testing, i.e. without live power applied. For desktop testing, both the Demo and Debug board may be powered with their 5VDC power supplies.

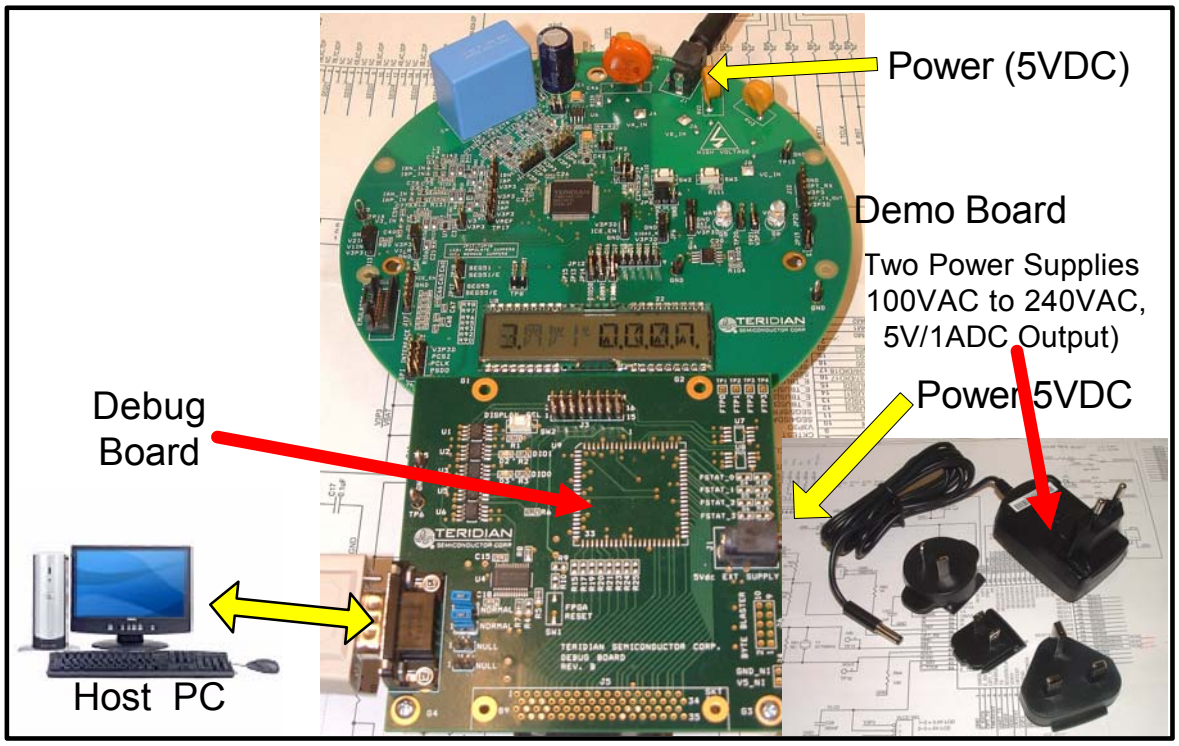


Figure 1-1: TERIDIAN D6534T14A2 Demo Board with Debug Board: Basic Connections

The D6534T14A2 Demo Board block diagram is shown in Figure 1-2. It consists of a stand-alone meter Demo Board and an optional Debug Board. The Demo Board contains all circuits necessary for operation as a meter, including display, calibration LED, and internal power supply. The Debug Board provides magnetic isolation from the meter and interfaces to a PC through a 9 pin serial port. For serial communication between the PC and the TERIDIAN 71M6534H, the Debug Board needs to be plugged with its connector J3 into connector J2 of the Demo Board.

Connections to the external signals to be measured, i.e. AC voltages and current signals derived from shunt resistors or current transformers, are provided on the rear side of the demo board (see Figure 3-1).

Caution: 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 V3P3 (3.3V power supply to the chip).

DEMONSTRATION METER

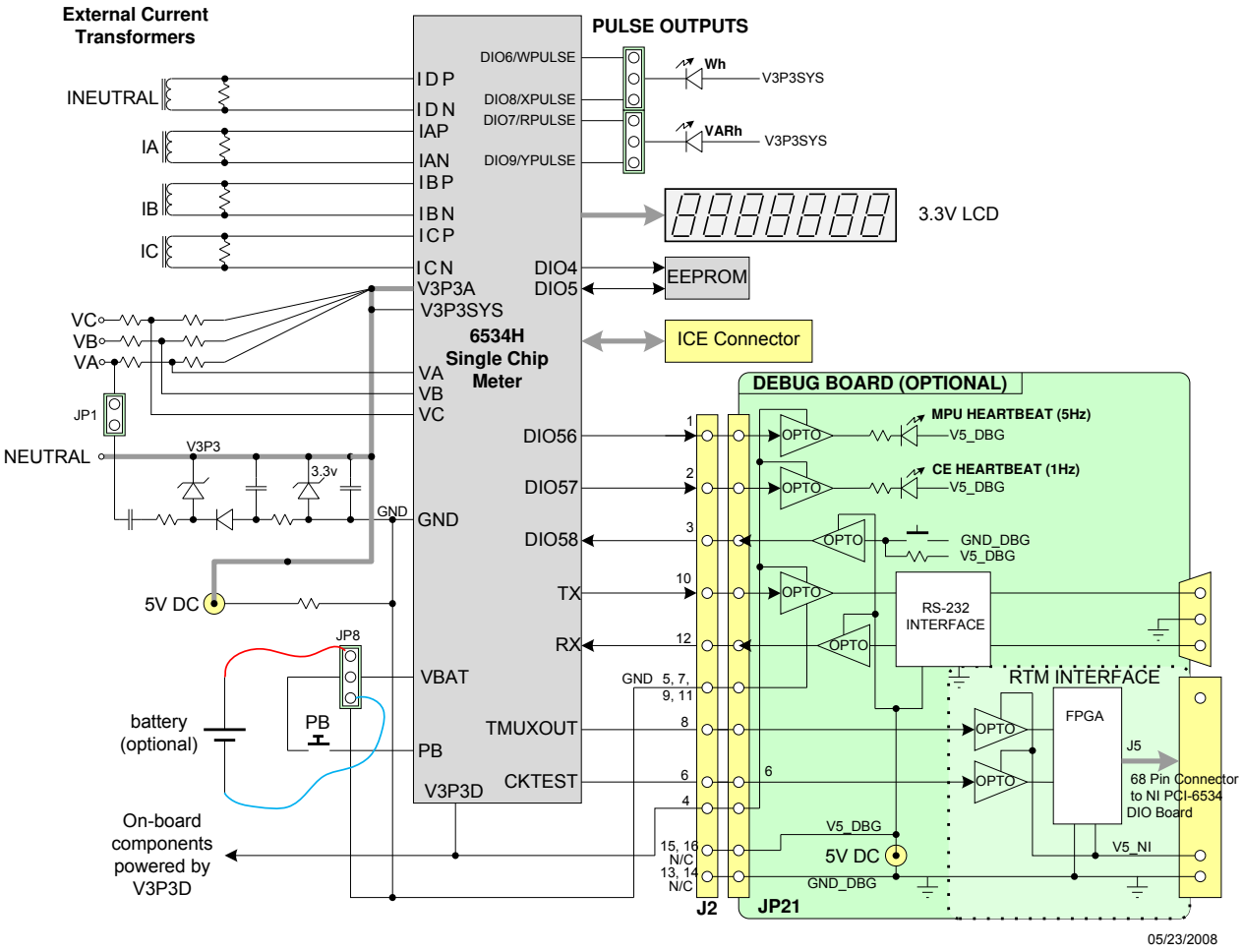


Figure 1-2: Block diagram for the TERIDIAN D6534T14A2 Demo Board with Debug Board

1.7.1 POWER SUPPLY SETUP

There are several choices for meter power supply:

- Internal (using phase A of the AC line voltage). The internal power supply is only suitable when phase A exceeds 220V RMS.
- External 5VDC connector (J1) on the Demo Board
- External 5VDC connector (J1) on the Debug Board.

The power supply jumper JP1 must be consistent with the power supply choice. JP1 connects the AC line voltage to the internal power supply. This jumper should usually be left in place.

1.7.2 CABLE FOR SERIAL CONNECTION (DEBUG BOARD)

For connection of the DB9 serial port to a PC, 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

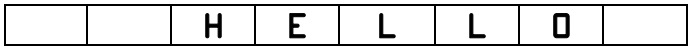
Table 1-3 shows the connections necessary for the null-modem DB9 cable and the pin definitions.

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

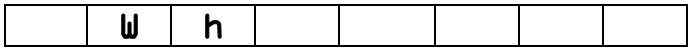
Table 1-3: Null-modem cable connections

1.7.3 CHECKING OPERATION

A few seconds after power up, the LCD display on the Demo Board should display this brief greeting:



The "HELLO" message should be followed by the display of accumulated energy alternating with the text "Wh".



If the PB switch on the Demo Board is pressed and held down), the display will cycle through a series of parameters, as shown in Table 1-4.

Step	Displayed Text	Description	Step	Displayed Text	Description
1	DELTA C	Deviation from nominal temperature [°C]	10	DATE	Date from RTC [yyyy.mm.dd]
2	HZ	Line frequency [Hz]	11	PF	Power factor, calculated from current Wh/VAh
3	Wh	Accumulated real energy [Wh]	12		
4	Wh	Exported real energy [Wh]	13	EDGES	
5	VARh	Accumulated reactive energy [VARh]	14	PULSES	Accumulated pulses
6	VARh	Exported reactive energy [VARh]	15	A	Current
7	VAh	Accumulated apparent energy [VARh]	16	V	Voltage
8	HOURS	Hours of operation since last reset [1/100 h]	17	VBAT	Battery voltage
9	TIME	Real time from RTC [hh.mm.ss]	--	--	--

Table 1-4: Selectable Display Parameters

Once, the Debug Board is plugged into J2 of the Demo Board, LED DIO1 on the Debug Board will flash with a frequency of 1Hz, indicating CE activity. The LED DIO0 will flash with a frequency of 5Hz, indicating MPU activity.

1.7.4 SERIAL CONNECTION SETUP

After connecting the DB9 serial port to a PC, start the HyperTerminal application and create a session using the following parameters:

Port Speed: 9600 bd or 300bd, depending on jumper JP16 (see section 3.1)

Data Bits: 8

Parity: None

Stop Bits: 1

Flow Control: XON/XOFF

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 1-4, left), bit settings are configured by pressing the Configure button (Figure 1-5, 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.

Port parameters can only be adjusted when the connection is not active. The disconnect button, as shown in Figure 1-3 must be clicked in order to disconnect the port.

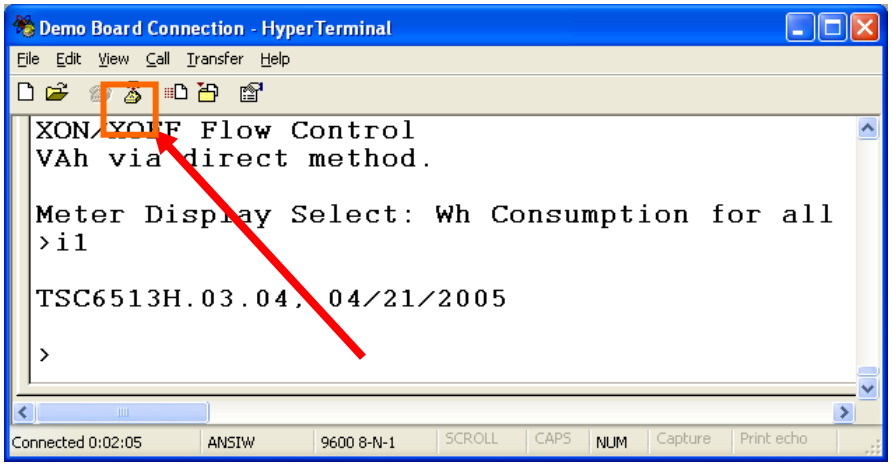


Figure 1-3: Hyperterminal Sample Window with Disconnect Button (Arrow)

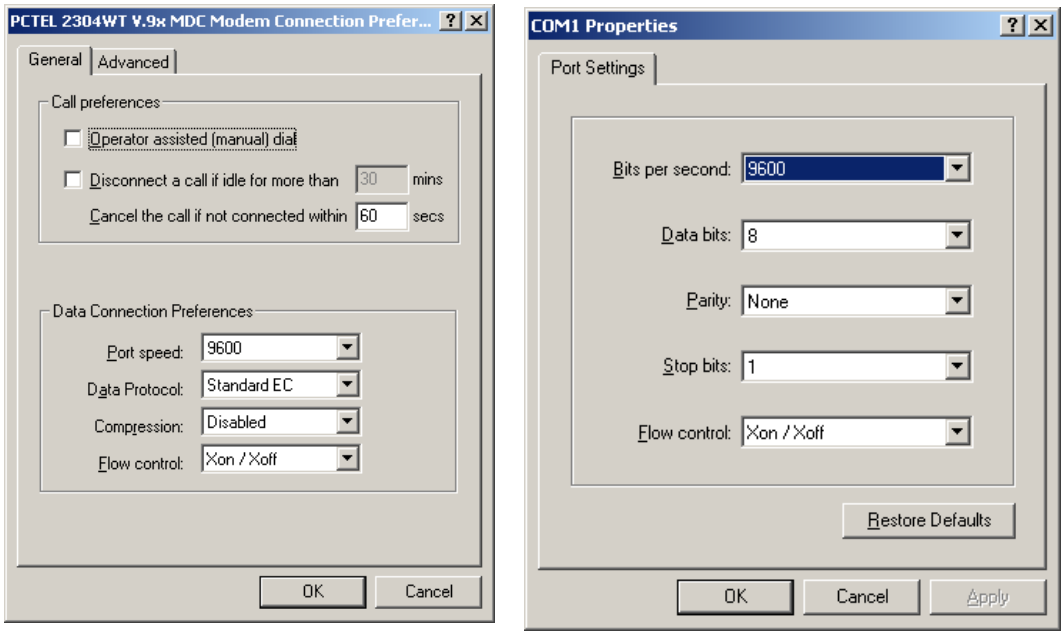


Figure 1-4: Port Speed and Handshake Setup (left) and Port Bit setup (right)

Once, the connection to the demo board is established, press <CR> and the 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 71M6534/6534H Demo Board is a ready-to-use meter prepared for use with external current transformers.

Using the Demo Board involves communicating with the Demo Code via the command line interface (CLI). The CLI allows modifications to the metering parameters, access to the EEPROM, initiation of auto-cal sequences, selection of the displayed parameters, changing of calibration factors and more operations that can be used to evaluate the 71M6534 chip.

Before evaluating the 71M6534/6534H 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 71M6534/6534H provides a convenient way of examining and modifying key meter parameters. Once the Demo Board is connected to a PC or terminal per the instructions given in Section 1.7.2 and 1.7.4, typing '?' will bring up the list of commands shown in Figure 1-5.

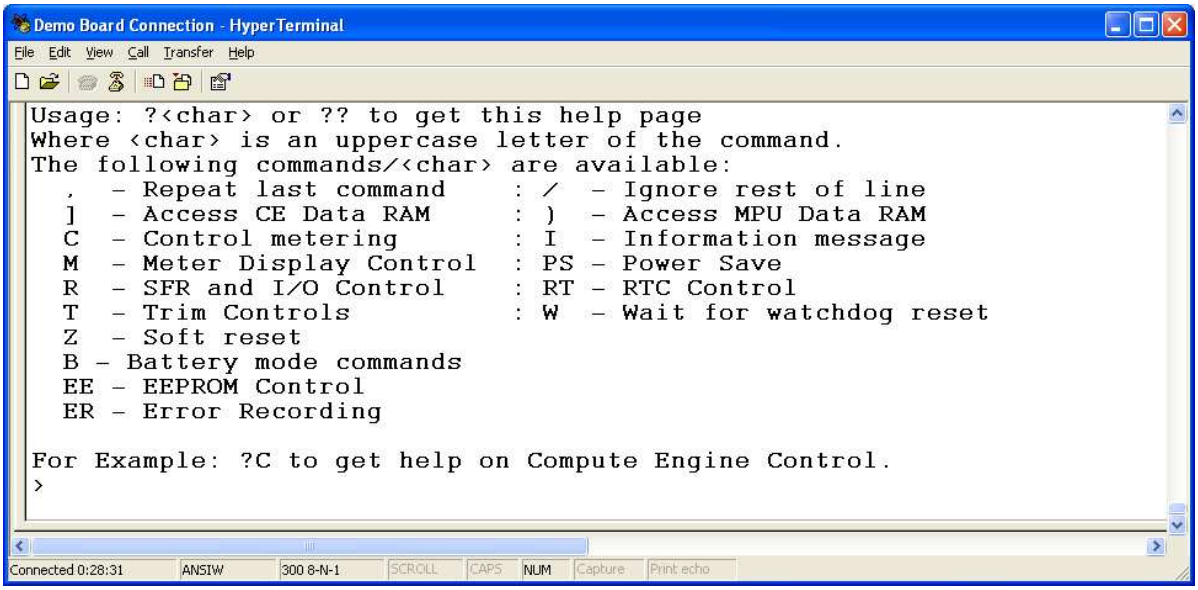


Figure 1-5: Command Line Help Display

The tables in this chapter describe the commands in detail.

Commands to Display Help on the CLI Commands:

?	HELP	Comment
Description:	Command help available for each of the options below.	
Command combinations:	?	Command line interpreter help menu.
	?]	Display help on access CE data RAM
	?)	Display help on access MPU RAM
	?,	Display help on repeat last command
	?/	Display help on ignore rest of line
	?C	Display help on compute engine control.
	?CL	Display help on calibration.
	?EE	Display help on EEPROM control
	?ER	Display help on error recording
	?I	Display help on information message
	?M	Display help on meter display control
	?MR	Display help on meter RMS display control
	?R	Display help on SFR control
	?RT	Display help on RTC control
	?T	Display help on trim control
	?W	Display help on the wait/reset command
	?Z	Display help on reset
Examples:	??	Display the command line interpreter help menu.
	?C	Displays compute engine control help.

Commands for CE Data Access:

]	CE DATA ACCESS	Comment
Description:	Allows user to read from and write to CE data space.	
Usage:	] [Starting CE Data Address] [option]…[option]	
Command combinations:	]A???	Read consecutive 16-bit words in Decimal, starting at address A
	]A$$$	Read consecutive 16-bit words in Hex, starting at address A
	]A=n=n	Write consecutive memory values, starting at address A
	]U	Update default version of CE Data in flash memory
Example:	]40$$$	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 0x1000 + 4 * A = 0x1028.

Commands for MPU/XDATA Access:

)	MPU DATA ACCESS	Comment
Description:	Allows user to read from and write to MPU data space.	
Usage:	) [Starting MPU Data Address] [option]…[option]	
Command combinations:	)A???	Read three consecutive 32-bit words in Decimal, starting at address A
	)A$$$	Read three consecutive 32-bit words in Hex, starting at address A
	)A=n=m	Write the values n and m to two consecutive addresses starting at address A
	?)	Display useful RAM addresses.
Example:	)08$$$$	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 0xFFF). 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
Description:	Allows the user to read from and write to DIO RAM and special function registers (SFRs).	
Usage:	R [option] [register] … [option]	
Command combinations:	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$$$...	Read consecutive registers in Hex, starting at address a
	Ra=n=m…	Set values of consecutive registers to n and m starting at address a
Example:	RI2$$$	Read DIO RAM registers 2, 3, and 4 in Hex.

DIO or Configuration RAM space is the address range 0x2000 to 0x20FF. This RAM contains registers used for configuring basic hardware and functional properties of the 71M6534/6534H and is organized in bytes (8 bits). The 0x2000 offset is automatically added when the command RI is typed.

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
Description:	Allows user to enable read and write to EEPROM.	
Usage:	EE [option] [arguments]	
Command combinations:	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
Example:	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.

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:

C	COMPUTE ENGINE CONTROL	Comment
Description:	Allows the user to enable and configure the compute engine.	
Usage:	C [option] [argument]	
Command combinations:	CEn	Compute Engine Enable (1 → Enable, 0 → Disable)
	CTn	Select input n for TMUX output pin. n is interpreted as a decimal number.
	CREn	RTM output control (1 → Enable, 0 → Disable)
	CRSa.b.c.d	Selects CE addresses for RTM output
Example:	CE0	Disables CE, followed by "CE OFF" display on LCD. The Demo Code will reset if the WD timer is enabled.
	CT3	Selects the VBIAS signal for the TMUX output pin

Commands controlling the Auto-Calibration Function:

CL	AUTO-CALIBRATION CONTROL	Comment
Description:	Allows the user to initiate auto-calibration and to store calibration values.	
Usage:	CL [option]	
Command combinations:	CLB	Begin auto-calibration. Prior to auto-calibration, the calibration coefficients are automatically restored from flash memory.
	CLS	Save calibration coefficients to EEPROM starting at address 0x0004
	CLR	Restore calibration coefficients from EEPROM
	CLD	Restore coefficients from flash memory
Example:	CLB	Starts auto-calibration and saves data automatically.

Before starting the auto-calibration process, target values for voltage, duration and current must be entered in MPU RAM (see section 1.9.5), and the target voltage and current must be applied constantly during calibration. Calibration factors can be saved to EEPROM using the CLS command.

Commands controlling the Pulse Counter Function

CP	PULSE-COUNT CONTROL	Comment
Description:	Allows the user to control the pulse count functions.	
Usage:	CP [option]	
Command combinations:	CPA	Start pulse counting for time period defined with the CPD command. Pulse counts will display with commands M15.2, M16.2
	CPC	Clear the absolute pulse count displays (shown with commands M15.1, M16.1)
	CPDn	Set time window for pulse counters to n seconds, n is interpreted as a decimal number.
Example:	CPD60	Set time window to 60 seconds.

Pulse counts accumulated over a time window defined by the CPD command will be displayed by M15.2 or M16.2 **after** the defined time has expired.

Commands M15.1 and M16.1 will display the **absolute** pulse count for the W and VAR outputs. These displays are reset to zero with the CPC command (or the XRAM write)1=2).

Commands M15.2 and M16.2 will display the number of pulses counted during the interval defined by the CPD command. These displays are reset only after a new reading, as initiated by the CPA command.

Commands for Identification and Information:

I	INFORMATION MESSAGES	Comment
Description:	Allows user to read information messages.	
Usage:	I	Displays complete version information

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

Commands for Controlling the RMS Values Shown on the LCD Display:

MR	METER RMS DISPLAY	Comment

	CONTROL (LCD)	
Description:	Allows user to select meter RMS display for voltage or current.	
Usage:	MR [option]. [option]	
Command combinations:	MR1. [phase]	Displays instantaneous RMS current
	MR2. [phase]	Displays instantaneous RMS voltage
Example:	MR1.3	Displays phase C RMS current.

Phase 4 is the measured neutral current.

No error message is issued when an invalid parameter is entered, e.g. MR1.8.

Commands for Controlling the MPU Power Save Mode:

PS	POWER SAVE MODE	Comment
Description:	Enters power save mode	Disables CE, ADC, CKOUT, ECK, RTM, SSI, TMUX VREF, and serial port, sets MPU clock to 38.4KHz.
Usage:	PS	

Return to normal mode is achieved by resetting the MPU (Z command).

Commands for Controlling the RTC:

RT	REAL TIME CLOCK CONTROL	Comment
Description:	Allows the user to read and set the real time clock.	
Usage:	RT [option] [value] … [value]	
Command combinations:	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.
Example:	RTD05.03.17.5	Programs the RTC to Thursday, 3/17/2005
	RTA1.+1234	Speeds up the RTC by 1234 PPB.

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

These commands are only accessible for the 71M6534H (0.1%) parts. When used on a 71M6534 (0.5%) part, the results will be displayed as zero.

Reset Commands:

W	RESET	Comment
Description:	Watchdog control	
Usage:	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 Controlling the Metering Values Shown on the LCD Display:

M	METER DISPLAY CONTROL (LCD)	Comment
Description:	Allows user to select internal variables to be displayed.	
Usage:	M [option]. [option]	
Command combinations:	M	Wh Total Consumption (display wraps around at 999.999)
	M0	Wh Total Consumption (display wraps around at 999.999)
	M1	Temperature (C° delta from nominal)
	M2	Frequency (Hz)
	M3. [phase]	Wh Total Consumption (display wraps around at 999.999)
	M4. [phase]	Wh Total Inverse Consumption (display wraps around at 999.999)
	M5. [phase]	VARh Total Consumption (display wraps around at 999.999)
	M6. [phase]	VARh Total Inverse Consumption (display wraps around at 999.999)
	M7. [phase]	VAh Total (display wraps around at 999.999)
	M8	Operating Time (in hours)
	M9	Real Time Clock
	M10	Calendar Date
	M11. [phase]	Power factor
	M13	Mains edge count for the last accumulation interval
	M13.1	Main edge count (accumulated) – zero transitions of the input signal
	M13.2	CE main edge count for the last accumulation interval
	M14.1	Absolute count for W pulses. Reset with CPC command.
	M14.2	Count for W pulses in time window defined by the CPD command.
	M15.1	Absolute count for VAR pulses. Reset with CPC command.
	M15.2	Count for W pulses in time window defined by the CPD command.
Example:	M3.3	Displays Wh total consumption of phase C.
	M5.0	Displays VARh total consumption for all phases.

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.

When entering the phase parameter, use 1 for phase A, 2 for phase B, 3 for phase C, and 0 or blank for all phases.

1.8.2 USING THE DEMO BOARD FOR ENERGY MEASUREMENTS

The 71M6534/6534H Demo Board was designed for use with current transformers (CT).

The Demo Board may immediately be used with current transformers having 2,000:1 winding ratio and is programmed for a Kh factor of 3.2 and (see Section 1.8.4 for adjusting the Demo Board for transformers with different turns ratio).

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 71M6534/6534H Demo Board is shipped with a pre-programmed scaling factor Kh of 3.2, i.e. 3.2Wh 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. The current transformers should be connected to the dual-pin headers on the bottom of the board. The connection is the same for single-ended or differential mode. See chapter 3.1 for proper jumper settings.

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:

$$Kh = IMAX * VMAX * 66.1782 / (In\_8 * WRATE * N_{ACC} * X) = 3.19902 \text{ Wh/pulse.}$$

The small deviation between the adjusted Kh of 3.19902 and the ideal Kh of 3.2 is covered by calibration. The default values used for the 71M6534/6534H Demo Board are:

WRATE:	171	
IMAX:	208	
VMAX:	600	
In_8:	1	(controlled by *IA_SHUNT* = -15)
N_{ACC}:	2520	
X:	6	

Explanation of factors used in the Kh calculation:

WRATE:	The factor input by the user to determine Kh
IMAX:	The current input scaling factor, i.e. the input current generating 176.8mVrms at the IA/IB/IC input pins of the 71M6534. 176.8mV rms is equivalent to 250mV peak.
VMAX:	The voltage input scaling factor, i.e. the voltage generating 176.8mVrms at the VA/VB/VC input pins of the 71M6534
In_8:	The setting for the additional ADC gain (8 or 1) determined by the CE register *IA_SHUNT*
N_{ACC}:	The number of samples per accumulation interval, i.e. *PRE_SAMPS *SUM_CYCLES*
X:	The pulse rate control factor determined by the CE registers *PULSE_SLOW* and *PULSE_FAST*

Almost any desired Kh factor can be selected for the Demo Board by resolving the formula for WRATE:

$$WRATE = (IMAX * VMAX * 66.1782) / (Kh * In\_8 * N_{ACC} * X)$$

For the Kh of 3.2Wh, the value 171 (decimal) should be entered for *WRATE* at CE location 0x21 (using the CLI command **>]21=+171**).