

MODBUS Master
Software Development Guide
For Network Programmable Model 777s

DOC-777-05

December 23, 2004

This guide is addressed to systems integrators who will be developing software for a MODBUS master device to communicate with a Model 777. Experienced programmers should note that Appendix A contains the Model 777 memory map.

The MODBUS master device would typically be a Programmable Logic Controller (PLC) or a Personal Computer (PC) that will communicate with one or more slave devices. A PLC normally would have the MODBUS command protocols and CRC word calculation routines built into it, so the programmer would not have to develop them. If programming a Personal Computer, these would have to be developed.

If programming a PC, it may be worth noting that it is the responsibility of the master controller to initiate communication. In other words, the master controller must be programmed to periodically poll the slave devices and initiate a request for data or to issue a command to the Model 777 to stop or reset the Model 777's control relay. When the Model 777 responds with the requested data or confirmation of the stop command, it is the responsibility of the master controller to determine if the information arrived correctly with no communication errors. If there are communication errors or if there is a time-out waiting for a response, it is the responsibility of the master controller to reissue the command to the slave device. If the response arrives correctly, the master controller is then required to further process the data to put it in a form suitable for viewing by an operator.

MODBUS Protocol on an RS485 Network

The Model 777 uses the MODBUS protocol in Remote Terminal Unit (RTU) mode to receive commands and send information as a slave device on an RS485 network. The RTU mode essentially means that the characters sent between the master and slave devices are binary numbers, not ASCII digits.

RS485 uses a differential voltage signal to represent the zeros and ones. The RS485 standard allows a single network to contain up to 4000 feet of shielded twisted-pair network cable. The cable only needs to be 22 or 24 gauge to transmit 4000 feet at 9600 baud. Refer to DOC-485-02 for more information.

The MODBUS standard allows up to 255 devices on a single network, but the address restrictions of the Model 777 allow only 99 different addresses. In a practical sense, it is difficult to scan more than 20 or 30 devices in a timely manner.

Special Hardware

Each Model 777 requires a Model RS485MS or RS485MS-2W Communication Module to connect to the RS485 network. It is important to recognize that the nine-pin connector on the Model 777 is NOT an RS232 connector! The Communication Module provides electrical isolation from the high voltages present in the Model 777 and it also converts the 5 volt signals from the microprocessor to RS485 levels.

MODEL RS485MS COMMUNICATION MODULE

The Model RS485MS or RS485MS-2W Communications Module serve two very important functions. The module electrically isolates the communications network from the high voltages present in the Model 777 and also converts the communications signals from the microprocessor's 5 volt levels into RS485 levels.

The Model 777 is connected to high AC voltages with a floating ground circuit. As long as there are three balanced line voltages present, the resulting ground level will often be near case ground. However, if one phase is lost or if the line voltages become unbalanced, the floating ground may be as much as 480 volts above the case ground. The Communication Module has two high speed optical isolation chips on the Receive and Transmit pins and a low speed opto-isolator on the Transmit/Receive pin to isolate the communication network from the AC line voltages. In addition, a separate isolated power supply system provides power for

the transceiver used for RS485 level conversion. The Model RS485MS-2W also provides a power source for a remotely mounted Model RM-1000.

The second function of the Communication Module is to convert the microprocessor signal levels to RS485 levels. The microprocessor is a CMOS unit with 0 and 5 volt levels. The signals from the microprocessor go through resistors to provide current-limiting before connecting to the 9 pin external connector. Therefore, the 9 pin sub-d connector on the Model 777 provides unisolated CMOS signals and is **NOT** RS232 or TTL compatible.

IMPORTANT NOTE!

DO NOT PLUG A MODEM OR ANY OTHER PC-COMPATIBLE SERIAL DEVICE INTO THE 9 PIN CONNECTOR ON THE MODEL 777!

Master Device I/O Port

Your MODBUS master device should have an RS485 port. If your master device only has RS232 ports, an RS232 to RS485 converter will be required. Before ordering a converter, you may need to know if you can program your master device to independently control the RTS line. Some RS232 to RS485 converters use the RS232 signal called RTS (Request-To-Send) to turn on the RS485 lines before transmitting a command. If your master device cannot control the RTS line, you will need to order an RS232 to RS485 converter that automatically turns on the RS485 line whenever a command is being written.

Communication Parameters

The communication parameters for a standard Model 777 are:
9600 baud, **EVEN** parity, **8** data bits, **1** stop bit.

Bench Testing Communications

You can apply ordinary single phase 120VAC power to a 480 volt Model 777 on the L1 and L2 terminals and set the operating parameters. Some of the earliest Rev B models may require higher voltages, such as 125 to 140VAC to set the operating parameters. However, you must supply 160VAC if you want to test the communications with the Model RS485MS or RS485MS-2W connected. If you only have 120 volt power available, you may need to use a 2:1 step up transformer to supply 240v AC to conduct the communications test.

Note that the Model 777 will not start with only L1 and L2 connected, but you can read the voltage registers to test the communications.

MODBUS Memory and Data Location Terminology / Register vs. Address

The MODBUS standard defines a memory locations in terms of registers and addresses. The 'Register' numbering system starts Xxxxxx1 and goes up to X65536. Where the leading X is a reference number that designates a register type. The 'Address' numbering system starts at 0 rather than 1 and does not contain a prefix. The prefix indicates which read and write functions should be used to get or set the corresponding location. The Modicon MODBUS Protocol Reference Guide refers to these XX references, such as 4X reference for holding registers. However, the MODBUS standard that can be found at www.MODBUS-ida.org does not use these 'references'.

Older standards and products tend to use a five digit numbering system for registers. (Ex: 40,001 for the first holding register) However, other documentation is written using a 6 digit numbering system, which makes sense since MODBUS supports registers up to 65536. (Ex: 400,001 for the first holding register).

The ‘Address’ numbering system is defined in the standard to describe the message that is actually sent to the physical communications bus. By starting the addresses at 0 rather than 1 and by truncating the register type prefix or reference, the number of usable memory or data locations is maximized. This document will use the terms ADDRESS and LOCATION interchangeably to refer to the actual ‘address’ placed on the bus to get the intended piece of data.

Physical Address Versus Logical Address

In our older versions of documentation (DOC777-01 & DOC777-02), we often referred to the PHYSICAL address which is the actual address used inside the Model 777 code. References to the PHYSICAL address were dropped in DOC777-03 and DOC777-04). **The PHYSICAL address also happens to conform to the REGISTER number as defined by the MODBUS standard.** *The Model 777 takes the incoming logical byte address from the MODBUS command, increments it to point to the next byte, and then returns the number of words requested from physical memory.* The LOGICAL address referred to the actual address that was sent on the communications bus. The LOGICAL address is/was less than the PHYSICAL address. The logical address is equal to the ‘Address’ as defined by the MODBUS standard. It should be noted that the PHYSICAL and LOGICAL designations are actually opposite to what an end user might expect. An end user may consider the register numbers to be ‘logical’ addresses and the ADDRESS to be physical, because the register is manipulated to come up with the ADDRESS which is placed on the bus.

Some of the previous documents were written more from the perspective of the product designer rather than that of the end user. To better conform to the standard nomenclature, this document will be written more from the end user perspective using the REGISTER and ADDRESS terminology as defined by the MODBUS standard. By clearly defining both the REGISTER and ADDRESS numbering systems, this document should be equally clear to those that are using software utilities that use the REGISTER or ADDRESS location numbering systems and those that are writing their own software to talk to the Model 777 family of products.

Model 777 Commands

The Model 777 will respond to two MODBUS commands. The first command is:

INSTRUCTION CODE 03 - Read Holding Registers (or Read a block of words).
The 03 code is used to read data from the Model 777.

The second command is:

INSTRUCTION CODE 06 - Preset Single Register (or Write One Value).
The 06 code is used to send a command to stop the motor attached to the Model 777. The 06 code can also be used to modify the setpoints of the Model 777.

Broadcast is not supported.

Read Command Example

A typical request for a model 777 would be to ask for the 4 voltages starting at address 43, or 2B hexadecimal, which are the Voltage in Phase C-A, the Voltage in Phase B-C, the Voltage in Phase A-B, and the Average Voltage. In the example below, the values will be returned as 481, 476, 483 and 480 volts for these variables.

Assume that the Model 777 has been programmed with a device address of A02. The MODBUS command message from the master device to a slave device would look like:

Byte	Contents	Example (in Hex)	
1	Address of Slave Device	02	
2	Command to Slave Device	03	
3	High Byte of Address	00	(Address of VCA)
4	Low Byte of Address	2B	
5	High Byte of Number of Words	00	(Read 4 words)
6	Low Byte of Number of Words	04	
7	LOW byte of CRC word	34	
8	HIGH byte of CRC word	32	

The above sequence would be a request to read 4 words (8 bytes) starting at address 43. The normal response from the Slave device to the master device would look something like:

Byte	Contents	Example (in Hex)	
1	Address of Slave Device	02	
2	Echo of Command to Slave Device	03	
3	Number of Bytes sent back	08	
4	High Byte of Word at 002C	01	(VCA = 481)
5	Low Byte of Word at 002C	E1	
6	High Byte of Word at 002E	01	(VBC = 476)
7	Low Byte of Word at 002E	DC	
8	High Byte of Word at 0030	01	(VAB = 483)
9	Low Byte of Word at 0030	E3	
10	High Byte of Word at 0032	01	(VAVG = 480)
11	Low Byte of Word at 0032	E0	
12	LOW byte of CRC word	8A	
13	HIGH byte of CRC word	41	

The voltage values listed would be values that might be expected from a 480 volt system.

***Special Note*:** *Note that the CRC (Cyclic Redundancy Check) word is sent with the LOW byte FIRST followed by the HIGH byte.*

The CRC bytes are sent in a different order from the order of the Address and Number-Of-Words-To-Send words. The Address and Number-Of-Words-To-Send words are sent with the high byte first followed by the low byte.

WRITE COMMAND EXAMPLES

If a Model 777 has been programmed with a device address of A01, the command to turn off the relay would be:

Byte	Contents	Example (in Hex)	
1	Address of Slave Device	01	
2	Command to Slave Device	06	
3	High Byte of Address	00	(Address of COMLINE)
4	Low Byte of Address	64	
5	High Byte of Value to write	00	(Sending STOP command)
6	Low Byte of Value to write	DD	
7	LOW byte of CRC word	08	
8	HIGH byte of CRC word	4C	

The above sequence would be a request to write 1 byte starting at address 100, or 64 hexadecimal, which is the address of the command word, COMLINE. Refer to Appendix A, Table 2.3 and Table 2.4 for more information about Model 777 commands.

The normal response from the Model 777 is to echo the same byte sequence back to the master device. This is a confirmation that the command was carried out.

CRC TESTING

If you need to test your CRC calculations, you can generate a STOP command exactly like the one above and compare the CRC bytes that your program generates with the CRC bytes listed above. If you set the Model 777's address to A01 and send the above string, the Model 777 should turn off its relay and the display should show "**oFF**". If the first six bytes are exactly like the above sequence, the Model 777 will ONLY respond correctly if the CRC bytes are also exactly like the above sequence. If the Model 777 receives any other CRC bytes, it will assume a communication error occurred and will NOT turn off its relay.

NOTE: *If you are using an oscilloscope to capture the sequence of bits that are being transmitted, note that the MODBUS RTU mode specifies that the LEAST significant bit of each byte is transmitted first. Thus, for the sequence above, you would see a Start bit, followed by a high, then low, low, low, then low, low, low, low, followed by the Parity and Stop bits for the first byte (01 hex) sent.*

Similarly, the command to reset the same Model 777 would be:

Byte	Contents	Example (in Hex)	
1	Address of Slave Device	01	
2	Command to Slave Device	06	
3	High Byte of Address	00	(Address of COMLINE)
4	Low Byte of Address	64	
5	High Byte of Value to write	00	(Sending RESET command)
6	Low Byte of Value to write	AA	
7	LOW byte of CRC word	48	
8	HIGH byte of CRC word	6A	

Again, note the CRC bytes. These STOP and RESET command examples are excellent test commands to verify CRC calculations and communication problems since the only thing that will change in a particular installation is the address of the Model 777 and, of course, the CRC bytes. For example, if the Model 777 has been programmed with device address A11, then the series of bytes would be:

Byte	Contents	Example (in Hex)	
1	Address of Slave Device	0B	
2	Command to Slave Device	06	
3	High Byte of Address	00	(Address of COMLINE)
4	Low Byte of Address	64	
5	High Byte of Value to write	00	(Sending RESET command)
6	Low Byte of Value to write	AA	
7	LOW byte of CRC word	48	
8	HIGH byte of CRC word	C0	

Notice that in this example, only the Address of the Model 777 and the CRC bytes have changed from the series of bytes sent to the Model 777 at device address A01.

READING VERSUS WRITING SETPOINT VALUES

It is important to note a distinction between reading byte values listed in Table 2.2, the Limits or Setpoint block, and writing byte values to change operating parameters of the Model 777.

> *When reading byte values, the MODBUS READ command (03) will return two bytes for every word requested. When writing to a variable that is listed as a single byte, the MODBUS WRITE command (06) will only modify the single byte specified by that address.*

As an example, if we send a MODBUS Read command (03) to read OC, the Over Current Trip Limit, starting at address 236 and read 1 word, we would receive the values for both OC, the Over Current Trip Limit, and UC, the Under Current Trip Limit.

When writing to a single byte value, ONLY the byte at that address will be changed. In other words, if we wanted to change UC, the Under Current Trip Limit, we would write a single byte, such as a value of 25 to address 237 and it would only change the single byte that represents UC, the Under Current Trip Limit.

The Write command sends a zero as the High Byte of the data, which would seem to write a Zero value into the byte representing OC, the Over Current Trip Limit. However, the Model 777 is specifically scanning each write address and determining if it is a single byte value or a double byte value. In this case, only the Under Current Trip Limit byte would be changed. The Over Current Trip Limit byte would not be changed.

Currently, the only two byte values that can be modified by a MODBUS Write command (06) are:

address	Code	Description
211	LKMSK	Field Change Lock Mask
215	HKW	High Kilowatt Trip Limit
221	LKW	Low Kilowatt Trip Limit
230	LV	Low Voltage Trip Limit
232	HV	High Voltage Trip Limit

All other Read/Write values can only be modified by writing a single byte to the address.

A second implication of this is that you can read from certain addresses, but you cannot write to them. For example, you can send a read command to start reading address 231 and you will receive the low byte of the Low Voltage Trip Limit and the high byte of the High Voltage Trip Limit. But if you try to write to address 231, you will receive a Negative Acknowledgement (NAK) code indicating an invalid address.

NUMBER OF WRITE OPERATIONS

The Model 777 Limits are stored in Electrically Erasable Programmable Read Only Memory (EEPROM). EEPROM has a finite number of write cycles before the material is unable to hold a new value. The current implementation of the Model 777 is rated at 100,000 writes to the EEPROM.

If an application were programmed to re-write a given setpoint too often, the EEPROM could be unable to hold the value. In earlier versions of the Model 777, the setpoints had to be changed by pressing and releasing the RESET button, so it would take a concerted effort to cycle the setpoints too many times, but a network application could easily write a value too many times. For example, if an application wrote the HV or High Voltage limit once every second for 24 hours a day, in less than 12 days the 100,000 limit could be exceeded.

If there is a concern about the setpoints being changed by an operator, the application should read the value of the setpoints and compare them to the desired setpoints and only change the setpoints when a discrepancy is detected.

The Model 777 Limits can be read indefinitely without degradation of the EEPROM.

SPECIAL NOTES WHEN USING THE 4X ADDRESSES

Some software packages, such as Human-Machine-Interface (HMI) software packages for PLCs, can only use registers from 400001 to 465536 in the MODBUS 03 and 06 commands.

If this is the case, add 400001 to the addresses in the tables to select the start of the data to read. Many of these software packages will automatically subtract the 400001 part of the address before sending the actual address in the MODBUS command. However, notice that the addresses in Appendix A refer to the Starting Address. These addresses do NOT represent a typical 4X register address.

Processing Byte Data

The Model 777 is byte-oriented. Some MODBUS slave devices are word-oriented and return the value of one variable in each word requested. In the Read examples above, where the voltage are being read, each word in the response contains two bytes that represent a value for only one variable. However, there are instances where the Model 777 will return 2 bytes for each word requested, but each byte contains data from two different variables.

If you look at Appendix A, Table 2.1, Run Time Information, for VUNBAL, the Voltage Unbalance, and CUNBAL, the Current Unbalance, you will see an example of this. If you request one word starting at address 40061, you will get both the Voltage Unbalance and the Current Unbalance values returned in one word. If you request one word starting at address 40062, you will get both the Current Unbalance and the Current Multiplier returned in one word. Your application will have to separate the High byte value from the Low byte value.

If your master device's programming language does not have byte-wise AND and SHIFT functions, you may have to treat the word as an integer and divide by 256 to get the High byte value. Then multiply the result by 256 and subtract that from the original word to get the Low byte value.

As an example, assume the voltage unbalance is 2 percent and the current unbalance is 5 percent. If we read starting location 40061, the Model 777 will return the 16 bit value 517. If we divide 517 by 256, we get VUNBAL, the voltage unbalance, which is 2 percent. If we multiply the resulting value (2) by 256, we get 512. If we subtract 512 from 517, we get CUNBAL, the current unbalance, which is 5 percent.

Internally Mapping Byte Addresses

Since the addresses in Appendix A represent BYTE addresses, not WORD addresses, you may have to interpret the data based on a different address map used internally in your application. As an example of what would be a typical read request, assume we want to read all of the Run Time information in a single read

block. If you start reading at REGISTER 40044 and ask for 15 words, you would expect to fill internal registers 40044 through 40058. You could consider the resulting internal memory map to look like:

	Model 777	
Internal		
4X REGISTER	Address	Description
40044	43	Voltage from Phase C to Phase A
40045	45	Voltage from Phase B to Phase C
40046	47	Voltage from Phase A to Phase B
40047	49	Average Voltage
40048	51	Current in Phase C
40049	53	Current in Phase B
40050	55	Current in Phase A
40051	57	Average Current
40052	59	Voltage Unbalance * 256 + Current Unbalance
40053	61	Current Multiplier * 256 + Power factor angle
40054	63	Ground Fault Current * 256
40055	65	Remaining Rapid Cycling Restart Delay
40056	67	Remaining Normal Restart Delay
40057	69	Remaining Undercurrent Trip Restart Delay
40058	71	Motor Run Hours

Note that the addresses in the first column represent ONLY addresses used inside your application. Based on the table above, you might be tempted to read the three current registers by issuing a READ command starting at address 40048 and ask for 3 words. This will not return the currents.

Instead, you need to use the 4X STARTING address from Appendix A and then re-interpret the resulting internal register addresses. For example, in order to read only the three current values, you need to use the starting REGISTER 40052 and ask for 3 words. The data will then appear to be mapped for your application as:

	Model 777	
Internal		
4X REGISTER	Address	Description
40052	51	Current in Phase C
40054	53	Current in Phase B
40056	55	Current in Phase A

If this causes problems in your application, it might be best to pick a starting address block and always ask for the same starting address and number of words in order to read the data from the Model 777.

Similarly for reading the Setpoint values, you could ask for a single block of data starting at location 230 and request 11 words. The equivalent internal register map would look like:

	Model 777	
Internal		
4X REGISTER	Address	Description
40231	230	LV (Low Voltage Trip Limit)
40232	232	HV (High Voltage Trip Limit)
40233	234	VUB * 256 + MULT
40234	236	OC * 256 + UC
40235	238	CUB * 256 + TC
40236	240	RD1 * 256 + RD2

40237	242	RD3* 256	+ #RU
40238	244	#RF * 256	+ UCTD
40239	246	GF * 256	+ LF1
40240	248	LF2 * 256	+ LF3
40241	250	LF4 * 256	+ ADDR

However, for writing Setpoint values, the (MODBUS) address listed in Table 2.2 is required to write a value. See the section "READING VERSUS WRITING SETPOINT VALUES" above for more information. As an example, if you wanted to reset the UC value. You would read the Setpoint values as a block, and mask off the UC setting at internal 4X address 40234 in order to determine the present value. If the UC was set to 20 and you wanted to change it to 15, you would have to write the new value, 15, to register 40238 (per Table 2.2) in order to change the UC value. Then you may want to re-read the entire block starting at register 40231, requesting 11 words, in order to verify that the UC value did change.

DATE RELATED FEATURES

Over time, certain features have been added to the basic Model 777. Often, the date of manufacture will allow you to tell if a particular Model 777 has a certain feature or not.

Date Code

The date of manufacture is coded in the Model 777 serial number. You should see the serial number on the Model 777 sticker in the form 777VYYMMSSSS. The YYMM portion is the year and month representing the date of manufacture. The V represents the voltage and SSSS represents a serial build number.

Older Protocol

The Model 777 was initially developed with a proprietary communications protocol from Cimetrics. Generally speaking, units built since the middle of 1997 have used the MODBUS protocol. However, certain versions continued to use the Cimetrics protocol for a period after that. The MODBUS protocol was listed as Option 11. During the late 1990's, all Model 777's with MODBUS protocol had a label with "MODBUS" printed on it near the 9 pin sub-d connector.

If you have any older Model 777's that have the Cimetrics protocol, contact SymCom at 800-843-8848 for upgrade details.

Network Programming and Motor Run Hours

Model 777's built before September 2001 were not network programmable. In other words, you could not use the MODBUS 06-Write command to change the setpoints such as OC, the OverCurrent trip limit. Also the Motor Run Hour (MRH) information was not available before this date.

If the date code is prior to 0109 (Year = 2001, Month = Sept), the Model 777 will have to updated if you require network programming. Please contact SymCom for information about upgrades.

Clearing Last Fault

Model 777's built before February 2002 did not respond to a CLEAR LAST FAULT Command (hexadecimal 77). The CLEAR LAST FAULT command was added at the same time that the "cLr" function was added to the Ground Fault position on the front of the Model 777.

These units can be identified by turning the Model 777's MODE SELECT switch to the "GF" mode. Note the Ground Fault reading. Turn the DISPLAY/PROGRAM pot fully clockwise. Press and hold the RESET/PROGRAM button. You should see "unL" in the Model 777 display. Rotate the DISPLAY/PROGRAM pot clockwise. You should see "unL" followed by "Loc". If you continue turning the pot and you see "cLr", the unit has the Clear Last Fault feature. If you only see "unL" and "Loc", then the unit does not have this feature. Be sure to turn DISPLAY/PROGRAM pot fully clockwise before releasing the RESET/PROGRAM button so that you don't accidentally change the Ground Fault setting.

KW Units

Currently, only the Model 777 KW's have the Kilowatt information (RTKW) available. If you have a Model 777 KW, you will not be able to set the UnderCurrent Limit (UC) to anything other than 0 (No UC trip). If you have a regular Model 777, you will not be able to set the Low Kilowatt Limit (LKW) to anything other than 0 (OFF).

You should also be aware that the Model 777 KW units do not allow the Under Current Trip Delay to be set by the front of the Model 777. That position is taken up by the KW Input Scaling Factor. It is still possible to change the Under Current Trip delay for KW units, but it must be done by using a MODBUS master device to send a Write (06) command to change the UCTD setpoint at address 245.

Related Documentation

SymCom can also provide documentation for connecting Model 777's in an RS485 network. This document is DOC-485-02. Also available is DOC-485-03 which describes troubleshooting RS485 communication problems using an oscilloscope. If you need to develop MODBUS master Software for an RM-2000, request DOC-RM2K-01.

PROCESSING THE RUN TIME INFORMATION

Current Multiplier

The Current Multiplier for the Run Time (RTMULT) information is a Read-Only, single byte value at address 61 which can be interpreted as an integer with a value 0 to 255 decimal.

For Multiplier values 1-10: Actual Current = Raw Current / (Multiplier * 10)

For Multiplier value 11: Actual Current = Raw Current * 0.4

For Multiplier values 12 - 79: Actual Current = Raw Current * Multiplier / 20

For Multiplier values 80-200: Actual Current = Raw Current / (Multiplier)

For Multiplier values >200: Actual Current = Raw Current * (Multiplier -200) / 40

Restart Delays Remaining

The restart delay remaining times (RD1R, RD2R, and RD3R) need to be multiplied by 0.569 to be converted to seconds. RD2R and RD3R read out in seconds even though the limit is in minutes.

Restart Delay Remaining (seconds) = [Restart Reading] * 0.569

Power Factor

You must take the Cosine of the power factor angle to calculate the Power Factor.

Power Factor = Cos([power factor angle])

The power factor angle is read as a value in degrees. If your Cosine function requires the angle to be expressed in *radians*, you can convert degrees to radians by multiplying by (Pi / 180.0)

Voltages

The voltages read correctly as integer values. No calculating is necessary to display the same value that the Model 777 displays.

> Note that some installations have Potential Transformers (PT's) installed to reduce to voltage to the Model 777. If this is the case, your application may require a voltage multiplier to scale the voltage readings back up to the actual value. This is usually required for a Medium Voltage unit like the 777 MV.

Kilowatts

The kilowatts need to be divided by 100.

Kilowatts = [KW reading] / 100

PROCESSING THE LIMIT (SETPOINT) INFORMATION

Current Multiplier

The Current Multiplier for Limits (MULT) is a Read/Write single byte value at address 235 which can be interpreted as an integer with a value 0 to 255 decimal. It applies directly to OC, the Overcurrent Trip Limit and to UC, the Undercurrent Trip Limit. GF, the Ground Fault Trip Limit uses the MULT factor, but the Ground Fault Trip Limit must also be divided by 10.

For Multiplier values 1-10:	Trip Limit = Raw Limit value / Multiplier
For Multiplier value 11:	Trip Limit = Raw Limit value * 4.0
For Multiplier values 12 - 79:	Trip Limit = Raw Limit value * Multiplier / 2
For Multiplier values 80-200:	Trip Limit = (Raw Limit value * 10) / (Multiplier)
For Multiplier values >200:	Trip Limit = Raw Limit value * (Multiplier -200) / 4

NOTE: MULT values of 1-10 represent a loop count for the standard Model 777. Values 11 and greater represent CT ratios. Refer to Table 1.4.1 for the CT ratio represented by a particular value.

Ground Fault Trip Limit

If the raw Ground Fault limit (GF) reads 255 (FF hex), the unit will not trip on a Ground Fault.
The Ground Fault limit uses the Limits Current Multiplier (MULT), but the calculations are similar to the Run Information current calculations, since the raw Ground Fault value is 10 times actual. For example:
For Multiplier values 1-10 Ground Fault Limit = Raw GF value / (Multiplier * 10)
Etc.

Unbalance Limits

If either the voltage (VUB) or current (CUB) unbalance limit is 255 (FF hex), the unbalance limit is turned OFF.

Restart Delays

The RD1, RD2 and RD3 limits are one half of the actual setting. Therefore the readings must be multiplied by 2 to get to the actual limit setting. For the standard Model 777, the RD1 Restart Delay is in seconds, and the RD2 and RD3 delays are in minutes.

Number of Restarts after an Undercurrent Fault

If #RU reads 255 (FF hex), the unit will automatically restart after all undercurrent faults.
Note that if #RU is zero, the unit will not start after an undercurrent fault until the Reset button is pressed or a RESET command is sent to the Model 777.

Number of Restarts after any other Fault

The #RF value contains certain bit settings. If Bit 0 (the least significant bit) is set, the Number of Restarts will apply to over current faults. Bits 1 through 3 represent the Number of Restarts. A value of 0 to 4 is the Number of Restarts. If the value is 5, the unit will automatically restart after any other fault.

As an example, if #RF contains the decimal value 11, it represents the bit pattern “0 0 0 0 1 0 1 1”. This means that the unit will automatically start after other faults, including over current.

Low Kilowatt Trip Limit

If the Low Kilowatt trip limit (LKW) reads 0, the unit will not trip on Low Kilowatts.

If you are programming a 777 KW from a PLC, you can set LKW to any value from 0 to 65000 (650 KW), regardless of the KW Input Scaling Factor. If you are programming a 777 KW unit from the front panel, you must first set the Input Scaling Factor (1 through 4) and then set the Low Kilowatt Limit.

High Kilowatt Trip Limit

If the High Kilowatt trip limit (HKW) reads 65535, the unit will not trip on High Kilowatts. Also, if bit 7 of ENDIS is clear, the unit will not trip on High Kilowatts.

If you are programming a 777 KW from a PLC, you can set HKW to any value from 0 to 65535. If you are programming a standard Model 777, the HKW value can only be set to 65535. The HKW value cannot be set from the front panel of the 777.

Enable/Disable Trip bits

If bit 7 of ENDIS is clear, the unit will not trip on High Kilowatts. Future bit definitions are reserved

WRITING LIMIT (SETPOINT) VALUES

Table 1.0 - Limits Information for Network Programming

Addr	4X Write REGISTER	Code	Description	Bytes	Min Value	Max Value
211	40212	LKMSK	Field Lock Mask	2	0	65535
214	40215	ENDIS	Enable/Disable Trip	1	0	255
215	40216	HKW	High Kilowatt Trip Value = KW * 100	2	0	65535 (Disabled)
221	40222	LKW	Low Kilowatt Trip Value = KW * 100	2	0	65000 (650 KW)
. . .						
For Model 77C						
226	40227	LIN	Linear OC Trip Delay	1	2	60 (seconds)
227	40228	TU	Time Units	1	0	3
. . .						
For Model 601						
226	40227	HF	Over Frequency (35.0 + Value/5 i.e. 0=35.0, 200=75.0)	1	0	200
227	40228	LF	Under Frequency	1	0	200
228	40229	TD1		1	1	50
229	40230	TD2		1	1	50
. . .						
For All Models						
230	40231	LV	Low Voltage Trip	2	170	< HV, 524
232	40233	HV	High Voltage Trip	2	172, > LV	528
234	40235	VUB	Voltage Unbalance	1	2	15, (255=Disable)
235	40236	MULT	Current Multiplier (See Table 1.2)	1	1	255
236	40237	OC	Over Current Trip	1	20, > UC	100
237	40238	UC	Under Current Trip	1	(0=Disable), 10 < OC, 98	
238	40239	CUB	Current Unbalance	1	2	25, (255=Disable)

239	40240	TC	Trip Class (133, 138, 143, 148, 158 with Jam)	1	5, 10, 15, 20, 30 (Add 128 for Jam)	
240	40241	RD1	Restart Delay 1 Value = 1/2 of RD1 Time. (RD1 time = 0 to 500 seconds)	1	0	250
241	40242	RD2	Restart Delay 2 Value = 1/2 of RD2 Time. (RD2 time = 2 to 500 minutes)	1	1	250
242	40243	RD3	Restart Delay 3 Value = 1/2 of RD3 Time. (RD3 time = 2 to 500 minutes)	1	1	250
243	40244	#RU	Restarts (After UC)	1	0, 1, 2, 3, 4 or 255 (255 = Auto)	
244	40245	#RF	Restarts (Other trips) Num. Restarts = 0,1,2,3,4 or 5 (5=Auto) RF value = (2 x Num. Restarts) (+ 1 for OC)	1	0	11
245	40246	UCTD	UC Trip Delay	1	2	60 (seconds)
246	40247	GF	Ground Fault(x 10) (3.0 to 20.0 amps)	1	30	200

Table 1.1 Limit Information By Model

Variable	777	777HVR	777575	777LR	777HVR-LR	777575-LR
Unit Code	1	2	3	11	12	13
Low Voltage	170-524	340-523	450-649	170-524	340-523	450-649
High Voltage	172-528	341-528	451-660	172-528	341-528	451-660
Curr. Mult	Table 1.4.1	Table 1.4.1	Table 1.4.1	Table 1.4.2	Table 1.4.2	Table 1.4.2
Over Curr.	20-100	20-100	20-100	20-100	20-100	20-100
Under Curr.	0,10-98	0,10-98	0,10-98	0,10-98	0,10-98	0,10-98

Variable	777MV
Unit Code	31
Low Voltage	85-262
High Voltage	86-264
Curr. Mult	Table 1.4.3
Over Curr.	20-61
Under Curr.	0,10-45

Table 1.2 Model Codes - Addresses 253 and 254

Unit Code	Model
777	Model 777
77	Model 77C (Single phase voltage and current monitor)
601	Model 601 (3 phase voltage monitor only)

Table 1.3 Model Revisions – Address 224

Model	(Model Revision) Minor Software Revision	Model	(Model Revision) Minor Software Rev
777	04	777-KW	47
777-HVR	27	777-LR-KW	48
777-575	05	777-575-KW	50
777-LR	02	777-MV	38
777-HVR-LR	07		
777-575-LR	08		

Table 1.4 MULT Current Multiplier Values

Table 1.4.1 For Standard Model 777:

1-10 = Looping Multiplier
11 = 100:5 CT's
12 = 150:5 CT's
16 = 200:5 CT's
24 = 300:5 CT's
32 = 400:5 CT's
40 = 500:5 CT's
48 = 600:5 CT's
56 = 700:5 CT's
64 = 800:5 CT's

Table 1.4.2 For LR models (Low Range)

100: 100:5 CT's
200: 200:5 CT's

Table 1.4.3 For 777 MV (Medium Voltage)

202 = 25:5 CT's
204 = 50:5 CT's
206 = 75:5 CT's
208 = 100:5 CT's
212 = 150:5 CT's
216 = 200:5 CT's
224 = 300:5 CT's
232 = 400:5 CT's
240 = 500:5 CT's
248 = 600:5 CT's

Table 1.5 - Fault Codes Used in the Model 777

Code	Definition	
0	Cleared	
1	High Voltage	(Model 601)
2	Low Voltage	(Model 601)
4	Contactor Failure	
6	Single Phased Current	

7	Ground Fault	
8	Current Unbalance	
10	Overcurrent	
11	Undercurrent	
13	Over Frequency	(Model 601)
14	Under Frequency	(Model 601)
15	Low Kilowatt Trip (Low Power)	
16	PTC Off	
17	High Kilowatt Trip (High Power)	

Table 1.6 - Error Code bit values

Bit	Definition
0	Low Voltage
1	High Voltage
2	Voltage Unbalance
3	Under Current/Low KW
4	Reverse Phase Error
5	Current Unbalance
6	Voltage Single-Phase
7	Current Single-Phase

Table 1.7 – Overload Status bit values

Bit	Definition
0	Overload Detected
1	Ground Fault Detected
2	High KW
7	Relay ON

Table 1.8 – Trip Reason bit values

Bit	Definition
0	Fault Lockout
1	Network OFF Command
2	Contactor Failure
3	Undercurrent / Low KW
4	Over Current
5	Ground Fault
6	Current Unbalance
7	Current Single-Phase
8	Network PTC OFF Command
9	High KW trip

Table 1.9 – Network Status bits

Bit	Definition
0	Network Communication Watchdog Timer Enabled
1	Network Programming Enabled
2	Display Lock

Note: Only bit 0 is Writable, bits 1 & 2 are Read-Only. Refer to Table 2.4 for commands 68, 85, 136 & 153 to set and clear bits 1 and 2.

APPENDIX A

MODEL 777 MEMORY LOCATIONS

Table 2.1 Run Time Information

(MODBUS) Addr	Hex	4X * (Starting) REGISTER	Code	Description	Bytes
43	2B	40044	VCA	Voltage from Phase C to Phase A	2
45	2D	40046	VBC	Voltage from Phase B to Phase C	2
47	2F	40048	VAB	Voltage from Phase A to Phase B	2
49	31	40050	VAVG	Average Voltage	2
51	33	40052	IC	Current in Phase C	2
53	35	40054	IB	Current in Phase B	2
55	37	40056	IA	Current in Phase A	2
57	39	40058	IAVG	Average Current	2
59	3B	40060	VUNBAL	Voltage Unbalance	1
60	3C	40061	CUNBAL	Current Unbalance	1
61	3D	40062	RTMULT	Current Multiplier	1
62	3E	40063	PFANGLE	Power factor angle	1
63	3F	40064	GFCUR	Ground Fault Current	1
64	40	40065		NOT USED	1
65	41	40066	RD1R	Remaining Rapid Cycling Restart Delay	2
67	43	40068	RD2R	Remaining Normal Restart Delay	2
69	45	40070	RD3R	Remaining Undercurrent Trip Restart Delay	2
71	47	40072	MRH	Motor Run Hours (Not in all units)	2
73	49	40074	RTKW	Kilowatts (Not in all units)	2
75	4B	40076	TRIPRN	Trip Reason Code (See Table 1.8)	2
77	4D	40078	OLSTAT	Overload Status (See Table 1.7)	1
78	4E	40079	ERCODE	Error Code (See Table 1.6)	1
For Model 601 only:					
102	66	40103	FRQ6	Frequency, Model 601 (times 5)	2

* 4X – See section “SPECIAL NOTES WHEN USING THE 4X REGISTERS” for more information.

Table 2.2 - Limits (Setpoint) Information

(MODBUS) Addr	Hex	4X * (Starting) REGISTER	Code	Description	Bytes *
For Model 777, Major Rev 25 and newer					
211	D3	40212	LKMSK	Field Change Lock Mask	2 (R/W)
214	D6	40215	ENDIS	Enable/Disable Trip conditions	1 (R/W)
215	D7	40216	HKW	High KW trip limit	2 (R/W)
217	D9	40218	IMDLY	Time Delay before updating Imax	1 (R/W)
218	DA	40219	NETST	Network Status (See Table 1.9)	1 (R/W b0)
219	DB	40220	IMAX	Highest Recorded Current	2

(MODBUS) Addr	Hex	4X (Starting /) (Write) REGSISTER	Code	Description	Bytes *
For Model 777, Major Rev 23 and newer					
221	DD	40222	LKW	Low Kilowatt Trip Limit	2 (R/W)
223	DF	40224	MAJORVR	Major Software Revision	1
224	E0	40225	MINORVR	Minor Software Rev (Model Rev.)	1
. . .					
For Model 77C					
226	E2	40227	LIN	Linear OC Trip Delay	1 (R/W)
227	E3	40228	TU	RD1 & RD2 Time Units	1 (R/W)
. . .					
For Model 601					
226	E2	40227	HF	Over Frequency Limit (35.0 + Value/5)	1 (R/W)
227	E3	40228	LF	UnderFrequency Limit (35.0 + Value/5)	1 (R/W)
228	E4	40229	TD1	(1-50)	1 (R/W)
229	E5	40230	TD2	(1-50)	1 (R/W)
. . .					
For All Models					
230	E6	40231	LV	Low Voltage Trip Limit	2 (R/W)
232	E8	40233	HV	High Voltage Trip Limit	2 (R/W)
234	EA	40235	VUB	Voltage Unbalance Trip Limit	1 (R/W)
235	EB	40236	MULT	Current Multiplier for Limits	1 (R/W)
236	EC	40237	OC	Over Current Trip Limit	1 (R/W)
237	ED	40238	UC	Under Current Trip Limit	1 (R/W)
238	EE	40239	CUB	Current Unbalance Trip Limit	1 (R/W)
239	EF	40240	TC	Trip Class	1 (R/W)
240	F0	40241	RD1	Rapid Cycling Restart Delay	1 (R/W)
241	F1	40242	RD2	Restart Delay after OC fault	1 (R/W)
242	F2	40243	RD3	Restart Delay after UC fault	1 (R/W)
243	F3	40244	#RU	Number of Restarts after UC fault	1 (R/W)
244	F4	40245	#RF	Number of Restarts after other faults	1 (R/W)
245	F5	40246	UCTD	Under Current Trip Delay	1 (R/W)
246	F6	40247	GF	Ground Fault Trip Limit (x 10)	1 (R/W)
247	F7	40248	LF1	Last Fault (See Table 1.5)	1
248	F8	40249	LF2	Second to Last Fault " "	1
249	F9	40250	LF3	Third to Last Fault " "	1
250	FA	40251	LF4	Fourth to Last Fault " "	1
251	FB	40252	ADDR	MODBUS Device Address	1
For Model 777, Rev B					
252	FC	40253	UNITID	Unit ID	1
253	FD	40254	MODELCD	Model Code (See Table 1.3)	2

For Model 777, Rev A

252	FC	40253	MMSN	Month Manufactured & Serial Number	2
254	FE	40255	YM	Year Manufactured	1

* (R/W) indicates Read / Write values. See section "READING VERSUS WRITING SETPOINT INFORMATION" for further information.

Table 2.3 - Command Location

(MODBUS) Addr	Hex	4X (Starting /) (Write) REGISTER	Code	Description		Bytes *
100	64	40101	COMLINE	Command Location	(See Table 2.4)	1 (R/W)

* (R/W) Although this location can be read as well as written to, the value that is written to this location will be cleared (set to zero) after the command is processed.

Command Codes

If a write request is issued to the Model 777 to write a 221 (or DD hex) to address 100, the Control relay will be requested to be turned off. Note that the request may not be executed immediately, but may require several hundred milliseconds to complete.

If a write request is issued to the Model 777 to write a 170 (or AA hex) to address 100, the Model 777 will be requested to be reset. If there are no voltage error conditions, the Model 777 control relay will be turned ON.

Table 2.4 - Command Codes

(for Writes to COMLINE at ADDRESS 100)

Code	Hex	Function
51	33	PTC Fault and Turn Model 777 OFF
68	44	Enable Network Programming
85	55	Disable Network Programming
102	66	Clear Motor Run Hours
119	77	Add "clr" as Last Fault
136	88	Enable Network Watchdog Timer
153	99	Disable Network Watchdog Timer
170	AA	Reset Model 777
221	DD	Turn Model 777 OFF