

Tucson Amateur Packet Radio
METCON 1 System Manual
Hardware Revision 2
Firmware Revision 1.06

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Tucson Amateur Packet Radio Corporation
P.O. Box 12925
Tucson, AZ 85732-2925
(602) 749-9479

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CHAPTER ONE - INTRODUCTION

Overview

This manual describes METCON, a flexible teleMETry and CONtrol system. METCON-1 allows you, via a serial port, to read and control external electrical signals. While METCON-1 is optimized to use a packet radio TNC as a host, the serial port may be connected to a computer, TNC, telephone modem, etc.

At its most basic level of operation, METCON-1 can control binary (on/off) outputs via on-board relays and read binary inputs (such as switches and other on/off devices).

Additional features include:

- 1) A time-of-day clock.
- 2) Automatic system status transmission every 15 minutes (every minute for testing).
- 3) Automatic transmission whenever a binary-input change occurs.

Advanced features include:

- 1) Any of the eight digital inputs can also serve as a frequency counter for voltage-to-frequency (VTF) converters.
- 2) Any of the eight digital inputs can also serve as a pulse counter that can be used to totalize inputs, such as from rain gauges.
- 3) An interface for an external eight-channel Analog-to-Digital converter (ADC) board.
- 4) Authentication procedures when "logging in" to prevent unauthorized access to METCON over a shared radio channel (such as a packet radio channel).

5) Non-volatile EEPROM to save parameters at other than default conditions. This allows you to customize METCON-1 without replacing the EPROM-based microcomputer.

Background

Telemetry is the ability to read sensors from a remote location. For example, imagine a repeater site on a mountain top. The control operator of the repeater would probably be interested in knowing at least several critical conditions of the site:

- 1) If the AC power is on or off.
- 2) The float voltage of the battery backup system.
- 3) The temperature inside the building or inside the power amplifier compartment.
- 4) Perhaps the status of a motion detector at the site to see if intruders are, or have in the past, gained entry into the building.

Tele-command (or control) is the ability to control devices at remote location.

Citing the example above, suppose that the AC power at the repeater is off and the battery float voltage is dipping toward low levels. The control operator might want to switch to low transmit power to save batteries. This would be an example of control.

One way of controlling such functions is through a commercial repeater controller. A better way might be to use a packet radio system to communicate with a METCON-1 module located at the repeater site.

There are important advantages that a packet-radio-operated METCON system has over a multi-tone control system. These include enhanced security through authentication, error-free data gathering and control and the ability for a large number of METCON-controlled repeaters to share a common command-and-control RF channel.

Functions and Features

The METCON-1 module is a single printed circuit board with several integrated circuits and passive components. Essentially, it consists of a single chip microcomputer (87C51), some buffers and some relays.

METCON-1's microcomputer includes a serial port that is usually attached to a packet radio TNC. Once your packet station is connected with the remote system, you can exchange data with METCON-1. Simple single-line commands are used to command METCON's outputs and options and read METCON's inputs.

METCON-1 uses isolated relays for control output. It expects SPST switches for inputs.

Any input can be used as a frequency counter up to 10 kHz. This is useful for voltage-to-frequency (VTF) converter outputs used for analog signal monitoring.

It also supports an optional eight-channel analog-to-digital converter for eight (8) additional analog measurement points.

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CHAPTER TWO - SERIAL PORT INTERFACING

Overview

This chapter presents information on interfacing METCON to various serial communications devices, including computers, modems and TNCs. Hardware hookup information is included, along with signal descriptions and communications port hardware protocol details.

Commands that you type are underlined. Further details on all commands are given in Chapter Five, Commands and Messages.

Communicating with METCON

You communicate with METCON via the serial port. Commands are entered in a line oriented format and METCON responds with information in response to the command.

There are three major ways that you can connect your computer, TNC, modem or terminal to METCON:

- 1) direct connection through a cable,
- 2) dial up (or private line) modem connection via the telephone network, or
- 3) radio modems (like AX.25 packet or HF AMTOR/SITOR).

You will want to select different system options (linefeed on/off, echo on/off, terminal speed, etc.) to suit the method you use to connect your terminal to METCON.

Direct Connection

The direct connection is simple. There are no security issues since unauthorized users can't access METCON. If the METCON system is easily accessible, you may want to leave the SYS jumper installed. (The main disadvantage to leaving this jumper installed is that you may accidentally overwrite the memory location that sets the serial port baud rate.)

To configure METCON, install a jumper at DCD if you are going to operate with a three-wire RS-232 cable. This is a "null modem" cable without all the control signals.

Wire up an RS-232 cable according to Table 1, below.

(DTE) METCON (P2)	FUNCTION (TNC or MODEM)	(DCE) DB25P (PC)	(DTE) DB25S (AT)	DE9S
5	GND	7	7	5
3	TXD ->	2	3	2
2	RXD <-	3	2	3
4	DTR ->	20	-	-
1	DCD <-	8	-	-

TABLE 1 - RS232 Cable Options

If your computer or TNC doesn't provide DCD, you must place the DCD jumper on the METCON PC board.

Now, enter the terminal program on your computer and set the serial port parameters for 1200 bps, eight-bit data, no parity and one stop bit.

Enter the following commands to METCON:

Note :<CR> means to press the "enter" or "return" key on your computer keyboard. What you enter is underlined and the response from METCON is **bold** .

```
=AED<CR>
-A- COMMAND OK
=AWYFCOO<CR>
-A- FC-000 00 0000 0000
```

This tells METCON to use default parameters and disables security. Make any other changes you wish (pulse counter setup, A/D converter, etc.) then end the session with the command

```
=AEW<CR>  
-A- EEPROM WRITE/READ OK
```

to save the changes you just made to the METCON EEPROM. This allows METCON to remember your settings and use them the next time you power up or otherwise reset METCON.

Telephone Modem Connection

Connecting METCON to a land-line (telephone) modem is straightforward. There is probably a security issue (since anyone could dial the number and connect to your modem); password security is likely adequate for this (see SECURITY in the COMMANDS AND MESSAGES chapter of this manual).

To configure METCON, install jumpers at the SYS and DCD connectors. Connect a terminal or computer to METCON using the DIRECT CONNECTION cabling described above, and set the computer terminal program to 1200 bps, even parity, seven-bit data.

NOTE: <CR> means to press the "enter" or "return" key on your computer keyboard.

Enter the following commands to METCON:

```
=AED<CR>  
-A- COMMAND OK  
=AWBFB31<CR>  
-A- FB3-1
```

This initializes METCON to factory defaults and enables automatic disconnect (which allows you one minute to get the password right before METCON hangs up the phone).

Next, set up your password (see PASSWORD SECURITY in the COMMANDS AND MESSAGES chapter of this manual for more details on this). Let's assume the password you want is 12AB34 . Type the following commands to enter this into METCON:

```
=AWYFC12<CR>  
-A- FC-018 12 001 0010  
=AWYFDAB<CR>  
-A- FD-171 AB 1010 1011  
=AWYFE34<CR>  
-A- FE-052 34 0011 0100
```

Set up any configuration items you need for your application, such as pulse counters, A/D converter, etc. End the session with the command:

```
=AEW<CR>  
-A- EEPROM WRITE/READ OK
```

to save these changes to METCON's EEPROM.

Remove the SYS jumper from the METCON PC board and type

```
=ALO<CR>  
-A- LOGGED OUT
```

to log out.

Now it's time to set up your modem. Let's assume you have a "Hayes compatible" modem and that it is connected to your computer. Give the modem the command

```
AT&F
```

to select factory default settings then issue the commands

```
ATSO=1  
AT&WO
```

to tell the modem to answer on the first ring of the phone and save the parameters to internal memory in case of power failure.

Wire up a cable between METCON and your modem using the "TNC" connections specified in the DIRECT CONNECTION section of this chapter, above, and connect them together.

Use another modem connected to your computer to dial up the METCON modem. Ensure that the METCON modem answers. Log in using your new password with the command

```
=ALI12AB34<CR>  
-A- LOGGED IN
```

Next, logout using the command

```
=ALO<CR>  
-A- LOGGED OUT
```

to log out but don't hang up. Instead, wait to see that METCON drops the phone line within ninety seconds.

Turn off power to METCON and its modem, then turn power back on and run the test again to be sure everything is remembered by both units.

That's it!

Packet Radio Connection

When METCON is operated over an packet radio channel, there's definitely a security issue! Authentication is needed.

To configure METCON, install jumpers at SYS and DCD on the METCON PC board. Connect a terminal or PC to METCON using the DIRECT CONNECTION wiring listed above.

NOTE: <CR> means to press the "enter" or "return" key on your computer keyboard.

Issue the command

```
=AED<CR>  
-A- COMMAND OK
```

Follow this with any other application-specific setup information you require (pulse counter, A/D converter, etc.).

Next set the authentication information (see AUTHENTICATION SECURITY in the COMMANDS AND MESSAGES chapter of this manual for more details on this). Let's assume that your authentication seed will be FF0298. To set this up, enter the commands

```
=AWYFCFF<CR>  
-A- FC-255 FF 1111 1111  
=AWYFD02<CR>  
-A- FD-002 02 0000 0010  
=AWYFE98<CR>  
-A- FE-152 98 1001 1000
```

You will probably want automatic disconnect set so that someone else can't hold the link if they don't log in within one minute. To select auto disconnect send the command

```
=AWBF931<CR>  
-A- F93-1
```

You won't want METCON to echo characters back to you, or to generate line feeds, so give it the commands

```
=AWBF941<CR>  
-A- F94-1  
=AWBF951<CR>  
-A- F95-1
```

End the configuration by writing the changes to EPROM. Do this by entering

```
=AEW<CR>  
-A- EEPROM WRITE/READ OK
```

Now you need to get the authentication table from METCON. Set your terminal program copy to disk or the printer. Then give METCON the command

```
=ALA<CR>
```

and the authentication table will be sent to the terminal.

Now, remove the jumper from SYS and enter

=ALO<CR>

Now you need to set up your TNC. This discussion assumes a TNC-2 using TAPR firmware 1.1.7b pr 1.1.8a. Other controllers will probably use the same or similar commands.

Connect your terminal or PC to the packet controller. Give it the command

RESET<CR>

to select the factory default settings. Next, tell the TNC your callsign. To do this give it the command

MYCALL urcall<CR>

where urcall is your Amateur callsign. Next, tell the TNC not to monitor by giving the command

MON OFF<CR>

The TNC should be run in transparent mode, so issue the commands

PACTIME AFTER 1<CR>

CONMODE TRANSPARENT<CR>

Now wire the TNC to METCON through an RS-232 cable with the pinout described in the DIRECT CONNECTION section of this chapter, above.

Use another packet station to connect to the METCON TNC. Login by issuing the command

=ALI<CR>

and respond to the challenge using the data in your secret authorization table. Details on how to do this are given in the AUTHENTICATION SECURITY section of the COMMANDS AND MESSAGES chapter of this manual. Logout by entering

=ALO<CR>

-A- LOGGED OUT

and wait to see if METCON tells the TNC disconnect within 90 seconds. Turn the power for METCON and the TNC off, and then on, and test the system again to ensure that each board remembered what it needed to remember. That's it!

Serial Port Details

METCON communicates with you via its serial port. The 87C51 microcomputer's on-chip serial port is configured as an 8 bit start/stop UART. On the input side, the most significant bit can either be set high or low (METCON will strip out this bit). On the output side, METCON will always set the most significant bit so that it looks like an additional stop bit. METCON defaults to 1200 bps, but you can configure it for 300, 1200, 2400 or 9600 bps operation. These values can be stored in the EEPROM so that they will be effective after a power failure.

METCON uses the DCD and DTR control lines as part of the serial port communications protocol.

DCD (Data Carrier Detect or Receive Signal Detect)

This is on pin 8 of a 25-pin RS232 cable and pin 1 of a 9-pin RS232 cable. DCD is a signal from the modem to METCON. METCON's RS232 receiver chip defaults DCD to the inactive state. If you don't provide a signal for the DCD input pin, you must install a jumper across the DCD pins on the METCON PC board. METCON uses DCD to tell it when a connection has been established or concluded. METCON uses this information to mark you as LOGGED OUT if the connection is dropped.

DTR (Data Terminal Ready)

This signal is on pin 20 of a 25-pin RS232 cable and pin 4 of a 9-pin RS232 cable. METCON uses DTR to tell the telephone modem when METCON wants to terminate a telephone connection. METCON will do this if the user doesn't LOGIN with 60 seconds of a connection or if you enter the wrong password three times, whichever comes first.

When METCON wants to terminate a connection it does several things to ensure that it will work for all devices.

The disconnect routine generates an error message, pauses ten (10) seconds, sends three (3) control-C characters (packet radio attention signal), pauses two (2) seconds, sends an ASCII "D" character (packet radio disconnect command) followed by <CR> and <LF>, pauses for five (5) seconds, then places a five-second "break" on the RS232 port (dial-up modem disconnect signal) and sets DTR inactive while the TXD signal is in the break condition, then pauses for five (5) seconds.

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CHAPTER THREE - SIGNAL INTERFACING

Overview

This chapter details signal level and timing requirements for METCON's inputs and limits on the use of METCON's outputs. It includes a partial overview of METCON's internal operation to help you understand some of these limits.

Relay Output

Input/output (I/O) pins of the 87C51 microcomputer are used to activate relays for output (control). The contacts of these relays are normally open and are isolated from other circuits on the METCON-1 module (often called dry contacts).

METCON-1's relay contacts are specified for non-inductive loads with a maximum current of 200 mA. Open-circuit voltage should not exceed 100 VDC or 30 VAC.

NOTE: Even though these contacts are isolated, DO NOT connect them to 120/240 VAC circuits! If you need to control such a circuit, use METCON-1's relay to control another relay that can safely handle that level of voltage and current. And be very careful how you hook it up. If you aren't completely sure of what you are doing, do not use METCON-1 to control 120/240 VAC circuits!

Switch Inputs

Other I/O pins of the microcomputer are used to read data from external SPST switches (telemetry). Current to drive each switch is provided by METCON-1; all you need to add are switches (or other binary sensors) between the IN and GND terminals on J1.

Typical sensors include magnetic reed switches, motion detectors, thermostats, mercury tilt switches, etc. Such sensors are available from many sources.

Input switches are connected between the input pin (INO-IN7 at J1 on the METCON-1 PC board) and ground or common (also available at J1).

Since the switches are returned to ground, open-collector or open-drain signal lines may be used in place of mechanical switch contacts.

Because the switch contacts are referenced to METCON's common (ground), be sure the circuit you are monitoring is compatible with this restriction. If not, you may need to interpose a relay, opto-coupler or other isolating circuit.

Frequency Counter

Each digital input on METCON is also connected to a multiplexer whose output drives a frequency counter. This counter measures the frequency of each input for one second out of every eight seconds. This frequency counter may be used to measure the outputs of voltage-to-frequency (VTF) converters. VTF converters offer several advantages over Analog-to-Digital Converters (ADC) for monitoring analog signals.

VTF Advantages

- 1)The signal to be measured can be converted to a frequency at the source. The resulting audio-frequency signal (0 to 10 kHz) can then be transmitted over wires (or radio) to the METCON-1 module where the frequency is captured and stored in memory for remote access.
- 2)The VTF output signal can be passed through a simple opto-isolator to provide a large voltage isolation capability between the signal source and the METCON-1 module.
- 3)The VTF output signal characteristics are more noise immune than typical analog signals.

For example, the VTF audio signal can be transmitted over telephone-type house wires as a 5 volt peak-to-peak digital signal. There could be up to 0.5 VAC RMS of hum on the line but the "digital" frequency counter on METCON won't respond to signals less than 2 volts peak-to-peak. Also, it's unlikely that external noise induced into the wires would convert a 2360 Hz signal to, say, 2130 Hz.

However, the analogous situation for an ADC doesn't fare so well.

What do you think the chances are of transmitting a 0.236 VDC signal down a 500 foot run of telephone wire and having a digital voltmeter at the other end read 0.236 volts? Probably not good; especially when the air conditioner compressor motor kicks in, or the refrigerator starts up, or ... well you get the idea.

4)VTF inherently integrates the input signal over the sampling period (in METCON's case, one second). This helps filter random and noise and many periodic signals (such as AC power-induced hum) and reduce their effects on the reading being taken.

VTF Disadvantages

1) VTF typically doesn't provide as many updates per unit time as ADC. However, the METCON system isn't designed to quickly take a large number of samples. Since METCON can only acquire and transmit a few samples per second, ADC offers few advantages over VTF.

2)VTF may not be as accurate as ADC. VTF is typically accurate to about one percent.

Frequency Counter Limitations

METCON performs its frequency counting function via software routines within the microcomputer. As a result, there are two important limitations that you should be aware of when designing a system that uses this feature.

1) The upper frequency limit of each frequency counter channel is about 10 kHz. This reflects the design intent to support VTF modules.

2) Channels are sampled round-robin, so each channel is only counted once in an eight-second period of time. Thus, rapidly changing signals can't be handled well by this system. You could, however,

connect channels in parallel to decrease the apparent time spent between samples.

Finally, the RFI suppression capacitors (C1 through C8) should be removed for any channel used as a frequency counter input.

Pulse Counters

Some transducers, such as a dripping rain gauge, require the telemetry unit to count the total number of pulses over a long period of time. The frequency counter inputs are not suitable for this function for two reasons.

- 1)The frequency is measured only one second out of every eight seconds. You cannot safely assume that the number of pulses received during the other seven seconds is simply seven times greater than the number of pulses received during the one second observation period.

- 2)The frequency measured cannot be reported to the host frequently enough to ensure that every measurement is captured.

Consequently, software settable program switches have been added to allow the frequency counter operation on a particular input channel to be suspended and an accumulating pulse counter substituted in its place.

When a pulse counter flag for a particular channel is set, the frequency counter operation of that channel is inoperative. Instead, the input is sampled every 20 milliseconds. If a transition from high to low is detected between consecutive samples, the pulse counter register is incremented by one. This is a totalized count.

To reset the counter, the pulse counter flag for the input must be cleared (enabling the frequency counter function for that input). Within eight seconds, the frequency counter function will zero the counter (assuming the frequency at the input is less than one Hz).

Because the pulse count input is sampled, pulses shorter than twenty milliseconds in duration (high or low) may not be captured.

Analog-to-Digital Converter (ADC)

VTF systems should meet most of your needs to measure analog signals. However, there are some cases where the use of traditional analog-to-digital converter (ADC) techniques is warranted, so METCON-1 is programmed to accept signals from an ADC module based on the National Semiconductor ADC0838C Integrated Circuit (IC). This module offers the following features and limitations:

- 1) It uses a special serial interface (a seven-pin connector is provided on the METCON-1 board) to communicate with the METCON-1 microcomputer. Thus, all binary/frequency counter/pulse counter inputs are still available.
- 2) The module provides eight differential inputs with a voltage range selectable between 0 to +2.55 VDC or -1.28 to +1.27 VDC.
- 3) All inputs must have a common ground reference with METCON-1.
- 4) The input ranges are set by resistors on the module, so they may be customized to suit your requirements.
- 5) Any other input conditioning (other than scaling) must be performed externally to the module.

Clock

METCON-1 includes several automatic output functions. Many of these updates may be generated when an operator is not in a position to notice them. Thus, the time an event took place may not be easily determined.

To solve this problem, a time-stamp is included with all automatically-generated output messages. Since the internal METCON-1 clock used for the time stamping is implemented in software, you must set it via the serial port following a power interruption or a hardware reset.

If you plan to use the automatic functions you might want to consider a battery-backup power system for METCON so you aren't frequently

resetting the clock. See the TIME-STAMP CLOCK command for details on how to set or check the clock.

Bi-Directional I/O

The default configuration for METCON-1 at reset is with port 0 (P0) programmed as inputs and port 2 (P2) programmed as outputs. However, you can easily re-program any I/O port to be input or output. This change can be stored in the EEPROM so METCON-1 will remember your configuration at the next reset. Changing the direction of the I/O ports can be done remotely and as often as desired.

The 87C51 microcomputer chip used in METCON employs a method of outputting high signals called "weak-pull-ups". Any port's bits that are written to with 1s will output a logic high through a high resistance. Port bits written to with 0s will output a logic low via a low resistance. This means that outputs programmed high can easily (and safely) be pulled low by a short to ground, but outputs programmed low may be damaged if you pull them high via a short to +5 volts.

Thus, if you want to use a port as an input, write 1s in the bits of that port's output image in the METCON memory map. When you later read the same bits of that port image, you will be reading the values present on the external pins of that port.

One word of caution. METCON assumes that inverters are attached to all ports, so it inverts data between the memory map and the ports. So, if you want to write a 1 to a port pin, you need to put a 0 into the memory map. You can choose to turn off the automatic inverting of reads and writes to the ports but this can cause problems if you aren't very careful. See the NII and NIO bit flags in the COMMANDS AND MESSAGES chapter of this manual for more information on this feature.

CHAPTER FOUR - MEMORY MAP

Overview

This chapter describes the METCON memory map. This information is essential to understand how to use METCON to full advantage. Chapter 5's information on commands will not make sense without an understanding of the METCON memory map!

Memory Map Concept

METCON operation is based on the concept of a memory map.

The memory map reflects the status of all ports (sometimes called a port image). When you issue a command to change an output port bit (e.g., to close a relay), you are really giving METCON a command to change a bit in the memory map which corresponds to the relay port control bit.

METCON runs a background program that continually scans the memory map and changes output bits to match the map. The same program also scans inputs, reads frequencies and the like, and reflects what it finds in the memory map which you can then read.

The important concept here is that you are not actually looking at METCON's ports nor activating them; you are reading a section of memory that mirrors the input ports and altering memory which is mirrored to the output ports.

System and User Memory

The Internal Data Memory (RAM) within the 87C51 microcomputer chip is divided into two sections: system and user.

You can never read from or write to the system memory. This memory is used exclusively by the internal program running on the microcomputer.

The user memory, which you can alter, is divided into two sub-sections: open and restricted.

You can read from or write to all of the open memory area whenever you are logged in to METCON.

When the SYSTEM ADMINISTRATOR contacts (labelled SYS on the METCON-1 PC board) are open (inactive) you cannot access the restricted memory. When the SYSTEM ADMINISTRATOR contacts are closed (active), you can read from and write to any address in the restricted memory area.

Memory Organization

METCON's memory looks like a linear array of memory bytes with each memory byte containing eight (8) 8 bits. These bits are labeled 0 through 7, with 0 corresponding to the least-significant bit (LSB) and 7 corresponding to the most significant bit (MSB).

User open memory consists of bytes 0 through 49.

User restricted memory consists of bytes -1 (FF) through -5 (FB). See Figure 1 for a pictorial of a portion of the memory.

Byte	Bit Position							
Addr	7	6	5	4	3	2	1	0
00	x	x	x	x	x	x	x	x
01	x	x	x	x	x	x	x	x
02	x	x	x	x	x	x	x	x
03	x	x	x	x	x	x	x	x
04	x	x	x	x	x	x	x	x
05	x	x	x	x	x	x	x	x
06	x	x	x	x	x	x	x	x
07	x	x	x	x	x	x	x	x

Figure 1: A section of user memory

Bit and Byte addressing

One final point in the concept of the METCON memory map. METCON firmware supports two kinds of addressing: bit and byte. Bit addresses (abbreviated Badr) are used when you want to change a single output, or read a single input point.

Byte addresses (abbreviated Yadr) are used to change many bits at a time, such as a password, reading multiple inputs or controlling multiple outputs with a single command.

Memory Layout

The following charts show the layout of METCON's restricted and open user memory.

TABLE 2 - User Memory Map
Restricted Addresses

Yadr	Name	Description
F9	RSTAT0	Restricted System Status Byte 0
FA	RSTAT1	Restricted System Status Byte 1
FB	ACHGMSK	Byte Mask for Auto Change Display
FC	PSWD0	Login Password First Byte
FD	PSWD1	Login Password Middle Byte
FE	PSWD2	Login Password Last Byte
FF	STNADR	Station Address Byte

TABLE 3 - User Memory Map
Open Addresses

Yadr	Name	Description
00	SYSSTO	System Status Flags
01	SPARE	Undefined
02	PULCTR	Pulse Counter Flags
03	ADCFLG	Analog-to-Digital Converter Configuration
04	ODP0	Output Data Memory Image for Port 0
05	ODP2	Output Data Memory Image for Port 2
06	ODP4	Output Data Memory Image for Port 4
07	ODP5	Output Data Memory Image for Port 5
08	ODP6	Output Data Memory Image for Port 6
09	IDP0	Input Data Memory Image for Port 0
0A	IDP2	Input Data Memory Image for Port 2
0B	IDP4	Input Data Memory Image for Port 4
0C	IDP5	Input Data Memory Image for Port 5
0D	IDP6	Input Data Memory Image for Port 6
0E	ICP0	Input Change Flags for Port 0
0F	ICP2	Input Change Flags for Port 2
10	ICP4	Input Change Flags for Port 4
11	ICP5	Input Change Flags for Port 5
12	ICP6	Input Change Flags for Port 6
13	CCN0L	LS Byte of counter channel 0
14	CCN0H	MS Byte of counter channel 0
15	CCN1L	LS Byte of counter channel 1
16	CCN1H	MS Byte of counter channel 1
17	CCN2L	LS Byte of counter channel 2
18	CCN2H	MS Byte of counter channel 2
19	CCN3L	LS Byte of counter channel 3
1A	CCN3H	MS Byte of counter channel 3
1B	CCN4L	LS Byte of counter channel 4
1C	CCN4H	MS Byte of counter channel 4
1D	CCN5L	LS Byte of counter channel 5
1E	CCN5H	MS Byte of counter channel 5
1F	CCN6L	LS Byte of counter channel 6
20	CCN6H	MS Byte of counter channel 6
21	CCN7L	LS Byte of counter channel 7
22	CCN7H	MS Byte of counter channel 7

23	ADCH0	Analog to Digital Converter Channel 0
24	ADCH0	Analog to Digital Converter Channel 1
25	ADCH0	Analog to Digital Converter Channel 2
26	ADCH0	Analog to Digital Converter Channel 3
27	ADCH0	Analog to Digital Converter Channel 4
28	ADCH0	Analog to Digital Converter Channel 5
29	ADCH0	Analog to Digital Converter Channel 6
2A	ADCH0	Analog to Digital Converter Channel 7

CHAPTER FIVE - COMMANDS AND MESSAGES

Overview

This chapter details all of METCON's commands and messages. Detailed breakdowns of the restricted memory map and certain portions of the user memory map are included along with the default values that the control bits and bytes of the memory perform.

METCON provides a simple command structure to allow you to read an open area of memory where status information about the I/O is kept. These reads can take place in bit, byte or word mode. Word reads are done with checks to ensure that the data is not mis-phased because of interrupt processing. Writes can be done in a bit or byte mode. There is no word write mode.

In addition, the METCON time-of-day clock can be read and set and special functions performed by command.

First, let's discuss the command structure in detail.

- 1.) Commands must begin on a new line (i.e., follow a RETURN character).
- 2.) They must use an equal sign (=) as the first character on the line.
- 3.) The METCON station address (default of "A") must follow the equal sign.
- 4.) The command abbreviation is entered (1 or 2 characters) followed by the address and optional data. Appendix A is a listing of all commands.
- 4.) There must be no spaces or other characters between the equal sign, station address, command abbreviation or optional data.

In the discussion that follows, METCON commands and responses will be shown. Commands to METCON will shown underlined while responses and messages from METCON will shown in bold type. <CR> will be used to indicate sending the ASCII carriage return character (hex 13).

Time-Stamp Clock

METCON's automatic output functions include a time stamp. You must set the clock used for time stamping following a power interruption or a hardware reset. If you plan to use the automatic functions, you might want to consider using a battery-backed power supply system for METCON so you aren't resetting the clock after a power hit.

The command to read or set the time is "=sTx", where "s" is the METCON station address (default A), and x is a 0 to 6 digit string of numeric characters.

To read the clock, just enter <CR> following the T. That will cause the clock to tell you what it thinks the correct time is.

Example:

```
=AT<CR>  
-A- SUN/000000/0001/10
```

You asked the METCON unit whose station address is A (the default address for all METCON units) for the time. METCON responded with its address followed by the day-of-the-week / year&month&day / hour&minute / second of its clock.

To set the clock to the current year, month, and day enter "=sTyymmdd<CR>" where "yy" are last two digits of the current year, "mm" are the two digits of the current month and "dd" are the two digits of the current day. The string "yymmdd" must have six characters --use zeroes where necessary.

Example:

```
=AT910831<CR>  
-A- SUN/910831/0001/25
```

You told METCON to set its year to 1991, the month to August (the eighth month) and the date to the 31st.

To set the clock to the current hour and minute enter "=sThhmm<CR>" where "hh" are the two digits of the current hour and "mm" are the two digits of the current minute. METCON uses a 24-hour format for the clock, so 6 P.M. is entered as (12+6=) 18. The string "hhmm" must have four characters -- use zeroes where necessary.

Example:

```
=AT1844<CR>
```

```
-A- SUN/910831/1844/32
```

You told METCON to set the hour to 18 (6 P.M.) and the minute to 44.

To set the clock to the current second enter "=sTss<CR>" where "ss" are the two digits of the current second. The string "ss" must have two characters -- use zeroes where necessary.

Example:

```
=AT50<CR>
```

```
-A- SUN/910831/1844/50
```

You told METCON to set the seconds to 50.

To set the clock to the current day-of-the-week enter "=sTd <CR>" where "d" is a single number for the day-of-the-week:

- 1 = Sunday
- 2 = Monday
- 3 = Tuesday
- 4 = Wednesday
- 5 = Thursday
- 6 = Friday
- 7 = Saturday

Example:

```
=AT7<CR>
```

```
-A- SAT/910831/1844/50
```

You told METCON to set the day of the week to Saturday.

Upload/Download

Most of the commands for METCON are designed for a human user. However, a good use for METCON might be feeding information to a PC with a graphics display to present a "picture" of METCON's inputs on the display. You could then get a clear picture of what METCON is sensing and controlling. Unfortunately, commands designed for humans are probably not the best choice for a computer to use when communicating with METCON. That's where the "fast upload" and "fast download" come into play.

Fast Download

The Fast Download (FD) command is used to send information to METCON. To do a download, the host computer would send to METCON the command "=sFD<CR>" where "s" is the METCON station address (default A). METCON would then wait for data from the host computer.

The format of the expected data is straightforward.

Bytes are sent to METCON starting at user open memory address 0 and working upward (a computer can't download to restricted memory; it must use the byte write, bit write, bit set and bit clear commands).

Each byte is represented as four hex characters. The first two characters must be the same and they represent the upper half (nibble) of the byte. The succeeding two characters must be the same and they represent the lower nibble.

There is no checksum for a Fast Download command. The checking is done by the double transmission of each nibble. The double nibble technique is needed to ensure that only correct data is loaded into the user memory. To end the download, just send a <CR> (or any other non-hex character). METCON will respond with an address marker and the number of bytes stored.

Example:

=AFD<CR>

110055AA22CC33FF<CR>

-A- LOADED-04

In this case, you told METCON to write its first four memory locations with the sequence 10 5A 2C 3F. Note that METCON doesn't distinguish between upper and lower case letters.

The use of four hex characters per byte is simple but inefficient. In a system with sufficient RAM, the conventional way to download code would be to send bytes as two (instead of four) hex characters and then, at the end of a 32 or 64 byte record, send a checksum. If the data are wrong, the receiving unit will simply throw away that block and flag the error. If the data are correct, it will move them into the memory locations specified.

METCON lacks space to buffer up a whole record of data and then move them to their final location once the check is done. Two ways to ensure the data are correct are to use very short blocks or to check each byte as it is entered. METCON uses the latter method.

The double-nibble-checking scheme's inefficiency is negligible because you should never download more than eight bytes. The first four bytes downloaded are open user memory status information and the following four bytes are output data. There is no sense in writing beyond that point because METCON will overwrite that data the next time it gets inputs from a port, a frequency or pulse counter or an analog-to-digital converter.

Fast Upload

The Fast Upload (FU) command is used to get information from METCON.

To do an upload, the host computer sends to METCON the command "=sFUUn<CR>" where "s" is the METCON station address (default A) and "n" is the block of data to be sent.

METCON responds with a string of bytes represented as pairs of hexadecimal characters. The bytes are sent from lowest memory first and work their way upward through the memory map. When bytes are transmitted, the first character represents the high nibble (upper half-byte) and the following character represents the low nibble. The last byte

of the string is a checksum that is the eight-bit sum of all previous bytes plus the number of bytes sent.

Additionally, to help the host find the beginning and end of the data, the hex characters are enclosed in parentheses (like this).

Finally, the FU command divides the memory map into five (5) blocks, numbered 0 through 4.

The blocks of memory are partitioned as follows:

Block 0:Address 00H through 27H inclusive for a total of 48 bytes plus checksum. This represents all of the user open memory.

Block 1:Addresses 00H through 07H inclusive for a total of 8 bytes plus checksum. This represents the user open memory status bytes plus the output bytes.

Block 2:Addresses 08H through 0FH inclusive for a total of 8 bytes plus checksum. This represents the input port image and input change flag bytes. The input port 0 image is sent first and input change flags for port 6 are sent last.

Block 3:Addresses 10H through 1FH inclusive for a total of 16 bytes plus checksum. This represents the frequency counter inputs (or pulse counter inputs). Channel 0 data are sent first and channel 7 data are sent last.

Block 4:Addresses 20H through 27H inclusive for a total of 8 bytes plus checksum. This represents the analog-to- digital converter inputs. Channel 0 data are sent first and channel 7 data are sent last.

Example:

```
=AFU4<CR>  
-A- (BB783D0000003DBB70)
```

In this case, the host requested the data from METCON memory block four, and METCON responded with the eight (8) byte sequence BB 78 3D 00 00 00 3D BB and the checksum value 70.

Bit Commands

To display (read) a bit, enter the command "=sRbaab" where "s" is the station address (default A), "aa" is the user memory address, and "b" is the bit position.

Both "aa" and "b" are hexadecimal (base 16) numbers, while "s" can be any printable character but should be limited to "A" through "Z". Hex numbers can take a value of 0-9,A,B,C,D,E or F. METCON defaults to "A" for the "s" value.

The format of METCON's response to a bit command is:

```
-s- bbb-v
```

where -s- is the METCON station address, bbb is the bit address (Badr) and -v is the value of the bit (0 or 1).

Example:

```
=ARB091<CR>  
-A- 091-0
```

In this case, a request to display the state of memory location 9 bit 1 was made to METCON. The response indicates that this bit is clear (0).

Similar commands are used to set and clear any other bit in memory.

To write a bit, enter the command "=sWbaabc" where "s" is the METCON station address (default A), "aa" is the user memory address, "b" is the bit position and "c" is the data value (0 or 1).

Example:

```
=AWB0511<CR>  
-A- 051-1
```

In this case, a request to write a 1 to memory location 5 bit 1 was made to METCON. The response indicates that this bit is now set (1).

Special Addresses

Certain addresses are of special interest.

The memory at address 5 is used to store the bits that will be output to the relays. Set the bit at address 5, bit 1, and relay K2 will pull in. Clear the bit at address 5, bit 0, and relay K1 will release.

The memory at address 9 is used to read the bits from the J1 input connector. Read the bit at address 9, bit 0 and you will be told if there is a closed circuit (0) at the J1-1/J1-2 inputs (labelled "INO" and "GND" on the METCON-1 PC Board) or an open circuit (1). Read the bit at address 9, bit 4 and you will be told if there is a closed circuit (0) at the J1-7/J1-8 inputs (labelled "IN4" and "GND" on the METCON-1 PC board) input or an open circuit (1).

Byte Commands

To display (read) a byte, enter the command "=sRYaa" where "s" is the station address (default A) and "aa" is the user memory address.

"aa" is a hexadecimal (base 16) number, while "s" can be any printable character but should be limited to "A" through "Z". Hex numbers can take a value of 0-9,A,B,C,D,E or F. METCON defaults to "A" for the "s" value.

The format of METCON's response to a byte command is:

```
-s- aa-ddd hh bbbb bbbb
```

where -s- is the METCON station address, aa is the byte address (Yadr), -ddd- is the decimal (base 10) value of the data, hh is the hexadecimal (base 16) value of the data and bbbb bbbb is the binary value of the data (the bit order displayed is 7-6-5-4 3-2-1-0).

Example:

```
=ARY09<CR>  
-A- 09-006 06 0000 0110
```

In this case, a request to display the state of memory location 9 was made to METCON. This is the location of METCON-1's inputs, and the response indicates that inputs 1 and 2 are open, while inputs 0 and 3-7 are closed.

To write a byte, enter the command "=sWYaadd" where "s" is the METCON station address (default A), "aa" is the user memory address, and "dd" is the hexadecimal data value.

Example:

```
=AWY0501<CR>  
-A- 05-001 01 0000 0001
```

In this case, byte 5 was written with a value of 01. The effect of this would be to activate relay 0 and deactivate relays 1-7 on a METCON-1 board.

Word Commands

METCON offers the capability to read memory as 16-bit values, called words. A word is simply two adjacent bytes. Word reads are particularly useful for pulse counter and frequency displays which are the only METCON values that are larger than a byte.

To display (read) a word, enter the command "=sRWaa" where "s" is the station address (default A) and "aa" is the user memory address.

"aa" is a hexadecimal (base 16) number, while "s" can be any printable character but should be limited to "A" through "Z". Hex numbers can take a value of 0-9,A,B,C,D,E or F. METCON defaults to "A" for the "s" value.

The format of METCON's response to a word display command is:

```
-s- aa-ddddd hhhh bbbbbb bbbb bbbb bbbb
```

where -s- is the METCON station address, aa is the lower byte of the word address (Yadr), -dddd- is the decimal (base 10) value of the data, hhhh is the hexadecimal (base 16) value of the data and bbbb bbbb bbbb is the binary value of the data (the bit order displayed is 15-14-13-12 11-10-9-8 7-6-5-4 3-2-1-0)

Example:

```
=ARW13<CR>  
-A- 13-01063 0427 0000 0100 0010 0111
```

In this case, a request to display the state of memory locations 13 and 14 was made to METCON. This is the location of METCON-1's INO frequency counter, and the response indicates that a frequency of 1063 Hz was measured. With a VTOF board, this might indicate a reading of 10.63 volts.

System Bit Controls

If you are familiar with TNCs, you are probably accustomed to issuing specific commands to change the unit's behavior. METCON has some commands that operate similarly. The clock is a good example of this.

However, due to program memory limitations, you must control METCON's behavior by directly altering data memory locations. The bit and byte commands may be used to accomplish these changes.

There are several bits in user restricted memory and in the lower portion of user open memory that have special purposes. Many of these bits can be thought of as flags: set a bit high and METCON behaves a particular way, set a bit low and METCON behaves a different way.

Restricted User Memory

Restricted user memory exists because these values, if altered while the unit is at a remote site, might be difficult to reset. As a result, the SYS jumper must physically be in place on the METCON PC board when altering these values.

Below is a list and description of the user restricted memory bits.

Serial Port Speed

SPS0 (Badr: F90)

default: 1

SPS1 (Badr: F91)

default: 0

These bits are used to determine the baud rate of METCON's serial port according to the following:

<u>Port Speed</u>	<u>SPS0</u>	<u>SPS1</u>	
300 bps	0	0	
1200 bps	1	0	(default)
2400 bps	0	1	
9600 bps	1	1	

Because these are bit controls, and because byte address F9 contains controls other functions (see below), the bit commands will normally be used alter the baud rate.

Example:

Assume you wish to change the METCON serial port speed to 2400 bps. After logging in, and with the SYS contacts on the METCON-1 PC board shorted, you would enter:

```
=AWBF900<CR>
```

```
-A- F90-0
```

```
=AWBF911<CR>
```

```
-A- F91-1
```

NOTE: These commands take immediate effect, so if you do the example, you will have to reset your computer to 300 bps after executing the first command in order to enter the second one. Alternatively, you may use the byte write command and load all bits of memory at one time.

Default is set for 1200 bps.

Automatic Output when Not Logged In

AONLI (Badr:F92)

default: 0

This bit determines if METCON will send automatic display and change messages when you are not logged in. When AONLI=0 (default), automatic messages will not be sent to the serial port.

When AONLI=1, automatic messages will be sent to the serial port whether or not you are logged in.

This can be useful if a system is desired where users do not login. They cannot change values but they can still get the automatic display messages. An example might be a weather monitoring station where a number of people might want to access the weather information (say, for tornado warnings) but only a small number of stations need be empowered to modify the settings of the METCON unit.

Example:

To enable AONLI, enter

```
=AWBF921<CR>  
-A- F92-1
```

To disable AONLI, enter

```
=AWBF920<CR>  
-A- F92-0
```

NOTE: METCON checks the state of its DCD pin before sending each and every character out its serial port. If DCD is not asserted (either by an RS232 signal or by placing a short across the DCD jumper on the PC board) then automatic messages will not be sent.

Default is off.

Automatic DISCONnection

ADISCON (Badr:F93)

default:0

This bit determines if METCON will automatically disconnect you from packet or dial-up modem connections if you fail to successfully login after four (4) tries within sixty (60) seconds of connecting to METCON.

METCON uses the DCD input pin of its RS232 connector to determine if a connection has been established.

The disconnect routine generates an error message, pauses ten (10) seconds, sends three (3) control-C characters (packet radio attention signal), pauses two (2) seconds, sends an ASCII "D" character (packet radio disconnect command) followed by <CR> and <LF>, pauses for five (5) seconds, then places a five-second "break" on the RS232 port (dial-up modem disconnect signal), then pauses for five (5) seconds.

After the disconnect routine has finished, you may attempt to connect with METCON again.

To enable ADISCON, enter

```
=AWBF931<CR>  
-A- F93-1
```

The default is off.

No ECHO

NECHO (Badr:F94)

default: 0

This bit controls the suppression of character echoing from the serial port. When the NECHO bit is 0, echoing of characters will take place. When the NECHO bit is 1, echoing will be suppressed.

For packet radio operation you will probably want NECHO set to 1.

Example:

To suppress METCON's echo function, enter

```
=AWBF941<CR>  
-A- F94-1
```

Default value is 0 (echoes).

No Line Feed

NLF (Badr:F95)

default: 0

This bit controls the suppression of line feed characters from the serial port. When the NLF bit is 1, line feed characters will not be generated by METCON. When the NLF bit is 0, line feed characters will be generated by METCON following every carriage return (<CR>) character.

For packet radio operation you will probably want NLF set to 1.

Example:

To append the ASCII <LF> character to METCON's <CR> output, enter

```
=AWBF951<CR>  
-A- F95-1
```

Default value is 0 (off).

No Invert Input

NII (Badr:F96)

default: 0

When the NII bit is 1, METCON will not invert data moved from the I/O ports to memory. When the NII bit is 0, METCON will invert data moved from the I/O ports to memory.

Inversion is used because there are physical inverters between the input lines at J1 and the 87C51 chip on the METCON-1 board.

Example:

To suppress inverting of the output bits from the 87C51, enter

```
=AWBF961<CR>  
-A- F96-1
```

Default value is 0 (data is inverted).

No Invert Output

NIO (Badr:F97)

default: 0

When the NIO bit is 1, METCON will not invert data moved from memory to the I/O ports. When the NIO bit is 0, METCON will invert data moved from memory to the I/O ports.

Inversion is used because the relays effectively invert the output line between the 87C51 chip and connector J3 on the METCON-1 board.

Example:

To suppress inverting of the output bits from the 87C51, enter

```
=AWBF971<CR>
```

```
-A- F97-1
```

Default value is 0 (data is inverted).

Automatic CHAnGe MaSK

ACHGMSK (Yadr:FB)

default: 00H

When an ACHGMSK bit is 1 and the corresponding binary input (not VTF or ADC) changes state, METCON will transmit a time-stamp and the current (new) value of that input signal. Clearing the ACHGMSK bit to 0 will disable this function. The ACHGMSK bits correspond to the inputs on J1 -- bit 0 for IN0, bit 1 for IN1, and so on.

Example:

Command ACHGMSK for IN2 on by entering

```
=AWYFB04<CR>
```

```
-A- FB-004 04 0000 0100
```

Later, a change takes place and DCD is asserted, so METCON sends

```
-A- WED/920902/1907/08 INPUT STATUS CHANGE: 094-1
```

which indicates that the IN2 input went from a low to a high.

NOTE: Inputs used for frequency or pulse counting should have their ACHGMSK bits cleared to 0 to prevent this flag from being triggered by these repetitive signals.

Default value is 0 (off).

PaSsWoRd

<u>PSWDO</u> (Yadr: FC)	default: 12H
<u>PSWD1</u> (Yadr: FD)	default: 34H
<u>PSWD2</u> (Yadr: FE)	default: 56H

METCON contains three (3) levels of access security: no security, password security and authentication security. METCON defaults to password security with a value of 123456 .

The first level is no security. This means that anyone can connect to METCON and alter any user open memory locations. If the SYS connector is jumpered, then anyone can also alter any user restricted memory location. This level is typically used for a dedicated-wire connection to METCON.

The second level is password security. This means you must "login" to METCON before you can read from or write to any memory location in METCON, or perform any other METCON command. This level is typically used when METCON is attached to a dial-up modem.

The third level is authentication security. You must login to METCON before you can do anything with it, but the login procedure is more complex than with simple password security. This level is typically used when access to METCON is via an open radio channel where "bad guys" might be lurking.

METCON uses the value of PSWDO to determine the security level.

PSWDO is the first byte you must enter to login to METCON when using password security. This byte can be considered a 2 character hexadecimal value or a 2 digit packed-BCD value. There are two (2) special cases for this byte.

If PSWDO is programmed to 00 then user login is not needed. The user is considered to always be logged in when the RS232 DCD input is active and logged out when it is not.

If PSWDO is programmed to FF, then authentication is used. This is useful on radio channels where "bad guy" attacks might be expected.

Default value is 12H.

PSWD1 is the second byte you must enter to login to METCON when using password security. If authentication is being used (PSWDO= FF), then PSWD1 is the first byte of a two-byte seed (see below).

Default value is 34H.

PSWD2 is the third byte you must enter to login to METCON when using password security. This byte can be considered a 2 character hexadecimal value or a 2 digit packed-BCD value. If authentication is being used (PSWDO=FF), then PSWD2 is the second byte of a two-byte seed (described below).

Default value is 56H.

Since these are byte values, the METCON byte commands are used to alter the values in PSWD.

NO SECURITY

No security is typically used when you have METCON next to your computer and connected to it with a cable. This is primarily for testing and experimenting, not for actual use at a remote site.

PASSWORD SECURITY

Password security is used when the communications link is private (e.g., using a dial-up modem). METCON uses the all three bytes of PSWD for the password. Of course, the first two characters (PSWDO) can't be FF or 00. That's the only restriction on passwords other than they must consist of hex characters. When you want to log in, you must provide the six-character password as part of the login command.

Example:

In this example, we will first reconfigure METCON to use a password of 654321 in place of the default 123456 sequence.

Since this requires access to restricted memory, be sure the SYS jumper is shorted on the METCON-1 PC board. The following assumes you have already logged in to METCON using whatever security was in effect.

```
=AED<CR>
-A- COMMAND OK
=AWYFC65<CR>
-A- FC-101 65 0110 0101
=AWYFD43<CR>
-A- FD-067 43 0100 0011
=AWYFE21<CR>
-A- FE-033 21 0010 0001
=AEW<CR>
-A- EEPROM WRITE/READ OK
```

The first command set the EEPROM to METCON default values. The second through fourth commands performed a byte write to METCON's restricted memory area. The fifth command wrote the restricted memory values into EEPROM. The METCON responses were confirmation of the command taking effect.

Now, remove the shorting plug at SYS to tell METCON that you are no longer System Administrator. Whenever SYS is shorted, METCON automatically logs you in so you need to log out.

```
=ALO<CR>
-A- LOGGED OUT
```

Assume a new user has connected to METCON. He logs in with the wrong password, then corrects the error and logs out when done.

```
=AL123456<CR>
-A- !!! ERROR, USER MUST LOGIN !!!
-A- CHAL: A1 B8 8F
=AL654321<CR>
-A- LOGGED IN
```

(User proceeds to interact with METCON, then finishes.)

```
=ALO
-A- LOGGED OUT
```

NOTE: When using password security, the "CHAL:" line should be ignored. It has no meaning for password security.

AUTHENTICATION SECURITY

Authentication is used when the communications link is not private (and perhaps shared) such as Amateur Radio packet data channel. METCON uses the last two bytes of PSWD as a seed to create an authentication table (NOTE: don't use 0000). The seed value will work best when it is more than 0277 hexadecimal and less than 0D74 hexadecimal.

After you store a new value in PSWD, you next enter a command to tell METCON to output an authentication table. Give a copy of this table to all authorized users (but not by sending it over the air!).

When you want to log in, you must ask METCON for a challenge (or enter a dummy login command and get the challenge from the error message). METCON will include data in the challenge response for you to use as an index into the authentication table. You then respond to the challenge with the appropriate data from the authentication table as part of the next login command.

The example below should clarify these procedures.

Example:

In this example, we will first reconfigure METCON to use authentication security and a seed value of 0298 in place of the default 123456 password sequence.

Since this requires access to restricted memory, be sure the SYS jumper is shorted on the METCON-1 PC board.

```
=AED<CR>
-A- COMMAND OK
=AWYFCFF<CR>
-A- FC-255 FF 1111 1111
=AWYFD02<CR>
-A- FD-002 02 0000 0010
=AWYFE98<CR>
-A- FE-152 98 1001 1000
=AEW<CR>
-A- EEPROM WRITE/READ OK
```

The first command set METCON defaults. The next three commands performed a byte write to METCON's restricted memory area. The METCON responses were confirmation of the command taking effect. The last command stored the changes to EEPROM.

Next, ask METCON to print out the authentication table. You should set your computer up to capture this information so you can print it out on paper for later use. Be sure to keep this table private so others can't easily bypass your METCON access security.

```
=ALA<CR>
```

METCON responds with:

SEED: FF0298

00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F

00: A0 22 60 43 3E 47 A2 84 3E 43 5E FE 38 8E 5E 5C
10: AC 39 A8 2E 8E 2E 3F DA 39 B8 2E 38 08 E9 11 AC
20: 22 A0 87 9C A0 4C 9C 3A 37 9C 2D 22 4C 7B 2B A0
30: 12 5C 74 26 22 60 43 F0 60 92 3C 24 F0 12 D0 9C
40: 3C 47 A7 27 D0 60 95 92 60 43 F0 12 92 3C 24 22
50: 22 D0 9C 92 20 5E EE 40 9C 40 3E 3E 3B 22 A0 9C
60: 42 9C 33 16 9C 32 16 A0 5E 16 A0 40 16 A0 3E 9C
70: F0 12 D6 9C 24 22 60 43 90 43 17 A7 A7 D0 34 40
80: 9C 41 19 60 69 09 70 08 3E 3D 75 27 22 D0 53 4E
90: 4B 3E 3D 75 41 22 D0 4E 16 A0 33 9C A0 3B 9C 38
A0: 2D 34 92 43 43 F0 12 D0 43 24 22 60 D0 5B 2D 92
B0: 3E 3D 75 22 22 D0 4C 26 17 19 8C 41 B2 F0 09 BC
C0: 34 2E 38 CD 69 89 3D 22 2E 41 0C 84 38 8E 90 59
D0: 2E 3D B7 2E 3D E3 D6 A7 F0 12 5E AC 24 22 60 43
E0: 5E 16 8C 43 CD 2E 38 09 0C 22 2E 38 90 59 2E 41
F0: 38 CD E9 0B 3E 22 34 2E 2E 41 0C 89 E9 0B 90 59

Now, remove the shorting plug at SYS to tell METCON that you are no longer System Administrator. Whenever SYS is shorted, METCON automatically logs you in, so you need to log out.

=ALO<CR>

-A- LOGGED OUT

Assume a new user now connects to METCON. He logs in with the wrong password, then corrects the error and logs out when done.

=ALC<CR>

-A- CHAL: DC A3 2A

The user issues the command to elicit a challenge, then looks up the proper response from the table. The first challenge is DC, so the user looks up row D0 and column 0C. The table indicates 24 as the correct value. Similarly, the user finds the answer for A3 and 2A, but mistypes the 2A response (he types "2C" rather than "2D").

=ALI24432C<CR>

-A- !!! ERROR, USER MUST LOGIN !!!

-A- CHAL: A1 B8 8F

METCON now issues a new challenge sequence which the user correctly looks up and enters.

=ALI34174E<CR>

-A- LOGGED IN

(User proceeds to interact with METCON, then logs out when done.)

=ALO<CR>

-A- LOGGED OUT

LOGIN/LOGOUT STATUS

Although there isn't a command to tell you if you are logged in or not, there's a simple test that will give you that answer. If you give a command that looks at a user open address (we'll use address 0 in the example)

```
=ARY00<CR>
```

the response from METCON will tell you if you are logged in or not. If you get data from this command, similar to

```
-A- 00-000 00 0000 0000
```

then you are logged in. If you get an error message, similar to

```
-A- !!! ERROR, USER MUST LOGIN !!!  
-A- CHAL: 18 EF 26
```

then you are logged out.

The same thing can be done to see if you are System Administrator. Give a command that looks at a user restricted address (we'll use byte FF in this example)

```
=ARYFF<CR>
```

the response will tell you if you are System Administrator or not. If you get data from this command, similar to

```
-A- FF-065 41 0100 0001
```

then you are System Administrator. If you get an error message

```
-A- ??? ONLY FOR SYSTEM ADMINISTRATOR ???  
-A- ??? ADDRESS ERROR ???
```

then you are not System Administrator.

NOTE: Whenever the SYS jumper is in place, METCON automatically logs you in regardless of the level of security that is in effect! Never leave the SYS jumper in place when you have METCON installed in anything other than a test environment!

STatioN ADDress

STNADR (Yadr:FF)

default: "A"

This byte is used to program the station address used to access this particular METCON module. This address is in restricted user memory. It can only be read from or written to when the SYSTEM ADMINISTRATOR plug is shorted. The address value should correspond to an ASCII A-Z (41 to 5A hexadecimal) or 0-9 (30 through 39 hexadecimal).

Example:

You wish to change the station address of your METCON unit to Z. After verifying that the SYS jumper is shorted, enter

```
=AWYFF5A<CR>  
-Z- FF-090 5A 0101 1010
```

5A is the hex value for ASCII "Z". Note that in the response, METCON specifies its address as Z, showing the command took immediate effect.

Default value is 41 hexadecimal (ASCII "A").

OPEN USER MEMORY

Below is a list and description of the open user memory. This can be altered by anyone who is logged in to METCON. Because of this, access security (no, password or authentication) will be enforced whenever the SYS jumper is not in place.

While they may be annoying, it should be possible to recover from any incorrect patterns in open memory by remote access.

Automatic Display 1 minute

AD1 (Badr:000)

default: 0

This bit causes automatic display of the memory map once every minute. When the AD1 bit is 1, METCON will send a memory map display every minute to the serial port if DCD is asserted. Clearing the AD1 bit to 0 will disable this function. Sending memory maps every minute on a packet radio channel is not advised. Enable this function only for wire-line systems or for diagnostics.

Example:

To set AD1 to send a memory map once per minute, enter

```
=AWB0001<CR>  
-A- 000-1
```

Default value is 0 (off).

Automatic Display 15 minutes

AD15 (Badr:001)

default: 0

This bit causes automatic display of the memory map once every 15 minutes. When the AD15 bit is 1, METCON will transmit a memory map display every 15 minutes to the serial port if DCD is asserted. Clearing the AD15 bit to 0 will disable this function.

If you want automatic display of memory on a packet channel, this is the bit to set. One transmission every 15 minutes shouldn't be disruptive even on a heavily used channel.

Example:

To set AD15 to send a memory map every 15 minutes, enter

```
=AWB0011<CR>  
-A- 001-1
```

Several minutes later, METCON checks and finds DCD asserted and transmits a memory map:

-A- WED/910904/1845/00 AUTO TIMEOUT FOR MEMORY DISPLAY

```
  P6    P5    P4    P2    P0
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 OUT (08 07 06 05 04)
0000 0000 0000 0000 0000 0000 0000 0000 0011 1111 IN  (0D 0C 0B 0A 09)
0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 CHG (12 11 10 0F 0E)
```

```
  7  6  5  4  3  2  1  0
00000 00000 00000 00000 00000 00000 00000 00000 F/P CTRS (21/22-
13/14)
```

```
  7  6  5  4  3  2  1  0
255 255 255 255 255 255 255 255 ADC (2A-23)
```

-A- MEMORY DISPLAY COMPLETE

The memory map displayed lists the possible ports (0, 2, 4, 5 and 6 -- only 0 and 2 are present on METCON-1), their output states if the ports are configured for output, their input levels if the ports are configured as inputs and whether they have changed state since the last time the "change state" bits were reset. These values are all in binary.

The next lines in the display indicate the values of the frequency counters and pulse counters in decimal.

The final status lines indicate the values read by the optional ADC board on its eight analog channels, in decimal.

The default value of AD15 is 0 (off).

Fast Sample Rate

FSR (Badr:002) default: 0

When the FSR bit is 1, METCON samples the binary inputs at a rate of 10 times a second. When the FSR bit is 0, METCON will sample the binary inputs at a rate of once a second.

Example:

To set FSR, enter

```
=AWBOO21<CR>
-A- 002-1
```

Default value is 0 (off).

PULse CounTeR 0

PULCTRO (Badr:020) default: 0

When PULCTRO is 0, INPUT-0 will be a frequency counter input. When PULCTRO is 1, INPUT-0 will be an accumulating pulse counter input.

Example:

To set IN0 as a pulse counter, enter

=AWBO201<CR>
-A- 020-1

Default value 0 (frequency counter input).

PULse CounTeR 1

PULCTR1 (Badr:021) default: 0

When PULCTR1 is 0, INPUT-1 will be a frequency counter input. When PULCTR1 is 1, INPUT-1 will be an accumulating pulse counter input.

Example:

To set IN1 as a pulse counter, enter

=AWBO211<CR>
-A- 021-1

Default value 0 (frequency counter input).

PULse CounTeR 2

PULCTR2 (Badr:022) default: 0

When PULCTR2 is 0, INPUT-2 will be a frequency counter input. When PULCTR2 is 1, INPUT-2 will be an accumulating pulse counter input.

Example:

To set IN2 as a pulse counter, enter

=AWBO221<CR>
-A- 022-1

Default value 0 (frequency counter input).

PULse CounTeR 3

PULCTR3 (Badr:023) default: 0

When PULCTR3 is 0, INPUT-3 will be a frequency counter input. When PULCTR3 is 1, INPUT-3 will be an accumulating pulse counter input.

Example:

To set IN3 as a pulse counter, enter

=AWBO231<CR>
-A- 023-1

Default value 0 (frequency counter input).

PULse CounTeR 4

PULCTR4 (Badr:024)

default: 0

When PULCTR4 is 0, INPUT-4 will be a frequency counter input. When PULCTR4 is 1, INPUT-4 will be an accumulating pulse counter input.

Example:

To set IN4 as a pulse counter, enter

=AWB0241<CR>

-A- 024-1

Default value 0 (frequency counter input).

PULse CounTeR 5

PULCTR5 (Badr:025)

default: 0

When PULCTR5 is 0, INPUT-5 will be a frequency counter input. When PULCTR5 is 1, INPUT-5 will be an accumulating pulse counter input.

Example:

To set IN5 as a pulse counter, enter

=AWB0251<CR>

-A- 025-1

Default value 0 (frequency counter input).

PULse CounTeR 6

PULCTR6 (Badr:026)

default: 0

When PULCTR6 is 0, INPUT-6 will be a frequency counter input. When PULCTR6 is 1, INPUT-6 will be an accumulating pulse counter input.

Example:

To set IN6 as a pulse counter, enter

=AWB0261<CR>

-A- 026-1

Default value 0 (frequency counter input).

PULse CounTeR 7

PULCTR7 (Badr:027)

default: 0

When PULCTR7 is 0, INPUT-7 will be a frequency counter input. When PULCTR7 is 1, INPUT-7 will be an accumulating pulse counter input.

Example:

To set IN7 as a pulse counter, enter

=AWB0271<CR>

-A- 027-1

Default value 0 (frequency counter input).

ADC channels 0 & 1 Balanced

ADC01B (Badr:030) default: 0

When the ADC01B bit is 1, METCON will consider ADC inputs 0 and 1 as a balanced pair. When the ADC01B bit is 0, METCON will consider ADC inputs 0 and 1 as separate positive single ended inputs measured relative to the COMMON input.

The value of ADC01R has no effect when ADC01B is 0.

Default value is 0.

ADC channels 0 & 1 Reversed

ADC01R (Badr:031) default: 0

When the ADC01R bit is 1 (and ADC01B is set to 1), METCON will consider ADC input 0 as the negative input and input 1 as the positive input of a balanced pair. When the ADC01R bit is 1 (and ADC01B is set to 1), METCON will consider ADC input 0 as the positive input and input 1 as the negative input of a balanced pair.

When ADC01B is set to 1, channels 0 and 1 are single ended at ADC01R has no effect.

Default value is 0.

ADC channels 2 & 3 Balanced

ADC23B (Badr:032) default: 0

When the ADC23B bit is 1, METCON will consider ADC inputs 0 and 1 as a balanced pair. When the ADC23B bit is 0, METCON will consider ADC inputs 0 and 1 as separate positive single ended inputs measured relative to the COMMON input.

The value of ADC23R has no effect when ADC23B is 0.

Default value is 0.

ADC channels 2 & 3 Reversed

ADC23R (Badr:033) default: 0

When the ADC23R bit is 1 (and ADC23B is set to 1), METCON will consider ADC input 0 as the negative input and input 1 as the positive input of a balanced pair. When the ADC23R bit is 1 (and ADC23B is set

to 1), METCON will consider ADC input 0 as the positive input and input 1 as the negative input of a balanced pair.

When ADC23B is set to 1, channels 0 and 1 are single ended at ADC23R has no effect.

Default value is 0.

ADC channels 4 & 5 Balanced

ADC45B (Badr:034) default: 0

When the ADC45B bit is 1, METCON will consider ADC inputs 0 and 1 as a balanced pair. When the ADC45B bit is 0, METCON will consider ADC inputs 0 and 1 as separate positive single ended inputs measured relative to the COMMON input.

The value of ADC45R has no effect when ADC45B is 0.

Default value is 0.

ADC channels 4 & 5 Reversed

ADC45R (Badr:035) default: 0

When the ADC45R bit is 1 (and ADC45B is set to 1), METCON will consider ADC input 0 as the negative input and input 1 as the positive input of a balanced pair. When the ADC45R bit is 1 (and ADC45B is set to 1), METCON will consider ADC input 0 as the positive input and input 1 as the negative input of a balanced pair.

When ADC45B is set to 1, channels 0 and 1 are single ended at ADC45R has no effect.

Default value is 0.

ADC channels 6 & 7 Balanced

ADC67B (Badr:036) default: 0

When the ADC67B bit is 1, METCON will consider ADC inputs 0 and 1 as a balanced pair. When the ADC67B bit is 0, METCON will consider ADC inputs 0 and 1 as separate positive single ended inputs measured relative to the COMMON input.

The value of ADC67R has no effect when ADC67B is 0.

Default value is 0.

ADC channels 6 & 7 Reversed

ADC67R (Badr:037)

default: 0

When the ADC67R bit is 1 (and ADC67B is set to 1), METCON will consider ADC input 0 as the negative input and input 1 as the positive input of a balanced pair. When the ADC67R bit is 1 (and ADC67B is set to 1), METCON will consider ADC input 0 as the positive input and input 1 as the negative input of a balanced pair.

When ADC67B is set to 1, channels 0 and 1 are single ended at ADC67R has no effect.

Default value is 0.

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CHAPTER SIX - HARDWARE

Circuit Description

Microcomputer

U5 (87C51) is the microcomputer that runs METCON-1. Y1, C15 and C16 provide the clock frequency of 11.0592 MHz.

R15, R16, C14 and D2 form the reset circuit. This circuit provides power up reset as well as a reset anytime a short is placed across connector JP1 (RST).

JP2 (SYS), when shorted, asserts interrupt 0 (INT0) to signal U5 that you want SYSTEM ADMINISTRATOR privileges. When this plug is open, you are prevented reading from and writing to the restricted area of user memory. The interrupt function of this pin is disabled; it functions as a single-bit input port.

The METCON-1 firmware allows you to configure Port-0 and Port-2 as input or output, on a bit by bit basis. The defaults set Port-0 for inputs and Port-2 for outputs.

METCON-1 hardware is configured to use these defaults. However, if you wish, you can configure METCON-1 to have 16 bits of output, 16 bits of input, or any combinations thereof.

NOTE: Port-0, unlike the other 87C51 ports, doesn't include internal pull-ups. So, if Port-0 is used for output, there must be an external pull-up for Port-0 if the external circuit doesn't source current to the 87C51.

Port-1 and Port-3 are configured for special purposes and you cannot change them. Port-1 is used to control the VTF multiplexer, the EEPROM and an optional outboard A/D converter. Port-3 is used for serial port (RXD, TXD, WR, RD), VTF input (TO), and the system administrator switch (INT0).

Serial Port

U7 (MAX232) provides RS232-compatible drivers and receivers for the serial port. U7 includes an oscillator, voltage doubler and inverter to generate +/- 10 VDC for the RS-232 output drivers. The RS-232 level signals from U2 are connected to P2.

If the attached RS232 serial device does not provide DCD, JP3 (DCD) may be shorted to provide this required signal. METCON uses DCD to determine connection status, so this jumper should only be used for testing, not operation.

Sensor Inputs

Sensor input signals are applied to METCON-1 via J1.

Each line is pulled up to +5 volts by 2.2K ohm resistors within SIP1 or SIP2, 6-pin SIP packages.

Each signal passes through a 100K resistor (R1 through R8) before being applied to the input of U2 (74HC14) or U3 (74HC14). The purpose of the 100K resistors is to protect the 74HC14 from damage during overvoltage input conditions. Capacitors (C1 through C8) from the inputs of U2 and U3 to ground are provided to improve immunity to Radio Frequency Interference (RFI). These capacitors are omitted from channels that will act as frequency counters and should only be installed if there is confirmed RFI from these points and they are not being used as counter inputs.

The output signals from U2 and U3 pass through 4.7K resistors (R9 through R14, R19 and R20) before going to Port-0 of U5. The purpose of the 4.7K resistors is to protect U5 in case you inadvertently configure U5 to have Port-0 as outputs. The 4.7K resistors limit the current flow into U5 to less than 1.5 mA during this condition.

The sensor inputs connected to J1 should not source current of their own. METCON-1 should be the only source of current flow through the sensor signal.

The inputs on J1 can either be dry switch contacts or the outputs of opto-isolators.

Frequency Counter

METCON-1 includes a frequency counter to measure the frequency from voltage-to-frequency converters. The same input buffers that provide signals to Port-0 of U1 are also sampled in round-robin fashion to measure frequency.

U1 (74HC151) is a multiplexer used to select the current input to be measured for VTF applications.

Interrupt firmware within U5 causes it to select a new sensor input every second and measure the number of transitions on that input for almost exactly one second (about 10 uSec of the one second is used for changing the multiplexer address). The number of transitions during that one-second period is the frequency. The measured value is then written to memory to be read and the next multiplexer address is selected.

Pulse Counter

An alternative function for the inputs of Port-0 is to act as pulse counters. In this mode, individual pulses are accumulated in a 16-bit counter and stored in memory to be read when you desire. Unlike the frequency counter mode, the pulse counters continue to build a count rather than resetting every eight seconds.

Pulses must have a minimum width of 20 mSec to be reliably counted.

Relay Outputs

Port-2 is connected to U8 (2595A) which drives the output relays (K1-K8) directly. Diodes D3-D10 (1N4148) across the relay coils are used as "snubbers" to ensure that the voltage kick generated by de-energizing a relay doesn't damage U8 or generate other signals on the power bus.

The relay contacts are available at connector J3.

Power

Input power of +8 to +15 volts is applied to J2.

C13 is used for RFI filtering. D1 (1N4002) protects from reversed power without forcing an external fuse to blow every time reverse power is applied. C17 provides bulk filter capacity to help smooth out any ripple or perturbations of the power source.

U6 (LM340-5 or LM7805) provides a regulated +5 volt power source for the ICs in METCON-1. C9-C12, C18-C20 and C25-C29 provide filtering and decoupling of the +5 volt power bus.

Non-Volatile Memory

U4 (9306 or 9346) is a 256-bit EEPROM in an 8-pin package and is used for non-volatile memory. U4 can be used to save the current system options and relay output settings. Following a reset or power-on, if the EEPROM is present and the data is correct (protected by checksum) the EEPROM data will be used to initialize the METCON-1 module.

Analog-to-Digital Converter Interface

An eight channel ADC0838 Analog-to-Digital Converter (ADC) can be connected to METCON-1 via P1. Each of the eight channels are sampled in round-robin fashion and the eight-bit value is stored in memory for you to read.

Unlike the VTF inputs that are interrupt driven on a very accurate schedule, the A/D inputs are part of a "polled loop". Typically, one channel is sampled every 100 mSec. That means that it takes 800 mSec for all eight channels to be sampled (or about once a second). The firmware assumes that the ADC is always present and will try to access it, even if it isn't in the circuit.

If the ADC module is not connected to P1, the values at the A/D memory addresses are undefined, but no damage will occur to METCON.

Counter Calibration Source

The T1 timer function in U5 is programmed to generate a 20 Hz square wave whenever METCON is running. This output is buffered by an inverter section in U3 (74HC14) and is presented at test point TP1. This signal may be used for checking the operation of the frequency counter and pulse counter inputs.

Notes

If a binary digital input is used as a frequency counter input then the RFI bypass capacitor must be removed from the circuit. Otherwise, signals above several hundred Hertz will be inaccurately counted.

APPENDIX A - COMMAND SUMMARY

Bit Read and Write Commands

=sRBaabREAD STN s, ADDRESS aa, BIT b
=sWBaabcWRITE STN s, ADDRESS aa, BIT b, DATA BIT c

Byte Read and Write Commands

=sRYaaREAD STN s, ADDRESS aa, BYTE SIZE
=sWYaaddWRITE STN s, ADDRESS aa, DATA BYTE dd

Word Read Command

=sRWaaREAD WORD OF STN s, ADDRESS aa

Miscellaneous Commands

=sMAPSHOW CURRENT MEMORY MAP DISPLAY OF STN s
=sVERSHOW CURRENT VERSION AND SIGNON MESSAGE OF STN s
=sZAPZAP ALL CHANGE INPUTS BACK TO ZERO OF STN s
=sEWITWRITE STATUS AND OUTPUT MEMORY TO EEPROM
=sEREADREAD STATUS AND OUTPUT VALUE FROM EEPROM
=sEDEFSET DEFAULT STATUS AND OUTPUT VALUES
=sLIxxxxxLOGIN USING PASSWORD xxxxxx (XXXXXX IS SIX HEX CHARS)
=sLOLOGOUT
=sLADISPLAY LOGIN TABLE
=sLCISSUE LOGIN CHALLENGE
=sTREAD/SET TIME-STAMP CLOCK

Addresses (aa) and bit positions (b) are always in hex (base 16).

Output is always in base 10 followed by base 16 followed by base 2.

Word reads are always protected from phasing errors (an example of a phasing error is when an interrupt routine updates a RAM memory address at the same time a non-interrupt routine is reading the same address).

Notes

METCON is a contraction of teleMETry and teleCONtrol.

The station address is of importance when several METCON systems are on some sort of a party line (point-multipoint data line). METCON will not respond unless the command it receives matches its own station address. Station address is defaulted to "A" and may be changed by the system administrator. Station addresses should be limited to the characters A-Z and 0-9.

UART stands for Universal Asynchronous Receiver and Transmitter

The information in this document was written by Paul Newland, AD7I, and edited into its present form by Brian Kassel, W5VBO and Lyle Johnson, WA7GXD.