

Mini-Link

PIC Based Analog & Digital I/O Node
for the Circuit Cellar[®] Home
Control System (HCS)

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Mini-Link Overview

The Mini-Link chip for the HCS Home Automation System (or any other serial based automation system) allows users to monitor Analog voltages or control digital inputs or outputs in an extremely small package. The Mini-Link chip has three multi purpose IO ports that can be configured as 8-bit analog inputs or digital input/output ports. An extra digital input is always available, regardless of configuration. Its 8-pin package means you can build a COMPLETE HCS network node with two 8-pin chips, a tiny TO-92 voltage regulator and a couple of tiny capacitors for supply filtering. That is it. A complete HCS node in less than 1 square inch (without terminal blocks of course 😊)

One of the main uses for a Mini-Link node is embedding an HCS node inside an existing piece of equipment (like a thermostat). This allows you to take an off the shelf component and integrate it into your Home Automation system. Taking the thermostat example, you could configure a Mini-Link to have one Analog Input, two digital inputs, and a digital output. This would allow you to monitor the temperature from the existing temp sensor, monitor if the user uses the temp up/down buttons, and the digital output could be used to turn the system on and off in parallel with the thermostat. Thus the user maintains some local control with the existing thermostat but you can integrate some HCS control into the equation using a very tiny node, which can easily be hidden in the existing case.

Since the Mini-Link uses a simple text based command protocol, it can be used in almost any system, which has a serial port. While the commands are tailored toward the HCS Home Automation System, they are flexible enough to allow use in other systems.

Since the Mini-Link appears like an AnswerMan Jr.[®] module to the HCS II, your HCS must have XPRESS 3.5 or higher to recognize and communicate with a Mini-Link.

NOTE! There is a problem with 8-bit analog readings from AMAN Jr. modules (and thus Mini-Links) in XPRESS 3.5 & 3.6. The analog values sent to the HCS by an AMAN module (or Mini-Link) are not converted to decimal properly in XPRESS and the values are way off. This problem has been fixed by Circuit Cellar and should be in the next version of XPRESS. Contact Circuit Cellar regarding the availability of this fix and how to obtain it.

Mini-Link Protocol Overview

The Mini-Link appears as an AnswerMan Jr.[®] module to the Circuit Cellar[®] HCS II Home Automation system. It recognizes a subset of the AMAN Jr. command set. However, because these commands are simple ASCII strings, Mini-Links can be used on systems other than the HCS II Home Automation System where analog & digital I/O is needed somewhere on a serial network. When used on an HCS RS-485 network, up to eight may be connected on the same network. Or you can have a mix of Mini-Links and AnswerMan modules with a total of eight on a given HCS II.

Commands are sent to the Mini-Link via a standard serial port. When connected to a Circuit Cellar[®] HCS II, they send and receive commands over the HCS II RS-485 multi-drop serial network. When connecting Mini-Links to an RS-485 network, use a converter such as a 75176.

The Mini-Link communicates with its host using the following serial settings:

```
9600 Baud
8 Bits
No Parity
1 Stop Bit
```

Command/Packet Format

When commands are sent to a Mini-Link, they must be in one of the following formats:

```
! MAN# command\n
#XX MAN# command\n
```

Packets starting with ! do not use checksums. If you are using checksums (see below) all packets sent to the Mini-Link must start with #. The computed checksum goes in place of the XX. Replace the # after MAN with the address number of the node which must be between 0 and 7. All packets must end with a carriage return (ASCII 13) and/or line-feed (ASCII 10).

Replies from the Mini-Link will always start with \$. If the original command packet used a checksum, the response will also have a checksum, otherwise it will not:

```
$ MAN# reply\n
$XX MAN# reply\n
```

Checksums

To ensure reliable communications between the host computer and the Mini-Link, checksums can be used in packets to help ensure the validity of data. If the Mini-Link receives a packet with an invalid checksum, the packet is simply ignored and no response is sent. Your controller must recognize the lack of a response (if it was a query command) and resend the packet after a given timeout period. When connected to an HCS II controller, a Mini-Link response packet with a bad checksum is indicated by an E in the node status window in the AMAN row.

Checksums for command packets are generated as follows:

1. Construct the command packet with zeros in the checksum location. Do **NOT** include the trailing carriage return:

```
#00 MAN4 QE
```

2. Add up all ASCII values of all characters in the packet, except for the \n:

```
#          23      (these are HEX values)
0          30
0          30
space     20
M          4D
A          41
N          4E
4          34
space     20
Q          51
E          45
Total  69      (only the low byte is kept)
```

3. Take the 2's complement of the checksum byte computed above:

```
-(69) = 17
```

4. Convert the checksum byte into 2 ASCII chars and replace the zeros in the checksum location:

```
#17 MAN4 QE
```

To validate the checksum of a received packet from a Mini-Link, do the following:

1. Discard the trailing carriage return (and linefeed if present):

```
$B4 MAN1 I:08 O:07 A0:00 A1:AE A2:FF A3:00 A4:000 A5:000 D0:000 D1:000
```

2. Convert the ASCII checksum into a single hex byte.

3. Replace the checksum characters with zeros in the packet:

```
$00 MAN1 I:08 O:07 A0:00 A1:AE A2:FF A3:00 A4:000 A5:000 D0:000 D1:000
```

4. Add all ASCII values of the characters in the packet, minus any trailing \n or \r:

```
Total      4C      (only the low byte is kept)
```

5. Add the checksum byte to the packet total. If the result is 00, the packet is probably valid:

```
B4 + 4C = 00      (The packet is okay)
```

That's all there is to it! Here is a great hint from the original Circuit Cellar® DIO-Link User Manual:

“After you think about it for a while you'll write a single subroutine to calculate or verify the checksum. If you hand the routine a line with a 00 checksum, it'll replace the zeros with the new checksum so you can send the line. If you hand it a (presumably) valid received line it will do the same, but also return the calculated checksum to the caller as an integer.”

Mini-Link Command Overview

The Mini-Link recognizes a subset of the AnswerMan Jr. control commands used in a Circuit Cellar® HCS II System. These commands are all that is needed to query the analog and digital inputs and set the IO pins via a byte or bits. Configure your Mini-Link using the `AMAN-Link XPRESS` command. Consult the XPRESS 3.5/3.6 Addendum for info on AMAN Jr. commands for querying & controlling Analog and Digital Pins.

All command packets must end with a carriage return (indicated by `<CR>`).

- **Query Configuration**

This command is used by the HCS to determine what is enabled on an AnswerMan Jr. Since the Mini-Link's configuration doesn't change (it always does 8-bit Analog & Digital IO and nothing more), this query will always generate the same response bytes (saying 8-bit Analog inputs are in use).

```
! MAN1 QC<CR>
#cc MAN1 QC<CR>      (cc is computed checksum byte)
```

The response will always be:

```
$cc MAN1 0022
```

If a checksum was included in the original packet, one will be included in the response.

If you don't use the Mini-Link in an HCS II system, you can ignore this command. It isn't necessary for proper operation of the Mini-Link. Also, if you have a Mini-Link configured for ALL Digital I/O and no Analog I/O, the QC command will still return 0022.

- **Query Everything**

This command allows you to query all the inputs and outputs of the Mini-Link. Any of the AMAN Jr. I/O values that aren't supported by the Mini-Link (12-bit Analog I/O, the 4th 8-bit A/D and Bits 4-7 of the digital I/O byte) will return 0's. The proper format of a Query Everything command is:

```
! MAN1 QE<CR>
#cc MAN1 QE<CR>      (cc is computed checksum byte)
```

This will return the current value of the Mini-Link I/O ports. Each 8-bit analog input that is configured will be returned as a hex byte representing the voltage (A0-A2). If an I/O

port is configured as a digital I/O, the corresponding analog value will always be 00. The digital I/O pins are returned as the lower nibble of the digital I/O byte (I:). The last value of bits set via an output command (SO) will be returned in the O: value. Supported values are in bold. All other values will always return 00 and can be ignored:

```
$B4 MAN1 I:08 O:07 A0:00 A1:AE A2:FF A3:00 A4:000 A5:000 D0:000 D1:000
```

If a checksum was included in the original packet, one will be included in the response.

Analog values can be read in XPRESS using the ADC command. Consult the XPRESS 3.6 Addendum for the associated ADC numbers. The NetBit command is used to read the state of a given digital input.

- **Set I/O Port Direction**

This command allows you to set the direction of any configured digital I/O ports (Bits 0-2) Note that Bit 3 is an input only port whose direction cannot be changed. If you try to change the direction of a configured Analog input, it will be ignored. Bit directions are set via a single byte. A '1' in the corresponding bit position will make that bit an input while a '0' makes it an output. Only bits 0-2 are valid and they must be configured as digital IO pins for the direction command to have an effect. All other bits are ignored and can be anything.

```
! MAN2 SB XX<CR>
#cc MAN2 SB XX<CR>          (cc is computed checksum byte)
```

where XX is the port direction byte.

NOTE! Be careful that your XPRESS code doesn't switch a pin to output when it is being driven by an external source. *It can damage the chip.* It may also cause false readings. If you drive a pin high, but it is pulled low by an external source, it will read low since the 12C671 reads directly from the pin, not the pin latch.

No response is generated to a Set Port Direction command.

The associated XPRESS command for this is BitDirection.

NOTE! XPRESS 3.6 has a bug where the checksum sent with a BitDirection command packet is invalid so it is ignored by the Mini-Link. CCI is aware of this issue. There is a workaround. Use the Network command in XPRESS to send the raw network command. So to set all digital ports to outputs on module #4, you would include:

```
Network = "MAN4 SB 00"
```

where you would normally use the Bit Direction command. The Network command generates the proper checksum value. You can also send this command using the Network command in HOST.

- **Set Output Byte**

Any pins that are not configured as analog inputs become digital I/O pins. These three pins along with the digital only pin make up the lower half of the netbyte nibble. IO0 corresponds to bit 0 of the netbyte and so on. If some bits are configured as analog, the

remaining digital I/O bits still relate to their corresponding netbyte bits. The bits corresponding to the configured analog inputs will just read 0 and any attempt to set them as outputs is ignored. Pin IN3 is always bit 3 of the netbyte.

The state of any configured digital outputs is done with one byte. The upper nibble is ignored and the bottom nibble is applied to any configured digital outputs. To set this byte, send the following command to the Mini-Link:

```
! MAN2 SO XX<CR>
#cc MAN2 SO XX<CR>          (cc is computed checksum byte)
```

where X is the byte to apply to the digital outputs. So sending 04 would set pin IO2 high if configured as a digital output. Sending 08 would do nothing since IN3 is always an input.

No response is generated to a Byte Set command.

Use the XPRESS NetBit command to set the state of a Mini-Link port. See the XPRESS 3.6 Addendum for more information.

See the NOTE above.

Mini-Link Configuration

The Mini-Link can be used in a multi-drop configuration where each unit has a unique address. Addresses are 4 characters: MAN# where # is the unique ID of the node which must be between 0 and 7. Up to eight Mini-Links can be used on the same HCS RS-485 network. Up to 16 can be used on a custom RS-485 network in accordance with the RS-485 specs and the MAN# addressing scheme. If you plan to use the Mini-Link in a network other than an HCS II and want to use more than 8, we can configure the address between 0 and F for up to 16.

Since the Mini-Link has no internal EEPROM, the network address must be burned into ROM when it is ordered. The same goes for the configuration of the 3 I/O ports. You simply specify how many Analog inputs you want when you order your Mini-Link and that configuration option will be burned in.

Based on the number of requested analog inputs, the pin functions are configured as follows:

Number of Analog Inputs	Pin IO0	Pin IO1	Pin IO2	Pin IN3
0	Digital I/O	Digital I/O	Digital I/O	Digital Input
1	Analog Input	Digital I/O	Digital I/O	Digital Input
2	Analog Input	Analog Input	Digital I/O	Digital Input
3	Analog Input	Analog Input	Analog Input	Digital Input

Mini-Link Pinout



Below is the pinout for the Mini-Link:

Pin 1	Vcc
Pin 2	Serial Enable
Pin 3	Serial I/O
Pin 4	Digital In 3
Pin 5	Multi I/O 2
Pin 6	Multi I/O 1
Pin 7	Multi I/O 0
Pin 8	GND

Mini-Link Miscellaneous



The Mini-Link chip has a 20-character buffer to store incoming packets. This is more than enough to handle both query and set commands. The Mini-Link serial port is not interrupt driven. Since the processing of the set command is extremely fast (since most checksum processing and the address matching is done while the packet is being received), sending consecutive commands to the same node should not be a problem. However, it is probably a good idea to wait at least a millisecond or two between commands if possible.

The Mini-Link I/O ports can sink 25mA each but the combined current of all pins cannot exceed 100mA.

Constructing your Mini-Link

If you purchased a kit from CCC, check the contents to ensure you have all the necessary parts:

Mini-Link

Qty	Description	Board Ref
1	Mini-Link Circuit Board	
1	8-Pin Mini-Link IC (12C671)	U1
1	75176 RS-485 IC	U2
1	100Ω ¼ watt Resistor	R1
2	8-Pin IC Sockets	U1 & U2
1	78L05 Voltage Regulator	U3
1	0.1μF Monolithic Capacitor	C1
1	100μF 16V Electrolytic Capacitor	C2
5	2 Position Terminal Blocks	J1-J5
1	1x2 Header	J6
1	1x3 Header	J7
2	Shorting Blocks	N/A

Here are some hints when constructing your Mini-Link:

- When building the circuit, mark off each connection on the schematic after it is soldered into place.
- Use ESD protection when handling the ICs! If you do not have a strap, touch something grounded before handling the chips.
- Use the included PCB mask diagram to place the components in the proper place. Ensure your PCB is properly oriented with the diagram. Note the Component and Solder Side notations. When all parts are in place, some holes will remain. These are vias to pass signals from one side to the other.
- Construct the circuit using the IC sockets, leaving the chips out. When you are done, check that +5V and GND appear on the proper pins in the IC sockets. Then remove power and install the chips.
- Install the shorting block to terminate the RS-485 network if necessary (i.e. if this module is on an extreme end of the network run). Only 2 modules can have active terminators on the same network!
- The kit includes a 78L05 voltage regulator which can handle up to 100mA. If your Mini-Link circuit will draw more than 100mA (via high current buffers, opto-isolators, etc.), replace the 78L05 with a normal 1Amp 7805 regulator with a heatsink!
- Remember that the I/O pins can only handle 25mA each. If you need more current, use a relay or high current buffer/driver
- The 8-bit analog inputs can only handle 5V Max! Use zener diodes for protection if necessary
- The Analog inputs are referenced against the Vcc supply to the Mini-Link. If the 78L05 is off and you need a more accurate reference, try an adjustable regulator with a multi-turn pot and set it for exactly 5.00 volts.

Step by Step Construction

- 1) Orient your circuit board so Component Side is on top. All components should be installed on this side (the side with the white part outline legend).
- 2) Install R1 - 100Ω Resistor (brown – black – brown).
- 3) Install the 8-Pin DIP sockets. **Note** they face opposite directions. Orient them so their notches line up with the small box on the board silkscreen.
- 4) Install the 78L05 voltage regulator (U3) so the flat side imatches the flat side of the outline on the board.
- 5) Install C1 (0.1uF Monolithic Cap). It can be installed either way.
- 6) Install the 1x2 header in position J6. Ensure it remains straight during soldering. If this module will be at the extreme end of your RS-485 network, install the shorting block on J6 to terminate the network. **REMEMBER!** You should only have **TWO** boards terminated on your network at any given time! If it won't be terminated, put the shorting block on **ONE** pin so it won't get lost.
- 7) Install the 1x3 header in position J7. This is used to select the output on the +5V/GND terminal. For +5V, install a shorting block on the two pins near the +5 label. For GND, install the shorting block on the two pins near the GND label. If you select +5V, it should be used for **REFERENCE ONLY**. It cannot supply external circuitry, as the Mini-Link regulator supplies 100mA only!
- 8) Install C2 (100uF Electrolytic Cap) with the positive lead in the square pad near the + symbol on the board.
- 9) Install the Terminal Blocks. Assemble 3 together using the dovetail slides on the side of the blocks. Do the same with the remaining two.
- 10) Without installing the chips, apply +12V and use a voltmeter to check that +5V appears at the proper pins for U1 & U2 (See Schematic)
- 11) Disconnect the power and install the ICs. Connect to your HCS network and power it up!

Mini-Link I/O Buffering

PIC microcontrollers tend to be pretty robust when it comes to their I/O pins, but they can be damaged if you are not careful. If you want to ensure reliable performance or have a noisy environment, buffer your I/O to protect your Mini-Link.

Digital Outputs

- Each pin can sink/source only 25mA. The combined current of all outputs cannot exceed 100mA.
- If you need a high current or voltage output, try using an Allegro driver which can source/sink up to 500mA at up to 48VDC. Make sure you beef up your voltage regulator if you do this!
- If you connect a relay to an output, make sure you place a 1N4001 diode across the coil to absorb any spikes generated by the coil when the relay de-energizes. If the coil is not 5VDC or draws more than 25mA, use an appropriate driver to drive the coil. You might also look at a solid state relay, which handles a control voltage of 5V. All Electronics has many low current (1-3A) solid state relays available for a good price.

Digital Inputs

- If you expect voltages in between +/- 30VDC, an MC1489 serial receiver connected to a 74LS14 hex buffer makes a great input buffer.
- Other I/O protection can include opto-isolators fed into a 74LS14 schmitt trigger fed to the input or low voltage MOVs if you expect spikes.

Analog Inputs

- The analog inputs can only handle 0-5V DC. Zener diodes or some other protection setup should be used if you think the voltage might exceed 5 volts.
- The analog inputs are referenced against the Vcc supply. If you need a lot of accuracy, check your Vcc voltage and if the 78L05 is slightly off, use an adjustable voltage regulator instead with a multi-turn pot to adjust the Vcc to exactly 5.00 volts.

A great diagram of I/O protection methods can be found in Circuit Cellar Ink® Issue #78, Page 52.

Need Help?



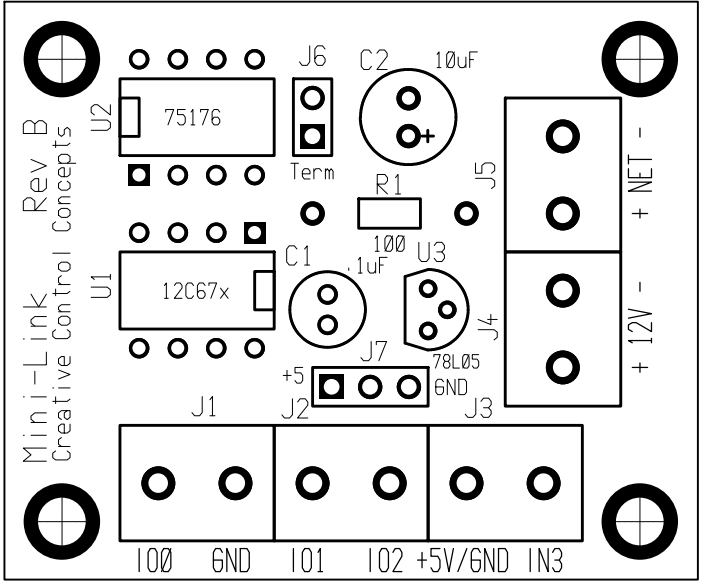
If you get stuck trying to get your system to work, drop us a line at support@cc-concepts.com and we will do our best to help you get your Mini-Link working.

Check out our web site at <http://www.cc-concepts.com/> for updates, bug reports, etc.

Here are some useful links for additional info referenced in this manual:

Microchip PICs: <http://www.microchip.com>

Circuit Cellar® HCS: <http://www.cc-concepts.com/products/hcs/>



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