Control Design, Inc.

C46 User Manual

Revision 1.00

For Hardware Revision F (Model 6)

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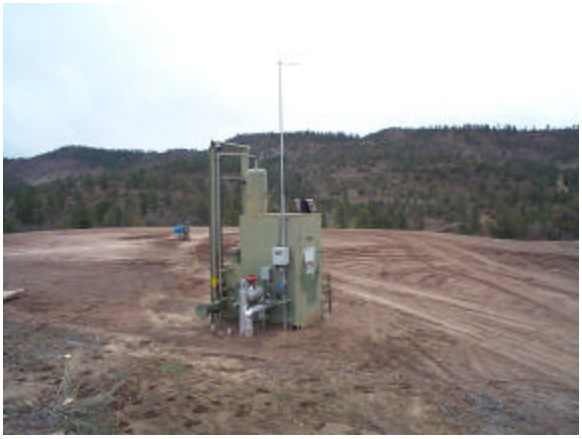

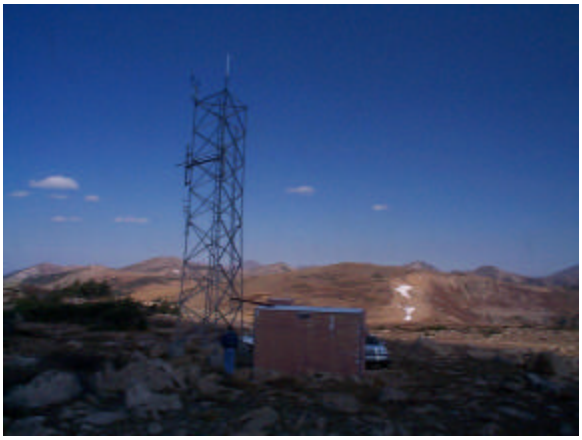

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General Product Overview

The Control Design Wireless Radio-Modem with Programmable I/O (C18, C46) are micro-controller-based computers that provide functions and algorithms required for remote control, monitoring, data logging, etc. They are designed to establish reliable, long-range, wireless data links for industrial control applications.

The I/O (Input/Output) section is designed to be an integral part of the radio-modem to allow general-purpose I/O ports and external power sources to be added to the modem on site without the need for other devices.
The Modem and I/O Unit are built in several configurations to provide wireless serial links and I/O ports to fit many applications:

The **C18A, B, C Units** are self-contained, NEMA 4 weatherproof enclosure, wireless Radio-Modem with I/O controller unit and battery. They are designed for easy installation in many applications for wireless data transfer, monitoring and control.

The **C46A, B Units** are complete, wireless, Radio-Modem with I/O controller units on a U-bracket designed to allow installation in a user-built enclosure or system.

The Radio-Modem provides the following functions:

- Hardware and Algorithms necessary for reliable, long-range, secure wireless data transfer.
- RS232 and RS485 serial connection for many devices such as PLCs, EFMs, Scientific Computers, Etc.
- Digital Data Transceiver on Licensed UHF, VHF or License Free VHF channels.
- LED status indicators for modem operation and troubleshooting.
- Modbus RTU protocol for programming and operation.
- Unique, Multi-Route (for Modbus protocol) and Single Route (for any protocol) Store and Forward capabilities.

The I/O module provides these standard features:

- 2(B version) or 4(A version) - 1amp, relay isolated digital outputs.
- 4(B version) or 8(A version) - optically isolated digital inputs. The A version also has 4 Pulse/Runtime Counters.
- 7 (B version) or 11(A version) - 12 bit analog inputs, 3 dedicated to Battery, Power Source and Temperature monitoring.
- Optional LC Display with Keypad for local user information display and input.
- Built-in Solar or AC to DC power supply regulation for battery charging.
- Heavy-duty, removable terminals for connection to power and sensors.
- Thermal, automatic reset fuse protection

The Modem and I/O units are designed to work together as a complete package for high thru-put, high reliability operation. All devices and logic are designed to work together for best performance and reliability using radio as the wireless connection between units.
All units (except C46x-NR) include the Radio/Modem and I/O modules along with all necessary, matched and calibrated, components to give the user complete monitoring and control, out-of-the-box, without the concern of compatibility between components.

Control Design's included Software Toolbox package is custom designed for use with all our products. This software can be used to efficiently program and troubleshoot all products as well as a driver to gather and process data from any remote Control Design or Modbus compatible device automatically.

Getting Started Information

To use all features of the C46 module you will need the following items:

1. Intel Basic-52 with C4x Extensions Manual, (used for writing programs in the I/O Processor)
2. C46 Product User Manual, (used for understanding how the Modem and I/O features function)
3. C46 Technical Manual v6.xx, (used for setting up the Modbus I/O functions thru Basic52 and in addition to the Basic52 manual for writing programs)
4. RS-232 Straight thru serial cable with Female D9 on PC end and Female or Male D9 on C4X end,
5. CDI Software toolbox v3.18d or later, (used for setting up and managing the Wireless Modem via Com2)
6. Terminal program such as Tera-Term Pro, (used to communicate with Basic 52 via Com0)
7. Word processor such as Notepad, WordPad or any editor that will save Text files.

First of all, keep in mind that all operations to do with BASIC-52 and Modbus for the Input/Output ports go through the “I/O Processor”. The I/O Processor manages BASIC-52 thru Com0 (RS232) and Modbus thru Com1 (RS485).

Second, all wireless communications go thru the “Modem Processor” which is connected to Com2 (RS232 & RS485). Com2 is wired internally to Com1, via the RS485 bus, so the Wireless Modem can be used to communicate with the I/O Processor via Modbus.

The C46 is basically a Programmable Controller and a Radio-Modem on one circuit board. The two devices operate independently and only share a common connection via the Com2 to Com1 RS485 bus.

The I/O Processor manages Com0 and Com1. The Modem Processor manages Com2 and data to/from Com1.

Getting connected and powered on:

Step1- load the CDI Software and the Terminal program onto your PC.

Step 2- start the Terminal program and set it for 19200,n,8,1 for use with Basic on the C4X Com0 port.

Step 3- start the CDI Toolbox and, on the “System Setup” tab, set it for 9600,n,8,1 for use with the Modem on the C4X Com2 port.
>>> NOTE: the CDI toolbox may conflict with the Terminal program if they are both on the same PC COM port. The CDI software releases the Com port automatically when it finishes a query/response. The terminal program may have to be disconnected via the menu, or if possible, setup on a different Com port.

Step 4- connect to the PC and Com0 on the C46 with the serial cable.
>>>NOTE: The C46 has Male D9 connectors on Com0 and Com2 with Female Gender changers installed in the Male D9. The Gender changers can be removed if Female-to-Female D9 cables are used.

Step 5- apply power, 12 to 24vdc, to the C4X “PWR” & “GND” or 12vdc to the “BAT” & “GND” terminals.
>>>NOTE: <100ma will supply the C4X without radio transmit. Approximately 1.2 amps are needed to supply the radio transmitter at 5 watts transmit power.

Step 6- the Basic 52 sign-on should appear on the Terminal program screen and the PWR (and CHG if PWR is connected) LED(s) should be flashing on the C46 unit.

Setting up some of the most used setup parameters:

1. In the "C46 Technical Manual" you will need to look at Registers 4x4807 thru 4x4827 to understand which I/O parameters to change.

- The most likely Registers to change will be:
  1. 4x4807- Auto-Run of a Basic program in Slot 1 on Power-Up,
  2. 4x4811- the Modbus ID of the I/O Processor,
  3. 4x4819 & 4x4820- Analog Input Voltage and Current settings.

The I/O must be setup via BASIC-52 Commands on Com0 or via Modbus Functions on Com1 using a RS232 to RS485 adaptor and Modbus software (such as the CDI Software Toolbox using the "Site Service" tab).

2. The "C4x BASIC-52 Manual with C4x Extensions" explains how unique BASIC-52 Commands for the C4x products allow use of Basic Program storage, the LCD & Keypad, Modbus commands and use of the RealTime Clock functions.

- REGREAD, POP are used to read Modbus Registers and REGWRITE is used to write them.
- PROG is used to store Basic programs to Flash "slots" and ERASE is used to clear Flash slots.

3. The Control Design Software Toolbox is used to setup the Modem thru the "Device Setup" tab. It can be used to setup the I/O if a connection is made to Com1 via RS485.

Remember, you are working with two devices, designed to do different tasks but sharing a common circuit board. The setup and use of these two devices is little different from previously separate Radio-Modem and PLC setup except the fact they are designed to work together seamlessly.

If you experience any problems, want help or have questions, call toll free >1-888-422-1442 for support.

Initial Setup of C18/C46 Units

5 Basic Setup Steps

1. Locate and mount the unit,
2. Locate and connect the antenna,
3. Connect sensors and/or controls,
4. Connect the power terminal and
5. Set the unit ID.

The following 5 sections will describe each of the above basic steps in more detail. The remainder of this manual will describe each feature of the Radio-Modem and I/O unit in detail.

1. Locating and Mounting the Unit

The C18 Unit comes in a NEMA 4 enclosure suitable for indoor or outdoor locations. 4 mounting feet (included) attach to the rear of the enclosure to allow mounting to any flat surface.
The C46 Unit comes on a 7" wide by 5.5" tall bracket with four mounting holes in the corners. This device must be mounted inside an enclosure suited for the location in which it will be installed.
Try to locate the unit as far as possible from any electromagnetic devices such as transformers, computers and other electrical and electronic devices.

2. Locating and Connecting the Antenna

***Caution!* When locating and mounting the antenna, keep the antenna and yourself a safe distance from power lines or other dangers. Take the time to observe the installation carefully before starting!! If the antenna and/or you should come in contact with high voltage sources you could be injured or killed!!!**

This is the most important step of the installation process. The antenna location will directly affect how well the unit functions over the wireless link. The antenna should be positioned as high as possible and as far as possible from any obstructions or possible interference and at least 5 to 10 feet from the Unit.
If using a Yagi antenna, the radio signal radiates from an element that is different from the others and usually located one element from the rear (mounting portion) of the antenna. The antenna should be oriented with the radiating stub pointing up. The signal direction is toward the end opposite the mounting.
The C18 units have an N-Female bulkhead connector protruding through the side of the enclosure for connection to the antenna cable (the antenna cable should have a N-Male connector).

NOTE: The power (1 to 5 watts) radiated directly from the unit antenna can cause interference to some electronic devices if the antenna is located too close to them.

FCC NOTICE: UL or FCC Part 15 does not rate this product for EMI. This product may radiate harmful signals, which can interfere with other electronic devices.

3. Connecting Sensors and/or Controls

The I/O section has Input/Output (I/O) ports to allow connection of external sensors, relays, switches and many other devices with contact closures, voltage outputs, etc. This is explained in more detail in the "Input/Output Ports" section.
Removable terminal blocks, attached to the I/O PC board, allow easy access to the I/O ports. The front cover of the C46 PCB describes the location of each I/O port for quick reference and easy connection.
Cables can be routed into the enclosure of the C18 unit via holes or cable grommets drilled in the enclosure by the user or through an adjustable, gasket sealed wire entry bracket on the bottom of standard units.
See the section "Input/Output Ports" for further information on specific ports and connections.

4. Turning the Power On

Power is supplied to the unit by inserting the terminal block, with power connected, into the appropriate terminal receptacle. On the C18 or C46 units, 12 Volt battery power connects to the two far right terminals and the two left of the battery input are for 14 to 24 VDC charging power.
If the C18 battery has been installed, the C18 terminal block comes pre-wired to the battery and is left disconnected to prevent battery discharg**e.**
If it becomes necessary to disconnect the battery wires from the terminal block, disconnect the plug-on spade terminals from the battery first!! No Fuse protection is provided from the battery to the terminal block!!!

See the section "Power Control Circuits" for further information on battery and power source connections.

5. Setting the Unit ID

The included (or available form the www.cdione.com web site) Software Toolbox allows ID setup quickly and simply. After installing the software on a suitable computer, connect a straight (not null) serial cable from the computers serial port to the C46 serial port. Program the unit ID according to the instructions in the “Unit Adjustments/Setup” section of this manual.
See the section "Unit Adjustments- Address" for further information and suggestions on ID setup.

Input/Output Ports

The C46A version I/O module has 8 Analog Inputs on the terminals, 3 Analog Inputs dedicated to Battery, Charge and Temperature, 1 SDI-12 port, 8 Digital Inputs, 4 Pulse/Runtime Counters, 4 Digital Outputs, Switched Battery voltage, Switched 24 volts. Also included, for convenient sensor connection, are Power Supply Ground terminals beside each switched voltage output.

The C46B version I/O module has 4 Analog Inputs, 3 Analog Inputs dedicated to Battery, Charge and Temperature, 4 Digital Inputs, 2 Digital Outputs, Switched Battery voltage and Grounds next to each switched voltage output.

The specifications for the I/O ports are as follow:

Analog Inputs

Located on the left most terminals are 12 bit, 0 to 5 volt, 0 to 20 milliamp or Auto-Recalibrated 4 to 20milliamp, low pass filtered inputs.
The Analog Inputs are high impedance (0-5volt mode) or low impedance (0-20 or 4-20ma mode), 12 bit, single end, sensing inputs. The standard reference voltage is 5 volts dc. The maximum input to each single end (standard) input is 5 volts dc or 20 milliamps dc.

The 12-bit resolution means there are 4096 divisions (0-4095) to any voltage measurement. For example, a 5-vdc maximum input voltage would be divided by 4096 for a .00122-vdc measurement per division. Each input can be set for 0 to 5 Volts DC, 0 or 4 to 20 milliamps DC. 250-ohm resistors are automatically switched into the input circuit to allow 0 or 4 to 20 milliamp input measurement.

When 0 to 5 volts is selected for an input, the 250 ohm resistor is removed from the circuit and recalibration of the scale is set to normal- 0 volts = 0 from the analog converter and 5 volts equals 4095.
When 4 to 20 ma is selected for an input, a 250-ohm resistor is inserted in the circuit and the 0 to 4095-step scale is automatically recalibrated to equal 0 at 4 milliamps and 4095 at 20 milliamps. An input signal less than 4 milliamps will cause the C4X to output a negative value (65535= -1, 65534=-2, 65533=-3, and so on…) which indicates a current less than 4 milliamps being applied to the analog input.
When 0 to 20 ma is selected for an input, a 250 ohm resistor is automatically inserted in the circuit and the 0 to 4095-step scale is recalibrated to equal 0 at 0 milliamps and 4095 at 20 milliamps.

Dedicated Analog Inputs

3 Analog inputs come factory wired to read the Power Source, Battery Voltage and Temperature respectively. Power and Battery each have a range of 0 to 30 VDC. Divide the maximum input voltage by 4095 to get a multiplier for use in calculating actual voltage being read by the analog converter.

For Example: 30 / 4095 = .007326. If a reading from the battery input to the analog converter (Analog Input 10 or Modbus Reg 4x00011) is 1710 then multiplying 1720 by .007326 would equal approximately ~12.53 vdc on the battery input.

Digital Inputs

Located to the right of the analog terminals are optically isolated, low pass filtered, Ground or +10 to 24vdc = active (Bi-Polar), inputs. The Digital Inputs are made active (on) by applying ground or +10 to 24 volts DC (supplied from the V+ terminals) to the input terminal. The user connected switch, relay or other sensor should pass the ground or +10 to 24 volts dc to the digital input to cause a change of status.

Open circuit is considered the LOW or OFF state, while ground or greater than 10 vdc or closed circuit is considered the HIGH or ON state. A high or low state is a valid condition for input sensing.

Jumpers are provided to allow changing the inputs from Bi-Polar operation (Ground or Positive voltage causes activation) to Uni-Polar operation (only Positive voltage causes activation).

- JP17 located just above the lower center terminal block sets Inputs 1 thru 4. Setting JP17 to pins 1 & 2 (left most pins) causes Bi-Polar operation (Default). Setting JP17 to pins 2 & 3 (right most pins) causes Uni-Polar operation.
- JP19, located in the upper, right area of the PCB, sets Inputs 5 thru 8. Setting JP19 to pins 1 & 2 (lower 2 pins) causes Bi=Polar operation (Default). Setting JP19 to pins 2 & 3 (upper 2 pins) causes Uni-Polar operation.

Digital Input Considerations

Applying a positive voltage to the input for active state is a more certain way of getting a contact closure reading than using a grounded input. Grounded inputs can be affected by noise and ground loops, which can cause a false reading to be sensed at the input circuit. By requiring a positive voltage greater than 10 vdc, the circuit is much less likely to be affected by noise or current loops which would rarely be able to generate as much as 10 volts of offset into the circuit.
A suggestion for secure digital input circuits is to feed positive voltage to the input loop constantly. The software or other monitoring system would be programmed to consider a high state the normal condition. The low state, or no voltage at the digital input, would be considered the alarm or abnormal state. One of two possibilities would exist when the voltage is removed from the input:

A) The switch or other device being monitored opened normally or
B) A wire, switch or other component in the loop opened or failed abnormally.

Either condition will tell the operator something is wrong at the site. If the digital input loop were only fed voltage when the circuit closed, then a failed wire, switch, relay, etc. would go undetected possibly allowing a severe situation to develop at the remote site.

Digital Outputs

Located to the right of the Digital Input terminals are Form C, 125 Volts AC/DC, 1 Amp current rating, Normally Open Relays. On C46A units, relay output 3 can be jumper selected for use as a relay output (default) or as a precision 5 volt DC output.

Switched Voltage Outputs

The C4X units have the ability to supply power to sensors or other devices via terminals marked SWV+1, SWV+2 and GND. Each pair of SWV+1 and GND terminals can be used to supply battery voltage only on the C4XB units. On the C4XA units, both battery on SWV+1 and 24 vdc on SWV+2 are supplied.
The 24vdc power supplied on the C4XA SWV+2 terminals is limited to about 100 milliamps of current. The C4xA has a built-in inverter that takes the 12vdc battery supply and converts it to 24vdc.
The SWV+1 and SWV+2 outputs can be turned on and off manually via Modbus Register 4x4823. They can also be set to come on automatically when an Analog or Digital Input is polled via Modbus Registers 4x4821 (Power Save enable) and 4x4822 (Power Save delay time).

Input/Output Expansion

The C46A-NR and C46B-NR are designed as local controllers without radio communications support. These devices have the full programmable I/O functionality and RS-232/RS-485 communication ports of the C46 units at a lower cost.
The RS-485 port allows connection of up to 32 C4X units for expanded, multi-drop I/O capability. The C46x-NR I/O ports are simply an extension of the master unit. Analog and Digital inputs are extended in groups of 4(C4XB) and 8(C4XA). Digital outputs are extended in groups of 2(C4XB) or 4(C4XA).
The expansion units can be connected up to 4000 feet from the master unit provided the remote expansion board has it's own power source.

LED and LC Display

I/O and Modem LEDs

The LEDs on the C46 serve two purposes:

First they indicate normal operation of the unit by displaying power status and activity on the serial and radio ports during normal use.

Second, they are used to indicate problems within the unit. Problems that occur during power up or normal operation are indicated.

The following describes each LED and its functions in normal and trouble operation:

The I/O processor controls the PWR and CHG leds.

PWR: The Power LED indicates operation of the voltage regulators and I/O processor. If it is not flashing power is probably not applied to the unit, the LEDs have been turned OFF by the user or the voltage regulator and I/O processor have malfunctioned. When enabled (default) this LED flashes to conserve power.

CHG: The Charge LED on the C4X indicates the charging input voltage is adequate to supply a charging current to the battery. When this LED is flashing, it indicates the voltage at the charging or PWR terminal is greater than the battery voltage on the BAT terminal by approximately 1 volt.

The DCD, STX, TXD, SRX and ERR leds are controlled by the Modem processor.

DCD: The Data Carrier Detect LED indicates a clear or busy radio channel and data receive. When lit steady, the radio channel is in use. When off, the radio channel is available. On the C4X units, the Data Carrier Detect LED will come on steady when a carrier is present and it will flash rapidly when data is detected or is being received.

A second use for the DCD LED is to indicate, during power on sequence, whether the EEPROM and SRAM are OK. If the EEPROM does NOT pass initialization tests, the STX and SRX LEDs will stay lit and the ERR LED will flash once per second. If the SRAM does not pass initialization tests, the DCD, STX, TXD and SRX LEDs will stay lit and the ERR LED wil flash once per second.

A third use for this LED is to indicate data being sent to the log buffer area. If the log buffer option is installed and being used, the DCD LED will light when data is being sent to the buffer. The SRX LED is lit while data comes in the serial port before the DCD led lights. If the SRX LED lights, and the DCD LED does not follow, this indicates the log buffer is full.

STX: The Serial Transmit LED indicates data is being sent from the Modem Com2 RS232 or RS485 port to the C4X I/O processor or an external attached device.

TXD: The Transmit Data LED indicates data is being sent to the radio from the modem. Before the radio has been 'keyed' for the specified key-up delay time, the TXD LED will light steady. The TXD LED will flash rapidly to indicate data is being sent to the radio after the key up delay period has expired and data is being transmitted.

A second use of the TXD LED is to indicate a problem with the EEPROM during power-up as described in the RXD LED above.

A third use of the TXD LED is to indicate when the default mode is successfully entered on power-up with SW1 closed. When the MODE button is depressed while the unit is powering up, the Modem will go into the "Default" mode of operation. The TXD led will indicate the modem is operating in this mode by staying lit.

SRX: The Serial Receive LED indicates the Modem Com2 serial port, RS232 or RS485, is receiving data from the C4X I/O processor or from an external attached device.

ERR: The error LED has two basic functions as follow:
First, the Error LED indicates when one of six possible receive data error conditions exist:

1. RF Synchronization error
2. RF Start/Stop bit error
3. RF LRC error
4. RF CRC error
5. Serial Buffer overflow error
6. Serial CRC error

If one of the above errors is detected this LED will light and stay lit until a valid data packet is received or the unit is reset. The actual type and number of occurrences of a particular error will be saved in the appropriate Modem Modbus error count Register 23 thru 25. (See the Technical Manual for exact register locations and description).

Second, the ERR LED is used to indicate a Modem external expanded SRAM or EEPROM problem. If, during initialization, a memory error is detected in the expanded buffer memory or the eeprom device, the error led will flash on and off at a ½ second per flash rate and the unit will not initialize until the memory error is corrected.

LED Control (On/Off)

The PWR and CHG LEDs, under I/O Processor control, can be enabled/disabled via Modbus Register 4x4826. The DCD, STX, TXD, SRX and ERR LEDs, under Modem Processor control, can be enabled/disabled via the CDI Software Toolbox setting for "LED Control" on the "Device Setup" tab.

NOTE: When the above Modem Leds are disabled (OFF) no activity will be indicated relating to Radio functions of the Modem. The STX and SRX leds will contiue to operate.

LCD and Keypad

The optional 4 line by 20 character LCD and the 2 by 5 key keypad can be used for local user interface to allow the user to see data values displayed locally and to allow data entry or respond to prompts setup by the programmer through Basic 52.

Commands for use with the LCD and Keypad are in the "BASIC-52 Manual with C4x Extensions"

The PRINT @ Statement is used to write data to the LCD.
The UI1 (User Input 1) Statement is used for reading the Keypad.

Power Control Circuits

The terminal connections on the far right end of the C46 I/O board are used to connect Battery and Charging power to the unit. The "BAT" and “GND” terminals are for a 12-volt battery. The "PWR" and “GND” terminals are used for connecting an external charging/operating power source from 14 to 24 vdc.

The "GND" terminals are used for the negative battery and power supply inputs. The Unit uses negative ground and operates on 12 vdc.

Battery (BAT) Input Terminals

User selectable charging voltages allow a constant charge voltage setting of ~13.7 vdc or ~14.8 vdc to the “BAT” terminal. For systems where the unit may be connected to constant power, such as an AC powered site, the battery should be kept at a constant 13.7 vdc. For systems where the charging voltage will be intermittent, such as solar powered sites, the battery should see a 14.8 vdc charge during the charge period.

Modbus Register 4x4827 allows selection of the charge voltage.

The "BAT"tery voltage is monitored by a dedicated analog input via Modbus Register 4x0011 with a 0 to 30 volt scale (30/4095=.007326 multiplier).

Power (PWR) Input Terminals

Power sources to the C4X board are from a battery connected to the unit, and/or a power source, which can be a direct solar panel input or 14 to 24 volts dc from an AC to DC power supply.
To use Solar charging simply connect the solar panel output of 14 VDC or greater to the "PWR" (Positive) and “GND” (Negative or Ground) terminals. The logic board has built in voltage regulation suitable for controlling voltage input levels from 14 to 24 vdc and managing current up to 1.5 amps. The circuit will pass all the current from a 30-watt panel and will tolerate up to 40 watts input but the extra current is wasted in heat.

External DC voltage connected to the "PWR" terminal is used to power the controller and radio as well as charge the battery connected to the "BAT" terminal. If external voltage connected to the "PWR" terminal is not present, due to power failure, sun setting on solar, etc., the unit automatically operates from the battery on the BATtery terminals. The charge indicator LED (CHG) will be flashing when the "PWR" input terminal has a voltage high enough to send charging current to the Battery terminal.

The "PWR" voltage is monitored by a dedicated analog input via Modbus Register 4x0010 with a 0 to 30 volt scale (30/4095=.007326 multiplier).

Current Consumption

The Radio, CPU and I/O unit current consumption is typically less than 75 milliamps in the standby/monitoring mode. A 7.0 amp-hour battery can power the unit, polling at 1-hour intervals, for approximately 72 hours. A 2 amp-hour battery will power the unit for approximately 24 hours.

DC Protection

DC input protection consists of a 2.6-amp PTC (thermal) automatic reset device. Switched V+ Output DC protection is a .75-amp PTC. If an overload should occur on the I/O module or to an external connected device on the SWV+ output bus, the PTC will shut current flow off to the affected circuit until the overload condition is removed. Power will be restored automatically when the overload is below the PTC rating.

Power-On Messages

The Modem (Com2) and I/O (Com0) processors each generate a message to their respective local serial port on power up. This message can be viewed using any terminal package such as ProComm or Windows HyperTerminal.

The following is an example Modem (Com2) message:

```
RESET v6.10.07 DH1120
Unit Slave Addrs---- 001
Radio Port Rate----- 4800
Serial Port Rate------9600, N,8,1
EEPROM Device ----4K Byte
```

1. The first line indicates a power-on reset was initiated followed by the firmware revision number and the unit serial number.
2. The second line is this units slave ID. 001 typically indicates a new unit.
3. The third line is the RF or Radio Port data rate. 4800 baud is the factory default.
4. The fourth line is the serial port baud, parity, data and stop bit settings. 9600,N, 8,1 is the factory default.
5. The fifth line indicates the size of the non-volatile memory, used for the modem configuration settings, the store and forward database and the data logging option if included. The minimum is 2 kilobytes, the standard is 4 kilobytes and the maximum is 8 kilobytes for the model D (model 4) modem.

The message below is an example of what is seen on power-up from the Basic 52 (Com0) I/O processor port:

```
Control Design C4X v01.12 DH
>
```

1. The first line indicates a power-on reset with no Auto-Run enabled. The v01.12 DH indicates this is Basic 52 version 1.12 and was last serviced in the year 2004 (D) in the month of August (H).
2. The second line is the Basic 52 prompt awaiting user input. If the Auto-Run mode is enabled via Modbus Register 4x4807, the unit will skip the sign-on message and go directly to the program in slot 1 to begin running the program.

Protocol

The Modem and I/O processor adhere to the Modbus RTU protocol format to allow set up with other systems and software. Functions and Error messages follow the standard as described in the Modbus protocol manual.

The Modbus protocol has proven to be the simplest and most effective 'standard' protocol currently used in industry to achieve communications most reliably via radio. An in-depth discussion of the Modbus protocol can be found in the Modbus protocol manual part number PI-MBUS-300 available from Modicon or Group Schneider Automation at www.modicon.com.

A brief description of each function supported by the products follows.
(See the Technical Manual for details on each function and register).

- Function 03 is used to retrieve data from multiple registers.
- Function 05 is used to set/clear Digital Outputs and specific functions of the Modem.
- Function 06 is used to write data to a single register.
- Function 16 is used to write data to multiple registers.
- Function 17 is used to retrieve information for setup of the unit.

Radio Port Description

The Modem radio port is designed to interface to the standard Digital Radio included with the Unit. Key-up delays, Receive turn-around times, Noise output frequency and levels, Modulation input and output circuit capacitances and wave shaping are all critical to the proper operation of high-speed data. These are taken into account through the Radio and Modem's internal algorithms and hardware designs.

Baud Rate Setting

The Software Toolbox setting for “Radio Port Baud Rate” allows changing the data rate the Radio Modem will operate at over the air. Settings from 4800 bits per second (bps) to 7200 bps will work on the standard narrowband radios supplied with the C46. The faster baud rates will not work as effectively in fringe areas as the slower rates. The signal level must be about 3db stronger for each faster rate to work as good as the next slower rate.

For example, a system working at –115dbm and 4800bps would need a signal of –112dbm to work the same at 5800bps. To go from 4800bps to 6400bps, the signal would need to go from –115dbm to –109dbm. The baud rate must match on all modems within a system. Different baud rates can be used on the same radio channel to allow multiple systems with the same IDs to operate.

For example, a system using modems at 4800bps cannot decode data from a system at 5800bps. Effectively, the two systems can run on the same radio channel, using the same IDs and they won’t interfere with each other.

NOTE: Two radio modems cannot be on the air at the same time on the same radio channel in the above baud rate example.

RADIO Connections

Pin 1 of the radio connector is located at the bottom right of the 10 pin Male IDC connector.

Radio Pin #	C46 JP12 IDC Pin #
1-RFT	1 TX Data to radio direct modulation circuit
2-RFR	3 RX Data from radio discriminator
3-PTT	5 Push to talk (Transmit) to the radio
4-GND	7 Ground connection to radio
5-PWR	9 Battery power to the radio
6-CD	2 *Carrier Detect from radio
7-CTL	4 Frequency select F1/F2 to Ritron
8- RSSI	6 RSSI from Ritron
9-SPK	8 Audio (speaker) from radio
10- PGM	10 Programming line for Ritron

Radio Keyup Delay Setting

The Software Toolbox setting for “Radio Keyup Delay” allows the user to alter the amount of time the radio push-to-talk is activated to allow the radio to “warm up” before data is actually sent to the radio. This allows the radio time to stabilize before data is put on the radio carrier.

C46 Serial Ports

C46 Com Ports Description

The Com 0 RS-232 port:

- Allows direct interface to Basic 52 and Basic 52 Modbus access.
- Defaults to 19,200bps, No parity, 8 data bits, 1 stop bit.
- Is programmable for other setting via Basic 52 or Modbus.

The Com 1 RS-485 port:

- Allows direct interface to Modbus and all Modbus registers.
- Defaults to 9600bps, No parity, 8 data bits, 1 stop bit.
- Is programmable for other settings via Modbus or Basic 52.

The Com 2 RS-232 and RS-485 port:

- Allows direct interface to the Modem only via RS-232 and to the Modem and I/O Modbus via Com 1 RS-485.
- Defaults to 9600bps, No parity, 8 data bits, 1 stop bit (to match Com 1 since they are physically tied together for Modem to Modbus I/O communications).
- Is programmable via Modbus or using CDI software for other settings.

The maximum cable distance for RS-232 is typically 50 feet.
The maximum cable distance for RS-485 is typically 4000 feet.

Com Port Connections

Com 0 and Com 2 RS-232 Pin Connections (Standard DCE pin out)

DCE (Com 0, Com 2) DTE (Computer)
Pin 2 = TXD (Transmit data) >>>>> >>> RXD (Receive data)
Pin 3 = RXD (Receive data) <<<<<<<<< TXD (Transmit data)
Pin 5 = Ground <----------> Ground

Com 1 RS-485 Pin Connections

Terminals on the top right edge of the C4XA and B units allow direct wire connection to Com 1 and Com 2 RS-485. Terminals are marked on the unit for polarity.

Com 2 RS-485 Pin Connections

Pin 6 = B or + connection to Com 2 and Com 1 RS-485
Pin 9 = A or – connection to Com2 and Com 1 RS-485

The Com 2 RS-485 is always active simultaneously with the Com 2 RS-232 port. The RS-232 port will allow communication with the Modem only. The RS-485 port is tied to the I/O processor RS-485 and allows communication with both the Modem and the I/O processors simultaneously.
Be aware, when communicating with devices on the Com 1/Com 2 RS-485 bus, both processors will be able to respond to a query and therefore require they each have a unique ID to allow proper communication via the same bus.

Serial Data Rate and Modem Timing

The Com 2 Modem RS-232 and 485 ports operate at user selectable rates of 1200 to 115,200 baud, None, Even or Odd Parity and 1 or 2 stop bits. When data begins entering the port, the modem goes into a timing loop to wait a minimum of 3 to 4 byte times (3 to 4 milliseconds @9600 bps) for the next byte.

When data input stops (a break of 3 to 4 byte times) a timeout occurs and the packet is processed locally for response (ID matches and Modem is in Active mode) or is sent to the radio for transmission (ID does not match or the Modem is in Silent mode).

Modem Flow Control and Buffer

Automatic/Internal flow control is built-in to the Control Design modem. The standard 152-byte (v6.0x.xx) or 384+ byte (v6.1x.xx) buffer captures the incoming data and times out automatically when it calculates the data input has stopped. The modem then starts a timer that counts down a user-set delay to allow the radio time to “key up”. After the delay expires, the modem automatically sends the data from its internal buffer to the radio.

RTS/CTS (Hardware) flow control can be enabled and used between devices using any protocol or data format. The Modem waits for a CTS signal to come from the attached device (DTE). A user-set timeout is then applied before the modem “raises” its RTS line to signal the DTE to send its data.
This is an older method of allowing attached serial devices to get the modem “warmed” up and ready to send data before the data is actually sent. This was used to prevent the first few bytes of data from being chopped off while the modem radio was keying up.

RTS/CTS is not needed or supported with the Control Design modems.

RS-485 Serial Ports Description

The RS-485 ports allow connection of the Modem or I/O processors to a balanced 2 wire twisted pair (1 pair) hookup such as a telephone line or microwave 2-wire interface. The communication is half-duplex (one-way at a time).
This allows use of the C46 by direct wire or microwave interface. The C46 will allow "local" Modbus command and response functions through the RS-485 just as with the RS-232 and Radio ports.
(See the RS-232 port details, previous page, for operation.)

The maximum distance for RS-485 to a remotely connected device is typically 4000 feet using a direct connected 1 pair wire line and communicating @9600 bps. Shorter distances will allow faster data rates.

RS-485 Connections

Com2 D9 Pin 6 = Data -
Com2 D9 Pin 9 = Data +

Terminals located on the top right edge of the C4XA or B allows connection to both processors via RS-485 on I/O port Com1 and Modem port Com2.
Polarity is important for this connection. All devices (up to 32) on the two-wire connection must be tied to the same polarity (+ to +). Also, there is a loading resistor on the Modem just below the D9 connector. (R20) This resistor must be inserted in the board at each end of a connection but NOT in any units between.

Com1 is RS-485 only, Com2 is RS-485 and RS-232 simultaneously. The Modem Com2 and I/O Com1 ports are connected internally to the same RS-485 bus. This means the I/O processor is simply one of what can be multiple devices “dropped” onto the RS-485 common bus. This bus is available to the outside world via either Com2 pins 6 & 9 (as described above) or via the terminals on the top right edge of the C46.

Serial Port Data Logging

The unique ability to use the serial port for logging data to a non-volatile buffer in the Modem is available in Firmware v6.x2.xx as an optional feature.

When this feature is installed and enabled in the Modem processor of the C4X, any type of data can be sent to the Modem serial port and it will be logged to a non-volatile, 2 Kilobyte buffer. The data can then be retrieved using standard Modbus commands or the Control Design Setup/Service software has built-in features for managing the buffer.

If serial port data logging is installed and enabled, data coming into the Modem serial port Com2 (RS-232 or RS-485) is checked for Carriage return and Line Feed characters as the first 2 characters received or all data entering the serial port will be logged to the serial buffer depending on user settings.

When the data log buffer is used, Modem Register 4x0011 will contain a value from 0 to 2040. A value of 0 in register 11 means no data exists in the buffer area. A value from 1 to 2040 indicates how many bytes of data exist in the log buffer.

The actual data buffer exists in 1,020 Modem registers beginning at register 4x3333 through 4x4353.The buffer can be read, 128 bytes (64 registers) maximum per query, beginning at any location in the buffer.
The data buffer is read as Modbus registers, two bytes of data per register. This buffer cannot be written to by any method other than data entering the serial port.

The data will be returned as a Modbus encapsulated packet with the actual user data inside the Modbus framing. Each Modbus data register returned will simply be bytes of user data as it appears in the log buffer.

The Modem firmware will not allow data to be written beyond the end of the buffer space. If a data packet coming in the serial port is larger than the buffer will hold, the packet will not be saved to the buffer but will be discarded by the Modem processor.

Data coming in the serial port is also limited in packet sizes by the Modem buffer size. Standard Modem buffer size for this firmware feature is 136 bytes.
When the data logging option is used, two Leds are used to indicate data flow into the buffer area. When data enters the serial port, the SRX Led will always light. If the data is actually sent to the buffer area, the DCD Led will light. If the SRX Led lights and the DCD Led does not follow immediately, the data was either sent to the radio port or it was not allowed into the buffer area due to a full buffer.

If the data went to the radio port, the TXD would light.

SDI-12 Support

C46A version I/O boards have circuitry to support SDI-12 (Serial/Digital Interface at 1200 Baud) communications to sensors supporting this protocol. Modem firmware v6.x1.xx or greater is required for this feature to function.

SDI-12 is a serial data protocol used to communicate with microprocessor based sensor devices. The hardware connection is a one-wire bus on which data is sent to and received from a sensor in half-duplex mode (one direction at a time). The C4X units equipped with SD I-12 have a jumper selectable terminal for either Analog Input 8 or SDI communications. Power and Ground are, typically, the only other connections to a SDI sensor.

Terminals for power and ground to the sensor are available on the terminals next to the SDI terminal. Switched power can be used by enabling the Power Saver feature via Modbus Registers 4x4821 and 4x4822 or by switching power through Basic or manually via Modbus Register 4x4823.

The Modbus register for SDI communications is Modem Register 4x0012. This implies the Modem must be in the "Active" mode to use this feature. In this instance, the Modem and I/O processors would each need a unique ID to communicate with both.
Since SDI data is ASCII information, not standard Modbus data, this register must be polled by itself or it will not be allowed to attempt to return data. Therefore, the Modbus Starting Register must always be 12. If register 12 is polled along with other registers a 0 value will be returned.
Also note the data returned would be SDI ASCII information encapsulated in a Modbus response packet.

If the C4XA Unit sees a Modbus data query with the Start Register = 12 then it will expect the Number of Registers value to mean the SDI sensor address being queried. Up to 16 sensors can be connected to one SDI port. The Modbus Number of Registers (or Number of Points) field is used to supply the SDI address. A value from 0 to 15 is acceptable in the Modbus number of registers field.

Register 12 is read-only and cannot be written to using any Modbus function.

OTHER C46 FEATURES

Serial Port Options

Listening Station

Serial Port to RF Disable

CRC Check Disable

Silent Feature

The Modem has a feature to allow data to pass through to the serial port regardless of the protocol or ID. The Silent Feature, when enabled, will cause the Modem to ignore all data coming into its radio port except for Store and Forward data. When Silent is enabled, any data received by the Modem will be sent to the serial port immediately if it is one of two situations:

1. The final forward of a store and forward packet or
2. A direct data packet (no store and forwards).

The included Setup/Service software allows this feature to be enabled/disabled. This feature can also be enabled/disabled, as all features in the Unit, using standard Modbus protocol functions. (See the Technical Manual for specific information on using the Modbus programming capability.)

An example of how the Silent Feature might be used:

If the ID (Address) of a Modem unit needed to be the same as the ID of the C4X I/O processor or a PLC attached to the Modem serial port (This might occur if more than 255 units exist in a system and there is a shortage of ID's.) then the Silent Feature would be enabled to allow Modbus messages to pass through to the C4X or external PLC.

The Silent Feature can be enabled and disabled during routine system polling so the C4X I/O could be polled for data in one poll and the Modem could be polled in the next poll after enabling the Silent Feature in the Modem.

Sending a Modbus function 05 to register 9900 will set or clear (depending on Force Data Hi value) the Silent feature in Ram only. This allows the feature to be switched on and off frequently so the Unit can be polled and then disabled to poll the attached unit often.

Sending a Modbus function 05 to register 9901 will set or clear the Silent feature in the EEPROM for non-volatile storage of the Silent feature.

NOTE: When the Silent feature is used with Store and Forward, the ID of the Modem MUST match the ID of the C4X I/O processor or the attached PLC.

Modem Transparent Operation

Transparent serial port operation offers the user the ability to send data through a Modem unit to a device attached to the Modem serial port (RS-232/RS-485) for wireless communications. This allows the user to extend the I/O and functionality of the Modem to PLC's, Data Loggers, Gas Flow Computers and other devices using serial communication ports.

The transparency of the serial port is based on the following considerations:

- The Address byte (ID) must NOT match the ID of the Modem the data is being sent to.
- If the ID does match, the Silent feature must be enabled.
- The data buffer holds 136 (v6.0x.xx) or 384+ bytes (v6.1x.xx – 384+ bytes) of data.
- Protocol conflicts. Users 'transparent' data matches Modbus protocol and local or remote Modem address.

The Modem will packetize, generate error checking and transport most data without problems as long as the above conditions do not exist or are controlled through proper setup of the Modem.

Store and Forward

Description

The Store and Forward feature is setup using the included Control Design "Setup/Service" software. Three basic Store and Forward (SnF) methods exist. Refer to Screen 1 (below) under the "Store and Forward Method" drop down selection box.

SCREEN 1

The **first** method is referred to as "Auto-Return (Slave)".
This method is the default and is typically used in remote slaves. This method allows the slave to automatically return a data packet by the route from which it came. The slave examines the data packet routing info (added to the user data by the originating modem) to determine what the route was the data packet was sent from. The slave then uses this data to assemble a return route, which is identical to the originating route except reversed to accomplish a path back to the originating unit.

No software setup is required to use this method. The software heading for this method is on the "Device Setup" tab and is under the "Store and Forward Method" drop down box. It is the selection named "Auto-Return (Slave)".

The **second** SnF method is referred to as "Multi-Route (Master)".
This method, when selected and setup at the originating modem, will cause the originating modem to add SnF header information to the user data packet which will tell other modems how to route the data packet to reach a destination. This method must be used with the supported protocol(s) listed in the software "System Setup" tab (Refer to Screen 2).
Other protocols may be supported but must be ordered specifically. The distinct advantage to "Multi-Route" SnF is that each destination unit in the system can have a unique and different route as well as a different number of SnFs (up to 4) to be reached.

The **third** method is called "Single-Route (Master)".
This method allows other protocols or any non-supported data types to pass through the modem system without regard to protocol or data format.
The disadvantage to this method as compared to the "Multi-Route" method is that all data must pass through the same repeating modem(s). Up to four modems can be used to SnF all data but all destination units must be within range of the last repeating modem.

The advantages with any SnF scheme are:

- Setup is fast and simple and only needs to be done at the "Host" modem.
- Data flows rapidly on one simplex channel instead of 2 (duplex) frequencies.
- Data is regenerated as a new packet with each SnF so no degradation of data occurs.
- All modems have this feature built-in so no special units are required.

Multi-Route Store and Forward Enable

The software has one selection box on the "Device Setup" tab and 1 section on the "System Setup" tab to allow SnF setup for this method. Follow the next steps to setup this method:

1. Select the "Device Setup" tab. Make sure the number 0 appears in the "R/W Unit ID" box in the upper left corner.
2. Click on the blue "Read Device" button. Assuming the modem is connected to the PC properly, all data boxes on the "Device Setup" screen should fill with data.
3. Go to the drop down box labeled "Store and Forward Method" and select "Multi Route (Master)".
4. Click the green "Write Device" button. The modem should go through a reset and respond to the software text messages window.

This completes enabling the "Multi-Route" Store and Forward feature.

Multi-Route Store and Forward Route Setup

The SnF route is setup on the tab labeled “System Setup” (see Screen 2). At the bottom of the System Setup tab there is a section labeled “Store and Forward (SnF) Setup”. This is where the route(s) are entered for each slave or device to be communicated with using Multi-Route SnF.

SCREEN 2

Multi-Route allows two ways to communicate with a remote device:
A) Direct Communications:
If a unit is to be communicated with directly simply do NOT setup a route for the destination unit that will be communicated with directly. Even though SnF was enabled on the “Device Setup” tab, the modem will not setup a route for an ID if nothing exists in the setup table. This allows using Multi-Route SnF for Direct communications without disabling the SnF feature for those units that need SnF.
B) SnF Communications
If a unit is to be communicated with by SnF follow the next steps:

1. Enter the ID of the originating modem in the box labeled “SnF Origin” (the modem connected to the PC or the one messages will originate from).
2. Enter the ID(s) of modems along the route (up to 4) beginning with the box labeled “SnF 1” through “SnF 4”. This is the path the data will take to reach the destination unit.
3. Enter the ID of the slave to be reached in the “SnF Dest” box. This ID can be the ID of a modem in the system or the ID of a device attached to a modem.

Any Modbus device can be routed to using this SnF method.
This completes the “Multi-Route” route setup.

Single-Route Store and Forward Enable

Follow the same steps as shown on the previous setup for “Multi-Route Store and Forward Enable” (Page 25) except for Step 3.

At step 3, select “Single Route (Master)” as the Method.

Single-Route Store and Forward Route Setup

As with Multi-Route SnF Route Setup, go to the tab labeled “System Setup”. Follow steps 1 and 2 for Multi-Route route “SnF Communications” setup.

At step 3: Enter the number 1 in the box labeled “SnF Dest”.

No other route needs to be setup. Unit Ids are not used for this method so this is all that needs to be done. The modem will always go to the SnF Destination unit 1 to find the route for all data packets as long as SnF is enabled. All units in the system must be communicated with using Store and Forward. Direct communication is not allowed in this method since the modem always defaults to “look up” the route for all data packets in the location for unit ID 1.

SCREEN 3

Multi-Protocol Support

Support for Multi-Routing with protocols other than Modbus is allowed in version v6.11.xx firmware. Screen 2 shows some protocols supported in the “SnF Protocol Select” section.
On the “Device Setup” tab, shown in Screen 3, there is a check box labeled “Enable Multi-Proto SnF”. Checking this box enables the host modem to “look” for supported protocols as well as automatically supporting Modbus.

Due to the convoluted nature of some protocols, the disadvantage to enabling this feature is the modem will now have a greater chance of mistaking one protocol for another if many types of data are being sent to the modem. The advantage of enabling this feature, if one protocol is being used, is the modem will recognize the supported protocol and allow all the advantages of Multi-Routing store and forward.

Directly below the “Enable Multi-Proto SnF” check box is a data entry box labeled “1st Group Offset”. This box is used to allow setup of multiple groups for protocols that support extended address or ID groups.

Because there is not enough memory in the modem to allow setup of a database for every possible ID in an extended address scheme, the modem must know which group is the first. It will then use this first group as a reference from which to set up all group routes above the first group.

The Multi-Group SnF support has the following limitations:

1. Eeprom Memory limits the number of groups that can be stored in the SnF database of the host modem. A 4K eeprom will store ~4 groups. An 8K eeprom, ~8 groups.
2. The groups must go up consecutively beginning with the first group.

For example, if the group offset is left at its default value of 0 and the eeprom size is 4Kbytes (as shown on the “Device Setup” tab in the box labeled “Eeprom”) then groups 0 thru 3 will be allowed. If a value of 105 is entered in the group offset box, and an 8Kbyte eeprom is installed in the modem, then groups 105 thru 112 will be allowed.

Important Store and Forward Operation Notes

The following information should be considered when using the Store and Forward feature:

1. A remote slave can be used as a local host under the following conditions:
    - If the slave I/O or attached PLC has been polled via SnF, when the Slave/Host sends out a query it will automatically use the SnF return route (it received during it’s previous Master/Host query) on the first query it sends out. This will cause what appears to be a failed response from the polled slave.
    - Retries from the Slave/Host are absolutely required. On the second query the polling host/slave’s SnF flag will clear and the query will go direct to the remote slave being queried.
    - Only direct communications are allowed between remote slaves.

2. Multiple Master SnF hosts are not a good idea. While there may be circumstances where this will work correctly, be careful how you set it up. Master/Hosts always use the route stored in its local database. Auto-Return routes will not function.

3. The ID of a Modem receiving SnF packets must match the ID of the I/O or attached PLC for the Modem to setup and retain SnF return path information. (The modem only checks its return route info when it sees its ID.)
    - This is true for Silent or Active modes. If the Modem is being used in the Active mode, with or without I/O or PLC polls, the modem must be polled once in a while to cause it to setup, retain and check it’s SnF return route info.

4. The Modem must be in the “Silent” mode for packets to go ‘through’ it to reach the attached C46 I/O or a PLC. If the Modem is in the “Active” mode:
    - and the ID of the Modem and I/O devices match, due to the nature of Modbus Query/Response similarities, the device response may cause the modem to “lock up” in a never-ending conversation between the local I/O and Modem.
    - the ID of the Modem and the I/O device must differ.

Unit Adjustments/Setup

Address (Unit ID)

Each Modem must have a unique address (ID) before using it over the wireless link. The ID is the only method for communicating with each remote unit on an individual basis.
The Modem architecture allows for automatic master/slave operation. Every Unit can be used as a sending and receiving Unit in a system. Peer to peer operation is supported automatically.

Screen 3, above, shows the “Device Setup” tab of the included “Setup/Service Software”. Setting the ID to 1 of 254 different values is done in the box labeled “Change ID”. ID 0 should not be used for any remote unit since this ID can only be communicated with via the wire line serial connection. If ID 0 is used, it should only be used on a unit such as a host unit in a system.
All remote units must have a unique ID other than 0 (1 to 254). No unit within a system can have the same ID (or Address).

NOTE: ID 1 is the default ID of a new unit. ID 255 is reserved for multi-group support.

Values from 2 to 254 should be used for remote units. Any unit having the same ID as another will cause collisions when communicating over the wireless link. All Units default to an ID of 1 when new or un-programmed. With a default ID of 1, a unit can be programmed over the wireless port.

Address Considerations

ID 1 should be left unused in a system so a new unit can be accessed by wireless if installed accidentally in an un-programmed state. All features can be programmed over the radio network if the ID of each unit differs and does not = 0.
ID 255 should be left unused in a system unless address extension is used. Then ID 255 will cause the receiving unit to look for an extended address. (NOTE- This feature is not implemented in the firmware revisions described in this manual but may be in future revisions.)

Repeating (SnF) units are normally assigned Slave IDs beginning at 254 and working down.
Remote units are normally assigned IDs beginning at 2 and going up. This will leave room to expand in both directions.

Carrier Detect

Carrier Detect allows the modem to know when the radio channel is busy so it will not transmit.
If the modem is about to send data, it will first check the carrier detect status for busy or clear. If clear, it will transmit immediately. If channel busy is detected, the unit will go into a loop, for up to 3 seconds, to look for a “channel clear” condition. When the channel clears, the unit will transmit the data packet.
If the channel does not clear within 3 seconds the modem will terminate the data packet and the software must retry to send a new packet.

Modbus CRC Check Disable

Modem Default Setup

All Units default to the following factory settings when new or when the MODE switch (located in the upper left corner of the C46) is closed during power up:

- Unit ID = 001
- RF Data Rate = 4800 bps
- RF Key up Delay = 60 milliseconds
- Serial Port Settings = 9600 Baud, No Parity, 8 Data Bits, 1 Stop Bit (9600,N, 8,1)
- Silent Mode = Disabled

Pressing the MODE switch during power-up on the C4X is a good method to temporarily restore Modem default settings on a unit that is programmed to an unknown state. To verify the default mode is entered successfully, the TXD Led will stay lit after initialization (power up) of the unit.

Modem Reset to Factory defaults

Two methods to reprogram the Modem to factory defaults exist.

The first, selective method, is to reprogram Modbus register 33 and/or 34 to a value other than the factory default. Writing a value other than 32383 to Register 33 will cause a complete reset of all upper memory locations (Reg33 thru top of non-volatile memory) in the EEPROM to = 0 when the unit is rebooted.

Writing a value other than 32383 to Register 34 will cause a complete reset of all lower memory locations (Reg1 thru Reg32 of non-volatile memory) that includes all unit setup parameters.

To "clean" a corrupted Modems entire setup and memory to factory defaults, write a value other than 32383 to both Register 33 and 34, then reboot the unit.

The second, software method, is to use the red “Reset Unit” button on the bottom of the “Device Setup” tab of the setup/service software. To do this, the unit must first be read using the “Read Device” button. This method will reset the entire memory and setup and will reboot the unit.

If the unit is in an unknown condition and cannot be communicated with directly, then use the above step, “Default Setup”, to put the unit in a temporary known state. Then read the unit by clicking the blue “Read Device” button (make sure 0 is in the “R/W Unit ID” box), and then reset the unit by clicking the red “Reset Unit” button.

Rebooting the Unit

Two methods for rebooting the unit are:

- If local to the unit, simply remove the power terminal and replace.
- If resetting by remote control, write the value 256 to Register 15. (Writing a value to any of the setup registers 15 through 22 will cause an automatic warm reboot.).

Modem Test Modes

Test Mode A

Test Mode A is used to check and align the radio transmitter. The first test mode can be initiated with the following three methods:

1. Pressing and releasing the MODE button on the C46.
2. In the Setup/Service Software, “Device Setup” tab, “R/W Unit ID” box, enter the ID of the modemto test, and then click the yellow “Test Mode A” button.
3. A standard Modbus Function 05 command to Register 0x9916.

Any of the above three methods will cause the transmitter to turn on and transmit a tone (the tone frequency will vary depending on the RF Baud rate- 4800bps = 2400Hz, 5800bps = 2900 etc.) for approximately 10 seconds, followed by steady 101010 data for approximately 10 seconds.

During the transmitter turn on time, the **deviation** level may be checked and adjusted. (On C46 units, the deviation must be adjusted inside the radio by a qualified technician.)

The following deviation settings are recommended:

For **wideband** 25Khz radios this is typically **+/- 4.8 KHz** deviation.
For **narrowband** 12.5Khz radios this level is **+/- 2.4 KHz** deviation.

During the transmitter turn-on time the transmitter **frequency** and power can also be checked and adjusted. *Qualified technicians should make all the above transmitter adjustment*s.

1) Test Mode B

Test Mode B is used to test the radio path for data thru-put reliability. The second test mode can be initiated with the following two methods:

1. In the Setup/Service Software, “Device Setup” tab, “R/W Unit ID” box (see previous page for “Device Setup” tab example), enter the ID of the modem that will transmit the test, and then click the orange “Test Mode B” button.
2. A standard Modbus Function 05 command to Register 0x9915.

Either of the above two methods will cause the modem to send a response message then, after a short pause, to begin transmitting 100 data packets rapidly. The test takes about 20 seconds or less (depends on system RF Baud rate).

The method to utilize this test is as follows:

1. In the Service/Setup Software, “Site Service” tab, “Slave ID” box, enter the ID of the local (or remote) unit that will receive the test data. Press tab to go to the “Start Reg” box.
2. In the “Start Reg” box, enter “25”. Press tab to go to the “# of Regs” box.
3. In the “# of Regs” box, enter 1. Press tab once.
4. Click the green “Write (Func16)” button to clear Register 25 in the unit that will be receiving the data packets.
5. Go to the “Device Setup” tab and enter the ID of the remote modem that will be sending the data, in the “R/W Unit ID” box.
6. Click the orange “Test Mode B” button. This will cause the remote modem to begin transmitting the test data back to the receiving unit.
7. Wait about 20 seconds for the test to complete. The DCD LED should stay lit during the entire test and the STX Led on the receiving modem will flicker during the test.
8. When the 20-second time is up or the DCD/STX Leds go off on the receiving modem, repeat steps 1 thru 3 above (the values previously read may still be there when the “Site Service” tab is selected).
9. On the “Site Service” tab, click the blue “Read (Func03)” button.
10. The data value contained in Register 25 will indicate, from 0 to 100, the percentage of data thru-put achieved. The data values, if any, in Registers 23 and 24 will indicate the number and type of errors that occurred.

Wireless Data Features

All C4X units contain the following unique features for wireless data transfer:

- Unique Packet Synchronization firmware to insure positive data transfer.
- Data Encryption for security of data transmitted over the radio channel and to allow "sorting" of received data from noise.
- Store and Forward (Repeat) capability for extended communications range.
- Extensive Error Detection for data integrity.

Packet Synchronization

Every unit contains, in the firmware, the ability to set its receiving synchronization clock to the sending units data stream, thereby eliminating out-of-sync errors once the units have locked onto each other. This eliminates out-of-tolerance crystal clocks between units as well as aging effects on components over time.

Data Encryption

A proprietary data encryption technique, which adds no overhead to the packet size, is utilized to allow all data sent over the wireless connection to be secure. This technique also allows the modem to recover its data stream from noise and interference, which would stop most data techniques. This encryption technique also eliminates the need for error correction techniques, which typically add overhead and time to wireless data transfers.
Different encryption schemes can be set at the factory for individual systems so users of the same Modem equipment cannot interfere or have access to data from other systems.

Store and Forward

All Control Design modems contain a unique auto-store and forward technique that allows for greater distances and flexibility in accessing difficult to reach units. The store and forward path is entered at the sending unit using the Setup/Service software. The receiving units program themselves automatically to handle and respond to the forwarded data. This allows the user to set up different paths for every unit (using Modbus, BSAP and other protocols) in the system if needed.
This also allows the user to change the path quickly if a unit in the path (such as a repeater) should fail and another path is available.
The distant unit being forwarded to will send its response back by the same route it was received thereby eliminating the need for field programming or concern for frequently changing paths.
Store and forward setup is covered in this manual for simplified setup and in the Technical Manual for specific setup details.

Error Detection

Extensive error detection methods mean your data will not be allowed to exit the serial port unless it is exactly as it was sent from the originating unit.

First, every byte of data has a start and stop bit on each end. These are checked as each byte is received. Every byte must have a correct start and stop bit or the entire packet is rejected.

Second, a Longitudinal Redundancy Check is calculated on each byte of data as it is sent and received. This value is stored and calculated during the entire data reception process for evaluation at the end of reception. If the value received does not match the value calculated, the packet is rejected.

Third, a 16-bit Cyclic Redundancy Check is performed on the entire data packet after it is received. If the CRC-16 calculated locally does not match the one received from the sending unit, the packet is rejected.

Fourth, if the packet sent is a Modbus data packet, another CRC-16 is performed on the Modbus portion of the data.

The ultimate result of the above four features means the data packets sent will be accurate (>99.9999%) and will typically (>95% on first attempt in actual field tests) get through the first time. This results in a net system throughput that is better than modems running at faster speeds. These features also insure long-term reliability in the field.
The reality is: getting through the first time at 4800 baud, is faster than getting through the second, third or fourth time at 9600 baud.

No Response Conditions - Possible Causes

- The slave never receives the message due to RF interference or failure.
- An error is detected in the data at the receiving unit.
- The message sent to the remote unit is not a valid function or the message is for an attached device that is not responding.
- The message sent is not for the Control Design operating system. User data sent through the transparent serial port is not acknowledged by the Control Design system.

APPENDIX A

Serial and Date of Manufacture Information

The Serial number embedded in the micro controller IC of every Control Design product contains information relating to the date of manufacture of the unit. This is an approximate date (+/- 1 month) and is used to calculate the warranty period for defective units.
Units shipped outside the warranty date will be warranted form the date of shipment if the Serial is not consistent with the +/- 1 month serial date.

An example and explanation follows:

AL0342 is a typical serial number.

To decode the manufacture info, use the following chart:

First character = Year manufactured- A=2001, B=2002, C=2003, D=2004, E=2005, etc…
Second Character = Month manufactured- A=January, B=February, C=March, D=April, etc…
The last four digits indicate the order of that units build in the year or month built.

Firmware Revision Information

V6.01.10 or v6.10.07 are typical revision codes.

The first letter, v, simply indicates “version”.

The **first digit** after the v indicates the model of PCB this code is written to operate in.
All Control Design PCBs have a letter revision on them at the end of their model designator. For example a typical PCB has a model designator of CPU45RFD. The “D” at the end indicates this is a model 4 PCB. (The letter D is simply synonymous with the number 4, E with 5, F with 6, and so on.)
Differences with this digit indicate hardware changes that might not function with other firmware revisions having a different first digit.

The **next two digit**s, between the dots, indicate major revisions and compatibility issues. While the first digit might indicate the same PCB revision, digits 2 and 3 could mean they will not communicate or some other major difference exists.

For example v4.10.xx and v4.30.xx, while being able to exist in the same PCB, will not communicate with each other over the radio port.

The **last two digits** indicate minor revisions and bug fixes within a code version. Differences here should not mean any incompatibilities exist.

APPENDIX B

Radio Communications Timing

The following timing parameters should be noted for system planning:

First, timing for data to enter and exit the serial buffer of the radio modem is 1 millisecond per byte for a 9600bps serial port rate. This rate becomes .5 milliseconds @19,200bps, .25 milliseconds @38,400bps, .175 milliseconds @57,600bps.

> Example: a 10 byte query would require 10 milliseconds @9600bps. A 260-byte response would require 260 milliseconds to enter the buffer @9600bps.

Second, add the radio key-up delay time of (normally) 60 milliseconds. 80 milliseconds should be a worst-case key-up delay.

> Example: the 10-byte query above would total 70ms after key-up delay. The 260-byte response would equal 320ms after key-up delay.

Third, the over-the-air rate of 4800bps requires about 4 milliseconds per byte. This rate becomes 3.4 milliseconds @5800bps, 3ms @6400bps, 2.8ms @7200bps.

> Example: the 10-byte query would require 34ms over-the-air @5800bps. Add 70ms from the first two steps and you have 104ms now. Add 10 more ms for the query to exit the serial port at the slave and you have a total of 114ms for the query to get to the slave in a direct communication.

The 260-byte response, from the slave, would require 884ms over-the-air @5800bps. Add 320ms from the first two steps and you have 1,204ms now. Add 260 more ms for the response to exit the serial port at the host and you have a total of 1,464ms for the response to get through the system in a direct communication.

Add 114ms for the query and 1,464ms for the response and the total turnaround time for a direct communication is 1,578ms.

Fourth, if a store and forward is involved, the delay time is simply 3.4ms per byte in each direction @5800bps. (Buffering does not add to the delay in this case.)

> Example: using the direct communication above, the query would require 34ms (10 bytes x 3.4ms per byte) going to the slave thru 1 SnF and the response would require 884ms (260 bytes x 3.4ms per byte) returning to the host. This means the total time added to the above direct transaction would be 918ms.

Add the normal turnaround time, for a direct communication, of 1,578ms plus 918ms for the SnF and you have a total of 2,496ms total turnaround with 1 SnF.

All the above examples assume there is no delay in the radio network due to carrier detect. If the modem detects a signal on the radio channel, it will hold the data in the buffer for up to 3 seconds, checking every 20ms for a clear channel to transmit, before the attempt to transmit is abandoned. In this scenario, the modem assumes the host will retry.