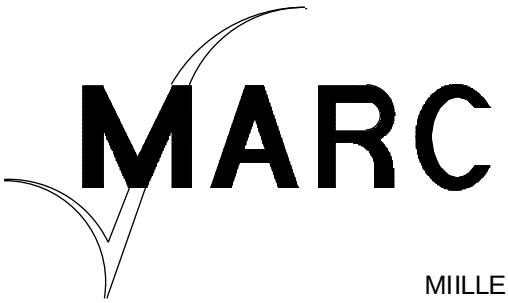
COMM-MASTER™

USERS MANUAL
Rev. 1

September, 1992



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1.1 OVERVIEW

The MARC Communications Master Controller (Comm-Master™) is a "polling master" for use in PLC systems. The Comm-Master™ provides the capability to automatically collect data from remote devices and move it into the local memory of a central or master PLC. The Comm-Master (MARC PN 166-001-0) described in this manual permits a standard off-the-shelf Allen Bradley Programmable Controller to be used as a sub-master in a SCADA system. The Comm-Master handles all communications with the remote devices using the remote devices standard communications protocol. After the data has been collected it is automatically transferred to the memory of the master PLC using standard Allen-Bradley DF1 protocol. A set-up table is read from the master PLC when power is first applied. The table provides all the information that the Comm-Master requires in order to operate. There is **NO LADDER LOGIC PROGRAMMING** required in the master PLC in order to collect data from the remote devices. The user merely 'sees' the remotes data appearing in the memory of the master PLC at a rate specified in the initialization table. The Comm-Master takes care of all polling, modem control, data validation, error retries etc. The Comm-Master translates between the SCADA protocol on one side and one or more Allen Bradley PLCs on the other side.

1.2 MANUAL'S PURPOSE

This manual tells how to install and operate the Comm-Master. The manual covers the following areas:

- **Hardware Specifications**
- **Installation of the Comm-Master**
- **Functional Operation**
- **Configuration Information**

The Comm-Master is a programmable device. Through custom programming it is capable of supporting a wide variety of communication protocols. Several standard SCADA host protocols have already been implemented with others currently under development.

1.3 AUDIENCE

In order to properly utilize this manual, the reader should first be familiar with the set-up and operation of the Allen-Bradley Programmable Logic Controller (PLC) system to be used with the Comm-Master.

INTRODUCING THE COMM-MASTER

2.1 OBJECTIVES

This section discusses the functions and features of the Comm-Master. After finishing this section the reader should:

- **Understand and be able to identify the hardware components of the Comm-Master.**
- **Understand the basic features and functions of the Comm-Master.**

2.2 GENERAL FEATURES

The 166-001 Comm-Master is a module which plugs into a standard Allen-Bradley 1771 I/O chassis. The Comm-Master draws only power from the PLC backplane. The Comm-Master communicates with the PLC by means of an RS-232 serial communication cable connected between it and an RS-232 Interface module in the PLC. Up to eight (8) PLC's may be connected to the Comm-Master at a site using an Allen-Bradley Data Highway network. The Comm-Master uses a second RS-232 serial communications port to communicate with the remote devices. This port is commononly connected to the remotes using a modem or some other similar type device.

The Comm-Master communicates with remotely located PLCs or RTUs using either asynchronous or synchronous protocols. The standard communications protocol of the remote is emulated by the Comm-Master's unique microprocessor controlled hardware. The Comm-Master has two serial ports for connection to the remote devices. One (port P1) is used when the remote communication protocol is an asynchronous byte oriented protocol and the other (port P3) is used when the communications protocol is a bit oriented protocol.

The Comm-Master continuously communicates with and collects data from the remote devices. The data to be collected, the frequency of collection, the location in the local PLC where the data is to be placed, time out intervals and other information is defined by tables in the master PLC which are read only at initialization time. These tables can be defined and changed easily using standard PLC programming tools. The data gathered from the remote devices is transferred to the PLC's memory as it is collected. Control commands can be sent from the master PLC to any of the remote devices using a standard Message instruction.

2.3 HARDWARE FEATURES

The principal hardware components of the Comm-Master are shown in Figure 1. They are:

- **Two MC6809 Microprocessors**
- **Two RS232 Asynchronous Serial Ports**
- **One Universal Serial Port, programmable to a wide variety of synchronous or asynchronous communication formats**
- **Three 8/32 Kbyte Memory Chip Sites Per Microprocessor, usable for RAM, EPROM, or EEPROM**
- **4 Kbytes of Shared Ram.**

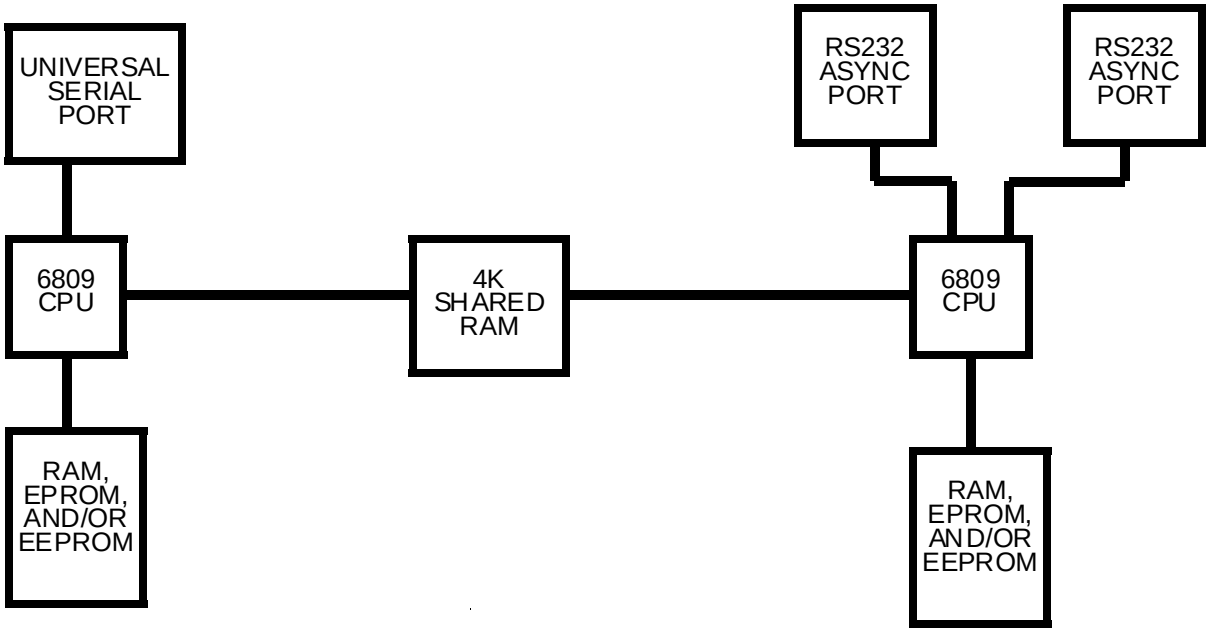


Figure 1 Comm-Master Block Diagram

2.4 SOFTWARE FUNCTIONALITY

The software in the Comm-Master is implemented in two parts which run asynchronously to each other. One part, the PLC side, communicates to one or more Allen-Bradley PLC's in Allen-Bradley DF1 protocol. The other part, the REMOTE side, communicates with remote devices in another communication format. Data is passed between the two parts by means of a common data base located in the shared RAM memory.

2.5 SPECIFICATIONS

Physical:

- **Requires one module slot in an Allen-Bradley 1771 I/O chassis**
- **1.1" W X 10" H X 5.75" D (Standard Allen-Bradley Module Size)**
- **2 pounds 5 ounces**

Microprocessors:

- **2 6809 Microprocessors**

I/O Ports:

- **2 Asynchronous Serial Data Ports**
- **1 Universal Serial Data Port (asynchronous Or Synchronous)**
- **RS-232 Signal Levels**
- **Modem Control Lines on all ports**

Port Connections:

- **3 15 pin "D" type connectors (DE15S)**

Communication baud rates:

- **300, 600, 1200, 2400, 4800, 7200, 9600 bits/sec**

Backplane Power Supply Load:

- **1.5 A from 5 Vdc**

Memory Capacity:

- **SIx 8K/32K-byte Universal Memory Sites**
- **4-Kbyte Dual Ported RAM**

Operating Environment:

- **0 to 60 degrees C**
- **Relative Humidity 0% to 90% (non-condensing)**

2.6 SYSTEM CONFIGURATIONS

The Comm-Master can be used with a single PLC or with a network of up to eight PLC's connected on an Allen-Bradley data highway.

2.6.1 Single PLC Configuration

Figure 2 shows two examples of single PLC configurations One configuration shows an Allen-Bradley 1771-KG module tied directly to the Allen-Bradley PLC-2. The Comm-Master connects to the SCADA communications line using a leased telephone line modem on the SCADA side and the 1771-KG module on the PLC side. The second example shows a PLC-5 system using an Allen-Bradley 1785-KE module for the PLC interface and a radio modem for the SCADA interface. Many other single PLC configurations are possible. Only one Comm-Master can be connected to a SCADA communication line at a time.

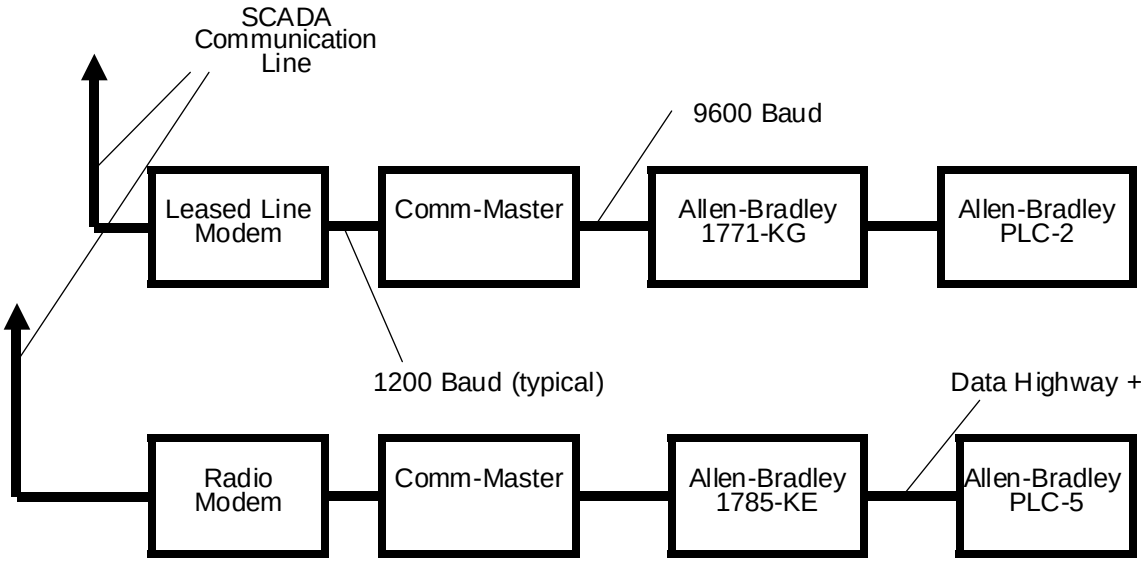


Figure 2 Single PLC Configuration

2.6.2 Multiple PLC Configuration

The Comm-Master can be used as an interface between a SCADA communication line and up to eight Allen-Bradley PLC's at one site. This configuration is shown in Figure 3. The PLC's are tied together on an Allen-Bradley data highway+, a 57.6 Kb local area network that provides peer-to-peer communication with a floating master. An Allen-Bradley 1771-KF or a 1785-KE module is used to connect the Comm-Master to the data highway+.

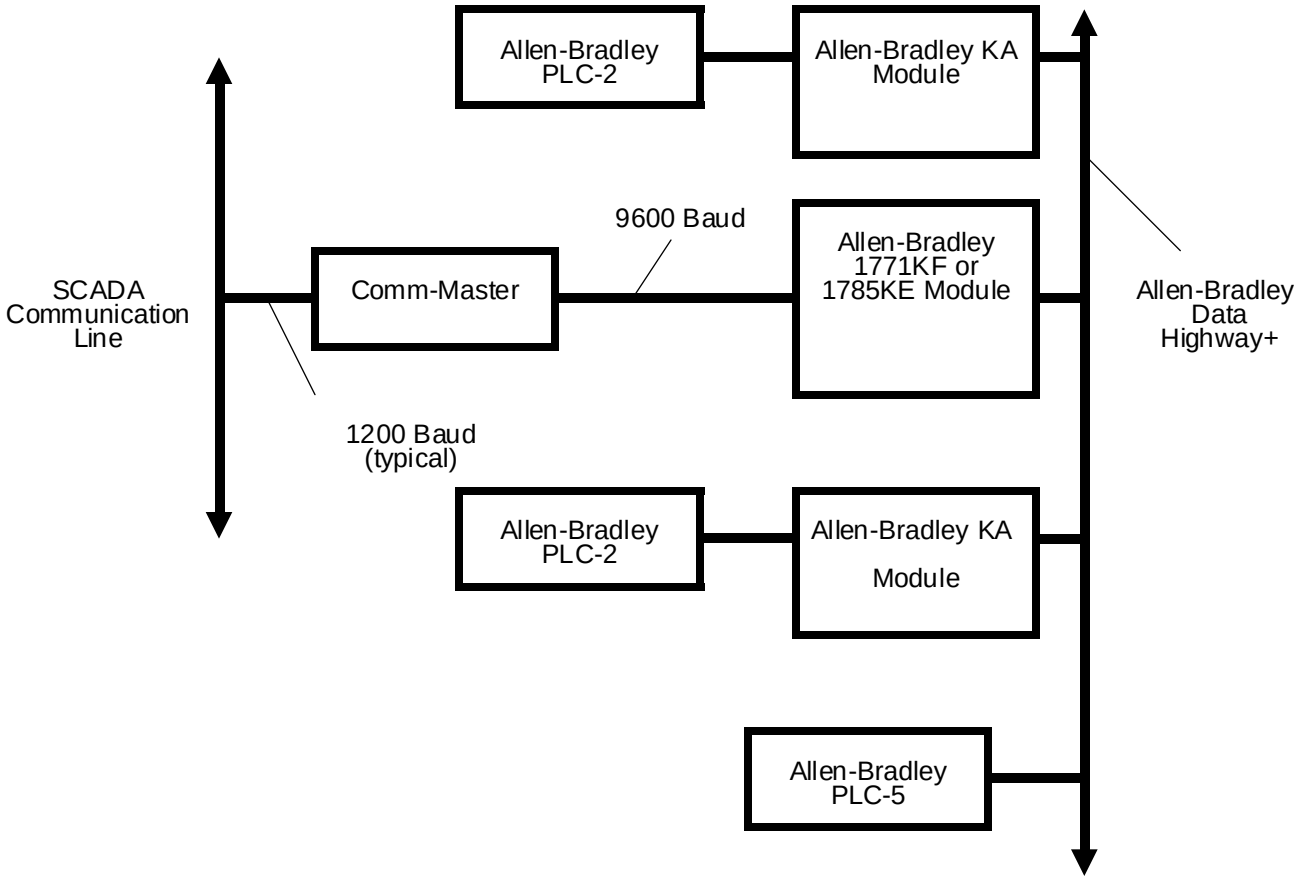


Figure 3 Multiple PLC Configuration

INSTALLING THE COMM-MASTER

3.1 OBJECTIVES

This section tells how to install the Comm-Master into a 1771 I/O Rack. It also provides information on connecting the Comm-Master to the SCADA system and the local PLC(s). After finishing this section the reader should be able to:

- **Configure the options on the Comm-Master**
- **Insert the Comm-Master into a 1771 I/O backplane**
- **Connect the Allen-Bradley protocol cable**
- **Connect the SCADA communication line cable**
- **Understand Comm-Master status indicators**
- **Install additional RAM, EPROM and EEPROM chips**

3.2 INSTALLATION OF THE Comm-Master

Before installing the Comm-Master in the 1771 I/O chassis the following steps should be taken:

- **Insure that adequate power is available on the I/O chassis backplane. (Section 3.2.1)**
- **Determine the location of the Comm-Master in the I/O chassis. (Section 3.2.2)**
- **Configure the options on the Comm-Master. (Section 3.2.4)**

3.2.1 Power Requirements

The Comm-Master receives its power through the 1771 I/O chassis backplane from the chassis power supply. It does not require any other external power to function. It is important to calculate the total power required by all modules plugged into the I/O chassis and insure that it is within the power supply specifications. The Comm-Master requires a maximum of 1.5 amps at +5V DC. Typical power requirements are approxomately .75 Amps.

3.2.2 Comm-Master Location in the I/O Chassis

The Comm-Master can be placed in any slot in the 1771 I/O chassis that is not reserved for another module.

3.2.3 Module Keying

No module keying is required. The Comm-Master can be installed in any slot of the Allen-Bradley 1771 I/O Chassis.

3.2.4 Hardware Strapping Options

The Comm-Master is an extremely versatile module which can be configured in many different ways to allow it to be used in numerous applications. The hardware strapping configurations are application dependent and are explicitly defined in the appendix for each SCADA protocol application. The Comm-Master is ordered and shipped with a specific protocol installed. The jumpers will be factory set for operation with the installed protocol. The following paragraphs detail the functions of each of the hardware jumper options for information purposes only.

J1____ A three position jumper which is used to allow connector P3 pin 1 to function as either an input to the host side VIA signal CB1 or as a buffered output from CB1.

J2____ A three position jumper which is used to select the size of EPROM or RAM chips installed in socket U13. A jumper will be connected from 1-2 for 4K or 8K devices. The jumper should be connected from 2-3 for 16K or 32K devices.

J3____ A three position jumper which is used to select the size of EPROM or RAM chip installed in socket U16. It will be installed as described for jumper J2.

J4____ A two position jumper which is used to invert the signal on Connector P4 Pin 15. This line is normally used for an external Transmit Clock (TxC). If J4 is installed, the clock signal will be inverted; if not installed, the clock signal will not be inverted.

J5____ A two position jumper which is used to invert the signal on Connector P4 Pin 14. This line is normally used for an external Receive Clock (RxC). If J5 is installed the clock signal will be inverted; if not installed, the clock signal will not be inverted.

J6____ A three position jumper which is used for selection of the type of device to be used in socket U13. If the memory device is an 8K EPROM or RAM, then J6 will be connected from 1-2. If it is a 32K RAM, then it will be connected from 2-3.

J7____ A three position jumper which is used to select the size of memory device to be installed in socket U23. It is connected as described for jumper J2.

J8____ A three position jumper which is used to select the type of device to be used in socket U16. It is connected as described for jumper J6.

J9____ A three position jumper which is used to select the size of memory device to be installed in socket U20. It is connected as described for jumper J2.

J10___ A dual row, 5 position jumper which is used for configuration of the PLC side VIA chip (U29). Almost any connection required can be accomplished by interwiring pins on jumper J10. The application program will determine the connections required.

J11___ A three position jumper which is used to select the size of memory device to be installed in socket U30. It is connected as described for jumper J2.

J12___ A three position jumper which is used to select the type of device to be used in socket U23. It is connected as described for jumper J6.

J13___ A three position jumper which is used to select the type of device to be used in socket U20. It is connected as described for jumper J6.

J14___ A three position jumper which is used to select the size of memory device to be installed in socket U27. It is connected as described for jumper J2.

J15___ A three position jumper which is used to select the type of device to be used in socket U30. It is connected as described for jumper J6.

J16___ A three position jumper which is used to select the type of device to be used in socket U27. It is connected as described for jumper J6.

J17___ A three position jumper which is used to select the type of interrupt which will be generated when the host side processor signals the PLC side processor. Connection of the jumper from 1-2 will select an NMI interrupt. Connection from 2-3 will select an IRQ interrupt. The application software will determine the type of interrupt required.

J18___ not present

J19___ A three position jumper which is used to connect an external RESET switch to the Comm-Master. The Comm-Master will automatically reset whenever power is first applied. An external reset switch can be connected to this jumper for use during program development if desired. Connection from 1-2 will provide a RESET to the Comm-Master. Connection of an external switch from 2-3 will provide a Non-Maskable Interrupt (NMI) to the Host Side microprocessor. This jumper is only available on artwork revisions D and later.

J20___ A two position jumper that is used to enable the watchdog timer hardware on the Comm-Master board. The watchdog timer will be enabled if this jumper is installed. If the jumper is not installed the watchdog timer function is disabled. The watchdog timer and jumper are only available on artwork revisions C and later. If jumper J20 is installed the Comm-Master firmware must exercise the watchdog timer.

J21___ A three position jumper which is used to select the mode of operation of port P2. If the jumper is installed from 1-2 then port P2 is configured to operate as an RS232 port. If the jumper is installed from 2-3 then port P2 is configured to operate as either a RS422 or RS485 port depending on the cable connections. See Section 3.6 for additional details.

J22___ A two position jumper that is used to invert the level of the receive signal line from port P3. The signal will be inverted if the jumper is not installed.

J23___ A three postion jumper which is used to select the mode of operation of port P1. See the definition for jumper J21.

J24___ A three position jumper which is used to select the mode of operation of port P3. See the definition for jumper J21.

3.2.5 Comm-Master Installation

The following paragraphs provide the user with suggested inspection, preparatory procedures, considerations, and background information needed prior to using the Comm-Master.

3.2.5.1 Unpacking and Inspection

Carefully remove the Comm-Master card from the anti-static protection bag. Since many of the components of the Comm-Master are subject to damage by static discharge, the bag should be saved for card storage or future return, if necessary. Closely inspect the card for signs of shipment related damages such as loose socketed components or bent and broken pins. Should evidence of damage be found, notify the carrier and the manufacturer at once.

3.2.5.2 Installing Comm-Master in I/O Chassis

The Comm-Master can be installed in any empty mounting position in an Allen-Bradley 1771 I/O Rack.

CAUTION: Always remove power from the I/O Rack prior to inserting or removing the Comm-Master. Failure to remove power can result in severe damage to the Comm-Master or the I/O chassis.

Push the card retainer latch to the right and rotate the card retainer upward to gain access to the selected mounting slot. Carefully align the Comm-Master card with the card guides and push the card into the I/O chassis until fully installed. Rotate the card retainer back into position. The retainer latch will click into position when the card has been locked into place. Connect serial I/O cables to the Comm-Master as described in the appendix for the protocol application and apply power. The Comm-Master will initialize itself upon the application of power and will be ready for operation.

3.3 USING THE COMMUNICATION PORTS

The Comm-Master has three (3) ports for communication with other devices. Two of the ports are standard asynchronous ports and one is a "Universal Serial Port" which can be programmed for any type of serial communication. The ports are numbered P1, P2, and P3. P1 is located at the top of the Comm-Master card when it is installed, P3 is at the bottom. A 15 pin "D" type connector is used for termination of the serial interface cables. The mating connector for the Comm-Master serial interface ports is a TRW/Cinch DE15P or equivalent. Ports P1 and P2 are asynchronous ports controlled by the master side microprocessor; Port P3 is the Universal Serial Port and is controlled by the slave microprocessor. All lines are buffered by RS-232 and RS485/422 drivers and receivers. Figures 4, 5 and 6 detail the pinouts for each of the serial interface connectors.

PIN	SIGNAL NAME
1	GND Signal Ground
2	TXD Transmit Data (output)
3	RXD Receive Data (input)
4	RTS Request To Send (output)
5	CTS Clear To Send (input)
6	DSR Data Set Ready (input)
7	GND Signal Ground
8	DCD Data Carrier Detect (input)
9	TX+ RS422/485 Transmit (output)
10	TX- RS422/485 Transmit (output)
11	DTR Data Terminal Ready (output)
12	RX- RS422/485 Receive (input)
13	RX+ RS422/485 Receive (input)
15	GPO General Purpose Output (output)

Figure 4 Connector P1 Pinouts

PIN	SIGNAL NAME
1	GND Signal Ground
2	TXD Transmit Data (output)
3	RXD Receive Data (input)
4	RTS Request To Send (output)
5	CTS Clear To Send (input)
6	DSR Data Set Ready (input)
7	GND Signal Ground
8	DCD Data Carrier Detect (input)
9	TX+ RS422/485 Transmit (output)
10	TX- RS422/485 Transmit (output)
11	DTR Data Terminal Ready (output)
12	RX- RS422/485 Receive (input)
13	RX+ RS422/485 Receive (input)
15	GPO General Purpose Output (output)

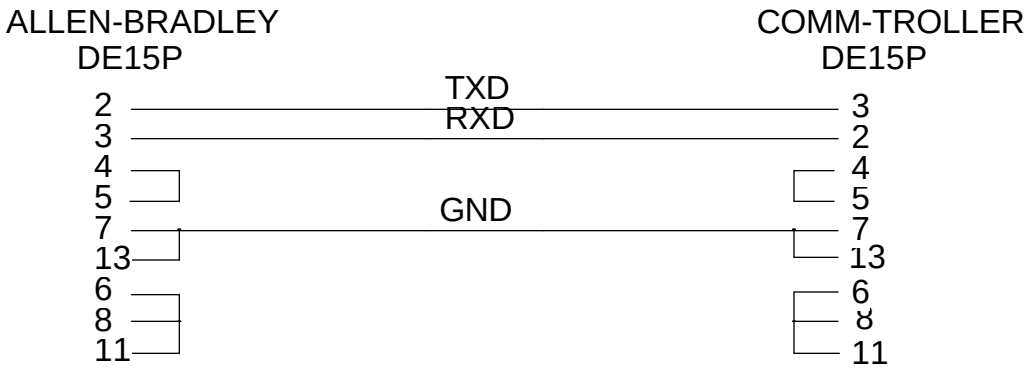
Figure 5 Connector P2 Pinouts

PIN	SIGNAL NAME
1	GND Signal Ground
2	TXD Transmit Data (output)
3	RXD Receive Data (input)
4	RTS Request To Send (output)
5	CTS Clear To Send (input)
6	DSR Data Set Ready (input)
7	GND Signal Ground
8	DCD Data Carrier Detect (input)
9	TX+ RS422/485 Transmit (output)
10	TX- RS422/485 Transmit (output)
11	DTR Data Terminal Ready (output)
12	RX- RS422/485 Receive (input)
13	RX+ RS422/485 Receive (input)
14	RXC Receive Data Clock (input)
15	TXC Transmit Data Clock (output)

Figure 6 Connector P3 Pinouts

3.3.1 Connecting the Allen-Bradley Protocol Port

Port P2 (center connector) is used to communicate with the Allen-Bradley 1771 KF or KG module in PLC-2 applications. Port P2 is connected to the 1785-KE in PLC-5 applications. The cable connections are shown in the following figures for the various Allen-Bradley RS-232 Interface modules. The communication rate, data format, and parity selections are fixed by the Comm-Master firmware. It automatically selects a rate of 9600 baud, 8 data bits, 1 stop bit, and no parity. The communications protocol is standard Allen-Bradley DF1 full-duplex with CRC error checking regardless of the type of interface module. Allen-Bradley connections always use RS232 levels.



Part # 127-052-12

Figure 7 KG or KE Cable

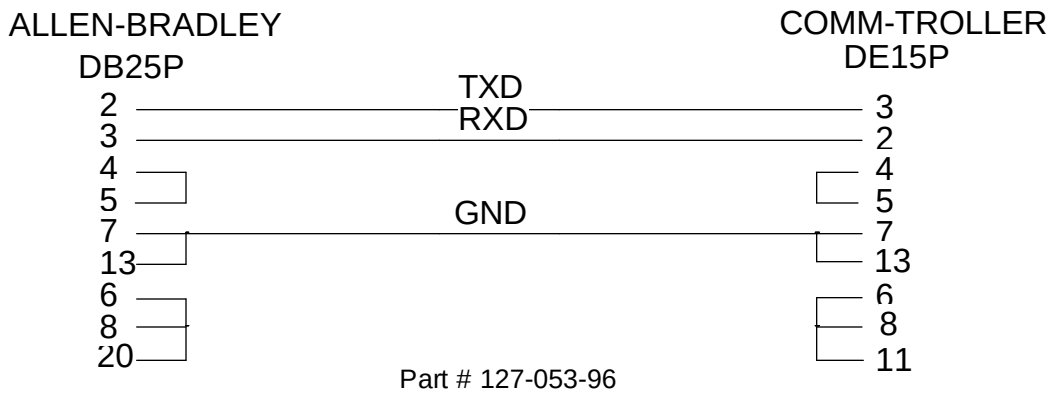


Figure 8 KF-2 Cable

3.3.2 Connecting the SCADA Protocol Port

The connections to the remaining ports of the Comm-Master are dependent on the SCADA protocol requirements. Details for connection to these ports can be found in the appendix for the specific protocol. A modem may be used in many applications for communication to the SCADA RTUs. The following figures detail the cable connections required for connecting to several types of modem modules.

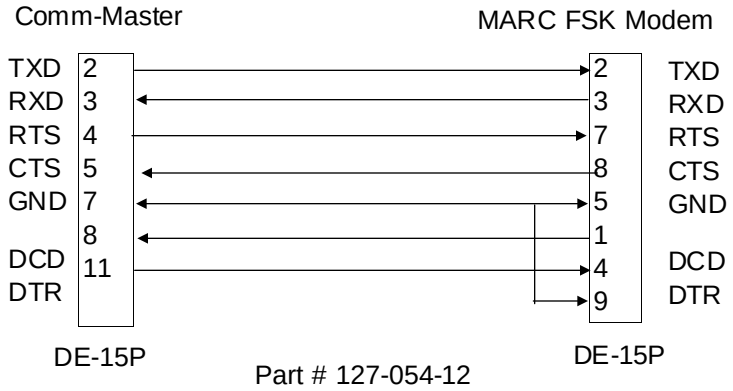


Figure 9 MARC FSK Modem Cable Connections

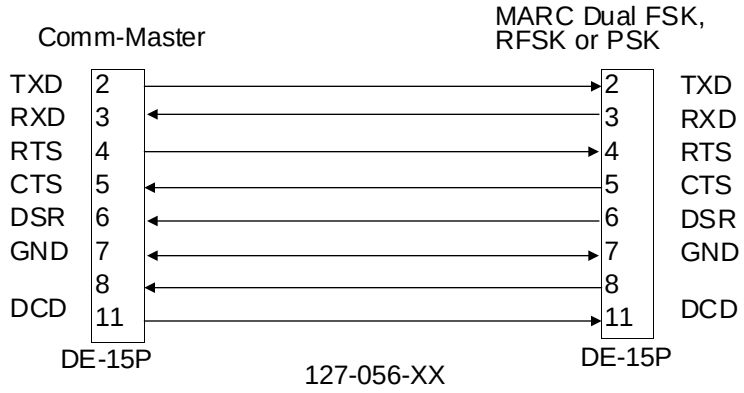


Figure 10 MARC DUAL FSK, RFSK and PSK Modem Connections

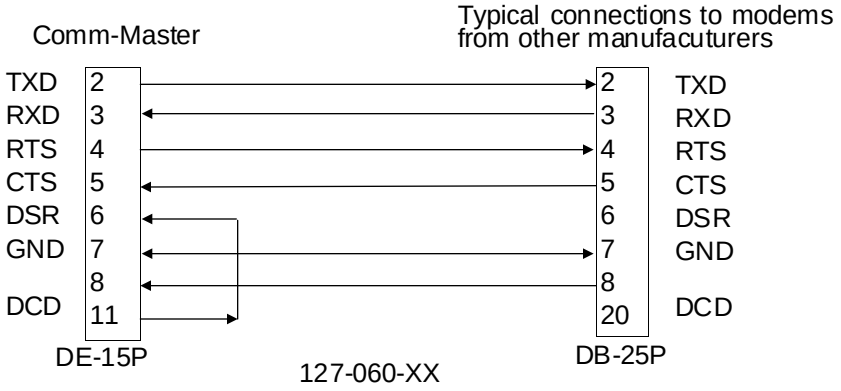


Figure 11 Comm-Master to other Modems (typical)

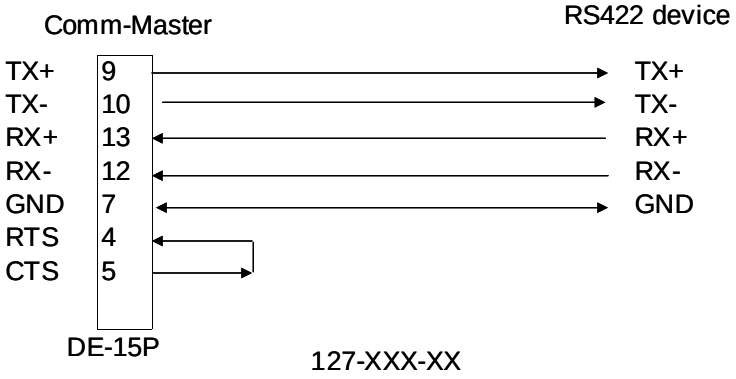


Figure 12 Comm-Master RS422 Connections

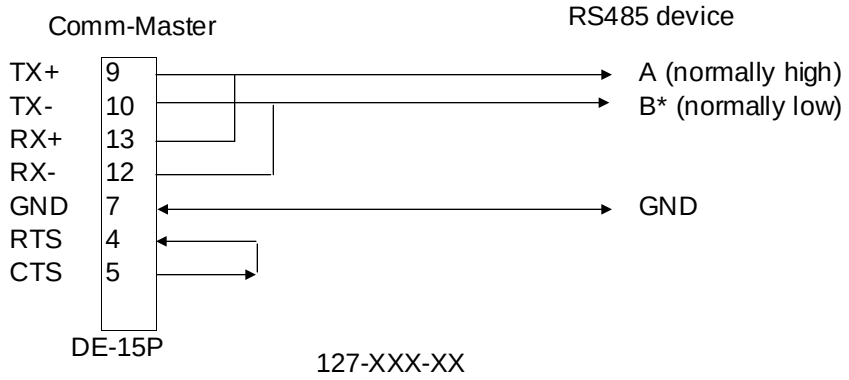


Figure 13 Comm-Master RS485 Connections

3.4 COMM-MASTER STATUS INDICATORS

The Comm-Master has seven (7) LED indicators located near the top of the module and visible through a slot in the module housing. These indicators provide status information for each of the serial interface ports. The LED's are numbered DS1 through DS7 starting from the top. Figure 12 defines the function for each of the LED indicators. Comm-Masters boards rev. D and above have an additional LED (DS8) located above DS1 which is used as a "heartbeat" LED and use the bottom LED (DS7) as an error indicator rather than as a Slave Processor Active light.

LED #	FUNCTION
DS8	Heartbeat (Rev. D and above)
DS1	Port P1 Receive Data
DS2	Port P1 Transmit Data
DS3	Port P2 Receive Data
DS4	Port P2 Transmit Data
DS5	Port P3 Receive Data
DS6	Port P3 Transmit Data
DS7	Slave Processor Active or ERROR for boards Rev. D and above

Figure 14 LED Indicators

3.5 INSTALLING PROGRAM CHIPS

The Comm-Master is a completely programmable device. The operation of each of the two microprocessors is controlled by programs stored in EPROM memory chips. Variable information for each processor is stored in Random Access Memory (RAM) chips. The type, size, and number of program chips is dependent on the application. The appendix for a specific protocol or application will contain the chip part numbers and jumper option selections. The Comm-Master is ordered and shipped with a specific protocol installed. The user does not normally need to install memory chips. This information is provided in the event that firmware updates require the changing of memory chips.

Each microprocessor has three (3) "Universal" memory sites. Each site can be used for RAM or EPROM type memory of various sizes depending on the jumper option selection. Locations U13, U23, and U30 are associated with the host side processor. Locations U16, U20, and U27 are connected with the Slave side processor. A seventh memory site (U37) is connected to both processors. Normally, sites U27 and U30 will be used with 8K x 8 RAM chips, and U13, U16, U20, and U23 will be used with 8K x 8 EPROM chips. Site U37 will always be used with a 8K x 8 RAM chip.

3.6 RS232/RS422/RS485 PORT SELECTION

All three ports of the Comm-Master can be operated in either RS232, RS422 or RS485 configurations. The mode of operation is determined by a combination of jumper selections and cable connections. Jumper J23 is used for port P1; Jumper J21 for port P2 and Jumper J24 for port P3. If the jumper is positioned from 2-3 the associated port will operate unsing RS232 drivers and receivers. Transmit and receive data lines should be connected to pins 2 and 3 of the connector. If the jumper is installed from 1-2 then the port can be operated in either RS422 or RS485 configurations depending on the cable connections used. For RS422 operation the transmit and receive signal lines will be connected to pins 9,10, 12 and 13 as shown in figure 12/ For RS485 operation the transmit and receive data wires are simply connected in parallel as shown in Figure 13.

3.7Allen-Bradley Interface Module Configuration

The Allen-Bradley Interface module must be configured for the type of communication network on which it will be used. The following table shows an example of the module switch selections for use with the Comm-Master.

1785-KE	1785-KE Series B	1771-KF	1771-KG
SW1-1 OFF	SW1-1 OFF	SW1-1 OFF	SW1-1 OFF
SW1-2 ON	SW1-2 ON	SW1-2 ON	SW1-2 ON
SW1-3 ON	SW1-3 ON	SW1-3 ON	SW1-3 ON
SW1-4 OFF	SW1-4 ON	SW1-4 OFF	
SW1-5 ON	SW1-5 ON	SW1-5 ON	SW2-1 OFF
	SW1-6 ON		SW2-2 ON
SW2-2 OFF		SW2-1 OFF	SW2-3 ON
SW2-3 OFF	SW2-1 ON	SW2-2 OFF	SW2-4 ON
	SW2-2 ON		SW2-5 ON
SW3-1 OFF	SW2-3 ON	SW3-1 OFF	
SW3-2 OFF	SW2-4 ON	SW3-2 OFF	SW3-1 OFF
SW3-3 ON	SW2-5 OFF	SW3-3 ON	SW3-2 OFF
	SW2-6 ON		
SW4-1 OFF	SW2-7 ON	SW4-1 OFF	SW4-1 OFF
SW4-2 OFF	SW2-8 OFF	SW4-2 OFF	SW4-2 OFF
SW4-3 ON		SW4-3 ON	SW4-3 ON
	SW3-1 ON		
SW5-1 ON	SW3-2 ON	SW5-1 ON	SW5-1 OFF
SW5-2 ON	SW3-3 OFF	SW5-2 ON	SW5-2 ON
	SW3-4 ON		SW5-3 OFF
SW6-1 OFF	SW3-5 ON	SW6-1 OFF	
SW6-2 ON	SW3-6 ON	SW6-2 ON	
SW6-3 ON		SW6-3 ON	
SW6-4 OFF	SW4-1 ON	SW6-4 OFF	
	SW4-2 ON		
	SW4-3 ON	SW7-1 ON	
		SW7-2 OFF	

Figure 15 Interface Module Switches

3.8 CONFIGURATION TABLE START ADDRESS SELECTION

The starting address of the configuration table is read by the Comm-Master at initialization . The address within the PLC which is read is defined by setting 3 rotary hex switches on the Comm-Master. The switches are accessible thru a slot in the cover of the module as shown in the figure below.

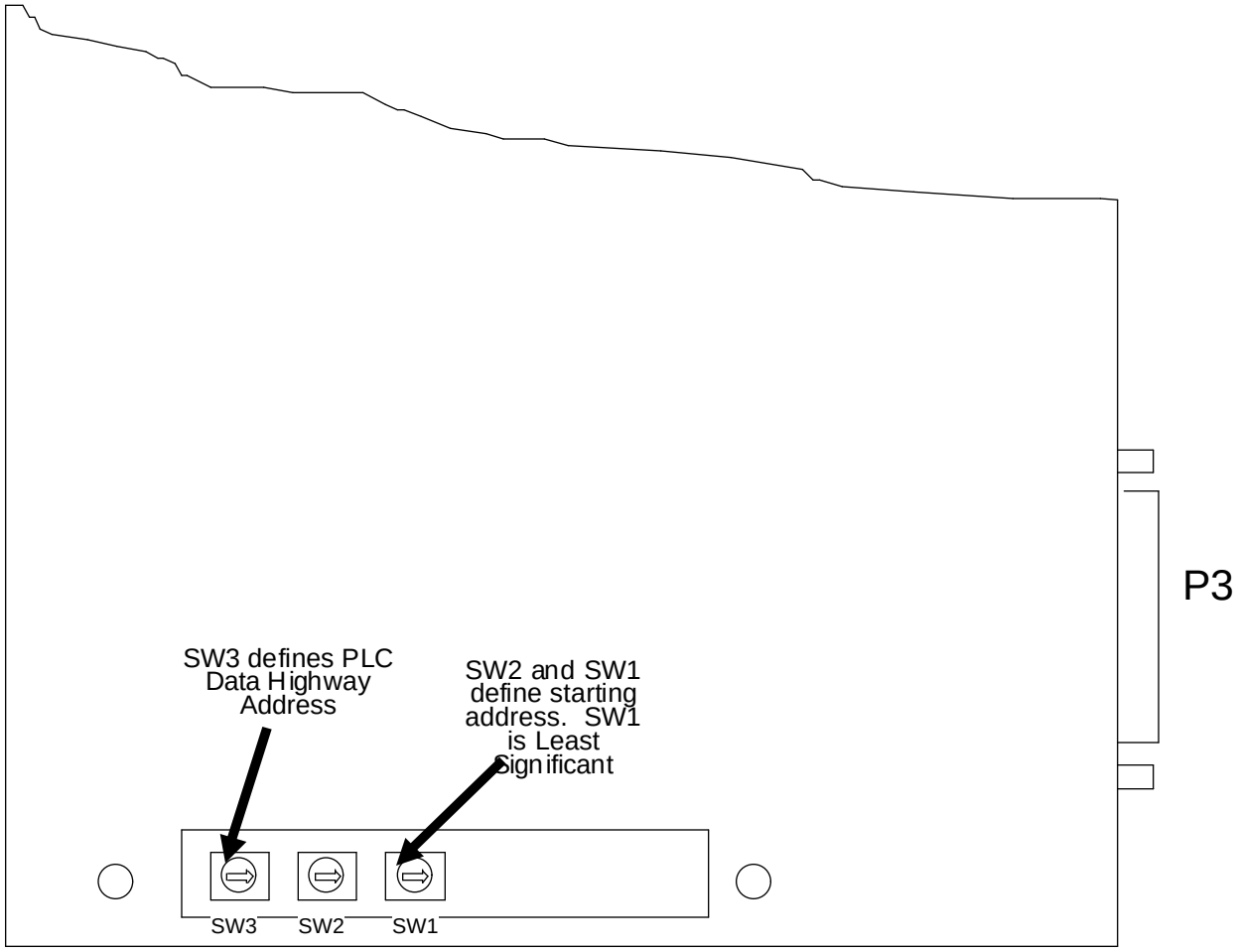


Figure 16 Address Selection Switches

COMM-MASTER OPERATING FUNCTIONS

4.1 OBJECTIVES

This section describes the operating functions of the Comm-Master and the methods used to accomplish the functions. Through custom programming by the manufacturer the Comm-Master is able to support many different SCADA protocols. The descriptions in this section apply to any SCADA protocol. Specific information on currently implemented protocols is supplied in the appendix.

4.2 GENERAL INFORMATION

The purpose of the Comm-Master as depicted in Figure 15 is to allow a PLC master to communicate to a network of remote devices (RTUs) using a SCADA protocol native to the remote devices. The primary purpose of the communications is to allow the master PLC to read the inputs connected to the RTUs and also change the outputs connected to the RTU. In order to accomplish this function the Comm-Master communicates to the remote devices in their native protocol and to the PLC in Allen-Bradley DF1 protocol. The Comm-Master determines a polling table for automatically retrieving data from the remote devices based on information read from the master PLC at initialization time.

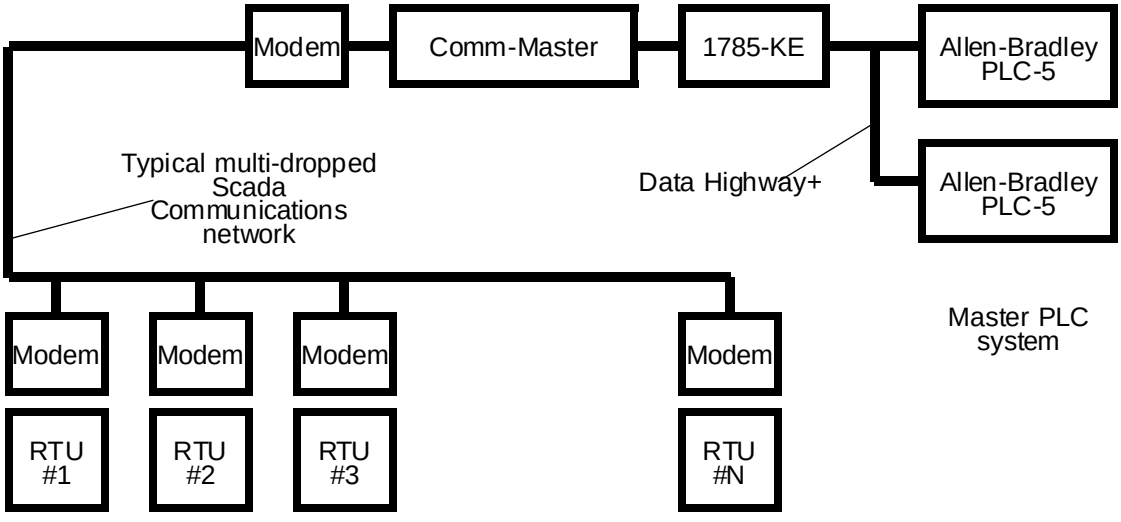


Figure 15 Functional Block Diagram

Figure 16 illustrates the primary functional software components of the Comm-Master and the associated Allen-Bradley PLC. These components fall into the following three categories:

- **Data storage sections of memory**
- **Software programs**

Figure 16 Software BLock Diagram

- **Data flow paths.**

The functional software components contained in the PLC consist of the following items:

- **A configuration data section defining parameters such as the number of polling table entries, the SCADA communication line baud rate and other communication details.**
- **Polling table entries specifing the location of the data to be collected, the rate at which the data will be collected, the place to store the data once received, error reporting words, time outs and other information required for operation.**
- **Ladder logic programs to analyze data moved in from the remote locations and Message instructions to control the remote devices.**

The functional software components of the Comm-Master can be broken down into three areas:

- **A data section containing the same configuration data as the PLC.**
- **A set of programs referred to as the "PLC side" which communicate with the PLC to move data collected from the remote devices into PLC memory and to relay Message instruction data on the specified remote.**
- **A set of programs referred to as the "SCADA side" which automatically poll the remote devices in a periodic fashion to collect data for the local master PLC. Control commands received from the master PLC are interpreted and a proper control message sent on to the specified remote.**

The Comm-Master provides two very important functions. First, it allows a standard PLC to collect data and send control requests to remote devices which do not use the protocol of the master PLC. Second, the Comm-Master performs its operation auotmatically, There is no ladder logic programming required in order to collect data from a remote device. Simple message instructions addressed to the Comm-Master are all that is required in order to control points in the remote device.

The remainder of this section describes each of the data sections and programs.

4.3 PLC SOFTWARE

The PLC software is supplied by the user. An understanding of it is necessary to appreciate the operation of the Comm-Master.

4.3.1 PLC Data Structures

The Comm-Master communicates with the programs in the PLC by reading data from and writing data into designated memory areas in the PLC. The PLC data structures are divided into two categories: configuration data and input/output data.

4.3.1.1 PLC Configuration Data

A configuration data section in the PLC defines the addresses and parameters necessary for the Comm-Master to communicate with the SCADA RTUs. The format of the configuration section allows a single Comm-Master to communicate with one or several PLC's. The start address of the configuration table and the configuration table itself are stored in the master PLC. The data highway address of the master PLC can be selected by setting SW3, a rotary HEX coded switch, on the Comm-Master to any data highway address from 1 to 17_{octal} (HEX 1 thru F).

The exact format of the configuration section depends on the SCADA protocol being used. A typical configuration data section is shown in Figures 19 and 20 (Chapter 5). This configuration section consists of two parts: a header which defines data common to all of the RTUs on the SCADA communication line and one data definition section per poll command which defines the location, size, polling frequency, time-out interval and other information for each piece of data that is to be collected.

4.3.1.2 PLC Input/Output Data

4.3.2 PLC Ladder Logic

4.4 COMM-MASTER SOFTWARE

The Comm-Master software is comprised of a data section, a set of programs which communicate with the PLC, a set of programs which communicate with the SCADA RTUs and a set of programs used to initialize the Comm-Master.

4.4.1 Comm-Master Data Structures

4.4.1.1 Comm-Master Configuration Data

4.4.1.2 Comm-Master Input/Output Data

4.4.1.3 Comm-Master Valid Data Bit Map

4.4.2 PLC Side Programs

The PLC side programs provide all communication with the PLC's in the local cluster. Messages between the PLC and the Comm-Master may be initiated by either the Comm-Master or the PLC.

The Comm-Master asynchronously writes the data collected from a remote device at the completion of each SCADA poll message. A status word is automatically updated to indicate the validity of the data collected.

Control commands are asynchronously passed to the Comm-Master from the PLC in the form of Message instructions issued from the PLC ladder logic programs. The Comm-Master extracts the data portion of a Message instruction, forms a control command for the SCADA network and saves it in a circular buffer. The Comm-Master then waits until the current SCADA message exchange is complete then issues the control command to the appropriate RTU. Success or failure of the control message to the RTU is not reported to the PLC.

4.4.3 SCADA Side Programs

The SCADA side software provides for all communications with the SCADA network. Most SCADA protocols require all communications between a host and a remote station to be initiated by the host. The Comm-Master is the host in this case so it initiates all communication transactions.

Polling requests are issued in a periodic fashion at the rate defined in the configuration section.

Returned messages are error checked for validity. Invalid messages are discarded. Messages with communication errors are retried one time.

Valid responses are processed by moving the data into the appropriate data section of the PLC.

4.4.4 Comm-Master Initialization

Upon power-up the PLC side of the Comm-Master will issue an unprotected block read to the master PLC at the data highway address specified by SW3. The read will be for 2 bytes starting at a byte address specified by switches SW1 and SW2. The memory location, which is called the Configuration Table Pointer that is specified by the switches is computed by multiplying the switch setting by 10_{HEX} and adding 4. The contents of this word must contain the starting byte address of the configuration data

section in PLC memory. A block read for 20 words starting at the configuration section start address will then be issued. This will read the fixed length portion of the configuration section including the number of polling table entries defined. Based on this number a block read for the remainder of the configuration section will be issued. The polling table will be established and the Comm-Master will begin to poll the RTUs.

If the PLC side of the Comm-Master does not receive valid responses to the requests for configuration data it will continuously retry the request. This cycle will be repeated until a valid response is received. If the configuration table does not contain valid data an error word will be written to the master PLC.. The error word will be stored in the word immediately following the Configuration Table Address Pointer word. For example if the switches on the Comm-Master module are set at A12 then the configuration table start address will be read from location 0124_{hex} of PLC A and the error word stored at location 0126_{hex}. The high byte of the error word will be a copy of the STS field in the message returned from the PLC (or RS-232 Interface Module). The low byte will contain error information originating within the Comm-Master itself. Figure 18 details the error byte bit definitions. The Comm-Master switch selections are in hexadecimal notation. Switch 3 with need to be converted from a hexadecimal number to an octal number for use on the data highway. Likewise switches SW1 and SW2 specify a **hexadecimal byte** address. This must be converted to the appropriate PLC memory address. PLC-2 systems use an **octal word** addressing scheme whereas the PLC-5 uses a **decimal word** addressing format. See Section 5.2.2 for additional details and an address selection example.

ERROR	DESCRIPTION
00000000	No Errors Found
00000001	Indexing Error in Xmit/RCV Handlers
00000010	Error In a Table
00000100	Receive Buffer Overrun
00001000	Master/Backup PLC's Swapped
00010000	Illegal PLC Address In Receive Message
00100000	Error In Configuration Information
01000000	Insufficient Data Returned From Poll
10000000	Illegal Write to Protected Memory in PLC

FIgure 17 PLC Error Word

Upon successful completion of initialization the SCADA side of the Comm-Master will begin its normal operation. Polling requests will be issued to the remotes and the data collected passed to the PLC side for subsequent insertion into PLC memory. Message instructions received from the PLC will be intrepreted and the proper command issued to the RTU from the SCADA side.

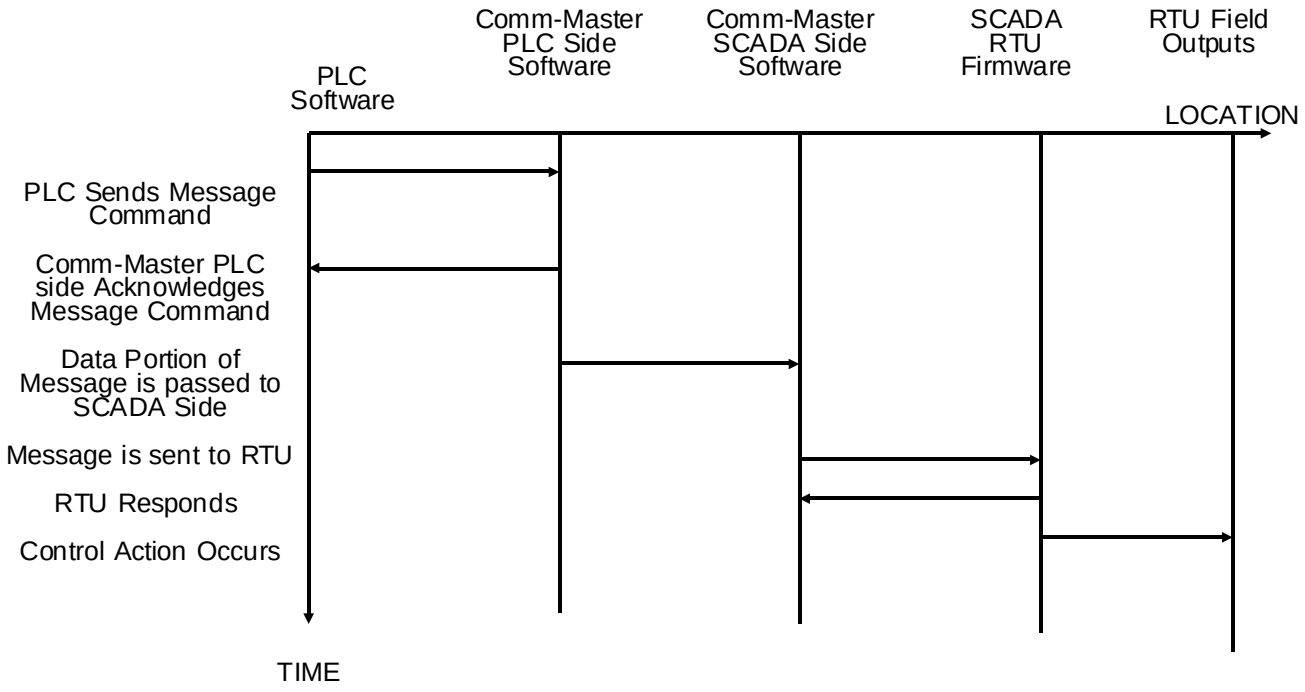


Figure 18 Command Message Sequence

4.5 ALLEN-BRADLEY PROTOCOL

4.5.1 General Description

Communications between the Comm-Master and the Allen-Bradley interface module use the Allen-Bradley DF1 master/slave full-duplex protocol. The 1771-KF, 1771-KG and 1785-KE modules all use the same protocol, are addressed the same by the Comm-Master and respond the same to poll requests. This protocol operates at a fixed I/O configuration of 9600 baud 8 data bits 1 stop bit and no parity.

PLC CONFIGURATION TABLE

5.1 OBJECTIVES

This section describes the data structure in the Allen-Bradley PLC which defines the operation of the Comm-Master. This description is general in nature and applies to all Comm-Master models, regardless of the specific SCADA communications protocol used. Specific information and an example configuration table for each protocol can be found in the appropriate appendix.

5.2 DATA STRUCTURES

The Comm-Master transfers data into data structures which reside within the PLC(s). In multi-PLC configurations each PLC may contain a data area which is accessed by the Comm-Master. In addition to the data areas there is a configuration area which resides in only one of the PLC's (the master PLC) regardless of the number of PLC's in the cluster.

5.2.1 Configuration Section

The configuration section contains information defining the environment of the Comm-Master as it relates to the SCADA network and information as to the number, type and frequency of the poll requests that will be issued. This section contains such information as the data highway address of the RS-232 interface module connected to the Comm-Master, the number of polling table entries, SCADA communication line parameters such as baud rate, parity and stop bit information, RTS/CTS delay times, radio "hold time" and other information. A block of memory is defined for each polling message on the SCADA network. Such data as the address of the RTU, the amount of data to be collected and the data collection frequency, the location reserved for storage of the data once received, error word definition, message time out specification and several other parameters.

The exact format of the configuration section will differ depending on the communication protocol used on the SCADA side of the Comm-Master, however general guidelines apply to all configuration tables.

The configuration section resides in only one PLC regardless of the number of PLC's in the local cluster. The master PLC containing the configuration section is defined by SW3 on the Comm-Master module. The configuration section start address is not fixed and must be defined for each application. The starting address of the configuration table is defined by a "Pointer Word" somewhere in PLC memory. The pointer word is defined by two (2) rotary HEX switches on the Comm-Master. The switches are set to reference a PLC Data Table BYTE address which contains the actual BYTE address of the beginning of the Configuration Section. The address switches are used to select two digits of the configuration table address pointer word. The most significant and the least significant digits of the address are fixed at 0 and 4 respectively.

5.2.2 PLC Addressing

Before a configuration table can be built for any application it is necessary to understand how the hex byte addressing used by the Comm-Master switch settings relate to PLC addressing. This relationship differs between the PLC-2 and PLC-5 families of Allen-Bradley processors.

5.2.2.1 PLC-2 Addressing

The PLC-2 Processors all have one data storage area called the Data Table. The size of this area is defined by the user based on his requirements. Portions of the Data Table in PLC-2 Processors are dedicated and cannot be used for the configuration table or data storage. The Allen-Bradley Programming Manual for the particular processor in use should be consulted for further details on the processor memory organization. In general the Comm-Master configuration table and data storage area should reside below any portion of the Data Table used for application programming. Additional space should be allotted when assigning the Data Table addresses to allow for future expansion. The **PLC-2** family uses **OCTAL WORD** addressing for the Data Table. A conversion to **HEX BYTE** addressing is therefore required. As an example, if the Comm-Master switches are set to A23 (A= PLC Data Highway address) the configuration table start address pointer will be read from location 0433_8 in PLC 12_8 on the data highway. The calculations are as follows:

- **Hex Byte Address of Table pointer = 0234_{16} (023_{16} X 10_{16} + 4_{16})**
- **Octal Byte Address= 1064_8 (234_{16} = 1064_8)**
- **Octal Word Address = 0432_8 (Byte Address /2)**

5.2.2.2 PLC-5 Addressing

The PLC-5 processors utilize a file structure for the Data Memory organization. The first nine data files have a default type designation which cannot be modified. The file type and size for the remaining data area is user defined. The file numbers can range from 9-999. Each file can be from 1 to 1000 elements. The PLC-5 manual has further details concerning file number assignments, sizing and use. The Comm-Master can only access one file in the PLC-5 Data Memory for configuration data. The file which is accessed is determined by the Station Address Switches on the RS-232 Interface module. Normally this module address is set to 11_8. Since the file numbers are in decimal the Comm-Master will be accessing file 9 ($11_8 = 9_{10}$). An additional conversion must also be made since the word addressing within the file is zero based decimal and the Comm-Master addresses are in Hex bytes. For example, if the Comm-Master switches are set to A23 it will attempt to read the configuration table pointer word from file #9 word 283 in PLC 12_8. The calculations are:

HEX byte address= 0234 (0230_{16} X 10_{16} + 4_{16})

Decimal Byte address = 0564_{10}

Decimal Word address = 0282_{10}

5.2.3 Polling Table Entries

The format of the polling table entries differs depending on the SCADA communication protocol utilized. A separate table exists for each poll message to be issued.

5.3 TYPICAL CONFIGURATION SECTION

WORD (BYTES)	DESCRIPTION
0 (0,1)	Interface Module Data Highway Address, Number of Polling Tables
1 (2,3)	Radio Turn-on Delay (10 ms per count)
2 (4,5)	Radio Turn-off Delay (10 ms per count)
3 (6,7)	Spare
4 (8,9)	SCADA Port Baud Rate, SCAD Port # Data Bits
5 (10,11)	SCADA Port Parity, SCADA Port Stop Bits
6 (12,13)	Reserved
7 (14,15)	Reserved,
8 (16,17)	SCADA Protocol Options (See Appendix)
9 (18,19)	SCADA Protocol Option, Reserved
10 (20,21)	Radio Key Address
11-19 (22,39)	Spare

* Baud Rate Code: 4=300, 5=600, 6=1200, 7=1050, 8=2400, 9=4800, A=7200, B=9600
** Parity Code: 0 = None 1 = Odd 2 = Even

Byte 0	Byte 1

PLC WORD

WORD (BYTES)	FUNCTION
0 (0,1)	RTU Address, Remote Type or Modbus Function Code
1 (2,3)	Data Point Count
2-5(4-11)	Data Source Address
6 (12,13)	Data Destination PLC Data Highway Address, Destination PLC Type
7-10 (14-21)	Data Destination Address
11 (22,23)	Scan Update Interval (10 ms per count)
12 (24,25)	Message Time Out Time (10 ms per count)
13 (26,27)	Reserved
14-17 (28-35)	Poll Message Error Address
18,19 (36-39)	Spare

Figure 20 Typical Polling Table Entry

IMPLEMENTATION OF SCADA PROTOCOLS

The Comm-Master uses software routines stored in EPROM to emulate different SCADA Host communication protocols. The routines may be executed in either the host side processor or the PLC side processor depending on the particular requirements of the protocol. The RTUs are continuously scanned for data based on information read from the PLC configuration tables during initialization. Refer to Section 4.0 for more details on communication with the PLC. The data collected is placed into a dual-ported memory area where it is available to either processor. When a RTU responds to a poll request with information it is passed to the PLC side processor via the dual-ported memory. The PLC side programs in turn write the data to the specified destination PLCs memory. The appendix to this manual contains specific information concerning the PLC configuration, EPROM part numbers and other information necessary for the specific SCADA protocol supplied.

MAINTENANCE AND TROUBLESHOOTING

7.1 GENERAL

The Comm-Master is constructed using modern integrated circuits soldered onto a printed circuit board. These components can be destroyed by improper soldering and handling procedures. Therefore maintenance and troubleshooting of the Comm-Master module should be limited to verification of proper option selections, proper EPROM program installation, correct PLC configuration table entries and cable connections. The Comm-Master does not include any user-accessible troubleshooting and diagnostic aids other than the LED's described in Section 3.4 and below. If the Comm-Master fails to function please contact a manufacturer's service representative for help.

7.2 STATUS LEDs

A good deal of information can be obtained by close observation of the LEDs located on the front of the Comm-Master. In normal operation the Port 1 LEDs (DS1 and DS2) or Port 3 LEDs (DS5 and DS6) will blink in a very regular manner depending on the polling table entries. The pair of LEDs that are active depend on the type of SCADA protocol that the Comm-Master is emulating. The Appendix will define the port that is used for each type of SCADA protocol. DS2 (DS6), the transmit LED will be on when the Comm-Master is sending information to a remote (poll message); DS1 (DS5) will be on when the RTU responds with the requested data. During normal operation the Comm-Master periodically polls each RTU for its data resulting in a very regular "cadence" of the blinking LEDs. As soon as the Comm-Master receives a reply it will immediately write the data to PLC memory. This transaction can be observed by watching LEDs DS3 and DS4. DS4 will be on when the Comm-Master sends the data to the PLC, DS3 should blink quickly when the PLC accepts the data. If an error occurs, the Comm-Master will attempt to write an error word back to the PLC in place of the data it should have received. All communication attempts are timed. Should any RTU fail to respond or if the SCADA communications channel fails. entirely there will be a noticeable delay between PLC write data transactions. Also, DS1 will not blink if the RTU does not respond.

A common error condition which occurs when the Comm-Master is first installed is an error in the configuration table information. When this occurs, the Comm-Master can never get to its normal polling mode of operation and the regular cadence will not be observed. When power is cycled, the Comm-Master attempts to read the configuration information from the master PLC.. The transmit and receive LEDs will blink for each block of configuration data read. The first block read is the starting address of the configuration table as defined by the address selection switches on the Comm-Master (see section 3.7 and in the appropriate Appendix for the

communication protocol being implemented). Next the Comm-Master will read the configuration table header, followed by the configuration polling table data. If an error is detected anywhere in this operation the initialization process is aborted and an error word will be written back to the PLC. After the error word is sent, the Comm-Master immediately returns to the start of the initialization sequence and starts over again. This results in a very rapid blinking of the transmit and receive LEDs (DS3 and DS4) on the front of the Comm-Master.

7.3 MAINTENANCE MANUAL

For advanced users, a complete maintenance manual is available which includes a complete description of the Comm-Master hardware, Parts Lists and Schematics. Contact the manufacturer for details on the Comm-Master Maintenance Manual.