

TRW2000 PROTOCOL EMULATION

1.1 GENERAL DESCRIPTION

This section briefly describes the TRW2000 communication protocol for reference purposes only. The appropriate TRW documentation should be consulted for complete details of the TRW2000 protocol.

The TRW2000 standard protocol is bit synchronous protocol designed to connect a TRW compatible RTU to a host computer communication port. The protocol may be used either in a point-to-point or in a multi-drop configuration. The protocol can be used in either half or full-duplex operation. A TRW2000 message consists of one or more multiple frames of data where each frame has a maximum of 14 bytes of information. Each frame can vary in length with respect to the number of bytes, but will always contain a byte count to define its length. The first frame of data is preceded by a preamble which is excluded from the byte count. Each frame contains an eight bit Bose-Chaudhuri-Hocquenghem (BCH) code for error detection.

All communications exchanges in TRW2000 protocol are initiated by the host. The remote cannot initiate any exchange with the host nor can the remote directly address or communicate with another remote. The remote will return a response to the host for all valid messages sent by the host and addressed to the remote except when the universal station address is used (broadcast), or a unit reset command or a D/A immediate operate command is received. Also, all messages received by the remote are validated by checking the Station Number (RTU Address) and BCH. If these bytes are not valid, the remote will ignore the message; no action or response will be initiated.

Typical Request

Preamble	Byte Count with parity	RTU Address	Command	Command Descriptors	BCH
8 bits	5 bits	5 bits	6 bits	0,8,16 or 24 bits	8 bits

Basic Response

Preamble	Byte Count with parity	RTU Address	Unit Status	BCH
8 bits	5 bits	5 bits	6 bits	8 bits

Figure E-1 Typical TRW2000 Message

1.2 REMOTE TO MASTER DATA RESPONSE

If the command received by a TRW2000 RTU requests information the basic response is extended to include the data requested. The maximum length of any frame is 14 bytes. If more information is requested than will fit in a 14 byte frame, additional frames are appended to send the remaining data. All frames except the last frame are 13 or 14 bytes in length. Figure E-2 below shows the remote to master data response.

Typical Request

Preamble	Byte Count with parity	RTU Address	Command	Command Descriptors	BCH
8 bits	5 bits	5 bits	6 bits	0,8,16 or 24 bits	8 bits

First Frame

Preamble	Byte Count with parity	RTU Address	Unit Status	Data	BCH
8 bits	5 bits	5 bits	6 bits	0 to 96 bits	8 bits

Additional Frames

Byte Count with parity	Frame ID	Data	BCH
5 bits	3 bits	8 to 104 bits	8 bits

Figure E-2 TRW2000 Data Response

1.3 FIELD DESCRIPTIONS

The TRW2000 message format is made up of a number of fields. Some of these fields appear only in the master to remote messages, some appear only in the remote to master messages and others appear in both. The following paragraphs further describe each field.

1.3.1 Preamble

The preamble portion of the message consists of eight bits to define the beginning of a message and also for synchronization of the timing circuits at the receiving unit. The bit pattern is 11111110 in the master to remote message and 11111101 in the remote to master message. The preamble only appears at the beginning of the first frame and not between frames.

1.3.2 Byte Count

The byte count field is the first 5 bits (excluding preamble) in all frames. The count includes each byte of information in the frame except the Preamble and the BCH. Because of the message protocol, a byte count of 0, 1 and 15 are invalid. An odd parity bit is the fifth bit of this field.

1.3.3 RTU Address

The RTU address field is 5 bits in length. It is used to designate a unique RTU in party-line applications. RTU address 0 is never used. RTU address 31 is used as a "universal station address" which all remotes on the line will accept. Unique addresses thus range from 1 thru 30.

1.3.4 Remote Unit Status

The remote unit status field consists of six bits of information pertaining to the remote unit. The first frame in all remote to master messages always contains this field. The bits are defined as shown in figure E-3 below.

Remote Unit Status Bits

Last Frame Indicator	RTU Restart	Status Change Flag	Field Power Loss	Internal Status Error	Status Acknowledge Request
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Figure E-3 Remote Unit Status

1.3.5 Command

The command field exists only in the master to remote message and can have additional descriptors associated with it. The field is 6 bits in length. Figure E-4 details the commands that have been implemented in this TRW2000 emulation.

Command-Modifier	Description
0001-00	A/D Dynamic Information Request (first 128 points)
0001-01	A/D Dynamic Information Request (2nd 128 points)
0011-01	Status Information Request (non latching)
0100-11	Report by Exception
0110-01	Accumulator Information Request (current value)
0111-10	Accumulator Clear
1000-00	D/A Select before Operate
1000-01	D/A Operate after Select
1000-10	D/A Immediate Operate
1001-00	Relay Controls Select before Operate
1001-01	Relay Controls Operate after Select
1110-11	Status/SOE Change Acknowledge
1111-00	Reset RTU
1111-01	Request Internal Status
1111-10	Reset Internal Status

Figure E-4 TRW2000 Commands

1.3.6 Frame Identification

The three bit frame identification field follows the byte count of the second and all succeeding frames. The bits are defined as shown in Figure E-5 below.

Last Frame Indicator	Command Change Bit	Frame Sequence Bit
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Figure E-5 Remote Unit Status

1.3.7 Data

Data consists of all information transmitted to and from an external I/O device.

1.3.8 BCH

A Bose-Chaudhuri-Hocquenghem 8-bit cyclic code is used for error detection. The generator polynomial for the TRW2000 protocol is $x^8 + x^7 + x^6 + 1$

1.3.9 Zero Bit Insertion

If a sequence of data after the preamble consists of six "one" bits a zero bit can be optionally inserted. This implementation of the TRW2000 protocol **does not implement the zero bit insertion feature.**

1.4 MESSAGE TYPES

TRW2000 protocol communications exchanges can be divided into two types: information requests and control requests. In information requests, the host transmits a message requesting data values from the remote. The remote responds by transmitting the requested data values. These data values may be discrete (status), analog, accumulator, report by exception data or RTU internal status. The format of the data types are as required by the host. Some variations may exist from site to site provided the host and remote are consistent in the data format (e.g. if the host expects BCD accumulator values, the remote must transmit BCD accumulator values). Note that the Comm-Troller does not do any processing on the data collected from the PLC. The PLC ladder logic must perform any data formatting that is required prior to placing the information in the data area which is read by the Comm-Troller.

Control requests are defined as any message from the host requesting the remote to change the state of a field device or to change or modify an internal condition of the remote. Control requests are used to change the state of an output, either digital or analog. All digital controls use a select before operate sequence. Analog outputs can be either select before operate or immediate operate commands.

1.5 TRW2000 CONFIGURATION TABLE

The following sections describe the configuration table used to define the operation of the Comm-Troller with TRW2000 protocol. The Configuration Table is located in the first PLC on the data highway. This PLC must have an address of 0A_{HEX} (012_{OCTAL}). If a PLC2 is used the Configuration Table can be located anywhere within the PLC memory. If a PLC5 is used then the Configuration Table must be located in a file which has the same address as the RS232 Interface device (1785 KE or 1771 KF2). The Configuration Table consists of at least two sections: a Configuration Header and a Configuration Data section. The Configuration Data section is repeated for each PLC connected on the data highway. Up to 8 PLCs can be connected to a single Comm-Troller. The Configuration Table Data Section(s) immediately follow the Configuration Table Header. The start address of the Configuration Table Header is defined by a pointer word which can be located on any HEX byte address which is divisible by 10_{HEX}. The pointer word is addressed by setting three rotary switches located on the Comm-Troller. The following paragraphs further define each of the fields of the Configuration Table. In the following definitions the table locations are specified as byte addresses. In this case the even bytes (0,2,4,6 etc.) are the left-half of the PLC word and the odd bytes (1,3,5,7 etc.) are the right-half of the PLC word.

1.5.1 TRW2000 Configuration Header

Byte # 0 in the configuration header is used to define the RTU address to which the Comm-Troller will respond when communicating with the host. This entry is an 8-bit binary number in the range of 1 to 30 (00000000 to 00011110).

Byte # 1 is used to define the number of PLCs in the system. This entry is a 4 bit binary number which is right justified in the byte. The valid range for this number is from 1 to 8 (00000001 to 00001000). The Comm-Troller will use this number to determine the number of PLC Configuration blocks to read.

Bytes # 2 and 3 are reserved for use as a Radio Delay Timer. The current implementation of the TRW2000 protocol in the Comm-Troller ignores these bytes.

Byte # 4 is used to define the baud rate which will be used while communicating with the host. This entry is a binary number which is right justified in the byte. Valid selections are: 300 baud (00000100), 600 baud (00000101), 1200 baud (00000110), 2400 baud (00001000), 4800 baud (00001001) and 9600 baud (00001011).

Bytes # 5 thru 14 are not recognized by the Comm-Troller for the TRW2000 protocol. Set all bytes to zero.

APPENDIX E

TRW2000 PROTOCOL EMULATION

Byte # 15 is the PLC "SWAP" enable flag. If this byte is non-zero any failure detected by the Comm-Troller while communicating with the PLC will result in an automatic switch-over to a backup PLC. The backup PLC must have exactly the same configuration information as the primary PLC and be installed on the same data highway as the primary PLC. The backup PLC address must be address 0B_{HEX}. If the backup PLC subsequently fails the Comm-Troller will attempt to switch back to the primary unit. If this byte is zero then a switch will not be attempted.

BYTE	DESCRIPTION
0	RTU Number
1	Number of PLC's
2,3	Not Used
4	Baud Rate
5,14	Not Used
15	PLC Swap Enable Flag
16,17	RTS/CTS Delay Time 6.3us/cnt
18-49	Not Used

Figure E-6 Configuration Header

BYTE	DESCRIPTION
0	PLC Address
1	# Bytes per Digital Input Card
2	# Digital Input Cards
3,4	Start Address for Digital Inputs
5	# Bytes per Analog Input Card
6	# Analog Inputs
7,8	Start Address Analog Inputs
9	# Bytes per Accumulator
10	# Accumulators
11,12	Start Address Accum. Inputs
13	# Bytes per Digital Output Card
14	# Digital Output Cards
15,16	Start Address Digital Outputs
17	# Bytes per SBO Analog Output
18	# SBO Analog Outputs
19,20	Start Addx. SBO Analog Outputs
21-24	Not Used (must be zero)
25	# Bytes per Direct Analog Output
26	# Direct Analog Outputs
27,28	Start Addx. Direct Analog Outputs
29	# Bytes per Special Function
30	# Special Functions
31,32	Start Addx. Special Functions

Figure E-7 PLC Data Section

Bytes 16, and 17 are used to specify the RTS/CTS delay time. The delay time will be set to a value equal to 6.313 usec times the number entered in bytes 16 and 17.

Bytes # 18 thru 49 are not used for the TRW2000 Comm-Troller and should be set to zero.

1.5.2 PLC Data Configuration for TRW2000 Protocol

The PLC Data Configuration section(s) are each 57 bytes long. There is one section for each PLC connected to the Comm-Troller. The number of PLCs and thus the number of configuration sections to read is defined by byte # 1 in the header section of the configuration table.

Byte # 0 is used to define the address of the PLC on the Data Highway. The first PLC must be at address 0A_{HEX}. The Comm-Troller is restricted to reading a maximum message of 240 bytes from each PLC. If more than 240 bytes of data are required up to 4 logical PLCs can be defined by setting the upper two bytes of the PLC address as follows: 0A= first logical PLC, 4A= 2nd logical PLC, 8A= 3rd logical PLC and CA= 4th logical PLC.

Byte # 1 is used to define the number of bytes of data for each status input card. Normally it will be set to 2 because each input card in an Allen-Bradley PLC provides 16 bits of status information. In special applications however, PLC ladder logic could be used to form "cards" of any width.

Byte # 2 is used to define the number of status input cards associated with this PLC. A maximum of 128 bytes (1024 points) of status input information can be defined per Comm-Troller.

Bytes # 3 and 4 define the starting address in the PLC for the status input data.

Bytes # 5, 6, 7 and 8 are used in a similar fashion to define the analog input cards for the PLC. A total of 512 bytes (256 inputs) of analog input information can be defined per Comm-Troller.

Bytes # 9, 10, 11 and 12 are used to define accumulator inputs. A total of 256 bytes of accumulator information can be defined per Comm-Troller. Normally TRW2000 accumulators are 4 bytes in length each, giving a maximum capability of 64 accumulators.

Bytes 13, 14, 15 and 16 are used to define control outputs. A total of 128 bytes (1024 points) of control output information can be defined per Comm-Troller

APPENDIX E

TRW2000 PROTOCOL EMULATION

Bytes # 17, 18, 19 and 20 are used to define Select Before Operate (SBO) analog outputs. A total of 96 bytes (48 points) of analog output information can be defined per Comm-Troller.

Bytes # 21 thru 24 are not used in the TRW2000 Comm-Troller. They must be set to zero.

Bytes # 25, 26, 27 and 28 are used to define Immediate Operate (DO) analog outputs. A total of 128 bytes (64 points) of immediate operate analog outputs can be defined per Comm-Troller.

Bytes # 29, 30, 31 and 32 are used to define a special function control word. This control word is used to reset specified accumulators in the PLC. The number of bytes is always 2, and the number of special function control words is always 1 for the TRW2000 application. Currently there is only one bit defined in the special functions field. Bit 0 will be set whenever accumulators are to be reset.

Bytes # 33 thru 56 are not used in the TRW2000 Comm-Troller. Set all bytes to zero.

1.6 JUMPER SELECTIONS FOR TRW2000 PROTOCOL

The Comm-Troller jumper selections and EPROM part numbers for TRW2000 protocol operation is detailed in the following figure.

JUMPER	POSITION	JUMPER	POSITION
J2	1-2	J10	1-3, 11-13,
J3	1-2		4-8,6-10
J4	IN	J11	1-2
J5	OUT	J12	1-2
J6	1-2	J13	1-2
J7	1-2	J14	1-2
J8	1-2	J15	1-2
J9	1-2	J16	1-2
		J17	1-2

TRW2000 Protocol Communication is on Port P3 (bottom port), Allen-Bradley Communication is on Port P2 (center port)

U13 = # 148-002-1 (10/31/89)

U16 = # 148-004-1 (10/31/89)

Figure E-8 Jumper Option Selections

1.7 SERIAL PORT CONNECTIONS FOR TRW2000

Because of special requirements in interfacing using the TRW2000 protocol custom features in the Comm-Troller are enabled in order to communicate with the SCADA host. Specifically options are enabled which will invert the incoming data line. This requires that the cables used to connect to the TRW2000 port (port P3) be wired differently than "standard cables" as shown in section 3 of the Comm-Troller Users Manual. The TRW2000 pin definitions for port P3 are as shown in Figure E-9 below.

PIN	SIGNAL NAME
1	GND Signal Ground
2	TXD Transmit Data (output)
14	RXD Receive Data (input)
4	RTS Request To Send (output)
5	CTS Clear To Send (input)
7	GND Signal Ground
8	DCD Data Carrier Detect (input)
11	DTR Data Terminal Ready (output)
15	Inverted Received Data

Note: pin 15 must be connected to pin 3 by the interface connector.

Figure E-9 Port P3 Pinouts

1.8.2 Example Table Entries

PLC WORD (HEX)	VALUE		PLC WORD	VALUE (HEX)	
296	258	Configuration Table Pointer = 286 (error location = 297)	325	0A02	1st PLC Address = 0A
300	0103		326	1000	
301	0000	RTU Address= 1	327	0002	256 Status (10 _{HEX} 2-byte entries)
302	0600		328	6000	
303	0100	3 PLCs (1 physical PLC, 3 logical PLCs because of the amount of data to be transferred)	329	2000	96 Analog Inputs (60 _{HEX} 2-byte
304	0000		330-352	0000	
305	0000	1200 baud	353	004A	2nd PLC Address = 0A
306	0000		354	0000	
307	0000	20msec RTS/CTS delay	355	0000	62 Analog Inputs (3E _{HEX} 2-byte entries)
308	0C60		356	023E	
309 - 324	0000		357	00E0	20 Accumulators (14 _{HEX} 4-byte entries)
			358	0414	
			359	015C	96 Control Outputs (6 2-byte entries)
			360	0206	
			361	01AC	3rd PLC Address = 0A
			362-381	0000	
			382	8A00	42 Immediate Operate Analog Outputs (2A _{HEX} 2-byte entries)
			383-393	0000	
			394	0002	1 2-byte Special Function Word
			395	2A01	
			396	B802	
			397	0102	
			398	0C00	
			399-410	0000	

Figure E-11 Example Table Entries