

REFTEK™

RT422C-B02 Asynchronous Serial Communications Card

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RT422C-B02 Asynchronous Serial Communications Card

Overview

The RT422 *Asynchronous Serial Communications Card* provides IP network connectivity for the REF TEK 72A Data Acquisition System (DAS) via Point-to-Point Protocol (PPP) connections over asynchronous links. The RT422 also provides the ability to communicate with the network using FreeWave digital spread-spectrum radios in their Multipoint configuration.

The RT422 implements the *REF TEK Protocol (RTP)*¹ at the application layer over User Datagram Protocol (UDP)/Internet Protocol (IP) at the transport and network layers and PPP at the data link layer. The card is equipped with an Electronic Industries Association (EIA)/Telecommunications Industry Association (TIA)-232-E (RS-232) asynchronous serial interface and can connect at speeds up to 57.6 kilobaud.

The RTPD (a server) software is used to serve many DASs equipped with RT422s. This software is available on various platforms and in conjunction with user interface software, provides the operator with command and control functions for the DASs. RTPD provides data to client applications and can load an on-line archive as well. Please refer to the *RTPD Installation & Users Guide* for more information about the server software and tools.

It has been our goal to strictly adhere to the various standards for the IP protocol family in this implementation to provide interoperability with all standard network hardware. The implementation is based on a five-layer architecture shown in Figure 1.

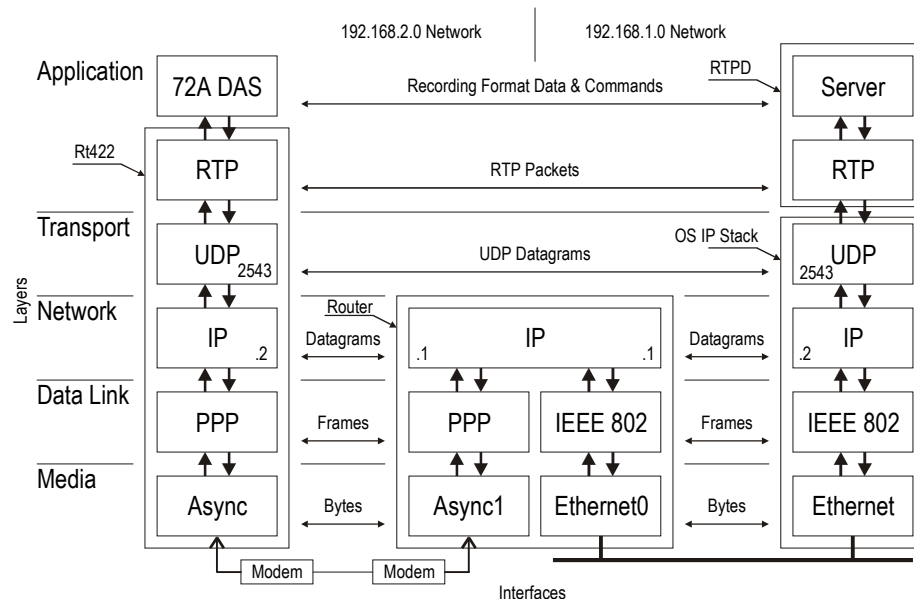


Figure 1. Schematic View of a Typical RT422 Network Connection

¹ See the REF TEK Protocol (RTP), Rev 1.0, Refraction Technology, Inc, November 1998.

At the application layer, RTP is used to provide error-free packet service to the application, in this case, the DAS. The RTP implementation is completely self-contained in the RT422 and it does not impact the operation of the DAS. RTP provides a robust server discovery mechanism to find the server using UDP broadcasts and there will be issues concerning forwarding these packets if the RT422 and the server are on different networks. Please refer to the RTP manual for detailed treatment of RTP and networking issues.

At the transport layer, only UDP is implemented by the RT422. All other protocols are discarded at the transport layer (i.e., Transmission Control Protocol [TCP]).

At the network layer, IP and Internet Control Message Protocol (ICMP) are implemented. The ICMP implementation provides echo request processing so that IP applications such as ping and traceroute will function correctly. No other network protocols are implemented. Anything other than IP and ICMP packets are discarded at the network layer.

At the data link layer PPP, Link Control Protocol (LCP), IP Control Protocol (IPCP) and Password Authentication Protocol (PAP) are implemented. Once LCP has established the connection IPCP is used to bring up the network layer. The peer must assign an IP address to the RT422 during the IPCP negotiation. We have implemented PAP to allow a basic level of security at the peer. The RT422 will respond to PAP authentication requests from the peer. The user name and password sent by the RT422 will always be `das#nnnn`, where `nnnn` is the four digit unit ID number of the DAS that contains the RT422 card. The RT422 does not require PAP authentication from inbound connections.

Interface Requirements

As stated above, the asynchronous serial interface implemented on the RT422 is a full-duplex EIA/TIA-232-E (RS-232) serial interface. The RT422 can operate at 9.6k, 19.2k, 57.6k baud with no parity, 8 data bits and 1 stop bit. Industry standard hardware (Request-to-Send [RTS]/Clear-to-Send [CTS]) flow control is implemented and required from the peer Data Communications Equipment (DCE) or Data Termination Equipment (DTE).

The RT422 provides two methods of line control: direct-wire or Asynchronous Transfer (AT) command set modem. One of these two methods is selected by setting *Jumper 3* (reference *Jumper Setting Options* for details) on the card. When the AT command set modem is selected (*Jumper 3 OFF*) the RT422 will respond to incoming calls and initiate a connection to the peer as required.

EIA/TIA-232-E Terminology

Data communications terminology can be quite confusing. Here we'll take a moment to define the terminology used in this document to avoid any confusion.

Communications Hardware Defined		
DTE	Data Termination Equipment	This is equipment that terminates a communications channel. Examples of DTEs include the RT422 itself, routers and computers with asynchronous serial interfaces.
DCE	Data Communications Equipment	This is equipment that connects a DTE to a communications medium. Examples of DCEs include modems and X.3 PADs.
Interface Signals Defined		
TXD	Transmit Data	This signal carries data transmitted by the DTE. This signal is outbound at the DTE. Other identifiers commonly used for this signal include TX, TD and SD.
RXD	Receive Data	This signal carries data received by the DTE. This signal is inbound at the DTE. Other identifiers commonly used for this signal include RX and RD.
RTS	Request-to-Send	This signal indicates the DTE is willing to receive data from the DCE. This signal is outbound at the DTE. The EIA/TIA-232-E standard re-defined its meaning to be <i>ready-to-receive</i> , because most equipment manufacturers have used it for this purpose on full-duplex connections for many years.
CTS	Clear-to-Send	This signal indicates that the DTE is free to transmit data to the DCE. This signal is inbound at the DTE.
DTR	Data Terminal Ready	This signal indicates that the DTE is ready to communication with the DCE. This signal is outbound from the DTE.
DSR	Data Set Ready	This signal indicates that the DCE is ready to communication with the DTE. This signal is inbound to the DTE.
DCD	Data Carrier Detected	This signal is used by the DCE to indicate to the DTE that it is connected and able to communicate. This signal is inbound to the DTE. Other commonly used identifiers for this signal include Carrier Sense (CS), Carrier Detected (CD), and Receive Line Signal Detected (RLSD).

Flow Control

The RT422 implements RTS/CTS flow control. This is commonly called *hardware flow control*. The RTS and CTS signals are used in the industry standard way (now formalized as EIA/TIA-232-E) where an asserted CTS signal is interpreted as permission to send bytes to the peer and RTS is asserted to indicate *ready-to-receive*. This is the method of *hardware flow control* employed by almost all modems, routers and other communication devices in use today.

No other flow control method is implemented on the RT422. Specifically, *Xon/Xoff* or *software flow control* is not implemented. However, the *Xon* and *Xoff* characters are masked in PPP Asynchronous Control Character Map (ACCM) and will not be transmitted by the RT422 across the interface.

Installing the RT422 Board into the DAS unit (if-required)

Install the RT422 board into the DAS unit per the following:

Initial Conditions: The DAS unit must be powered down and all external cables disconnected.

1. Remove the DAS unit's lid (reference the REF TEK *Technical Overview of the 72A-07 Series DAS*).
2. Disconnect P1 connector located on the backplane (RT346).
3. Disconnect J4 connector on the lid interface board. (Note: this cable is no longer needed.)
4. At this point you must determine what slot the RT422 board must go into. If your unit is a 72A-08 the board goes directly into **slot 4**. If your unit is a 72A-07 the board could possibly go into anyone of three slots. Normally, if your unit does **not** contain an internal GPS board (RT380) the RT422 board goes into **slot 6**. However, if your unit contains an RT380 board the RT422 board must be inserted into **slot 7**. If your unit contains both an RT380 board and a RT275 board you must use **slot 5**. If for some reason you have an RT380, RT275 and two RT373 (6-channels) boards a compromise of one of these board is necessary in order to support the RT422 board.

Obtain the RT422 board and slide it into the appropriate slot of the DAS cage. Make sure the board is seated properly before locking the extraction ears. If your unit is a 72A-07 and your using **slot 5** or **slot 7** you will need to perform a modification to the backplane board (RT346) – proceed to next instruction. If your using **slot 6** there is no modification required – proceed to instruction number 6.

5. Modification to the backplane board (RT346):

Slot 5 Using 28-gauge insulated jumper wire solder across from **J25C Pin 21** to **J26C Pin 21**. This modification re-routes the packet-framing signal.

Slot 7 Using 28-gauge insulated jumper wire solder across from **J27C Pin 21** to **J26C Pin 21**. This modification re-routes the packet-framing signal.

6. Take the new internal ribbon cable (40-pin connector end), slide it from the lower side of the cage (backplane side) to the RT422 board and connect to P1 on the RT422 board. (Note: Pin 1 [red side of cable] should be towards the lid.)
7. Take the other end of the new internal ribbon cable (two 20-pin connectors) and connect Pin 1-10 connector (red side of cable indicates Pin 1) to J4 on the lid interface board. (Note: The notched arrow on the J4 connector indicates Pin 1.). Take Pin 11-20 connector and connect to P1 on the backplane. (Note: The notched arrow on the backside of P1 indicates Pin 11.) Neatly tuck the internal ribbon cable in the lower half of the card cage.
8. Reassemble DAS unit (reference the REF TEK *Technical Overview of the 72A-07 Series DAS*).

RT422 to DTE Connection (Computer or Router [Asynchronous Serial I/F])

The EIA/TIA-232-E standard defines the interface used for DTE to DCE connections. It does not define the connection between two DTEs. It has become common to connect DTE to DTE and there is a widely accepted way to make this type of connection. We have implemented the interface on the RT422 to allow DTE to DTE connection using these methods. When connecting the RT422 directly to a router, Windows NT *Remote Access Services*, or a UNIX box running PPPD (a server) you are making a DTE to DTE connection.

The RT422 is connected to a DTE with the 72-8293 cable. This cable provides a female DB-9F connector to the DTE. This cable crosses over the signals between the two DTEs. This type of connection is called a *modem eliminator* or *null modem*.

In reference to the following table, there are basically three pairs of signals that are used for three distinct purposes.

RT422	Direction	DTE	Pin (DB-9F)
TXD	⇒	RXD	2
RXD	⇐	TXD	3
RTS	⇒	CTS	8
CTS	⇐	RTS	7
DTR	⇒	DCD and DSR	1 and 6
DCD	⇐	DTR	4
DSR	⇐	Not Connected	—
GND	↔	GND	5

- The TXD/RXD pair is used to move the actual data to/from the peer.
- The RTS/CTS pair is used to perform *hardware flow control*. The RTS signal is seen at the peer as CTS and this allows each end to control data flow from the peer. When the RT422 is receiving data from the peer faster than it can deliver it to the DAS, it will de-assert RTS to tell the peer to temporarily stop transmitting data. When it is able to receive data once again, it will assert RTS to signal the peer to resume transmission.
- The DTR/DCD pair is used to detect and control the state of the line. The DCD signal is interpreted directly as the state of the line. If DCD is asserted, the line is active and available for use, otherwise it's not. The RT422 asserts the DTR to indicate that it desires to connect to the network. The peer will see this as both DSR and DCD and should in turn assert DTR so that the RT422 will see DCD and the RT422 can begin to communicate with the peer.
- The DSR signal is not used by the RT422 and is not connected. The DTR signal at the RT422 is connected to both the DCD and DSR signals at the peer. This is accomplished by interconnecting pin 6 to pin 1 in the DB-9F connector of the 72-8293 DTE cable.

In summary, the RT422 interprets DCD as the presence of the peer and CTS as the peer's willingness to receive data. It asserts DTR to indicate that it is present and wishes to communicate with the network and it asserts CTS to indicate its willingness to receive data.

RT422 to DCE Connection (Modems or X.3 PADs)

When connecting an RT422 to a modem, you are making a DTE to DCE connection. The RT422 communicates with DCE through a 72-8294 cable. This cable provides a DB-25M connector to the DCE. The labeling of signals, in the following table, is from the perspective of the DTE connection (reference table above).

<i>RT422</i>	<i>Direction</i>	<i>DCE</i>	<i>Pin (DB-25M)</i>
<i>TXD</i>	⇒	<i>TXD</i>	2
<i>RXD</i>	⇐	<i>RXD</i>	3
<i>RTS</i>	⇒	<i>RTS</i>	4
<i>CTS</i>	⇐	<i>CTS</i>	5
<i>DTR</i>	⇒	<i>DTR</i>	20
<i>Not Connected</i>	⇐	<i>DSR</i>	4
<i>DCD</i>	⇐	<i>DCD</i>	8
<i>GND</i>	⇔	<i>GND</i>	7

Jumper Setting Options

The JP2 block of jumpers are used to set the default behavior of the RT422. Options include: async line speed, modem or direct-wire connection, line-down behavior and server discovery method.

The jumper block is on the left edge of the card when the backplane connectors are pointed away from the viewer. Jumper 1 towards the viewer and jumper 8 is away nearest to the backplane connector.

The card is shipped from the factory with all jumpers *ON*.

Note: The RT422 always performs hardware flow control regardless of the settings on its jumpers.

Jumpers 1 and 2 – Async Line Settings.

Use these jumper to set the line speed, also known as the baud rate, of the asynchronous interface on the RT422 as follows:

<i>Jumper 1</i>	<i>Jumper 2</i>	<i>Line Speed</i>
ON	ON	9.6 Kbaud
OFF	ON	19.2 Kbaud
ON	OFF	57.6 Kbaud
OFF	OFF	Reserved

Jumper 3 – Modem / Direct-Wire Connection.

Jumper 3 on the RT422 selects the line control method: direct-wire or AT command set modem.

ON Direct-wire connection with 72-8293 DTE cable. When *Jumper 3* is *ON*, the signals behave as described in the previous table. This setting is typically used for DTE to DTE connections.

OFF Standard AT command set modem connected with 72-8294 DCE cable. When *Jumper 3* is *OFF*, the RT422 always asserts DTR to indicate to the attached modem that it is ready to communicate. It de-asserts DTR momentarily - only when disconnecting from the peer. The modem responds to the loss of DTR by disconnecting the line and going on-hook, which in turn will cause a loss of DCD.

Note: The RT422 interprets DCD as the state of the connection in general and does not look at the DSR signal from the DCE. When the RT422 initiates a connection it looks for DCD to show that the connection is established, and when it responds to an incoming connection DCD is the signal that activates the connection.

Jumper 4 – Line-Down Behavior.

ON Fills DAS RAM and stops acquisition, restarts acquisition after reconnection and transfers the data in RAM.

OFF Waits 3 minutes for reconnect and then tosses the data; it will catch up when reconnected.

Jumpers 5 – RTP Server Discovery Method.

ON RTP Server Discovery packets are sent as subnet-directed broadcasts.

OFF RTP Server Discovery packets are unicast the PPP peer IP address.

Typically this jumper should be on. For details about the RTP Server Discovery process please refer to the RTP protocol documentation.

Jumper 6 – FreeWave Multipoint Slave.

ON Standard PPP over asynchronous serial interface. This is the normal setting.

OFF PPP over FreeWave Multipoint radio network. Use this setting only when attaching the RT422 to a FreeWave spread-spectrum radio configured as a Multipoint Slave in DTR Connect mode 2. For details about using FreeWave radios with the RT422 refer to the FWMaster documentation.

Jumpers 7 and 8 – Reserved.

These jumpers are reserved for future use and should left in the on position.

RT422 Console Port (Test Port [Diagnostics])

This port is only accessible once the DAS has been opened. The RT422 provides access to its console through the DB-9F connector P2 at the top edge of the card. The port settings are 9600, N, 8, 1.

To enable input at the console, press open bracket, period, close bracket ([.]) quickly in succession. Now keystroke commands can be issued.

There are four levels of status output: 0 - none, 1 - errors only, 2 - verbose, and 3 - debug. By default, the RT422 status output level is 1 (errors only); to increase the verbosity of the status information press + (plus), and to decrease press - (minus).

Once console input is enabled press ? to see a *Help* screen. Some useful commands, particularly while debugging network problems are as follows:

Command	Descriptions
p	Send LCP Echo request to peer (data link layer ping)
P	Send ICMP echo request to server (network layer ping)
Ctrl-p	Send ICMP echo request as subnet directed broadcast (broadcast ping)
s	Terse system status summary
S	Verbose system status summary

The following is the verbose status output at the console:

```
RTP Stack Status: Running for 001+01:20:27.042
Storage: total 64, allocated 1, head 21, tail 20
DAS unit: 7377, Console status level: 1
Application layer: Up (RTP:Opened) for 000+11:09:39.669
RTP: Unit ID: 7377, Line down behaviour: Fill RAM
RTP: Sequence numbers, in: 9, out: 202
RTP: Packets: in: 55853, out: 59109
RTP: Discards: in: 200, out: 0
RTP: Retransmissions out: 3098, Bad codes in: 0
RTP: Bad length in: 0, Duplicates: 0
RTP: Old packets in: 0, Protocol errors in: 0
RTP: Short packets in: 0
Network layer: Up (IPCP:Opened) for 000+11:09:42.054
IP: Local: 192.168.2.11 - Server: 192.168.1.4
IP: Next hop: 192.168.2.1 - Broadcast: 192.168.2.255
IP: Datagrams in: 56437 - Datagrams out: 59335
IP: In discarded: 17 - Out discarded: 0
IP: Checksum errors in: 0 - Bad IP version in: 0
IP: Fragments in: 0
UDP: Local port: 2543 - Server port: 2543
UDP: Checksum errors in: 0 - Bad length in: 0
UDP: UDP/IP length mismatches in: 0
ICMP: Round-trip time to server: 117 milliseconds
ICMP: Checksum errors in: 0 - Messages in: 0
IPCP: In, dropped: 0 - In, short: 0
Data link layer: Network (LCP:Opened) for 000+11:09:43.563
PPP: MRU: 1500 - MTU: 1500
PPP: Rx ACCM: 0x000A0000 - Tx ACCM: 0x000A0000
PPP: Local magic: 0x1B3DE0E0 - Peer magic: 0xE90B28CD
PPP: Rx valid frames: 56529 - Tx frames: 59413
PPP: Rx dropped frames: 0 - Tx dropped frames: 0
PPP: Rx FCS (CRC) errors: 36 - Rx invalid frames: 0
LCP: Round-trip time to peer: 135 milliseconds
LCP: Rx short frames: 0 - Rx dropped frames: 0
LCP: Rx sunk frames: 0
Media layer: Up (Async:Connected) for 000+11:09:44.770
Line speed: 19.2 kbaud, Link type: Direct-wire
Rx bytes: 2623259 - Tx bytes: 63202001
Rx frames: 56567 - Tx frames: 59413
Rx invalid frames: 0 - Tx errors: 0
Rx giants: 0 - Rx runts: 1
```

Connections

This card's communication interface is via card connector P1. The 40-conductor ribbon cable from P1 splits in two and pins 1-20 connect to the DAS lid interface card (usually an RT387) and then pass on to the front panel **COMM** connector (reference table for each pin description); pins 21-40 connect to the DAS backplane (either an RT291 or an RT346) at P1. The 72-8293 DTE cable attaches the DAS to data terminal equipment (DTE) such as a computer or router. The 72-8294 DCE cable attaches the DAS to data communications equipment (DCE) such as a modem.

Communications Connection (PT07A14-19S)

Pin	Description	Card Destination	Card Connection
A	+High Speed Serial (HS+)	RT371	P2: 24C
B	-High Speed Serial (HS-)	RT371	P2: 24A
C	Ground	RT371	P2: 23A
D	Carrier Detect (CD*)	RT371	P2: 26C
E	Modem Serial Data In (SDIB*)	RT371	P2: 27A
F	Modem Serial Data Out (SDIO*)	RT371	P2: 27C
G	External Trigger In (CTSB*)	RT371	P2: 28A
H	Event Declared Out (RTSB*)	RT371	P2: 28C
J	Ground	RT371	P2: 29C
K	Packet Framing (PKTFRM)	RT371	P2: 29A
L	Transmit +12 Volts (TX12)	RT371	P2: 30A
M	Ground	RT371	P2: 30C
N	GPS Serial Data In (SDIA)	RT319	P2: 31A
P	GPS Serial Data Out (SDOA)	RT319	P2: 31C
R	1 Hertz	RT371	P2: 26A
S	Ground	RT371	P2: 31C
T	Receiver +12 Volts Power (RX12V)	RT371	P2: 31A
U	Receiver +5 Volts Power (RX5V)	RT371	P2: 32A
V	Ground	RT371	P2: 32C

A type 68301 microprocessor (U15) controls card operations; it has dual 256K EPROMs and dual 256K SRAMs. A single SCC device U8, is clocked by an 11.0592 MHz oscillator on U3.

A test port (console port), P2, with its associated driver, U19, is provided for diagnostic purposes, and the jumper JP3 that powers U19 is therefore normally open.

In both the 72A-07 and -08 series DAS the RT422 will occupy slot # 6 of a seven card backplane (RT346) or slot # 4 of a ten card backplane (RT291).

Parts List

Parts lists omit common hardware items (nuts, screws etc.) and some descriptors are truncated.

RT422-B02	PCB, ECC SERIAL INTERFACE CARD		
CAEM0100F	CAPACITOR, 100uF, 25V, ECEB1EU101, PANASONIC	C1	1
CMCM00.1H	CAPACITOR, .1uF, 50V, CW30C104K	C2-4, 6-13, 16-22	18
CMCP0018NPO	CAPACITOR, 18pF, NPO	C5	1
CR1N4004	DIODE, 1N4004	D1	1
MCHD6960	HEADER, SHORT PIN SET OF 40 PAIRS	JP2	8
MP929647-01-32-10	HEADER, SINGLE ROW	JP1, 3-8	4
MS808AG11D	SOCKET, 8 PIN 808AG11D	U18	1
MS818AG11D	SOCKET, 18 PIN 818AG11D	U7, 19	2
MS832AG11D	SOCKET, 32 PIN 828AG11D	U1, 2, 4, 5	4
MS840AG11D	SOCKET, 40 PIN 840AG11D	U8	1
MSHC-1002	SHORTING BAR AMP 531220-2	JP1-8	9
P609-4007ES	CONNECTOR, 40 PIN	P1	1
P69001-821	CONNECTOR, 69001-821 C96/64M	P1A, C, P2A, C	2
P745394-2	CONNECTOR, D-SUB, RIGHT ANGLE	P2	1
RCFK010.0B	RESISTOR, 10.0K, 5%, 1/4W	R10	1
RCFM015.0B	RESISTOR, 15.0M, 5%, 1/4W	R1	1
RNK101R10K	RESISTOR NETWORK, 4610-101-103	R2, 9	2
U27C256	IC, E-PROM, CMOS, 32KX8 NM27C256Q150	U4, 5	2
U74HC138	IC, 3-TO-8 LINE DECODER	U16	1
U74HC14	IC, HEX INVERTING SCHMITT TRIGGER	U17	1
U74HC32	IC, QUAD 2-INPUT OR GATE	U6	1
U74HC74	IC, DUAL D FLIP-FLOP WITH PRESET & CLEAR	U20	1
U74HCU04	IC, HEX UNBUFFERED INVERTER	U3	1
UDS1232	IC, POWER MONITOR	U18	1
UHM628512LP5	IC, 4M MEMORY MOD	U1, 2	2
ULT1280CN	IC, HIGH SPEED OP AMP	U7, 19	2
UTMP68301F-12	IC, MICROPROCESSOR	U15	1
UZ85C30	IC, SERIAL COMMUNICATION CONTROLLER	U8	1
YFPX115-20	CRYSTAL, 11.0592 MHz	Y1	1

Drawings

The following REFTEK drawings complete this document:

Drawing No. 00-1422	RT422A Assembly	Rev. C	Sheet 1 of 1	08/06/98
Drawing No. 00-3422	RT422 ECC Serial Interface Schematic	Rev. C	Sheet 1 of 3	08/07/98
Drawing No. 00-3422	85C30 Communications	Rev. C	Sheet 2 of 3	08/07/98
Drawing No. 00-3422	Central Processor	Rev. C	Sheet 3 of 3	08/07/98