bc632D
Wall Mount LED Display
8500-0015

User's Guide
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User's Guide
March, 1997

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WALL MOUNT LED DISPLAY

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ADDENDUM A

OFFSET PROGRAMMING

A.0 SET LOCAL OFFSET TIME (SHIFT-D)

The SET TIME function key (SHIFT-D) is used for both set internal clock and set local offset time features. To enter SET LOCAL OFFSET TIME menu by pressing SHIFT-D, the display first appears on the SET TIME menu "TIME hh:mm:ss". Without any modification on the SET TIME menu, press the SELECT key to set local offset time. The display prompts the offset time of the first source display "OFFSET 1 +/- XX" hour(s). The local offset time can be set to +/- 19 hours. The bc632D module has the capability to display eight (8) different local offset times from a single time source. When the SELECT key is pressed again, the display scrolls to the next source display offset time menu. You may press the RUN function key to exit the SET TIME menu any time.

A.1 PROGRAMMING OFFSET via REMOTE

The following brief example shows set local offset time on source display one:

Press SHIFT D **TIME hh:mm:ss**	To enter SET TIME menu.
Press SELECT **OFFSET 1 +00**	Go to next menu.
Type in -08	Type in -08 hours.
Press RUN	Exit SET TIME menu.

The time is -08 hours on source 1 (SRC 1)

A.2 PROGRAMMING OFFSET via RS-422

addr aaa	set bc632D display address
offset 1 -08	set to -08 hours
end	

Note: See Appendix B for bus protocol.

A.3 SET LEAP YEAR

The standard IRIG time code does not carry leap year information. When local offset time is set for the display, the leap year flag is required for the bc632D display time rollovers from 365 days or 366 days to 1 day.

A.3.1 PROGRAMMING LEAP YEAR via REMOTE

The SET LEAP YEAR feature also shares the same function key with SET TIME and OFFSET. The following example sets current year to be leap year:

Press SHIFT D	
TIME hh:mm:ss	SET TIME menu.
Press SELECT	
OFFSET 1 +/-XX	OFFSET 1 menu.
Press SELECT	
OFFSET 2 +/-XX	OFFSET 2 menu.
Press SELECT	
OFFSET 3 +/-XX	OFFSET 3 menu.
Press SELECT	
OFFSET 4 +/-XX	OFFSET 4 menu.
Press SELECT	
OFFSET 5 +/-XX	OFFSET 5 menu.
Press SELECT	
OFFSET 6 +/-XX	OFFSET 6 menu.
Press SELECT	
OFFSET 7 +/-XX	OFFSET 7 menu.
Press SELECT	
OFFSET 8 +/-XX	OFFSET 8 menu.
Press SELECT	
Leap Year? Y/N	LEAP YEAR menu.
Type in Y	Set LEAP YEAR flag to leap year.

A.3.2 PROGRAMMING LEAP YEAR via RS422

addr aaa	display address
leapyear 1	set LEAP YEAR flag
end	

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CHAPTER ONE
INTRODUCTION

1.0 GENERAL

The bc632D Wall Display Operation and Technical Manual provides the following information:

- General Introduction.
- Installation and Setup Details.
- Operation and Programming.
- I/O Signal Information.
- Theory of Operation.
- Drawing Set.

1.1 FEATURES

The salient features of the bc632D Wall Display include:

- Real Time Clock operation with millisecond precision.
- Decodes commonly used time code formats, IRIG B, IRIG A, NASA 36 and 2137.
- Decodes modulated or un-modulated (DC level shift) time codes.
- Master/Slave operation allows digital synchronization of multiple bc632D's.
- Up to six separate time channels multiplexed on one cable to multiple bc632D's.
- Continues to provide time, “flywheels,” during loss of the external time code source.
- Battery-backed Real Time Clock maintains time during power loss and can be synchronized to an external time code.
- Battery-backed control values allow one-time setup.
- Supports external event time capture input with programmable polarity.
- Flexible programming displays allow multi-screen time formats.

1.2 OVERVIEW

The bc632D is a wall-mounted time display designed to read serial time code signals, and digitally synchronize multiple displays. The bc632D also incorporates a battery-backed real time clock which maintains time during power loss and can be synchronized to an external time code signal.

The bc632D is programmed using a hand-held infrared remote control keyboard. The keyboard is used in selecting the display format and time source that the bc632D decodes. It sets and reads the real time clock, activates event time capture operations, and reads the captured time and status.

The principal performance characteristics are listed in Table 1-1.

Table 1-1
Principal Performance Characteristics

Item	Item	Description
Time Code Reader	Time Code Formats	IRIG A, B, NASA 36, 2137.
	Carrier Range	IRIG A - 10kHz ± 2%. IRIG B - 1 kHz ± 2%. NASA 36 - 1 kHz ± 2%. 2137 - 1 kHz ± 2%.
	Flywheel Accuracy	Less than 3.6 milliseconds per hour.
	Modulation Ratio	3:1 to 6:1.
	Input Amplitude	100 mVrms to 1 Vrms.
	Input Impedance	10K Ω (AC coupled).
Real Time Clock	Format	24 Hour.
	Accuracy	± 10PPM.
Power		7 VAC from provided power supply; 40 W.
TTL/CMOS Input Signals	Event Capture	TTL/CMOS, positive or negative edge triggered, 50 ns min width.
TTL Output Signals	1 Pulse Per Second	TTL/CMOS, positive edge on time.
RS-485 Input/Output Signals	Serial Time/Message	TX/RX (+), TX/RX (-). 9600 Baud, 8 bits, 1 stop bit, no parity. TX (-) compatible with most RS-232 devices.
RS-232 Input/Output Signals	Control Bus	RS-232 IN, RS-232 OUT. 9600 Baud 8 bits, 1 stop bit, no parity. Pins selectable as RS-23 or RS-485.
Operating and Storage Environments		The display is intended for indoor use only.

1.3 TIME CODE FORMATS

The widespread use of coded timing signals to assist in the correlation of intercept and test data began in the early 1950's. These signals can be decoded in real time to indicate the current Time of Day (TOD) or recorded along with intercept/test data on magnetic tape recorders for post processing and time correlation.

Hundreds of time code formats were developed - one for each agency involved. During the early 1960's the InterRange Instrumentation Group promoted a series of "standard" time code formats now loosely referred to as "IRIG Time Codes." The bc632D decodes four of these formats: IRIG A, IRIG B, 2137, and NASA 36.

More complete details on these and other time code formats are available free of charge, on request from either Bancomm Division or Datum Inc in the form of the Datum Inc, Handbook of Time Code Formats. Figure 1-1 illustrates a frame of IRIG A, B or G time code.

Figure 1-1
IRIG Time Code Frame

IRIG B Time Code Frame

Symbols:

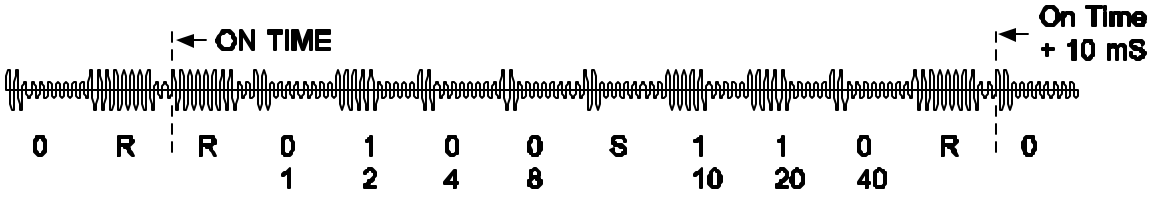
Reference Mark: 8 HC, 2 LC

Logical '1': 5 HC, 2 LC

Logical '0' or Space: 2 HC, 8 LC

10 Cycles or 10 milliseconds for IRIG B or IEEE1344

On Time and First Sub Frame:



A double reference mark denotes the start of the frame, 'On Time'. Encoded BCD data is the time at On Time. The encoded data is this first subframe is 32 Seconds.

Frame:

IRIG B:

OT
R R SS R MM R HH R DD R D _ R C C R C C R C C R B B R B B R
Seconds
Minutes
Hours
Days
Control Characters
Control Characters
Control Characters
17 ***B***IT ***B***INARY
TOD

CHAPTER TWO
INSTALLATION AND SETUP

2.0 GENERAL

To begin using the bc632D, you may need to move some of the internal jumpers, and mount the display to a wall, ceiling or countertop. This chapter gives instructions on jumper settings and mounting. You may also need to program the bc632D for your application. A full description of all the programmable options can be found in Chapter Three.

2.1 SETUP - INTERNAL JUMPERS

There are five jumpers on the internal circuit board which are used to modify the operation of the bc632D. They are set (at the factory) to the following:

Time Bus	Un-Terminated.
Control Bus	Un-Terminated.
J3 Rx Pins 1 and 6	RS-232 Levels.
BNC J2	1PPS Out.
BNC J4	Modulated Time Code Input.

If you only have one bc632D, and you are using it with the internal clock or modulated time code, and you have no need to use the event capture input, then you do not need to change any of the jumpers.

If you need to use the event capture input, DC level shift time codes, or the networking capabilities of the bc632D, then you will have to change the jumpers accordingly.

2.1.1 ACCESSING JUMPERS

To change the jumpers, follow this procedure:

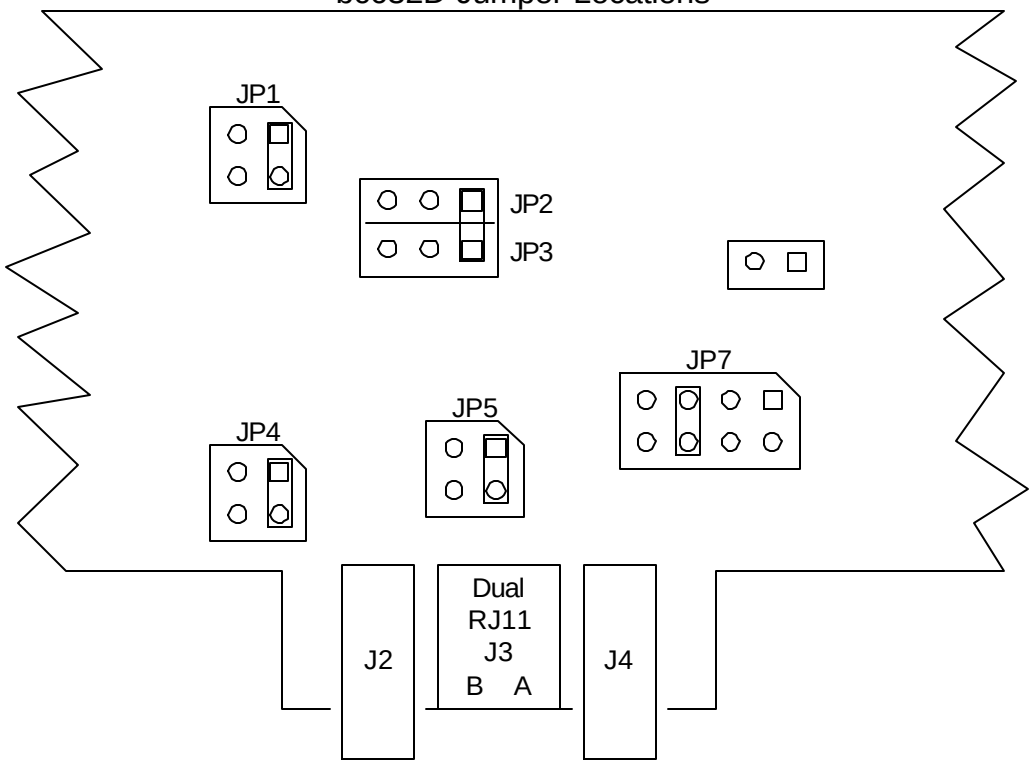
- Lay the bc632D face down on a soft non-marring surface.
- Remove the screws from the rear of the case.
- Carefully remove the back cover, rotating it toward the bottom of the display to clear the connectors.
- Move jumpers to the desired configuration.
- Replace the back cover and screws.

2.1.2 JUMPER LOCATION

There are several circuit boards in the bc632D case. All the user-configurable jumpers are on the timing board. When you look at the back of the display, the timing board is found at the right hand side of the display, mounted on four white plastic spacers.

Figure 2-1 shows the location of the jumpers on the timing board.

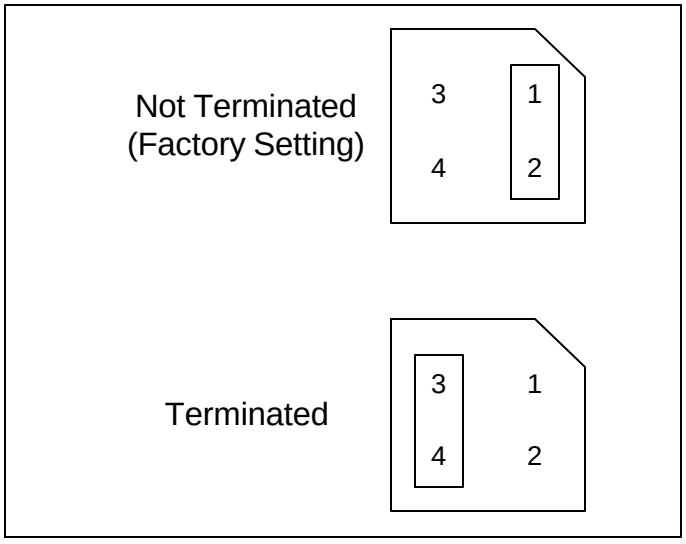
Figure 2-1
bc632D Jumper Locations



2.1.3 JUMPER JP1 - CONTROL BUS TERMINATION

When you use the Control Bus, you must terminate the ends of the network with a 100Ω resistor. The resistor may be external or internal to the bc632D. To use the internal terminating resistor, place the jumper on JP1 between pins 3 and 4. Otherwise place the jumper between pins 1 and 2.

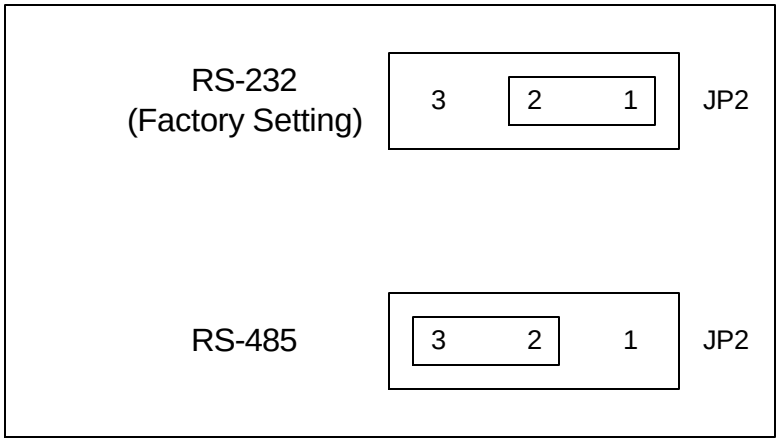
Figure 2-2
Jumper JP1 Settings



2.1.4 JUMPER JP2 - RS-232/RS-485 SELECT FOR J3 PIN A6

Two pins on connector J3 are dual-purpose. They provide an RS-232 port to a controlling computer, or an RS-485 port for connecting a network of displays. If the display is to be connected directly to the RS-232 port of a computer, then leave the jumpers between pins 1 and 2 of JP2. This routes pin A6 to an RS-232 driver. If you are using the display as part of a daisy-chained network, put the jumper on pins 2 and 3, which routes pin A6 to the (+) terminal of an RS-485 transceiver.

Figure 2-3
Jumper JP2 Settings

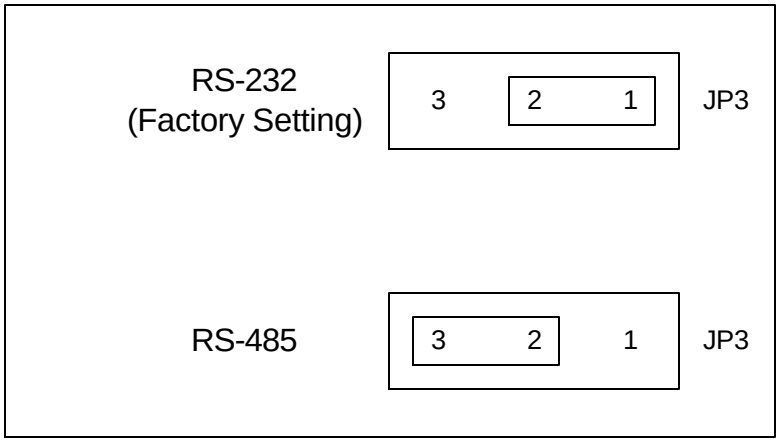


2.1.5 JUMPER JP3 - RS-232/RS-485 SELECT FOR J3 PIN A1

If the display is to be connected directly to the RS-232 port of a computer, then leave the jumpers between pins 1 and 2 of JP3. This routes pin A1 to an RS-232 receiver. If you are using the display as part of a daisy-chained network, put the jumper on pins 2 and 3, which routes pin A1 to the (-) terminal of an RS-485 transceiver.

Note: If you use the RS-232 input, be sure that JP6 is installed as described in Section 2.1.8.

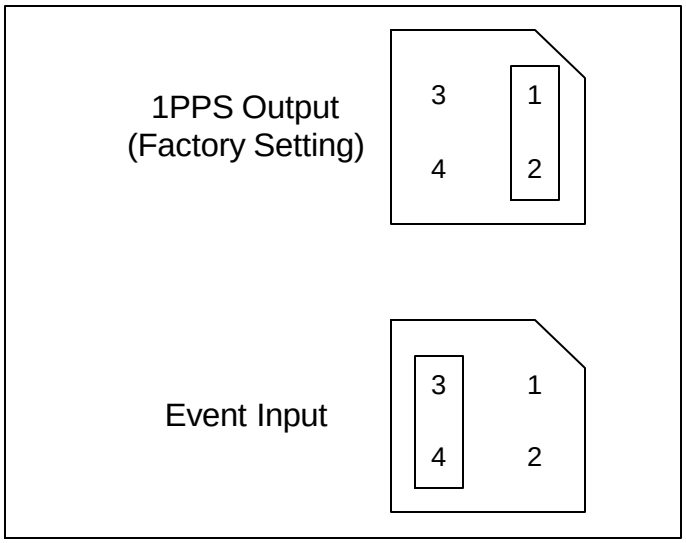
Figure 2-4
Jumper JP3 Settings



2.1.6 JUMPER JP4 - SELECT EVENT OR 1PPS FOR BNC J2

Jumper JP4 is used to select the signal present on BNC connector J2. Normally, the jumper is connected between pins 1 and 2, so that BNC J2 is used as a 1PPS output. To use BNC J2 as an event input, move the jumper to pins 3 and 4.

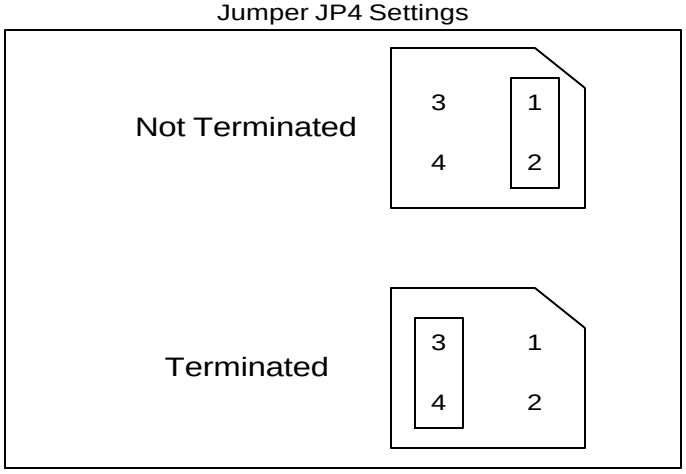
Figure 2-5
Jumper JP4 Settings



2.1.7 JUMPER JP5 - TIME BUS TERMINATION

When you use the Digital Time or Multiplex Time protocols, you must terminate the ends of the network with a 100Ω resistor. The resistor may be external or internal to the bc632D. To use the internal terminating resistor, place the jumper on JP2 between pins 3 and 4. Otherwise place the jumper between pins 1 and 2.

Figure 2-6
Jumper JP4 Settings

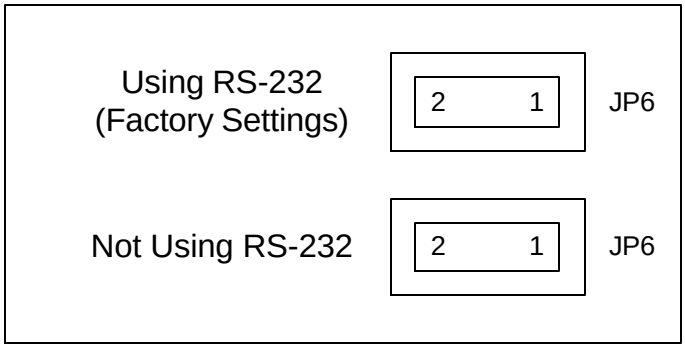


2.1.8 JUMPER JP6 - CONTROL BUS SELECT

Install the jumper on JP6 if RS-232 pins are being used, that is, if jumper JP3 is on pins 1 and 2. This tells the display that it must enable the RS-485 drivers that are being driven from the controlling computer. If you are not using the RS-232 pins or a controlling computer, then remove jumper JP6. This will cause the display to keep those RS-485 drivers off.

Note: Only one display in a network can have its JP6 installed. Otherwise, control signals from the computer be corrupted.

Figure 2-7
Jumper JP6 Settings

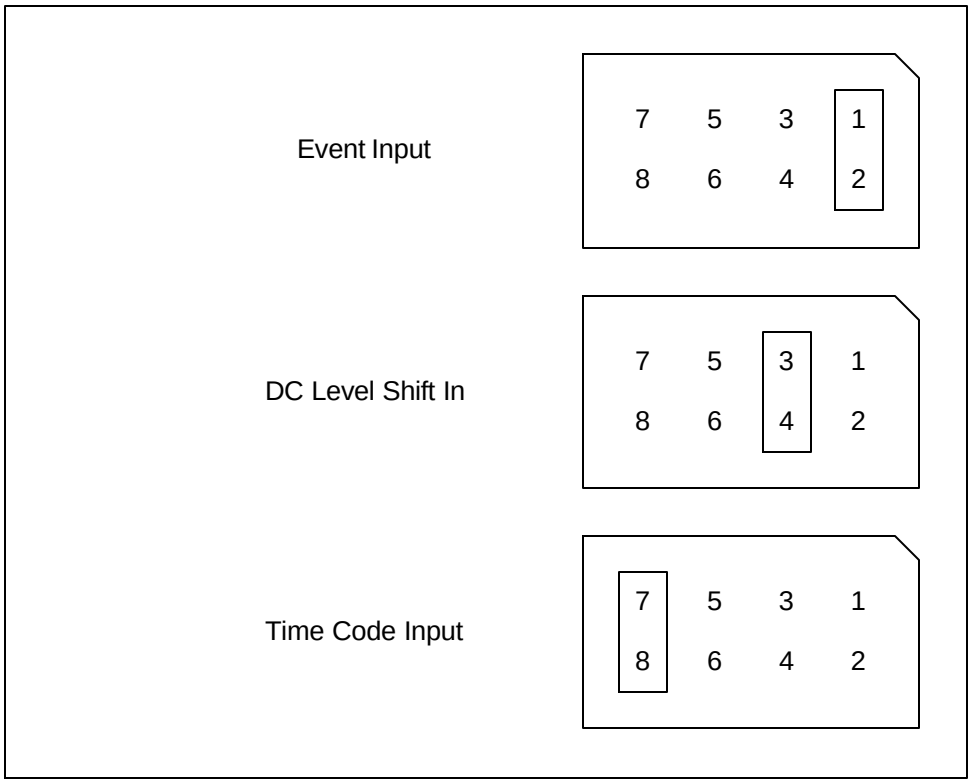


2.1.9 JUMPER JP7 - BNC J4 FUNCTION SELECT

Jumper JP7 selects the signal present on BNC connector J4. Normally, the jumper is connected between pins 7 and 8, so that BNC J4 is used as the modulated time code input. BNC J4 can be used for other functions as shown in Figure 2-4.

Note that the Event Input is available on either BNC J2 or J4. The Event Input would only be selected on J4 if the 1PPS output is required *and* the bc632D is using its internal clock or the RS-485 port as the source of time.

Figure 2-8
Jumper JP7 Settings



2.2 MOUNTING INSTRUCTIONS

The bc632D can be mounted in four different ways:

- Wall flush mount.
- Ceiling hanging.
- Countertop.
- Wall mounting brackets.

For installation purposes, please note that the bc632D display weighs 4 lbs. Select the mounting instructions appropriate for your needs.

2.2.1 WALL FLUSH MOUNT

Step 1
Locate the keyhole slots on the back of the case at either end. Note, two sets of keyhole slots are available. The slots are spaced 16 or 24 inches apart. Use the keyhole slots most appropriate for your needs.

Step 2
Place two #8 screws into the wall/mounting surface at the selected distances, either 16 or 24 inches apart. Use the type of screws and anchoring methods appropriate for the mounting surface. For example, use wood screws if you are mounting to a wood surface. (These screws are not supplied.)

Step 3
Hang the display on the two screws located on the wall/mounting surface.

2.2.2 CEILING SUSPENSION

Step 1
Locate the hanging links in the seam at the top back of the case, near each end.

Step 2
Turn the sign upside down and the links will turn out. The links are spaced 24 inches apart and can be bent for angle adjustment if needed.

Step 3
From the ceiling, install two chains (or other means) 24 inches apart.

Step 4
Connect the chains to the hanging links to suspend the display from the ceiling.

2.2.3 WALL MOUNTING USING BRACKETS

Step 1
Attach the large end of the brackets to the wall mounting surface, 27.65 inches apart, using two #8 screws per bracket.

Note: The brackets are different for the left and right sides. Also, use the type of screws and anchoring methods appropriate for the mounting surface. For example, use wood screws if you are mounting to a wood surface. (These screws are not supplied.)

Step 2
Attach the small end of the mounting brackets to the display using the enclosed #10 screws and lock washers.

Note: The lock washers must be placed between the mounting bracket and the sign. DO NOT tighten the screws until the sign and brackets are adjusted to the desired angle.

2.2.4 COUNTERTOP

Step 1
Attach the small end of the two mounting brackets to the display using the enclosed #10 screws and lockwashers. Note that the brackets are different for the left and right sides. The lockwashers must be placed between the mounting bracket and the sign. DO NOT tighten the screws until the display and brackets are adjusted to the desired angle.

Step 2
Place the display on the countertop using the mounting brackets as legs. The display is not very stable, so choose a location where it will not be accidentally bumped. Adjust the display to the desired angle and tighten the screws.

2.3 SERIAL TIME BUS

Each bc632D has two RJ11 jacks on the back. These can be used to connect several displays in a network. The jacks carry two busses. One bus distributes timing information. The other can be used to distribute control and programming information.

2.3.1 DIGITAL TIME PROTOCOL

The bc632D Wall Display has the capability of operating in a Master/Slave mode in which Slave bc632D's synchronize digitally to the timebase of a Master bc632D. This allows computer synchronization of two or more displays without external time code. Synchronization accuracy's of ± 1 microsecond can be achieved between the Master and Slaves. The Master/Slave mode of operation is summarized as follows:

- A Master bc632D decodes its selected time source. A 1PPS synchronization pulse and 9600 baud serial time message (days - seconds) is broadcast via two RS-485 lines each second through the TX side of the RJ11 connector (J3). The Master automatically broadcasts these digital time signals when decoding time or flywheeling.

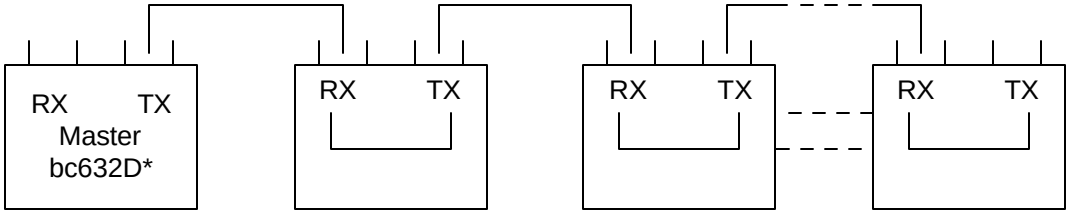
- Slave bc632D's are programmed with "Digital Time" as their time source. The RX side of the Slave's RJ11 connector (J3) is connected to the TX side of the Masters RJ11 with four-conductor telephone cable. When a valid 1PPS and time message is received from the Master, synchronization takes place. All features of the bc632D are available with this mode including "flywheeling." (Refer to Figures 2-9 and 2-10.) The signal received on the slaves RX connector are looped through to the TX connector, allowing signs to be connected in a "daisy-chain" fashion.

- Terminate the RS-485 line with the bc632D's termination resistors by moving the existing jumper on JP5 pins 1 and 2 to JP5 pins 3 and 4. (See Section 2.1.7). The two bc632D's on the end of the network should be terminated.

Note: On a Master\Slave bc632D network only two modules should be terminated.

- Any one of the bc632D's depicted in Figures 2-5 and 2-6 can serve as a Master. The Master is the only unit in the network that transmits Time and Synchronization pulses on the serial lines. See Section 3.3.10 for a description of how to set the display as a master. If more than one bc632D tries to operate as a Master, the time signals are corrupted. There is not any hardware damage when this occurs, but network synchronization is not possible. When a bc632D is designated as a Slave (Refer to step 2) all drivers are disabled.

Figure 2-9
Serial Daisy Chain Connection of Master/Slave bc632Ds

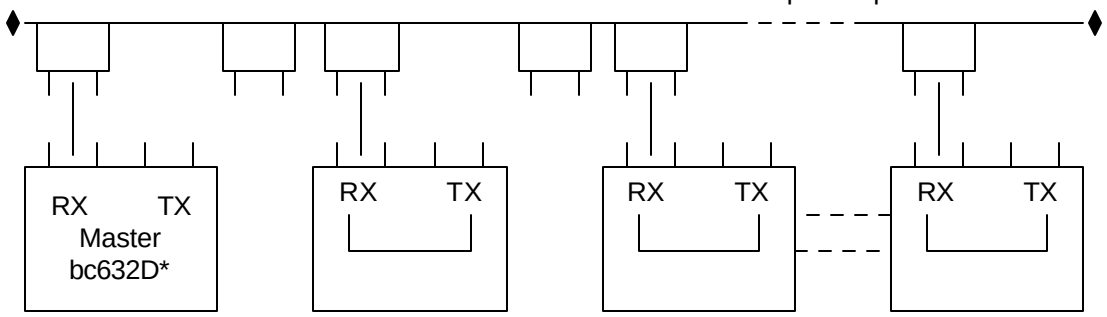


***** Denotes Termination by on-board 100Ω resistors.

——— 4- or 6-conductor cable with RJ11 male connectors.

⊥⊥⊥ bc632D RJ11 port (female mating connector).

Figure 2-10
bc632D Master/Slave Serial Distribution Bus with multiple Drop Points



Termination
Choice of one of the two methods listed below:

♦ Denotes direct 100W termination on RS-485 line.

***** Denotes termination by on-board 100W resistors (Necessary if RS485 line is not externally terminated).

2.3.2 MULTIPLEXED TIME PROTOCOL

The Multiplexed time protocol is similar to the Digital Time Protocol. It is intended for an installation of several bc632D displays which may have to show different times. It uses the same physical wiring configuration with the exception that a bc632D can not act as a master in the Multiplexed time operation. The master will typically be a computer with several time inputs and a serial port.

Another difference between the two protocols is the synchronization accuracy between the master and slaves. The multiplexed time protocol only keeps the master and slaves synchronized within one millisecond.

2.4 CONTROL BUS

If six-conductor cable is used between bc632D's, then the control bus pins will be connected. This allows a computer to issue programming commands to all displays on the network.

Since RS-232 ports are more commonly found on computers than RS-485 ports, the bc632D has been designed to accept RS-232 signal levels and convert them to RS-485 levels to drive the control bus. To do this, internal jumpers JP2, JP3 and JP6 must be set for RS-232 operation. See Section 2.1 for information on setting jumpers.

Appendix B defines the control bus command protocol.

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CHAPTER THREE
OPERATION AND PROGRAMMING

3.0 GENERAL

The bc632D is programmed using the hand-held remote control unit. This chapter describes how to configure the bc632D for use.

The bc632D can be programmed to perform many timing and display related functions. The following parameters can be programmed:

- Source of time for display.
- Alphanumeric Labels for each time source.
- Time or sync mode of internal real time clock.
- Display format and color.
- Event input polarity and activity.
- Display Address for network operation.

3.1 OPERATION

When power is applied, the bc632D begins displaying time using the parameters in memory. This is it's normal "Run" mode. When running, one of several display formats will be displayed. The bc632D allows you to select from several display formats to suit your application.

3.1.1 LABELS

In some formats, an alphanumeric label is displayed on the left-hand side of the display. The label can be used to indicate the time source that is being displayed. For example, if the time code input is connected to a timecode carrying Greenwich Mean Time, you might use the label "GMT" to indicate that. Perhaps another display might need the label "Local" to differentiate it from the GMT display.

3.1.2 STATUS LIGHTS

On the right-hand side of the display, three of the lights are used to indicate various status information on the display. The status lights form a vertical row:

- O Flywheel Light
- O Synchronizing Light
- O Event Light

The flywheel light goes on when the display loses its source of time. It indicates that the display is not currently reading any time source, but is "coasting" with the last known time and rate. It may indicate a noisy or disconnected input signal. Depending on the source of time, it may take up to six seconds after the time code is lost for the flywheel light to come on.

The synchronizing light goes on when you have selected one of the synchronization options for the internal clock. See Section 3.3.11, SET TIME (SHIFT-D) - Set Internal Clock. The light will be on while the display acquires the time code or other time source. It will go off when the real time clock has been synchronized to the time source.

The event light shows the status of the event capture input. When the event capture is disarmed, the event light is off. When the event capture is armed, the light is green. It remains green until an event is detected, when it turns red. You must clear the event to capture a new event (See Section 3.3.12 for programming the event capture parameters).

3.1.3 PROGRAMMING

The display remains in Run mode, displaying time, until the PROGRAM key is pressed, which puts the display in "Program" mode. In Program mode the operator can modify all the operating parameters. The display remains in Program mode until the RUN key is pressed.

Most programming is done by selecting items from a list. You may select an item from the list in two ways. First, you can use the SELECT key to advance through the list, one item at a time. Second, you may press one of the number keys "1" through "9" to select items in the list. The "0" key is used to undo any changes made since the last command.

There are some cases where the number keys are used as entries in text strings, so they do not select items in the list. For example, when setting the internal clock, the keys 0-9 are used to enter the time rather than select items in the list. These exceptions are noted on the following page.

3.2 INFRARED KEYBOARD

3.2.1 KEYBOARD OPERATION

The infrared (IR) keyboard is a wireless programming tool used to provide a convenient way to program the bc632D display. The keyboard transmits a beam of infrared light with a special code for each key pressed. The front panel of the keyboard includes an indicator that flashes when the keyboard is operating.

The IR receiver is located near the right side of the display. There is a small window near the bottom edge of the display for receiving IR commands. Be sure this window is not blocked. When using your infrared keyboard, keep the following points in mind:

- The keyboard must be pointed at the infrared receiver (located on the right hand bottom of the display) whenever keys are pressed.

- The operator should have a clear view of the entire display when programming and MUST be at least 5 feet, but not more than 30 feet from the unit.

- The operator should be standing within 30 degrees of the direct front of the infrared receiver.

- Make sure nothing reflective is located in front of the display message center. Light from the display that is reflected back at the receiver interferes with keyboard operation. Additionally, fluorescent light bulbs could interfere with keyboard operation.

3.2.2 KEYBOARD FUNCTIONS

Refer to Figure 3-1 to familiarize yourself with the keyboard functions. Please note that some keys have two functions. Most of the keys are used for numbers and letters. The other keys are labeled to provide specific functions.

Figure 3-1
Infrared Remote Keyboard

Here is a brief description of the function keys:

PROGRAM
Initiate the Program mode, where you can program the display. It is also used to abort a programming operation. Programming always begins at step 1.

RUN
Complete programming and resume normal operation.

SOURCE
Select the source of time to be displayed.

LABEL
Edit the alphanumeric label for the time display.

FORMAT
Select the format of the time display.

COLOR
Select the color of the time display.

DURATION
Program number of seconds that this step will be displayed before going on.

LINK
Link this step to next step in a sequence.

SELECT
Step through a list of items during programming.

MASTER
(SHIFT-C) Enable or disable digital time transmissions.

SET TIME
(SHIFT-D) Set the time of the internal Real Time Clock, or set up the RTC to synchronize to other time sources.

EVENT
(SHIFT-E) Show the event time and set up the event capture function.

ADDR
(SHIFT-F) Set the address of the display.

RETURN
Answer "yes" to an option.

SHIFT
Access the function or character above another key.

CAPS
Toggle between using upper-case and lower-case letters.

INSERT
Insert characters in a string, rather than typing over existing characters.

BACK
Move backwards (left) through a string of characters.

ADV
Move forwards (right) through a string of characters.

DELETE
Remove a character from a string.

The keyboard operates similarly to a typewriter keyboard. If the character above the main key is desired, press and hold down the SHIFT key and press the main character key. If the character on the main key is desired, simply press the key. No SHIFT key is needed. The CAPS key only works on the 26 main letters “A” through “Z.” Pressing a letter key normally produces a capital letter. To produce lower case letters, press the CAPS key. To return to producing capital letters, press the CAPS key again.

3.2.3 SOUND CONTROL

The wall display is equipped with a speaker and can generate a tone when you press any key except SHIFT. If you want the wall display to emit tones while you are programming, press and hold the SHIFT key while pressing the RUN key. This will turn the tones ON. To turn the tones OFF, press SHIFT and RUN again. The unit defaults to tone ON when restarting after the loss of power.

3.2.4 ON - OFF

The wall display can be turned on and off without unplugging it. The ON/OFF option does not clear the programming information stored in memory. Additionally, the internal time clock is continually updated

even though the wall display is turned off. Note, actual power to the unit is not lost. The display is merely turned off. To perform maintenance or set jumpers, the unit MUST BE UNPLUGGED.

To turn the wall display off, press the SHIFT key while pressing the PROGRAM key. The wall display is turned off. Press the same keys to turn the display back on.

3.2.5 KEYBOARD BATTERIES

The keyboard requires four (4) AAA alkaline batteries.

Note: The batteries MUST BE ALKALINE. To access the battery compartment, turn the keyboard over and slide the cover forward. Replace batteries as needed.

3.3 PROGRAMMING DETAILS

The following sections describe the programming operations of the display.

3.3.1 MEMORY STRUCTURE

The bc632D has eight memory locations which can each store a time source, label, format, color, duration, and link flag. Each memory location is called a "step" since they can be linked together to form a sequence of steps.

In the simplest case, all steps are unlinked. When a step is selected, the time source, label, etc. for that source are used to form the display.

Steps can be linked together to form sequenced displays. For example, Steps 2 through 5 could be linked together so that the message displays:

1. "Welcome to" ... for 2 seconds.

2. "Bancomm" ... for 2 seconds.

3. "The time is" ... for 2 seconds.

4. xx:xx:xx ... for 4 seconds.

(In a repeating sequence.)

3.3.2 SELECTING STEPS

When you enter the program mode, you may change the settings for step 1. You can always tell which step you are editing by the number in the prompt. You may access the other steps at any time, by pressing SHIFT-n, where n is the number of the step you want to access, from 1 to 8.

When the display is running, the SHIFT-n keys also select the step. If the step is part of a sequence, then the sequence will begin with the step that you selected.

If the display changes from one step to another, and the time changes between the two steps, the display will have to acquire the new time source. If the time source is not present, then the display may stay in this state, looking for the time source. If the time source is present, the display may take several seconds to acquire it. For this reason, it is not recommended that you change time sources within a sequence, unless you can tolerate lapses in the time display while the bc632D acquires the time source.

3.3.3 EDITING

When entering a label or setting the clock time, one character will flash. The flashing character is the cursor. The cursor shows you where the next character will appear.

The four keys on the bottom row of the keyboard are used during editing. The BACK and ADV keys are used to move the cursor right or left so that you can edit different parts of the message. The INSERT key is used to switch between the overtype mode of editing and the insert mode. Normally, if you type a character it replaces the next character in the string. When you press the INSERT key, new characters are inserted between existing characters. Pressing INSERT again returns you to overtyping. When the insert mode is active, the prompt at the left end of the display changes to the word "INSERT." When you press the DELETE key, the character under the cursor is removed and any following characters are shifted one position to the left.

3.3.4 SOURCE - SELECT TIME SOURCE

Pressing SOURCE causes the display to show the input source, which will be one of the following:

1. Channel 1.
2. Channel 2.
3. Channel 3.
4. Channel 4.
5. Channel 5.
6. Channel 6.
7. Digital Time.
8. Time Code.

9. Internal Clock.
    a. Datum CD0.

Channels 1 through 6 are individual channels in Datum's multiplexed time transmission system.

Digital Time is Datum's Digital Time Protocol. This protocol uses the RS-485 serial ports to synchronize displays to within one microsecond. If this transmission is interrupted, the display continues with its last known time and rate.

Time Code is IRIG B, IRIG A, 2137 and NASA 36, all auto-selected.

The bc632D will maintain synchronization to the time code to within 1 millisecond. If the time code is interrupted, the display will continue with its last known time and rate.

Datum CD0 is a pseudo IRIG B countdown Time Code. The display synchronizes to the external time code within 1 millisecond. If the time code is lost, the display will not continue to count. Refer to Figure 3-2 for time code format.

You may run through the list of time sources by pressing the SELECT key, or you may use the numbers "1" through "A" to select the corresponding time source.

Pressing the zero ("0") key will cause the display to revert to the current time source.

Once you have selected the time source, you may press the RUN key to operate with that time source, or you may press one of the other programming keys.

3.3.5 LABEL - EDIT TEXT LABELS

The LABEL function lets you set an alphanumeric label for each step. When you press the LABEL key, the display will show the prompt "LBLn," where n is the step you are editing. Labels can be up to 14 characters long, but fewer characters may actually be displayed, depending on the display format selected.

3.3.6 FORMAT - CHANGE DISPLAY FORMAT

Pressing the FORMAT key displays a sample of the current display format. You may use the SELECT key and number keys to select a new format. Formats 1 through 5 do not show the status lights on the right-hand end of the display.

1. C DDD HH:MM:SS
(C = Source Code, Clock would be blank.)

2. LABEL HH:MM:SS
(Uses the first 5 label characters.)

3. DW MON/D/YR
(DW = Day of week (MON-SUN), MON/D/YR is month, day, year.)

4. LBL DDD.FRACT
(LBL = first three label characters, DDD = days, FRACT = 1/10,000 of a day.)

5. LABEL
(Alphanumeric label with no time data.)

Formats 6 through 10 are identical to steps 1 through 5 except that the status lights on the right-hand end of the display are active.

6. C DDD HH:MM:SS
(C = Source Code, Clock would be blank.)

7. LABEL HH:MM:SS
(Uses the first 5 label characters.)

8. DW MON/D/YR
(DW = Day of week (MON-SUN), MON/D/YR is month, day, year.)

9. LBL DDD.FRACT
(LBL = first three label characters, DDD = days, FRACT = 1/10,000 of a day.)

10. LABEL
(Alphanumeric label with no time data.)

In format 1, the first character displays the time source or time code format that is being decoded. The following are possible:

1 = Multiplexed time channel 1.

2 = Multiplexed time channel 2.

3 = Multiplexed time channel 3.

4 = Multiplexed time channel 4.

5 = Multiplexed time channel 5.

6 = Multiplexed time channel 6.

A = IRIG A time code format.

B = IRIG B time code format.

C = 2137 time code format.

D = Digital time protocol.

N = NASA 36 time code format.

(blank) = Internal real time clock.

When Datum CD0 mode is selected, the following display format is used:

CD SH HH:MM:SS

CD = pseudo IRIG B Countdown code format.

S = +/- sign.

H = Hold/Run mode.

L = Lost Signal.

3.3.7 COLOR - CHANGE DISPLAY COLOR

The COLOR key is used to select the color of the time display when it is running. It does not affect the colors used in Program mode. The display will show the prompt "COLn," where n is the current step. Press use the SELECT key or the number keys to select a color.

1. RED

2. GREEN

3. YELLOW

3.3.8 DURATION - CHANGE RUN TIME OF A STEP

This key is used to set the number of seconds that a step will run. If the step is not linked in a sequence, then the duration value has no effect. The display will show the prompt "DURn," where n is the current step. Use the editing keys to enter a number between 0 and 255. When entering numbers, you must use leading zeroes. For example, 10 seconds would be entered as "010."

3.3.9 LINK - LINK TO NEXT STEP

The LINK key allows you to link the current step to the next step to form a sequence. Press SELECT to toggle between ON and OFF. If link is ON, the display will show this step for the time set in DURATION, and then it will display the next step. If link is OFF, then the display will run the step for its DURATION and then go to the beginning of the sequence. The last step in a sequence must have its link turned OFF. If the link is ON for step 8, then the sequence will continue with step 1.

3.3.10 MASTER (SHIFT-C) - ENABLE DIGITAL TIME MASTER TRANSMISSIONS

The MASTER key can be used to enable or disable the digital time transmissions of the bc632D. If several displays are wired together on the same network, one can act as a time master for the network. The remaining displays on the network can synchronize to the master's digital time signals.

To enable this bc632D as a digital time master, use the SELECT key to change MASTER to ON. Otherwise leave it OFF.

3.3.11 SET TIME (SHIFT-D) - SET INTERNAL CLOCK

The SET TIME key is used to set the time of the Real Time Clock.

There are three ways to set the time of the RTC. First, the clock can be set manually by typing in the desired time using the remote keyboard. Second, the clock can be synchronized once to the current time source. And third, the display can be programmed to synchronize to the current source each time the unit is powered up.

TIME HH:MM:SS DD/MM/YR	Set internal clock.
Sync clock?	Synchronize clock to time code.
et Autosync?	Synchronize clock on every power-up.

Clr Autosync?	Turn off Autosync feature.

When the first item is displayed, the number keys can not be used to select the other items in the list, since the number keys are used to set the time. However, the number keys do select items in the list when items 2 through 4 are displayed.

When you first press the SET TIME key, the display will read "TIME hh:mm:ss." You may press the ADV key to scroll through the current time, and make changes. Or, you can type in the new time in exactly the format shown above. The day of week will be calculated automatically by the bc632D.

The "Sync clock" item lets you set the internal clock to the same time as the current time source. The message will be "Sync clock?" You may press “Y,” RETURN, or RUN to start the setting process. If you do not want to synchronize the clock to the time source, you may press a number key (1-4) or SELECT to select another item, or you may press PROGRAM to abort.

Autosync sets the display to automatically synchronize the internal clock to the time source each time power is applied to the display. When the display reads "Set Autosync?" you may press “Y,” RETURN, or RUN to activate this feature. If you do not want to activate the autosync feature, you may press a number key (1-4) or SELECT to select another item, or you may press PROGRAM to abort.

The autosync feature is disabled by selecting the message "Clr Autosync?" and pressing “Y,” RETURN, or RUN. If you do not want to deactivate the autosync feature, you may press a number key (1-4) or SELECT to select another item, or you may press PROGRAM to abort.

3.3.12 EVENT (SHIFT-E) - CHANGE EVENT CAPTURE PARAMETERS

The bc632D can display the time at which an external event occurred. The event time is displayed to milliseconds.

E: HH:MM:SS.mmm	Captured Time. (mmm = milliseconds).
Clear Event?	Clear the current event time to allow for a new event.
Rising Edge?	Set event to be captured when input goes high.
Falling Edge?	Set event to be captured when input goes low.
No Edge?	Disables event capture input.

When you first press the EVENT key, the display will read "E:--- --:--.--." If a time has previously been captured, the dashes will be replaced by digits indicating the time of the event. To clear the event

and allow for a new one, press '2' or SELECT to display the message, "Clear Event?" You may then press "Y," RETURN or RUN to clear the event.

The event capture can detect rising edges or falling edges of the input signal. To select a rising edge detect, press “3” or SELECT to display the message "Rising Edge?" You may press “Y,” RETURN, or RUN to set the event capture for rising edges. To select a falling edge detect, press “4” or SELECT to display the message "Falling Edge?" You may press “Y,” RETURN, or RUN to set the event capture for falling edges. To disable the event capture, press “5,” or SELECT to display the message "No Edge?" You may press “Y,” RETURN, or RUN to disable event capture. If you do not want to change the edge polarity of the event capture you may press a number key (1-6) or SELECT to select another item, or you may press PROGRAM to abort.

3.3.13 ADDR (SHIFT-F) - CHANGE LOCAL ADDRESS.

The address key is used to enter a local address so a remote computer can selectively program displays.

The address is three characters long. Any character can be used, and case is significant; "Adr" is not the same as "adr" or "ADR." When entering addresses, be careful of using zero or the letter "Oh," since both look identical on the display.

Address "000" (all zeroes) is a "wildcard" address. All displays will respond to commands that begin with this address.

3.3.14 PROGRAM RETENTION

The wall display will retain programming information for approximately one month after a power interruption without access to power. However, to ensure sufficient charging time, the wall display must be plugged into a power source for at least eight hours prior to a power interruption. If the unit is plugged into a power source for only a short time, the unit's information retention time will be shorter.

When power is restored to the unit, the previously programmed parameters will be used automatically.

3.4 PROGRAMMING SUMMARY

PROGRAM: Select time source

1. Serial Channel 1.

2. Serial Channel 2.

3. Serial Channel 3.

4. Serial Channel 4.

5. Serial Channel 5.

6. Serial Channel 6.

7. Digital Time.

8. Time Code.

9. Internal Clock.
   a. Datum CD0

LABEL: Edit label.

FORMAT: Select display format.

1. C DDD HH:MM:SS
(C = Source Code, Clock would be blank.)

2. LABEL HH:MM:SS
(Uses the first 5 label characters.)

3. DW MON/D/YR
(DW = Day of week (MON-SUN), MON/D/YR is month, day, year.)

4. LBL DDD.FRACT
(LBL = first three label characters, DDD = days, FRACT = 1/10,000 of a day.)

5. LABEL
   (Alphanumeric label with no time data.)

Formats 6 through 10 are identical to steps 1 through 5 except that the status lights on the right-hand end of the display are active.

6. C DDD HH:MM:SS
(C = Source Code, Clock would be blank.)

7. LABEL HH:MM:SS
(Uses the first 5 label characters.)

8. DW MON/D/YR
(DW = Day of week (MON-SUN), MON/D/YR is month, day, year.)

9. LBL DDD.FRACT
(LBL = first three label characters, DDD = days, FRACT = 1/10,000 of a day.)

10. LABEL
(Alphanumeric label with no time data.)

COLOR: Select display color.

1. RED

2. GREEN

3. YELLOW

MASTER (SHIFT-C)
Enable digital time master.

SET TIME (SHIFT-D)
Set the time of the internal clock.

TIME HH:MM:SS DD/MM/YR (Set internal clock.)

Sync to TC?

Set Auto Sync?

Clear Auto Sync?

EVENT (SHIFT-E)
Set up event input.

HH:MM:SS.[mmm] (captured time.)

Clear Event? Clear the current event time to allow for a new event.

Rising Edge? Set event to be captured when input goes high.

Falling Edge? Set event to be captured when input goes low.

No Edge? Turn off event capture input.

ADDR (SHIFT-F)
Edit local address.

SHIFT-number
Select step (1-8).

3.5 INITIAL PARAMETERS

The bc632D initial factory parameters are shown below:

Source of time	Internal real time clock.
Labels	All labels are blank.
Formats	Format 1 (C DDD:HH:MM:SS).
Color	Red.
Duration	000 seconds.
Link	Off.
Master	Off.
Event	Off (No Edge).
Address	"000" (all zeroes).

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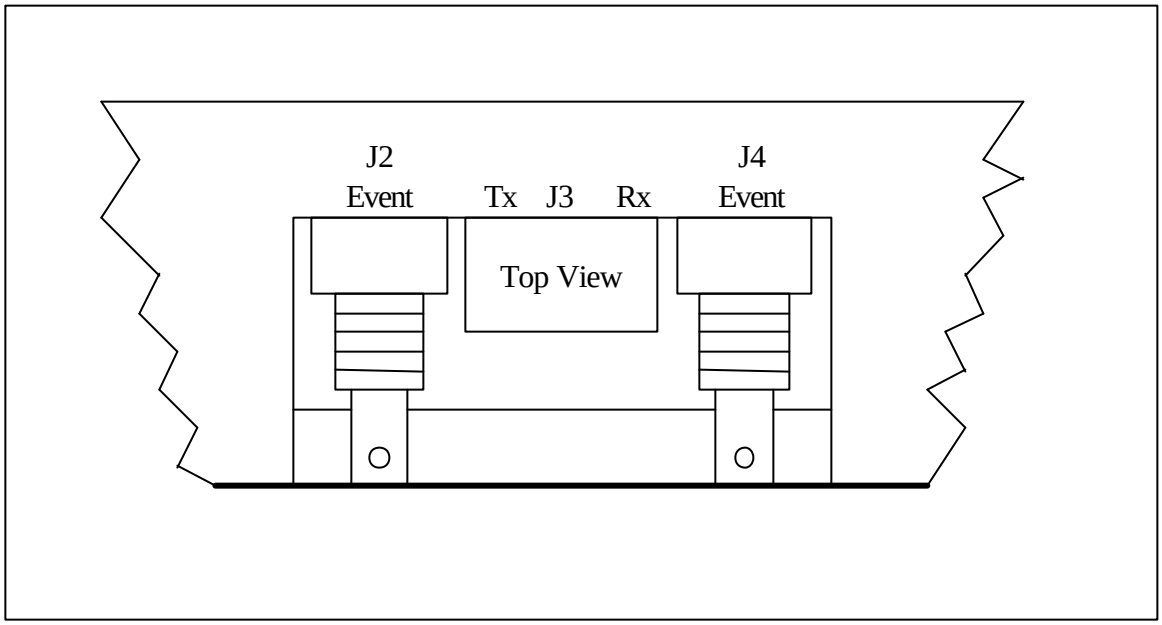
CHAPTER FOUR
I/O CONNECTORS

4.0 GENERAL

All I/O signals are available on the rear panel connectors. Time code input is available on the rear panel BNC connector. The locations of all connectors are shown in Figure 4-1.

Figure 4-1
Connector Location



4.1 J2 EVENT INPUT/1PPS OUTPUT BNC CONNECTOR

J2 is a BNC connector that is normally used as a 1PPS output. It may also be changed via internal jumper JP4 to an event input. In both cases the signals use standard CMOS/TTL levels. See section 2.1.6 for setting JP4.

4.2 J3 RS-485 SERIAL DIFFERENTIAL INPUT/OUTPUT

A serial RS-485 differential input/output is available on the rear panel phone jack connector J3. The pinouts for J3 are listed in Tables 4-1 and 4-2. Figure 4-2 shows the orientation of the J3 pins. These connectors are used for linking bc632D's in a network configuration using Datum's Digital Time protocol. Standard telephone wire can be used to connect Slave bc632D's to a Master. The bc632D can also be used as a Digital Time master.

The output port can also be used for diagnostic purposes. The bc632D broadcasts time, measured code period, code detection status, code search status, software version and date code, AGC slice level, and control byte information. Data is sent at 9600 baud, 8 data bits, one stop bit, no parity. Each line is terminated by a cariage return (0DH) and a line feed (0AH).

The Tx(-) signal will drive most RS-232 interfaces such as a serial port to a PC. The data pacing signals RTS, CTS, DSR and DTR may need to be jumpered depending on the specific terminal emulation software in use.

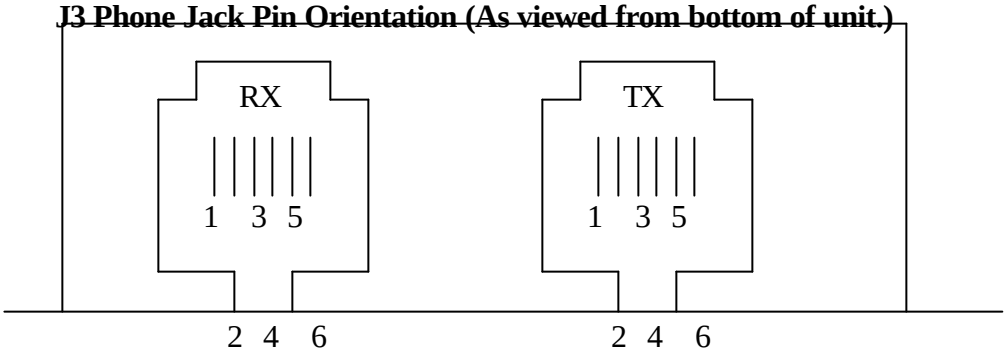
Table 4-1
J3-RX Serial RS-485 I/O Pinouts

J3-RX	Signal Description
1	RS-232 IN / Control Rx (+).
2	Ground.
3	DATA RX (-).
4	DATA RX (+).
5	Ground.
6	RS-232 OUT / Control Rx (-).

Table 4-2
J3-TX Serial RS-485 I/O Pinouts

J3-TX	Signal Description
1	Control Bus Tx (+).
2	Ground.
3	DATA TX (+).
4	DATA TX (-).
5	Ground.
6	Control Bus Tx (-).

Figure 4-2
J3 Phone Jack Pin Orientation (As viewed from bottom of unit.)



4.2.1 SERIAL OUTPUT MESSAGES

When a valid time code signal is being decoded, a packet of data is sent every second, about half a second after the 1PPS signal occurs. The following are examples of message data when decoding the respective time code signals, real time clock, and other time sources. All lines are terminated by a carriage return and line feed characters.

Initialization Message:

bc632D f/w #9501066 9/30/92
initialization complete

time source = XX

Decoding modulated time code:

*
(Time code type) {iriga, irigb, nasa36, 2137}
lev = XX {X represents a hexadecimal digit}
dif = XXXX
Time yy ddd hh:mm:ss.::::: {See Note 7}

Using internal clock:

**
RTC
dif = XXXX
Time yy ddd hh:mm:ss.::::: {See Note 7.}

Decoding RTC, DC Level Shift time code:

*
(Time Source) {iriga - dcls, irigb - dcls, nasa36 - dcls }
dif = XXXX
Time yy ddd hh:mm:ss.::::: {See Note 7.}

Searching for time code:

checking (time code type){Modulated time code: irigb, iriga, nasa36, 2137}
lev = cannot find (time code type)

checking (time code type){Non-modulated time codes: irigb - dcls, iriga - dcls, nasa36 - dcls}

cannot find (time code type)

Time code error message:

decode error !!

Flywheeling message:

*
flywheeling!!
Time yy ddd hh:mm:ss.:::::

Notes:

- "lev" is a hex representation of the "slice" level of a modulated time code. It is used to determine whether a cycle is a high or low cycle.
- "dif" is hexadecimal representation of the time code period measurement. It is used to scale the internal time. The dif value reflects the difference between the internal crystal and the external time signal.
- No data is transmitted out the serial port when the bc632D is set up as a Slave.
- RS-485 data is only received by the bc632D when the display is configured as a Slave. The normal message data broadcast from the Master is decoded by the Slave for time synchronization.
- No control codes or commands are accepted through the time bus.
- The RS-485 messages were provided primarily for diagnostic purposes. However, you may use the data to obtain time externally from the board. Once a valid time code is being decoded, time/message data is broadcast once each second about 1/2 second after the 1PPS signal. The time being broadcast, following the "Time" label, is valid at the rising edge of the preceding 1PPS pulse.
- µ µ µ µ µ gives time offset information for the digital time protocol.

4.3 J4 TIMECODE INPUT BNC CONNECTOR

The BNC connector J4 can be chosen to carry one of three different signals from the bc632D. The signal desired is selected with jumper JP7. See Section 2.1.9 to set jumper JP7.

CHAPTER FIVE
ADJUSTMENTS

5.0 PHASE-LOCKED LOOP ADJUSTMENT

The bc632D has a single adjustment which should never require alteration by the user. This section outlines a method for correctly setting the phase-locked loop adjustment, variable resistor RV1. The following steps assume that the power is applied and the bc632D rear cover has been removed to allow access by an oscilloscope probe. A source of IRIG B timecode is required.

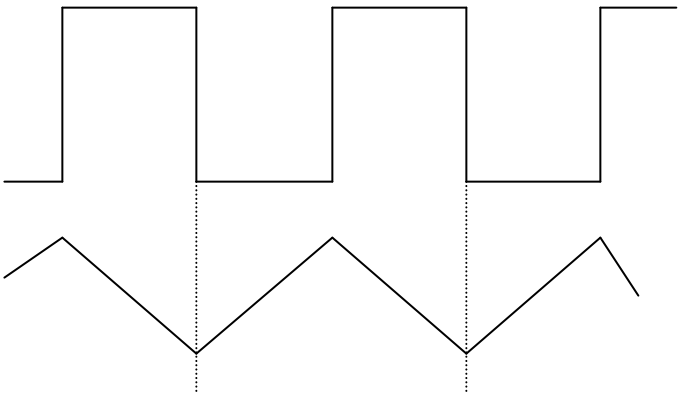
- Using the remote control, select "Timecode" as the source of time.

- Input the IRIG B timecode through the BNC connector (J4).

- Use pin 16 of U13 as the input to channel A of a dual channel oscilloscope. Use the reference carrier selected in (2) above as the input to channel B of the oscilloscope. Use channel A as the oscilloscope horizontal synch input.

- The signal on pin 16 of U13 (channel A) is a square wave with nominal frequency of 1kHz. It will jump to 10kHz periodically when the unit is looking for IRIG A time code, and will turn off when it is looking for DC level shift time codes. Adjust R6 so that the negative going transitions of the 1kHz square wave are centered on the negative "peaks" of the carrier. See figure 1.0 below. The signal on pin 16 of U13 should remain at 1kHz once the unit has started decoding the IRIG B input.

Figure 5-1
Phase-Locked Loop Adjustment



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CHAPTER SIX
DRAWING SET

6.0 GENERAL

This chapter contains the schematic diagram, assembly drawing, and parts list for the bc632D, following page 6-2.

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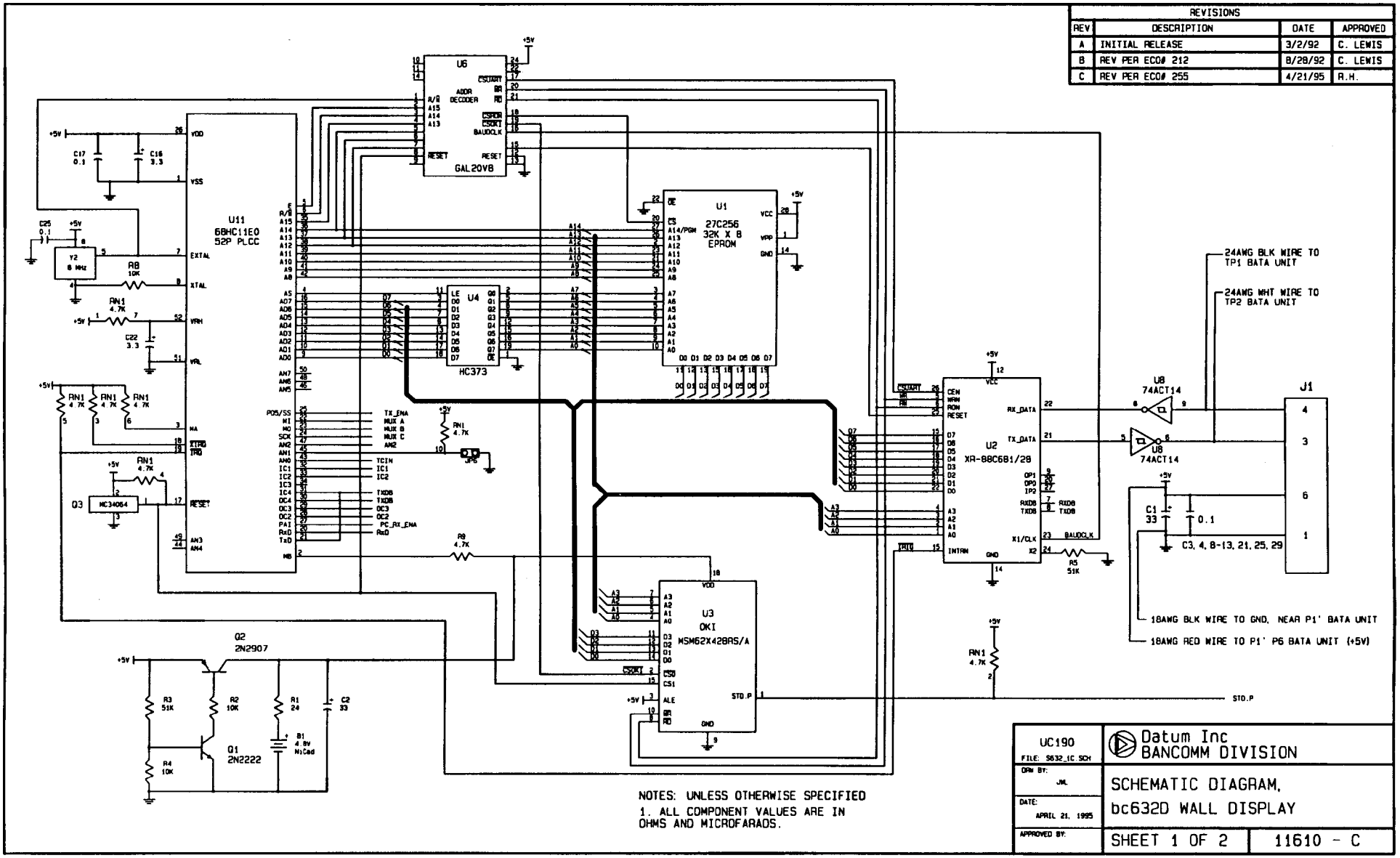
REVISIONS
REV | DESCRIPTION | DATE | APPROVED
A | INITIAL RELEASE | 3/2/92 | C. LEWIS
B | REV PER ECO# 212 | 8/28/92 | C. LEWIS
C | REV PER ECO# 255 | 4/21/95 | R.H.
U6
GAL20V8
U11
68HC11E0
52P PLCC
U1
27C256
32K X 8
EPROM
U4
HC373
U2
XR-88C681/28
U3
OKI
MSM62X428RS/A
U8
74ACT14
J1
24AWG BLK WIRE TO TP1 BATA UNIT
24AWG WHT WIRE TO TP2 BATA UNIT
18AWG BLK WIRE TO GND, NEAR P1' BATA UNIT
18AWG RED WIRE TO P1' P6 BATA UNIT (+5V)
C3, 4, 8-13, 21, 25, 29
Q2
2N2907
Q1
2N2222
Q3
MC34064
NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL COMPONENT VALUES ARE IN OHMS AND MICROFARADS.
UC190
FILE: S632_IC.SCH
DRN BY: JML
DATE: APRIL 21, 1995
APPROVED BY:
Datum Inc
BANCOMM DIVISION
SCHEMATIC DIAGRAM,
bc632D WALL DISPLAY
SHEET 1 OF 2
11610 - C

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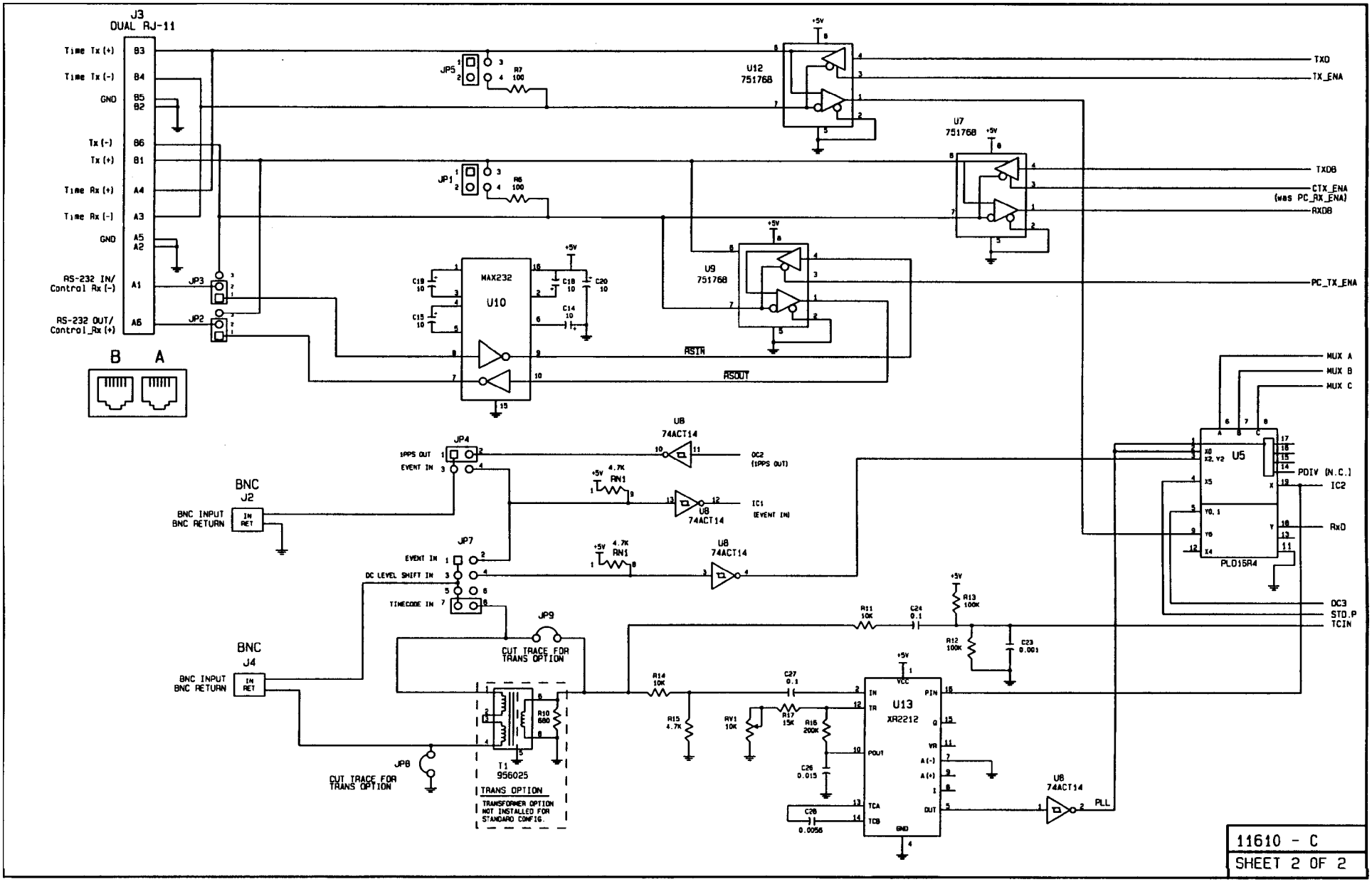

11610 - C

SHEET 2 OF 2

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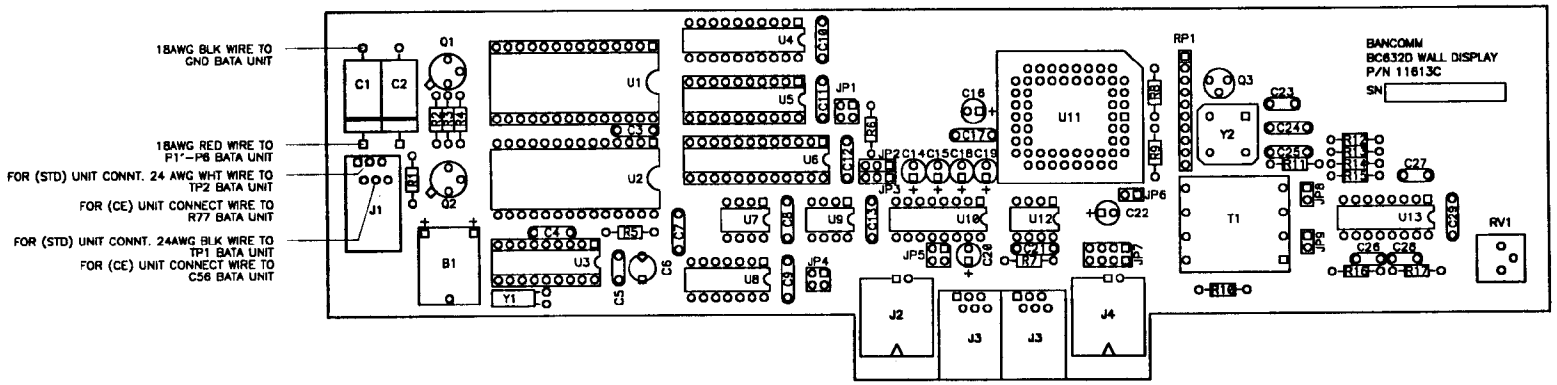
REVISIONS			
LTR	DESCRIPTION	DATE	APVD
A	FIRST RELEASE	03/20/92	C.L
B	REV PER ECO# 212	08/28/92	C.L
C	REV PER ECO# 255	04/21/95	R.H.



UC190 FILE: A632_1C.SCH	Datum Inc BANCOMM DIVISION	
DRW BY: JWL	ASSY, DIAGRAM bc632D WALL DISPLAY PCB	
DATE: APR 21, 1995		
APP. BY:	SHEET: 1 OF 2	11613-C

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ASSEMBLY, PARTS LISTING
bc632D Wall Display

Ref: Drawing No. 11613C

Ref: UC 190

April 21, 1995

BC P/N	OPT	MANF P/N	MANUFACTURE	VALUE	DESCRIPTION	QTY#	REF DESIG.
1411002		11615A	DATUM INC, BC		PCB MOUNTING BLOCK	4.00	MB1
1502104		SR265C104MAA	AVX	.1 MF, 50V	MONOLITHIC CERAMIC CAP.	1.00	C27
1503106		106RMR025M	IC	10 MF,35V	ALUM ELEC CAPACITOR	5.00	C14,15,18,19,20
1503335		335RMR035M	IC	3.3 MF,35V	ALUMINUM ELECTROLYTIC CAP.	2.00	C16,22
1506102		SR211C102KAA	AVX	1000 PF,50V	MONO CERAMIC CAPACITOR .2 R/L	1.00	C23
1506153		SR211C153KAA	AVX	15000 PF,100V	MONO CERAMIC CAPACITOR .2 R/L	1.00	C26
1506562		SR211C562KAA	AVX	5600 PF,100V	MONO CERAMIC CAPACITOR .2 R/L	1.00	C28
1508336		336TTA035B	IC	33 MF,35V	ALUM. ELEC. CAPACITOR AXIAL/L	2.00	C1,2
1515104		MD015E104MAA	AVX/67349	0.1 MF,50V	DIP GUARD CAPACITOR	14.00	C3,4,7-13,17,21,24,25,29
1701190		11612B	DATUM INC, BC	bc632D DISPLAY	PRINTED CIRCUIT BOARD	1.00	PCB1
2105001		227161-2	AMP		RTANG,PC MOUNT, BNC RECEPT.	2.00	J2,4
2117061		TSW-130-07-G-D	SAMTEC	2X30 POS	STRAIGHT TERMINAL STRIP	0.00	JP6=1x2,JP7=2x4
2117061		TSW-130-07-G-D	SAMTEC	2X30 POS	STRAIGHT TERMINAL STRIP	1.00	JP1,4,5=2x2,JP2,3=1x3
2149024		824-AG31D	AUGAT	24 POS	SLIM DIP SOCKET	1.00	REF: U6
2150020		10620-01-445	ANDON/SPECIRA	20 POS	DIP SOCKET	1.00	REF: U5
2150028		10628-01-445	ANDON/SPECIRA	28 POS	DIP SOCKET	1.00	REF: U1
2152052		641748-2	AMP	52 POS	PLCC REC CHIP CARRIER	1.00	REF: U11
2190002		SS-666602-NF	STEWART	2 PORT 6POS	PHONE JACK RECEPTICAL	1.00	J3
2306008		X209	DIGI-KEY	8MHz	HALF SIZE TTL/CMOS CLOCK OSC	1.00	Y2
3902001		PMB4.8-15-H3	PLAINVIEW INC.	4.8V	NICAD PCMNT BATTERY	1.00	B1
4701101		RC07GF101J	ALLEN BRADLEY	100 OHM,1/4W	FIXED RESISTOR	2.00	R6,7
4701103		RC07GF103J	ALLEN BRADLEY	10 K OHM,1/4W	FIXED RESISTOR	5.00	R2,4,8,11,14
4701104		RC07GF104J	ALLEN BRADLEY	100 K OHM,1/4W	FIXED RESISTOR	2.00	R12,13
4701153		RC07GF153J	ALLEN BRADLEY	15 K OHM,1/4W	FIXED RESISTOR	1.00	R17
4701204		RC07GF204J	ALLEN BRADLEY	200 K OHM,1/4W	FIXED RESISTOR	1.00	R16
4701240		RC07GF240J	ALLEN BRADLEY	24 OHM,1/4W	FIXED RESISTOR	1.00	R1
4701472		RC07GF472J	ALLEN BRADLEY	4.7 K OHM,1/4W	FIXED RESISTOR	2.00	R9,15
4701513		RC07GF513J	ALLEN BRADLEY	51 K OHM,1/4W	FIXED RESISTOR	2.00	R3,5
4703103		72P103	BECKMAN	10 K OHM,1/2W	SINGLE TURN POTENTIOMETER	1.00	RV1
4705472		710A472	ALLEN BRADLEY	4.7 K OHM,1/8W	C-SIP RESISTORS, 10 PIN 'X'	1.00	RN1
4801002		2N2222			NPN SWITCHING/AMPLIFIER (TO18)	1.00	Q1
4802002		2N2907A	MOTOROLA	3P D PKG	PNP SWITCHING/AMPLIFIER (TO18)	1.00	Q2
9002510		74ACT14	RCA	14P DIP PKG	HEX SCHMITT INVERTER	1.00	U8
9008657		74HC373	VARIOUS	20P DIP PKG	OCTAL D TRANSPARENT LATCH, T/S	1.00	U4
9102003		MC68HC11E0FN	MOTOROLA	52P PLCC PKG	MICROCOMPUTER	1.00	U11 (SKT)
9103035		MSM62X42BRS/A	OKI	18P DIP PKG	REAL TIME CLOCK/CALENDAR	1.00	U3
9201030		MC34064P-5	MOTOROLA	3P CASE29-04 PKG	UNDERVOLTAGE SENSING DEVICE	1.00	Q3
9207037		MAX232CPE	MAXIM	16 PIN PKG	QUAD DRV/REC RS-232, V.28	1.00	U10
9207055		XR-88C681-28CP	EXAR	28 PIN PKG	CMOS DUAL CHANNEL UART	1.00	U2
9207076		SN75176B	TI	08P DIP PKG	DIFF BUS TRANS	3.00	U7,9,12
9307030		XR2212CP	EXAR	16P DIP PKG	PHASE LOCKED LOOP	1.00	U13
9405020		PAL16R4ACN	MMI	20P DIP PKG .3W	PAL 35 NS	1.00	U5 (SKT)
9405065		GAL20V8A-25LP	LATTICE	24P DIP PKG	GAL 25NS	1.00	U6 (SKT)
9406040		27C256	VARIOUS	28P DIP PKG .6W	32 K BYTE, CMOS EPROM	1.00	U1 (SKT)
9700005		10401111	ADAPTIVE MICRO SYS	BETA-BRITE	ELEC MESSAGE DISPLAY ASSEMBLY	1.00	CH1
	XFM				TRANSFORMER OPTION		
4701681	XFM	RC07GF681J	ALLEN BRADLEY	680 OHM, 1/4W	FIXED RESISTOR	1.00	R10
5603002	XFM	956025	DATUM INC	08P DIP PKG	TRANSFORMER	1.00	T1

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APPENDIX A

DIGITAL TIME TRANSMISSION PROTOCOL

A.0 INTRODUCTION

This document defines the Digital Time Transmission Protocol as used by Datum timing products. The protocol allows devices to be synchronized to a common source of time. In addition, it allows several devices (typically displays) to synchronize to multiple time references using a common cable.

A.1 PHYSICAL

A.1.1 DEVICE CONNECTORS

Each device will have at least one RJ11 connector for receiving timing signals. Optionally, the device can have a second RJ11 for transmitting or daisy-chaining the signal.

The pin assignments for the devices are as follows:

Receiver	**Transmitter:**
1 n.c.	**1** n.c.
2 GND	**2** GND
3 TX(+)	**3** RX(-)
4 TX(-)	**4** RX(+)
5 GND	**5** GND
6 n.c.	**6** n.c.

A.2 SIGNAL DESCRIPTION

TX(+), TX(-)
5-Volt balanced signal, complying with EIA RS-485. These lines carry the timing signals. Several transmitters may share the same line.

RX(+), RX(-)
5-Volt balanced receiver, complying with EIA RS-485. These lines carry the timing signals. Several transmitters may share the same line.

GND
Signal ground.

n.c.
Not Connected. These pins are not used. Do not connect to these pins unless you have a specific use for them.

A.3 CABLE

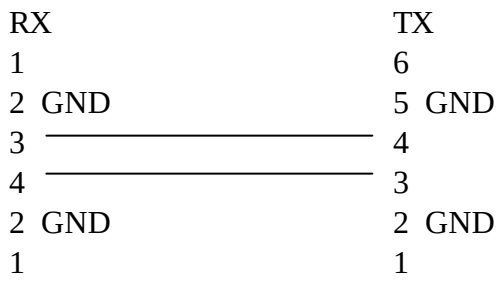
Connections are made using a 6-conductor RJ11 jack. The cable has an RJ11 plug on each end, wired in this way:

This is the wiring of a standard phone cable. Conductors on pins 1 and 6 are not used, and they can be omitted in the cable.

A.4 DAISY-CHAINING

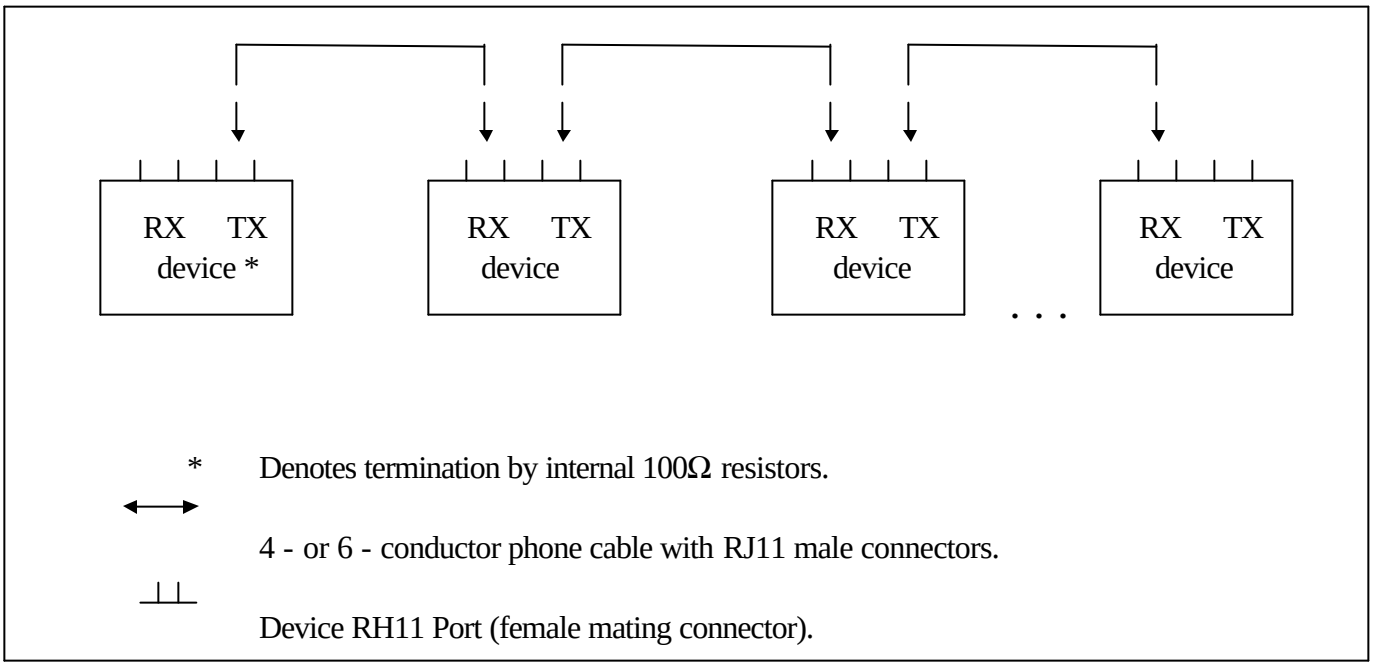
You may connect a limited number of devices on a network by daisy-chaining. Daisy-chaining is simple to install. However, the drawback is that any connector failure in the middle of the chain will block timing signals to devices beyond the failure. Daisy-chaining more than five devices is not recommended.

If a device has both a transmit and receive jack, they should be connected internally like this:

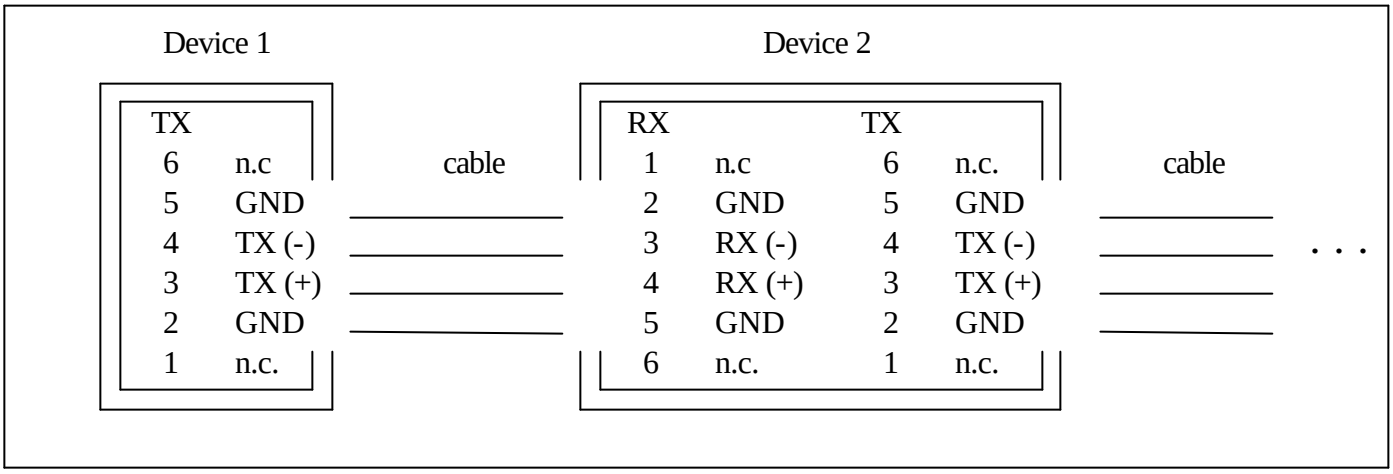


This arrangement allows the signal to be daisy-chained. Drivers should be selected that do not load the line excessively when power to the device is off. This allows a device to be turned off without shutting down the whole network or breaking the daisy-chain.

Using this connector arrangement yields a connection like this:

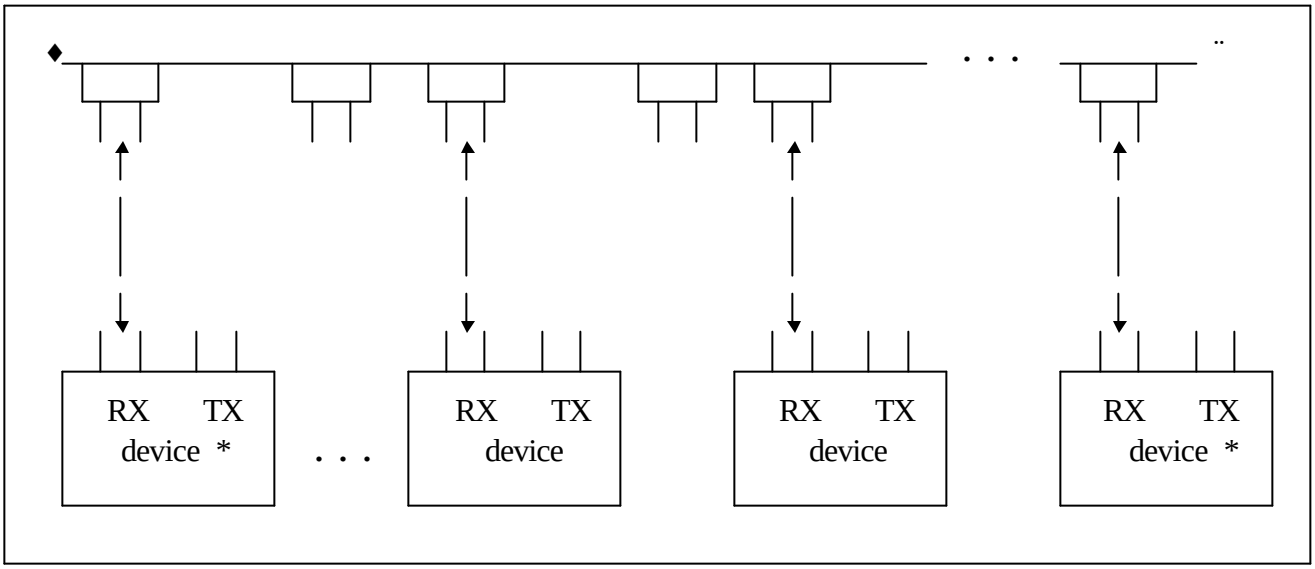


And a detailed view of the signal paths is shown here:



A.5 BUSSING

Large numbers of devices should be connected in a bussed arrangement. Up to 32 devices may be connected this way, with a maximum cable length of 4,000 feet. The main bus should be a shielded twisted pair to increase noise immunity. Stubs off the main bus should be kept as short as possible.



Device RJ11 Port (female mating connector).

4 conductor phone cable with RJ11 male connectors.

Wall mount junction connector with female RJ11 mating connector.

Termination
Choice of one of the following methods:

♦ Denotes external junction connector with female RJ11 mating connector.

* Denotes termination by on-board 100Ω resistors (necessary if RS-485 line is not externally terminated).

A.6 TERMINATION

Each end of a network should be terminated with a 100Ω ¼ Watt resistor between pins 2 and 5. This may be an external resistor, or a resistor inside the unit at the end of the cable.

A.7 LOGICAL DESCRIPTION

A.7.1 BIT RATE, PARITY AND FRAMING BITS.

The timing signals are sent as asynchronous serial messages. Characters are sent at 9600 BPS, with one start bit, one stop bit, and no parity bit.

A.7.2 MESSAGE FORMATS

There are three possible message formats. A device may be designed to read any or all of them.

A.7.3 DIGITAL TIME - CHARACTER MODE

Digital time is the highest-precision method of transmission. With good local clocks, synchronization to less than 5 microseconds is easily achieved. A digital time message consists of two messages in this format:

```
* <CR> <LF>
Time YY+DDD HH:MM:SS.:::::: <CR> <LF>
```

Where:

"*" is an asterisk, which is transmitted as soon after to the on-time mark as possible. It is followed by a carriage return ($0D) and a line feed ($0A).

There is a space after the word Time, and case is significant.

"YY" is two ASCII numeric characters representing the year, followed by a space. Numbers from "90" to "99" refer to 1990-1999 and numbers from "00" to "89" refer to 2000-2089.

"+" is a single character representing the sign of the time. It may be "+" or " ", representing time greater or equal to zero, or "-" representing time less than zero. It may be ignored for receiving devices that do not operate with count down times.

"DDD" is three ASCII numeric characters representing days, followed by a space. This can range from "000 " to "999."

"HH:" is two ASCII numeric characters representing hours, followed by a colon. This can range from "00:" to "23:."

"MM:" is two ASCII numeric characters representing minutes, followed by a colon. This can range from "00:" to "59:."

"SS." is two ASCII numeric characters representing seconds, followed by a period. This can range from "00:" to "59:."

"μ μ μ μ μ μ" is six ASCII hexadecimal characters representing the time tag of the beginning of the stop bit of the asterisk. The unit of time is a half-microsecond (see "Time Tags" below). It is followed by a carriage return ($0D) and a line feed ($0A).

The message must be transmitted within the one second period following the on-time mark.

A.7.4 DIGITAL TIME - PULSE MODE

In some master devices, the serial transmitter is not available to send a reference character near the on-time mark. In that case, an alternative format is used. In this format, the reference is an 8 uS low-going pulse near the on time mark. Receiving devices can detect the pulse by setting the baud rate to 125kbps. The pulse will be received as an $FF character with no framing errors.

The format of the message is:

8 μs pulse.

* * <CR> <LF>
Time YY+DDD HH:MM:SS.μ μ μ μ μ μ <CR> <LF>

Where:

The pulse must be sent within the first 32.760 ms after the true on-time mark.

There is a space after the word Time, and case is significant.

"**" is two asterisks followed by a carriage return ($0D) and a line feed ($0A).

"μ μ μ μ μ μ" is six ASCII hexadecimal characters representing the time tag of the trailing edge of the reference pulse. The unit of time is a half-microsecond (See "Time Tags" below). It is followed by a carriage return $0D) and a line feed ($0A).

The remainder of the message is the same as in the previous section.

The message must be transmitted within the one second period following the on-time mark.

Note: If the receiving device remains at 9600 BPS, it may detect the 8 microsecond pulse as a start pulse and interpret this as a character, or it may ignore it completely, depending on the serial receiver. The reference pulse may also be thought of as a valid asynchronous character $FF at 125K Baud.

A.7.5 MULTIPLEX TIME

The multiplex time protocol is similar to the digital time protocol. It is intended for an installation of several displays which may have to show different times. It uses the same physical wiring configuration.

The format of the multiplexed time messages is:

CHNx YY+DDD HH:MM:SS.:::::: <CR> <LF>

Where:

"CHN" is all capitals.

"x " is an ASCII character specifying the channel, followed by a space.

":::::" is six ASCII hexadecimal characters representing the time tag of the beginning of the stop bit of the first "C" in the "CHN" message. The unit of time is a half-microsecond (see "Time Tags" below). It is followed by a carriage return ($0D) and a line feed ($0A).

The other fields are the same as above.

The message must be transmitted within the one second period following the on-time mark.

A.8 TIME TAGS

Receiving devices can read the time message to keep their clocks synchronized to within one second. To adjust to tighter synchronization, the receivers must adjust their clocks to the true on-time mark using the time tags.

Each message has a reference point. For digital time, the reference point is the stop bit of the first asterisk, or the trailing edge of the 8 uS reference pulse. For multiplex time, the reference point is the stop bit of the first 'C' of the "CHN" message.

The time tags specify the number of half-microsecond units between the master's on-time mark and the reference point. For example, a value of "0007D0" indicates that the stop bit of the most recent reference character was sent at 1000 microseconds after the on-time mark (7D0 hex = 2000 decimal, 2000 * 0.5 microseconds = 1000 microseconds).

APPENDIX B

bc632D CONTROL BUS PROTOCOL

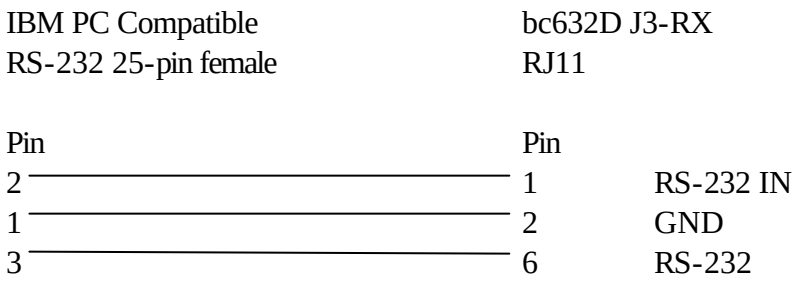
B.0 INTRODUCTION

Receiving devices can read the time message to keep their clocks synchronized to within one second. To adjust to tighter synchronization, the receivers must adjust their clocks to the true on-time mark using the time tags.

Each message has a reference point. For digital time, the reference point is the stop bit of the first asterisk, or the trailing edge of the 8 uS reference pulse. For multiplex time, the reference point is the stop bit of the first “C” of the "CHN" message.

The time tags specify the number of half-microsecond units between the master's on-time mark and the reference point. For example, a value of "0007D0" indicates that the stop bit of the most recent reference character was sent at 1000 microseconds after the on-time mark (7D0 hex = 2000 decimal, 2000 * 0.5 microseconds = 1000 microseconds).

Figure B-1
IBM PC Compatible Connection

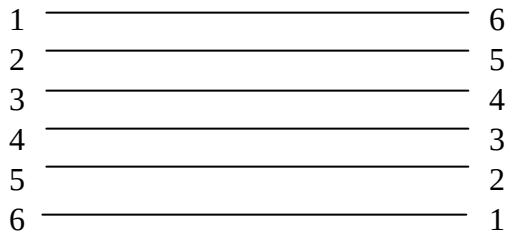


Because both transmitters and receivers are connected to the same pair of lines, all characters transmitted by the computer will be echoed back to the receiver. This is a good way to determine whether or not the physical connection has been made correctly.

B.1 RS-485 SIGNALS

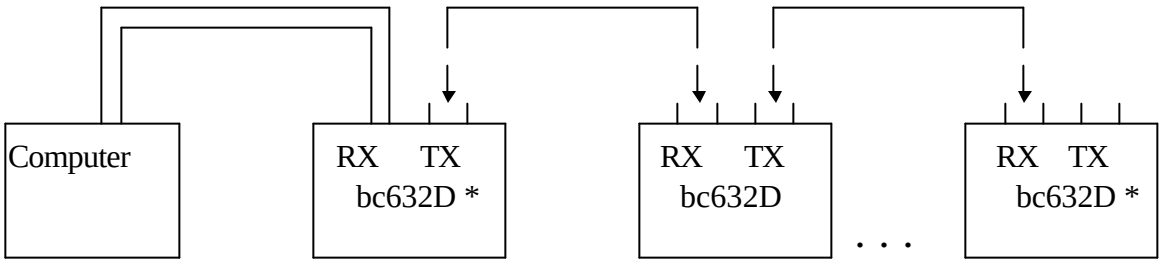
The signals carried between bc632D's are RS-485 compatible. The two RJ11 jacks on each display are wired together so that standard telephone cable can be used between devices. Standard telephone cables are wired as shown in Figure B-2. Notice that signals get swapped between pins 1 and 6; 2 and 5; and 3 and 4 from one end of the cable to the other. The wiring inside the displays swaps the signals back to the correct pins to continue the daisy-chain. Because of the internal swapping, the control bus will not operate properly with cable that is wired pin 1 to pin 1.

Figure B-2
Standard RJ-11 Telephone Cable



B.2 DAISY-CHAINING

You may connect a limited number of displays on a network by daisy-chaining. Daisy-chaining has the advantage of being simple to install, with the drawback being that any connector failure in the middle of the chain will block control signals to devices beyond the failure. Daisy-chaining more than five devices is not recommended. A daisy-chained configuration is shown below.



***** Denotes termination by internal 100Ω resistors.

6-conductor phone cable with RJ11 male connectors.

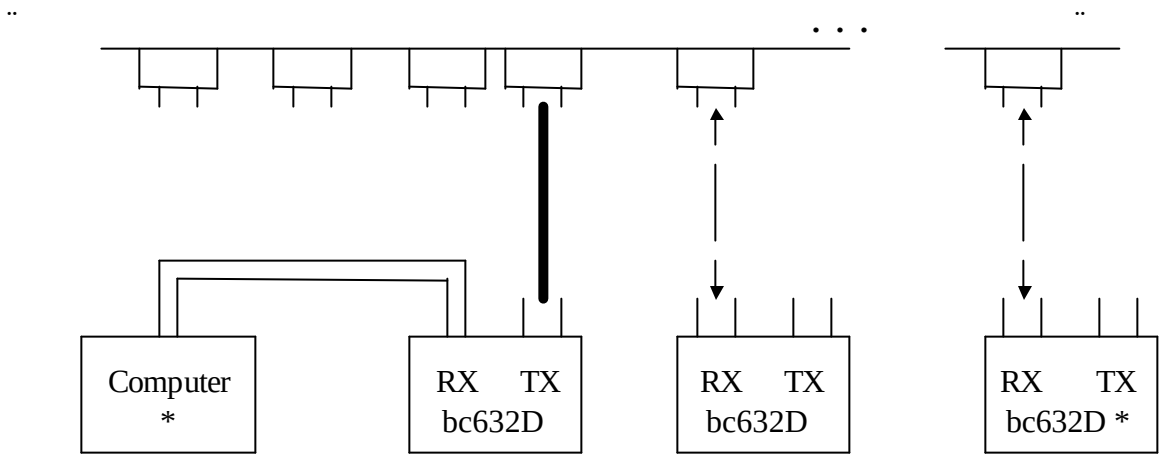
RS-232 cable described above.

Device RJ11 port (female mating connector).

B.3 BUSSING

Large numbers of devices should be connected in a bussed arrangement. Up to 32 devices may be connected this way, with a maximum cable length of 4000 feet. The main bus should be a shielded twisted pair to increase noise immunity. Stubs off the main bus should be kept as short as possible. If one display is connected to a computer using RS-232 signals, then it must be connected to the bus from

it's TX jack using a straight-through cable; that is, one that has pin 1 wired to pin 1. This is because the RX jack is occupied by the cable to the computer, and pins are reversed on the TX jack.



Device RJ11 port (female mating connector).

6 conductor phone cable with RJ11 male connectors.

6 conductor cable WIRED STRAIGHT THROUGH (pin 1 to pin 1).

Wall mount junction connector with female RJ11 mating connector.

Termination
Choice of ONE of these methods:

¨ Denotes external 100Ω termination on RS-485 line.

* Denotes termination by on-board 100Ω resistors. (Necessary if RS-485 line is not externally terminated.)

B.4 TERMINATION

Each end of a network should be terminated with a 100Ω ¼ Watt resistor between pin 2 and 5. This resistor may be inside the unit at the end of the cable or an external unit.

B.5 LOGICAL DESCRIPTION

B.5.1 BIT RATE, PARITY AND FRAMING BITS.

The control signals are sent as asynchronous serial messages. Characters are sent at 9600 baud, with one start bit, one stop bit and no parity bit.

B.5.2 COMMAND FORMATS

There are two different ways to program the bc632D. You may use the remote keyboard or you may program it with the serial port. However, you can not do both simultaneously. Commands should not be issued while the unit is being programmed with the remote keyboard.

The following sections define the formats of the commands that are recognized by the bc632D. All lines are terminated by a carriage return/line feed. Letters may be upper or lower case. There is only one space between fields.

B.5.2.1 ADDRESS

Each display on the network is programmed with a unique three-character address using the remote keyboard. The address cannot be changed using the serial port. All displays on the network monitor all the messages on the network but only respond after they have received an address message with their own address. The format of the address message is:

ADDR xxx

where xxx is the three-character address.

Valid characters for the address are all ASCII values between Space (ASCII $20) and tilde ('~', ASCII $7E) inclusive. The address stays in effect until the next END command is received.

Address 000 is a wildcard address. All displays will respond to commands preceded by ADDR 000.

B.5.2.2 EVENT

The Event command configures the event capture input of the display. The message format is:

EVENT x

Where x is one of:

R - event capture on Rising edges.
F - event capture on Falling edges.
O - turn event capture Off and.
C - Clear last event captured.

B.5.2.3 MASTER

When several displays are connected in a network, only one can be the time Master. The Master transmits time messages to all other displays on the network. Turning Master OFF inhibits the display from transmitting time messages. The message format is:

MASTER x

where x is 0 (Master off) or 1 (Master on).

B.5.2.4 SET REAL TIME CLOCK

To set the internal clock of the bc632D, use this command:

TIME hh:mm:ss MM/dd/yy w

Where:

hh is the hours.
mm is minutes.
ss is seconds.
MM is month.
dd is day of month.
yy is year.
w is day of week (1=Monday, 7=Sunday).

Use leading zeros if necessary. For Example, 1:00:00 am, February 3, 1992, Monday, would be sent as:

TIME 01:00:00 02/03/92 1.

B.5.2.5 SOURCE

Each step of the display sequence has a time source associated with it. To program the source use this command:

SOURCE s x

Where:

s is the step (1-8)
x is one of
- 1 - Multiplex channel 1.
- 2 - Multiplex channel 2.
- 3 - Multiplex channel 3.
- 4 - Multiplex channel 4.
- 5 - Multiplex channel 5.
- 6 - Multiplex channel 6.
- 7 - Digital Time slave.
- 8 - Timecode input.
- 9 - Internal Real time clock.
- A - Datum CD0.

B.5.2.6 LABEL

Each step has a text label which can be displayed along with the time. The format of the Label message is:

LABEL s labeltext

Where:

s is the step (1-8).
labeltext is the content of the label, up to 14 characters.

B.5.2.7 FORMAT

Each step is programmed with its own display format. The format message is:

FORMAT s x

Where:

s is step (1-8).
x is the format (1-9).

The format numbers are the same ones that are used when programming from the remote keyboard.

Formats 1 through 5 do not show the status lights on the right-hand end of the display.

1. C DDD HH:MM:SS
(C = Source Code, Clock would be blank.)

2. LABEL HH:MM:SS
(Uses the first 5 label characters.)

3. DW MON/D/YR
(DW = Day of week (MON-SUN), MON/D/YR is month, day, year.)

4. LBL DDD.FRACT
(LBL = first three label characters, DDD= days, FRACT = 1/10,000 of a day.)

5. LABEL
(Alphanumeric label with no time data.)

Formats 6 through 10 are identical to steps 1 through 5 except that the status lights on the right-hand end of the display are active.

6. C DDD HH:MM:SS
(C = Source Code, Clock would be blank.)

7. LABEL HH:MM:SS
(Uses the first 5 label characters.)

8. DW MON/D/YR
(DW = Day of week (MON-SUN), MON/D/YR is month, day, year.)

9. LBL DDD.FRACT
(LBL = first three label characters, DDD= days, FRACT = 1/10,000 of a day.)

10. LABEL
(Alphanumeric label with no time data.)

B.5.2.8 COLOR

To change the color of a step, use this command:

COLOR s x

Where:

s is the step (1-8)
x is the color:

1 - Red.
2 - Green.
3 - Yellow.

B.5.2.9 DURATION

To change the duration of a step, use this command:

DURATION s xxx

Where:

s is step (1-8).
xxx is three-digit seconds, 000 to 255.

Leading zeroes must be used with seconds less than 100.

B.5.2.10 LINK

Each step may be linked to the following step to form a sequence.

To program the link, use this command:

LINK s x

Where:

s is step (1-8).
x is 0 (Link off) or 1 (Link on).

B.5.2.11 HALT

The Halt command turns off time-keeping in the display so that it can keep up with a large number of commands sent without delays. This command will freeze the display, then restart it when the END command is received. The restart sequence is similar to the power-on sequence. The Halt command is not required if a short message is sent, for example "ADDR AAA/COLOR 1 2/END."

The Halt command is simply:

HALT

B.5.2.12 STEP

To force the display to jump to a specific step, use the Step command. This is equivalent to pressing SHIFT-<number> on the remote keyboard. The format is:

STEP s

Where s is the step (1-8).

B.5.2.13 SET

The bc632d can be used as a standalone timer for countdown/countup operations. The Set command is used to initialize countdown operation and set the starting time. Unlike the Time command, Set does not affect the contents of the internal clock. When the Set command is issued, the display will immediately show the time that has been set. The timer does not begin running until the Start command is received.

There are a couple of things to keep in mind when using the countdown mode. Countdown mode only works correctly with a single-step sequence. You can not have a sequence of display formats as described in the Section 3.3.1 of the bc632D User's Guide. The time source should be programmed to the Internal clock. On power-up, the display will show the contents of the internal clock, as normal. When the display receives any of the countdown commands (Set, Start, or Stop) the display is forced into countdown mode. From this point on, the display will not show the internal clock time. If you wish to resume operation using the internal clock, you can send a Halt command followed by an End command. This sequence will reset the display to normal operation.

The only display formats that shows the plus/minus sign are formats 1 and 6 (C DDD HH:MM:SS). The first character is replaced with a plus or minus sign.

The Set command can also be used to operate the display in a static mode, where the display itself does not do any timekeeping. A computer can be programmed to send a Set command once each second to update the display.

The format of the Set command is:

SET -ddd hh:mm:ss

Where:

- is a plus or minus sign (hyphen).
ddd is days in ASCII.
hh is hours.
mm is minutes.
ss is seconds.

B.5.2.14 START

The Start command is used to begin countdown time-keeping. The display will begin counting from the preceding time. The time begins counting again within one millisecond after the carriage return at the end of the Start command.

Start will also restart time-keeping after a Stop command. Since the stop command saves the fractional part of the second, the start command can begin within one millisecond of where the Stop occurred.

The format of the Start command is:

START

B.5.2.15 STOP

The Stop command will hold the countdown time on the display and freeze the time, including the fractional part of a second. It can also be used to initiate the countdown mode of operation before a Set command is issued.

The Stop command is simply:

STOP

B.5.2.16 ECHO

The Echo command tells the display to respond with a description of its internal programming. The format is:

ECHO

The display will respond with a series of commands that are identical with the ones described in this appendix. An example response to the Echo command is:

ADDR aaa.
EVENT O.
MASTER 0.
SOURCE 1 9.
LABEL 1 Labeltext1.
FORMAT 1 1.
COLOR 1 1.

```
DURATION 1 000.
LINK 1 0.
SOURCE 2 1.
LABEL 2 Labeltext2.
...                                    (continued for steps 2-8).
LINK 8 0.
END.
```

The display waits for three milliseconds after the time the Echo command is sent before beginning its transmission. This is to give the computer time to disable its RS-485 driver to release the line. If the computer is connected using the RS-232 interface, the display handles enabling and disabling the drivers automatically.

Using the Echo command will cause disruptions in timecode decoding, since the display must devote CPU time to sending the long response message.

A final note about the Echo command: Do not use the Echo command with address 000 if more than one display is on the network. Doing so will cause all displays to respond at once, resulting in garbled data.

B.5.2.17 END

The End command is used to terminate a group of commands begun with the Address command. After the End command is received, all displays are in a state in which they will not respond to any commands until another valid Address command is received. The End command is:

```
END
```

B.6 EXAMPLES

Following are some examples of the commands in use:

Single Step, Internal Clock
This command sequence sets up step 1 to display contents of internal clock.

```
ADDR 000        Talk to display.
SOURCE 1 9      Set source to internal clock.
FORMAT 1 1      Display C DDD HH:MM:SS format.
COLOR 1 2       Display in green.
LINK 1 0        Do not link to next step.
STEP  1         Start at this step.
END             End of programming.
```

Set Up Two Displays

This example sets up two displays to show different colors. The displays have been programmed as address aaa and bbb. The example shows the operation of the Address command.

ADDR 000	Talk to all displays.
SOURCE 1 9	Set source to internal clock for aaa and bbb.
FORMAT 1 2	Display LABEL HH:MM:SS format for aaa and bbb.
LABEL 1 Time:	Display will be "Time: HH:MM:SS" for aaa and bbb.
LINK 1 0	Do not link to next step.
ADDR aaa	Talk to display aaa. Display bbb will ignore commands. Note that the End command is not required to change the address.
COLOR 1 1	Set display aaa to red.
ADDR bbb	Talk to display bbb. Display aaa will ignore commands that follow.
COLOR 1 3	Set display bbb to yellow.
END	End of programming.

Using Halt for a Long Message

This example shows the use of the Halt command when a lot of data is being sent to a display. The display only allocates a small portion of its CPU time to processing the serial commands. Most of the time is taken in decoding time code and updating the display. Because of this, the display can lose characters when trying to read long messages that have no pauses between characters. There are two ways to deal with this problem. First, the computer can be programmed to insert pauses between characters so that the display can keep up. Second, the computer can issue a Halt command to stop the time-keeping and display update tasks, leaving the CPU free to process characters at full speed. After the programming is completed, the End command will cause the display to reset itself and start operating with the new programming. Here is an example that sets up every step of one display.

ADDR bbb	Talk to display bbb.
HALT	Turn off time-keeping functions.
SOURCE 1 1	Set up time sources for all steps.
SOURCE 2 2	
SOURCE 3 3	
...	
LABEL 1 labeltext1	Set up labels.
...	
LINK 8 1	Last command.
END	End. At this point display will reset and begin running with new programming.

Countdown

This display shows a typical sequence of countdown operation. The display is running step 1 and the time source is the internal clock. Format 1 is being used (C DDD:HH:MM:SS).

ADDR aaa	Talk to display aaa.
SET -000 00:00:10	Set time to 10 seconds before zero. The display will freeze, showing "- 000 00:00:10."
START	The display will start counting. Since it starts at the beginning of the second, there will be one second between when the Start command is received and when the display changes to "- 000:00:00:09."
END	End. At this point, the display continues to count past zero and into positive time values. The computer can freely issue commands to other displays if desired.
ADDR aaa	Talk to display aaa again.
STOP	Freeze display and halt time-keeping.
START	Resume time keeping.
HALT	Issue Halt to stop time-keeping and force a reset to get to normal internal clock operation.
END	Display aaa resets and resumes displaying internal clock time.

Datum Standard Countdown (Datum CD0)

This display shows a typical sequence of countdown operation. The display is running step 1 and the time source is the Datum CD0. A special format is being used (CC SH:HH:MM:SS).

ADDR aaa	Talk to display aaa.
SOURCE 1 A	Select Datum CD0 mode.
STEP 1	
END	