Options:_____

Date Received:_____

Software Revision:_____

AEC-BOX-1

INSTRUCTION MANUAL

ADRIENNE ELECTRONICS
CORPORATION

(Play Speed LTC Reader with RS232/RS422 Outputs)

The serial interface is programmed as follows (change as needed):

Protocol:_____ Op Mode:_____ Address:_____

Baud Rate:_____ # Data Bits:_____ Parity:_____
(protocol related)

1 2 3 4 5 6 7 8
Switches = _ _ _ _ _ _ _ _

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*** FCC NOTICE ***

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, could cause harmful interference to radio communications. Operation of this equipment in a residential area may cause harmful interference, in which case the user will be required to correct the interference at his or her own expense.

*** COPYRIGHT NOTICE ***

*** TRADEMARK NOTICES ***

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INTRODUCTION

Adrienne Electronics Corporation (AEC) developed the AEC-BOX-1 play speed LTC reader with RS232 and RS422 outputs to provide a low cost way of reading Longitudinal Time Code (LTC) using a variety of personal computers and other devices. It works equally well with both the SMPTE (30fps) and EBU (25fps) time codes, in both the forward and reverse tape directions.

Longitudinal Time Code (LTC) is a specialized audio signal which contains digital time-of-day and frame count information relating to an accompanying video signal. As an audio signal, it can be recorded and played back by video and audio tape machines. LTC is used for audio/video editing, logging, and/or automation purposes. Time code standards have been around for many years, and are sponsored by both SMPTE (for NTSC) and the EBU (for PAL).

Related products include our PC-LTC, PC-VITC, and PC-VLTC families of Longitudinal Time Code (LTC) and Vertical Interval Time Code (VITC) readers and generators for IBM PC personal computers, along with other members of the AEC-BOX family of standalone VITC, LTC, video, RS232, and RS422 interface boxes. Call us if you want more information on any of these products.

GETTING STARTED QUICKLY

If you want to use your AEC-BOX-1 right away, without reading the whole manual, just do the following:

1) Plug the AC power cord into a suitable voltage AC outlet.
2) Connect the LTC input signal to the "LTC IN" RCA jack.
3) Use a serial data cable to connect the 9-pin D connector (on the box) to your computer or other device.

The box should now be spewing out serial data corresponding to the time code it sees at the LTC input. The software protocol is described elsewhere in this manual. If no LTC is present, the power LED will blink every 1.5 seconds, and a short message will be sent. If something doesn't work, you will have to carefully read the "INSTALLATION" section of this manual.

AEC-BOX-1 SPECIFICATIONS

LTC INPUT (factory default single-ended mode):

Impedance	20kohms typical
Input Level	100mVpp to 20Vpp
DC on Input	+1V maximum

LTC INPUT (optional differential mode):

Impedance	20kohms typical
Input Level	100mVpp to 20Vpp
DC on Input	+1V maximum
CMRR	>26dB @ 60Hz

LTC READER:

Speed Range (2)	1/30x to 2.2x (w.r.t. play speed)
Tape Direction	Forward or Reverse
Bits Read	ALL time, user, and control bits.
Time Code Standard	Both SMPTE and EBU, without modification.

MISCELLANEOUS:

Box Dimensions (3)	16cm wide x 5cm high x 21cm long
Box Weight	1.2kg
Power Consumption	7W
Temperature Range	0 to 50 degrees Centigrade
Relative Humidity	Up to 95%, noncondensing

Notes:
(1) All specifications are subject to change without notice.
(2) LTC signals at much below play speed are often too distorted
    to read. Varies with tape format, tape, machine, etc.
(3) Allow at least 6cm in rear for power and other connectors.

AEC-BOX-1 HARDWARE DESCRIPTION

Throughout the following discussion you may want to refer to the AEC-BOX-1 schematic which is in the back of this manual. If your box has been customized in any way for your application, then the descriptions below may not be entirely accurate.

The power supply primary side comprises power transformer T1 and thermal "fuse" device F1. Of special note is the fact that this "fuse" does not burn out. If it trips, turn the power off for one minute to let it cool/reset, then turn the power back on.

The power supply secondary side starts with full wave rectifiers DB1 and DB2, plus large filter capacitors C72, C73, C82, and C83. The resulting unregulated DC supplies are then passed through voltage regulators U70(+5V), U72(+12V), and U73(-12V).

The LTC input at RCA jack J1 first goes through a differential amplifier centered about U10A. Note that the outer conductor on the RCA jack is normally grounded, but may be converted to a true differential input by cutting jumper X3. See the INSTALLATION section for details.

The output of the differential amplifier is AC coupled to eliminate DC offsets, then is fed into the window comparator made up of quad comparator U9 and surrounding components. This comparator automatically senses the incoming signal level and adjusts itself as needed to recover the LTC transition data even from very poor quality input signals.

The complementary outputs of the window comparator go directly to microcomputer U4, which decodes the LTC data via a proprietary software algorithm.

Microcomputer U4, together with address latch U20 and EPROM U1, form a completely self contained (but miniature) computer system. DIP switch SW1 allows easy modification of box operating modes, baud rates, and other features.

Serial data from microcomputer U4 is translated to RS232 levels by U7, and is translated to RS422 levels by U14. Nine pin "D" connector J3 contains the RS232 and RS422 transmit data lines.

LTC INPUT CONNECTION:
RCA jack J1 is the high impedance (20kohm) LTC input connector. The AEC-BOX-1 can read both SMPTE and EBU time codes without modifications.

As shipped from the factory, the RCA jack's outer conductor is connected to frame ground (the box chassis) via shunt X3 (next to J1). You may remove X3 in order to get a true differential LTC input, provided that the common mode voltage (usually 50/60Hz hum) is less than 2Vrms. In this configuration, you may also want to wrap electrical tape around the outside of the RCA input plug so that its outer conductor cannot short to the rear panel inadvertently.

SERIAL OUTPUT CONNECTIONS:
If you ordered a serial data cable with your AEC-BOX-1, just plug it in to the 9-pin "D" connector (which has socket contacts) on the back of the unit. Otherwise, you may use the kit of mating connector parts to wire up to the box as follows:

Pin #	Function
1	
2	TX422-
3	
4	
5	TX232
6	
7	TX422+
8	
9	GND

Notes:
1) Tiny pin numbers are molded into the connector face.
   Be careful not to be "off by one".
2) For RS422, note that the pinout is that of an ESbus Tributary.
3) Limit RS232 cables to 30 meters maximum.
4) Limit RS422 cables to 1200 meters maximum.

AC INPUT VOLTAGE RANGE SELECTION

Normally all AEC-BOX's are shipped with the transformer primary wired for 100-130VAC. Your box will bear a special marking if it has been wired for 200-260VAC instead. For your own safety, PLEASE do not proceed unless the line cord has been unplugged! Just turning off a power switch somewhere is not sufficient!

*** WARNING ***

NEVER OPEN UP THE BOX unless the line cord has been unplugged from its AC power source! To do otherwise risks damage to your AEC-BOX, and could even KILL you! We cannot assume responsibility for such careless behavior.

Box Cover Removal:
First you must UNPLUG the AC power cord, remove all other cables, then remove the bottom cover as follows:

1) Use a small (#1) Phillips screwdriver to remove the two small black screws which are on each side of the box.
2) Slide off the front and back black plastic bezels.
3) Turn the box over, then lift off the BOTTOM cover.

Note that you are now exposing yourself to a severe (FATAL) shock hazard if the box is still plugged in to an AC power source!

Voltage Strap Modification for 200-260VAC:
In the area underneath power transformer T1, you will find four large holes in a row, with "115V" and "230V" markings adjacent. Using sharp nosed cutters, or some other appropriate tool, cut out at least 2mm of the narrow trace next to each of the "115V" markings. Then solder a short wire between the two holes closest to the "230V" marking, being careful not to poke the ends of the wire too far into the holes (could damage power transformer T1). Also make sure that the wire you added is flush with the bottom of the board, and will not even come close to touching to bottom cover.

Voltage Strap Modification for 100-130VAC:
In the area underneath power transformer T1, you will find four large holes in a row, with "115V" and "230V" markings adjacent. Remove the wire between the two holes closest to the "230V" marking. Then solder a short wire between each pair of holes closest to the "115V" markings, being careful not to poke the ends of the wire too far into the holes (could damage power transformer T1). Also make sure that the two wires you added are flush with the bottom of the board, and will not even come close to touching to bottom cover.

AC POWER INPUT VOLTAGE RANGE SELECTION
(continued)

Box Cover Replacement:
Basically, just follow the earlier instructions in reverse order (power to the box must be OFF):

1) Put the bottom cover back in place.
2) Slide a black plastic bezel onto each end of the unit. The box looks better if the two small molding marks are facing towards the bottom of the unit.
3) Reattach the bezels to the chassis with the four small black screws you removed earlier. Be careful not to strip the threads in the aluminum side extrusions!

Label The Line Cord:
Attach a small label to the plug end of the line cord, so that the next person to use this AEC-BOX will know what AC power input voltage range it expects to see.

Test Your Work:
BEFORE connecting any cables to the box, plug it in to the appropriate AC power source and make sure it works (no smoke).

INSTALLING YOUR OWN AC POWER LINE PLUG

If the plug on the end of the AC line cord is not suitable, you can cut it off and put on your own. Where possible, please wire the new plug as follows:

1) Green = Ground (Chassis)
2) Blue = Neutral
3) Brown = Hot

In no case should the green wire be connected to anything but ground! Use a continuity tester to verify that the ground lug on your new power cord is connected directly to the AEC-BOX chassis.

DIP SWITCH PROGRAMMING

Box Cover Removal:
First you must UNPLUG the AC power cord, remove all other cables, then remove the top cover as follows:

1) Use a small (#1) Phillips screwdriver to remove the two small black screws which are on each side of the box.
2) Slide off the front and back black plastic bezels.
3) Lift off the top cover.

Note that the bottom cover will fall off easily at this point, exposing you to a severe (FATAL) shock hazard if the box is still plugged in to an AC power source!

*** WARNING ***

NEVER OPEN UP THE BOX unless the line cord has been unplugged from its AC power source! To do otherwise risks damage to your AEC-BOX, and could even KILL you! We cannot assume responsibility for such careless behavior.

Changing DIP Switch (SW1) Settings:
Note that the switches are numbered 1 through 8. Also note the small "1" and "0" numbers which are on the left and right ends of SW1. To set a switch to be a "1", simply press down on the "1" (OPEN) end of that switch. Conversely, to set a switch to be a "0", simply press down on the "0" end of that switch. All done!

DIP Switch Functionality:

Switch	Function
1	Baud Code #1
2	Baud Code #2
3	Odd(1) or Even(0) Parity
4	Parity Enabled(1) or Disabled(0)
5	Seven(1) or Eight(0) Data Bits, & Protocol Control
6	reserved (set to 0)
7	reserved (set to 0)
8	reserved (set to 1)

The two "Baud Code" bits function as follows:

1	2		
1	1	=>	38400 baud
1	0	=>	19200 baud
0	1	=>	9600 baud
0	0	=>	1200 baud

Note that at 1200 baud, it normally takes longer than one LTC frame to transmit a message, so some LTC frames will be skipped.

DIP SWITCH PROGRAMMING
(continued)

Factory Default Setting:
Unless you requested otherwise, the factory default setting is BINARY message protocol, 9600 baud, 8 bits, and ODD parity, so SW1 will normally be 01110001 for switches 1-8, respectively. There is no way to alter the factory default of 1 stop bit.

Message Protocol Notes:
It does not make sense to send 8-bit time code and user bits data in binary form over a 7-bit data link, since the top bit will be lost. Thus you will find that DIP switch #5 controls the message protocol as well as the number of data bits being sent per serial character.

If you select 8 data bits, the BINARY message protocol will be used. See page 12 for details.

If you select 7 data bits, the ASCII message protocol will be used. See page 13 for details.

Box Cover Replacement:
Basically, just follow the earlier instructions in reverse order (power to the box must be OFF):

1) Put the top cover back in place.
2) Slide a black plastic bezel onto each end of the unit. The box looks better if the two small molding marks are facing towards the bottom of the unit.
3) Reattach the bezels to the chassis with the four small black screws you removed earlier. Be careful not to strip the threads in the aluminum side extrusions!

BINARY MESSAGE PROTOCOL

Assuming that the LTC input is OK, the AEC-BOX-1 will use 8 data bits per character to transmit the following message every LTC frame:

```
     Byte 0  =  BREAK    (20 bits low, then 2 bits high)
     Byte 1  =  xBH      Status and length byte:
                           Bit 7 = 1
                           Bit 6 = reserved
                           Bit 5 = reserved
                           Bit 4 = 1 if skipped an LTC frame
                           Bits 3-0 = # of bytes which follow

     Byte 2  =  xxH      Time code frames (packed BCD)
     Byte 3  =  xxH      Time code seconds (packed BCD)
     Byte 4  =  xxH      Time code minutes (packed BCD)
     Byte 5  =  xxH      Time code hours (packed BCD)

     Byte 6  =  xxH      User bits frames
     Byte 7  =  xxH      User bits seconds
     Byte 8  =  xxH      User bits minutes
     Byte 9  =  xxH      User bits hours

     Byte 10 =  xxH      Various LTC flags:
                           Bit 7 = 1 if LTC parity is nonzero
                           Bit 6 = 1 if reading EBU (25fps) LTC
                           Bit 5 = LTC bit 59
                           Bit 4 = LTC bit 58
                           Bit 3 = LTC bit 43
                           Bit 2 = LTC bit 27
                           Bit 1 = LTC bit 11 (color frame flag)
                           Bit 0 = LTC bit 10 (drop frame flag)

     Byte 11 =  xxH      Status byte:
                           Bit 6 = FWD(1) or REV(0)
                           Bit 5 = PLAY SPEED (if 1)

     Byte 12 =  xxH      Checksum (sum of bytes 1-12 should be 0)
```

Notes:
1) All control bits have been removed from the time code data, and appear instead in byte 10.

If no LTC input is present, or if it is present but unreadable, the front panel LED will turn off briefly every 1-2 seconds, and the following message will be transmitted at the same time:

```
     Byte 0  =  BREAK
     Byte 1  =  11H      (indicates only 1 byte follows)
     Byte 2  =  EFH      (checksum byte)
```

ASCII MESSAGE PROTOCOL

This protocol is much simpler than the BINARY protocol, but it is also much more limited in its capabilities. Assuming that the LTC input is OK, the AEC-BOX-1 will use 7 data bits per character to transmit the following message every LTC frame:

Byte 1	=	0-2	Time code hours, tens digit.
Byte 2	=	0-9	Time code hours, units digit.
Byte 3	=	":"	Separator
Byte 4	=	0-5	Time code minutes, tens digit.
Byte 5	=	0-9	Time code minutes, units digit.
Byte 6	=	":"	Separator
Byte 7	=	0-5	Time code seconds, tens digit.
Byte 8	=	0-9	Time code seconds, units digit.
Byte 9	=	":"	Separator (= "." for drop frame LTC)
Byte 10	=	0-2	Time code frames, tens digit.
Byte 11	=	0-9	Time code frames, units digit.
Byte 12	=	0DH	Carriage Return

Notes:
1) The number ranges presented above, such as 0-9, are actually transmitted as ASCII numbers "0" (30H) through "9" (39H).

If no LTC input is present, or if it is present but unreadable, the front panel LED will turn off briefly every 1-2 seconds, and the following short message will be transmitted at the same time:

Byte 1	=	"?"	Question Mark
Byte 2	=	0DH	Carriage Return

BREAK CHARACTER DETECTION

The transmit data line on the microcomputer chip is normally high (inactive). When a normal serial data character is transmitted, the transmit pin first goes low for 1 bit period (the START bit), followed by 7 or 8 DATA bits, then a PARITY bit (if enabled), then finally goes high for 1 bit period (the STOP bit). The START bit for the next serial data character may start immediately thereafter.

Break characters are very different. A "break" character is defined as a special pulse which goes low for 20 bit periods, then goes back high for at least 2 bit periods.

The break character guarantees that the receiving UART will be properly locked to the serial data stream, even under worst case conditions. Since the message string includes user bits data, which can assume any value from 00H to FFH, the break character is necessary to unambiguously define the start of a message string.

The break character can be detected in several ways:

a) Some UART's have a break character flag and/or interrupt, which makes your job real easy.
b) A break character will be received as 00H data together with a framing error.
c) If odd parity is being used, a break character will cause reception of 00H data with a parity error.

RS232 Note:
The RS232 output signal on the 9-pin "D" connector has a polarity opposite from that described above. The TX232 line, which is normally low (at -6V), pulses high (to +6V) for 20 bit periods when the break character is transmitted, then goes back low.

SERIAL INTERFACE STANDARDS

For more information on any of these standards, contact the appropriate agency as indicated on page 20.

RS232 Standard:
Interface signals are inverted versions of the UART (TXD & RXD) signals. A valid "1" is -5V to -15V. A valid "0" is +5V to +15V. Since RS232 drivers are always on, you can't bus them together, which makes RS232 strictly a point-to-point communication link. RS232 is THE most commonly used interface in the computer industry, and is usually seen as a 25pin "D" connector on modems, terminals, serial ports (like IBM PC COM1 and COM2), and just about any type of peripheral you can think of. Cables should be limited to 30 meters max, and the data rate should be limited to 19200 baud max, in accordance with the RS232 standard. The AEC-BOX-1 does not have (and does not need) any of the handshake lines which are used by many RS232 devices.

RS422 Standard:
The RS422 transmission standard allows for cables up to 1200 meters long, and data rates up to 10Megabaud. It uses differential (2 complementary line) transmitters and receivers, which greatly reduces sensitivity to common mode noise. In addition, the transmitters can be set to a high impedance (Hi-Z) state, which allows several transmitters to share a pair of data lines. Thus many pieces of equipment can share the same data bus. For the "+" output, typical output low voltages are about 0V, and typical output high voltages are about +4V. For the "-" output, the signal polarity is reversed. In the AEC-BOX-1, the RS422 transmitter is always enabled.

ESbus Standard:
The ESbus (EBU/SMPTE Machine Control Bus) is used in the television industry to control VTR's, routers, switchers, mixers, and other equipment. The pinout of the AEC-BOX's 9-pin "D" connector is that of an ESbus Tributary.

AEC-BOX-1 TROUBLESHOOTING GUIDE

This guide lists anticipated problems and their solutions. If you really get stuck, call our Service Department.

Problem #1: Power LED does not blink ON when power is applied:
Solutions :
a) Check for presence of external AC power source.
b) Make sure AC voltage agrees with box wiring.
c) Leave off for 1 minute, then turn back on. PTC "fuse" will then be cooled and reset.
d) Fix broken LED wiring.
e) Return AEC-BOX for power supply repairs.

Problem #2: Power LED blinks ON initially, then stays off:
Solutions :
a) Return AEC-BOX for repairs.

Problem #3: Power LED blinks OFF every 1-2 seconds:
Solutions :
a) Provide a better quality LTC input to the box.
b) Check for large ground potential differences between the AEC-BOX and the LTC source.

Problem #4: Box is not transmitting anything:
Solutions :
a) Remove external serial cables - works now?
b) Make sure all DIP switches are set properly.
c) Use oscilloscope to check box output lines.

Problem #5: Box transmits, but I can't receive anything:
Solutions :
a) Check cables for shorts, opens, crossed wires.
b) Make sure UART parameters (baud rate, etc.) are the same for both the box and your serial device.
c) With LTC input disconnected, try to properly receive the short message which is sent every 1-2 seconds.
d) If using RS232, limit cable length to 30 meters.

Problem #6: Bytes are missing in the received data stream:
Solutions :
a) The receiving device must be able to receive ALL bytes in a message without any OVERRUN errors, even if interrupts occur during reception. Change interrupt priorities, disable some, etc.
b) Use a lower baud rate and see if the problem goes away (gives more time between characters).

Problem #7: Some time code messages are missing:
Solutions :
a) Use a higher baud rate so that the entire message can be sent before the next LTC frame arrives.
b) There may be dropouts or other LTC signal errors.
c) SMPTE drop frame counting eliminates some counts.

WARRANTY REGISTRATION

We no longer have a formal warranty registration procedure, but do like to keep in touch with our end users. If you did not purchase this product directly from us, please copy the User Feedback Request form in the back of this manual, fill it out, then fax or mail it back to us. This way we will know who and where you are and be able to provide you with the following:

1) product upgrade and and bug reports,
2) manual updates and application notes,
3) safety/recall notices, and
4) better service in many other ways.

OUR WARRANTY

For the first two years following the shipment of an AEC product, we will repair or replace, at our option, any such product which is found to be inoperative due to defects in materials or workmanship. Not covered is damage due to unusual electrical and/or physical abuse. Altered hardware, software, labels, or other identifying marks may also void the warranty.

GENERAL GUIDELINES

Before sending a product back to us for service, please do the following (we've found over 90% of returned items work fine):

1) Check the "Troubleshooting Guide" in this manual.
2) Call our Service Department for assistance if needed.
3) Obtain our current return address, and possibly an RMA number, before shipping anything back to us.
4) Package the unit carefully before shipping it (it's yours).

WARRANTY SERVICE PROCEDURES

All you have to do is call our Service Department and describe the nature of the problem. We will attempt to fix it over the phone, but if that doesn't work we will give you an RMA number and you can ship the defective product back to us. We will repair or replace the product and return it to you as soon as possible.

OUT-OF-WARRANTY SERVICE PROCEDURES

If the two year warranty period has expired, or if the product has been altered or damaged, we will repair the product for a charge to be agreed upon before the repairs are begun. Call our Service Department for assistance. We have the test equipment, parts, and experience to quickly find and fix any problems.

7-BIT ASCII CODE CHART

Dec	Hex	Key	Char	Description	Dec	Hex	Char	Dec	Hex	Char
0	00h	^2	NUL	null char.	43	2B	+	86	56	V
1	01h	^A	SOH	start heading	44	2C	,	87	57	W
2	02h	^B	STX	start of text	45	2D	-	88	58	X
3	03h	^C	ETX	end of text	46	2E	.	89	59	Y
4	04h	^D	EOT	end of trans.	47	2F	/	90	5A	Z
5	05h	^E	ENQ	enquiry	48	30	0	91	5B	[
6	06h	^F	ACK	acknowledge	49	31	1	92	5C	\
7	07h	^G	BEL	ring bell	50	32	2	93	5D	]
8	08h	^H	BS	backspace	51	33	3	94	5E	^
9	09h	^I	HT	horiz. tab	52	34	4	95	5F	_
10	0Ah	^J	LF	line feed	53	35	5	96	60	`
11	0Bh	^K	VT	vertical tab	54	36	6	97	61	a
12	0Ch	^L	FF	form feed	55	37	7	98	62	b
13	0Dh	^M	CR	carriage ret.	56	38	8	99	63	c
14	0Eh	^N	SO	shift out	57	39	9	100	64	d
15	0Fh	^O	SI	shift in	58	3A	:	101	65	e
16	10h	^P	DLE	data link esc	59	3B	;	102	66	f
17	11h	^Q	DC1	device ctrl 1	60	3C	<	103	67	g
18	12h	^R	DC2	device ctrl 2	61	3D	=	104	68	h
19	13h	^S	DC3	device ctrl 3	62	3E	>	105	69	i
20	14h	^T	DC4	device ctrl 4	63	3F	?	106	6A	j
21	15h	^U	NAK	no acknwldge	64	40	@	107	6B	k
22	16h	^V	SYN	synch. idle	65	41	A	108	6C	l
23	17h	^W	ETB	end TX block	66	42	B	109	6D	m
24	18h	^X	CAN	cancel	67	43	C	110	6E	n
25	19h	^Y	EM	end of medium	68	44	D	111	6F	o
26	1Ah	^Z	SUB	substitute	69	45	E	112	70	p
27	1Bh	^[	ESC	escape	70	46	F	113	71	q
28	1Ch	^\	FS	file sepratr.	71	47	G	114	72	r
29	1Dh	^]	GS	group sep.	72	48	H	115	73	s
30	1Eh	^6	RS	record sep.	73	49	I	116	74	t
31	1Fh	^-	US	unit sepratr.	74	4A	J	117	75	u
32	20h	SPC		space	75	4B	K	118	76	v
33	21h	!	!	exclamation	76	4C	L	119	77	w
34	22h	"	"	double quote	77	4D	M	120	78	x
35	23h	#	#	number sign	78	4E	N	121	79	y
36	24h	$	$	dollar sign	79	4F	O	122	7A	z
37	25h	%	%	percent sign	80	50	P	123	7B	{
38	26h	&	&	ampersand	81	51	Q	124	7C	|
39	27h	'	'	apostrophe	82	52	R	125	7D	}
40	28h	(	(	left parenth	83	53	S	126	7E	~
41	29h	)	)	right parenth	84	54	T	127	7F	DEL
42	2Ah	*	*	asterisk	85	55	U			

ASCII is an abbreviation for
"the American Standard Code for Information Interchange".

NOTE: The keystrokes indicated above are for IBM PC's,
and may be slightly different for your equipment.

NUMBER SYSTEM CONVERSION TABLE

This chart will help you make conversions between the various numbering systems which are used in this manual.

Hexadecimal	(MSB) Binary (LSB)	Decimal	BCD
0	0 0 0 0	0	0
1	0 0 0 1	1	1
2	0 0 1 0	2	2
3	0 0 1 1	3	3
4	0 1 0 0	4	4
5	0 1 0 1	5	5
6	0 1 1 0	6	6
7	0 1 1 1	7	7
8	1 0 0 0	8	8
9	1 0 0 1	9	9
A	1 0 1 0	10	invalid
B	1 0 1 1	11	invalid
C	1 1 0 0	12	invalid
D	1 1 0 1	13	invalid
E	1 1 1 0	14	invalid
F	1 1 1 1	15	invalid
(base 16)	(base 2)	(base 10)	

(BCD is an abbreviation for "Binary Coded Decimal")

PACKED BCD NUMBERS

A "packed BCD" byte contains two BCD digits in an 8-bit byte. Bits 7-4 (upper nibble) contain the upper BCD digit, and bits 3-0 (lower nibble) contain the lower BCD digit.

For example, incrementing BINARY 09h leaves you with 0Ah, but incrementing PACKED BCD 09h leaves you with 10h. A packed BCD number such as 0Ah would be invalid, because "A" is not a valid BCD digit.

Here is one more example, showing the packed BCD format as used for time bits I/O. The 30 second (half minute) mark would be read (or written) as a 30h byte, even though 30 decimal is the same as binary 1Eh.

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You must order the "Annual Volume of EBU Official Technical Texts",
which (for 250 Swiss Francs) includes the following:
1) N12 Time & Control Codes for Television
2) N18 Relationship Between Time Code and PAL 8-Field Sequence
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