TCG550

TIME CODE GENERATOR

Operation and Maintenance

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telcom research

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C H A P T E R

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Introduction

1.1 Description

The model TCG550 Time Code Generator provides generation and local display of both the 80-bit Society of Motion Picture and Television Engineers (SMPTE) end the European Broadcasting Union (EBU) time codes. These codes, when recorded on video or audio tape, permits exact addressing of points on the tapes for precise editing, synchronization, dubbing and splicing.

The following features are supported by the Telcom Research model TCG550 S.M.P.T.E./E.B.U. Time Code Generator:

- Generates both S.M.P.T.E., E.B.U. and 24 frames/sec. time code
- Color framing
- Two isolated time code outputs
- High brightness L.E.D. display
- Standard level (+11 dBm.) code output
- Video present and Lock front panel indicators
- Locks to power line if no video/sync

1.2 SMPTE and EBU Time Code

Time code is an electronic signal recorded on video tape and is synchronized to the accompanying video signal. The purpose of time code is to uniquely identify each frame of video on a video tape (or other video recording medium). This is done by assigning a number to each frame of video in an HOURS : MINUTES : SECONDS : FRAMES format. This is called the time information (time bits). There are two forms of time code and they both contain the same time and user bit information. They are referred to as longitudinal and vertical interval time codes.

There are also two organizations who set standards which specify the technical details of time code. They are the Society of Motion Picture and Television Engineers (SMPTE) and the European Broadcasting Union (EBU).

Longitudinal time code is a digital signal which uses a code format very similar to that used by computer floppy disks. This signal is recorded on an audio track, cue track or address track of a video tape. Time code uses a Bi-Phase Mark code format that is suitable for recording on magnetic tape. The format is based on transitions between clock pulses. Polarity of the signal, or the direction of the transition is unimportant. Bit positions are separated by clock transitions. If there is no transition between the clock transition for a given bit and the clock transition for the following bit the bit value is a logic 0. If there is a transition between clock transition, the bit value is a logic 1. The format of bi-phase mark encoding is shown in figure 1.1.

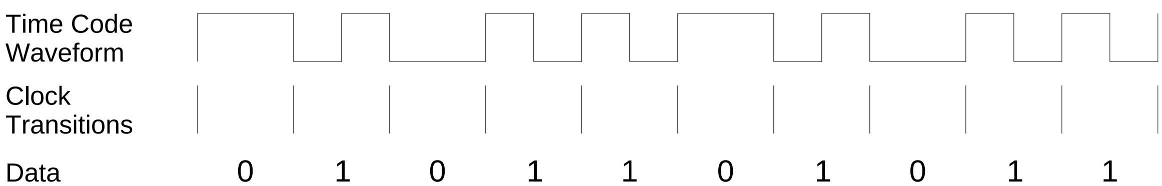

Figure 1.1: Bi-Phase Mark encoding

For each frame of video there is a corresponding frame of time code. Each time code frame consists of 80 bits. These are made up of 16 bits of synchronizing and direction sensing data (the sync word), 26 bits of time information, 32 bits of user information (user bits) and 6 bits of status information. The complete time code frame is repeated once per video frame. The 80 bit positions are divided into 16 four bit groups followed by a 16 bit sync word that identifies the end of one frame and the beginning of the next, as well as the direction of tape movement. 8 of the 16 four bit groups contain the time and status information and are arranged in frame numbers, seconds, minutes and hours order. The code consists of 4 bit time groups alternating with 4 bit groups dedicated to optional user bit information. Time code information is in binary coded decimal form. The *tens of frames* group uses only 2 bits for time (since it need only count up to “2”). The third bit position in this group is used to indicate the Drop Frame (DF) mode. The fourth bit position in this group is used to indicate the proper color lock of the time code generator (color frame flag CF). The *tens of seconds* group uses only 3 bits for time (since it need only count up to 5). The fourth bit position in this group is used to control parity.

Time codes are accurately phase-locked to the video signals with which the codes are to be used. This is necessary to insure that each time code frame is properly timed with respect to the video frame it identifies. This relationship is shown in figure 1.2 for NTSC video and in figure 1.3 for EBU video where the arrow points to the location in the video signal that corresponds to the starting point of the time code frame (the transition between code bit 79 and code bit 0).

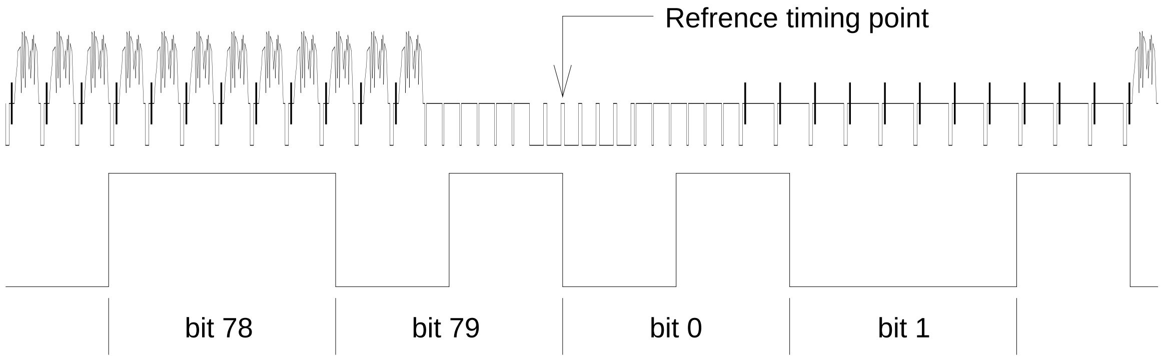

Figure 1.2: Timing Relationship Between NTSC Video and Time Code

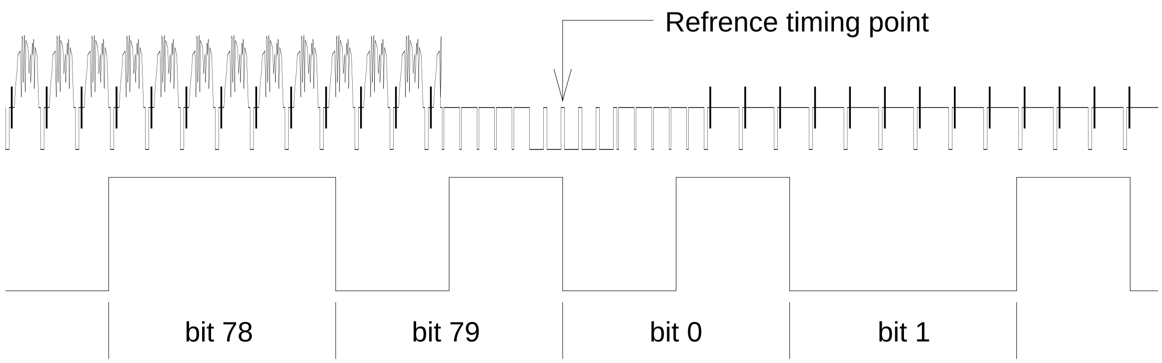

Figure 1.3: Timing Relationship Between EBU Video and Time Code

The format of a full frame of longitudinal time code is shown in figure 1.4. In this figure bit 0 (the start of the frame) is shown on the left and the last bit, bit 79 is shown on the right immediately followed by bit 0 of the next frame. Some of the status bits are labeled with their functions in the SMPTE standard. These bits have different meanings in EBU. except for the color frame flag.

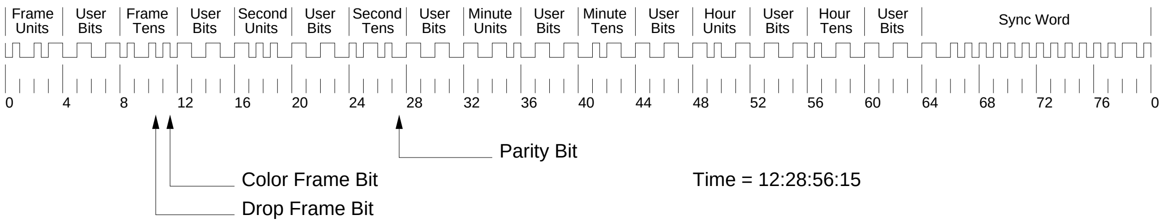

Figure 1.4: Longitudinal Time Code Waveform

SMPTE and EBU. longitudinal time codes are very similar. They use the same number of bits per frame and the sync word, the time and the user information are in the same bit positions in both code format standards. The main difference is the number of frames per second in the respective television systems. The SMPTE system has either 29.97 or 30 frames per second and the EBU. has a rate of 25 frames per second. This causes the number of bits per second to be 2400 in SMPTE and 2000 in EBU. Also some of the 6 status bits serve slightly different purposes in the two systems.

Vertical interval time code is a digital signal in the form of pulses which are placed on two nonadjacent video lines in the vertical interval of the video signal. Figure 1.5 shows an NTSC video signal with VITC inserted in lines 17 and 19. Figure 1.6 shows an EBU. video signal with VITC inserted in lines 19 and 21. There are 90 bits per line in VITC time code. The code is repeated twice in each video field, once on each of two nonadjacent video lines in the vertical interval. Each line contains 18 bits of synchronizing data (the sync bits), 26 bits of time information, 32 bits of user information (user bits), 6 bits of status information and an 8 bit cyclic redundancy check character (CRC). The CRC is the result of doing some arithmetic on the other bits in the code when it is being generated. When the code is recovered this arithmetic is repeated and the result is compared to the recovered CRC and is used to verify that the code is correct and error free. Errors can be caused by noise or dropouts. The CRC provides a 99.61% confidence level in the recovered code.

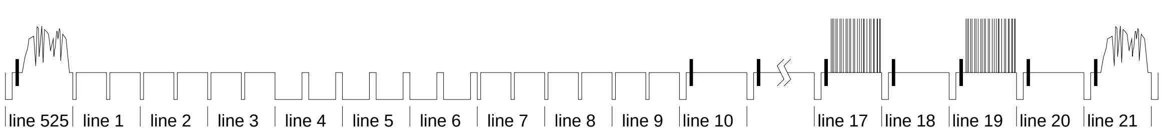

Figure 1.5: SMPTE Vertical Interval Time Code Waveform

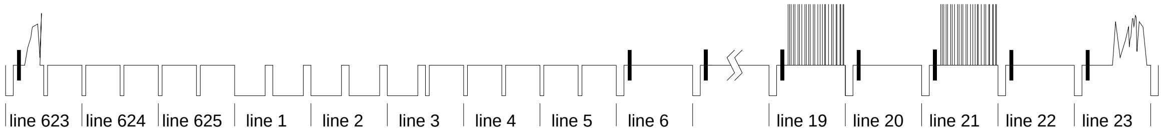

Figure 1.6: EBU Vertical Interval Time Code Waveform

SMPTE Drop Frame (DF) time code was conceived to correct for the NTSC color system frame rate not being exactly 30 frames per second. The NTSC frame rate is only 29.97 Hz, which results in 30 frames being equal to 1.001 seconds. This would produce an accumulative error of about –86.41 seconds per day (the time codes falling behind real time) if no correction was introduced. To fix this problem Drop Frame time code counts 30 frames per second except at the start of each minute not including minutes 0, 10, 20, 30, 40, and 50. At the start of each minute (except as noted above) the first two frames are skipped (or dropped), leaving only 28 frames in the first second of that minute. For instance **15:43:59:<u>29</u>** will advance to **15:44:00:<u>02</u>**. Time code frames numbered **15:44:00:<u>00</u>** and **15:44:00:<u>01</u>** do not exist in Drop Frame mode. This scheme keeps the time codes in step with real time when used with the NTSC color system. Utilizing the DF mode results in a static error of only +75 milliseconds per day, ± any inherent sub-carrier error. EBU time code has no equivalent of Drop Frame because the frame rate in that color system divides the second into 25 parts with no remainder.

Color Framing is a result of the growing sophistication of video tape editing. In color television not all frames are the same, even if there is no change in the picture content. The color part of the signal changes from frame to frame. In NTSC there are two variants of a frame and in EBU there are 4. These may be thought of as a repeating sequence of ‘A B A B A B’ in NTSC or ‘A B C D A B C D’ in EBU. The result of these minor differences between frames is that if the sequence is not preserved across edits, a horizontal shift in the picture occurs at the edit point. This is only visible if the picture content is substantially the same on either side of the edit. In most situations this shift is unnoticeable. In order to avoid disturbing the sequence the NTSC system assigns even frame numbers to ‘A’ frames (fields 1 and 2) and odd numbers to ‘B’ frames (fields 3 and 4). Therefore to maintain the sequence, if the frame on one side of the edit is odd make sure that the frame on the other side is even.

Modern sync generators provide a color frame identification pulse which identifies field one of the 4 field (NTSC) or 8 field (EBU) video signal. This is shown for the NTSC system in figure 1.7 on page 6. The video signal is shown as the top waveform, the color frame identification pulse is shown as the middle waveform and time code is shown as the bottom waveform. The color frame identification pulse is shown as occurring at line 10 of field 1.

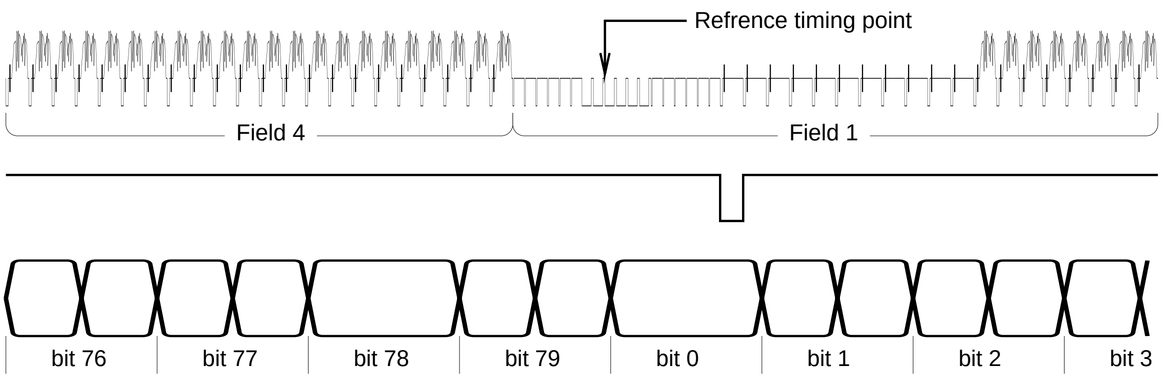

Figure 1.7: Relationship Between Video, Color Frame Identification Pulse and Time Code

In EBU the problem is a little more complicated because the sequence is 4 frames (an even number) and the time code is based on 25 frames per second (an odd number). Color framing is achieved by assigning time code numbers to the video frames in a sequence that guaranties that the remainder when dividing the sum of the frames count and the seconds count by 4 ((frames + seconds) / 4) is 0 for a 'D' frame (fields 7 and 8), 1 for a 'A' frame (fields 1 and 2), 2 for a 'B' frame (fields 3 and 4) and 3 for a 'C' frame (fields 5 and 6).

1.3 Specifications

Time Code Outputs Two isolated pseudo balanced outputs on 3 pin male XLR type connectors. These may be treated as 4 unbalanced outputs. See section 2.2 on page 9 for details. S.M.P.T.E. or E.B.U. time code at +11 dBm, 50% duty cycle, balanced line 600 ohms impedance, 25 microsecond rise time.

Reference Sync Input Composite sync or video loop through at 0.5 to 4 volt peak to peak level. This is the master timing reference for the time code generator. It must conform to E.I.A. RS170 or C.C.I.R. Report 624-1.

Color Framing Input Negative edge triggered input. Level 2 to 8 volts, A.C. coupled. 15 Hz. for NTSC, 6.25 HZ. for PAL. This pulse must occur after the sixth wide pulse in the vertical interval preceding field 1 and before the sixth wide pulse in the vertical interval preceding field 3 of the 4 (8 PAL) field color sequence. That is during fields 1 or 2 of the 4 (8 PAL) field color sequence.

Power	90 to 130 or 200 to 250 volts A.C. at 45 to 70 Hz., 5 VA. and 7.5 to 16 Volt D.C. operation).
Size	3 in. high, 8.5 in. wide, 9 in. deep.
Weight	1.25 kgm., 2.75 lbs.
Environmental	0°C to +60°C (32°F to +140°F) operating, –20°C to +85°C (8°F to +185°F) storage, 0 to 85% relative humidity (no condensation).

C H A P T E R

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Installation

2.1 Unpacking

The TCG550 time code generator is shipped, with Operation and Maintenance manual, in a single carton. After opening the carton, carefully examine the equipment for damage that may have occurred during shipment, and report any damage to the carrier and Telcom Research.

2.2 Connections

All signal connections to and from the TCG550 time code generator are made by means of industry standard BNC and XLR connectors at the back of the generator.

Time Code Outputs Each of the two time code outputs will drive a balanced 600 ohm line, providing a nominal level of +11 dBm. Each output may also be used as 2 unbalanced outputs, in which case they should be terminated with a 300 ohm resistor to ground. It is not necessary to terminate unused output pins. The required mating connectors are Switchcraft A3F or equivalent. Pin 1 is ground and the signal is on pins 2 and 3.

Reference Sync Input This input requires video or sync and is used as the main reference for the time code generator. The level of this signal is not critical and may vary from .5 to 5 volts peak to peak, however the sync portion of the signal must conform to E.I.A. RS170 or C.C.I.R. Report 624-1 broadcast specifications during the vertical interval. The sync input is a high impedance loop through input using BNC connectors. Connect the video or sync signal to the upper BNC connector. If this is the end of the video or sync line, place a 75 ohm termination on the lower BNC connector, otherwise, continue the video or sync line from the lower BNC connector. Be sure that this line is terminated at it's final destination.

Color Frame Input This input requires a 2 to 8 volt signal with a low going edge which indicates the start of the E.I.A. 4 or P.A.L. 8 field sequence. The negative edge must occur after the 6 (5 for E.B.U.) wide pulses in the vertical interval at the start of field 1 and before the 6 (5 for E.B.U.) Be sure that this line is terminated at it's final destination. wide pulses in the vertical interval at the start of field 3 for proper operation. This signal is A.C. coupled internally and may be positive or negative with respect to ground. If this signal is not available then leave this input unconnected. See page 5 for further details about color framing.

Standards selection The TCG550 time code generator can be set up to provide any two of the following standards E.I.A., DF (drop-frame), E.B.U., or 24 frame. The A/B switch on the back of the unit will select between the two programmed standards. The standard selected by the A/B switch is displayed on the front of the generator. To reprogram the A/B switch, open the case and move the jumper plugs to the standard required, on the standards pin selectors. If only one standard is desired in both switch positions of the A/B switch then place only one jumper in the standards pin selectors.

Line Voltage Selection The model TCG550 time code generator may set to operate in 2 line voltage ranges by changing a jumper on the main circuit board as shown in figure 2.1. The left side of figure 2.1 shows the setting for the 110 volt range and the right side shows the 220 volt range setting.

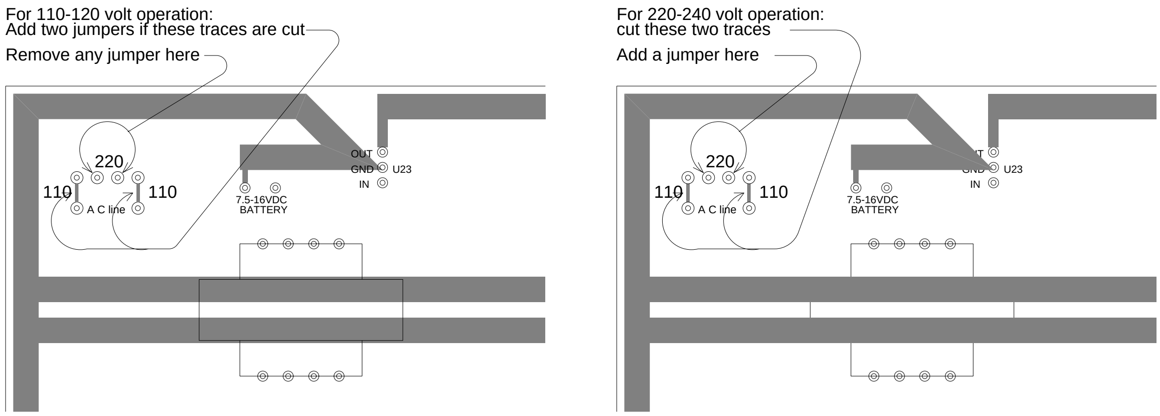

Figure 2.1: TCG550 Line Voltage Selector

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Operation

The operation of the TCG550 time code generator is very straight forward. This section describes the function of all the controls and indicators on the front panel of the TCG550 time code generator.

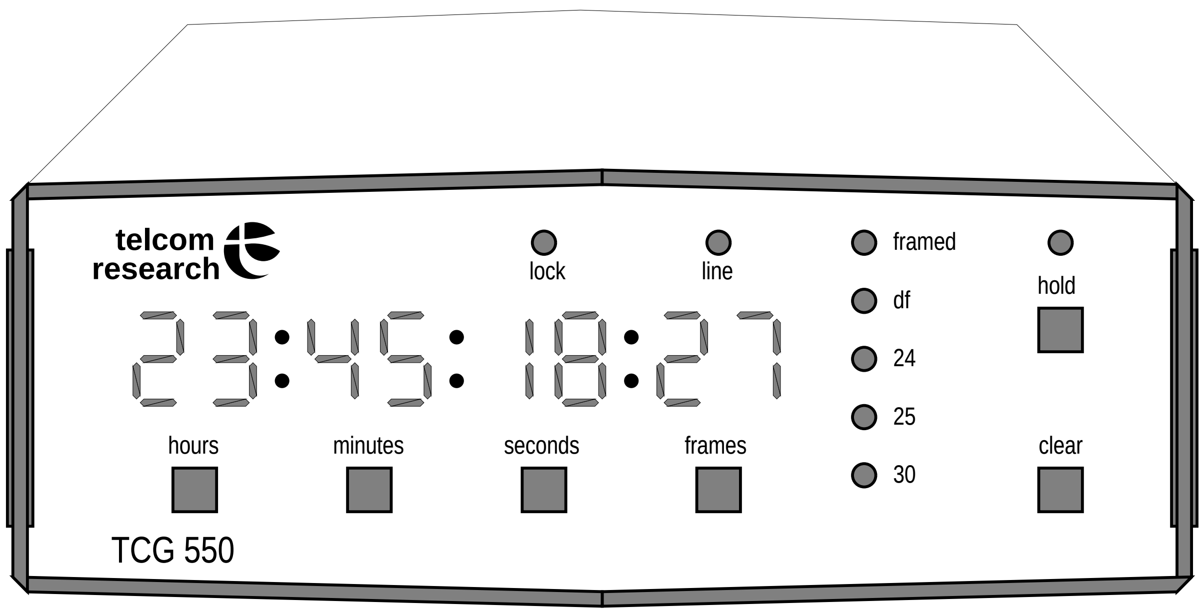

Figure 3.1: TCG550 Front Panel

3.1 Indicators

8 Digit L.E.D. Display Indicates the time in hours, minutes, seconds and frames.

Line Indicates that the reference sync or video signal is missing or defective, and the generator has reverted to power line lock.

Lock — Indicates that the phase locked loop for the transmit clock rate was able to lock to the supplied reference, if this light off, the supplied reference signal should be checked for noise spikes.

Framed — Indicates that the generator is producing time code which has a number sequence which has the proper relationship to the 4 field (N.T.S.C.) or 8 field (E.B.U.) standard. This indicator is inoperative in the 24 and 30 frame modes.

DF, 24, 25, 30 — The standard to which code is being generated is indicated by one of these four lights.

Hold — Indicates when lighted that the generator is stopped. Code is still being generated but the time is not being updated.

3.2 Controls

Hold — Stops the generator time count from advancing. The generator outputs repeat the same time code frame. Pressing the key again causes the generator to resume counting. An external hold connection is available on the back panel of the TCG550.

Clear — When pressed momentarily sets the generator time to 00:00:00:00 and when held down for more than 1 second sets the generator to 23:58:00:00. It is not necessary to place the generator in hold mode to use clear, but it may be more convenient.

Hours — Advances the Hours count when pressed. When held for more than one second the count will advance rapidly.

Minutes — Advances the Minutes count when pressed. When held for more than one second the count will advance rapidly.

Seconds — Advances the Seconds count when pressed. When held for more than one second the count will advance rapidly.

Frames	Advances the Frames count when pressed. When held for more than one second the count will advance rapidly.
A/B	Selects one of two standards which have been programmed inside the time code generator. (located on the back of unit).

C H A P T E R

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Theory Of Operation

4.1 Introduction

Schematics for the TCG550 time code generator may be found in the last section of this manual.

The heart of the TCG550 time code generator is an Intel 8039 microprocessor with external program memory.

A single level of interrupt is used for the time code generator function.

The purpose of an interrupt is to provide service to an external device, usually an input or output device, on demand. An alternate method would be for the main program to examine the status of all devices external to the CPU to see if they require service. Both schemes are used in the TCG550 time code generator. Interrupts are used mainly for external devices which cannot tolerate timing uncertainty when they need service. For example, the time code generator requires very predictable response timing when it requests the time code data from the CPU. This is because most of the counters in the generator phase locked loop are implemented in software. Any timing variations in these counters will show up as jitter in the time code output.

The interrupt circuit will interrupt the main program execution of the TCG550 time code generator and force the micro computer to execute a specific service program and then return to the main program at the point at which it was interrupted. The service program saves all the registers of the CPU and then services the device which caused the interrupt. When the device service has been completed, the service program then transfers control to a short program which restores all of the CPU registers and returns control to the program which was interrupted.

The input and output devices consist of several 8 bit parallel ports on the 8039 chip, U-8, and an 8251 synchronous port, U-5 .

4.2 Generator

The time code generator consists of a sync separator, a reference frame pulse detector, a serial output port from the micro computer, a phase-locked loop oscillator and phase detector and an integrating line driver. All other functions, including the bi-phase encoding and phase locked loop frequency divider, are handled by the micro computer software.

Reference sync or video enters the main board and is clamped at the tip of sync by D-1 and converted to a logic level by comparator U-10. Dual one-shot U-12 ignores equalizing pulses and generates a 10 microsecond pulse coincident with the leading edge of horizontal sync when enabled by vertical one shot U-11.

Separated sync is also feed to vertical integrals Q-1, which triggers one-shot U-11 to produce a 10 microsecond pulse during the vertical interval. This output enables U- 12 which will produce a reference frame pulse only during the vertical interval where horizontal and vertical sync are coincident.

This reference frame pulse drives the comparator reference input of the phase-locked loop U-16.

The oscillator output of the phase-locked loop is a square wave at 160 time frame rate. This is used to clock data out of serial port U-5. This data comes from the micro computer already encoded in bi-phase format. When U-5 requires data, it interrupts the micro computer, which then loads the next 8 time code bits into U-5. The micro computer does all the data formatting and time keeping for the code and also inserts the sync word. At 80 bit intervals, the program pulses the PROG pin of the 8039 which is connected to the phase-locked loop variable input (U-16, pin 3). This insures that the code frame starts during the vertical interval at the start of the video frame.

Data out of U-5 pin 19 is in Manchester II bi-phase format. U-22, Q-3, Q-4, Q-4, Q-4, R-40, R-41, C-38, and C- 41 form an integrating line driver with a rise time of 20 microseconds. This drives the output lines through source termination resistors R-47, to R-50.

4.3 Display

The 8 digit L.E.D. display is multiplexed from the lower half of port ‘1’ of U-8. Data in seven segment format from U-8 port ‘1’, drives the numeric display segment drivers Q-101 through Q-104 and Q-108 through Q-116. The multiplex count is decoded by U-105 whose outputs are connected to the digit drivers Q-107, Q-111, Q- 112, Q-113, Q-114, Q-115, Q-117, and Q-118, whose outputs are connected to the digit L.E.D. anodes. This multiplex output is also decoded by U-9 and is used to scan the time increment buttons and the standards pin grid.

4.4 Color Frame

U-17 section 1 is a ‘D’ flip-flop which is set by applying a logic low to Q-2 via the Color Frame connector. This is monitored by the generator software and is used to recognize the first field of either the SMPTE or EBU color field sequence. It is then reset by the micro computer.

4.5 Standards Switch

The A/B standard switch logic is, if the switch is in ‘A’ position then set the generator to the first standard grid pin which is shorted by a jumper plug. If the switch is in ‘B’ position then set the generator standard to the second standard grid pin which is shorted by a jumper plug or to the first one if a second jumper plug is not found.

4.6 Power Supply

The TCG550 is powered by a universal transformer. Selection of the correct primary winding configuration for a given line voltage is made changing jumpers on the main circuit board as shown in figure 2.1 on page 11.

A single positive 5 volts is derived from a center tapped full-wave bridge circuit, D-4 and D-5 and C-44. The positive 5 supply is regulated by U-23. This provides the L.E.D. display, power for logic devices and the microprocessor and it’s memory and peripheral devices.

C H A P T E R

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Maintenance

5.1 Preventive Maintenance

Under normal use, preventive maintenance is not required. There are no adjustments or controls in the TCG550 time code generator.

5.2 Performance Verification

Connect a video or sync signal to connector labeled SYNC with a BNC connector and terminate the other end of the loop through with a 75 ohm termination. With an oscilloscope, observe the pulse at pin 1 of U-16. This is a positive 5 volt level with a narrow pulse going to ground. (Note – This is the phase error in the phase locked loop.) The width of this pulse should average 5 microseconds, but will not be constant. This pulse should be at a 30 hz rate. Disconnect the SYNC signal and observe that this pulse becomes very wide. Reconnecting SYNC should cause this signal to revert to about 5 microseconds. The magnitude of this pulse is proportional to the phase difference between the time code output and the vertical component of the SYNC signal.

Observe the time code output signals and confirm that the rise time of each phase is 20 microseconds ±5 microseconds. The level should be about 4 volts peak to peak on each phase.

Connect the time code output to a time code reader and alternately press the HOLD button this should alternately stop and start the code displayed by the reader and the HOLD L.E.D. should light when the code is stopped.

If unsatisfactory results are obtained during any of the above procedures, refer to the Theory of Operation section for guidance in more detailed trouble shooting.

A

Glossary

ASCII American Standard Code for Information Interchange; a standardized, eight bit data character encoding system used internationally to code alphabetic, numeric, and other symbols into binary values for interchange between computers.

Assemble Editing Editing new material to the end of previously recorded material. This requires a jam sync time code generator. Assemble editing is done on fully erased tape. Also see insert editing.

Asynchronous In data communications, transmission in which the time interval between data characters may be of unequal length. Transmission is controlled by start and stop bits at the beginning and end of each character. See also SYNCHRONOUS.

Auto Assembly See Auto Conforming.

Auto Conforming Automatic editing of videotape to conform to previously generated edit decision list.

B.C.D. Binary Coded Decimal. A method of representing the digits 0 through 9 using four bits.

Back Porch The part of a composite signal that follows the horizontal sync pulse and extends to the trailing edge of the corresponding blanking pulse.

Back Time To calculate an in-point by selecting the outpoint and subtracting the duration, i.e. the length of the edit.

Bi-Phase Mark An encoding method used by SMPTE and EBU time codes to combine the clock and the data in the same signal.

Bit In the binary notation either of the characters 0 or 1. The smallest logical element.

Black Level The level of the television picture signal corresponding to the maximum limit of black peaks.

Blanking A signal which prevents the video information from registering on the face of a cathode ray tube. As a moving scanning-beam of a picture tube moves from the end of one line of picture information to the beginning of the next (or makes a longer move to the upper left corner of an entirely new picture field of video information), it must not make visible signal marks on the face of the tube. In effect the scanning beam must be blacked out during these moves. The signal controlling this black out is called the blanking signal. The length of time of the blackout is called the "blanking period" or "blanking interval".

Blanking Level In a composite video signal, blanking level corresponds with zero signal level. Below this level, in what might be termed the blacker-than-black or negative direction, are the sync pulses. Above this level, in the positive direction, the picture signals appear.

BNC A type of connector commonly used in the television industry for interconnection of video signals.

Buffer An information holding are in a computer, for temporary storage of data.

Burn In To superimpose: for example, to burn in a title means to super a title (usually white) over a scene. See also KEY.

Byte A unit of eight bits.

Cathode Ray Tube In video, an electron tube designed to emit electrons (cathode ray) from a cathode at one end and to project them onto a light emitting fluorescent surface at the other end.

Character Generator Electronic device used to create alpha numeric characters in video form.

Character Inserter See Character Generator.

Character Letters, numbers and punctuation marks.

Check Character See CRC.

Clean Edit An edit containing no electronic noise, distortion or other disruptions at the edit point.

Clipping Any action that cuts off the peaks of the television signal. This may affect the positive (white) or negative (black) picture-signal peaks or synchronous signal peaks.

CMOS Complimentary Metal Oxide Semiconductor. A very low power logic family.

Code A system of rules and conventions according to which data can be formed, transmitted, relieved and processed.

Color Bar Signal A test signal that provides the reference characteristics by which color equipment is adjusted. Also called "color bars" or "bars".

Color Black A composite video signal containing sync, bust and set up signals (without distortion or video information) and constituting a black picture on the screen.

Color Burst In NTSC color this refers to a burst of approximately 9 cycles of 3.6 mHz subcarrier on the back porch of the composite video signal. This is a color synchronizing signal to establish a frequency and phase reference for the chrominance signal.

Color Framing A method of numbering frames in the NTSC and EBU color systems that identifies the sync to color subcarrier phase relationship. If this relationship is not preserved over an edit point, a horizontal picture shift may occur. This is not normally noticeable unless parts of the picture do not change on either side of the edit.

Component Video A non-composite system in which a color picture is composed of three video signals; typically red, green and blue, or derivatives thereof.

Continuous Jam Sets the generator time from an external source of time code at every frame. If an error occurs in the external time code, the generator generates the next frame expected in order to cover any errors. This means that time code may be copied with errors corrected by a Telcom Research time code generator with the continuous jam feature.

Control Track The recorded track of a videotape that contains sync information. It consists of clean, constant electronic reference pulses recorded on the tape. The control track is used by the VTR for proper synchronization of the video head drum and capstan during playback of the video signal.

Crash Edit An assemble edit made by manually forcing the VTR into record. It is not frame accurate and may not be repeated at the same point on the tape.

CRC Cyclic redundancy check character. A method of detecting errors in serial data transmissions using polynomial manipulation and modulo arithmetic. During transmission the data stream (message polynomial) is divided by a selected polynomial. The remainder of this division (the check bits) is appended to the message. During receipt the both message and check bits are divided by the same polynomial. If there are no detectable errors the remainder of this division is zero. This is used in VITC error detection with a polynomial of X^8+1.

CRT See Cathode Ray Tube.

Cuts Only Editing A basic mode of editing using only cuts (i.e. no special dissolves) to progress from scene to scene.

Cyclic Redundancy See CRC.

Decoding Delay A delay in the time code caused by the fact that a time code frame occurs simultaneously with its associated video frame. This means that by the time the code has been recovered and decoded the video frame is almost over. This is especially important in time code character inserters and jam sync generators. Usually the time code information is required at the start of the frame so all Telcom Research products correct for this delay.

Digital An encoding method which uses binary numbers to represent data, such as video, audio or other signal information.

Digitize To convert information into representative numbers. To convert analog information into digital information.

Double System A production method in which the synchronous sound and picture are recorded as two separate elements.

Drop Frame — Drop Frame time code is an SMPTE operating standard that eliminates two frames at the beginning of each minute except for minutes 0, 10, 20, 30, 40, and 50. Drop Frame allows time code to run at almost exactly the same speed as a clock (real time) when used with NTSC color video.

Dropout — Loss of the picture, audio or time code signals, during tape play back. Usually caused by scratches or contamination on the tape or the oxide flaking off and leaving spots where no signal remains.

Dub — A copy of a tape. See also, "Master" and "Window Dub".

Dubbing — This word has two meanings. (1) Erasing an audio track and recording new words, music or sound effects in its place. (2) Making copies of a tape, i.e. duplication.

Duplication Master — The tape from which copies (dubs) are made by the duplication house. Film-to-tape transfer masters and edited masters can serve as duplication masters, or a special "duplication master" can be made for dubbing, in which case it is second generation to either the film to tape transfer master or the edited master.

E.I.A. — Electronic Industries Association. An organization which sets standards and recommended practices in the electronics industry.

EBU — European Broadcast Union. Organization which defines standards used for color television in Europe.

Edit (Assemble) — See Assemble Editing.

Edit (Crash) — See Crash Edit.

Edit (Rough) — See Rough Edit.

Edit — Any point on a videotape where either the audio or the video content has been added to, deleted, replaced, extended, shortened or otherwise changed from its original form.

Edit Decision List A permanent record (in the form of punched paper tape, floppy disk or printed copy) of all the edit decisions made for a video production. It contains information such as in-points, outpoints and effects; and is used for later automatic assembly of the selected portions of the original tapes into the final production or program.

Edit Log Same as “Edit Decision List”.

Edit Source Any Device that provides signals to be recorded in an edit session. Included are VTRs, ATRs, cameras, character generators, film chain, etc.

Edit Split An edit in which the audio and video edit points are selected independently from each other. New audio can begin wither before or after the new video material is recorded.

Edited Master The first generation of the fully edited videotape, the final program. Includes all video, all audio and all signals. The edited master incorporates images that are actually removed two or more generations form the master. Also called “edit master”.

Editing (Cuts Only) See Cuts-Only Editing.

Editing (Electronic) See Electronic Editing.

Editing (Off-line) See Off-line Editing.

Editing (On-line) See On-line Editing.

Editing (Time Code) See Time Code Editing.

Editing The process of executing a series of edits to reach the final form of a production or program. Not a physical assembly process, as in film editing, but a selective electronic transfer (dubbing) of video and/or audio sequences onto a new master videotape.

Editor A person who edits.

EDL See Edit Decision List

EDL See Edit Decision List.

EFP — Abbreviation for Electronic Field Production. Sometimes used interchangeably with the term ENG.

EIA — Abbreviation for Electronics Industry Association. EIA is an U.S.-based trade association (principally for electronics manufacturers) with great influence on radio, television, and audio technical standards.

Electronic Editing — Electronically controlled assembling of selections of different video and/or audio sequences to produce finished programming. Electronic editing is not a physical editing assembly process, as is the splicing of film. It is, however, selective retransfer (duping) of video and/or audio onto a new master tape. Electronic editing is a postproduction procedure.

Endpoint — Where an edit ends. Also called “outpoint”.

ENG — Abbreviation for “electronic news gathering”. The business, techniques, and technology of new broadcasting audiovisuals using electronic cameras and videotape recorder/playback equipment instead of film equipment.

Field — (1) One-half (every other line) of a single TV frame. Two interlaced fields make one TV picture frame. Each field in the NTSC color TV video system has 262 1/2 lines of video information, and a complete frame has 525 lines.

Field Dominance — In video disk mastering, the order of the video fields established on the videotape during the editing or film to tape transfer process. A tape may possess either field one or field two dominance, the number referring to the video field on which each new picture begins. Throughout any videodisc master it is essential to maintain a constant field dominance or flickering will result. See also “Flicker”.

Film to Tape Transfer — The process of transferring optical picture images recorded on film to electronic picture images recorded on video tape.

Flicker — The undesirable visual alteration of two unmatched pictures commonly seen in freeze frame video. Flicker is caused by a field dominance change within a given frame creating a 1/60 of a second alteration of nonidentical fields.

Flutter Rapid, undesired fluctuations in the pitch of reproduced sounds. If rate of fluctuation is less than 5Hz, the term “wow” is used.

Font A complete alphabet (including numbers and punctuation marks) in a specific type style.

Frame The total area occupied by a television picture, occurring in the NTSC system every 1/30 second and produced by a combination of two alternating fields.

Helical Scan A videotape recorder/playback technology in which the video signal information is recorded diagonally on adjacent tracks. Sometimes called “Slant track”.

Hertz A unit of frequency equal to one cycle per second. Cycles are referred to as Hertz in honor of Heinrich Hertz. Abbreviates Hz.

In-Point On the record VTR, the place where the new material is to be recorded. On the source VTR, the beginning of the scene to be recorded.

Insert Edit An edit in which new material is *inserted* into previously recorded material. The time code and control tracks are untouched. Only new audio or video or both are recorded. Normally a fully erased tape is recorded without audio and with black, time code and control track. Also see assemble editing.

Interlace The scanning method whereby the first field of a video frame contains the odd scan lines. The marriage of the two fields or alternating interlace creates one full frame.

Invalid Time Time code with frames greater than 29 (24 EBU) or seconds greater than 59 or minutes greater than 59 or hours greater than 23 or containing any digit above 9.

Iso Reels Multiple reels of videotape recorded simultaneously on individual “isolated” VTRs from different cameras.

Jam Sync Setting the generator time from an external source of time code such as a tape playback or another generator.

Key	A special effect accomplished by electronically "cutting a hole" in the video and inserting another picture or color in the area. The "hole" can be established in any size or shape by signals from a video camera, character generator or other video source.
kHz	One thousand Hertz. Abbreviated kHz. See Hertz, mHz.
Log	To keep a record. The record of events and / or decisions; such as edit logs and shooting logs.
Longitudinal	See LTC.
LTC	A form of time code recorded on a longitudinal track (audio or cue or address track) on an audio or video recorder. Also see VITC.
Manchester	See bi-phase.
Master	The original recording, the tape that comes directly form the videotape recorder. A master is first-generation recording.
Match Frame Edit	An invisible edit made by selecting an in-edit point that exactly matches a previously recorded frame. Usually used to extend the edit.
mHz	Megahertz, one million Hertz. Abbreviated mHz. See Hertz, kHz.
Microsecond	One millionth of a second, 10^{-6} second.
NAB	National Association of Broadcasters. An organization of the U.S. broadcasting industry, including networks, independents and cable system operators. Sets programming standards.
Nanosecond	One billionth of a second, 10^{-9} second.
Noise	Undesirable disturbances in a communications system. Noise can generate errors in transmission and reception. In audio, noise refers to extraneous sound interference.

NTSC — National Television Standards Committee, a broadcast engineering advisory group. NTSC also refers to the established 525-line, 60-field system for color television broadcasting that is standard in the North America and Japan.

Off-line Editing — A rough-cutting process using relatively inexpensive copies of original material, for purposes of establishing sources, continuity and timing of edit decisions.

On-line Editing — A term usually used to mean electronic editing and completion using equipment that produces the principal end results without intervening stages of either format or technology.

PAL-M — See PAL.

PAL — Phase Alternate Line, the 625-line, 50-field system used in the U.K., Western Europe, Scandinavia, Australia, South Africa and other regions. A complete sequence consists of eight fields, as opposed to four fields in NTSC. PAL-M is a the 525 line, 60 field variant of the PAL system used in Brazil.

Parallel — A method of data transfer in which all bits of information are transmitted simultaneously on separate wires.

Postproduction — All activities between the completion of the principle photography and the final approval of the production.

Preview — A rehearsal of an edit. Observing the results of a selected sequence of events without actually recording the signals on the record VTR. (1) BVB (Black-Video-Black) Preview: allows observation of the source VTR only so that the “fill” material can be viewed separately. The video monitor switches from black to source video and back to black during the preview. (2) VBV (Video-Black-Video) Preview: allows observation of the record VTR so that “information to remain unrecorded” may be viewed separately. The video monitor switches from record VTR to black / silence and back to record VTR, to help determine if material selected to remain on the tape is correct.

Protection Master A duplicate of any of master tape, made in case its master is lost or damaged. Also called a “safety copy”. See also “Dub” and “Generation”.

Real Time Actual time.

Rough Edit A preliminary, rapid assembly of the different sequences of a program or production in the order of their appearance. It provides an approximate idea of the final program but is neither an edit master nor a clean edit list.

Scan Line One single horizontal line of a TV picture.

Scene Log A record of scenes and their order, usually including tape time, air time, time code address and comments regarding quality, content and how they relate to the script. See also “Log”.

Search To program a tape-time location (by means of control track or SMPTE/EBU time code) and have the VTR go to that specific point on the tape.

SECAM Sequential couleur a memoire (sequential color with memory) the French color television system also used within the Soviet Union and many satellite countries. The basis of operation is the sequential recording of primary colors in alternate lines.

Serial A method of transmission in which each bit of information is sent sequentially on a single line rather than simultaneously as in parallel transmission.

Signal-to-Noise The ratio of extraneous picture information (noise) to good video picture information signal inherent in video equipment or in a piece of videotape stock. S/N is usually expressed in decibels (dB). The higher the S/N ratio, the less grain (noise) and therefore the better picture.

SMPTE Society of Motion Picture and Television Engineers. The organization which defines the the standards used for SMPTE time code.

SMPTE Time Code A standardized format for longitudinal time code established by the SMPTE for use in the USA. It consists of an eight-digit number specifying hours, minutes, seconds and frames (to identify each frame on a tape)—plus eight sets of user bits (four bits each) for each frame, and 16 bits for synchronization of the time code reader. See also “Drop Frame Time Code” and “Time Code”.

Sync Generator A signal generator used in a facility to synchronize all equipment, including edit controller. VTRs, etc.

Sync The part of a television signal containing timing information used to control the scanning circuitry in a receiver or monitor.

Synchronous In data communications, transmission in which the data bits are transmitted at a fixed rate with the transmitter and receiver synchronized. This eliminates the need for start/stop bits thus providing greater efficiency. Time code is a form of synchronous data transmission. See also ASYNCHRONOUS.

TCG See Time Code Generator.

TCR See Time Code Reader.

Three-Two Pull-down (3:2) A technique for compensating for the differential between the film frame of 24 fps and that of video, 30 fps, during film to tape transfer. The first film frame is recorded on three video fields and the following frame on two fields resulting in a five field sequence.

Time-Base Corrector An electronic unit for improving the stability of video signals by correcting the timing flaws inherent in videotape playbacks.

Time-Base Error An error in the playback video from a VTR that results in slight timing variations and appears as visual “jitter” in the signal.

Time Code An indexing address code using electronically generated numbers indexed as hours, minutes, seconds and frames as its reference. See also “SMPTE Time Code” and “Drop Frame Time Code”.

Time Code Editing Using time code addressing and indexing during editing. This saves time and permits many functions, particularly searches for specific edit points, to be performed automatically.

Time Code Generator A device for generating time code to be recorded on an audio or time code track in a VTR.

Time Code Reader A device for reading the time code from an audio or time code track in a VTR, and translating the code into signals which can be used by an edit controller or read by the operator on a status display screen.

Trim (1) To alter an edit point by the addition or subtraction of frames or time code value (hours, minutes, seconds, frames). (2) The sections of audiovisual material left over from the edit, i.e. a) head trim is the unused section prior to that which has been edited in, and b) tail trim is the unused section after that which has been edited in.

TTL Transistor, transistor logic. A medium power, fast logic family.

USART Universal Synchronous Asynchronous Receiver Transmitter. An integrated circuit which implements the logic to create either a synchronous or asynchronous data link. It converts bytes of data to serial form.

User Bits 32 bits or 4 bytes reserved in the time code for custom information. There is no preconceived format for this information and the bits may be interpreted in any way. Most Telcom Research time code readers and generators display these 32 bits in hexadecimal notation as 8 digits.

Valid Time A time which exists in the 24 hour clock system. 13:24:56:12 is a valid time but 13:64:56:12 is not because 64 is not a valid number for minutes.

Vertical Blanking Lines 1-21 of video field one and lines 263-284 of video field two, reserved for insertion of frame numbers, picture stops, chapter stops or other flags, captions or user defined information. These lines are not visually displayed on the screen.

VITC A form of time code recorded in the television signal's vertical interval on two nonadjacent scan lines. The two lines contain the same information. This is done to improve reliability. Also see LTC.

Window Dubs Duplicates of master tapes with time code usually displayed in a window in the picture. Used for off-line scene logging without a time code reader.

Word A unit of 16 bits or 2 bytes.

Wow Slow, undesired fluctuation in the pitch of reproduced sound. Wow is a form of flutter in which the rate of fluctuation is less than 5Hz.

XLR A type of multiple pin connector commonly used in the television and sound industries. The three pin version is used for interconnection of audio signals and the four pin version is used for connecting battery power to portable equipment.

Z80 An eight bit microprocessor designed and manufactured by Zilog.

B

Parts List

B.1 Resistors

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
R-1	330 K	CR25TOL5	PHILIPS
R-2	10 K	CR25TOL5	PHILIPS
R-3	10 K	CR25TOL5	PHILIPS
R-4	10 K	CR25TOL5	PHILIPS
R-5	10 K	CR25TOL5	PHILIPS
R-6	10 K	CR25TOL5	PHILIPS
R-7	10 K	CR25TOL5	PHILIPS
R-8	10 K	CR25TOL5	PHILIPS
R-9	27 K	CR25TOL5	PHILIPS
R-10	18 K	CR25TOL5	PHILIPS
R-11	10 K	CR25TOL5	PHILIPS
R-12	100	CR25TOL5	PHILIPS
R-13	10 K	CR25TOL5	PHILIPS
R-14	56 K	CR25TOL5	PHILIPS
R-15	47 K	CR25TOL5	PHILIPS
R-16	47 K	CR25TOL5	PHILIPS
R-17	220 K	CR25TOL5	PHILIPS
R-18	130 K	CR25TOL5	PHILIPS
R-19	1 MEG	CR25TOL5	PHILIPS
R-20	39 K	CR25TOL5	PHILIPS
R-21	1 MEG	CR25TOL5	PHILIPS
R-22	100 K	CR25TOL5	PHILIPS
R-23	330 K	CR25TOL5	PHILIPS
R-24	680 K	CR25TOL5	PHILIPS
R-25	100 K	CR25TOL5	PHILIPS
R-26	10 K	CR25TOL5	PHILIPS
R-27	100 K	CR25TOL5	PHILIPS
R-28	10 K	CR25TOL5	PHILIPS
R-38	10 K	CR25TOL5	PHILIPS

R-39	10 K	CR25TOL5	PHILIPS
R-40	15 K	CR25TOL5	PHILIPS
R-41	15 K	CR25TOL5	PHILIPS
R-42	1 K	CR25TOL5	PHILIPS
R-43	not used		
R-44	not used		
R-47	180	CR25TOL5	PHILIPS
R-48	180	CR25TOL5	PHILIPS
R-49	180	CR25TOL5	PHILIPS
R-50	180	CR25TOL5	PHILIPS
R-51	10 K	CR25TOL5	PHILIPS
R-52	10 K	CR25TOL5	PHILIPS
R-53	10 K	CR25TOL5	PHILIPS
R-54	10 K	CR25TOL5	PHILIPS
R-101	56 OHMS	CR25TOL5	PHILIPS
R-102	56 OHMS	CR25TOL5	PHILIPS
R-103	56 OHMS	CR25TOL5	PHILIPS
R-104	1 K	CR25TOL5	PHILIPS
R-105	1 K	CR25TOL5	PHILIPS
R-106	330 OHMS	CR25TOL5	PHILIPS
R-107	1 K	CR25TOL5	PHILIPS
R-108	4.7K	CR25TOL5	PHILIPS
R-109	4.7K	CR25TOL5	PHILIPS
R-110	4.7K	CR25TOL5	PHILIPS
R-111	4.7K	CR25TOL5	PHILIPS
R-112	4.7K	CR25TOL5	PHILIPS
R-113	4.7K	CR25TOL5	PHILIPS
R-114	4.7K	CR25TOL5	PHILIPS
R-115	4.7K	CR25TOL5	PHILIPS
R-116	56 OHMS	CR25TOL5	PHILIPS
R-117	1 K	CR25TOL5	PHILIPS
R-118	330 OHMS	CR25TOL5	PHILIPS
R-119	560 OHMS	CR25TOL5	PHILIPS
R-120	10K	CR25TOL5	PHILIPS
R-121	10K	CR25TOL5	PHILIPS
R-122	560 OHMS	CR25TOL5	PHILIPS
R-123	1 K	CR25TOL5	PHILIPS
R-124	1 K	CR25TOL5	PHILIPS
R-125	330 OHMS	CR25TOL5	PHILIPS
R-126	1 K	CR25TOL5	PHILIPS
R-127	56 OHMS	CR25TOL5	PHILIPS
R-128	680 OHMS	CR25TOL5	PHILIPS
R-129	56 OHMS	CR25TOL5	PHILIPS
R-130	56 OHMS	CR25TOL5	PHILIPS
R-131	1 K	CR25TOL5	PHILIPS
R-132	680 OHMS	CR25TOL5	PHILIPS

R-133	680 OHMS	CR25TOL5	PHILIPS
R-134	680 OHMS	CR25TOL5	PHILIPS
R-135	680 OHMS	CR25TOL5	PHILIPS
R-136	680 OHMS	CR25TOL5	PHILIPS
R-137	100 OHMS	CR25TOL5	PHILIPS
R-138	680 OHMS	CR25TOL5	PHILIPS
R-139	not used		
R-140	not used		
R-141	680 OHMS	CR25TOL5	PHILIPS

B.2 Capacitors

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
C-1	.1 MFD 12 V CERAMIC	405484	STETTNER
C-2	.1 MFD 12 V CERAMIC	405484	STETTNER
C-3	10 PF CERAMIC	CK05BX100K	AVX
C-4	1.5 MFD 35 V TANTALUM	TAP 1.5M 35	I.T.T
C-5	33 MFD 6V TANTALUM	TAP 33M 6	I.T.T
C-6	.33 MFD 20V TANTALUM	TAP .33M 20	I.T.T
C-7	1 MFD 35 V TANTALUM	TAP 1M 35	I.T.T
C-8	1000 PF CERAMIC	CK05BX102K	AVX
C-9	.1 MFD 12 V CERAMIC	405484	STETTNER
C-10	1000 PF CERAMIC	CK05BX102K	AVX
C-11	.22 MFD 20V TANTALUM	TAP .22M 20	I.T.T
C-12	1000 PF CERAMIC	CK05BX102K	AVX
C-13	1000 PF CERAMIC	CK05BX102K	AVX
C-14	.33 MFD 20V TANTALUM	TAP .33M 20	I.T.T
C-15	.1 MFD 12 V CERAMIC	405484	STETTNER
C-16	.22 MFD 20V TANTALUM	TAP .22M 20	I.T.T
C-17	4700 PF CERAMIC	CK05BX472K	AVX
C-18	1000 PF CERAMIC	CK05BX102K	AVX
C-19	.1 MFD 12 V CERAMIC	405484	STETTNER
C-20	.1 MFD 12 V CERAMIC	405484	STETTNER
C-21	10 MFD 16V TANTALUM	TAP 10M 16	I.T.T
C-22	.47 MFD 16V TANTALUM	TAP .47M 16	I.T.T
C-23	1800 PF CERAMIC	CK05BX182K	AVX
C-24	1 MFD 35 V TANTALUM	TAP 1M 35	I.T.T
C-25	.1 MFD 12 V CERAMIC	405484	STETTNER
C-26	3.3 MFD 20V TANTALUM	TAP 3.3M 20	I.T.T
C-28	.1 MFD 12 V CERAMIC	405484	STETTNER
C-31	.1 MFD 12 V CERAMIC	405484	STETTNER
C-35		not used	
C-36		not used	
C-37	33 MFD 6V TANTALUM	TAP 33M 6	I.T.T
C-38	33 MFD 6V TANTALUM	TAP 33M 6	I.T.T

C-39	1000 PF CERAMIC	CK05BX102K	AVX
C-40	33 MFD 6V TANTALUM	TAP 33M 6	I.T.T
C-41	33 MFD 6V TANTALUM	TAP 33M 6	I.T.T
C-42	1000 PF CERAMIC	CK05BX102K	AVX
C-43	.1 MFD 12 V CERAMIC	405484	STETTNER
C-44	4700 PF CERAMIC	CK05BX472K	AVX
C-101	10 MFD 16V TANTALUM	TAP 10M 16	I.T.T

B.3 Integrated Circuits

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
U-1	CMOS B SERIES	MC14538B	MOTOROLA
U-2	LOW POWER SCHOTTKY	74LS74	MOTOROLA
U-3	CMOS B SERIES	MC14049UB	MOTOROLA
U-5	NMOS USART	INS8251N	NATIONAL
U-6	LOW POWER SCHOTTKY	74LS373	MOTOROLA
U-7	NMOS MEMORY	D2716	INTEL
U-8	NMOS CPU	D8039L	INTEL
U-9	CMOS B SERIES	MC14051B	MOTOROLA
U-10	ANALOG COMPARATOR	MLM311P	MOTOROLA
U-11	CMOS B SERIES	MC14538B	MOTOROLA
U-12	CMOS B SERIES	MC14538B	MOTOROLA
U-13	CMOS B SERIES	MC14538B	MOTOROLA
U-14	CMOS B SERIES	MC14001UB	MOTOROLA
U-15	CMOS B SERIES	MC14538B	MOTOROLA
U-16	CMOS B SERIES	MC14046B	MOTOROLA
U-17	LOW POWER SCHOTTKY	74LS74	MOTOROLA
U-22	CMOS B SERIES	MC14049UB	MOTOROLA
U-101	LOW POWER SCHOTTKY	SN74LS138N	MOTOROLA

B.4 Diodes

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
D-1	GERMANIUM DIODE	1N270	MOTOROLA
D-2	SILICON DIODE	1N4148	MOTOROLA
D-3	not used		
D-4	SILICON RECTIFIER	1N4001	MOTOROLA
D-5	SILICON RECTIFIER	1N4001	MOTOROLA
D-6	SILICON RECTIFIER	1N4001	MOTOROLA
L-101	L.E.D.	MV5753	GEN. INST.
L-102	L.E.D.	MV5753	GEN. INST.
L-103	L.E.D.	MV5753	GEN. INST.
L-104	L.E.D.	MV5753	GEN. INST.
L-105	L.E.D.	MV5753	GEN. INST.

L-106	L.E.D.	MV5753	GEN. INST.
L-107	L.E.D.	MV5753	GEN. INST.
L-109	L.E.D.	MV5753	GEN. INST.
L-110	L.E.D.	MV5753	GEN. INST.
L-111	L.E.D.	MV5753	GEN. INST.
L-112	L.E.D.	MV5753	GEN. INST.
L-113	L.E.D.	MV5753	GEN. INST.
L-114	L.E.D.	MV5753	GEN. INST.
L-115	L.E.D.	MV5753	GEN. INST.
L-116	not used		
L-117	not used		
DP-101	7 SEGMENT DISPLAY	MAN6610	GEN. INST.
DP-102	7 SEGMENT DISPLAY	MAN6610	GEN. INST.
DP-103	7 SEGMENT DISPLAY	MAN6610	GEN. INST.
DP-104	7 SEGMENT DISPLAY	MAN6610	GEN. INST.

B.5 Transistors

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
Q-1	NPN	2N4401	MOTOROLA
Q-2	NPN	2N4401	MOTOROLA
Q-3	NPN	2N4401	MOTOROLA
Q-4	NPN	2N4401	MOTOROLA
Q-5	PNP	2N4403	MOTOROLA
Q-6	PNP	2N4403	MOTOROLA
Q-101	NPN	2N4401	MOTOROLA
Q-102	NPN	2N4401	MOTOROLA
Q-103	NPN	2N4401	MOTOROLA
Q-104	NPN	2N4401	MOTOROLA
Q-105	NPN	2N4401	MOTOROLA
Q-106	NPN	2N4401	MOTOROLA
Q-107	PNP	2N4403	MOTOROLA
Q-108	NPN	2N4401	MOTOROLA
Q-109	NPN	2N4401	MOTOROLA
Q-110	NPN	2N4401	MOTOROLA
Q-111	PNP	2N4403	MOTOROLA
Q-112	PNP	2N4403	MOTOROLA
Q-113	PNP	2N4403	MOTOROLA
Q-114	PNP	2N4403	MOTOROLA
Q-115	PNP	2N4403	MOTOROLA
Q-116	NPN	2N4401	MOTOROLA
Q-117	PNP	2N4403	MOTOROLA
Q-118	PNP	2N4403	MOTOROLA

B.6 Connectors

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
J-1	BNC CONNECTOR	31-221	AMPHENOL
J-2	BNC CONNECTOR	31-221	AMPHENOL
J-3	BNC CONNECTOR	31-221	AMPHENOL
J-4	OUTPUT CONNECTOR	D3M	SWITCHCRAFT
J-5	OUTPUT CONNECTOR	D3M	SWITCHCRAFT

B.7 Switches

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
SW-1	PUSH BUTTON SWITCH	D6	SCHADOW
SW-2	PUSH BUTTON SWITCH	D6	SCHADOW
SW-3	PUSH BUTTON SWITCH	D6	SCHADOW
SW-4	PUSH BUTTON SWITCH	D6	SCHADOW
SW-5	PUSH BUTTON SWITCH	D6	SCHADOW
SW-6	PUSH BUTTON SWITCH	D6	SCHADOW
SW-7	SPDT	MTF106D	ALCO
SW-8	SPST	TT13A-2T	ALCO

B.8 Miscellaneous

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
T-1	TRANSFORMER (117 / 220 V)	161G16	HAMMOND
XTAL	4MHZ	CTS 4000	CTS
P1	10 POS HEADER	9296650105I	AP
P2	26 POS HEADER	9296650113I	AP
P3	8 POS HEADER	9296650104I	AP
S1	IC SOCKET	640379-1	AMP
S2	IC SOCKET	640361-1	AMP
CASE	BLUE CASE	C-275-003 401	PAC-TEC

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