T6010

S.M.P.T.E. / E.B.U.
TIME CODE READER
CHARACTER INSERTER

Operation and Maintenance

Release 1.0
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telcom research

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Introduction

1.1 Description

The model T6010 Time Code Reader/Video Character Inserter provides local LED display of the 80-bit Society of Motion Picture and Television Engineers (SMPTE) longitudinal time code, as well as displaying this code in a composite video signal. The model T6010 also provides the time or user data from this code at a 34 pin connector on the rear panel. This code, when recorded on video or audio tape, permits exact addressing of points on the tapes for precise editing, synchronization, dubbing and splicing. Figure 1.4 on page 4 depicts the code format.

1.2 Features

This manual applies to main circuit board revision level 2.3 and higher.

The following features are supported by the Telcom Research model T6010 S.M.P.T.E./E.B.U. Time Code Reader:

- Reads both S.M.P.T.E. and E.B.U. time code
- Error indicator for Reader time code
- External start/stop control
- High resolution character inserter
- Front panel control of boxed or bordered characters
- Front panel control of reverse character video
- 4 modes of character inserter data display
- Characters position continuously variable

- Optional frames suppression in character inserter
- Color framing indicator
- Variable brightness L.E.D. display
- Standard level (+11 dBm.) reshaped time code output
- Parallel output of time or user bits
- Rack Mount

1.3 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.

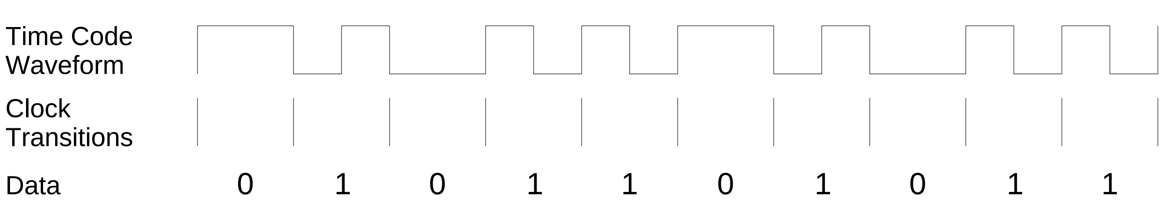

Figure 1.1: Bi-Phase Mark encoding

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).

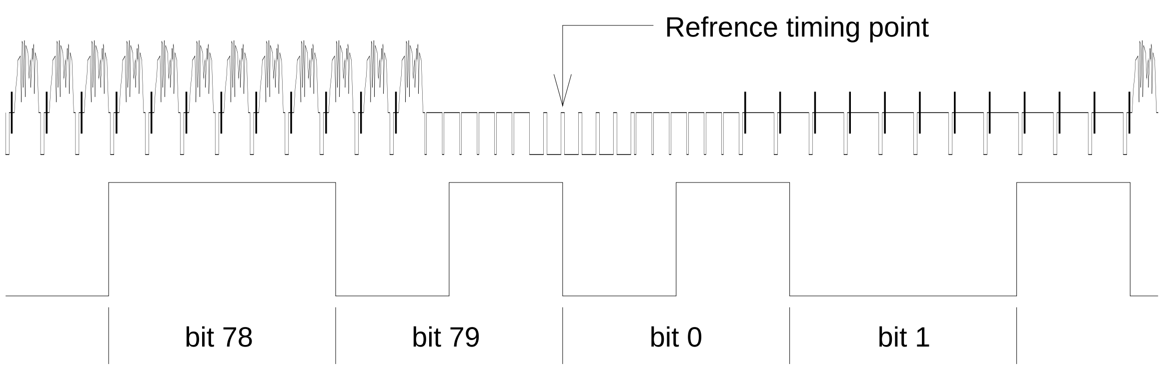

Figure 1.2: Timing Relationship Between NTSC Video and Time Code

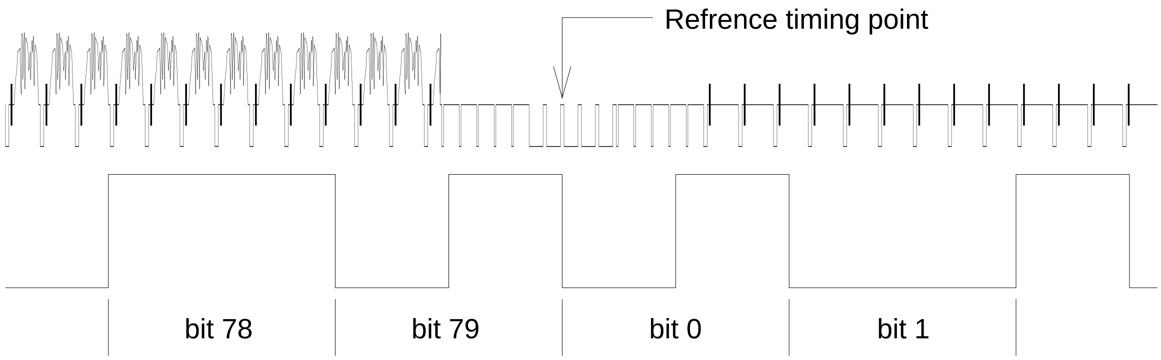

Figure 1.3: Timing Relationship Between EBU Video and Time Code

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.

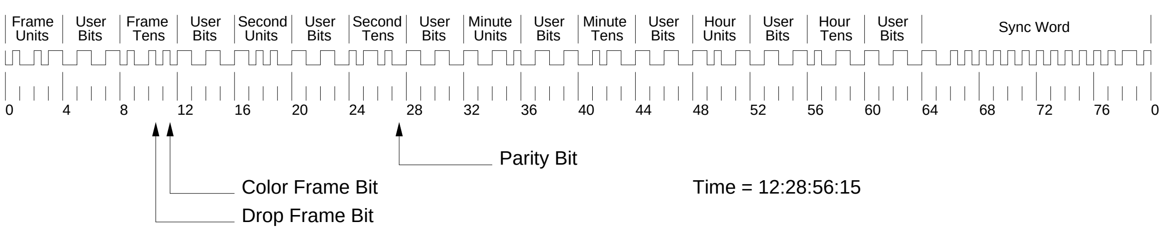

Figure 1.4: Longitudinal Time Code Waveform

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.

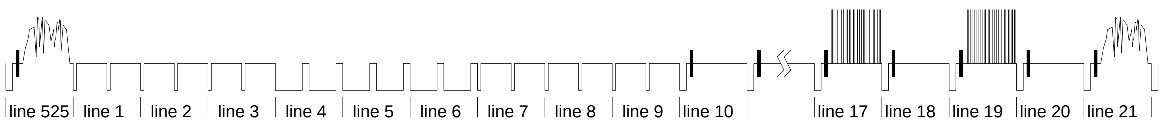

Figure 1.5: SMPTE Vertical Interval Time Code Waveform

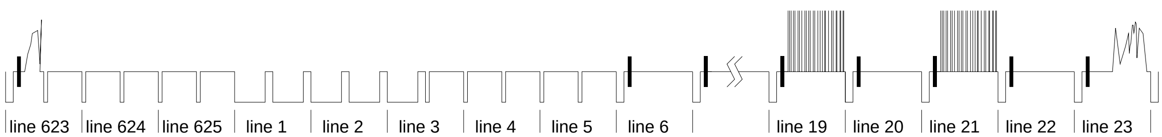

Figure 1.6: EBU Vertical Interval Time Code Waveform

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.

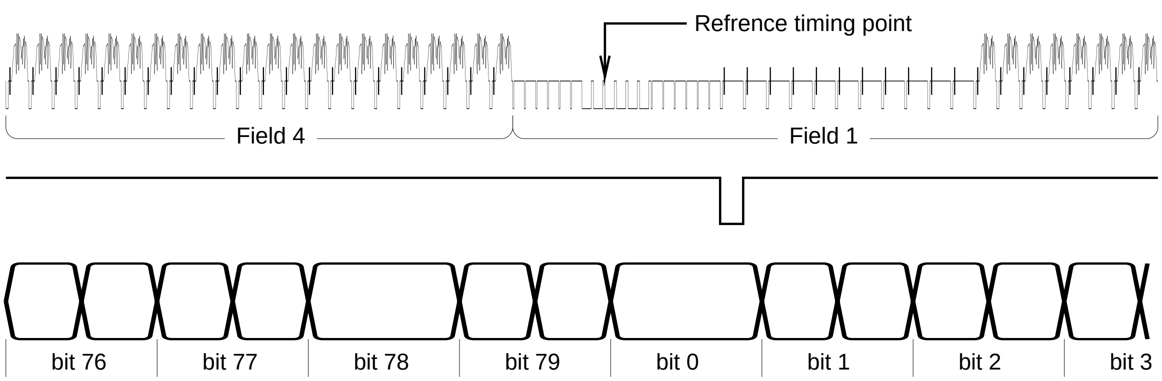

Figure 1.7: Relationship Between Video, Color Frame Identification Pulse and Time Code

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).

1.4 Specifications

Time Code Input S.M.P.T.E./E.B.U. time code between –25 and +25 dBm, 50% duty cycle ±15%, balanced line 20,000 ohms input at an XLR type 3 pin connector. (0.12 to 100 times play speed for E.B.U., 0.1 to 83.333 times play speed for S.M.P.T.E.). See section 2.3 on page 10 for details of S.M.P.T.E. or E.B.U. time code.

Time Code Outputs	One reshaped isolated pseudo balanced outputs on a 3 pin male XLR type connector at +11 dBm 600 ohms impedance, 25 microsecond rise time. This may be treated as 2 unbalanced outputs.
Video Input	Video (loop through) at 1 volt peak to peak nominal level. Is should be synchronous with the time code.
Video Outputs (2)	These outputs have unity gain from the character inserter input, 75 ohms source terminated. The white level of characters or border is internally adjustable from 0 to 140 units.
Parallel Output	TTL positive logic level, 32 bits.
Power	90 to 130 or 200 to 250 volts A.C. at 45 to 70 Hz., 20 VA.
Size	1.75 in. high, 19 in wide, 12 in. deep.
Weight	6 lbs., 2.75kg.
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).
Environmental	0 C to +55 C operating, –20 C to +85 C storage, 0 to 95% relative humidity (no condensation).

CHAPTER

2

Installation

2.1 Unpacking

The T6010 time code reader is shipped with this Operation and Maintenance manual and 3 conductor power cord 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 Jumper Selectable Options

There are 4 shorting plug positions located on the right hand edge of the main circuit board, as viewed from the front of the unit. They function as follows:

Time/User When the jumper is installed, the parallel interface will output the time code time information. When the jumper is omitted, the parallel interface will be contain the time code user bits information.

In/Out not used

Test not used

Jam User not used

2.3 Connections

All signal connections to and from the T6010 time code reader are made by means of industry standard XLR and BNC connectors located on the rear panel.

Time Code Input

The T6010 time code reader/character inserter will accept balanced or single ended S.M.P.T.E. or E.B.U. time code. For balanced input operation, connect the shield (ground) to pin 1 of the XLR input connector and the signal leads to pins 2 and 3. For unbalanced input operation, connect the shield (ground) to pins 1 and 2 of the XLR input connector and the signal lead to pin 3.

This is a bridging (high impedance) input and if used in a 600 ohm system a terminating resistor should be installed at the end of the time code line in order to maintain correct levels in the system.

Time Code Outputs

The time code output will drive a balanced 600 ohm line, providing a nominal level of +11 dBm. The time code 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.

Video Input

This is a loop through connection. Connect the video signal to the upper BNC connector. If this is the end of the video line, place a 75 ohm termination on the lower video in BNC connector, otherwise, continue the video line from the lower video input BNC connector. Be sure that this line is terminated at it’s final destination.

Video Output

The 2 video outputs are source terminated 75 ohm outputs which are isolated from each other. They provide unity gain from the video input point. It is not necessary to terminate an unused video output.

External Hold Input

This input is used to place the reader in the hold mode. It is an edge controlled TTL type input with an internal 4.7k pull-up to 5 volts which produces a 1 ma. current source. Remote hold operation may be implemented by connecting a normally open momentary contact switch to the T6010 time code reader external hold BNC connector. This switch when closed will cause the time code being displayed by the reader to ‘freeze’. Closing the switch again will cause the display to update normally.

Parallel Output Parallel access to the time and user bits (as selected by the jumper plug located on the main P.C. board) is provided at TTL levels. This is a 34 pin 'ribbon cable' type connector. Refer to table 2.1 on page 12 for the pin assignments for this connector. Also see to section 2.2 on page 9 for information on jumper settings.

Line Voltage Selection The model T6010 time code reader/character inserter may be set to operate in 2 line voltage ranges 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.

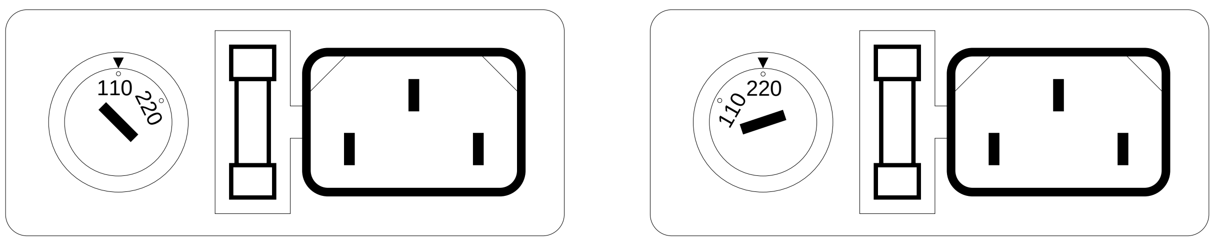

Figure 2.1: T6010 Line Voltage Selector

Pin	Time Function		User Function	
1	common			
2	common			
3	frames bit 0	LTC bit 0	user bit 0	LTC bit 4
4	frames bit 1	LTC bit 1	user bit 1	LTC bit 5
5	frames bit 2	LTC bit 2	user bit 2	LTC bit 6
6	frames bit 3	LTC bit 3	user bit 3	LTC bit 7
7	frames bit 4	LTC bit 8	user bit 4	LTC bit 12
8	frames bit 5	LTC bit 9	user bit 5	LTC bit 13
9	drop-frame flag	LTC bit 10	user bit 6	LTC bit 14
10	color-frame flag	LTC bit 11	user bit 7	LTC bit 15
11	seconds bit 0	LTC bit 16	user bit 8	LTC bit 20
12	seconds bit 1	LTC bit 17	user bit 9	LTC bit 21
13	seconds bit 2	LTC bit 18	user bit 10	LTC bit 22
14	seconds bit 3	LTC bit 19	user bit 11	LTC bit 23
15	seconds bit 4	LTC bit 24	user bit 12	LTC bit 28
16	seconds bit 5	LTC bit 25	user bit 13	LTC bit 29
17	seconds bit 6	LTC bit 26	user bit 14	LTC bit 30
18	parity bit	LTC bit 27	user bit 15	LTC bit 31
19	minutes bit 0	LTC bit 32	user bit 16	LTC bit 36
20	minutes bit 1	LTC bit 33	user bit 17	LTC bit 37
21	minutes bit 2	LTC bit 34	user bit 18	LTC bit 38
22	minutes bit 3	LTC bit 35	user bit 19	LTC bit 39
23	minutes bit 4	LTC bit 40	user bit 20	LTC bit 44
24	minutes bit 5	LTC bit 41	user bit 21	LTC bit 45
25	minutes bit 6	LTC bit 42	user bit 22	LTC bit 46
26	unassigned	LTC bit 43	user bit 23	LTC bit 47
27	hours bit 0	LTC bit 48	user bit 24	LTC bit 52
28	hours bit 1	LTC bit 49	user bit 25	LTC bit 53
29	hours bit 2	LTC bit 50	user bit 26	LTC bit 54
30	hours bit 3	LTC bit 51	user bit 27	LTC bit 55
31	hours bit 4	LTC bit 56	user bit 28	LTC bit 60
32	hours bit 5	LTC bit 57	user bit 29	LTC bit 61
33	unassigned	LTC bit 58	user bit 30	LTC bit 62
34	unassigned	LTC bit 59	user bit 31	LTC bit 63

Table 2.1: 32 BIT PARALLEL OUTPUT PIN ASSIGNMENTS

C H A P T E R

3

Operation

The operation of the T6010 time code reader is very straight forward. This section describes the function of all the controls and indicators on the front panel of the T6010 time code reader / character inserter.

3.1 Indicators

8 Digit L.E.D. Display	Indicates the time in hours, minutes, seconds and frames or the 8 groups of user bits in their 4 bit hexadecimal representation.
Error	Indicates that a sync word did not occur when expected in the time code being received by the jam sync reader.
Framed	Indicates that the time code has a number sequence which has the proper relationship to the 4 field (N.T.S.C.) or 8 field (E.B.U.) standard.
DF, 25, 30	The standard to which the time code being read was generated is indicated by one of these four lights.
Forward	Indicates that the tape is traveling in the forward direction if the error indicator is off.
Reverse	Indicates that the tape is traveling in the reverse direction if the error indicator is off.
Hold	Indicates when lighted that the reader is stopped. Code is still being read but the displays are not being updated.
Time	Indicates that the LED display is showing the contents of the time register.
User	Indicates that the LED display is showing the contents of the user register.

3.2 Controls

Hold Stops the reader display from updating or, if it was stopped, causes the display to resume updating normally.

Time Causes the T6010 reader to display the TIME DATA of the time code on the front panel L.E.D. readout.

User the T6010 reader to display the USER DATA of the time code on the front panel L.E.D. readout.

Border Alternates between video characters with a border and video characters contained within a rectangular cutout in the picture.

Inverse Reverses the video levels of the characters and the border (cutout). White characters black border become black characters with white border.

Frames Alternate action control which suppresses or enables the display of frames by the video character inserter.

Insert This key steps the character inserter through 4 modes of video information display as shown in table 3.1 on page 14.

1. READER TIME READER USER
2. READER TIME
3. READER USER
4. NO DISPLAY

Table 3.1: Insert Switch Functions

C H A P T E R

4

Theory Of Operation

4.1 Introduction

Schematics for the T6010 time code reader may be found in the last section of this manual.

The heart of the T6010 time code reader is a Zilog Z80A microprocessor. Extensive use has been made of large scale intelligent microprocessor support devices.

4.2 Microprocessor

The Z80A microprocessor (U-3) controls all operations of the T6010 time code reader. The control program is stored in U-8 with U-9 provided for future expansion. Data is stored in RAM chips U-10 and U-11. Memory devices are selected for bus transactions by U-5 and I/O devices by U-6. The 4 mHz. system clock signal is generated by crystal oscillator U-1, and it is used by U-2, U-3, U-12, U-13 as well as U-14. All data transfers are handled by the Z80A except in the reader interface where a Z80A-DMA (U-2) is used because of the high speed requirement. The DMA is programmed and controlled by U-3.

4.3 Reader

The time code entering through the XLR connector is AC coupled to input pins 2 and 3 of comparator U-40, which restores the code to a rectangular waveform by slicing at the zero crossings. A slight amount of positive feedback is provided by R-82 and C-41 to insure clean switching. This circuit will typically recover code down to a level of 10 mv. r.m.s. and has an upper limit above 20 volts r.m.s.

Integrated circuit U-39 pin 11 produces a positive pulse for every transition at its input. U-37 is a phase locked loop, which is locked to twice the clock frequency of the time code. When a zero bit cell is received a low output is produced at U-37 pin 1 at the middle of the zero bit cell time, which is then clocked by the output of the phase locked loop into U-39 and appears as inverted data at U-39 pin 12. This data is then inverted and level shifted by U-23 section 2 and clocked by the output of U-39 pin 11 through U-23 section 3 into pin 3 of U-12 and U-13. These are programmable communication interface circuits operating in the synchronous mode. Integrated circuit U-38 pin 2 and U-39 pin 6 produce a transition after the data has been clocked into U-38 pin 13 during a zero time code bit cell. This is required to keep the phase locked loop on frequency.

The received data in U-12 and U-13 is then examined bit by bit to find a 16 bit sync word. If U-12 detects the sync word then the tape is moving forward and U-13 is disabled by the program. If U- 13 detects the sync word then the tape is moving in the reverse direction and U-12 is disabled by the program. Time code data is then accumulated and transferred to memory by DMA controller U-1. The DMA controller also transfers the status information from U- 12 or U-13 into memory along with each byte of data. This is used by the software to aid in error checking the time code data. If the data passes several error checks then it is displayed on the L.E.D. readouts and in the video if video display is enabled.

4.4 Video and character generator

The character generator is built around an Intel 8276 CRT programmable controller U-16. This device is not normally used with an external video signal, however by externally controlling the character clock it can be made synchronous.

External video enters the T6010 main board at P5 pin 2 where it is A.C. coupled to emitter follower Q-18. The output of Q-18 is A.C. coupled to sync tip clamp diode D-2, sync separator U-42 and CMOS analog switch U-34. U-42 drives vertical integrator Q-17 and horizontal equalizing pulse remover U-19. Horizontal and vertical drive are then used by position monostable U-18.

U-15 is programmed to have a shorter line length and fewer lines per field than the external video signal. When U-15 reaches the end of a line or field it’s drive output (VRTC or HRTC) clocks one half of flip-flop U-20. This stops the video dot clock which in turn stops U-15. The dot clock is restarted by U-18 from external sync and the settings of vertical and horizontal position controls RV-201 and RV-202.

U-15 provides 7 character code outputs (CC0 to CC6) and 4 line count outputs (LC0 to LC3). These form the address lines for foreground PROM U-30 and background PROM U-31. The background PROM is used to cut a 'hole' in the external video signal which is slightly larger than the character to be inserted while U-30 provides the actual character. This leaves a border around the character. If U-31 is disabled by U-15 then a rectangular box is cut out of the video.

U-15 pin 36 (RVV) is used to invert the character and border levels, pin 32 (HLGT) is used to select border or box mode and pin 33 (GPA0) inhibits the display of characters in the video. Frames suppression is done by reprogramming the number of characters per line in U-15.

Character border width is set by RV-4 which stretches the switching signal to CMOS analog switch U-32, which switches between the external video and the character video. Character positioning within the cutout is adjusted by selecting a tap on digital delay line U-32. There are 6 jumper plug positions at a header labeled VIDEO DELAY. Position '0' is direct with no delay and positions '1' through '4' produce 1 to 4 dot clock periods of delay. The position marked 1/2 trims this delay by 1/2 a dot clock cycle. If position '0' is selected then no other jumper should be installed. Only one jumper should be installed at positions '1' to '4' with or without a jumper at position 1/2.

The output of U-34 is connected to video amplifier U-41. This provides a gain of 2 and sufficient power to drive two 75 ohm lines.

4.5 Display and control

The 8 digit L.E.D. display is multiplexed by U-14, a programmable keyboard/display interface circuit. This device also scans the 7 control keys on the front panel. The multiplex count (SL0 – SL2 of U-14) is decoded by U-7 whose outputs are connected to the digit drivers Q-1 through Q-8 whose outputs in turn are connected to the digit L.E.D. anodes as well as to the 10 L.E.D. status indicators. Transistors Q-10 through Q-16 drive the 7 cathode segments and Q-9 drives the status L.E.D. cathodes. Monostable multivibrator U-46 is triggered at the start of each digit interval and enables decoder U-7. Brightness of the display is controlled by adjusting RV-5 which controls the period of U-46.

4.6 Power supply

The T6010 is powered by a universal transformer. Selection of the correct primary winding configuration for a given line voltage is made by inserting the small printed circuit board in the fuse holder/EMI filter assembly so that the required voltage is visible. This board is marked with 4 voltage ranges and may be inserted 4 ways. Only one voltage marking is visible at one time. No component changes are necessary.

Three regulated voltages are provided, positive 5 volts, positive 12 volts and negative 5 volts. The positive 5 and negative 5 volts supplies are derived from a center tapped full-wave bridge circuit, D-8 through D-11, C-58 and C-59. The positive 5 supply is regulated by U-45 which is mounted on the rear panel for heat sinking. This provides the L.E.D. display, power for logic devices and the microprocessor and it's memory and peripheral devices. The negative 5 volt supply is regulated by U-43 which also requires no heat sinking. This supply is used by the reader input circuit, the video sync separator and the video amplifier circuit. The positive 12 volt supply is derived from a voltage doubler consisting of D-4 to D-7 and C-55 to C-58 and is regulated by U-44 which requires no heat sinking. This supply is used by the reader clock and data separator and the video amplifier circuit.

C H A P T E R

5

Maintenance

5.1 Preventive Maintenance

Under normal use, preventive maintenance is not required. There are however, 6 adjustments inside the T6010 which may be adjusted by the user.

5.2 Adjustments

Display Brightness RV-5 sets the brightness of all L.E.D. display devices on the front panel of the T6010.

Horizontal Limit Turn the front panel Horizontal Position control (RV-202) fully clockwise. Adjust Horizontal Trim (RV-2) to the point just before character height doubles.

Vertical Limit Turn the front panel Vertical Position control (RV-201) fully counterclockwise. Adjust Vertical Trim (RV-1) to the point just before character video appears on one field only (display flickers).

Character Level Observe the video output on a waveform monitor and a video monitor. Adjust RV-3 (Character Level) as required.

Video Delay Install a jumper plug at position ‘0’ on the Video Delay Header. Check that the character is centered within the border. If it is not, remove the jumper at ‘0’ and install it at position ‘1’ to ‘4’ until the best centering is obtained. Install a second jumper at position ‘1/2’ if required. This may make it necessary to move the original jumper 1 position.

Border Trim — Adjust RV-4 labeled Border Trim for a symmetrical border. If this adjustment is made, it may be necessary to repeat the Video Delay jumper selection.

5.3 Performance Verification

Connect a video signal to connector labeled ***video in***. Connect a time code signal to connector labeled ***code in***. Connect a video monitor and/or a waveform monitor to the connector labeled ***video out*** and verify that time code characters are properly displayed in the video signal.

Connect a time code source to a time code reader input and press the Hold button. This should alternately stop and start the code displayed by the reader and the Hold led 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 P P E N D I X

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.

APPENDIX

B

Parts List

B.1 Resistors

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
R-1	4.7K	CR25TOL05	PHILIPS
R-2	330 Ohms	CR25TOL05	PHILIPS
R-3	1 K Ohms	CR25TOL05	PHILIPS
R-4	1 K Ohms	CR25TOL05	PHILIPS
R-5	100 K Ohms	CR25TOL05	PHILIPS
R-6		not used	
R-7		not used	
R-8	27 Ohms	CR25TOL05	PHILIPS
R-9	27 Ohms	CR25TOL05	PHILIPS
R-10	27 Ohms	CR25TOL05	PHILIPS
R-11	27 Ohms	CR25TOL05	PHILIPS
R-12	27 Ohms	CR25TOL05	PHILIPS
R-13	27 Ohms	CR25TOL05	PHILIPS
R-14	27 Ohms	CR25TOL05	PHILIPS
R-15	220 Ohms	CR25TOL05	PHILIPS
R-16	220 Ohms	CR25TOL05	PHILIPS
R-17	220 Ohms	CR25TOL05	PHILIPS
R-18	220 Ohms	CR25TOL05	PHILIPS
R-19	220 Ohms	CR25TOL05	PHILIPS
R-20	220 Ohms	CR25TOL05	PHILIPS
R-21	220 Ohms	CR25TOL05	PHILIPS
R-22	220 Ohms	CR25TOL05	PHILIPS
R-23	4.7 K Ohms	CR25TOL05	PHILIPS
R-24	4.7 K Ohms	CR25TOL05	PHILIPS
R-25	4.7 K Ohms	CR25TOL05	PHILIPS
R-26	4.7 K Ohms	CR25TOL05	PHILIPS
R-27	4.7 K Ohms	CR25TOL05	PHILIPS
R-28	4.7 K Ohms	CR25TOL05	PHILIPS
R-29	4.7 K Ohms	CR25TOL05	PHILIPS

R-30	4.7 K Ohms	CR25TOL05	PHILIPS
R-31	1 K Ohms	CR25TOL05	PHILIPS
R-32	1 K Ohms	CR25TOL05	PHILIPS
R-33	1 K Ohms	CR25TOL05	PHILIPS
R-34	1 K Ohms	CR25TOL05	PHILIPS
R-35	1 K Ohms	CR25TOL05	PHILIPS
R-36	1 K Ohms	CR25TOL05	PHILIPS
R-37	1 K Ohms	CR25TOL05	PHILIPS
R-38	1 K Ohms	CR25TOL05	PHILIPS
R-39	10 K Ohms	CR25TOL05	PHILIPS
R-40		not used	
R-41		not used	
R-42		not used	
R-43		not used	
R-44		not used	
R-45		not used	
R-46		not used	
R-47	100 K Ohms	CR25TOL05	PHILIPS
R-48	100 K Ohms	CR25TOL05	PHILIPS
R-49	10 K Ohms	CR25TOL05	PHILIPS
R-50	1 K Ohms	CR25TOL05	PHILIPS
R-51	100 K Ohms	CR25TOL05	PHILIPS
R-52	100 K Ohms	CR25TOL05	PHILIPS
R-53	10 K Ohms	CR25TOL05	PHILIPS
R-54	18 K Ohms	CR25TOL05	PHILIPS
R-55	18 K Ohms	CR25TOL05	PHILIPS
R-56	Selected on test	CR25TOL05	PHILIPS
R-57	4.7 K Ohms	CR25TOL05	PHILIPS
R-58	Selected on test	CR25TOL05	PHILIPS
R-59	18 Ohms	CR25TOL05	PHILIPS
R-60	4.7 K Ohms	CR25TOL05	PHILIPS
R-61	1 K Ohms	CR25TOL05	PHILIPS
R-62	4.7 K Ohms	CR25TOL05	PHILIPS
R-63	5.1 K Ohms	CR25TOL05	PHILIPS
R-64	220 Ohms	CR25TOL05	PHILIPS
R-65	47 K Ohms	CR25TOL05	PHILIPS
R-66	100 Ohms	CR25TOL05	PHILIPS
R-67	330 Ohms	CR25TOL05	PHILIPS
R-68	4.7 K Ohms	CR25TOL05	PHILIPS
R-69	Selected on test	CR25TOL05	PHILIPS
R-70	2.2 K Ohms	CR25TOL05	PHILIPS
R-71	68 Ohms	CR25TOL05	PHILIPS
R-72	68 Ohms	CR25TOL05	PHILIPS
R-73	68 Ohms	CR25TOL05	PHILIPS
R-74	1 K Ohms	CR25TOL05	PHILIPS
R-75	2.2 K Ohms	CR25TOL05	PHILIPS

R-76	2.2 K Ohms	CR25TOL05	PHILIPS
R-77	10 K Ohms	CR25TOL05	PHILIPS
R-78	270 Ohms	CR25TOL05	PHILIPS
R-79	10 K Ohms	CR25TOL05	PHILIPS
R-80	4.7 K Ohms	CR25TOL05	PHILIPS
R-81	22 Ohms	CR25TOL05	PHILIPS
R-82	1 Meg.	CR25TOL05	PHILIPS
R-83	1 K Ohms	CR25TOL05	PHILIPS
R-84	1 K Ohms	CR25TOL05	PHILIPS
R-85	1 K Ohms	CR25TOL05	PHILIPS
R-86	1 K Ohms	CR25TOL05	PHILIPS
R-87	820 Ohms	CR25TOL05	PHILIPS
R-88	20 K Ohms	CR25TOL05	PHILIPS
R-89	130 K Ohms	CR25TOL05	PHILIPS
R-90	10 K Ohms	CR25TOL05	PHILIPS
R-91	1.8 K Ohms	CR25TOL05	PHILIPS
R-92	150 K Ohms	CR25TOL05	PHILIPS
R-93	100 K Ohms	CR25TOL05	PHILIPS
R-94	200 K Ohms	CR25TOL05	PHILIPS
R-101	10 K Ohms	CR25TOL05	PHILIPS
R-102	560 Ohms	CR25TOL05	PHILIPS
R-103	10 K Ohms	CR25TOL05	PHILIPS
R-104	560 Ohms	CR25TOL05	PHILIPS
R-105	10 K Ohms	CR25TOL05	PHILIPS
R-106	10 K Ohms	CR25TOL05	PHILIPS
R-107	560 Ohms	CR25TOL05	PHILIPS
R-108	560 Ohms	CR25TOL05	PHILIPS
R-109	68 Ohms	CR25TOL05	PHILIPS
R-110	68 Ohms	CR25TOL05	PHILIPS
R-111	10 K Ohms	CR25TOL05	PHILIPS
R-201	68 Ohms	CR25TOL05	Philips
R-202	10 K Ohms	CR25TOL05	Philips
R-203	68 Ohms	CR25TOL05	Philips
R-204	10 K Ohms	CR25TOL05	Philips
R-205	68 Ohms	CR25TOL05	Philips
R-301		not used	
R-302		not used	
R-303		not used	
R-304		not used	
R-305		not used	
R-306		not used	
R-307		not used	
R-308		not used	
R-309		not used	
R-310		not used	
R-311		not used	

R-312		not used	
R-313		not used	
R-314		not used	
R-315		not used	
R-316		not used	
R-317		not used	
R-318		not used	
R-319	4.7 K Ohms	CR25TOL05	PHILIPS
R-320	15 K Ohms	CR25TOL05	PHILIPS
R-321	15 K Ohms	CR25TOL05	PHILIPS
R-322	180 Ohms	CR25TOL05	PHILIPS
R-323	10 K Ohms	CR25TOL05	PHILIPS
R-324	180 Ohms	CR25TOL05	PHILIPS
R-325	10 K Ohms	CR25TOL05	PHILIPS
R-326	180 Ohms	CR25TOL05	PHILIPS
R-327	10 K Ohms	CR25TOL05	PHILIPS
R-328	180 Ohms	CR25TOL05	PHILIPS
R-329	10 K Ohms	CR25TOL05	PHILIPS
R-330	470 K Ohms	CR25TOL05	PHILIPS
R-331	10 K Ohms	CR25TOL05	PHILIPS
R-332	47 K Ohms	CR25TOL05	PHILIPS
R-333	4.7 K Ohms	CR25TOL05	PHILIPS
R-334	4.7 K Ohms	CR25TOL05	PHILIPS
R-335	1 Meg	CR25TOL05	PHILIPS
R-336	4.7 K Ohms	CR25TOL05	PHILIPS
R-337	4.7 K Ohms	CR25TOL05	PHILIPS
R-338	330 Ohms	CR25TOL05	PHILIPS
R-339	330 Ohms	CR25TOL05	PHILIPS

B.2 Variable Resistors

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
RV-1	1 Meg.	3386	Bourns
RV-2	1 Meg.	3386	Bourns
RV-3	2 K Ohms	3386	Bourns
RV-4	2 K Ohms	3386	Bourns
RV-5	1 Meg.	3386	Bourns
RV-101	100 K Ohms	388 N 100K	Clarostat
RV-102	100 K Ohms	388 N 100K	Clarostat

B.3 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	1000 PF CERAMIC	CK05BX102K	AVX
C-4	10 MFD 16V TANTALUM	TAP 10M 16	I.T.T
C-5	.1 MFD 12 V CERAMIC	405484	STETTNER
C-6	.1 MFD 12 V CERAMIC	405484	STETTNER
C-7	3.3 MFD 20V TANTALUM	TAP 3.3M 20	I.T.T
C-8	.1 MFD 12 V CERAMIC	405484	STETTNER
C-9	.1 MFD 12 V CERAMIC	405484	STETTNER
C-10	.1 MFD 12 V CERAMIC	405484	STETTNER
C-11	.1 MFD 12 V CERAMIC	405484	STETTNER
C-12	.15 MFD METALLIZED FILM	344 21154	PHILIPS
C-13	10 MFD 16V TANTALUM	TAP 10M 16	I.T.T
C-14	330 PF CERAMIC	CK05BX331K	AVX
C-15	.1 MFD 12 V CERAMIC	405484	STETTNER
C-16	.1 MFD 12 V CERAMIC	405484	STETTNER
C-17	330 PF CERAMIC	CK05BX331K	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 PF CERAMIC	CK05BX100K	AVX
C-22	10 PF CERAMIC	CK05BX100K	AVX
C-23	Select on test	CK05BX470K	AVX
C-24	100 PF CERAMIC	CK05BX101K	AVX
C-25	33 MFD 6V TANTALUM	TAP 10M 16	I.T.T
C-26	.1 MFD 12 V CERAMIC	405484	STETTNER
C-27	.1 MFD 12 V CERAMIC	405484	STETTNER
C-28	.1 MFD 12 V CERAMIC	405484	STETTNER
C-29	.1 MFD 12 V CERAMIC	405484	STETTNER
C-30	.1 MFD 12 V CERAMIC	405484	STETTNER
C-31	100 PF CERAMIC	CK05BX101K	AVX
C-32		not used	
C-33	.1 MFD 12 V CERAMIC	405484	STETTNER
C-34	4.7 MFD 16V TANTALUM	TAP 4.7M 16	I.T.T
C-35	4.7 MFD 16V TANTALUM	TAP 4.7M 16	I.T.T
C-36	2.2 MFD 20 V TANTALUM	TAP 2.2M 20	I.T.T
C-37	.1 MFD 12 V CERAMIC	405484	STETTNER
C-38	.1 MFD 12 V CERAMIC	405484	STETTNER
C-39	.1 MFD 12 V CERAMIC	405484	STETTNER
C-40	1 MFD 20V TANTALUM	TAP 1M 20	I.T.T
C-41	10 PF CERAMIC	CK05BX100K	AVX
C-42	1.5 MFD 35 V TANTALUM	TAP 1.5M 35	I.T.T
C-43	1.5 MFD 35 V TANTALUM	TAP 1.5M 35	I.T.T
C-44	220 PF CERAMIC	CK05BX221K	AVX
C-45	1000 PF CERAMIC	CK05BX102K	AVX
C-46	.1 MFD 12 V CERAMIC	405484	STETTNER
C-47	.1 MFD 12 V CERAMIC	405484	STETTNER

C-48		not used	
C-49	4700 PF CERAMIC	CK05BX472K	AVX
C-50	1.5 MFD 35 V TANTALUM	TAP 1.5M 35	I.T.T
C-51		not used	
C-52		not used	
C-53	.1 MFD 12 V CERAMIC	405484	STETTNER
C-54		not used	
C-55	470 MFD. 25 V	437ET F470	PHILIPS
C-56	470 MFD. 25 V	437ET F470	PHILIPS
C-57	470 MFD. 25 V	437ET F470	PHILIPS
C-58	470 MFD. 25 V	437ET F470	PHILIPS
C-59	10000 MFD 16 V	SM16T103	United Chemicon
C-60	330 PF CERAMIC	CK05BX331K	AVX
C-61	27 PF CERAMIC	CK05BX270K	AVX
C-62	27 PF CERAMIC	CK05BX270K	AVX
C-63	220 PF CERAMIC	CK05BX221K	AVX
C-301	.33 MFD 20V TANTALUM	TAP .33M 20	I.T.T
C-302	.1 MFD 12 V CERAMIC	405484	STETTNER
C-303	1000 PF CERAMIC	CK05BX102K	AVX
C-304	.22 MFD 20V TANTALUM	TAP .22M 20	I.T.T
C-305	1000 PF CERAMIC	CK05BX102K	AVX
C-306	1000 PF CERAMIC	CK05BX102K	AVX
C-307	1000 PF CERAMIC	CK05BX102K	AVX
C-308	.22 MFD 20V TANTALUM	TAP .22M 20	I.T.T
C-309	.33 MFD 20V TANTALUM	TAP .33M 20	I.T.T
C-310	1000 PF CERAMIC	CK05BX102K	AVX
C-311	.47 MFD 35 V TANTALUM	TAP .47M 35	I.T.T
C-312	.1 MFD 12 V CERAMIC	405484	STETTNER
C-313	1 MFD 35 V TANTALUM	TAP 1M 35	I.T.T
C-314	1000 PF CERAMIC	CK05BX102K	AVX
C-315	1000 PF CERAMIC	CK05BX102K	AVX
C-316	33 MFD 6V TANTALUM	TAP 33M 6	I.T.T
C-317	33 MFD 6V TANTALUM	TAP 33M 6	I.T.T
C-318	33 MFD 6V TANTALUM	TAP 33M 6	I.T.T
C-319	33 MFD 6V TANTALUM	TAP 33M 6	I.T.T
C-320	3.3 MFD 20V TANTALUM	TAP 3.3M 20	I.T.T
C-321	4700 PF CERAMIC	CK05BX472K	AVX
C-322	.1 MFD 12 V CERAMIC	405484	STETTNER
C-323	.1 MFD 12 V CERAMIC	405484	STETTNER
C-324	1800 PF CERAMIC	CK05BX182K	AVX

B.4 Integrated Circuits

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
U-1	SCHOTTKY I.C.	SN74LS04N	TEXAS INST.

U-2	not used		
U-3	NMOS I.C.	Z80A-CPU	ZILOG
U-4	SCHOTTKY I.C.	SN74LS04N	TEXAS INST.
U-5	SCHOTTKY I.C.	SN74LS138N	TEXAS INST.
U-6	SCHOTTKY I.C.	SN74LS138N	TEXAS INST.
U-7	SCHOTTKY I.C.	SN74LS138N	TEXAS INST.
U-8	NMOS I.C.	2732A	INTEL
U-9	not used		
U-10	NMOS I.C.	2114A-4	INTEL
U-11	NMOS I.C.	2114A-4	INTEL
U-12	NMOS I.C.	P8251A	INTEL
U-14	NMOS I.C.	8279	INTEL
U-15	NMOS I.C.	8276	INTEL
U-16	NMOS I.C.	P8255A	INTEL
U-17	NMOS I.C.	P8255A	INTEL
U-18	CMOS I.C.	MC14538B	MOTOROLA
U-19	CMOS I.C.	MC14538B	MOTOROLA
U-20	SCHOTTKY I.C.	SN74LS107N	TEXAS INST.
U-21	SCHOTTKY I.C.	SN74LS20N	TEXAS INST.
U-22	SCHOTTKY I.C.	SN74LS02N	TEXAS INST.
U-23	CMOS I.C.	MC14049UB	MOTOROLA
U-24	SCHOTTKY I.C.	SN74LS166N	TEXAS INST.
U-25	SCHOTTKY I.C.	SN74LS166N	TEXAS INST.
U-26	SCHOTTKY I.C.	SN74LS174N	TEXAS INST.
U-27	SCHOTTKY I.C.	SN74LS86N	TEXAS INST.
U-28	SCHOTTKY I.C.	SN74LS10N	TEXAS INST.
U-29	SCHOTTKY I.C.	SN74LS163N	TEXAS INST.
U-30	NMOS I.C.	2732A	INTEL
U-31	NMOS I.C.	2732A	INTEL
U-32	SCHOTTKY I.C.	SN74LS95AN	TEXAS INST.
U-33	SCHOTTKY I.C.	SN74LS02N	TEXAS INST.
U-34	CMOS I.C.	74HC4066	MOTOROLA
U-36	not used		
U-37	CMOS I.C.	MC14046B	MOTOROLA
U-38	CMOS I.C.	MC14013B	MOTOROLA
U-39	CMOS I.C.	MC14070B	MOTOROLA
U-40	LINEAR I.C.	LM311N	NATIONAL
U-41	LINEAR I.C.	CA3046	R.C.A.
U-42	LINEAR I.C.	LM311N	NATIONAL
U-43	5 VOLT REGULATOR	MC7905P	MOTOROLA
U-44	5 VOLT REGULATOR	MC7812P	MOTOROLA
U-45	5 VOLT REGULATOR	MC7805P	MOTOROLA
U-46	CMOS I.C.	MC14538B	MOTOROLA
U-47	CMOS I.C.	74HC4066	MOTOROLA
U-101	SCHOTTKY I.C.	SN74LS138N	TEXAS INST.
U-301	LINEAR I.C.	LM311N	NATIONAL

U-302	CMOS I.C.	MC14538B	MOTOROLA
U-303	CMOS I.C.	MC14538B	MOTOROLA
U-304	CMOS I.C.	MC14538B	MOTOROLA
U-305	CMOS I.C.	MC14001	MOTOROLA
U-306	CMOS I.C.	MC14538B	MOTOROLA
U-307	CMOS I.C.	MC14046B	MOTOROLA
U-308	SCHOTTKY I.C.	SN47LS74AN	MOTOROLA
U-309	CMOS I.C.	MC14584B	MOTOROLA

B.5 Diodes

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
D-1	GERMANIUM DIODE	1N270	
D-2	GERMANIUM DIODE	1N270	
D-3	SILICON DIODE	1N4148	PHILIPS
D-4	SILICON RECTIFIER	1N4001	PHILIPS
D-5	SILICON RECTIFIER	1N4001	PHILIPS
D-6	SILICON RECTIFIER	1N4001	GEN. INST.
D-7	SILICON RECTIFIER	1N4001	GEN. INST.
D-8	SILICON RECTIFIER	MR501	MOTOROLA
D-9	SILICON RECTIFIER	MR501	MOTOROLA
D-10	SILICON RECTIFIER	1N4001	GEN. INST.
D-11	SILICON RECTIFIER	1N4001	GEN. INST.
D-301	GERMANIUM DIODE	1N270	MOTOROLA
D-302	SILICON DIODE	1N4148	PHILIPS
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-108	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-201	L.E.D.	MV5753	GEN. INST.
L-202	L.E.D.	MV5753	GEN. INST.
L-203	L.E.D.	MV5753	GEN. INST.
L-204	L.E.D.	MV5753	GEN. INST.
L-205	L.E.D.	MV5753	GEN. INST.
L-206	L.E.D.	MV5753	GEN. INST.
DP-1	7 SEGMENT DISPLAY	MAN8610	GEN. INST.
DP-2	7 SEGMENT DISPLAY	MAN8610	GEN. INST.

DP-3	7 SEGMENT DISPLAY	MAN8610	GEN. INST.
DP-4	7 SEGMENT DISPLAY	MAN8610	GEN. INST.
DP-5	7 SEGMENT DISPLAY	MAN8610	GEN. INST.
DP-6	7 SEGMENT DISPLAY	MAN8610	GEN. INST.
DP-7	7 SEGMENT DISPLAY	MAN8610	GEN. INST.
DP-8	7 SEGMENT DISPLAY	MAN8610	GEN. INST.

B.6 Transistors

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
Q-1	PNP SILICON	MPS6562	MOTOROLA
Q-2	PNP SILICON	MPS6562	MOTOROLA
Q-3	PNP SILICON	MPS6562	MOTOROLA
Q-4	PNP SILICON	MPS6562	MOTOROLA
Q-5	PNP SILICON	MPS6562	MOTOROLA
Q-6	PNP SILICON	MPS6562	MOTOROLA
Q-7	PNP SILICON	MPS6562	MOTOROLA
Q-8	PNP SILICON	MPS6562	MOTOROLA
Q-9	NPN SILICON	2N4401	MOTOROLA
Q-10	NPN SILICON	2N4401	MOTOROLA
Q-11	NPN SILICON	2N4401	MOTOROLA
Q-12	NPN SILICON	2N4401	MOTOROLA
Q-13	NPN SILICON	2N4401	MOTOROLA
Q-14	NPN SILICON	2N4401	MOTOROLA
Q-15	NPN SILICON	2N4401	MOTOROLA
Q-16	NPN SILICON	2N4401	MOTOROLA
Q-17	NPN SILICON	2N4401	MOTOROLA
Q-18	NPN SILICON	2N4401	MOTOROLA
Q-101	NPN SILICON	2N4401	MOTOROLA
Q-102	NPN SILICON	2N4401	MOTOROLA
Q-103	NPN SILICON	2N4401	MOTOROLA
Q-104	NPN SILICON	2N4401	MOTOROLA
Q-105	NPN SILICON	2N4401	MOTOROLA
Q-301	NPN SILICON	2N4401	MOTOROLA
Q-302	NPN SILICON	2N4401	MOTOROLA
Q-303	PNP SILICON	2N4403	MOTOROLA
Q-304	NPN SILICON	2N4401	MOTOROLA
Q-305	PNP SILICON	2N4403	MOTOROLA
Q-306	NPN SILICON	2N4401	MOTOROLA

B.7 Connectors

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
P-1	20 PIN HEADER	IDH 20 NP	ROBINSON / NUGENT

P-2	20 PIN HEADER	IDH 20 NP	ROBINSON / NUGENT
P-3	34 PIN HEADER	IDH 34 NP	ROBINSON / NUGENT
P-4	14 PIN HEADER	87546-6	AMP
P-5	20 PIN HEADER	IDH 20 NP	ROBINSON / NUGENT
P-6	20 PIN HEADER	IDH 20 NP	ROBINSON / NUGENT
P-7	8 PIN HEADER	IDH 8 NP	ROBINSON / NUGENT
P-101	20 PIN HEADER	IDH 20 NP	ROBINSON / NUGENT
P-102	20 PIN HEADER	IDH 20 NP	ROBINSON / NUGENT
P-201	20 PIN HEADER	IDH 20 NP	ROBINSON / NUGENT
J-1	BNC JACK	31-221	AMPHENOL
J-2	BNC JACK	31-221	AMPHENOL
J-3	BNC JACK	31-221	AMPHENOL
J-4	BNC JACK	31-221	AMPHENOL
J-5	BNC JACK	31-221	AMPHENOL
J-8	LOCKING CONNECTOR	C3F	SWITCHCRAFT

B.8 Switches

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
SW-1	N.O. PUSH BUTTON	87CC3 201	GRAYHILL
SW-2	N.O. PUSH BUTTON	87CC3 201	GRAYHILL
SW-3	N.O. PUSH BUTTON	87CC3 201	GRAYHILL
SW-4	N.O. PUSH BUTTON	87CC3 201	GRAYHILL
SW-5	N.O. PUSH BUTTON	87CC3 201	GRAYHILL
SW-6	N.O. PUSH BUTTON	87CC3 201	GRAYHILL
SW-7	N.O. PUSH BUTTON	87CC3 201	GRAYHILL
SW-8	SPST TOGGLE	TT13A-2T	ALCO

B.9 Miscellaneous

ITEM	DESCRIPTION	PART NUMBER	MANUFACTURER
JP-1	JUMPER PLUG	530153-2	AMP
T-1	16V. 1 Amp. TRANSFORMER	DPC 16-1500	SIGNAL
BR-1	TRANSFORMER BRACKET	24-BR	SIGNAL
XTAL	4.0 MHZ	CTS4000	CTS
SO-1	24 PIN I.C. SOCKET	640361-1	AMP
SO-2		not used	
SO-3	24 PIN I.C. SOCKET	640361-1	AMP
SO-4	24 PIN I.C. SOCKET	640361-1	AMP
PWR-1	POWER SELECTOR / FUSE HOLDER	06A5	DELTA
F-1	FUSE	218.250	LITTLEFUSE
CA-1	FLAT CABLE ASSEMBLY	TC6010-01	TELCOM
CA-2	FLAT CABLE ASSEMBLY	TC6010-01	TELCOM

CA-3	FLAT CABLE ASSEMBLY	TC6010-02	TELCOM
CA-4	FLAT CABLE ASSEMBLY	TC6010-03	TELCOM
PCB-1	MAIN CIRCUIT BOARD	6010M REV 2.4	TELCOM
PCB-2	DISPLAY CIRCUIT BOARD	6010D REV 0.1	TELCOM
PCB-3	CONTROL CIRCUIT BOARD	6010C REV 0.1	TELCOM
CS-1	ALUMINUM CHASSIS	FCT-12 BLUE	TELCOM
RP-1	REAR PANEL	T820505	TELCOM
FP-1	FRONT PANEL	T810430	TELCOM
SP-1	SUPPORT ROD	MP-40754-2	TELCOM
KN-1	KNOB	KNS501BA 1/8	ALCO
KN-2	KNOB	KNS501BA 1/8	ALCO
FPO-1	FRONT PANEL OVERLAY	73540FP	TELCOM

A P P E N D I X

C

Schematics

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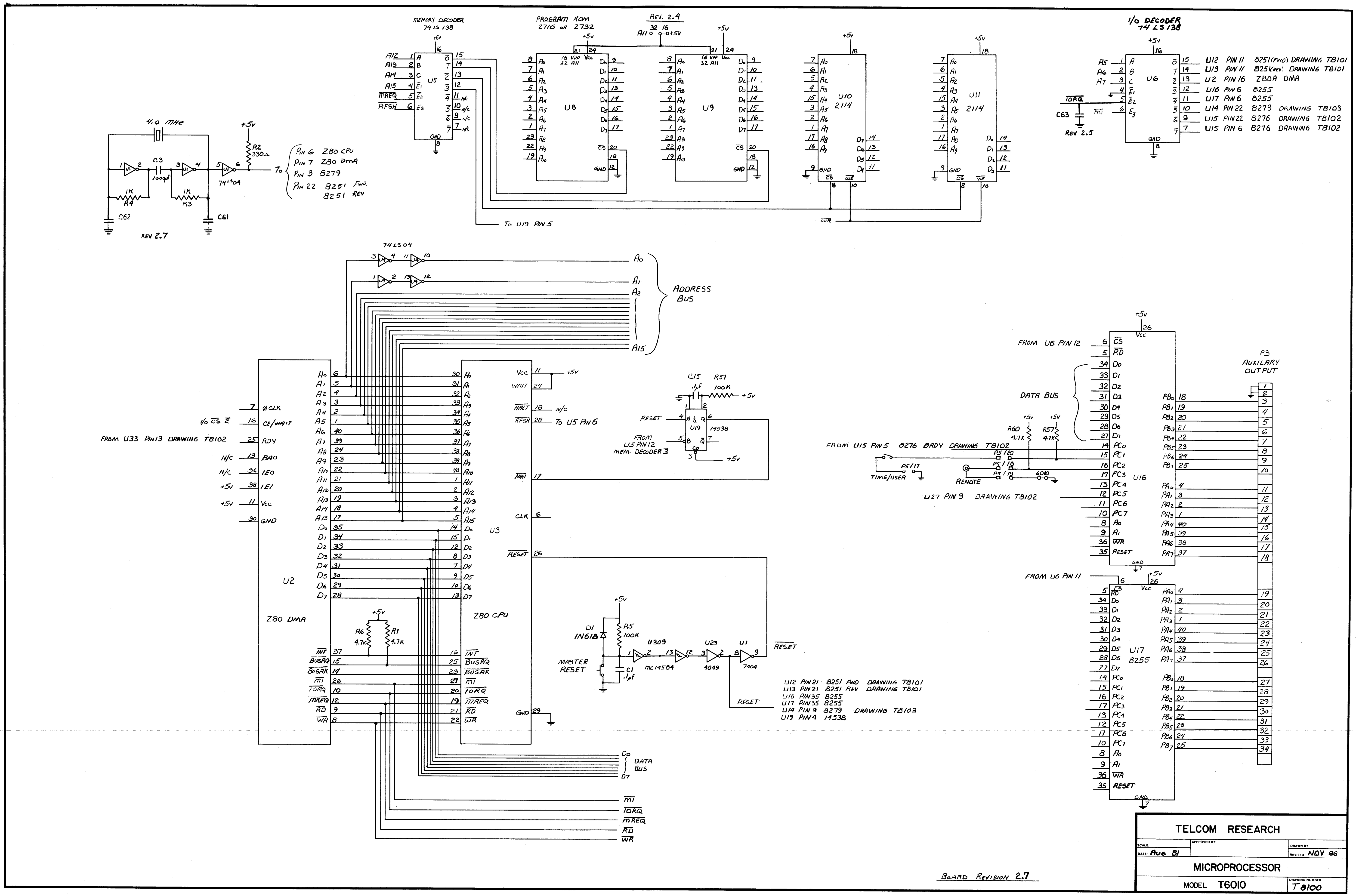


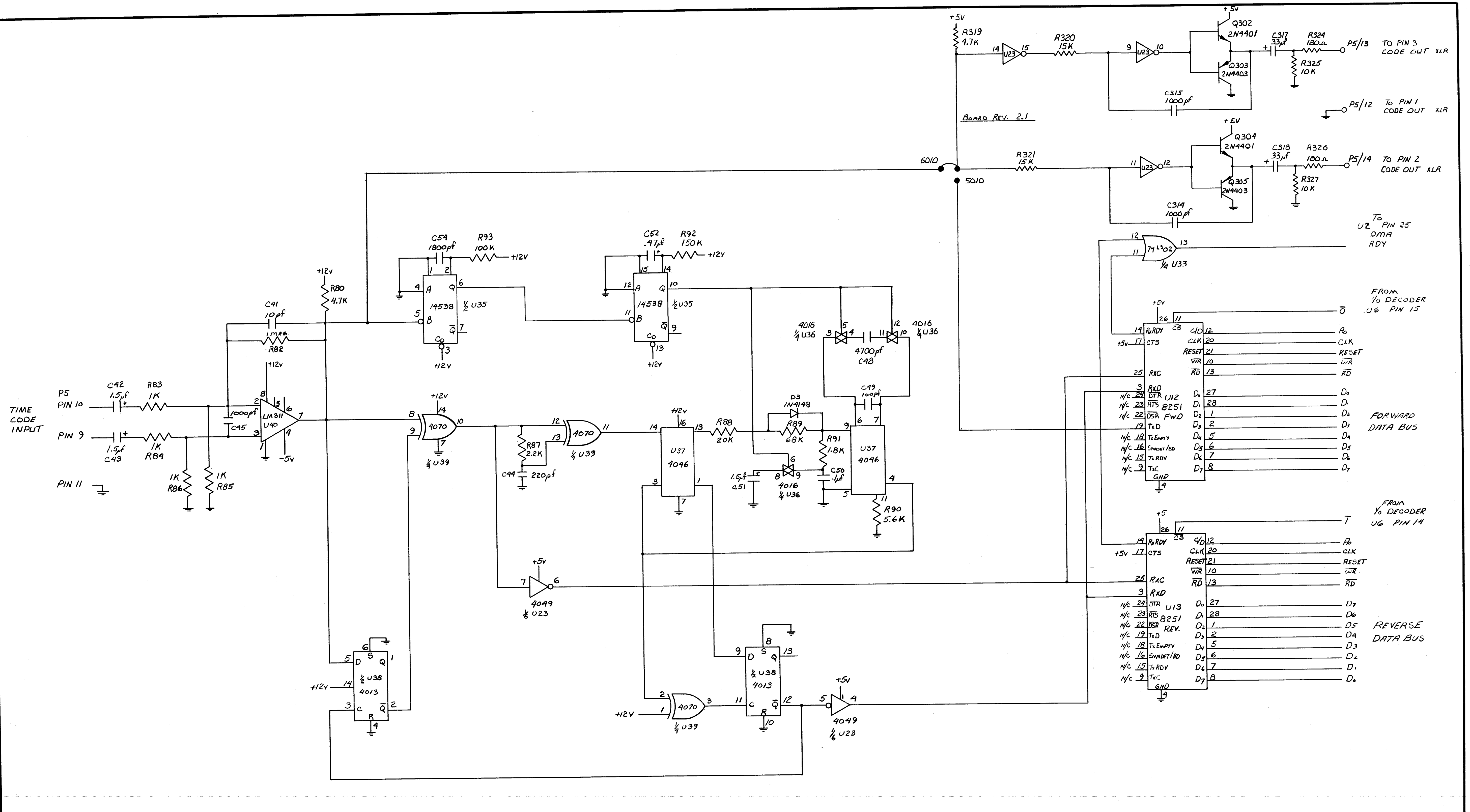
TELCOM RESEARCH

DATE: Aug 81 | REVISED: NOV 86

MICROPROCESSOR

MODEL T6010 | DRAWING NUMBER: T8100

BOARD REVISION 2.7



BOARD REVISION 2.4

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READER		
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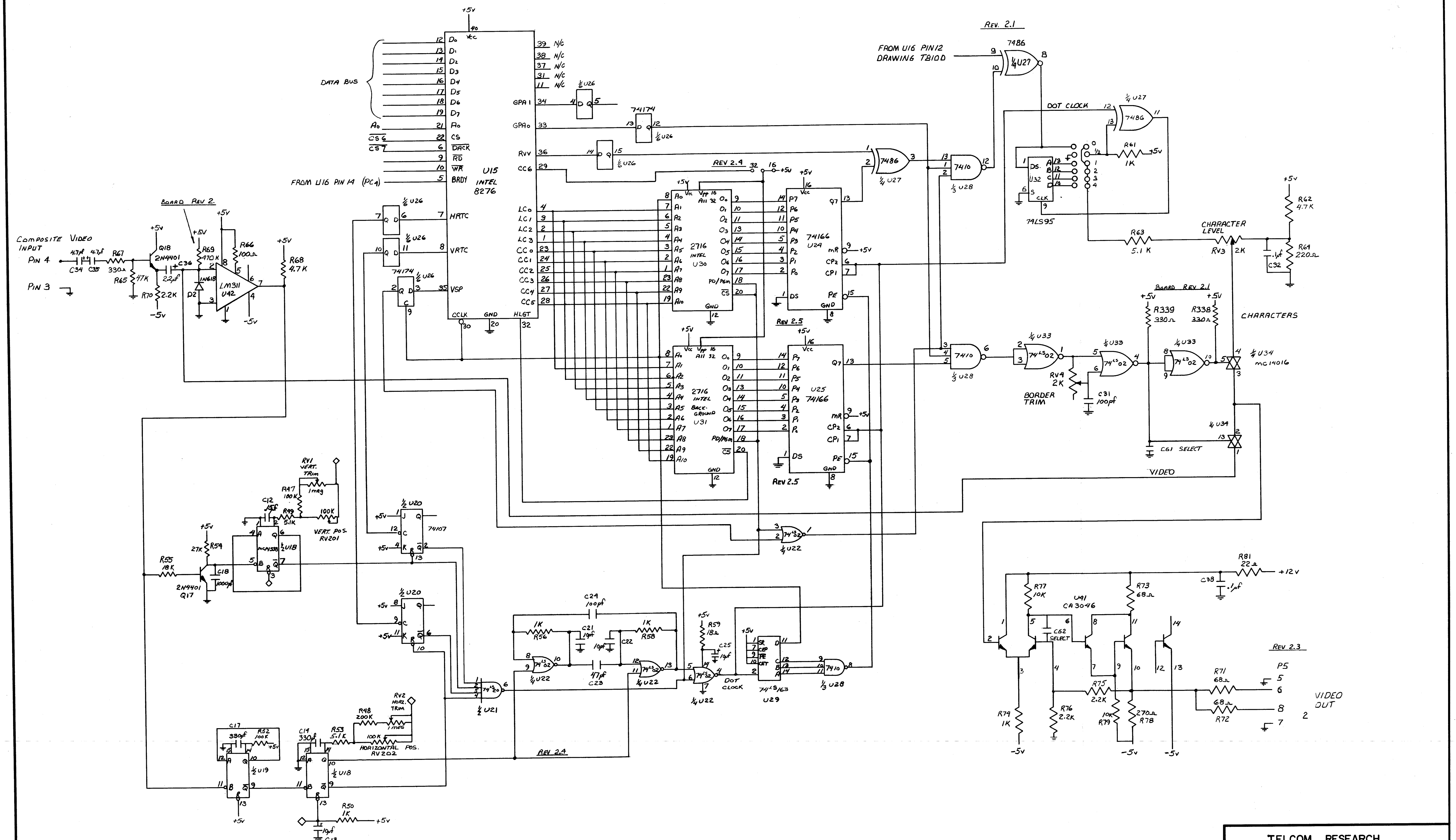

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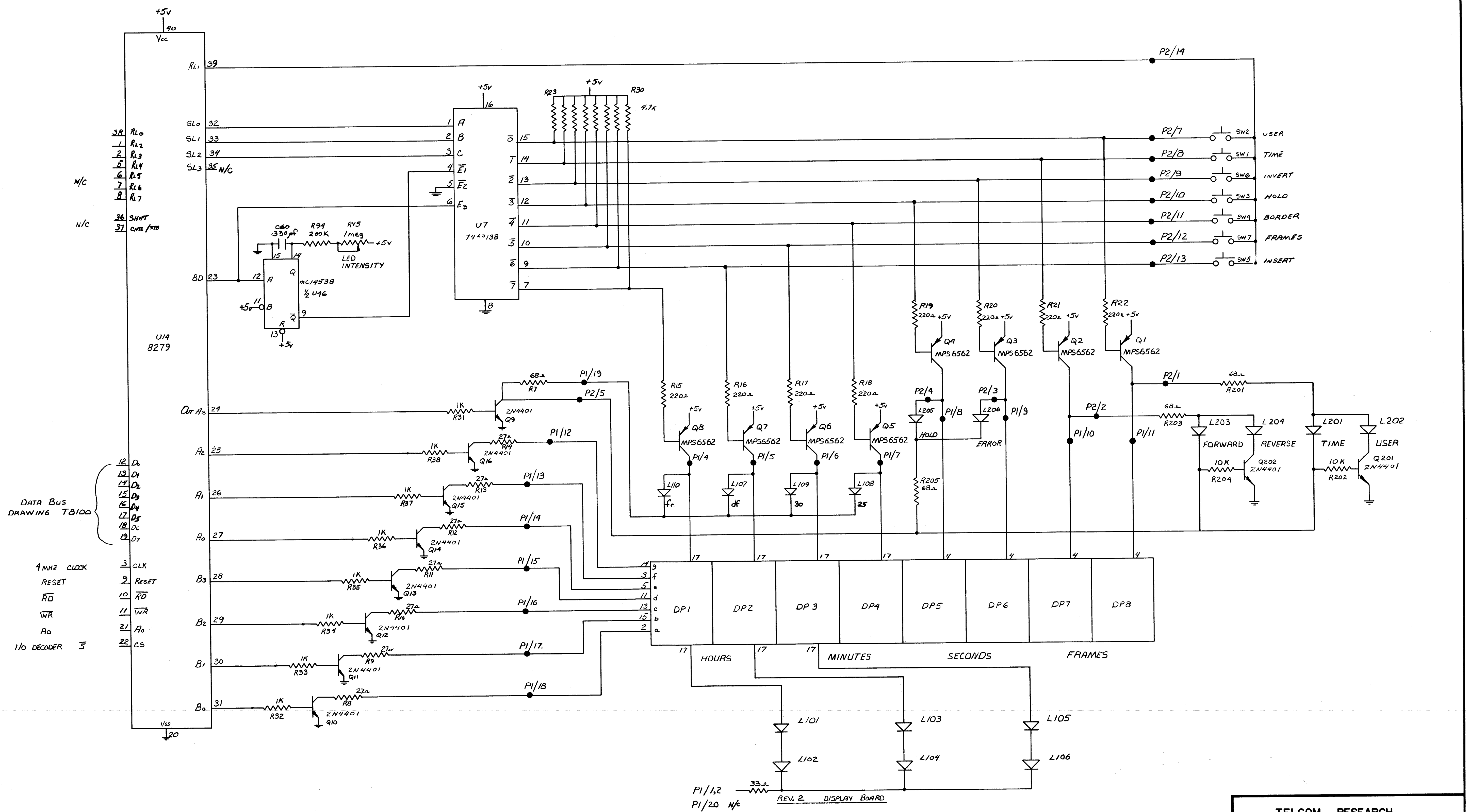


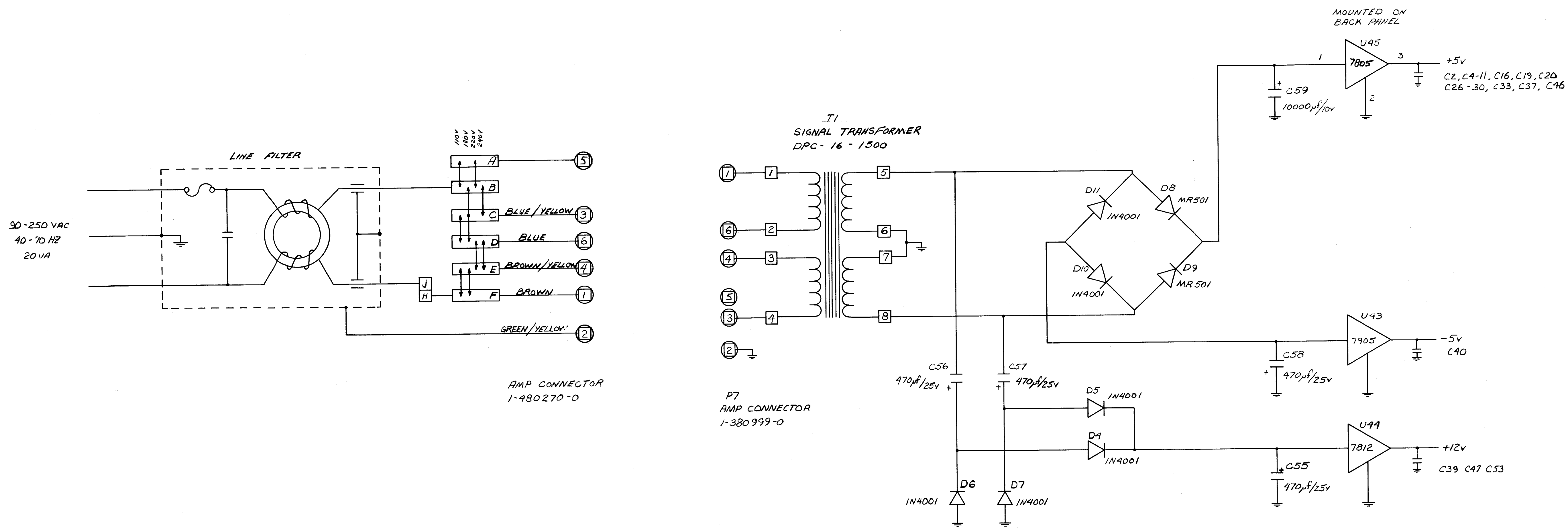
MAIN BOARD REVISION 2.4

TELCOM RESEARCH

SCALE:	APPROVED BY:	DRAWN BY
DATE: AUG 81		REVISED SEPT 83

FRONT PANEL DISPLAY & CONTROL

MODEL T6010 — DRAWING NUMBER T8103



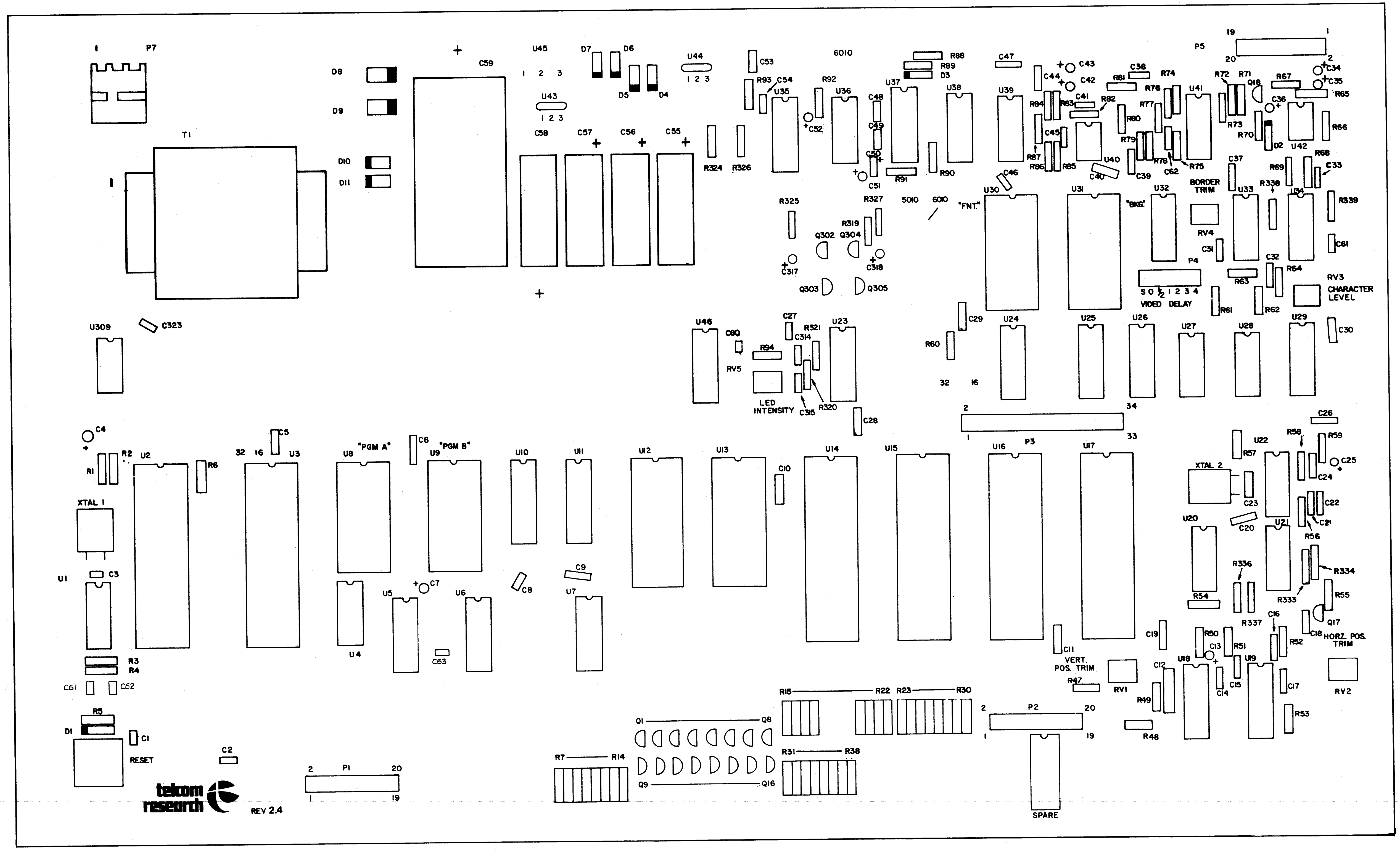
BOARD REVISION 2.4

TELCOM RESEARCH

SCALE:	APPROVED BY:	DRAWN BY
DATE: AUG 81		REVISED SEPT 83

POWER SUPPLY

MODEL T6010 — DRAWING NUMBER T8104



BOARD REVISION 2.7

TELCOM RESEARCH

SCALE	APPROVED BY
DATE Sept 83	DRAWN BY
	REVISED NOV 86

MAIN BOARD PARTS LAYOUT

MODEL T6010 — DRAWING NUMBER T8105