HARRIS SEMICONDUCTOR
A DIVISION OF HARRIS CORPORATION

APPLICATION NOTE HM005

HM-6100 CMOS MICROPROCESSOR TELETYPE INTERFACE

INTRODUCTION

The 6902-CPUTTY card forms the nucleus for a versatile tristate bus organized processor system. The card contains the HM-6100 microprocessor and a DEC™ PDP-8/E program compatible parallel Teletype interface. The microprocessor signals are buffered with standard high current TTL tristate buffers and transceivers to define a TTL compatible bus. The bus drivers can sink 32 mA at 0.4 volts or 40 mA at 0.5 volts (max.). The bus may be terminated or not terminated.

THE HM-6100 MICROPROCESSOR

All the HM-6100 signals are available externally. The input control lines have pull up resistors to permit open collector wire-ANDing of request lines as shown in Figure 1. The DX lines are buffered with tristate transceivers. The output control lines are buffered with high current buffers. The DX, LXMAR, MEMSEL, DATAF and XTC lines are disabled when the processor grants a Direct Memory Access (DMA) request, permitting the peripheral device which requested the DMA, to access the memory using the same bus lines as the processor. It is recommended that a pull up to V_{CC} be provided on the control line, XTC, to prevent unwanted "writes" to the memory when this line is tristated.

Since the 6901-CPUTTY card will be mainly used for prototyping, provisions are made to stop the free running crystal controlled oscillator (ICM7209) and to introduce a TTL compatible clock externally. Gating is provided to ensure integral clocking.

The RUN and LINK signals are inverted to active low to prevent erroneous RUN and LINK indication on the control panel display when the processor is unplugged.

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TELETYPE INTERFACE

The 6902-CPUTTY Teletype interface contains logic to transfer data between the HM-6100 and the Teletype keyboard/reader and printer/punch. A Universal Asynchronous Receiver Transmitter, UART, is used to convert the 8-bit parallel information provided by the HM-6100 to serial information for the Teletype transmitter. The ASR-33 Teletype requires one bit every 9.09 ms and, therefore, the UART is programmed to transfer a START bit, 8 DATA bits and 2 STOP bits to the Teletype in 99.99 ms. The data formatting is according to the RS232 standard for transmitting and receiving serial data.

The UART also receives the serial information from the Teletype receiver and converts it to parallel for the computer. The UART is capable of checking for parity, framing and data overun errors. The interface is designed to be program compatible with the DEC PDP-8/E Teletype interface. Since the DEC interface does not check for any error conditions, the error checking and parity generating functions of the UART are not utilized.

TELETYPE OPERATIONS DECODER

The processor communicates with the Teletype interface using Input-Output Transfer, IOT, instructions. The system software supplied by DEC for the PDP-8/E has preassigned IOT instructions to communicate with the Teletype, as shown in Table 1.

The Operations Decoder, shown in Figure 2, monitors the DX line for the Teletype instruction and generates the appropriate signals, as seen in Table 2 to the UART and the HM-6100 to execute these IOT instructions. The Clear All Flags, CAF-6007$_8$, instructions or RESET will clear the Accumulator and the Ready Flags, disable the Reader and enable the TTY Interrupt Enable FF.

TELETYPE OPERATIONS DECODER (cont'd.)

Note that the SKP line is enabled and the INTREQ line disabled when DEVSEL is active. The SKP and INTREQ lines can then be tied together, if so desired. Since the HM-6100 samples these lines at separate times, there is no degradation in system performance. SKP and INTREQ are time multiplexed on the same pin in the Parallel Interface Element-PIE HD-6101.

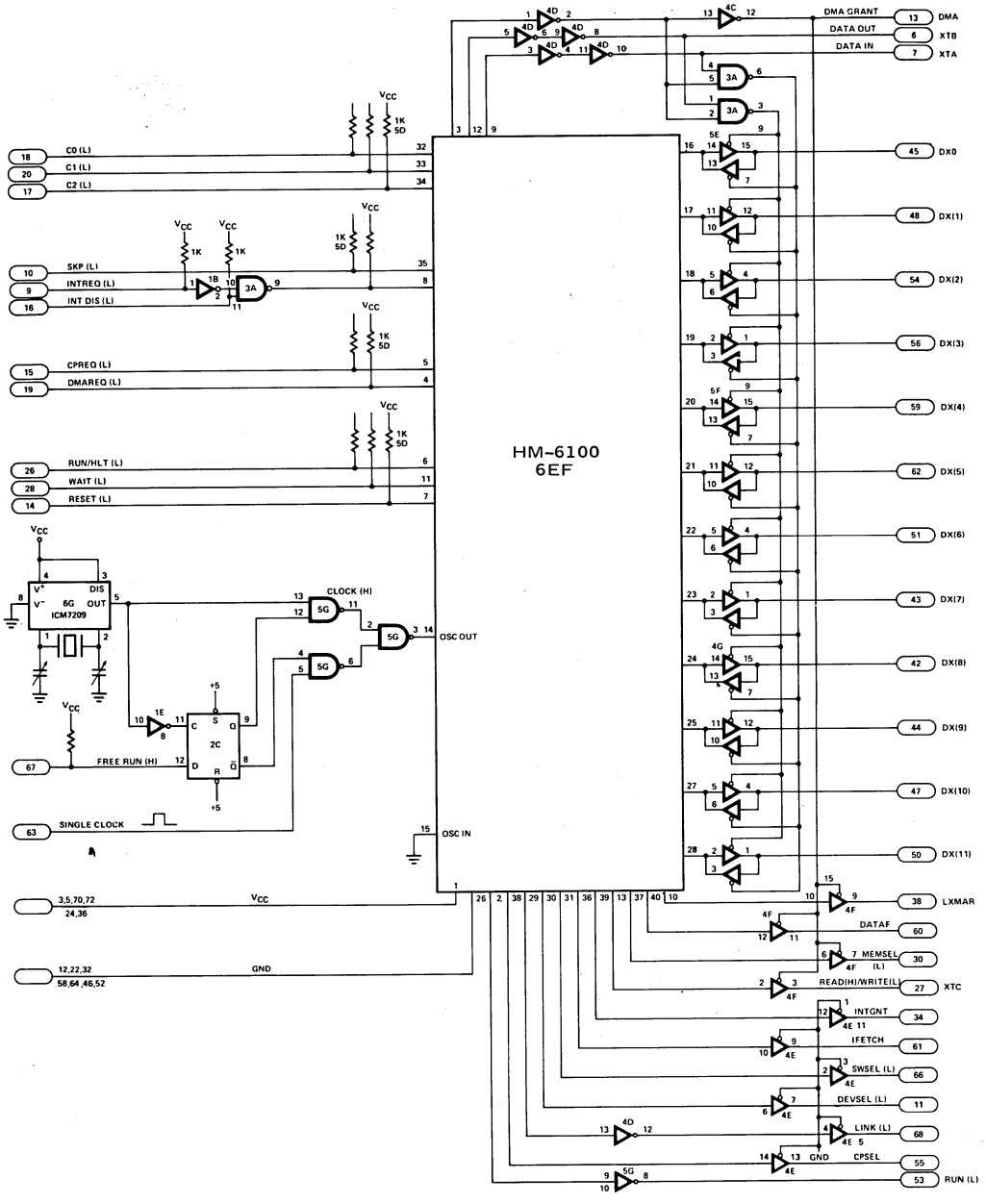

Figure 1

TTL Interface for the HM-6100

PRINTER/PUNCH INSTRUCTIONS

MNEMONIC	OCTAL	OPERATIONS
TFL	6040	Printer/Punch Ready flag is set.
TSF	6041	Skip the next instruction if the Printer/Punch flag is set.
TCF	6042	Printer/Punch Ready flag is reset.
TPC	6044	AC(4–11) Printer/Punch Buffer. Printer/Punch is activated. Printer/Punch Ready flag remains set. The Accumulator is not affected.
TLS	6046	This is a microprogrammed combination of TCF (6042) and TPC (6044). The Printer/Punch Ready flag is reset. AC(4–11) Printer/Punch Buffer. Printer/Punch is activated. The Printer/Punch Ready flag is set when Printer/Punch is ready to accept another character.
CAF/RESET	6007	Printer/Punch flag is reset.

KEYBOARD/READER INSTRUCTIONS

MNEMONIC	OCTAL	OPERATIONS
KCF	6030	Keyboard/Reader Data Ready flag is reset.
KSF	6031	Skip the next instruction if Keyboard/Reader Data Ready flag is set.
KCC	6032	The Accumulator is cleared. Keyboard/Reader Data Ready flag is reset. The Reader is enabled. Keyboard/Reader Data Ready flag will be set and the Reader disabled when a new character is read.
KRS	6034	AC(4–11) AC(4–11) V Keyboard/Reader Data (Keyboard/Reader Data Ready flag remains set and the Reader is not enabled).
KRB	6036	This is a microprogrammed combination of KCC (6032) and KRS (6034). AC(4–11) Keyboard/Reader Data. Keyboard/Reader Data Ready flag is reset and the reader is enabled to fetch the next character. The Data Ready flag will be set and the Reader disabled when a new character is read.
CAF/RESET	6007	Keyboard/Reader Data Ready flag is reset.

TELETYPE INTERRUPT CONTROL INSTRUCTIONS

MNEMONIC	OCTAL	OPERATIONS
KIE	6035	The content of AC(11) is loaded into the Teletype Interrupt Enable FF. If the TTY IEN FF is set (i. e. AC(11) = 1), Keyboard/Reader Data Ready flag or Printer/Punch Ready flag, being set, will generate an interrupt request to the HM-6100. If the HM-6100 interrupt system is enabled, it will grant this request.
TSK	6045	Skip the next instruction if the TTY IEN FF is set and the Keyboard/Reader Data Ready flag and/or the Printer/Punch Ready flag is set. This instruction is normally used for software polling of the device flags when multiple interrupt requests may be present.
CAF/RESET	6007	TTY IEN FF is set.

Table 1

TELETYPE INTERFACE OPERATIONS DECODER FUNCTIONS

	INSTRUCTIONS		UART CONTROL*			INTERNAL FLAG CONTROLS						SKP ENABLE			C-LINES	
	MNEMONIC	OCTAL				INT EN FF		RDR RUN		PRNT RDY		PRNT	DATA	INT	C0	C1
			TBRL (L)	RDE (L)	DRR (L)	CLOCK (H)	SET (L)	SET (L)	RESET (L)	SET (L)	RESET (L)	RDY (H)	RDY (H)	REQ. (H)	(L)	(L)
CAF/RESET	CAF	6007					L		L		L					
KEYBOARD/READER	KCF	6030			L											
	KSF	6031											H			
	KCC	6032			L			L							L	
	KRS	6034		L												L
	KRB	6036		L	L			L							L	L
PRINTER/PUNCH	TFL	6040								L						
	TSF	6041										H				
	TCF	6042									L					
	TPL	6044	L													
	TLS	6046	L								L					
INTERRUPT CONTROL	KIE	6035				H										
	TSK	6045												H		

*TBRL—Transmit Buffer Register Load (L)
*RDE—Receiver Data Enable (L)
*DRR—Data Ready Reset (L)

Table 2

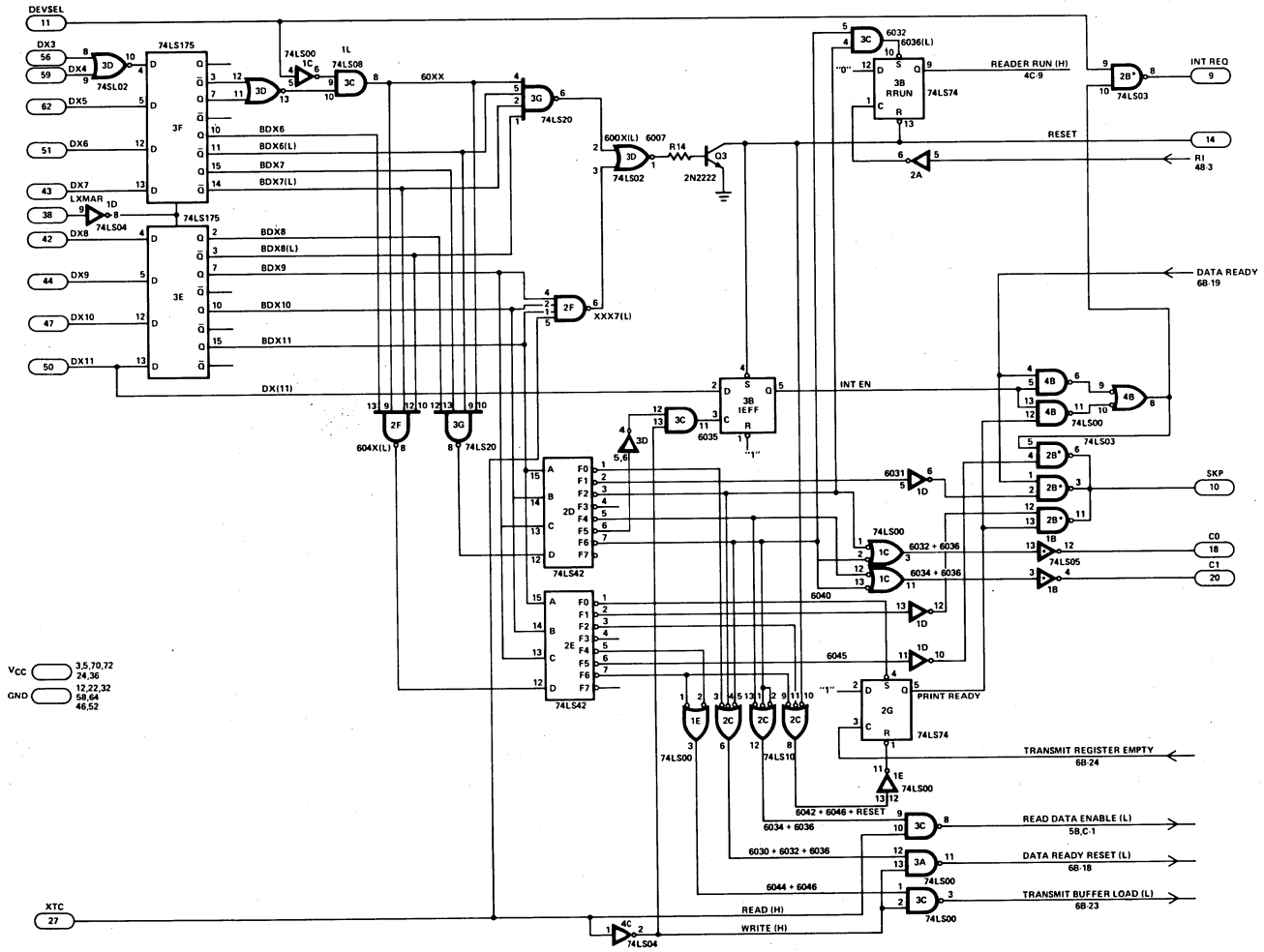

Figure 2

Teletype Operations Decoder

UART-TELETYPE INTERFACE

Receiver

The Teletype keyboard is always enabled. When a key on the keyboard is depressed, it automatically sends data from the Teletype to the UART. The Teletype receiver, when it is idle, is in the "mark", or logic 1 state, establishing a loop current of 20 mA. When the Teletype transmits the START bit ("space or logic 0 or no loop current), the RI input of the UART makes a logic 1 to 0 transition which activates the receiver section in the UART. The receiver then clocks in the 8 data bits into the Receiver Register as shown in Figure 3 and activates the Data Ready Flag. The HM-6100 checks the status of the Data Ready flag and transfers the Receiver Register information to the Accumulator with IOT instructions.

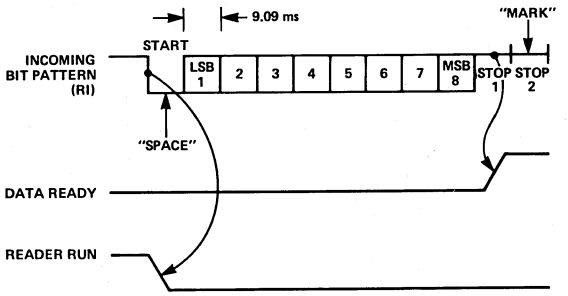

Figure 3

Receiver Timing Diagram

UART-TELETYPE INTERFACE (cont'd.)

The operations decoder automatically disables the paper tape with the reader run flip flop, when a character is received. The processor must explicitly reenable the reader for a new character to be read. This "hand shake" arrangement prevents data over-run when reading information via the Teletype paper tape reader.

The UART is clocked at 16X the basic data transfer rate. For a Teletype Interface, the clock rate will be 16 x 110 = 1.76 kHz. The timer circuit shown in Figure 4 provides this clock frequency.

The 8 data bits are read into the Accumulator, right justified. DX(0)-DX(3) are read in as logic 0's.

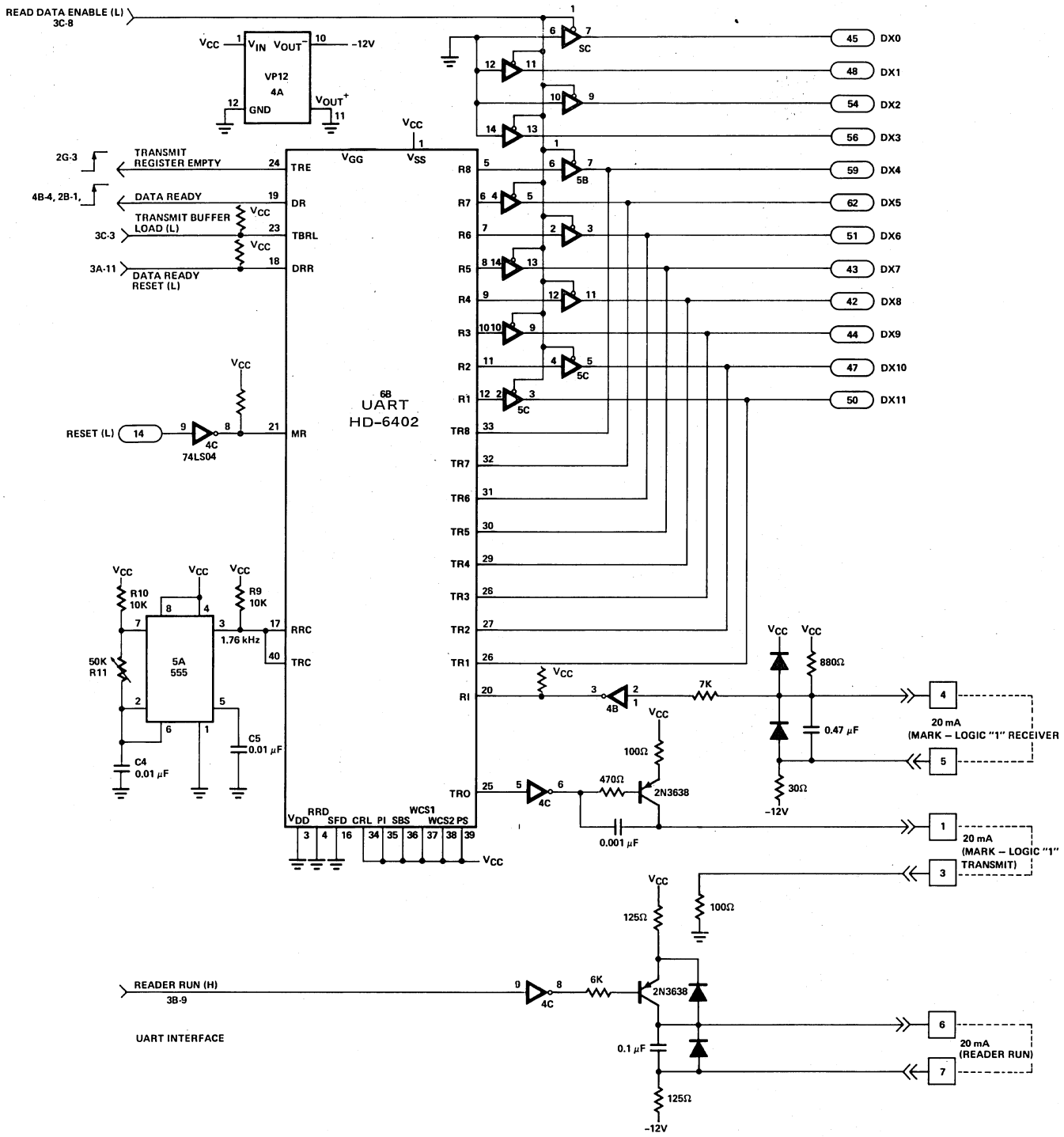

Figure 4

TRANSMITTER

The HM-6100 loads the data to be transmitted into the UART Transmit Buffer. The data transfer takes place in parallel from the Accumulator to the buffer with an IOT instruction. The UART transfers this data into the Transmit Register if the UART is not already busy transmitting a character. When the buffer register is ready to receive another character, the Transmit Register Empty, TBRE, signal goes high. This clocks the Print Ready Flip-Flop in the Operations Decoder. The HM-6100 monitors the status of the Print Ready Flag with an IOT instruction before transmitting data to the UART.

The Transmit Register in the UART formats the data word with START and STOP bits and then, transmits it serially to the Teletype as shown in Figure 5. A logic "1", or "mark" is transmitted by establishing a 20 mA current loop on the Teletype transmit line. A logic "0", or space, is transmitted when no current flows in the transmit loop. The Teletype recognizes the beginning of a new character when the transmit line makes a mark to space transition.

TELETYPE MODIFICATIONS FOR THE 6900 PROTOTYPING SYSTEM

The Harris 6902-CPUTTY has been designed to be used in conjunction with a Model ASR-33 Teletype. Before attempting to use your system inspect your teletype for the following modifications and additions. If they have not yet been performed, you must complete them before using the 6900 system.

To check for, or make, these modifications remove the cover of the Teletype. Loosen the three thumb screws in the back and remove the Platen that holds the roll of paper, the Mode Switch knob and the Face Plate. Remove the small screw on the Reader cover and the four screws under the Face Plate. You should now be able to lift the cover off. Use Figure 6 to locate the various parts described below.

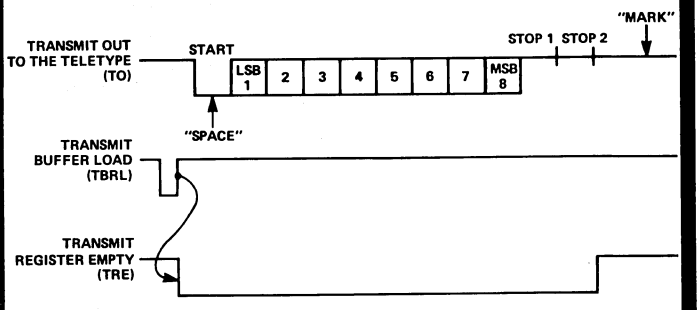

Figure 5

Teletype Transmitter Timing Diagram

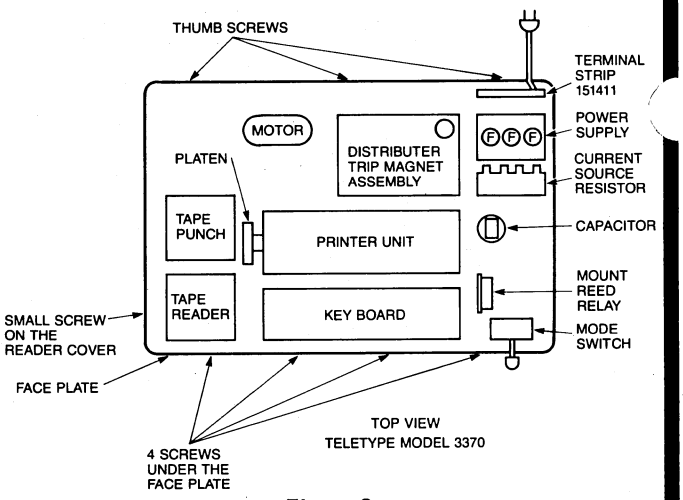

Figure 6

The modifications are:

Current loops changed from 60 to 20 milliamps.

The current Source Resistor must be changed from 750 ohms to 1450 ohms. This is accomplished by moving the wire connected to the 750 ohm terminal to the 1450 ohm terminal on the resistor shown in Photo # 1. The receiver current level is changed by moving the purple wire connected to terminal # 8 on the Terminal Strip 151411to terminal # 9 on the same strip. Terminal Strip 151411 is shown on Photo # 2 with the terminal # 1 at the far left.

The Teletype wired for Full-Duplex

The half duplex wiring must be changed by moving the BROWN/YELLOW wire from terminal # 3 to terminal # 5 and by moving the WHITE/BLUE wire from terminal # 4 to terminal # 5 on the Terminal Strip 151411.

The Reader Run Relay Added.

The Reader circuit should have a 12 volt relay inserted to allow program control of the Reader. This Relay is shown along with the mode switch in Photo # 3. The wire on the Run Relay circuit addition marked PICK-UP is spliced to the BROWN wire coming from the Distributor Trip magnet. This wire is shown along with the Trip Magnet in Photo # 4. The two wires marked LINE and LOCAL are then connected to the mode switch as shown in Figure 7. This mode switch is also visible in Photo # 3. No changes to the existing Reader circuitry need be made.

Connect CPUTTY outputs to the Teletype.

The TTY outputs of the CPUTTY board are connected to the Terminal Strip 151411 and the relay as shown in Figure 7 and 8.

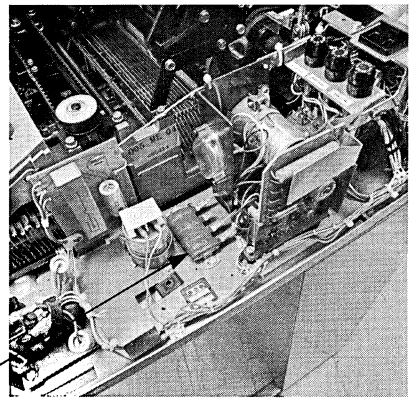

PHOTO 1

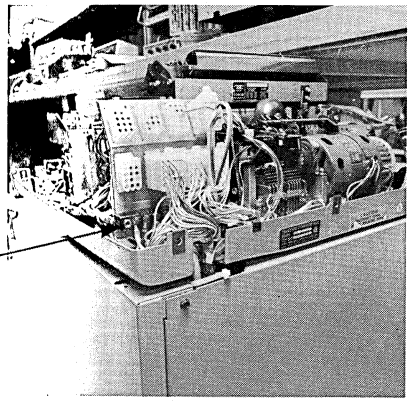

PHOTO 2

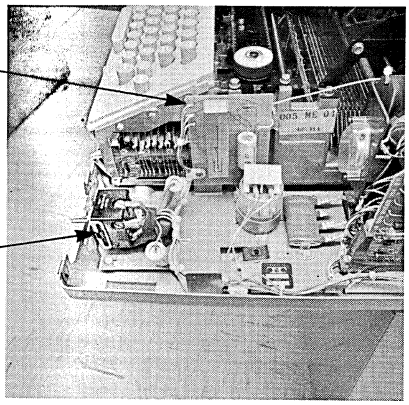

PHOTO 3

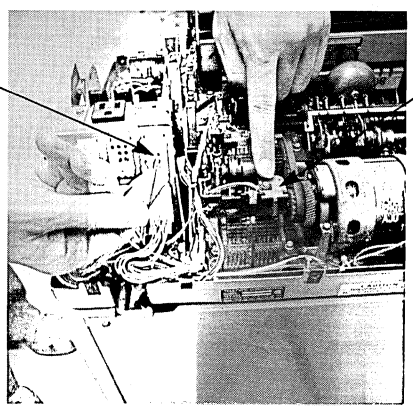

PHOTO 4

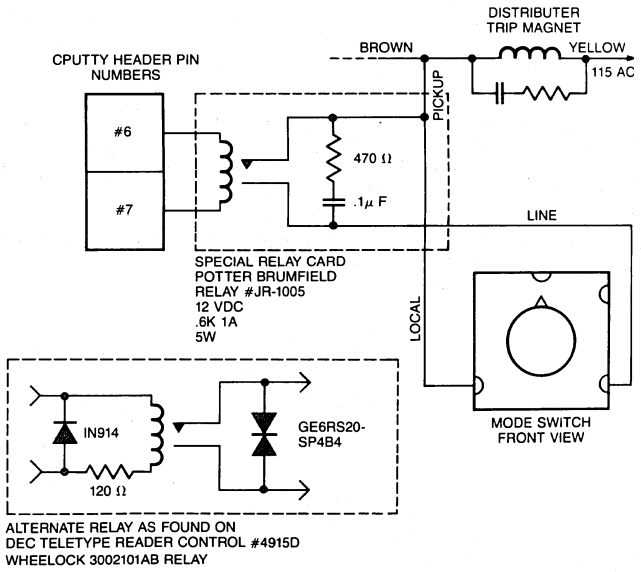

Figure 7

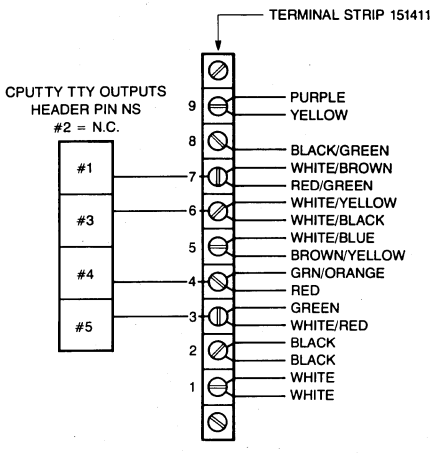

Figure 8

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SUITE 103
4014 LONG BEACH BLVD.
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(415) 964-6443

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(617) 237-5430

SUITE 132
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(612) 835-2505

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(607) 754-5464

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(516) 249-4500

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650 E. SWEDESFORD ROAD
WAYNE, PENN. 19087
(215) 687-6680

SUITE 7G
777 S. CENTRAL EXPRESSWAY
RICHARDSON, TEXAS 75080
(214) 231-9031

P. O. BOX 883
MELBOURNE, FL. 32901
(305) 724-7430
TWX-510-959-6259

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SEMICONDUCTOR
A DIVISION OF HARRIS CORPORATION