The Engineering Staff of
TEXAS INSTRUMENTS
Semiconductor Group

TMS 1121/2 UNIVERSAL TIMER CONTROLLER MANUAL

NOVEMBER 1980

TEXAS INSTRUMENTS
LIMITED

MP026

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1. TMS 1121 UNIVERSAL TIMER CONTROLLER INTRODUCTION

The TMS 1121 Universal Timer Controller is a mask-programmed version of the TMS 1000 Family 4-bit single chip microcomputer providing the function of a programmable time of day, day of week controller. When the TMS 1121 is used to implement the general purpose timer controller function, as shown in Figure 1, the system features:

- 18 daily or weekly programmable timer sets
- Memory display of programmed timer sets for switches and day of week
- 4 independent switch outputs with buffer
- Display day of week, AM/PM, switch, clock, ON/OFF/SLEEP status
- Key entry for clock set and timer set
- 50 Hz or 60 Hz clock synchronization

The system is configured with a keyboard for user inputs, a 4-digit LED clock display, and LED's to indicate AM/PM, day of week, switches, and ON/OFF/SLEEP status. The device operates from a 9-volt power supply, and is packaged in a 28-pin plastic package. A system incorporating the TMS 1121 is capable of performing both as a digital clock and as a timer/controller.

CLOCK OPERATION

The TMS 1121 operates as a real-time clock which displays the time of day, AM or PM, and the day of the week. The accuracy of the clock is defined by the variation of the 50/60 Hz signal supplied to the device. Time of day and day of the week are entered through the keyboard and displayed on a 4-digit LED display.

TIMER/CONTROLLER

The TMS 1121 is capable of retaining up to 18 timer sets (programs) which are entered through the keyboard. Each of these timer sets can control one of four independent output switches which, in turn, can be used to control external devices.

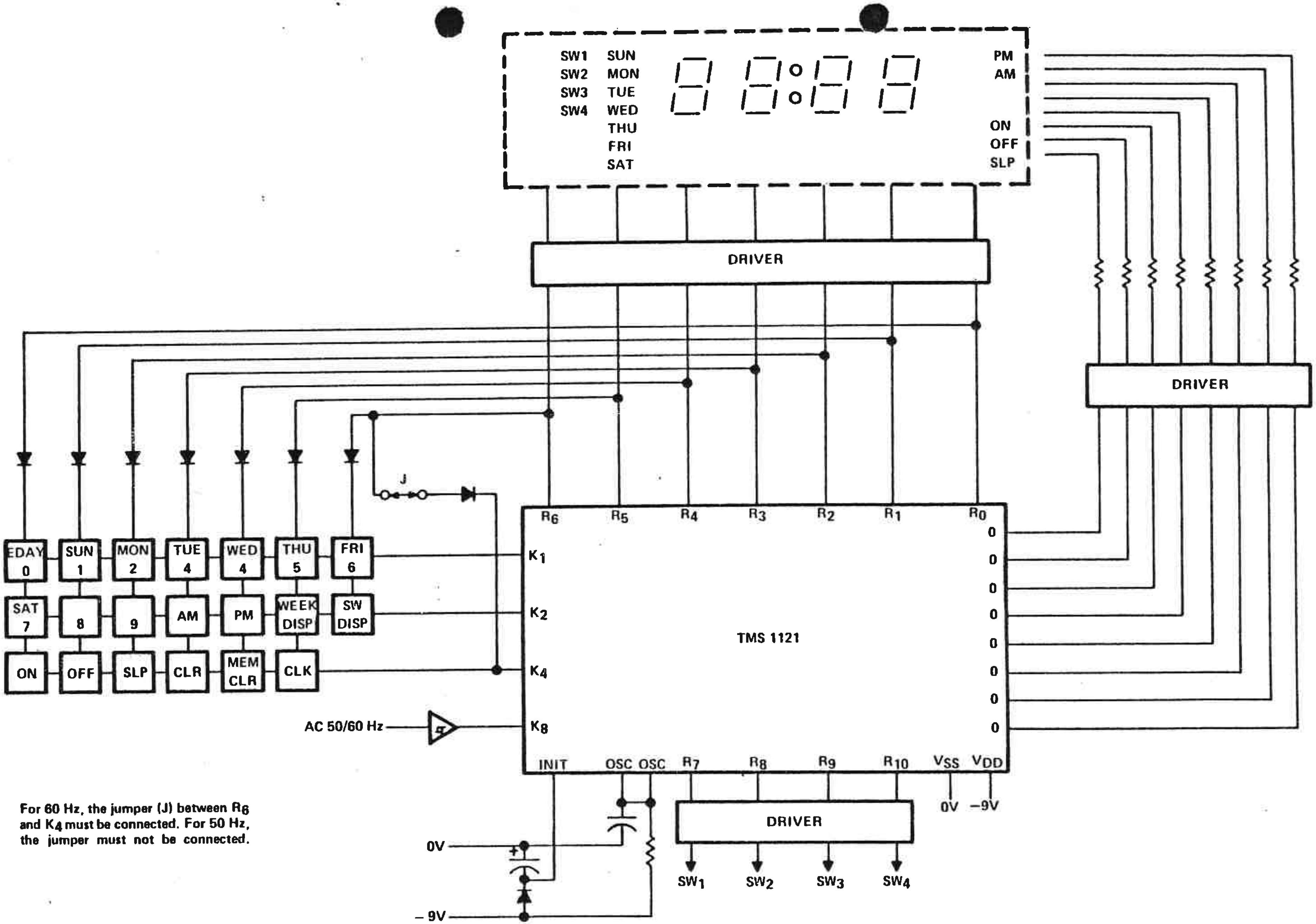
Timer sets can be segregated into two types: (1) Fixed time programs which toggle an output switch at a specific time, and (2) Interval programs which toggle an output switch after a specified interval of time has elapsed. Each timer set will toggle only one switch. The SLEEP function (SLP) is used to turn a switch ON for one hour and then OFF, thereby using one timer set to perform two functions and thus saving one timer set. Interval programs are automatically deleted from memory upon execution. Fixed-time programs will be retained in memory and repeatedly executed.

The TMS 1121 has been designed so that the user can easily interface with the system via the keyboard (Figure 2). For example, using the keyboard the user can turn any output switch ON or OFF without programming the action into memory, thus providing direct control of the switches. Additionally, the user can change the timer settings by either selectively deleting all the timer sets which refer to one day or one switch, or by deleting all timer sets in order to start programming into a cleared memory. Finally, any program in memory can be called to the display with the proper keyboard sequence in order to verify that the TMS 1121 had been programmed correctly.

2. OPERATION

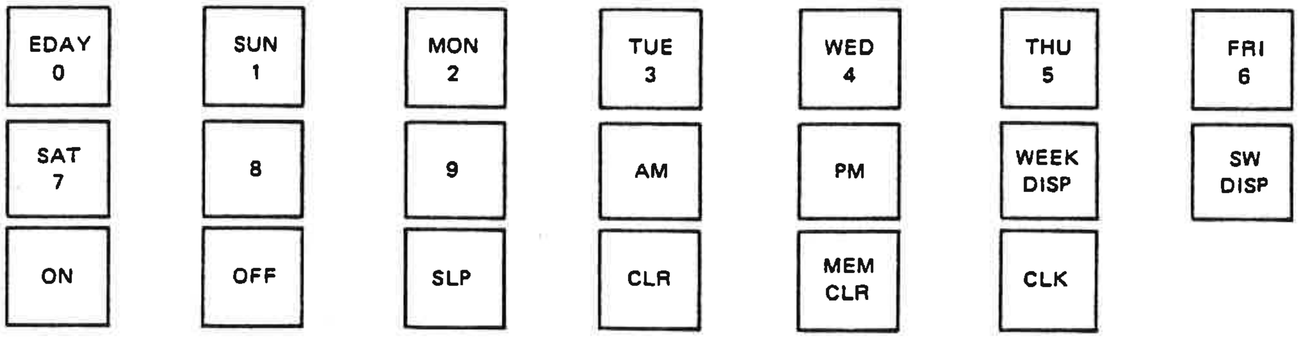
2.1 POWER-UP

When the TMS 1121 is powered up, the internal clock is automatically initialized to 12:00 PM on Sunday with all switches OFF and no programs stored. If the AC signal is 60 Hz, the clock setting is displayed immediately, if the AC signal is 50 Hz, the [CLK] key must be pressed to start and display the clock. After power-up the clock setting may be changed to a new value at any time.



For 60 Hz, the jumper (J) between R_6 and K_4 must be connected. For 50 Hz, the jumper must not be connected.

FIGURE 1. UNIVERSAL TIMER BLOCK DIAGRAM



<u>Double functions key inputs</u>

EDAY/0	–	Everyday or Numeric 0
SUN/1	–	Sunday or Numeric 1
MON/2	–	Monday or Numeric 2
TUE/3	–	Tuesday or Numeric 3
WED/4	–	Wednesday or Numeric 4
THU/5	–	Thursday or Numeric 5
FRI/6	–	Friday or Numeric 6
SAT/7	–	Saturday or Numeric 7
SW/DISP	–	Switch or Display of memory for switch
WEEK/DISP	–	Week or Display of memory for day of week and everyday

<u>Single function key inputs</u>

8	–	Numeric 8
9	–	Numeric 9
AM	–	AM setting
PM	–	PM setting
ON	–	ON setting
OFF	–	OFF setting
SLP	–	SLEEP setting
CLR	–	Clear entry and error
MEM CLR	–	Clear Memory
CLK	–	Clock Setting

FIGURE 2. KEYBOARD FOR THE UNIVERSAL TIMER CONTROLLER

2.2 SETTING THE CLOCK

A typical key sequence for setting the clock would be:

[MON] [WEEK] [PM] [5] [0] [0] [CLK]

which would start the clock at 5:00 PM on Monday. The pattern for the key sequence is always the same. A day of the week is registered with [WEEK] key. An [AM] or [PM] key is pressed and the desired time is entered, then the [CLK] key is pressed. Because the clock is not actually started from the new value until the [CLK] key is pressed, the timer clock may easily be synchronized with another clock. The value of the clock will only be changed if the key sequence has been correct, otherwise, the [CLK] key returns the display to the previous value of the clock, updated to the time the [CLK] key is pressed.

Errors in the key sequence may also be corrected before the [CLK] key is pressed. Correction Procedures are explained in the ERRORS section (2.5).

2.3 PROGRAMMING THE TIMER

2.3.1 FIXED-TIME PROGRAMS

Fixed-time programs change the state of a switch when the clock reaches a preset time. A typical key sequence for entering a fixed-time program would be:

[1] [SW] [MON] [WEEK] [PM] [5] [1] [0] [ON] , which would turn on switch number one on Monday at 5:10 PM. Keys [1], [2], [3], or [4] select the switch affected when followed by the [SW] key. The day and time are entered next, in the same order as the clock setting entry (section 2.2). The last key assigns a function to the program: [ON], [OFF], or [SLP]. [ON] or [OFF] turns the affected switch on or off at the programmed time. [SLP] causes the switch to be turned on at the time setting that has been entered, then turned off one hour later.

As the key sequence is entered, the digital readout and LED indicators display the program settings. The day of the week, time of day, switch number, and function of the program may remain on display without halting the operation of the timer; the clock runs and the switches are turned on or off regardless of the display status. Clock information may be redisplayed by pressing the [CLK] key.

If the next program is completely different from its predecessor, the above key sequence must be repeated in its entirety with the new parameters. If the switch affected and the day of the week are the same, a shortened key sequence suffices to store the program. An example of the shortened key sequence would be:

[PM] [5] [1] [5] [OFF]

If this sequence followed the above long sequence, output number one would be turned off at 5:15 PM on Monday. The shortened key sequence must follow the long one directly, without pressing the [CLK] key between programs. A succession of short sequences may follow each other, to program several actions of one switch on one day.

The [EDAY] key may be used in fixed-time programming in place of a day-of-the-week key. Programming an action with [EDAY] causes that action to occur at the programmed time on every day of the week.

2.3.2 INTERVAL PROGRAMS

In an interval program, the switch number, time interval (in hours and minutes) and function are entered. The function is performed after the time interval has passed. A typical interval program key sequence would be:

[3] [SW] [2] [0] [0] [ON]

In this case, switch number three would be turned on two hours after the [ON] key was pressed. Either the [ON] , [OFF] , or [SLP] functions may be used with an interval program. If [SLP] is used, the switch is turned on after the programmed interval, then turned off one hour later. As with fixed-time programs, a shortened key sequence may be used for a succession of programs following one with the ordinary sequence, as long as the switch is the same. An example of the short sequence for interval programs would be:

[2] [0] [1] [OFF]

Following the above entry, this sequence would turn switch three off two hours and one minute after the [OFF] key was pressed. The maximum time length for any interval is 11 hours, 59 minutes.

2.3.3 OVERLAPPING PROGRAMS

Programs may be overlapped in time. When several functions are programmed to occur at the same time on the same day, all of them are ignored except the last one. For example, if the memory contained the following programs:

[1]	[SW]	[MON]	[WEEK]	[AM]	[1]	[0]	[0]	[ON]
[1]	[SW]	[MON]	[WEEK]	[AM]	[1]	[0]	[0]	[OFF]
[1]	[SW]	[MON]	[WEEK]	[AM]	[1]	[0]	[0]	[ON]

the result would be to turn on switch one on Monday at 1:00 AM. Another example, the set of programs:

[4]	[SW]	[EDAY]	[WEEK]	[PM]	[6]	[4]	[5]	[ON]
[4]	[SW]	[SAT]	[WEEK]	[PM]	[6]	[4]	[5]	[OFF]

turns switch four on at 6:45 PM every day of the week except Saturday. Finally, the set of programs

[2]	[SW]	[FRI]	[WEEK]	[AM]	[7]	[0]	[0]	[SLP]
[2]	[SW]	[FRI]	[WEEK]	[AM]	[7]	[3]	[0]	[OFF]

would turn switch two off at 7:30 AM on Friday instead of 8:00 AM.

2.4 DIRECT SWITCH CONTROL

A switch may be operated directly from the keyboard. A sample key sequence would be:

[2] [SW] [SLP]

In this case, the [SLP] function would be immediately executed on switch number two. This switch would be turned on as soon as the [SLP] key is pushed and turned off one hour later. Any of the three functions may be specified for any of the four switches in this manner. The direct manipulations are not stored in RAM as programs.

2.5 ERRORS

The usual error indication is 99:99 on the display. This occurs if the key sequence is incorrect or if a program is attempted with an invalid time. The timer will convert times from the 24-hour system to 12-hour times for both clock setting and programming. The 12-hour time is found by subtracting 12 hours from a 24-hour time. If a 24-hour time, e.g. 22:10, is entered, it will be accepted as its 12-hour analog, 10:10, but the AM/PM selection is not affected by this conversion. Time values incorrect in both the 12-hour and 24-hour systems result in the 99:99 error indication.

The time conversion also holds true in interval programs and for this reason the interval length is limited to 11 hours, 59 minutes. Intervals up to 23 hours, 59 minutes will be accepted but corrected to 12-hour time-lengths. Again, interval programs incorrect in both systems will produce 99:99 on the display. The indication of 88:88 on the display occurs if an attempt is made to store more than 18 programs.

During program input, errors may be corrected by several methods. Depressing the [CLK] key will display the current clock setting and erase program or change of clock attempts that have not yet been stored, i.e. before keys [ON], [OFF], [SLP], or [MEM CLR] are pressed. The [CLR] key clears the display, and may therefore be used to clear errors before a program is stored. When more than four digits are entered from the keyboard, the leftmost digit is rolled off the display. Only the digits shown on the display when a key sequence is completed will be stored.

2.6 PROGRAM DISPLAY

The programs stored in memory can be displayed by depressing the [DISP] keys twice. For example, the key sequence:

[1] [SW/DISP] [SW/DISP] . . .

displays the programs for switch number one. One program is displayed for every two times [SW/DISP] is pressed. The programs for a day of the week are displayed in the same way but using the [WEEK/DISP] key. A key sequence for Wednesday would be:

[WED] [WEEK/DISP] [WEEK/DISP] . . .

Programs entered with the [EDAY] are displayed using that key and the [WEEK/DISP] key. For example,

[EDAY] [WEEK/DISP] [WEEK/DISP]

This key sequence only displays programs originally entered with [EDAY]. Programs entered on a specific day of the week must be displayed with the key corresponding to that day.

When a program is displayed, the digital readout shows the programmed time of the switch state change and the LED indicators show the day of the week, the number of the switch affected, and the function programmed. Both fixed-time and interval programs (before execution) can be displayed. When an interval program is shown, the display shows the programmed time of its execution, i.e. the time of day and day of the week corresponding to the end of the interval.

When programs using the [SLP] function are displayed, the display changes with the progress of the program execution. For example, the following key sequence would be used to turn switch three on for one hour on Friday at 10:00 AM.

[3] [SW] [FRI] [WEEK] [AM] [1] [0] [0] [0] [SLP]

Before this program is executed, displaying it would show it as a [SLP] program. The LED's would indicate switch three, Friday, 10:00 AM, and [SLP]. Between 10:00 and 11:00 AM on Friday, however, when the switch is on, displaying the program shows the time when the switch is to be turned off. In this case the LED's would show switch three, Friday, 11:00 AM, and OFF. After this time, the program display returns to the [SLP] settings. Each time the switch state of a [SLP] program changes, the program display is updated to show the next change in the switch state.

2.7 PROGRAM DELETE

The memory may be cleared entirely or selectively using the [MEM CLR] key. When pressed twice, this key clears everything stored in the RAM. The programs for an individual switch or day of the week may also be cleared without disturbing other stored programs.

[1] [SW] [MEM CLR]

is an example of a key sequence for deleting all the programs for switch number one.

[THU] [WEEK] [MEM CLR]

would delete the programs for Thursday. Programs stored specifically with the [EDAY] key are cleared using that key in place of a day of the week.

3. APPLICATIONS EXAMPLES

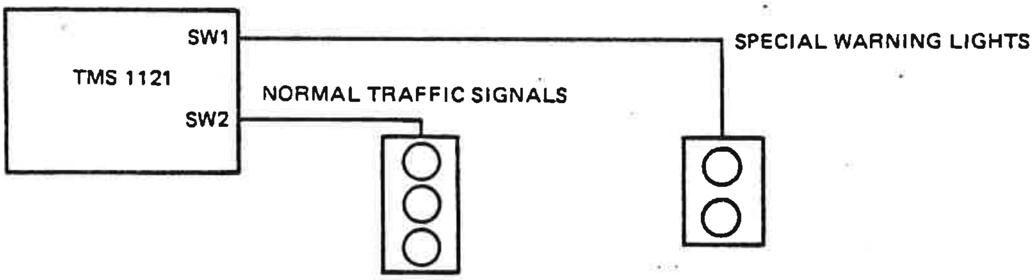
The TMS 1121 Universal Timer Controller can be used in systems designed for industrial, consumer and other applications. The four switches of the TMS 1121 can be used to control (turn ON and OFF) lights, sound signals, home appliances, etc.

The examples given below are intended only as illustrations to show how systems with TMS 1121 can be used and programmed. Design and implementation details are not discussed here and are left to the user's discretion.

3.1 TRAFFIC SIGNAL LIGHTS AT A SCHOOL ZONE (example)

Suppose it is desired that the timer control the signal lights at a street intersection near a school. For two hours in the morning and two hours in the afternoon, five days a week, the regular traffic signal at the intersection is to be turned off, to allow traffic to be manually directed, and special warning lights are to be turned on.

A block diagram of the system would be:



A set of programs for the TMS 1121 would begin by turning the traffic signal on initially with the sequence:

[2] [SW] [ON] .

The operation of the normal traffic signal would be governed by the set of programs:

2	SW	EDAY	WEEK	AM	7	0	0	OFF
				AM	9	0	0	ON
				PM	2	0	0	OFF
				PM	4	0	0	ON
2	SW	SAT	WEEK	AM	7	0	0	ON
				PM	2	0	0	ON
2	SW	SUN	WEEK	AM	7	0	0	ON
				PM	2	0	0	ON

This program set would turn the traffic signal off between 7:00 AM and 9:00 AM and between 2:00 PM and 4:00 PM, Monday through Friday. The signal would operate normally on Saturday and Sunday. In order to minimize memory usage, overlapping programs are used to keep the signal from being turned off over the weekend.

The operation of the special warning lights would be governed by the set of programs:

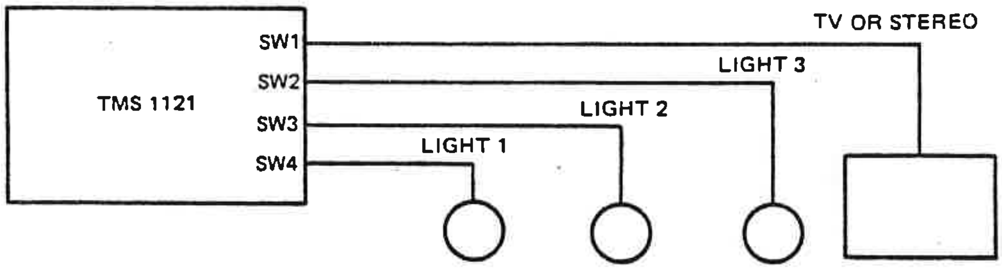
1	SW	EDAY	WEEK	AM	7	0	0	ON
				AM	9	0	0	OFF
				PM	2	0	0	ON
				PM	4	0	0	OFF
1	SW	SAT	WEEK	AM	7	0	0	OFF
				PM	2	0	0	OFF
1	SW	SUN	WEEK	AM	7	0	0	OFF
				PM	2	0	0	OFF

This set operates in the same manner as the previous one. In all, 16 programs are used.

3.2 HOME SECURITY (example)

The timer can be used to control the lighting in a home as a deterrent to potential burglars. The timer can be used to turn on lights and other electrical devices and make the house seem occupied when the residents are away. One problem with the implementation of this idea is that patterns in the lighting control are recognizable; the TMS 1121 has an advantage in this respect because of the number of programs that can be stored, and the long weekly cycle.

A block diagram of a system to control lights and other devices in a house would be:

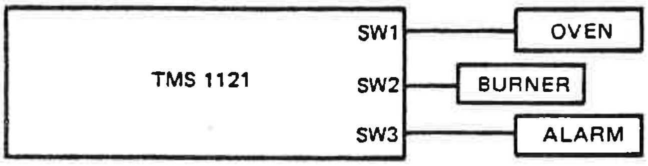


Programs operating the lights and television may be spread through a week in any order. An example for one evening might be:

1	SW	TUE	WEEK	PM		7	0	0	SLP
2	SW	TUE	WEEK	PM		6	1	7	ON
				PM	1	0	0	6	OFF
3	SW	TUE	WEEK	PM		6	3	3	ON
				PM		7	2	5	OFF
4	SW	TUE	WEEK	PM		8	1	1	ON
				PM	1	1	1	6	OFF

3.3 KITCHEN APPLIANCES (example)

A timer has numerous applications in the kitchen. In the control of an oven especially, timing is important. One example of connection to kitchen appliances is shown by the block diagram.:



In this example the sequence:

1	SW	ON		
1	SW	2	5	OFF

would turn the oven on when the [ON] key was pressed and off 25 minutes later.

The sequence

3	SW	2	5	ON
		2	6	OFF

entered at the same time as the oven program would sound the alarm for a minute after the oven has been turned off. The alarm could be stopped from the keyboard, before the minute was up, by the sequence

3	SW	OFF

Turning the oven on for 25 minutes could also be accomplished with fixed-time programs. They would turn the oven on between specific times of the day. The set of programs:

1	SW	TUE	WEEK	PM	6	0	0	ON
				PM	6	2	5	OFF
3	SW	TUE	WEEK	PM	6	2	5	ON
				PM	6	2	6	OFF

is an example for turning on the oven on Tuesday night between 6:00 and 6:25 PM.

A timed burner could be used in several ways. After turning it on the sequence

2	SW	ON

the cook could wait until it came up to a desired temperature before starting the timer. After this period, the program

2	SW	3	0	OFF

could be used to insure that the burner only remained on for thirty minutes, and an alarm could be sounded at the end of this period with

3	SW	3	0	ON
		3	0	OFF

4. TMS 1121 ELECTRICAL SPECIFICATIONS

4.1 ABSOLUTE MAXIMUM RATINGS OVER OPERATING FREE-AIR TEMPERATURE RANGE (Unless Otherwise Noted)*

Voltage applied to any device terminal (see Note 1)	−15 V
Supply voltage, V_{DD}	−15 V to 0.3 V
Data input voltage	−15 V to 0.3 V
Clock input voltage	−15 V to 0.3 V
Average output current (see Note 2): O outputs	−24 mA
R outputs	−14 mA
Peak output current: O outputs	−48 mA
R outputs	−28 mA
Continuous power dissipation: TMS 1121NLL	400 mW
Operating free-air temperature range	0°C to 70°C
Storage temperature range	−55°C to 150°C

*Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the "Recommended Operating Conditions" section of this specification is not implied. Exposure to absolute maximum rated conditions for extended periods may affect device reliability.

4.2 RECOMMENDED OPERATING CONDITIONS

PARAMETER		MIN	NOM	MAX	UNIT
Supply voltage, V_{DD} (see Note 3)		−8	−9	−10	V
High-level input voltage, V_{IH} (see Note 4)	K	−1.0	−0.8	0.3	V
	INIT or Clock	−1.0	−0.8	0.3	V
Low-level input voltage, V_{IL}	K	V_{DD}		−4	V
	INIT or Clock	V_{DD}	−9	−6	V
Clock cycle time, t_c (ϕ)		2.8	3	10	µs
Instruction cycle time, t_c		17		60	µs
Pulse width, clock high, t_w (ϕH)		1.2			µs
Pulse width, clock low, t_w (ϕL)		1.2			µs
Sum or rise time and pulse width, clock high, $t_r + t_w$ (ϕH)		1.4			µs
Sum of fall time and pulse width, clock low, $t_f + t_w$ (ϕL)		1.4			µs
Oscillator frequency, f_{osc}		250		350	kHz
Operating free-air temperature, t_A		0		70	°C

NOTES:
1. Unless otherwise noted all voltages are with respect to V_{SS}.
2. These average values apply for any 100 ms period.
3. Ripple must not exceed 0.2 volts peak to peak in the operating frequency range.
4. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for voltage levels only.

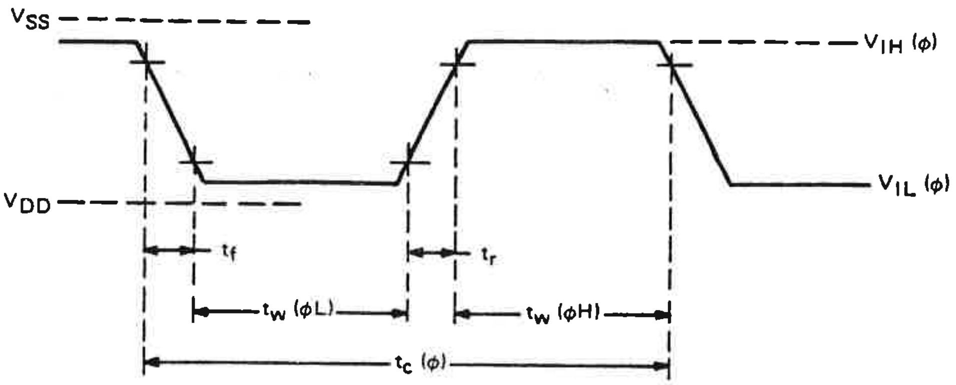


FIGURE 3. EXTERNALLY DRIVEN CLOCK INPUT WAVEFORM

4.3 ELECTRICAL CHARACTERISTICS OVER RECOMMENDED OPERATING FREE-AIR TEMPERATURE RANGE (Unless Otherwise Noted)

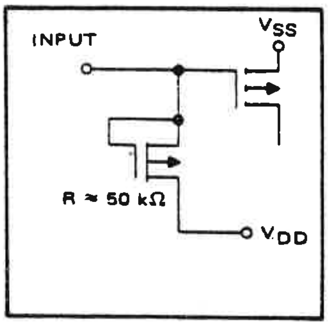
PARAMETER			TEST CONDITIONS	MIN	TYP*	MAX	UNIT
I_I	Input current, K inputs		$V_I = 0$ V	40	200	350	μA
V_{OH}	High-level output voltage (see Note 1)	O outputs	$I_O = -6$ mA	−1.1	−0.6		V
		R outputs	$I_O = -1.2$ mA	−0.75	−0.4		V
I_{OL}	Low-level output current		$V_{OL} = V_{DD}$			−100	μA
I_{DD}	Average supply current from V_{DD}		All outputs open		−5	−10	mA
$P_{(AV)}$	Average power dissipation		All outputs open		45	100	mW
f_{osc}	Internal oscillator frequency		$R_{ext} = 50K\Omega$, $C_{ext} = 47$ pF	250	300	350	kHz
C_i	Small-signal input capacitance, K inputs		$V_I = 0$, f = 1 kHz		10		pF
$C_{i(\phi)}$	Input capacitance, clock input		$V_I = 0$, f = 100 kHz		25		pF

*All typical values are at $V_{DD} = -9$ V, $T_A = 25°C$.

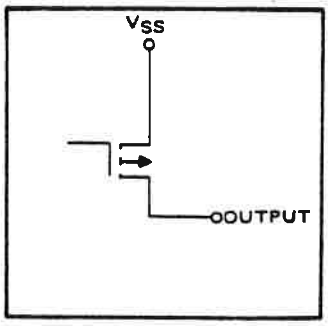
NOTE: 1. The algebraic convention where the most-positive (least-negative) limit is designated as maximum is used in this specification for logic voltage levels only.

4.4 SCHEMATICS OF INPUTS AND OUTPUTS

TYPICAL OF ALL K INPUTS



TYPICAL OF ALL O AND R OPEN-DRAIN OUTPUTS

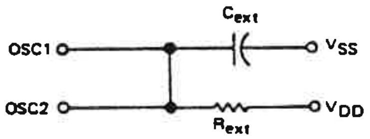


The O outputs have nominally 60 Ω on-state impedance.

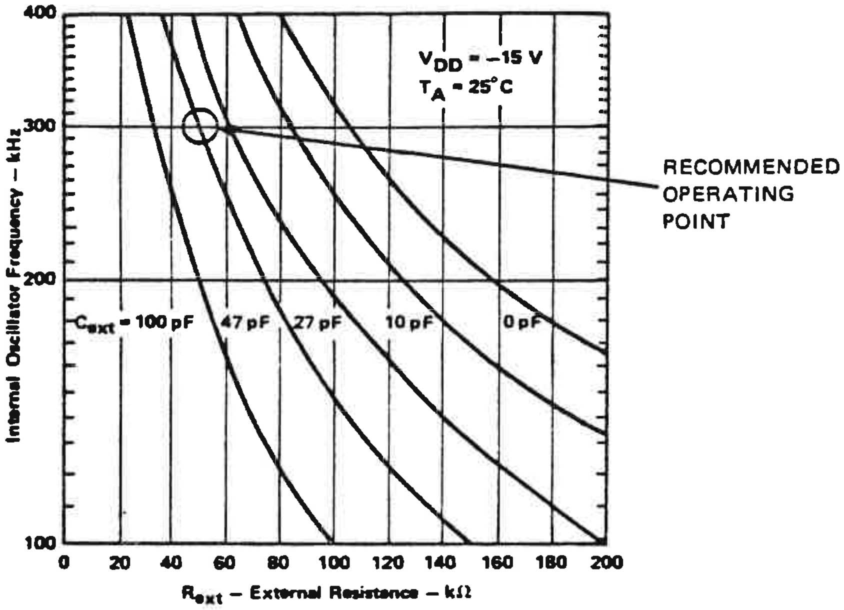
4.5 INTERNAL CLOCK

To use the internal oscillator, the OSC1 and OSC2 terminals are shorted together and tied to an external resistor to V_{DD} and a capacitor to V_{SS}.

CONNECTION FOR INTERNAL OSCILLATOR

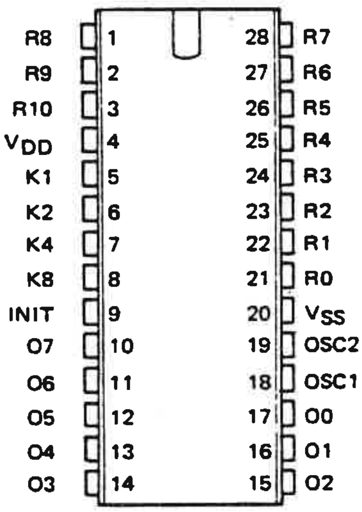


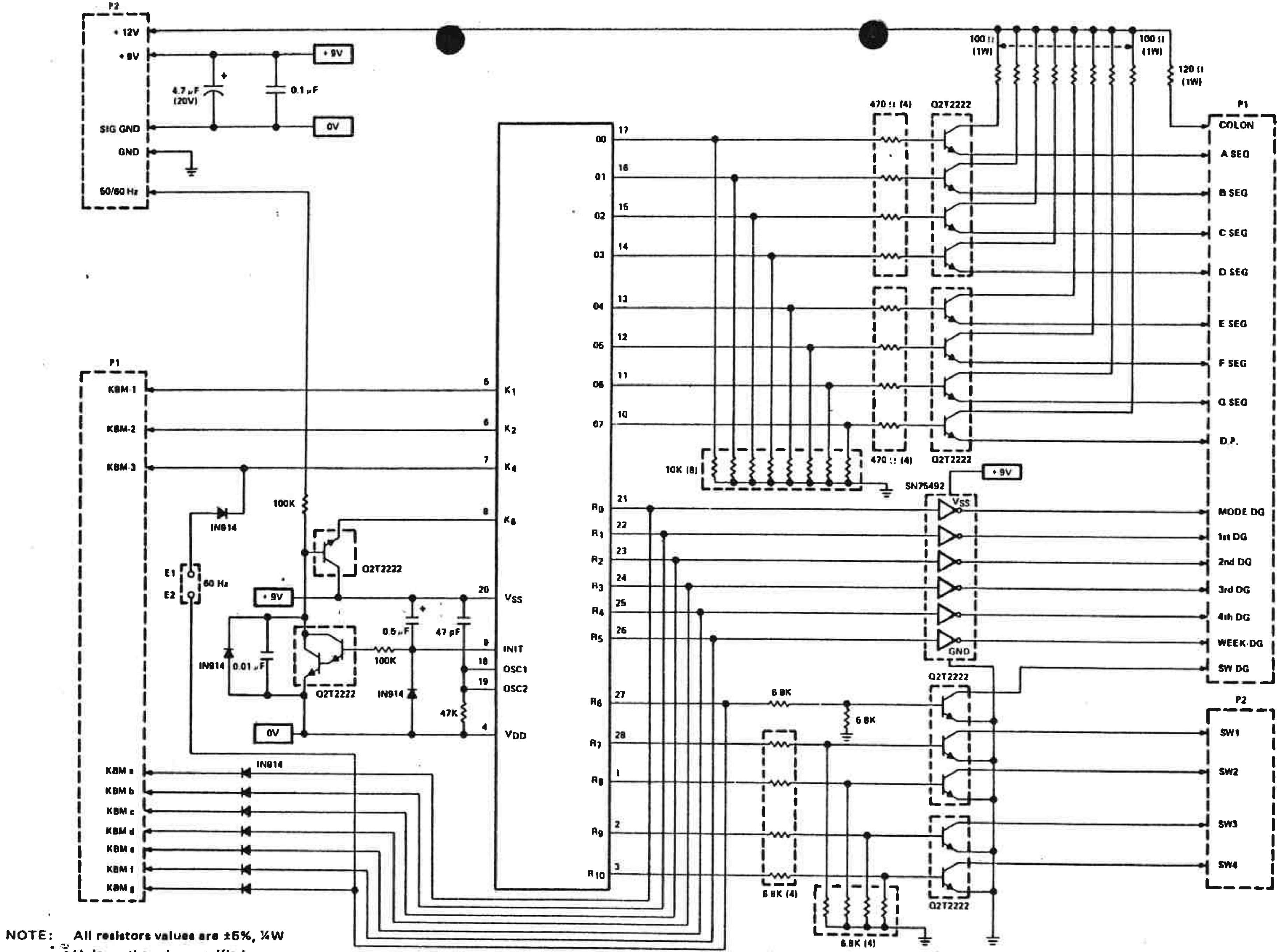
TYPICAL INTERNAL OSCILLATOR FREQUENCY
vs
EXTERNAL RESISTANCE



4.6 TERMINAL ASSIGNMENTS

TMS 1121





NOTE: All resistors values are ±5%, ¼W
Unless otherwise specified
E1, E2 connection for 60Hz operation

FIGURE 4. UNIVERSAL TIMER CONTROLLER SYSTEM DIAGRAM

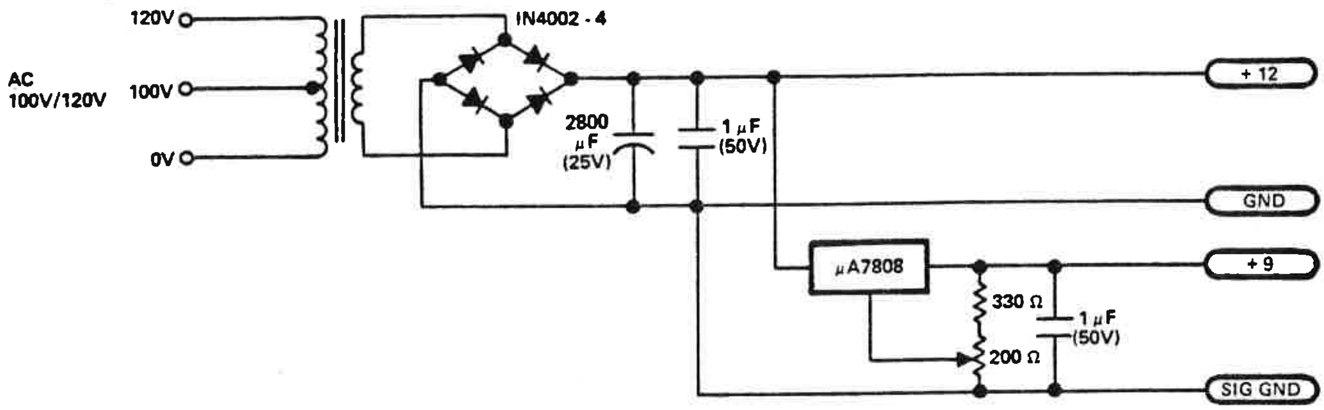
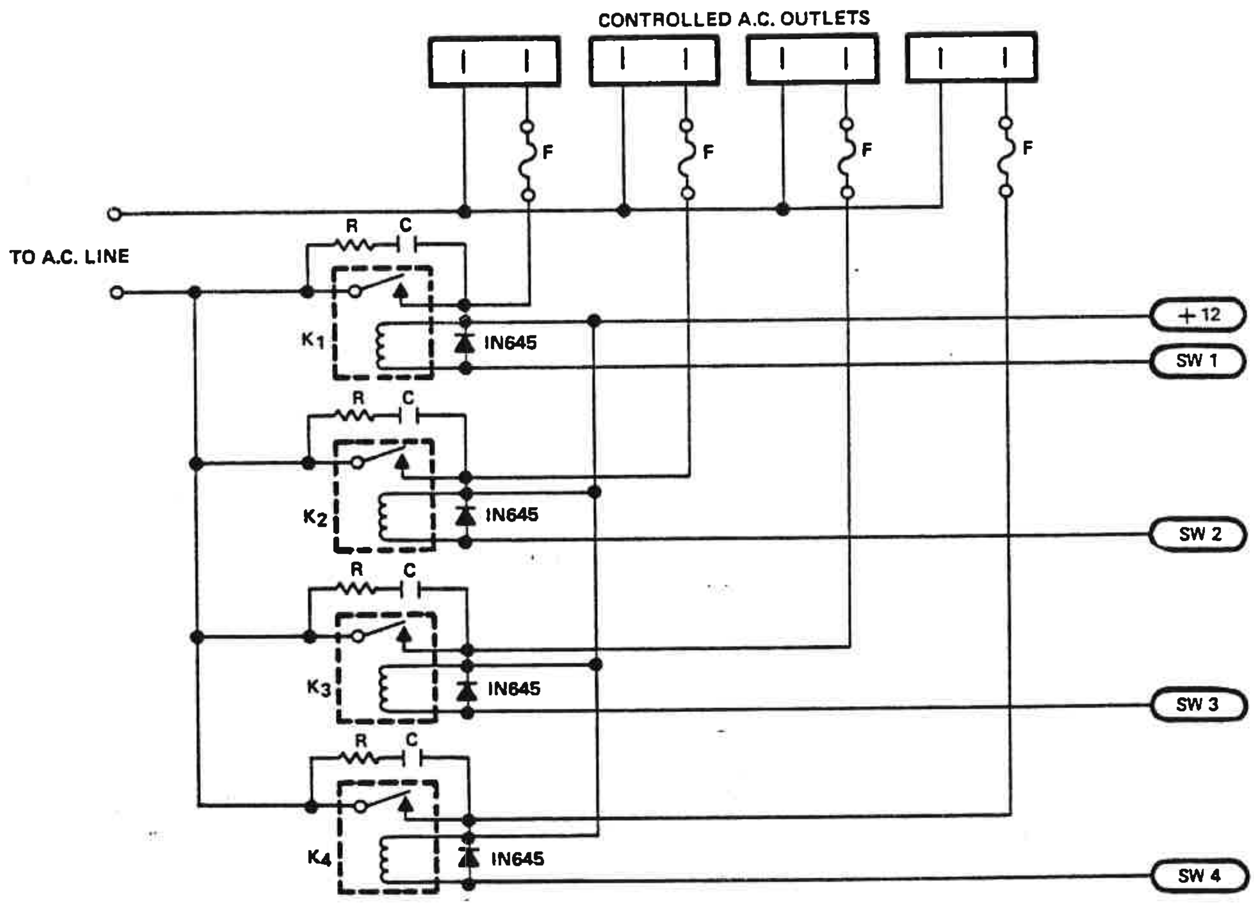


FIGURE 5. TYPICAL POWER SUPPLY FOR THE UNIVERSAL TIMER CONTROLLER



NOTE: R AND C ARE CONTACT ARCING SUPPRESSOR
R:10 20 Ω (TYP)
C:0.1 µF

FIGURE 6. TYPICAL A.C. OUTLET SWITCHING CIRCUIT FOR THE UNIVERSAL TIMER CONTROLLER

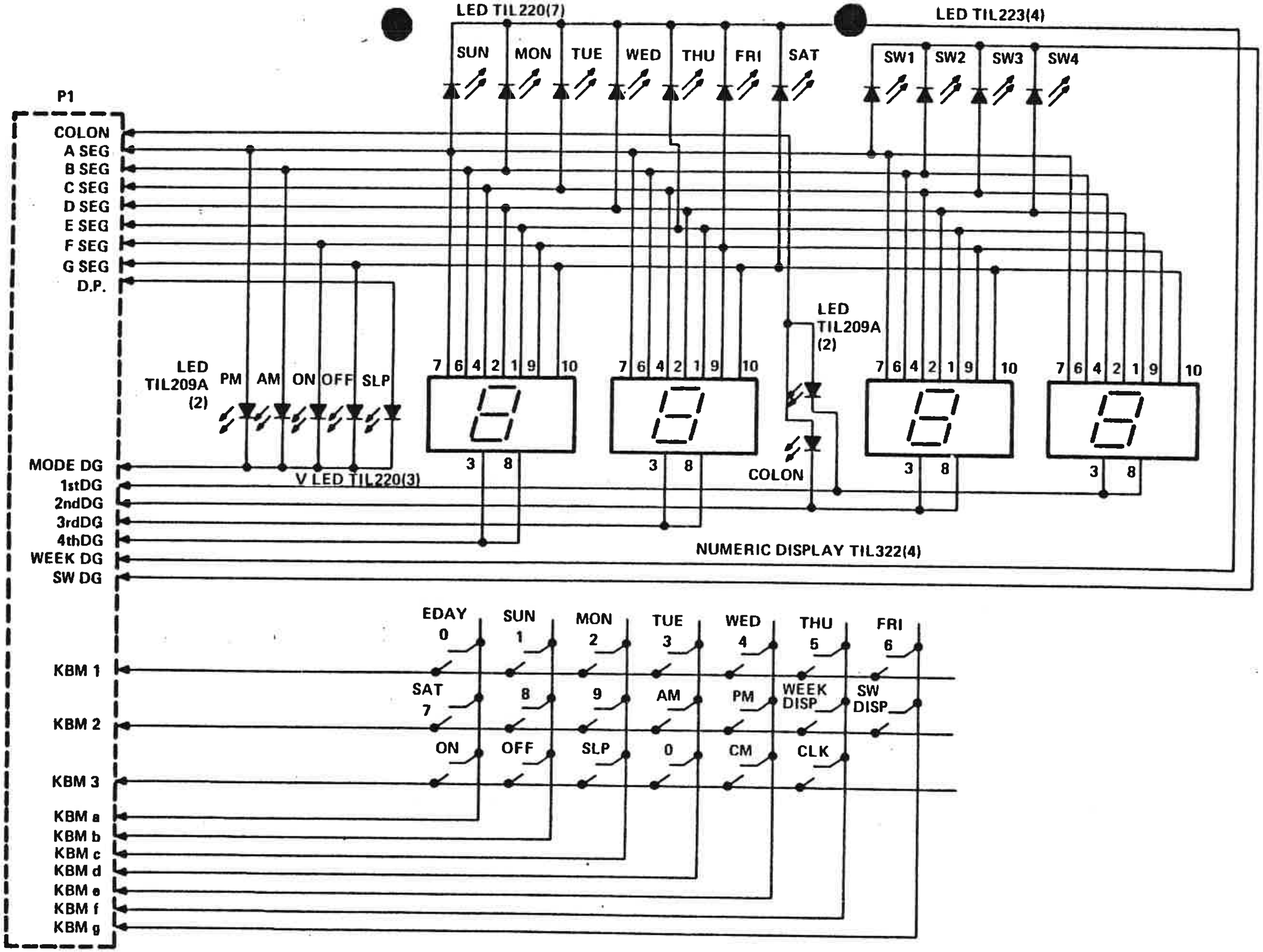
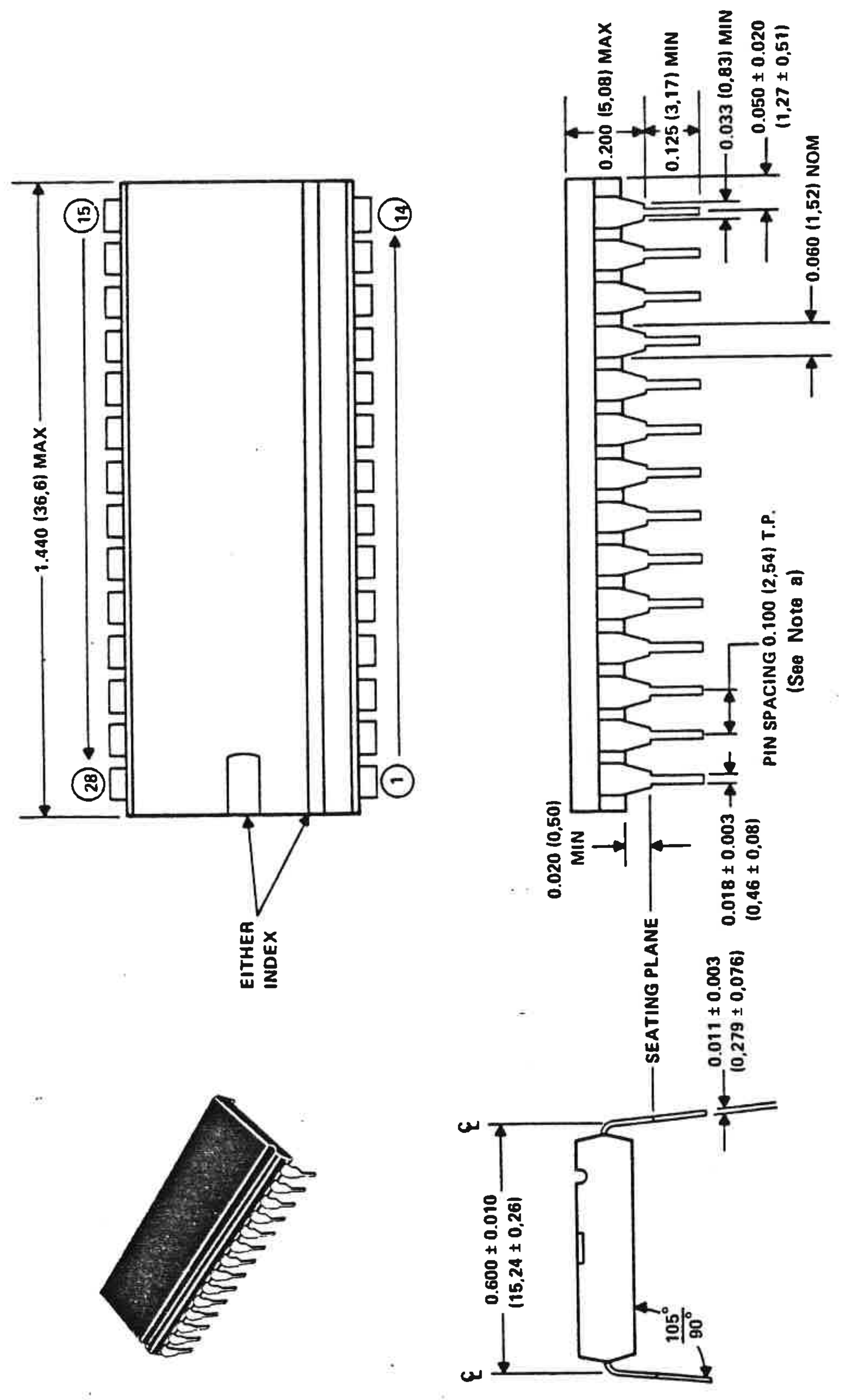


FIGURE 7. TMS 1121 DISPLAY AND KEYBOARD DIAGRAM

5. TMS 1121 MECHANICAL DATA – 28 PIN PLASTIC PACKAGE



NOTES: a. Each pin centerline is located within 0.010 inch (0.26 millimeters) of its true longitudinal position.
b. All linear dimensions are shown in inches (and parenthetically in millimeters for reference only). Inch dimensions govern.

6. TMS 1122

These are the functional differences between the TMS 1121 and TMS 1122 TIMER circuits.

- POWER UP display by flashing LED, connected across 06 and R5 outputs.
- SET CLOCK by depressing "CLK" (across the matrix points K2/R4). AM/PM keys and LED's do not exist.
- MAXIMUM interval timer set remains at 11 hours 56 minutes.
- ERROR DISPLAY of 9999 when entry exceeds "24" hours.