


**MOTOROLA**
**SEMICONDUCTORS**

TOULOUSE, FRANCE

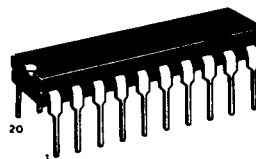
**MC144105**
**IR REMOTE CONTROL TRANSMITTER**

The MC144105 remote control transmitter converts a keyboard input into a pulse code modulated signal suitable for infra-red transmission to an appropriate receiver. Its large command capacity, 512 commands, makes it highly suited to remote control applications in TV, Video, Hi-Fi etc. The transmitter is an LSI circuit realised in complementary MOS technology.

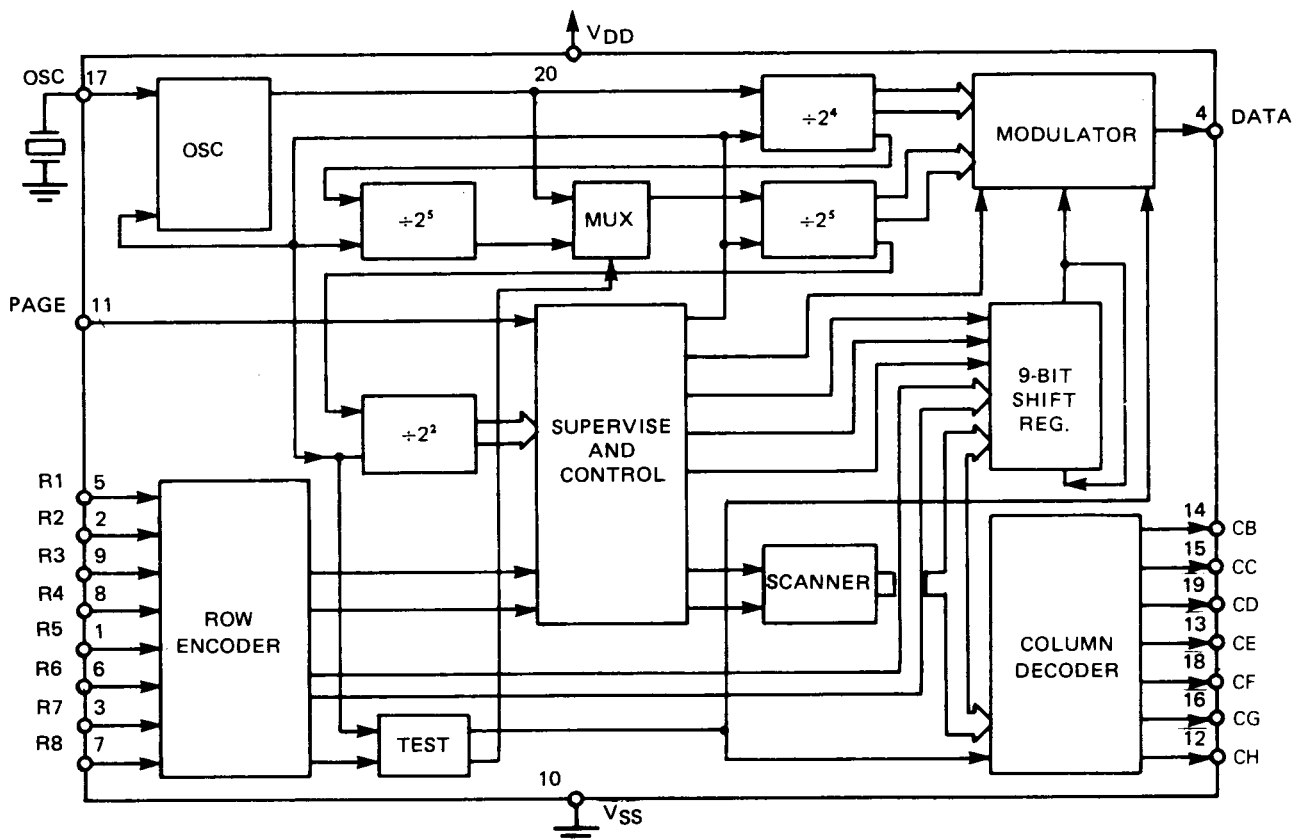
- Binary coded, 9-bit PCM data word
- Simple modulator requirements
- One pin reference oscillator for external ceramic resonator
- Very low, maximum  $1\mu\text{A}$ , standby current consumption
- Wide operating voltage range; 4 to 10V DC

**IR REMOTE CONTROL TRANSMITTER**
**CMOS LSI**

(LOW-POWER COMPLEMENTARY MOS)



**P SUFFIX**  
PLASTIC PACKAGE  
CASE 738-02

**FIGURE 1 – BLOCK DIAGRAM AND PIN ASSIGNMENT**


**MAXIMUM RATINGS** (Voltages referenced to VSS)

Rating	Symbol	Value	Unit
DC Supply Voltage	V <sub>DD</sub>	-0.5 to +12	Vdc
Input Voltage, all Inputs	V <sub>IN</sub>	-0.5 to V <sub>DD</sub> +0.5	Vdc
DC Current Drain per Pin (except Signal Out and V <sub>DD</sub> )	I	2	mAdc
DC Current Drain (Signal Out and V <sub>DD</sub> )	I	10	mAdc
Operating Temperature Range	T <sub>A</sub>	-40 to +85	°C
Storage Temperature Range	T <sub>STG</sub>	-65 to +150	°C

**ELECTRICAL CHARACTERISTICS**

Characteristic	Symbol	V <sub>DD</sub> Vdc	-40°C		+25°C			+85°C		Unit
			Min	Max	Min	Typ	Max	Min	Max	
Inputs R1 ... R8 and PAGE (with pull-up)	I <sub>IN</sub>	4	—	70	—	—	50	—	40	μA
I <sub>IN</sub> at V <sub>IN</sub> = 1.2V		10	—	350	—	—	250	—	200	μA
I <sub>IN</sub> at V <sub>IN</sub> = 3V		4	5	—	4	—	—	3	—	μA
I <sub>IN</sub> at V <sub>IN</sub> = 2.8V		10	25	—	20	—	—	15	—	μA
V <sub>IH</sub>	V <sub>IH</sub>	4	2.8	—	2.8	—	—	2.8	—	V
V <sub>IH</sub>		10	7	—	7	—	—	7	—	V
V <sub>IL</sub>	V <sub>IL</sub>	4	—	1.2	—	—	1.2	—	1.2	V
V <sub>IL</sub>		10	—	3	—	—	3	—	3	V
Outputs CB ... CH (open drain)	I <sub>ON</sub>	4	270	—	200	—	—	160	—	μA
I <sub>ON</sub> at V <sub>ON</sub> = 1.2V		10	1350	—	1000	—	—	800	—	μA
I <sub>OFF</sub>	I <sub>OFF</sub>	4	—	1	—	1	—	—	1	μA
I <sub>OFF</sub>		10	—	1	—	1	—	—	1	μA
Output DATA	V <sub>OH</sub>	4	3.2	—	3.0	—	—	2.8	—	V
V <sub>OH</sub> at I <sub>SOURCE</sub> = 1.0mA		10	9.6	—	9.5	—	—	9.4	—	V
V <sub>OL</sub> at I <sub>SINK</sub> = 1.0mA	V <sub>OL</sub>	4	—	0.8	—	—	1	—	1.2	V
V <sub>OL</sub> at I <sub>SINK</sub> = 1.0mA		10	—	0.4	—	—	0.5	—	0.6	V
Supply Voltage	V <sub>DD</sub>	—	4	10	4	—	10	4	10	V
Standby Current	I <sub>DDSTB</sub>	4	—	—	—	0.02	1	—	—	μA
		10	—	—	—	0.02	1	—	—	μA
Active Mode Current	I <sub>DDACT</sub>	4	—	—	—	0.07	1	—	—	mA
		10	—	—	—	0.45	2	—	—	mA
Oscillator Frequency	f <sub>osc</sub>	—	—	—	430	—	530	—	—	kHz

**CIRCUIT TIMING** (see Figure 3: Timing Diagram)

Modulation	a = 4/f <sub>osc</sub>	8μs	(1/f <sub>carrier</sub> )
	b = 16/f <sub>osc</sub>	32μs	
	c = 4/f <sub>osc</sub>	8μs	
	d = 256/f <sub>osc</sub>	512μs	
Message Timing	d = 256/f <sub>osc</sub>	512μs	(half-bit time)
	e = 512/f <sub>osc</sub>	1.02ms	(bit time)
	f = 1536/f <sub>osc</sub>	3.072ms	(pre-pulse time)
Command Timing	g = 32 X bit	32.8ms	
	h = 128 X bit	131ms	
	i = 128 X bit	131ms	
	t <sub>key</sub> = 64 X bit	65.6ms	

Times indicated are typical and refer to an oscillator frequency of 500kHz

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. For proper operation it is recommended that V<sub>in</sub> and V<sub>out</sub> be constrained to the range V<sub>SS</sub> ≤ (V<sub>in</sub> or V<sub>out</sub>) ≤ V<sub>DD</sub>.

Unused inputs must always be tied to an appropriate logic voltage level (e.g., either V<sub>SS</sub> or V<sub>DD</sub>).

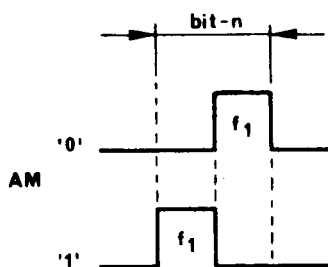


## CIRCUIT OPERATION

The transmitter emits a 9-bit, labelled A (LSB) to I (MSB), binary code able to encode 512 commands organised as 8 pages of 64 commands. All of these commands are user selectable except the last command, 511, which is used as an SST, Start/Stop Transmission code.

Each bit of the transmitted signal is in the form of a biphasic pulse code modulated (PCM) signal, whose coding is shown in Figure 2, below.

FIGURE 2 – SIGNAL CODING



$f_1$  is a train of pulses at the carrier frequency  $\div 16$ .

The keyboard can be a simple switch matrix, connected between the eight row inputs (1 to 8) and the seven column outputs (B to H).  $V_{SS}$  acts as the eighth column line to give the full complement of 64 commands per page. The maximum 'ON' resistance of the keyboard must be limited to  $500\Omega$ .

Page access is accomplished by connecting, by means of a key, the page input to one of the seven column outputs or by leaving the input open circuit.

One of the circuit's major features is its low standby current consumption – typically less than  $1\mu A$ . For this reason the battery may be left continuously in circuit.

As soon as a key is selected the circuit switches to its active mode and enables the oscillator. To allow for accidental activation and/or key bounce the circuit requires that the key is held for a minimum delay of  $t_{key}$  (see Figure 3) which in the case of a 500kHz oscillator is 65.6ms. After this delay the column/row/page command, consisting of a string of messages (see Figure 3), appropriate

to the key selected will be transmitted and repeated until the key is released.

Any page key required must be selected before, and held during the selection of the column/row matrix key, if this sequence is not followed the circuit will default to the appropriate command between 0 and 63. If two or more page keys are accidentally held down only the first one pressed will be detected.

A command consists of several messages. Each command starts with the message 511 (SST) followed by the message appropriate to the key selected. These messages are repeated until the key is released. The final message is always followed by the SST message, 511.

Every message consists of a pre-bit, a pre-bit pause, a start-bit and nine data bits, where the pre-bit and the start-bit are always logical '1'. The pre-bit allows for the set up of the AGC loop in the receiving preamplifier. The truth tables for the data bits are given in Tables 1 and 2 while Figure 3 shows the timing relationships between the commands, messages and modulation.

In the event of accidental multi-key operation the circuit will react in one of three ways, depending on the combination of the keys selected.

Where two, or more, keys are connected to the same row input and any column output except A; the command appropriate to the first key selected will be transmitted until that key is released. After the SST code has been transmitted, assuming another key is still selected, the command appropriate to that key will be transmitted. If the other key has been released in the meantime, the circuit will revert to standby.

If two keys are selected in the same row with one being connected to column A any transmission will terminate, with the SST code, and then the circuit will transmit the command appropriate to the key connected to column A.

In the case where two or more keys connected to the same column are selected the circuit reacts, totally normally, to the first key activated. Upon selection of the second key the SST code is transmitted and the circuit will revert to the standby mode. Only, when the multi-key condition is released and a single key is selected will the circuit resume operation, as previously described.



FIGURE 3 - TIMING RELATIONSHIPS

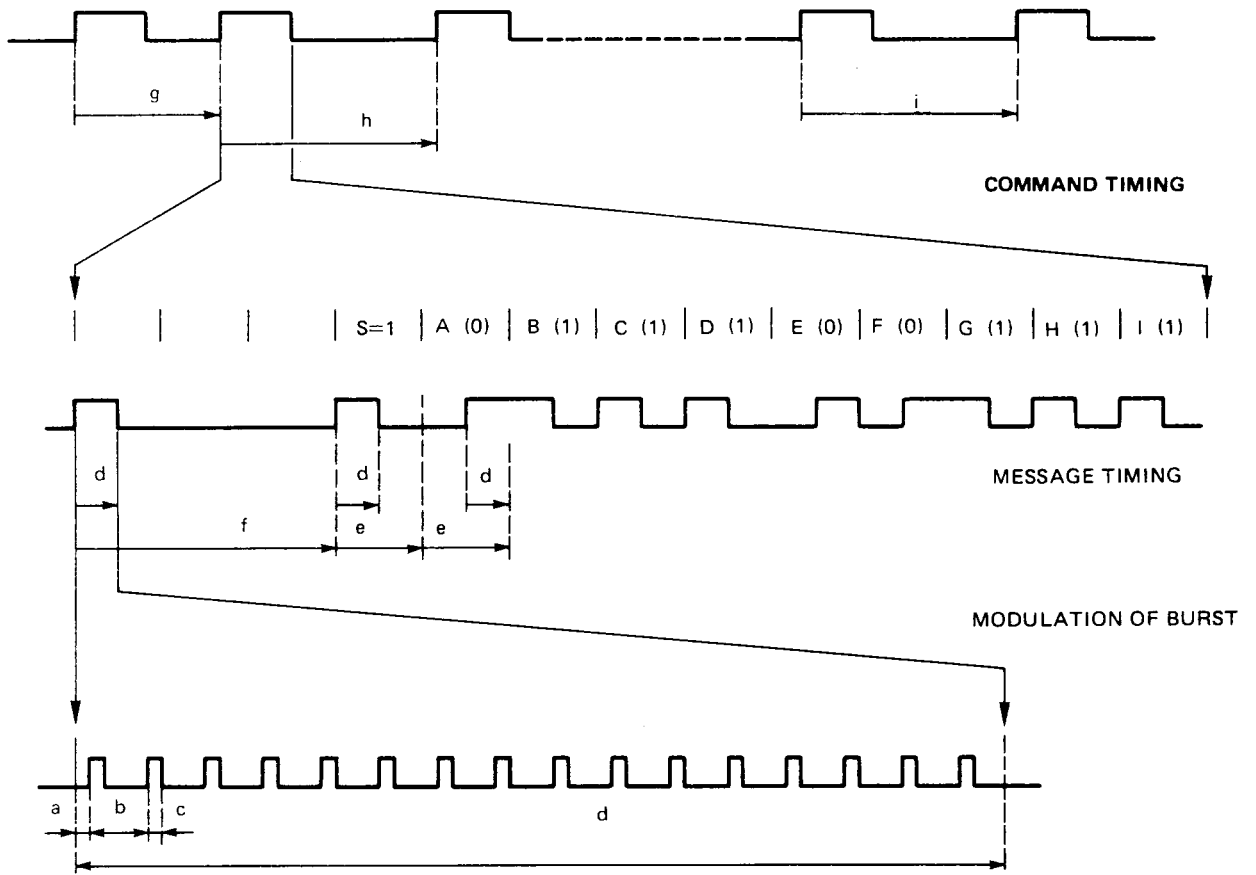
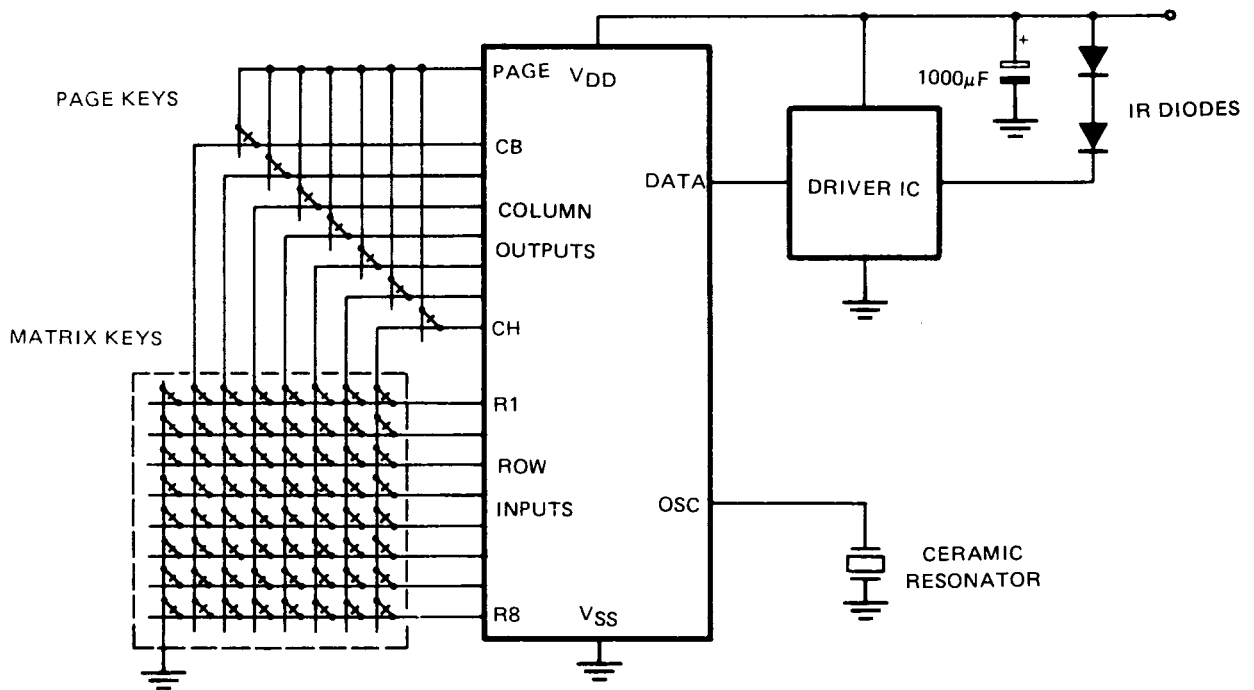


FIGURE 4 - TRANSMITTER CIRCUIT



## INPUT/OUTPUT FUNCTIONS

**ROW INPUTS** — 1 to 8 (pins 1, 2, 3, 5, 6, 7, 8 & 9) In the standby mode these inputs are held high by internal pull-up resistors. As soon as a key is pressed a logical '0' is presented by the column output on that particular line. This switches the circuit to the active mode and starts the oscillator.

**COLUMN OUTPUTS** — B to H (pins 12, 13, 14, 15, 16, 18 & 19) In the standby mode these pins are held low, logical '0'. When a key is selected and the oscillator starts the outputs are released and the scanning routine starts.

**PAGE INPUT** — (pin 11) This input is connected directly to the transmitter's supervisory and control circuitry and may be connected to one of the column outputs, via a key, or left open. If the pin is left open the first page of 64 commands will be available — see the truth table, Table 1. If connected to one of the column outputs the remaining pages become available — see Table 2. The specified standby current consumption is maintained regardless of the load applied to the input:

$$0V \leq V_{\text{page}} \leq V_{\text{DD}}$$

**OSCILLATOR** — (pin 17) A one pin oscillator is incorporated into the circuit which has been specifically designed for use with an inexpensive ceramic resonator between 430kHz and 530kHz. It is possible to use a tuned LC circuit with a series capacitor, in place of the ceramic resonator.

**DATA OUTPUT** — (pin 4) This output provides the modulated signal for subsequent amplification externally.

**SPECIAL NOTE: KEYBOARD** It is important, when considering a keyboard, that the maximum 'ON' resistance, even after aging, of 500Ω is strictly observed.

TABLE 1 — TRANSMITTED CODES

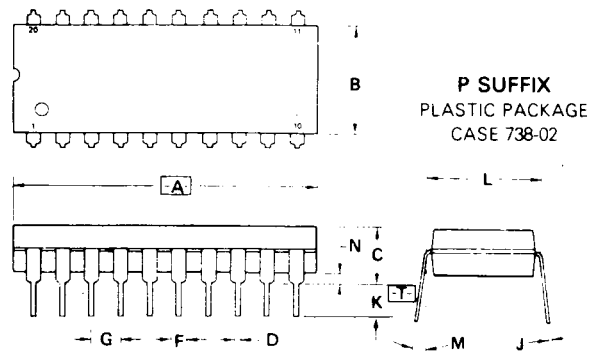
MESSAGE NUMBER	MATRIX CONNECT ROW/COL	BINARY CODE								
		A	B	C	D	E	F	G	H	I
0	1A	0	0	0	0	0	0	0	0	0
1	1B	1	0	0	0	0	0	0	0	0
2	1C	0	1	0	0	0	0	0	0	0
3	1D	1	1	0	0	0	0	0	0	0
4	1E	0	0	1	0	0	0	0	0	0
5	1F	1	0	1	0	0	0	0	0	0
6	1G	0	1	1	0	0	0	0	0	0
7	1H	1	1	1	0	0	0	0	0	0
8	2A	0	0	0	1	0	0	0	0	0
9	2B	1	0	0	1	0	0	0	0	0
10	2C	0	1	0	1	0	0	0	0	0
11	2D	1	1	0	1	0	0	0	0	0
12	2E	0	0	1	1	0	0	0	0	0
13	2F	1	0	1	1	0	0	0	0	0
14	2G	0	1	1	1	0	0	0	0	0
15	2H	1	1	1	1	0	0	0	0	0
16	3A	0	0	0	0	1	0	0	0	0
17	3B	1	0	0	0	1	0	0	0	0
18	3C	0	1	0	0	1	0	0	0	0
19	3D	1	1	0	0	1	0	0	0	0
20	3E	0	0	1	0	1	0	0	0	0
21	3F	1	0	1	0	1	0	0	0	0
22	3G	0	1	1	0	1	0	0	0	0
23	3H	1	1	1	0	1	0	0	0	0
24	4A	0	0	0	1	1	0	0	0	0
25	4B	1	0	0	1	1	0	0	0	0
26	4C	0	1	0	1	1	0	0	0	0
27	4D	1	1	0	1	1	0	0	0	0
28	4E	0	0	1	1	1	0	0	0	0
29	4F	1	0	1	1	1	0	0	0	0
30	4G	0	1	1	1	1	0	0	0	0
31	4H	1	1	1	1	1	0	0	0	0
32	5A	0	0	0	0	0	1	0	0	0
33	5B	1	0	0	0	0	1	0	0	0
34	5C	0	1	0	0	0	1	0	0	0
35	5D	1	1	0	0	0	1	0	0	0
36	5E	0	0	1	0	0	1	0	0	0
37	5F	1	0	1	0	0	1	0	0	0
38	5G	0	1	1	0	0	1	0	0	0
39	5H	1	1	1	0	0	1	0	0	0
40	6A	0	0	0	1	0	1	0	0	0
41	6B	1	0	0	1	0	1	0	0	0
42	6C	0	1	0	1	0	1	0	0	0
43	6D	1	1	0	1	0	1	0	0	0
44	6E	0	0	1	1	0	1	0	0	0
45	6F	1	0	1	1	0	1	0	0	0
46	6G	0	1	1	1	0	1	0	0	0
47	6H	1	1	1	1	0	1	0	0	0
48	7A	0	0	0	0	1	1	0	0	0
49	7B	1	0	0	0	1	1	0	0	0
50	7C	0	1	0	0	1	1	0	0	0
51	7D	1	1	0	0	1	1	0	0	0
52	7E	0	0	1	0	1	1	0	0	0
53	7F	1	0	1	0	1	1	0	0	0
54	7G	0	1	1	0	1	1	0	0	0
55	7H	1	1	1	0	1	1	0	0	0
56	8A	0	0	0	1	1	1	0	0	0
57	8B	1	0	0	1	1	1	0	0	0
58	8C	0	1	0	1	1	1	0	0	0
59	8D	1	1	0	1	1	1	0	0	0
60	8E	0	0	1	1	1	1	0	0	0
61	8F	1	0	1	1	1	1	0	0	0
62	8G	0	1	1	1	1	1	0	0	0
63	8H	1	1	1	1	1	1	0	0	0

TABLE 2 — PAGE TABLE

MESSAGE	PAGE INPUT CONNECTED TO	G	H	I
0 to 63	not connected	0	0	0
64 to 127	CB	1	0	0
128 to 191	CC	0	1	0
192 to 255	CD	1	1	0
256 to 319	CE	0	0	1
320 to 383	CF	1	0	1
384 to 447	CG	0	1	1
448 to 511	CH	1	1	1



OUTLINE DIMENSIONS




NOTES:

1. DIM [A] IS DATUM.
2. POSITIONAL TOL FOR LEADS:  
 $\oplus \ominus \varnothing 0.25 (0.010) \text{ (M) T A (M)}$
3. [T] IS SEATING PLANE.
4. DIM "B" DOES NOT INCLUDE MOLD FLASH.
5. DIM [L] TO CENTER OF LEADS WHEN FORMED PARALLEL.
6. DIMENSIONING AND TOLERANCING PER ANSI Y14.5, 1973.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	25.65	27.18	1.010	1.070
B	6.10	6.60	0.240	0.260
C	3.94	4.57	0.155	0.180
D	0.38	0.56	0.015	0.022
F	1.27	1.78	0.050	0.070
G	2.54 BSC		0.100 BSC	
J	0.20	0.38	0.008	0.015
K	2.79	3.56	0.110	0.140
L	7.62 BSC		0.300 BSC	
M	0°	15°	0°	15°
N	0.51	1.02	0.020	0.040



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