

T-45-17

**MC8503**
**UNIVERSAL POLYNOMIAL GENERATOR (UPG)**

The MC8503 Universal Polynomial Generator (UPG) is used in serial digital data handling systems for error detection and correction. The serial data stream is divided by a selected polynomial and the division remainder is transmitted at the end of the data stream as a Cyclic Redundancy Check Character (CRCC). When the data is received the same calculation is performed. If there were no errors in transmission, the new remainder will be zero.

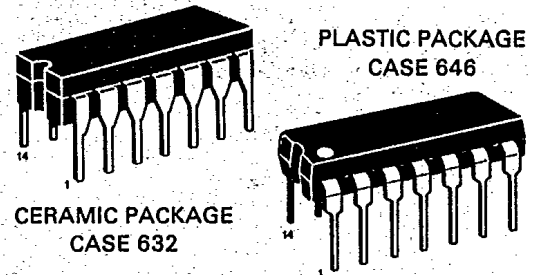
The MC8503 offers four of the more common polynomials for error detection techniques including a read forward and reverse on the CRCC-16 and CRCC-CCITT polynomial functions. These polynomials can be generated by changing the binary select codes as shown in Figure 1.

- Four Unique Polynomial Codes in One Package
- Compatible with TTL  
Maximum Fan-Out = 1 TTL Load
- Data Rate = 3.5 MHz Typical
- Total Power Dissipation = 400 mW Typical
- +5.0-Volt Operation

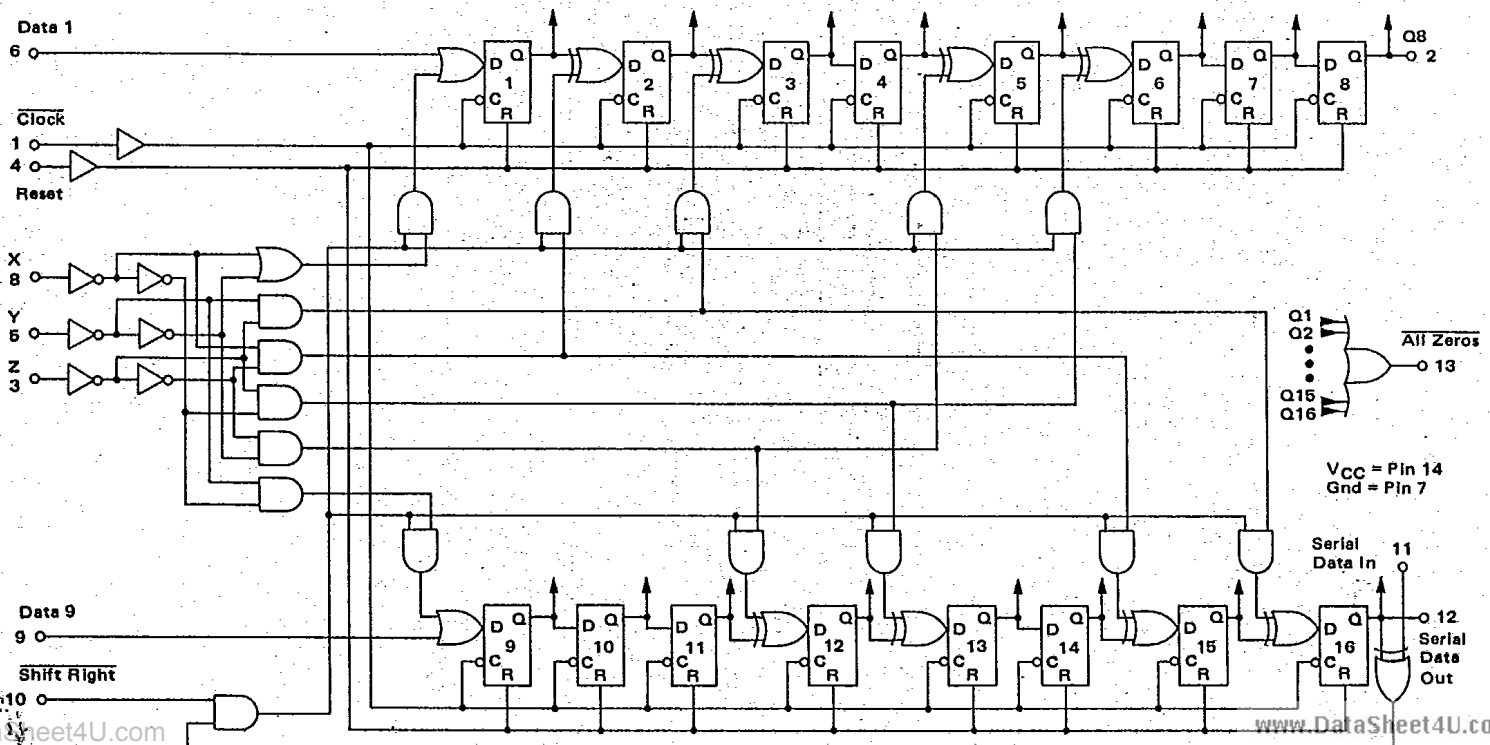
Typical Applications Include:

- Floppy Disks
- Cassettes
- Data Communications

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**BIPOLAR LSI**
**UNIVERSAL POLYNOMIAL GENERATOR**

**FIGURE 1 - AVAILABLE POLYNOMIALS**

CODE SELECT			POLYNOMIAL	
X	Y	Z		
0	0	0	CRCC-16 (Fwd)	$X^{16} + X^{15} + X^2 + 1$
0	0	1	CRCC-16 (Bkwd)	$X^{16} + X^{14} + X + 1$
1	1	0	CRCC-CCITT (Fwd)	$X^{16} + X^{12} + X^5 + 1$
1	1	1	CRCC-CCITT (Bkwd)	$X^{16} + X^{11} + X^4 + 1$
0	1	0	LRCC-16	$X^{16} + 1$
1	0	1	LRCC-8	$X^8 + 1$

**LOGIC DIAGRAM**


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## MAXIMUM RATINGS

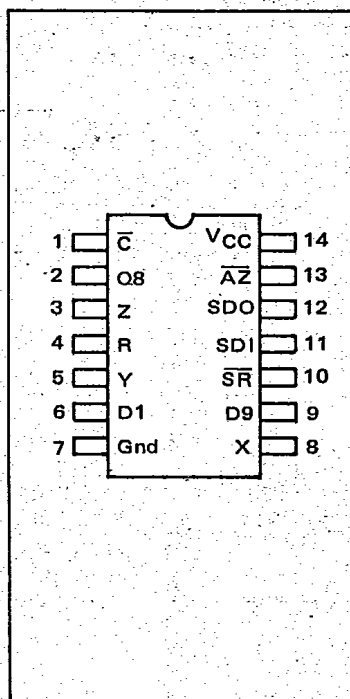
Rating	Symbol	Value	Unit
Supply Voltage	$V_{CC}$	-0.5 to +7.0	Vdc
Input Voltage	$V_{in}$	-1.0 to +5.5	Vdc
Output Voltage	$V_{OH}$	-0.5 to +7.0	Vdc
Thermal Resistance	$\theta_{JA}$	65	$^{\circ}C/W$
Operating Temperature Range	$T_A$	0 to +75	$^{\circ}C$
Storage Temperature Range	$T_{stg}$	-55 to +165	$^{\circ}C$

ELECTRICAL CHARACTERISTICS ( $V_{CC} = 5.0$  Vdc  $\pm 5\%$ ,  $T_A = 0$  to  $75^{\circ}C$  unless otherwise noted.)

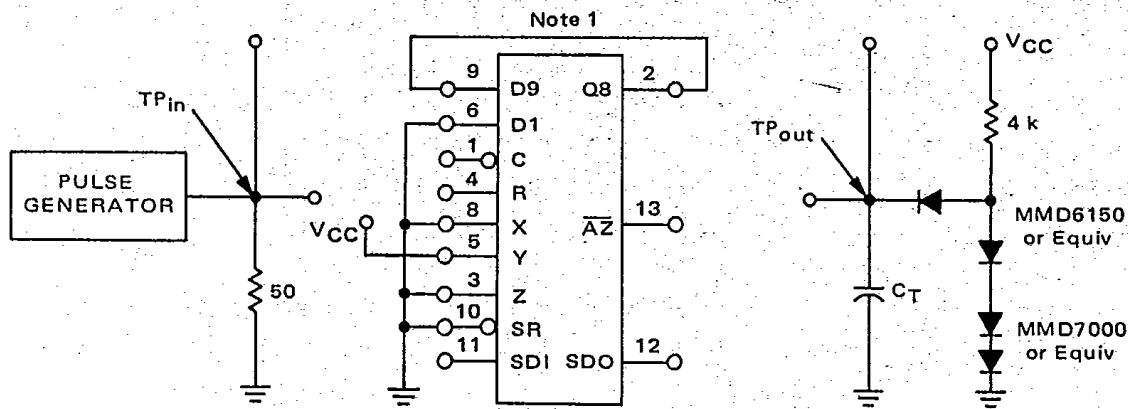
Characteristic	Symbol	Min	Max	Unit
Input Forward Current ( $V_{IL} = 0$ , $V_{CC} = 5.25$ Vdc, All Inputs)	$I_{IL}$	-	-75	$\mu A_{dc}$
Input Leakage Current ( $V_{IH} = 2.4$ Vdc, $V_{CC} = 5.25$ Vdc, All Inputs)	$I_{IH}$	-	120	$\mu A_{dc}$
Logic "0" Output Voltage ( $I_{OL} = 1.6$ mA <sub>dc</sub> , $V_{ILT} = 0.8$ Vdc, $V_{IHT} = 2.0$ Vdc, $V_{CC} = 4.75$ Vdc)	$V_{OL}$	-	0.5	Vdc
Logic "1" Output Voltage ( $I_{OH} = -0.3$ mA <sub>dc</sub> , $V_{ILT} = 0.8$ Vdc, $V_{IHT} = 2.0$ Vdc, $V_{CC} = 4.75$ Vdc)	$V_{OH}$	2.4	-	Vdc
Output Leakage Current ( $V_{CC} = V_{CEX} = 5.25$ Vdc)	$I_{CEX}$	-	100	$\mu A_{dc}$
Power Supply Drain Current ( $V_{CC} = 5.0$ Vdc, All Inputs Open)	$I_{CC}$	-	117	mA <sub>dc</sub>

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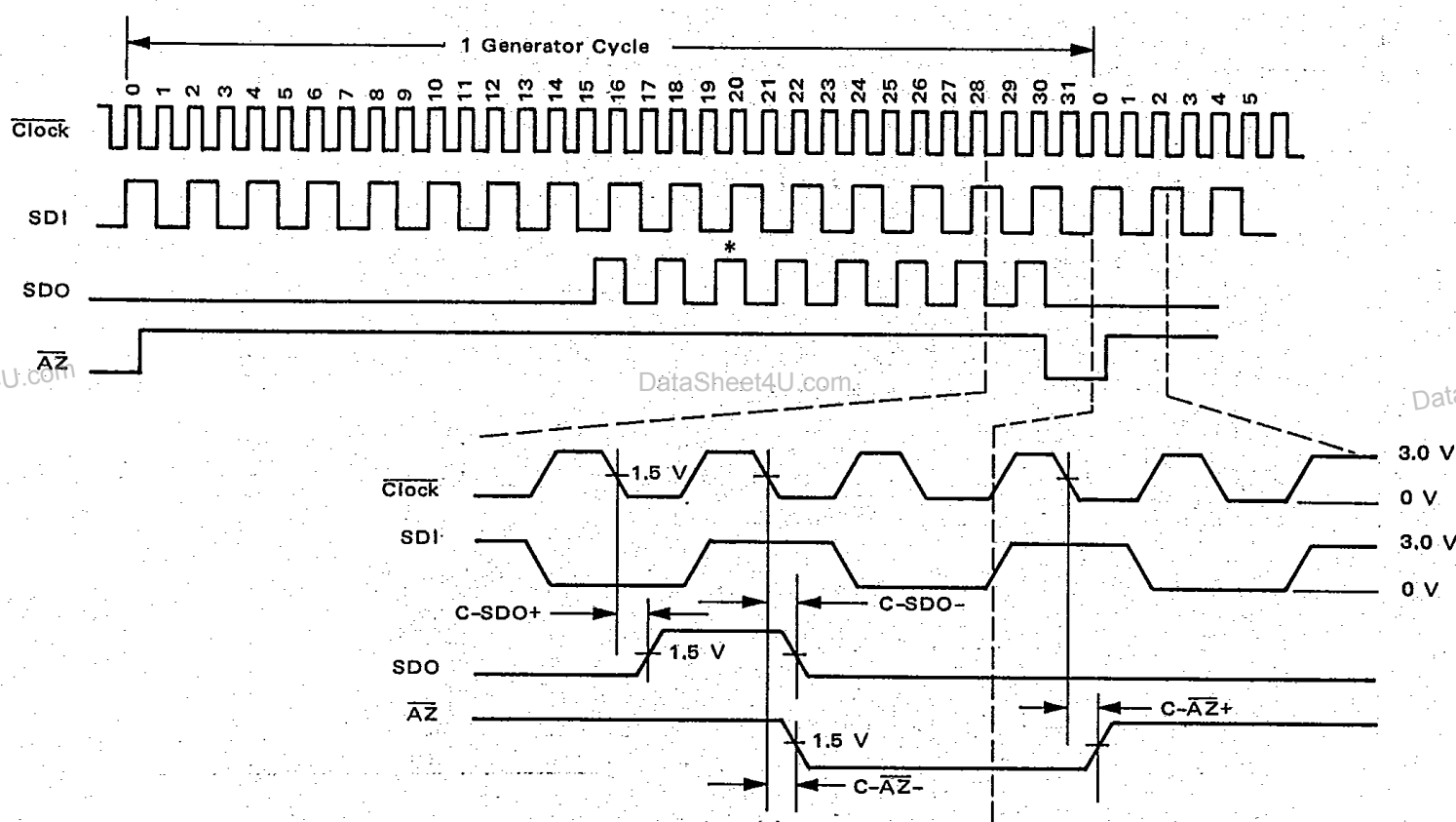
## PIN ASSIGNMENT



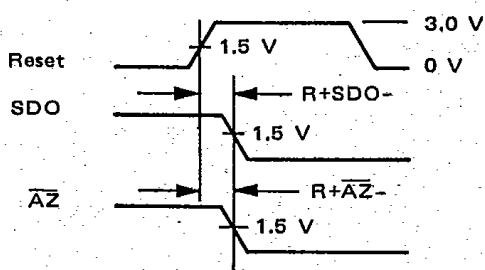
MOTOROLA Semiconductor Products Inc.



High-impedance probes ( $> 1.0$  megohm) must be used.  
 $C_T = 15$  pF = total parasitic capacitance, which includes probe, wiring, and load capacitances.  
 Note 1: Use minimum wire length to connect Q8 to D9.



\* RESET TEST TO BE MADE AT THIS POINT



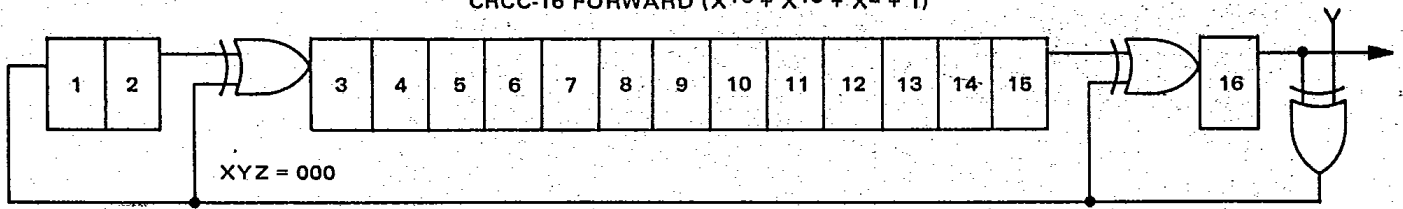
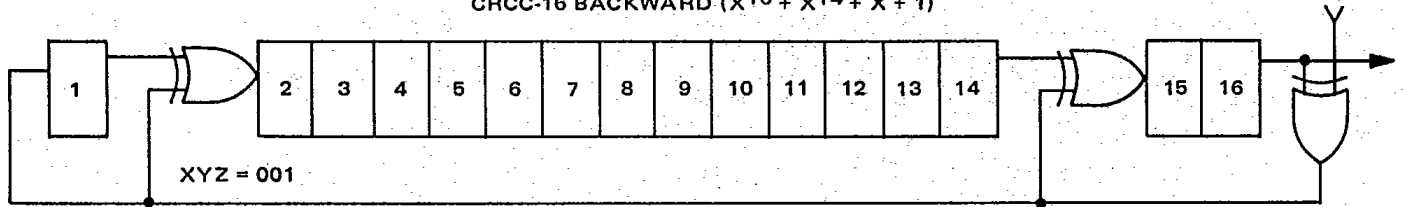
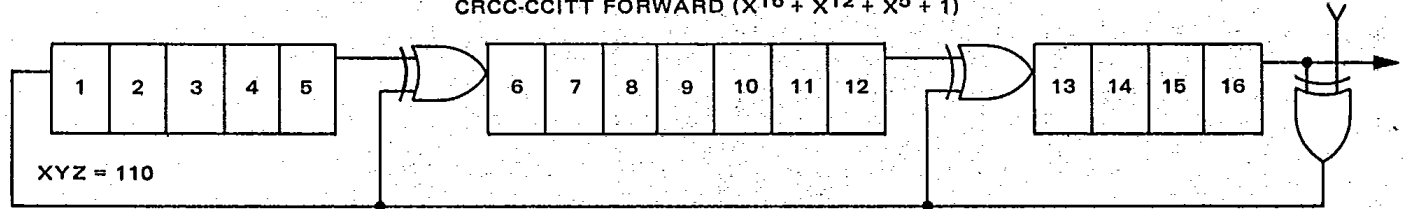
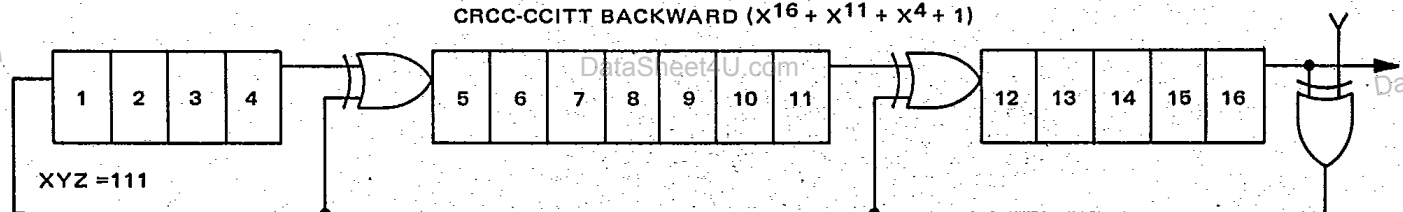
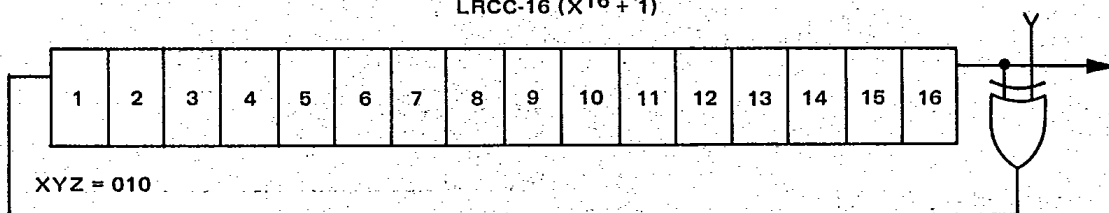
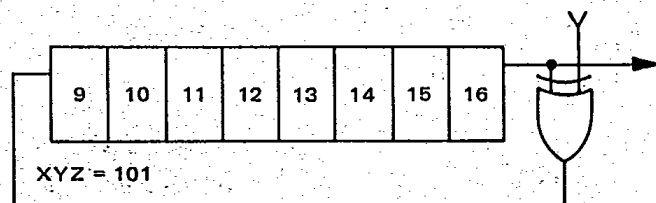
SWITCHING TIMES ( $V_{CC} = 5.0$  Vdc,  $T_A = 25^\circ$  C)

Characteristic	Symbol	Max	Unit
Clock to SDO Output – Turn-On Delay Time	$t_{C-SDO-}$	150	ns
	$t_{C-SDO+}$	125	ns
Clock to $\bar{AZ}$ Output – Turn-On Delay Time	$t_{C-\bar{AZ}-}$	130	ns
	$t_{C-\bar{AZ}+}$	175	ns
Reset to SDO Output – Turn-On Delay Time	$t_{R+SDO-}$	160	ns
Reset to $\bar{AZ}$ Output – Turn-On Delay Time	$t_{R+\bar{AZ}-}$	140	ns
Data Setup Time	$t_{setup}$	100 ns max	
Data Hold Time	$t_{hold}$	0 ns; min	
Minimum Reset Pulse Width	$t_{pw}$	100 ns; min	

Note: AC test in LRCC-16 Mode.



FIGURE 2 – ERROR CONTROL FUNCTIONS

CRCC-16 FORWARD ( $X^{16} + X^{15} + X^2 + 1$ )CRCC-16 BACKWARD ( $X^{16} + X^{14} + X + 1$ )CRCC-CCITT FORWARD ( $X^{16} + X^{12} + X^5 + 1$ )CRCC-CCITT BACKWARD ( $X^{16} + X^{11} + X^4 + 1$ )LRCC-16 ( $X^{16} + 1$ )LRCC-8 ( $X^8 + 1$ )

## OPERATING CHARACTERISTICS

The MC8503 Polynomial Generator may be used to implement any of the error control functions shown in Figure 2. These circuits are used in a variety of digital recording systems, and are used to both generate and check the check characters transmitted with a serial data stream.

Both the data and the encoding character are termed "polynomials" in the sense that each bit position of a serial data stream can be thought of as a coefficient of the general polynomial  $f(X) = a_0 + a_1X + a_2X^2 + \dots + a_{k-1}X^{k-1} + a_kX^k$ . For the binary case, each coefficient must be either one or zero. In this context the polynomial  $X^{16} + X^{15} + X^2 + 1$  is represented by the binary word 1100000000000101.

The check characters are generated by "dividing" the data by the encoding polynomial. The remainder resulting from the division is then appended to the message stream as a check character. During reception of the data it is again divided by the same polynomial. If no errors have occurred in transmission, the result of this division should be "zero" since adding the check character (remainder) to the message has the effect of making the received message evenly divisible by the code polynomial.

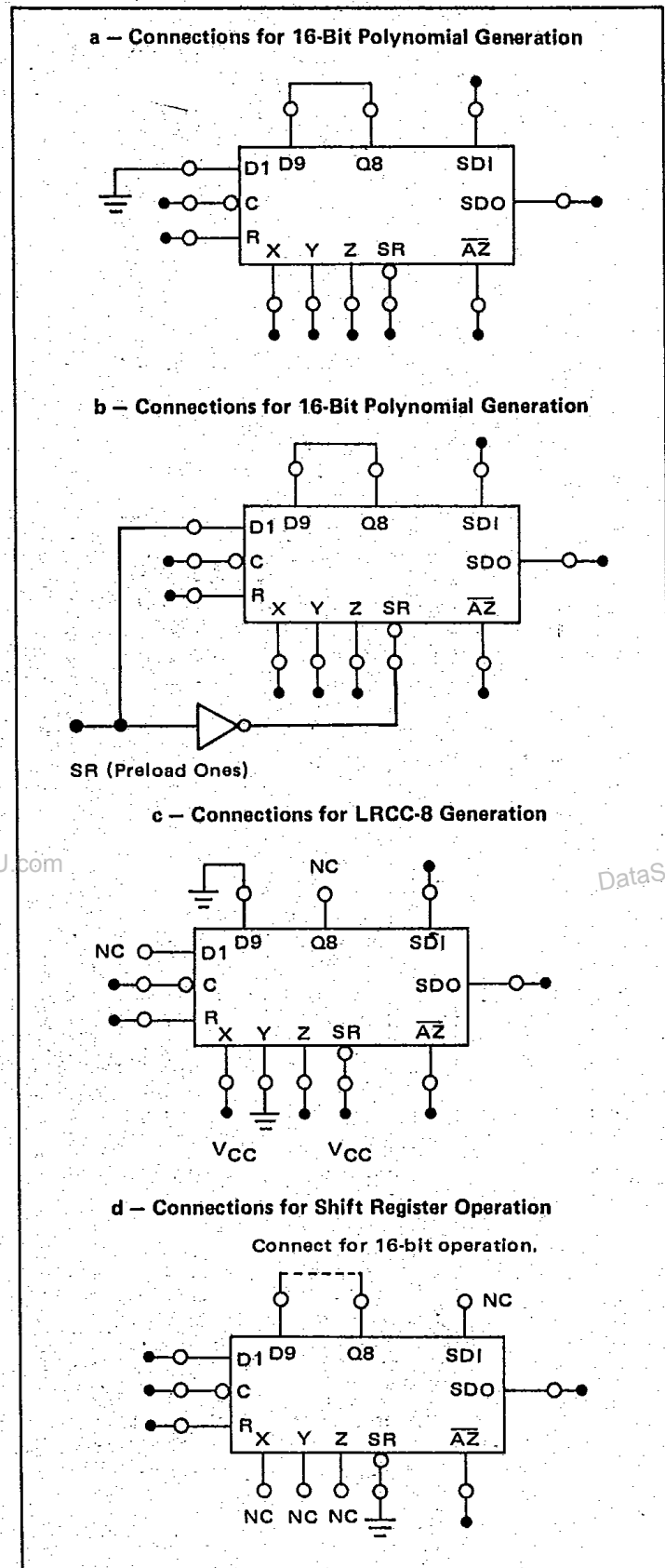
The MC8503 generates the check characters by entering each bit of the data stream into the Serial Data In terminal. This process effectively divides the data stream by the code selected by means of control lines X, Y, and Z as indicated in Figure 2. After the last data bit is entered, the check character is stored in the MC8503; it is then added to the data stream by taking the Shift Right control low and clocking the generator.

During reception the data is passed through an identical circuit and if no errors have occurred the internal All Zeros detector provides an indication that the data was correctly received. While the encoding techniques used provide some capability for error correction, the most common procedure is to request a re-transmission if errors are detected.

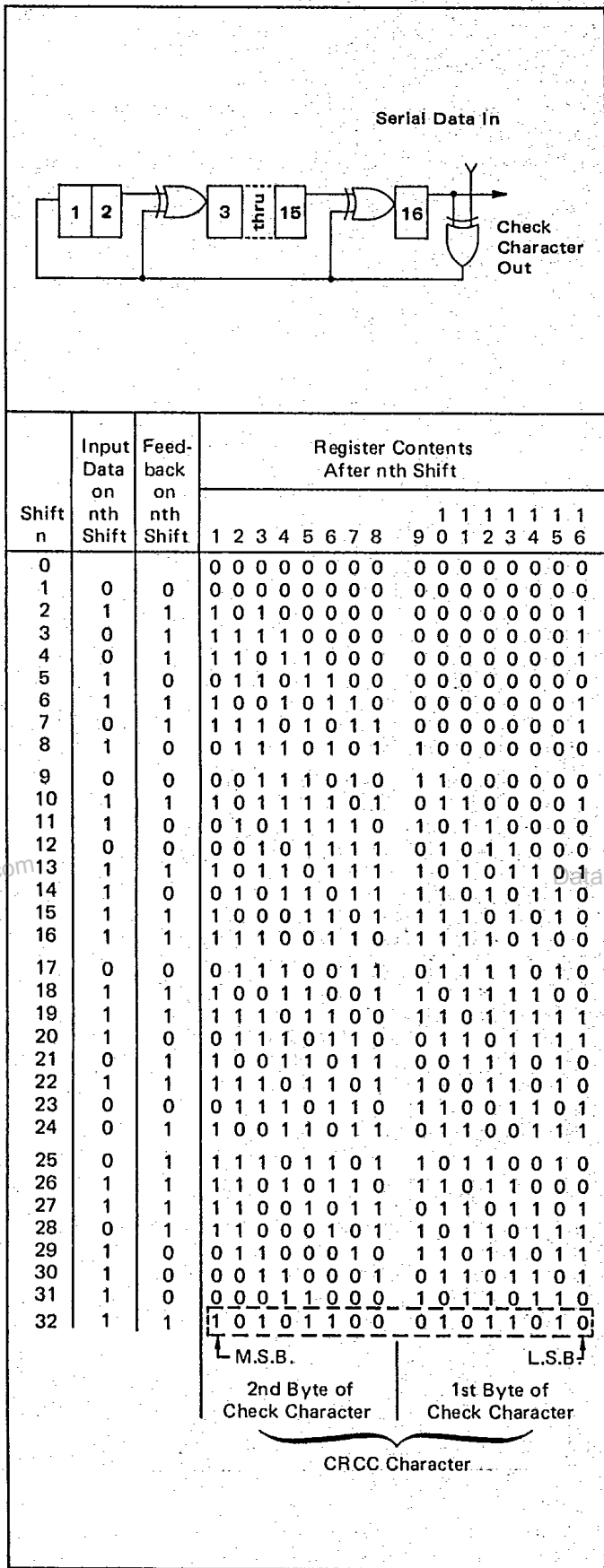
Figure 3 shows the external connections required for the various operating modes. Note that the circuit can be used as one sixteen-bit shift register, or as two synchronous eight-bit registers by holding Shift Right low and treating Data 1 and Data 9 as serial data inputs. Applications requiring the polynomial generator to be preset to all ones use the external connections shown in Figure 3b.

Operation of the MC8503 for each of the selectable codes is shown in Figures 4 thru 11. In Figure 4, the results of shifting a four byte data message into an MC8503 connected for CRCC-16 generation are shown (clock and control functions are omitted for clarity). After the last message bit has been entered by the 32nd shift pulse, the register contains the CRCC-16 check character. The check character would be shifted out (using the Shift Right control and 16 additional shift pulses) and transmitted as the last two data bytes of the message, with the least significant bit going first.

FIGURE 3 – EXTERNAL CONNECTIONS



**FIGURE 4 – GENERATION OF CRCC-16 (X<sup>16</sup> + X<sup>15</sup> + X<sup>2</sup> + 1) CHECK CHARACTER**



During reception, error checking is done by shifting the data, including the check character, through a similar circuit. This is illustrated in Figure 5. If no errors have occurred during transmission, the results of the first 32 shifts would be identical to those shown in Figure 4. Shifts 33 through 48 cause the check character to be entered, and for correct data will activate the All Zeros detector on shift 48.

Detection of errors is normally followed by a request for re-transmission of the data block. In cassette tape systems using this method of error detection, re-reading the data would require rewinding the tape to return to the beginning of the data block. The MC8503 eliminates this problem by providing the read backward mode shown in Figure 6. Note that the data is shown entering the MC8503 in reverse order, i.e., the most significant bit of the recorded check character is the first bit entered. The operation shown assumes a correct read is obtained as indicated by the all zeros condition of the register after the 48th shift.

Generation and checking examples similar to those just described, but for the CCITT check character, are shown in Figures 7, 8 and 9.

Longitudinal Redundancy Check Character (LRCC) operation, while related to CRCC operation, has significant differences. In Figures 4 thru 9, the CRCC circuits are shown operating on eight bit bytes since this is a common transmission or recording mode. However, the operation is equally valid for serial message streams of any length, i.e., the message length does not have to be a multiple of the byte length.

Longitudinal redundancy checking is used only with data bytes of specified length, i.e., LRCC-8 is used with eight-bit bytes and LRCC-16 is used with sixteen-bit characters. The value (1 or 0) of each bit position in the

**FIGURE 5 – CRCC-16 READ OPERATION**

Shift n	Input Data on nth Shift	Feed-back on nth Shift	Register Contents After nth Shift															
			1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6
•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	
31	1	0	0	0	0	1	1	0	0	0	1	0	1	1	0	1	0	
32	1	1	1	0	1	0	1	1	0	0	0	1	0	1	1	0	1	
33	0	0	0	1	0	1	0	1	1	0	0	0	1	0	1	0	1	
34	1	0	0	0	1	0	1	0	1	1	0	0	0	1	0	1	0	
35	0	0	0	0	1	0	1	0	1	1	1	0	0	0	0	1	0	
36	1	0	0	0	0	1	0	1	0	1	0	1	1	0	0	0	1	
37	1	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	1	
38	0	0	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	
39	1	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	0	
40	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	0	
41	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	
42	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	
43	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	
44	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	
45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
46	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
47	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	
48	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

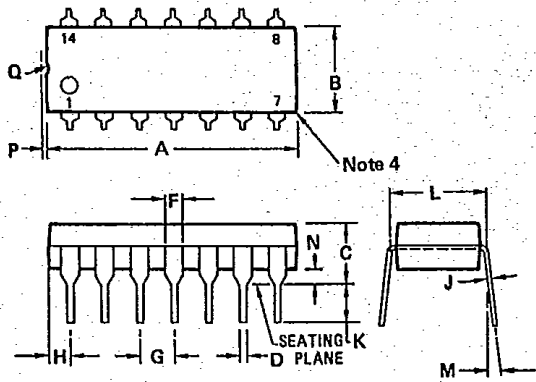








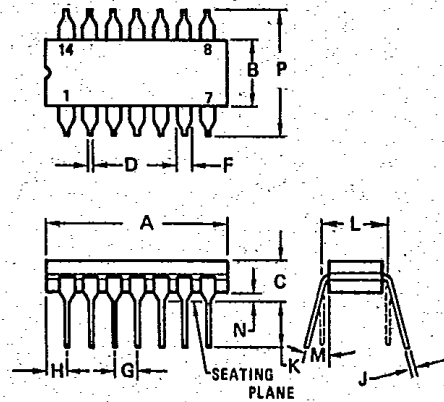
PACKAGE DIMENSIONS



- NOTES:
- LEADS WITHIN 0.13 mm (0.005) RADIUS OF TRUE POSITION AT SEATING PLANE AT MAXIMUM MATERIAL CONDITION.
  - DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
  - DIMENSION "B" DOES NOT INCLUDE MOLD FLASH.
  - ROUNDED CORNERS OPTIONAL.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	18.16	19.56	0.715	0.770
B	6.10	6.60	0.240	0.260
C	4.06	5.08	0.160	0.200
D	0.38	0.53	0.015	0.021
F	1.02	1.78	0.040	0.070
G	2.54 BSC		0.100 BSC	
H	1.32	2.41	0.052	0.095
J	0.20	0.38	0.008	0.015
K	2.92	3.43	0.115	0.135
L	7.62 BSC		0.300 BSC	
M	0°	10°	0°	10°
N	0.51	1.02	0.020	0.040

CERAMIC PACKAGE  
CASE 632-07



- NOTES:
- ALL RULES AND NOTES ASSOCIATED WITH MO-001 AA OUTLINE SHALL APPLY.
  - DIMENSION "L" TO CENTER OF LEADS WHEN FORMED PARALLEL.
  - DIMENSION "A" AND "B" (632-07) DO NOT INCLUDE GLASS RUN-OUT.
  - LEADS WITHIN 0.25 mm (0.010) DIA OF TRUE POSITION AT SEATING PLANE AND MAXIMUM MATERIAL CONDITION.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	19.05	19.94	0.750	0.785
B	6.10	7.49	0.240	0.295
C	-	5.08	-	0.200
D	0.38	0.58	0.015	0.023
F	1.40	1.77	0.055	0.070
G	2.54 BSC		0.100 BSC	
H	1.91	2.29	0.075	0.090
J	0.20	0.38	0.008	0.015
K	3.18	4.32	0.125	0.170
L	7.62 BSC		0.300 BSC	
M	-	15°	-	15°
N	0.51	1.02	0.020	0.040

PLASTIC PACKAGE  
CASE 646-05