

# 8X01A/9401 CRC Generator/Checker

## Product Specification

### Logic Products

#### FEATURES

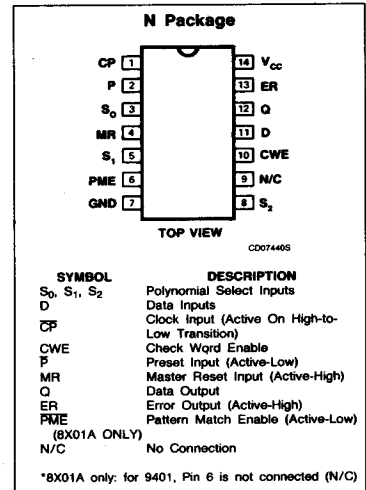
- TTL Inputs/outputs
- 12MHz (Max) data rate
- Separate preset/reset controls
- SDLC specified pattern match (8X01A only)
- Automatic right justification
- Pin-for-pin compatibility and functionally identical with 8X01 (8X01A only)
- $V_{CC} = 5V$
- 14-Pin DIP

#### DESCRIPTION

The CRC Generator/Checker (8X01A or 9401) provides error-correction capabilities for digital systems that handle serial data. The two parts differ in that the 8X01A provides Synchronous Data Link Control (SDLC).

The serial data stream is divided by a selected polynomial; the remainder resulting from this algebraic process is transmitted at the end of the data stream as a Cyclic Redundancy Check Character (CRCC). At the receiving end, the same calculation is performed on the data. If the received message is error-

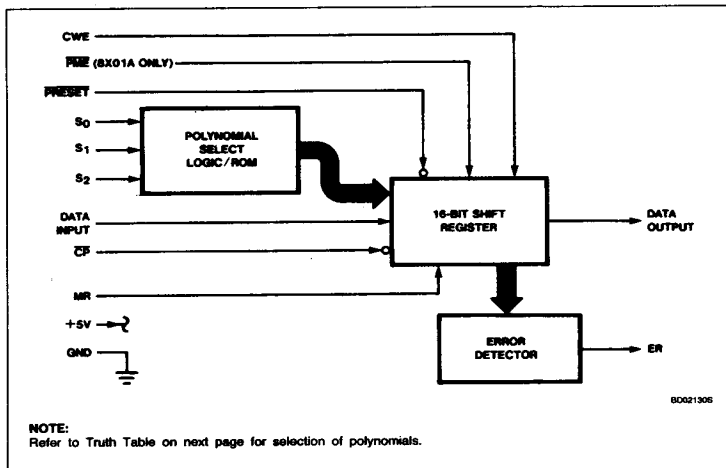
#### PIN CONFIGURATION



#### ORDERING INFORMATION

DESCRIPTION	ORDER CODE
14-Pin Plastic DIP	N8X01A
14-Pin Plastic DIP	N9401N

#### BLOCK DIAGRAM



#### APPLICATIONS

- Floppy and other disk systems
- Digital cassette and cartridge systems
- Data communication systems

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free, the calculated remainder should satisfy a predetermined pattern. In most cases, the remainder is zero; however, where SDLX protocols (8X01A only) are used, the correct remainder is 1111000010111000 ( $X^0 - X^{15}$ ).

Eight polynomials are provided and any of these can be selected via a 3-bit control bus. Popular polynomials, such as CRC-16 and CCITT are implemented and the one selected can be programmed to start with all zeroes or all ones. Right justification for polynomials of degree less than 16 is automatic.

### FUNCTIONAL OPERATION 8X01A and 9401

The CRC Generator/Checker circuit provides a means of detecting errors in a serial data communications environment. A binary message can be interpreted as a binary polynomial  $H(x)$ . This polynomial can be divided by a generator polynomial  $P(x)$  such that  $H(x) = P(x)Q(x) + R(x)$  whereby  $Q(x)$  is the quotient and  $R(x)$  is the remainder. During transmission, the remainder is appended to the end of the message as check bits. For a given message, a unique remainder is generated. Hardware implementation of division is simply a feedback shift register with Exclusive-OR gating. Subtraction and addition in modulo 2 is implemented by the Exclusive-OR function. The number of shift register

stages is equal to the degree of the divisor polynomial.

The accompanying truth table defines the polynomials implemented in the CRC circuit. Each polynomial can be selected via control inputs  $S_0$ ,  $S_1$  and  $S_2$ . To generate the check bits, the data stream is entered via the Data (D) input, using the High-to-Low transition of the Clock ( $\overline{CP}$ ) input. This data is gated with the most significant output (Q) of the shift register which, in turn, controls the Exclusive-OR gates. The Check Word Enable (CWE) must be held High while the data is being entered. After the last data bit is entered, the CWE is brought Low and the check bits are shifted out of the register and appended to the data bits using external gating—see Check Word Generation diagram.

To check an incoming message for errors, both the data and check bits are entered through the "D" input with the CWE input held High. The 8X01A, while not in the data path, monitors the message. After the last check bit is entered, in the 8X01A, the ERror output is made valid by a High-to-Low transition of  $\overline{CP}$ . If no error is detected during the data transmission, all bits of the internal register are Low and the ERror output is also Low; if an error is detected, it is reflected by the bit pattern and the ERror output is High. The ERror output status remains valid until the next High-to-Low transition of  $\overline{CP}$  or until initialized by the preset ( $\overline{P}$ ) or reset (MR)

functions. The  $\overline{PME}$  line must be High if the ERror output is used to indicate an all-zero result.

A High level applied to the Master Reset (MR) input asynchronously clears the shift register. A Low level applied to the Preset ( $\overline{P}$ ) input asynchronously sets all bits to the appropriate state if the control-code inputs ( $S_0$ ,  $S_1$ , and  $S_2$ ) specify a 16-bit polynomial. In the case of check polynomials that are 8 or 12 bits in length, only the most significant 8 or 12 bits of the shift register are set; all remaining bits are cleared.

### 8X01A ONLY

For data communications using the Synchronous Data Link Control (SDLC) protocol, the 8X01A is preset to an all-ones configuration before any accumulation is done; this applies to both transmitting and receiving modes of operation. Using SDLC, the check sum shifted out of the 8X01A must be inverted.

During the receiving mode, a special pattern of 1111000010111000 ( $X^0 - X^{15}$ ) is used in place of all-zeroes to check for a valid message. The Pattern Match Enable pin allows the user to select this option. If  $\overline{PME}$  is Low during the last bit time of the message, the ERror output is Low providing the result matches the special pattern; if an error occurs, ER is High.

### TRUTH TABLE

SELECT CODE			POLYNOMIAL	REMARKS
$S_2$	$S_1$	$S_0$		
L	L	L	$X^{16} + X^{15} + X_2 + 1$	CRC-16
L	L	H	$X^{16} + X^{14} + X + 1$	CRC-16 REVERSE
L	H	L	$X^{16} + X^{15} + X^{13} + X^7 + X^4 + X^2 + X^1 + 1$	
L	H	H	$X^{12} + X^{11} + X^3 + X^2 + X + 1$	CRC-12
H	L	L	$X^8 + X^7 + X^5 + X^4 + X + 1$	
H	L	H	$X^8 + 1$	LRC-8
H	H	L	$X^{16} + X^{12} + X^5 + 1$	CRC-CCITT
H	H	H	$X^{16} + X^{11} + X^4 + 1$	CRC-CCITT REVERSE

### RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	LIMITS			UNIT
		Min	Typ	Max	
$V_{CC}$	Supply voltage	4.75	5.0	5.25	V
$\overline{CP}$	Clock input	0		12	MHz

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**DC ELECTRICAL CHARACTERISTICS FOR 8X01A**  $V_{CC(MIN)} = 4.75V$ ,  $V_{CC(MAX)} = 5.25V$ 

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			Min	Typ	Max	
$V_{IH}$	High-level input voltage		2.0			V
$V_{IL}$	Low-level input voltage				0.8	V
$V_{IC}$	Input clamp diode voltage	$V_{CC} = \text{Min}$ , $I_{IN} = -18\text{mA}$		-0.9	-1.5	V
$V_{OH}$	High-level output voltage	$V_{CC} = \text{Min}$ , $I_{OH} = -400\mu\text{A}$	2.7	3.4		V
$V_{OL}$	Low-level output voltage	$V_{CC} = \text{Min}$ , $I_{OL} = 4.0\text{mA}$		0.35	0.4	V
		$V_{CC} = \text{Min}$ , $I_{OL} = 8.0\text{mA}$		0.45	0.5	V
$I_{IL}$	Low-level input current	$V_{CC} = \text{Max}$ , $V_{IN} = 0.4V$		-0.22	-0.36	mA
$I_{IH}$	High-level input current	$V_{CC} = \text{Max}$ , $V_{IN} = 2.7V$			20	$\mu\text{A}$
$I_{IH}$	Max input current	$V_{CC} = \text{Max}$ , $V_{IN} = 7V$			0.1	mA
$I_{OS}$	Short-circuit output current	$V_{CC} = \text{Max}$ , $V_{OUT} = 0V^1$	-10		-42	mA
$I_{CC}$	Supply current	$V_{CC} = \text{Max}$ , inputs open		60	110	mA

**DC ELECTRICAL CHARACTERISTICS FOR 9401**  $V_{CC(MIN)} = 4.75V$ ,  $V_{CC(MAX)} = 5.25V$ 

SYMBOL	PARAMETER	TEST CONDITIONS <sup>1</sup>	LIMITS			UNIT
			Min	Typ	Max	
$V_{IH}$	High-level input voltage	Guar. input High-voltage	2.0			V
$V_{IL}$	Low-level input voltage	Guar. input Low-voltage			0.8	V
$V_{IC}$	Input clamp diode voltage	$V_{CC} = \text{Min}$ , $I_{IN} = -18\text{mA}$		-0.9	-1.5	V
$V_{OH}$	High-level output voltage	$V_{CC} = \text{Min}$ , $I_{OH} = -400\mu\text{A}$	2.4	3.4		V
$V_{OL}$	Low-level output voltage	$V_{CC} = \text{Min}$ , $I_{OL} = 4.0\text{mA}$		0.35	0.4	V
		$V_{CC} = \text{Min}$ , $I_{OL} = 8.0\text{mA}$		0.45	0.5	V
$I_{IL}$	Low-level input current	$V_{CC} = \text{Max}$ , $V_{IN} = 0.4V$		-0.22	-0.36	mA
$I_{IH}$	High-level input current	$V_{CC} = \text{Max}$ , $V_{IN} = 2.7V$		1.0	40	$\mu\text{A}$
		$V_{CC} = \text{Max}$ , $V_{IN} = 5.5V$			1.0	mA
$I_{OS}$	Short-circuit output current	$V_{CC} = \text{Max}$ , $V_{OUT} = 0V^1$	-15		-100	mA
$I_{CC}$	Supply current	$V_{CC} = \text{Max}$ , inputs open		70	110	mA

**NOTE:**

1. No more than one output should be shorted at a time.

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AC ELECTRICAL CHARACTERISTICS FOR 8X01A  $V_{CC} = 5V$ ,  $T_A = +25^\circ C$ 

SYMBOL	PARAMETER	FROM	TO	TEST CONDITIONS	LIMITS			UNIT
					Min	Typ	Max	
$f_{MAX}$	Max clock frequency				12			MHz
$t_W - \overline{CP}(L)$	Clock Low pulse width			See Figure 2	35			ns
$t_W - \overline{P}(L)$	Preset Low pulse width			See Figure 3	35			ns
$t_W - MR(H)$	Master reset High pulse width			See Figure 4	35			ns
$t_S - D$	Setup time	Data	Clock		55			ns
$t_S - \overline{CWE}(L)$	Setup time	CWE	Clock	See Figure 5	55			ns
$t_H - D \& \overline{CWE}$	Hold time	Data & $\overline{CWE}$	Clock		0			ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	$\overline{PRESET}$	Data output	See Figures 1, 2, & 3			55	ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	Master reset	Data output	See Figure 4			55	ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	$\overline{PRESET}$	Error output	See Figure 3			55	ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	Master reset	Error output	See Figure 4			55	ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	$\overline{CP}$	Data output	See Figure 2			55	ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	$\overline{CP}$	Error output	See Figure 2			55	ns
$t_{REC}$	Recovery time	Preset, MR	Clock	See Fig. 3 & 4	35			ns

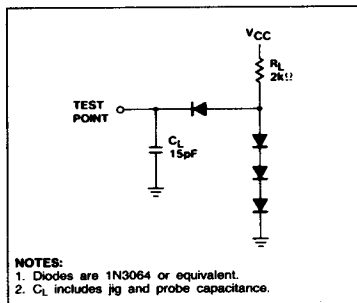
AC ELECTRICAL CHARACTERISTICS FOR 9401  $V_{CC} = 5V$ ,  $T_A = +25^\circ C$ 

SYMBOL	PARAMETER	FROM	TO	TEST CONDITIONS	LIMITS			UNIT
					Min	Typ	Max	
$f_{MAX}$	Max clock frequency				12	20		MHz
$t_W - \overline{CP}(L)$	Clock Low pulse width			See Figure 2	35			ns
$t_W - \overline{P}(L)$	Preset Low pulse width			See Figure 3	40	30		ns
$t_W - MR(H)$	Master reset High pulse width			See Figure 4	35	25		ns
$t_S - D$	Setup time	Data	Clock		55	35		ns
$t_S - \overline{CWE}$	Setup time	CWE	Clock	See Figure 5	55	35		ns
$t_H - D \& \overline{CWE}$	Hold time	Data & $\overline{CWE}$	Clock		0	-8		ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	$\overline{PRESET}$	Data output	See Figures 1, 2, & 3		40	60	ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	Master reset	Data output	See Figure 4		30	55	ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	$\overline{PRESET}$	Error output	See Figure 3		40	60	ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	Master reset	Error output	See Figure 4		40	60	ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	$\overline{CP}$	Data output	See Figure 2		30	55	ns
$t_{PLH}, t_{PHL}$	Low-to-High and High-to-Low	$\overline{CP}$	Error output	See Figure 2		40	60	ns
$t_{REC}$	Recovery time	Preset, MR	Clock	See Fig. 3 & 4	35	25		ns

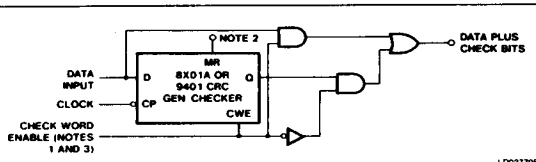
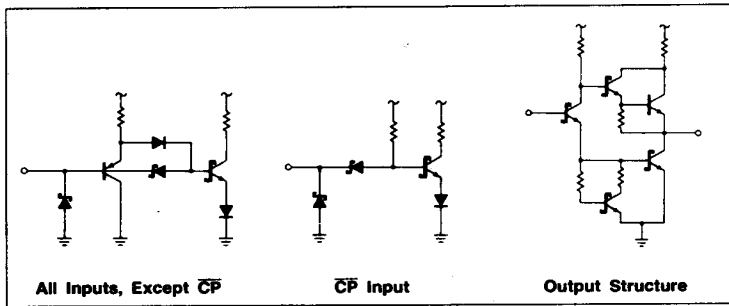
# CRC Generator/Checker

## 8X01A/9401

### TEST CIRCUIT

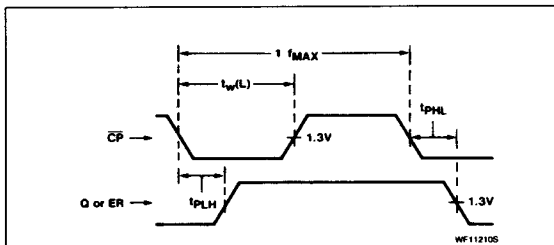


### INPUT/OUTPUT STRUCTURES



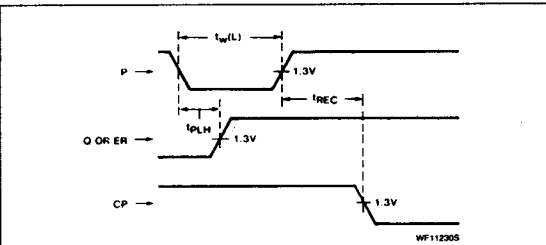
- NOTES:**  
 1. Check Word Enable is High while data is being clocked; it is Low during transmission of check bits.  
 2. The 8X01A (or 9401) must be RESET or PRESET before computation.  
 CRC check bits are generated and appended to data bits.

**Figure 1. Check Word Generation**



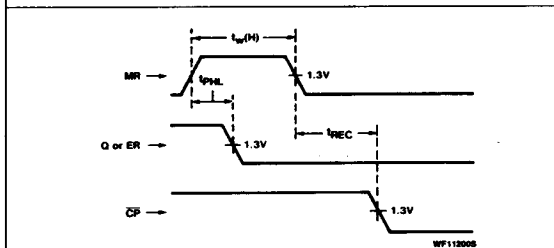
$V_M = 1.3V$  for 74S;  $V_M = 1.5V$  for all other TTL families.

**Figure 2. Propagation Delay —  $\overline{CP}$  to Q and  $\overline{CP}$  ER**



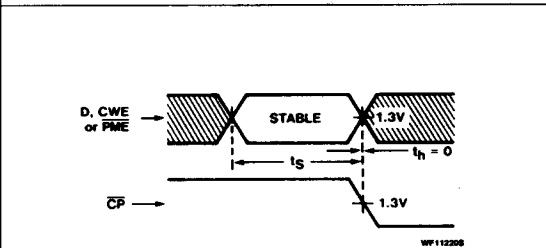
$V_M = 1.3V$  for 74S;  $V_M = 1.5V$  for all other TTL families.

**Figure 3. Propagation Delay —  $\overline{P}$  to Q and ER, Recovery Time —  $\overline{P}$  to  $\overline{CP}$**



$V_M = 1.3V$  for 74S;  $V_M = 1.5V$  for all other TTL families.

**Figure 4. Propagation Delay — MR to Q and ER, Recovery Time — MR to  $\overline{CP}$**



$V_M = 1.3V$  for 74S;  $V_M = 1.5V$  for all other TTL families. The shaded areas indicate when the input is permitted to change for predictable output performance.

**Figure 5. Setup and Hold Times — D to  $\overline{CP}$ , CWE to  $\overline{CP}$ , and PME to  $\overline{CP}$**