![Dynex Semiconductor logo]

The MA28151 is based on the industry standard 8251A Universal Synchronous Asynchronous Receiver/Transmitter (USART), modified for data communications with the MAS281 microprocessor.

The MA28151 is used as a peripheral device and is programmed by the CPU to operate using virtually any serial data transmission technique presently in use (including IBM "bi-sync"). The USART accepts data characters from the CPU in parallel format and then converts them into a continuous serial data stream for transmission.

Simultaneously, it can receive serial data streams and convert them into parallel data characters for the CPU. The USART signals the CPU whenever it receives a character for transmission or whenever it receives a character for the CPU. The CPU can read the complete status of the USART at any time, including data transmission errors and control signals such as SYNDET and TxEMPTY.

FEATURES

■ Radiation Hard to 1MRad(Si)

■ Latch Up Free, High SEU Immunity

■ Silicon-on-Sapphire Technology

■ Synchronous 5 - 8 Bit Characters; Internal or External Character Synchronisation; Automatic Sync Insertion

■ Asynchronous 5 - 8 Bit Characters; Clock Rate - 1, 16 or 64 Times Baud Rate; Break Character Generation, 1 ½ or 2 Stop Bits

■ All Inputs and Outputs are TTL Compatible

■ Compatible with the MAS281 (MIL-STD-1750A) Microprocessor

Figure 1: MA28151 Block Diagram

The MA28151 is based on the industry standard 8251A USART, modified for use with the MAS281 processor, incorporating the following features:

1. MA28151 has double-buffered data paths with separate I/O registers for control status, data in and data out, which considerably simplifies control programming and minimizes CPU overhead.

2. In synchronous operations, the Receiver detects and handles "break" automatically, relieving the CPU of this task.

3. A refined Rx initialisation prevents the Receiver from starting when in the "break" state, preventing unwanted interrupts from the disconnected USART.

4. At the conclusion of a transmission, the TxD line will always return to the marking state unless SBRK is programmed.

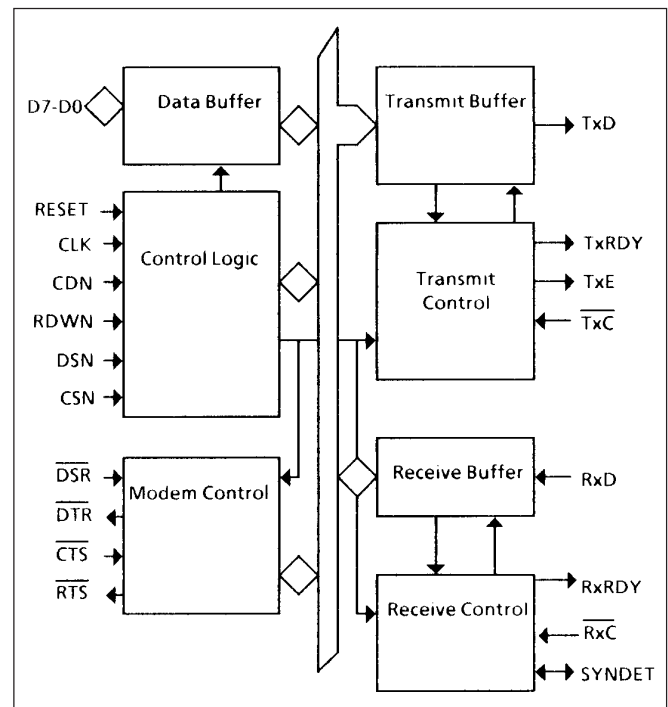5. Tx Enable logic enhancement prevents a Tx Disable command from prematurely halting transmission of the previously written data before completion. The logic also prevents the transmitter from turning off in the middle of a word.

6. When external Sync Detect is programmed, Internal Sync Detect is disabled and an External Sync Detect status is provided via a flip-flop, which clears itself upon a status read.

7. The possibility of a false sync detect is minimized in two ways: by ensuring that if double character sync is programmed, the characters will be continuously detected and by clearing the Rx register to all 1's whenever Enter-Hunt command is issued in Sync mode.

8. When the MA28151 is not selected, the RDWN and DSN lines do not affect the internal operation of the device.

9. The MA28151 Status can be read at any time but the status update will be inhibited during status read.

10. The MA28151 is free from extraneous glitches, providing higher speed and better operating margins.

11. Synchronous Baud rate is from DC to 64K.

12. Asynchronous Baud rate is from DC to 19.2K.

MA28151

1. FUNCTIONAL DESCRIPTION

1.1 GENERAL

The MA28151 is a Universal Synchronous/Asynchronous Receiver/Transmitter designed for use with the MAS281 microprocessor. Like other I/O devices in a microcomputer system, its functional configuration is programmed by the system's software for maximum flexibility. The MA28151 can support most serial data techniques in use, including IBM bi-sync.

In a communication environment, an interface device must convert parallel format system data into serial format for transmission, and convert incoming serial data into parallel system data for reception. The interface device must also delete or insert bits or characters that are functionally unique to the communication technique. In essence, the interface should appear transparent to the CPU for the simple input or output of byte-oriented system data.

1.2 DATA BUS BUFFER

This 3-state, bidirectional, 8-bit buffer is used to interface the MA28151 to the system data bus. Data is transmitted or received by the buffer upon execution of OUTput or INput instructions from the CPU.

Control word, Command words and Status information are also transferred through the Data Bus Buffer. The Command Status, Data-in and Data-out registers are separate 8-bit registers, communicating with the system bus through the Data Bus Buffer.

This functional block accepts inputs from the system control bus and generates control signals for overall device operation. It contains the Control Word Register and Command Word Register, which store the various control formats for the device's functional definition.

1.3 RESET

A high on this input forces the MA28151 into idle mode. The MA28151 will remain at idle until its functional definition is programmed with a new set of control words. Minimum RESET pulse width is 6 tcy (clock must be running).

The device can also be put into the idle state by a command reset operation .

1.4 CLOCK (CLK)

The CLK input is used to generate internal device timing and is normally connected to the clock generator (OSC) of the system.

Please note: None of the external inputs or outputs are referenced to CLK but the frequency of CLK must be greater than 30 times the Receiver or Transmitter data bit rates.

1.5 DATA STROBE (DSN)

This input indicates that a data transfer is taking place. During a CPU write operation the MA28151 reads data from the bus on the rising edge of DSN. During a read operation the MA28151 can output data while DSN is low. Data is valid on the rising edge of DSN.

1.6 READ/WRITE SELECT (RDWN)

A high on the RDWN input indicates a read of data or status information from the MA28151. A low on this input indicates a transfer of data or control words into the MA28151. The RDWN line is valid only when DSN is low. Figure 2 summarises the MAS28151 read/write operati ons.

1.7 CONTROL/DATA (CDN)

This input, in conjunction with the DSN and RDWN inputs, informs the MA28151 that the word on the Data Bus is either a data character, control word or status information.

1 = CONTROL/STATUS; 0= DATA

CDN	RDWN	DSN	CSN	ACTION
0	1	0	0	28151 TO CPU
0	0	0	0	CPU TO 28151
1	1	0	0	STATUS TO CPU
1	0	0	0	CPU TO CONTROL
x	x	1	0	BUS TRISTATE
x	x	x	1	BUS TRISTATE

Figure 2: Read/Write Control

1.8 CHIP SELECT (CSN)

A low on this input selects the MA28151. No reading or writing will occur unless the device is selected. When CSN is high, the Data Bus is in the float state and the DSN and RDWN lines have no effect on the chip.

1.9 MODEM CONTROL

The MA28151 has a set of control inputs and outputs which can be used to simplify the interface to almost any modem. The modem control signals are general purpose in nature and can be used for functions other than modem control, if necessary.

1.10 DATA SET READY ($\overline{DSR}$)

The $\overline{DSR}$ input signal is a general-purpose, 1-bit inverting input port. Its condition can be tested by the CPU using a Status Read operation. The $\overline{DSR}$ input is normally used to test modem conditions such as Data Set Ready.

1.11 DATA TERMINAL READY ($\overline{DTR}$)

The $\overline{DTR}$ output signal is a general purpose, 1-bit inverting output port. It can be set low by programming the appropriate bit in the Command instruction word. The $\overline{DTR}$ output signal is normally used for modem control such as Data Terminal Ready.

1.12 REQUEST TO SEND (RTS)

The $\overline{\text{RTS}}$ output signal is a general purpose, 1-bit inverting output port. It can be set low by programming the appropriate bit in the Command instruction word. The $\overline{\text{RTS}}$ output signal is normally used for modem control such as Request To Send.

1.13 CLEAR TO SEND (CTS)

A low on this input enables the MA28151 to transmit serial data if the Tx Enable bit in the Command byte is set to a high. If either a Tx Enable off or $\overline{\text{CTS}}$ off condition occurs while the Tx is in operation, the Tx will transmit all the data in the USART, written prior to Tx disable command, before shutting down.

1.14 TRANSMITTER BUFFER

The Transmitter Buffer accepts parallel data from the Data Bus Buffer, converts it to a serial bit stream, inserts the appropriate characters or bits (based on the communication technique) and outputs a composite serial stream of data on the TxD output pin on the falling edge of $\overline{\text{TxC}}$. The transmitter will begin transmission upon being enabled if $\overline{\text{CTS}}$ = 0. The TxD line will be held in the marking state immediately upon a master Reset, or when Tx Enable or $\overline{\text{CTS}}$ = 1, or the transmitter is empty.

1.15 TRANSMITTER CONTROL

The Transmitter Control manages all activities associated with the transmission of serial data. It accepts and issues signals both externally and internally to accomplish this function.

1.16 TRANSMITTER READY (TxRDY)

This output signals the CPU that the transmitter is ready to accept a data character. The TxRDY output pin can be used as an interrupt to the system since it is masked by TxEnable; or, for Polled operation, the CPU can check TxRDY using a Status Read operation. TxRDY is automatically reset by the falling edge of DSN (with RDWN low) when a data character is loaded from the CPU.

Note that when using the polled operation, the TxRDY status bit is not masked by TxEnable, but will only indicate the Empty/Full Status of the Tx Data input Register.

1.17 TRANSMITTER EMPTY (TxE)

When the MA28151 has no characters to send, the TxEMPTY output will go high. It resets upon receiving a character from CPU if the transmitter is enabled. TxEMPTY remains high when the transmitter is disabled. TxEMPTY can be used to indicate the end of transmission mode, so that the CPU can turn the line around in the half-duplex operational mode.

In the Synchronous mode, a high on the TxEMPTY output indicates that a character has not been loaded and the SYNC character or characters are about to be or are being automatically transmitted as fillers. TxEMPTY does not go low when the SYNC characters are being shifted out.

1.18 TRANSMITTER CLOCK (TxC)

The Transmitter Clock controls the rate at which the character is to be transmitted. In the Synchronous transmission mode, the Baud Rate (1x) is equal to the $\overline{\text{TxC}}$ frequency. In Asynchronous transmission mode, the baud rate is a fraction of the actual $\overline{\text{TxC}}$ frequency. A portion of the mode instruction selects this factor; it can be 1,1/16 or 1/64 the $\overline{\text{TxC}}$.

For Example:
If Baud Rate equals 110 Baud
$\overline{\text{TxC}}$ equals 110Hz in the 1x mode
$\overline{\text{TxC}}$ equals 1 72KHz in the 16x mode
$\overline{\text{TxC}}$ equals 7.04KHz in the 64x mode
The falling edge of $\overline{\text{TxC}}$ shifts the serial data out of the MA28151.

1.19 RECEIVER BUFFER

The Receiver accepts serial data, converts the data to parallel format, checks for bits or characters that are unique to the communications techniques and sends an assembled character to the CPU. Serial data is input to the RxD pin and is clocked in on the rising edge of RxC.

1.20 RECEIVER CONTROL

This functional block manages all receiver-related activities which consist of the following features:

The RxD initialisation circuit prevents the MA28151 from mistaking an unused input line for an active low data line in the break condition. Before starting to receive serial characters on the RxD line, a valid 1 must first be detected after a chip master Reset. Once this has been determined, a search for a valid low (start bit) is enabled. This feature is only active in the asynchronous mode and is only done once for each master Reset.

The False Start bit detection circuit prevents false starts as the result of a transient noise spike by first detecting the falling edge and then strobing the nominal center of the Start bit (RxD = low).

Parity error detection sets the corresponding status bit.

The Framing Error status bit is set if the Stop bit is absent at the end of the data byte (asynchronous mode).

1.21 RxRDY (RECEIVER READY)

This output indicates that the MA28151 contains a character that is ready to be input to the CPU. RxRDY can be connected to the interrupt structure of the CPU or, for polled operation, the CPU can check the condition of RxRDY using a Status Read operation. RxEnable, when off holds RxRDY in the Reset Condition. For Asynchronous mode, to set RxRDY, the Receiver must be enabled to sense a Start Bit and a complete character must be assembled and transferred to the Data Output Register. For Synchronous mode, to set RxRDY,

the Receiver must be enabled and a character must finish assembly and be transferred to the Data Output Register

Failure to read the received character from the Rx Data Output Register prior to the assembly of the next Rx Data character will set overrun condition error and the previous character will be written over and lost. If the Rx Data is being read by the CPU when the internal transfer is occurring, the overrun error will be set and the old character will be lost.

1.22 $\overline{RxC}$ (RECEIVER CLOCK)

The Receiver Clock controls the rate at which the character is to be received. In Synchronous Mode the Baud Rate (1x) is equal to the actual frequency of $\overline{RxC}$. In Asynchronous Mode, the Baud Rate is a fraction of the actual $\overline{RxC}$ frequency. A portion of the mode instruction selects this factor: 1,$\frac{1}{16}$ or $\frac{1}{64}$ of the Receiver Clock.

For example:
Baud Rate equals 300 Baud, if
$\overline{RxC}$ equals 300 Hz in the 1 x mode:
$\overline{RxC}$ equals 4800 Hz in the 16x mode
$\overline{RxC}$ equals 19.2 KHz in the 64x mode.
Baud Rate equals 2400 Baud if
$\overline{RxC}$ equals 2400Hz in the 1x mode
$\overline{RxC}$ equals 38.4 KHz in the 16x mode;
$\overline{RxC}$ equals 153.6 KHz in the 64x mode.
Data is sampled into the MA28151 on the rising edge of $\overline{RxC}$.

Note: In most communications systems, the MA28151 will be handling both the transmission and reception operations of a single link. Consequently the Receive and Transmit Baud Rates will be the same. Both $\overline{TxC}$ and $\overline{RxC}$ will require identical frequencies for this operation and can be tied together and connected to a single frequency source (Baud Rate Generator) to simplify the interface.

1.23 SYNC/BREAK DETECT (SYNDET/BRKDET)

This pin is used in Synchronous Mode for SYNDET and may be used as either input or output, programmable through the Control Word. It is reset to output mode, low upon RESET. When used as an output (internal Sync mode), the SYNDET pin will go high to indicate that the MA28151 has located the SYNC character in the Receive mode. If the MA28151 is programmed to use double Sync characters (bi-sync), the SYNDET will go high in the middle of the last bit of the second Sync character.

SYNDET is automatically reset upon a Status Read operation.

When used as an input (external SYNC detect mode), a positive going signal will cause the MA28151 to start assembling data characters on the rising edge of the next $\overline{RxC}$. Once in SYNC, the high input signal can be removed. When External SYNC Detect is programmed, Internal SYNC Detect is disabled.

1.24 BREAK (ASYNC MODE ONLY)

This output will go high whenever the receiver remains low through two consecutive stop bit sequences including the start bits, data bits, and parity bits. Break Detect may also be read as a Status bit. It is reset only upon a master chip Reset or Rx Data returning to a "one" state.

C/D	ACTION
1	MODE INSTRUCTION
1	SYNC CHARACTER 1 (SYNC ONLY) *
1	SYNC CHARACTER 2 (SYNC ONLY) *
1	COMMAND INSTRUCTION
0	DATA
1	COMMAND INSTRUCTION
0	DATA
1	COMMAND INSTRUCTION

Note: The second sync character is skipped if mode instruction has programmed the MA28151 to single character mode. Both sync characters are skipped if mode instruction has programmed the MA28151 to async mode

Figure 3: Typical data block

2. OPERATION DESCRIPTION

2.1 GENERAL

The complete functional definition of the MA28151 is programmed by the system's software. A set of control words must be sent out by the CPU to initialize the MA28151 to support the desired communications format. These control words will program the: Baud Rate, Character Length, Number of Stop Bits, Synchronous or Asynchronous Operation, Even/Odd/Off Parity, etc. In the Synchronous Mode, options are also provided to select either internal or external character synchronization.

Once programmed, the MA28151 is ready to perform its communication functions. The TxRDY output is raised high to signal the CPU that the MA28151 is ready to receive a data character from the CPU. This output (TxRDY) is reset automatically when the CPU writes a character into the MA28151. Alternatively, the MA28151 receives serial data from the MODEM or I/O device. Upon receiving an entire character, the RxRDY output is raised high to signal the CPU that the MA28151 has a complete character ready for the CPU to fetch. RxRDY is reset automatically upon the CPU data read operation.

The MA28151 cannot begin transmission until the TxEnable (Transmitter Enable) bit is set in the Command instruction and it has received a Clear To Send ($\overline{CTS}$) input. The TxD output will be held in the marking state upon Reset.

3. PROGRAMMING THE MA28151

3.1 MODE AND COMMAND INSTRUCTIONS

Prior to starting data transmission or reception, the MA28151 must be loaded with a set of control words generated by the CPU. These control signals define the complete functional definition of the MA28151 and must immediately follow a Reset operation (internal or external).

The control words are split into two formats:
1. Mode Instruction
2. Command Instruction

3.1.1 Mode Instruction

This instruction defines the general operational characteristics of the MA28151. It must follow a Reset operation (internal or external). Once the Mode instruction has been written into the MA28151 by the CPU, SYNC characters or Command Instructions may be written.

3.1.2 Command Instruction

This instruction defines a word that is used to control the actual operation of the MA28151.

Both the Mode and Command Instruction must conform to a specified sequence for proper device operation. The Mode instruction must be written immediately following a Reset operation, prior to using the MA28151 for data communications.

All control words written into the MA28151 after the Mode Instruction will load the Command Instruction. Command Instructions can be written into the MA28151 at any time in the data block during the operation of the MA28151. To return to the Mode Instruction format, the master Reset bit in the Command Instruction word can be set to initiate an internal Reset operation. This automatically places the MA28151 back into the Mode Instruction format. Command Instructions must follow the Mode Instructions or Sync characters.

3.2 MODE INSTRUCTION DEFINITION

The MA28151 can be used for either Asynchronous or Synchronous data communications. To understand how the Mode Instruction defines the functional operation of the MA28151, the designer can best view the device as two separate components, one Asynchronous and the other Synchronous, sharing the same package. The format definition can be changed only after a master chip Reset. For explanation purposes the two formats will be isolated.

NOTE: When parity is enabled it is not considered as one of the data bits for the purpose of programming the word length. The actual parity bit received on the Rx Data line cannot be read on the Data Bus. In the case of a programmed character length of less than 8 bits, the least significant data bus bits will hold the data; unused bits are 'don't care' when writing data to the MA28151, and will be zeros when reading the data from the MA28151.

3.3 TEST MODE

The Mode Instruction can be used to select a scan path test facility. In this mode a test vector is read in through RxD and read out in TxD. For further information of test mode please contact GEC Plessey Semiconductors.

3.4 ASYNCHRONOUS MODE (TRANSMISSION)

Whenever a data character is sent by the CPU the MA28151 automatically adds a Start bit (low level), followed by the data bits (least significant bit first,) and the programmed number of Stop bits to each character. Also, an even or odd Parity bit is inserted prior to the Stop bit(s), as defined by the Mode Instruction. The Character is then transmitted as a serial data stream on the TxD output. The serial data is shifted out on the falling edge of $\overline{TxC}$ at a rate equal to 1, $\frac{1}{16}$ or $\frac{1}{64}$ times that of the $\overline{TxC}$, as defined by the Mode Instruction. BREAK characters can be continuously sent to the TxD if commanded to do so.

When no data characters have been loaded into the MA28151 the TxD output remains high (marking) unless a Break (continuously low) has been programmed.

3.5 ASYNCHRONOUS MODE (RECEIVE)

The RxD line is normally high. A falling edge on this line triggers the beginning of a START bit. The validity of this START bit is checked by again strobing this bit at its nominal center (16x or 64X mode only). If a low is detected again, it is a valid START bit, and the bit counter will start counting. The bit counter thus locates the center of the data bits, the parity bit (if it exists) and the stop bits. If a parity error occurs, the parity error flag is set. Data and parity bits are sampled on the RxD pin with the rising edge of $\overline{RxC}$. If a low level is detected as the STOP bit, the Framing Error flag will be set. The STOP bit signals the end of a character. Note that the receiver requires only one stop bit, regardless of the number of stop bits programmed. This character is then loaded into the parallel I/O buffer of the MA28151. The RxRDY pin is raised to signal the CPU that a character is ready to be fetched.

If a previous character has not been fetched by the CPU, the present character replaces it in the I/O buffer, and the OVERRUN Error flag is raised (thus the previous character is lost). All of the error flags can be reset by an Error Reset Instruction. The occurrence of any of these errors will not affect the operation of the MA28151.
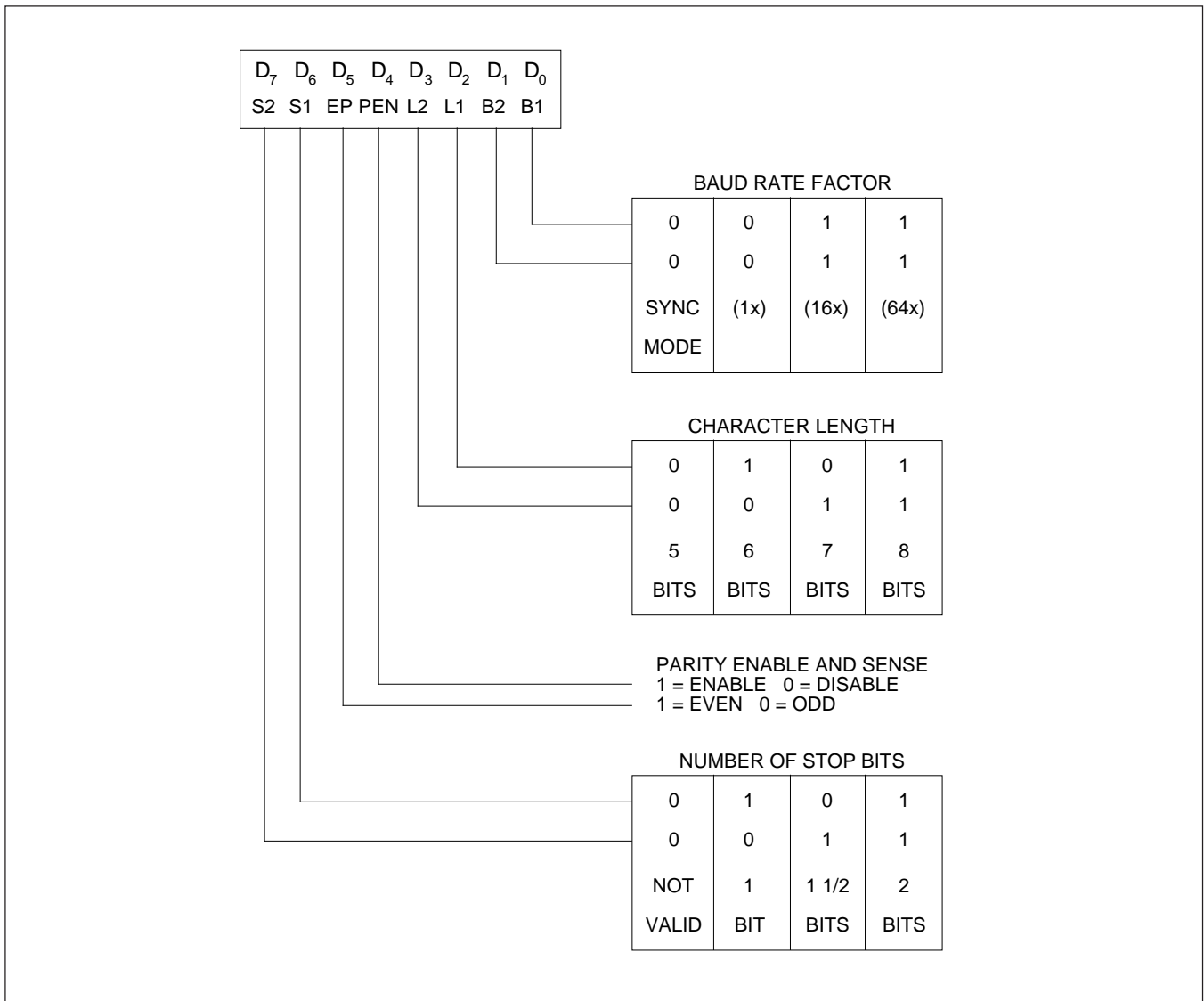
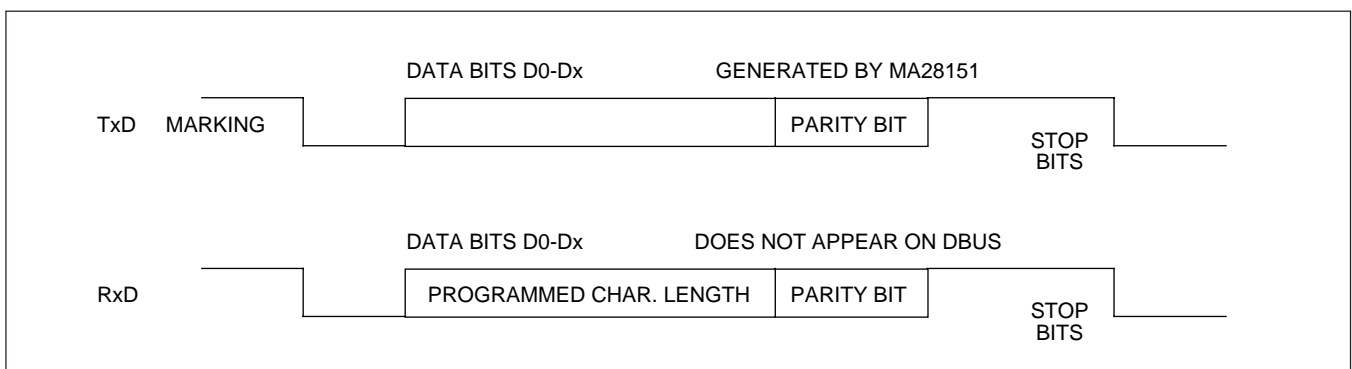*Figure 4: Mode Instruction Format, Asynchronous Mode*
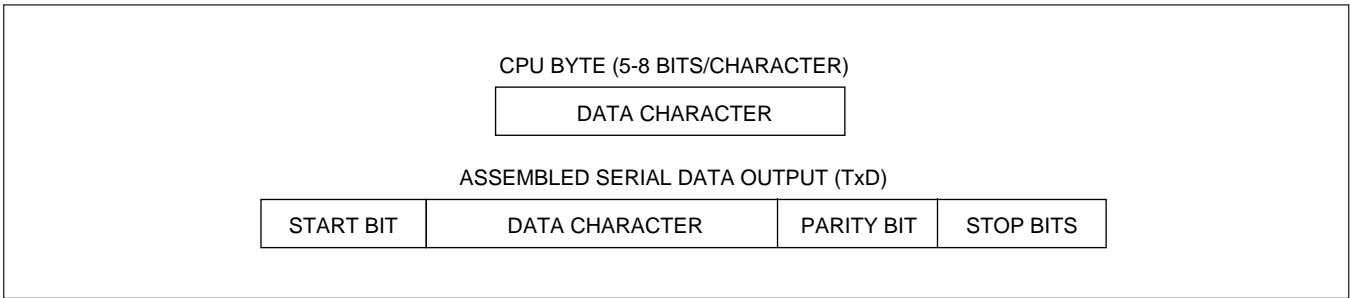

Figure 5: Asynchronous Mode

CPU BYTE (5-8 BITS/CHARACTER)

DATA CHARACTER

ASSEMBLED SERIAL DATA OUTPUT (TxD)

START BIT	DATA CHARACTER	PARITY BIT	STOP BITS

Figure 6: Transmission Format

SERIAL DATA INPUT (RxD)

START BIT	DATA CHARACTER	PARITY BIT	STOP BITS

CPU BYTE (5-8 BITS/CHARACTER) (See Note Below)

DATA CHARACTER

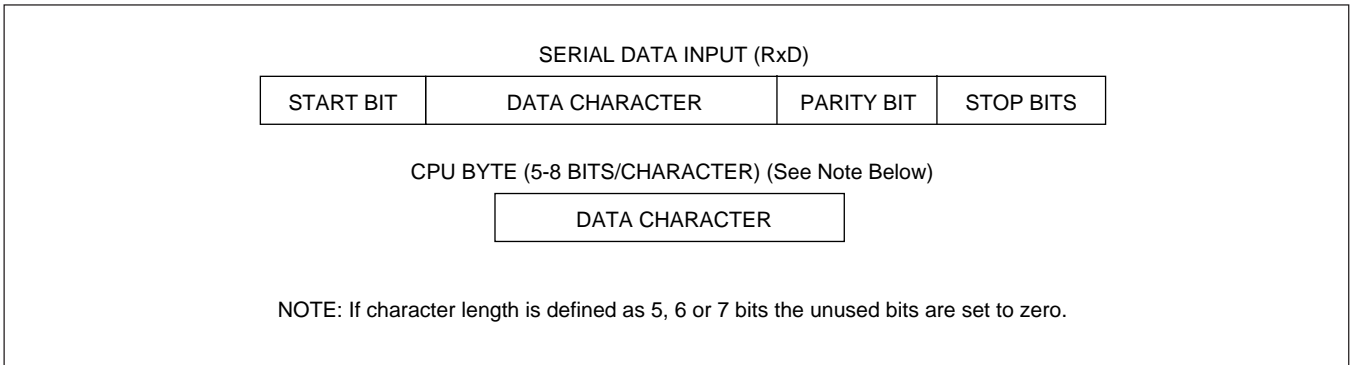NOTE: If character length is defined as 5, 6 or 7 bits the unused bits are set to zero.

Figure 7: Receive Format

3.6 SYNCHRONOUS MODE (TRANSMISSION)

The TxD output is continuously high until the CPU sends its first character to the MA28151 which usually is a SYNC character. When the $\overline{CTS}$ line goes low, the first character is serially transmitted out. All characters are shifted out on the falling edge of $\overline{TxC}$. Data is shifted out at the same rate as the $\overline{TxC}$.

Once transmission has started, the data stream at the TxD output must continue at the $\overline{TxC}$ rate. If the CPU does not provide the MA28151 with a data character before the MA28151 Transmitter Buffers become empty, the SYNC characters (or character if in single SYNC character mode) will be automatically inserted in the TxD data stream. In this case, the TxEMPTY does not go low when the SYNC is being shifted out (see figure 8). The TxEMPTY pin is internally reset by a data character being written into the MA28151.

3.7 SYNCHRONOUS MODE (RECEIVER)

In this mode character synchronisation can be internally or externally achieved. If the SYNC mode has been programmed, ENTER-HUNT command should be included in the first command instruction word written. Data on the RxD pin is then sampled on the rising edge of $\overline{RxC}$. The content of the Rx buffer is compared to every bit boundary with the first SYNC character until a match occurs.

If the MA28151 has been programmed for two SYNC characters, the subsequent received character is also compared; when both SYNC characters have been detected, the USART ends the HUNT mode and is in character

synchronization. The SYNDET pin is then set high, and is reset automatically by a STATUS READ. If parity is programmed, SYNDET will not be set until the middle of the parity bit, instead of the middle of the last data bit.

In the external SYNC mode, synchronization is achieved by applying a high level on the SYNDET pin, thus forcing the MA28151 out of the HUNT mode. The high level can be removed after one $\overline{RxC}$ cycle. An ENTER HUNT command has no effect in the asynchronous mode of operation.
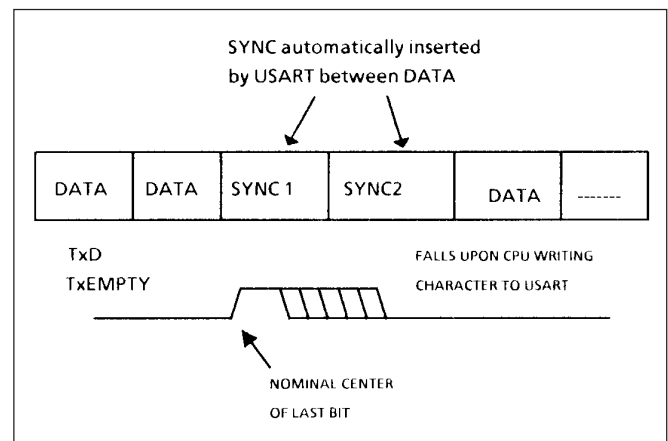

Figure 8: Sync Character Insertion

MA28151

Parity error and overrun error are both checked in the same way as in the Asynchronous Receive mode. Parity is checked when not in HUNT, regardless of whether the Receiver is enabled or not.

The CPU can command the receiver to enter the HUNT mode if synchronisation is lost. This will also set all the used character bits in the buffer to a one thus preventing a possible false SYNDET caused by data that happens to be in the Rx buffer at ENTER HUNT time.

Note: the SYNDET flip-flop is reset at each Status Read, regardless of whether internal or external SYNC has been programmed. This does not cause the MA28151 to return to the HUNT mode. When in SYNC mode, but not in HUNT, Sync Detection is still functional, but only occurs at the known word boundaries. Thus, if one Status Read indicates SYNDET and a second Status Read also indicates SYNDET, then the programmed SYNDET characters have been received since the previous Status Read. (If double character sync has been contiguously received to gate a SYNDET indication). When external SYNDET mode is selected, internal Sync Detect is disabled, and the SYNDET flip-flop may be set at any bit boundary.
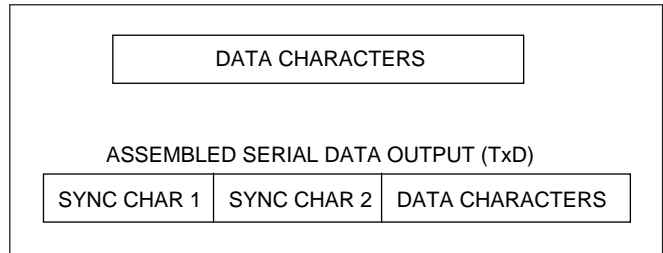
3.9 DATA FORMAT, SYNCHRONOUS MODE

DATA CHARACTERS

ASSEMBLED SERIAL DATA OUTPUT (TxD)

SYNC CHAR 1	SYNC CHAR 2	DATA CHARACTERS

Figure 9: Receive Format, Synchronous Mode

SYNC CHAR 1	SYNC CHAR 2	DATA CHARACTERS

CPU BYTES (5-8 BITS/CHARACTER)

DATA CHARACTERS
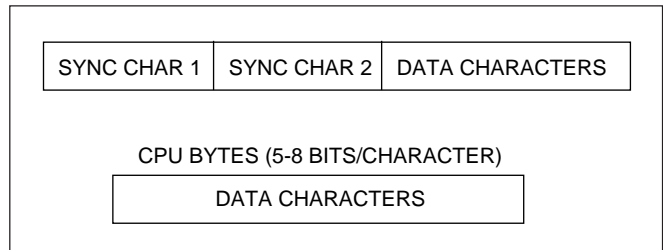
Figure 10: Data Format, Synchronous Mode

3.8 MODE INSTRUCTION FORMAT, SYNCHRONOUS MODE

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
SS	ES	EP	PEN	L2	L1	0	0

CHARACTER LENGTH

0	1	0	1
0	0	1	1
5	6	7	8
BITS	BITS	BITS	BITS

PARITY ENABLE AND SENSE

1 = ENABLE   0 = DISABLE
1 = EVEN   0 = ODD

EXTERNAL SYNC DETECT

1 = SYNCDET IS AN INPUT
0 = SYNCDET IS AN OUTPUT

SINGLE CHARACTER SYNC

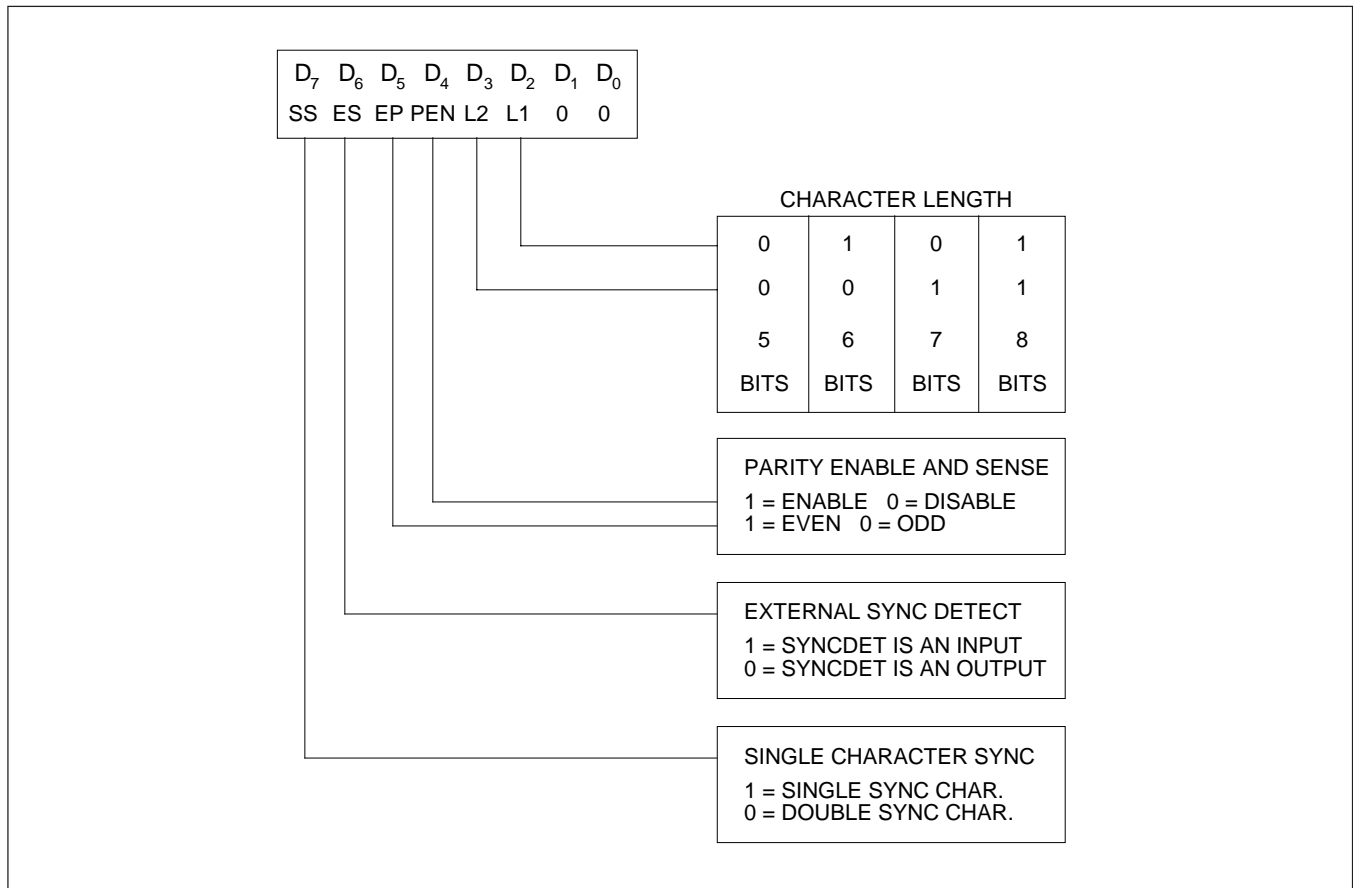1 = SINGLE SYNC CHAR.
0 = DOUBLE SYNC CHAR.

Figure 11: Mode Instruction Format, Synchronous Mode

3.10 COMMAND INSTRUCTION DEFINITION

Once the functional definition of the MA28151 has been programmed by the Mode Instruction and the sync characters are loaded (if in Sync Mode) then the device is ready to be used for data communications. The Command Instruction controls the actual operation of the selected format. Functions such as: Enable Transmit/Receive, Error Reset and Modem Controls are provided by the Command Instruction.

Once the Mode Instruction has been written into the MA28151 and Sync characters inserted, if necessary, then all further "control writes" (CDN=1) will load a Command Instruction. A Reset Operation (internal or external) will return the MA28151 to the Mode instruction format.

Note: Internal Reset on Power-up. When power is first applied, the MA28151 may come up in the Mode, Sync character or Command format. To guarantee that the device is in the Command instruction format before the Reset command is issued, it is safest to execute the worst-case initialization sequence (sync mode with two sync characters). Loading three 00_Hs consecutively into the device with CDN=1 configures sync operation and writes two dummy 00_H sync characters. An internal reset command (40_H) may then be issued to return the device to the idle state.

3.11 COMMAND INSTRUCTION FORMAT

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
EH	IR	RTS	ER	SBRK	RxE	DTR	TxEN

TRANSMIT ENABLE
1 = ENABLE
0 = DISABLE

DATA TERMINAL READY
HIGH WILL FORCE $\overline{\text{DTR}}$ OUTPUT TO ZERO

RECEIVE ENABLE
1 = ENABLE
0 = DISABLE

SEND BREAK CHARACTER
1 = FORCES TxD LOW
0 = NORMAL OPERATION

ERROR RESET
1 = RESET ERROR FLAGS
    PE, OE, FE

REQUEST TO SEND
HIGH WILL FORCE $\overline{\text{RTS}}$ OUTPUT TO ZERO

INTERNAL RESET
HIGH RETURNS THE MA28151 TO MODE INSTRUCTION FORMAT

ENTER HUNT MODE*
HIGH ENABLES SEARCH FOR SYNC CHARACTERS (HAS NO EFFECT IN ASYNC MODE)

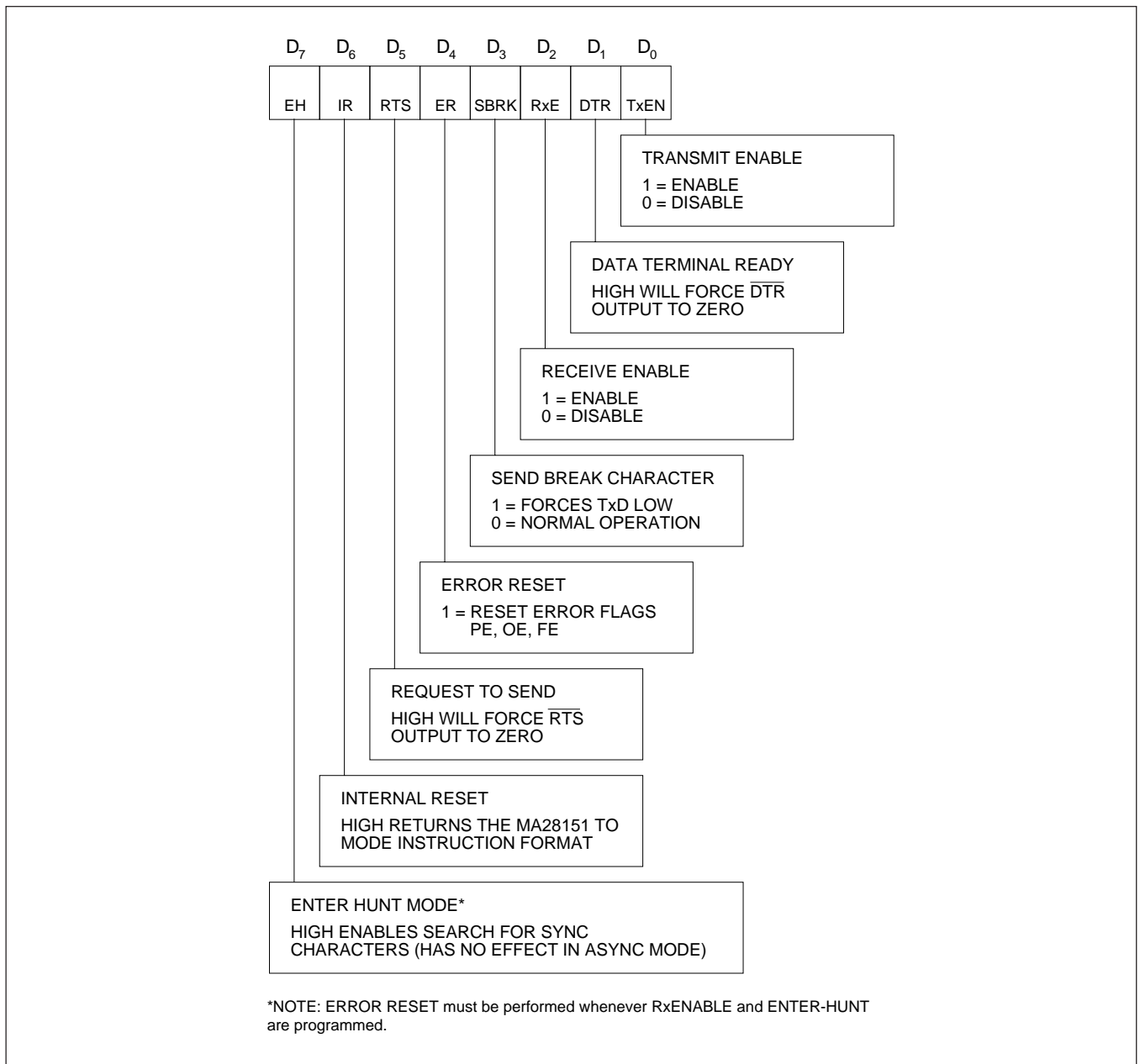*NOTE: ERROR RESET must be performed whenever RxENABLE and ENTER-HUNT are programmed.

Figure 12: Command Instruction Format

3.12 STATUS READ DEFINITION

In data communication systems it is often necessary to examine the status of the active device to ascertain if errors have occurred or other conditions that require the processor's attention. The MA28151 has facilities that allow the programmer to read the status of the device at any time during the functional operation. (Status update is inhibited during status read).

A normal read command is issued by the CPU with CDN high to accomplish this function.

Some of the bits in the Status Read Format have identical meanings to external output pins so that the MA28151 can be used in a completely polled or interrupt-driven environment. TxRDY is an exception.

Note that status update can have a maximum delay of 28 clock periods from the actual event affecting the status.
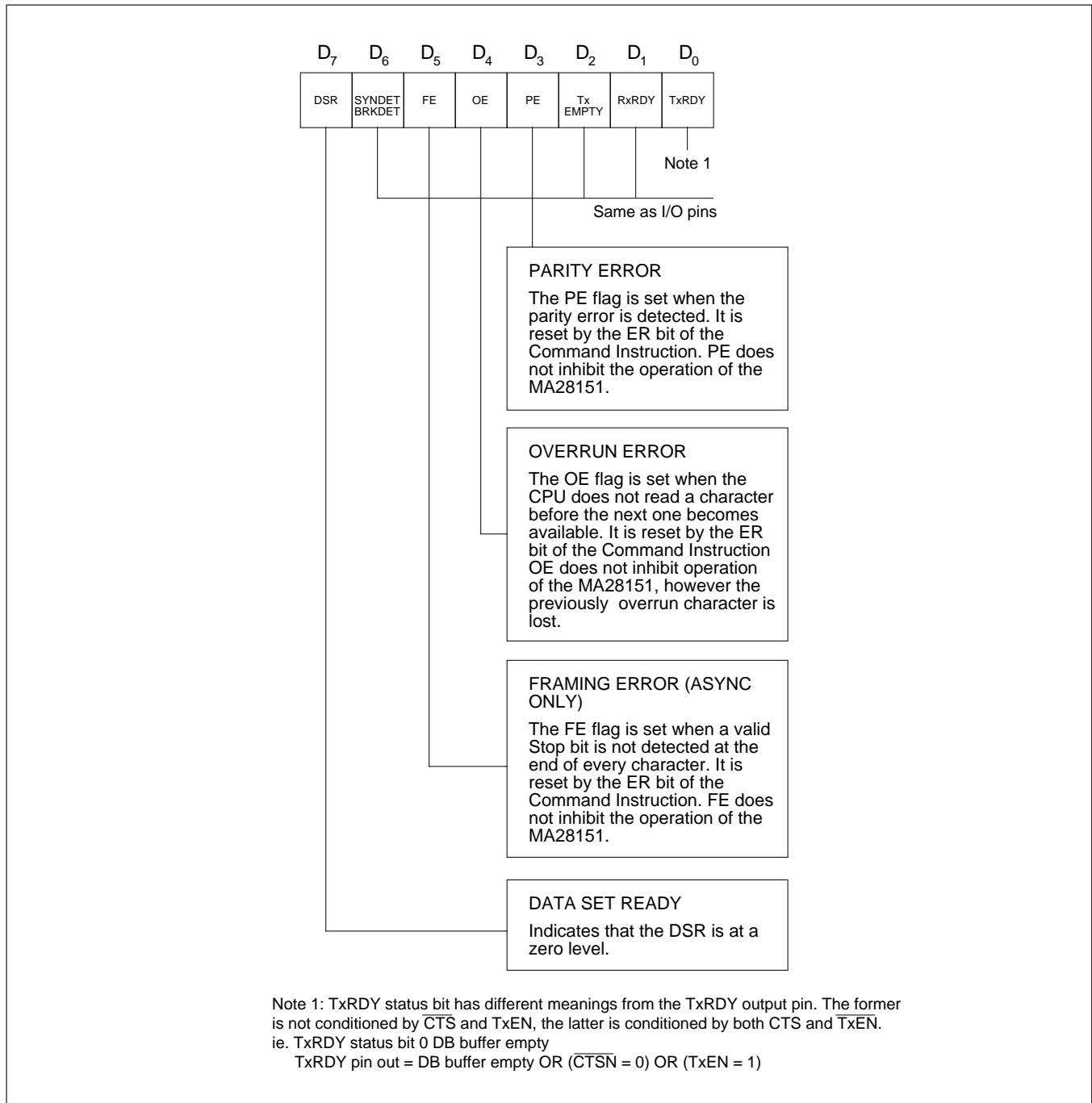
3.13 STATUS READ FORMAT

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
DSR	SYNDET BRKDET	FE	OE	PE	Tx EMPTY	RxRDY	TxRDY

Note 1

Same as I/O pins

PARITY ERROR

The PE flag is set when the parity error is detected. It is reset by the ER bit of the Command Instruction. PE does not inhibit the operation of the MA28151.

OVERRUN ERROR

The OE flag is set when the CPU does not read a character before the next one becomes available. It is reset by the ER bit of the Command Instruction OE does not inhibit operation of the MA28151, however the previously overrun character is lost.

FRAMING ERROR (ASYNC ONLY)

The FE flag is set when a valid Stop bit is not detected at the end of every character. It is reset by the ER bit of the Command Instruction. FE does not inhibit the operation of the MA28151.

DATA SET READY

Indicates that the DSR is at a zero level.

Note 1: TxRDY status bit has different meanings from the TxRDY output pin. The former is not conditioned by $\overline{CTS}$ and TxEN, the latter is conditioned by both CTS and $\overline{TxEN}$.
ie. TxRDY status bit 0 DB buffer empty
TxRDY pin out = DB buffer empty OR ($\overline{CTSN}$ = 0) OR (TxEN = 1)

Figure 13: Status Read Format

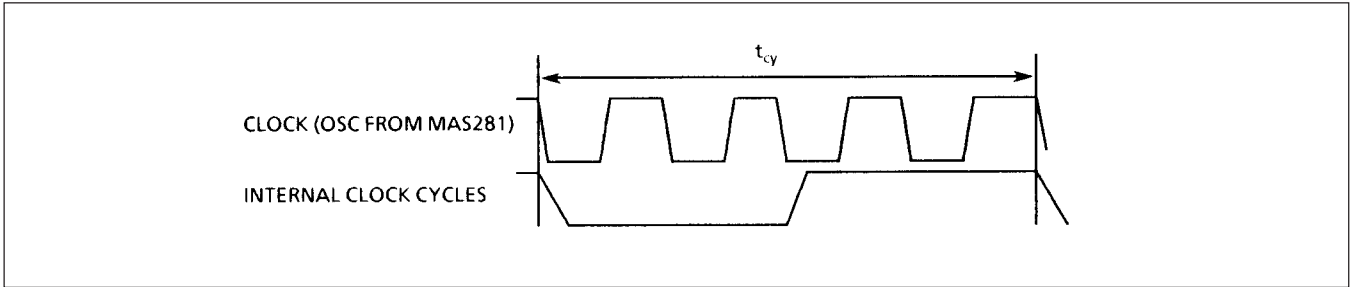## 4. TIMING WAVEFORMS

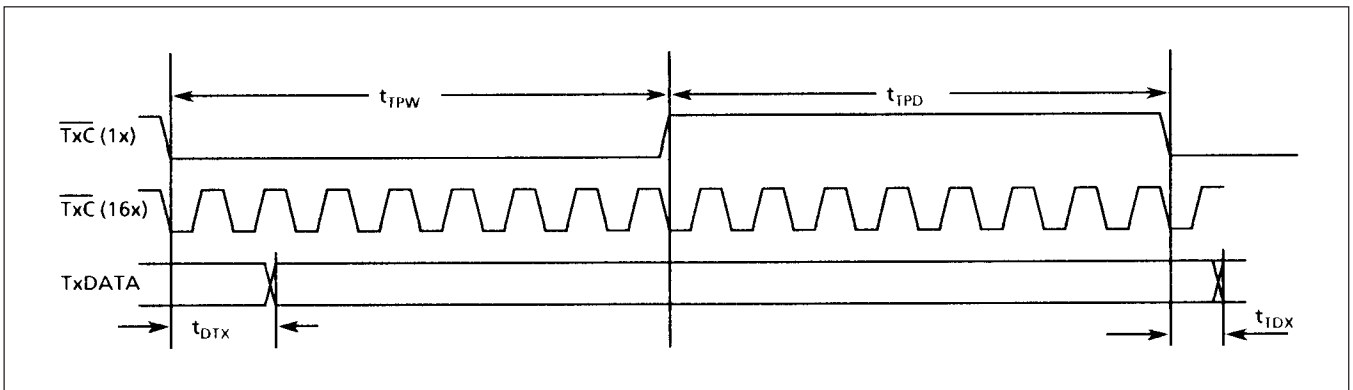Figure 14: System Clock Input

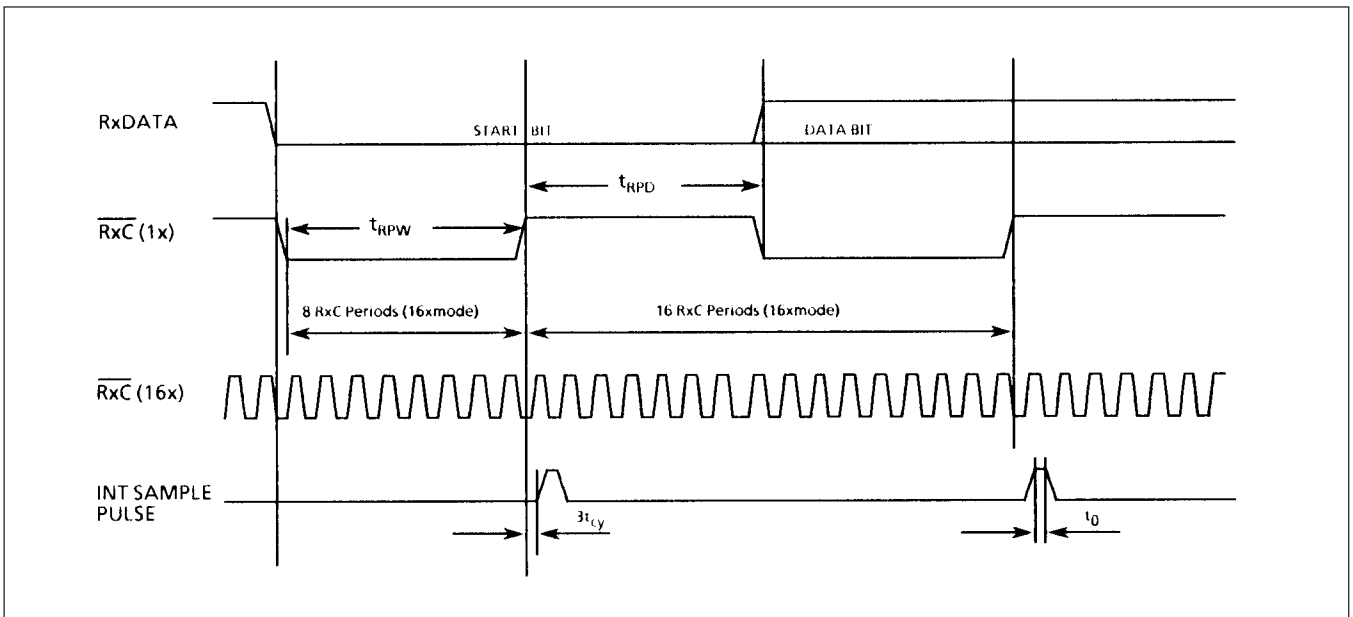Figure 15: Transmitter Clock and Data

Figure 16: Receive Clock and Data
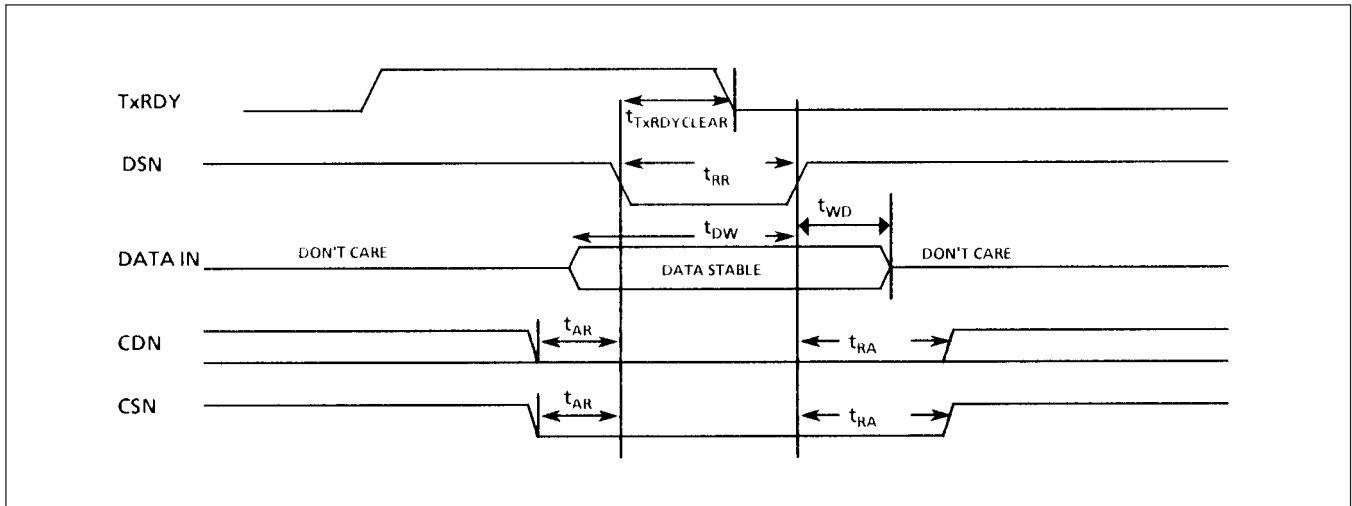
Figure 17: Write Data Cycle (CPU to USART)
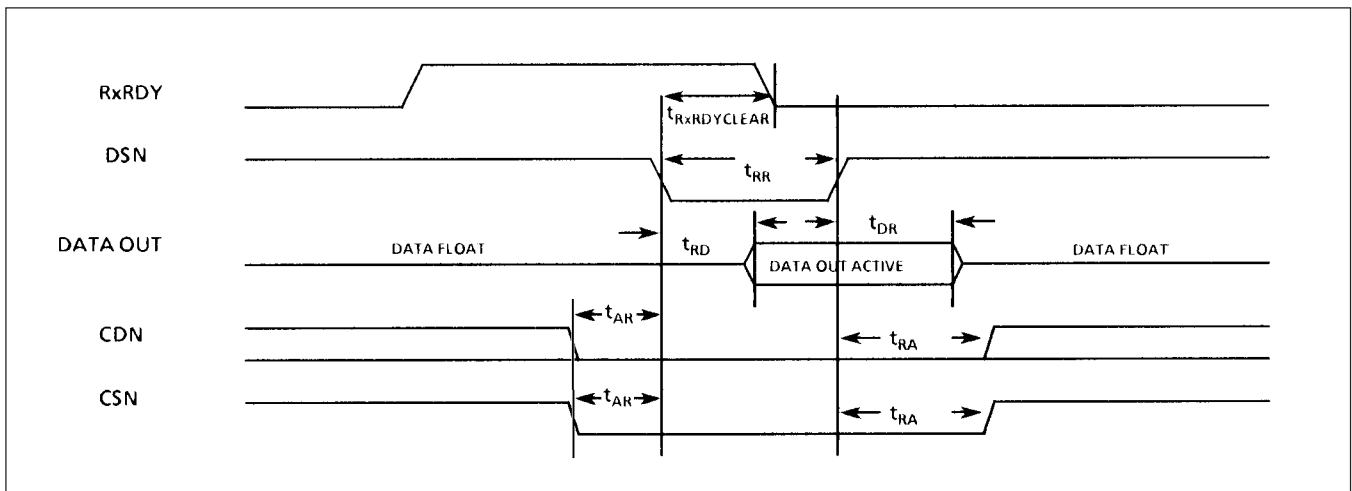

Figure 18: Read Data Cycle (USART to CPU)

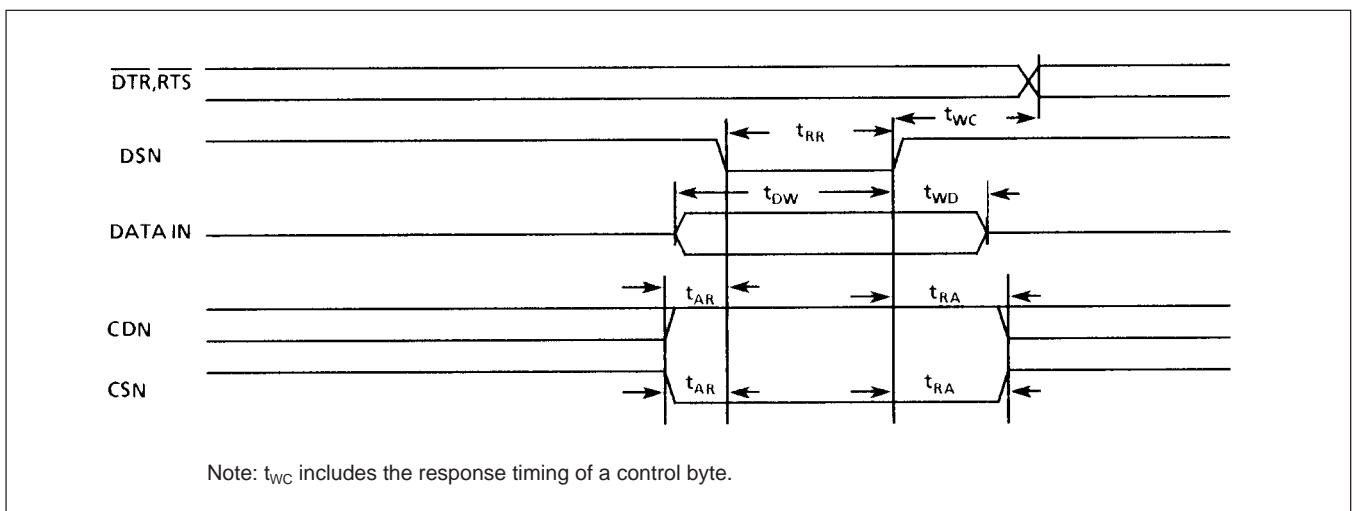Note: t_{WC} includes the response timing of a control byte.

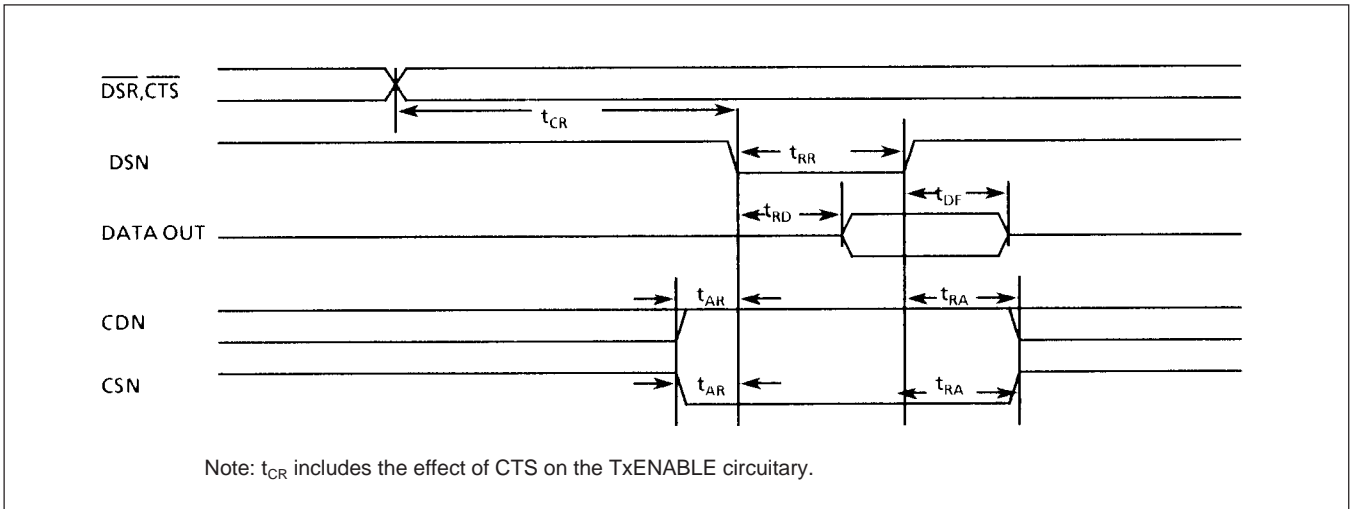*Figure 19: Write Control or Output Port Cycle (CPU to USART)*

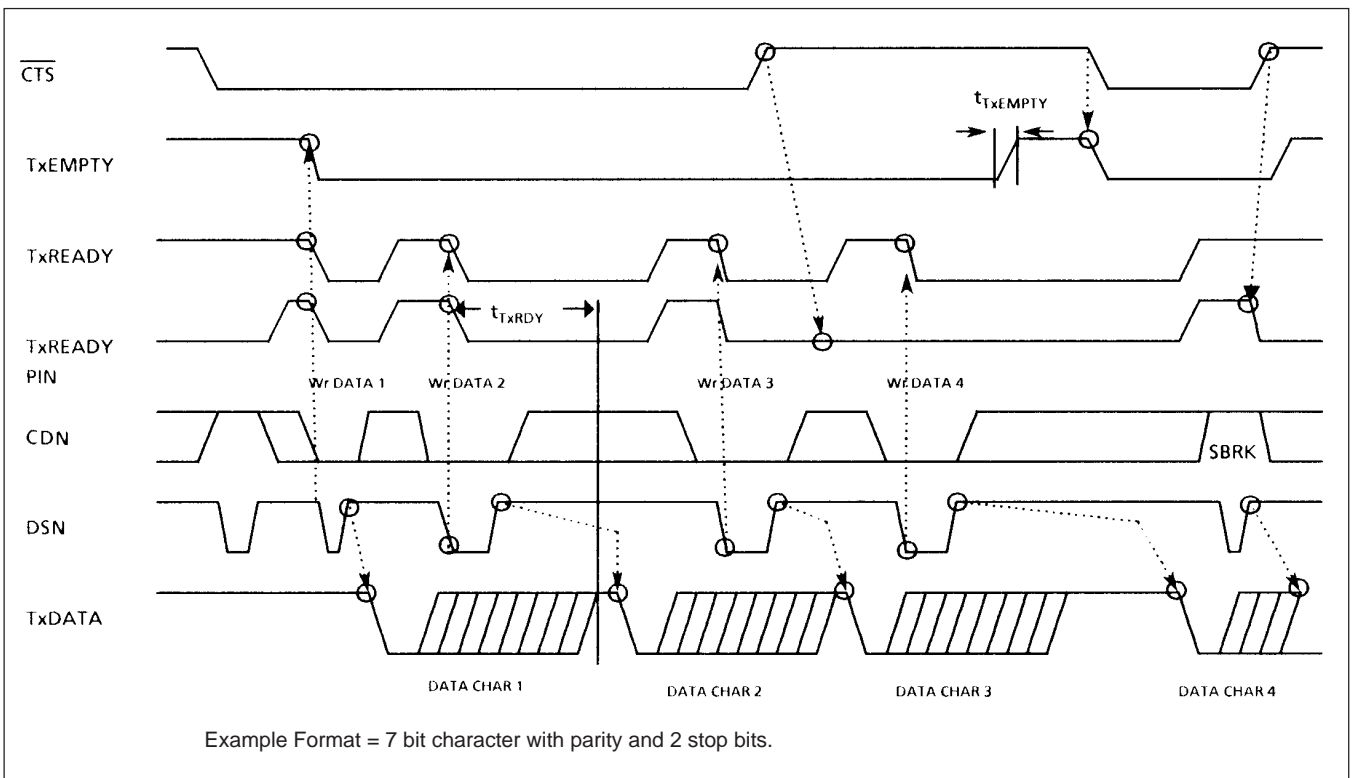*Figure 20: Read Control or Output Port Cycle (USART to CPU)*

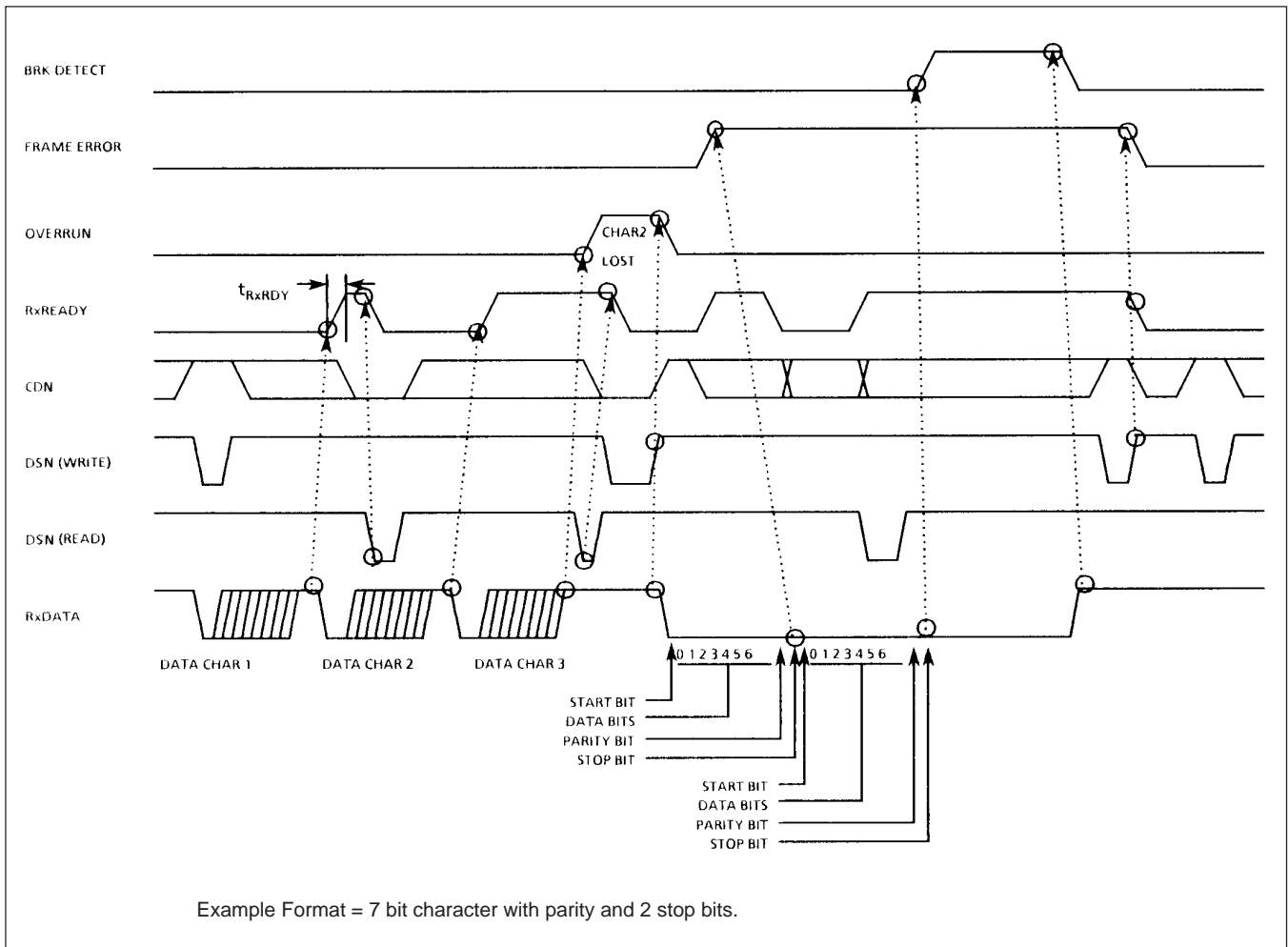*Figure 21: Transmitter Control and Flag Timing (ASYNC Mode)*

Figure 22: Receiver Control and Flag Timing (ASYNC Mode)

5. AC ELECTRICAL CHARACTERISTICS

Symbol	Parameter	Min.	Max.	Units	Condition
t_{CY}	Internal clock cycle time	200	1000	nS	Notes 1, 5, 6
t_0	External Clock high pulse width	25	-	nS	-
$t_{\bar{0}}$	External Clock low pulse width	25	-	nS	-
t_R, t_F	Clock rise and fall time	-	10	nS	-
t_{DTX}	TxD delay from falling edge of TxD	-	1	µS	-
t_{TPW}	Transmitter input clock pulse width	$12xt_{CY}$	-	-	1 x baud rate
		$1xt_{CY}$	-	-	16 x and 64 x baud rate
t_{TPD}	Transmitter input clock pulse delay	$15xt_{CY}$	-	-	1 x baud rate
		$3xt_{CY}$	-	-	16 x and 64 x baud rate
t_{RPW}	Receive input clock pulse width	$12xt_{CY}$	-	-	1 x baud rate
		$1xt_{CY}$	-	-	16 x and 64 x baud rate
t_{RPD}	Receive input clock pulse delay	$15xt_{CY}$	-	-	1 x baud rate
		$3xt_{CY}$	-	-	16 x and 64 x baud rate
t_{TxRDY}	TxRDY pin delay from CENTER of last bit	-	$8xt_{CY}$	-	Note 7
$t_{TxRDY\ CLEAR}$	TxRDY fall from falling DSN (WRITE)	-	45	-	Note 7
t_{RxRDY}	RxRDY pin delay from center of last bit	-	$26xt_{CY}$	-	Note 7
$t_{RxRDY\ CLEAR}$	RxRDY fall from falling DSN (READ)	-	45	-	Note 7
$t_{TxEMPTY}$	TxEMPTY from centre of last bit	$20xt_{CY}$	-	-	Note 7
t_{WC}	Control delay from rising edge of WRITE	$8xt_{CY}$	-	-	Note 7
t_{CR}	Control to READ set-up time ($\overline{DSR}$, $\overline{CTS}$)	$20xt_{CY}$	-	-	Note 7
t_{AR}	Address stable before DSN (CSN, CDN)	0	-	ns	Note 2
t_{RA}	Address hold time before DSN (CSN, CDN)	0	-	ns	Note 2
t_{RR}	DSN pulse width	20	-	ns	-
t_{RD}	Data delay from DSN falling (READ)	-	30	ns	Note 3
t_{DF}	DSN rising to data floating (READ)	10	45	ns	Note 8
t_{DW}	Data set-up time to DSN rising (WRITE)	15	-	ns	-
t_{WD}	Data hold time to DSN rising (WRITE)	5	-	ns	-
t_{RV}	Recovery time between writes (not shown)	$6xt_{CY}$	-	-	Note 4

Notes: 1. AC Timings measured V_{OH} = 1.5 V_{OL} = 1.5.
     2. CSN and Command/Data are considered as addresses.
     3. Assumes that address is valid before DSN goes low.
     4. This recovery time is for Mode Initialisation only. Write data is allowed when TxRDY = 1. Recovery time between writes for Asynchronous Mode is $8xt_{CY}$ and for Synchronous Mode is $16xt_{CY}$.
     5. The $\overline{TxC}$ and $\overline{RxC}$ frequencies have the following limitation with respect to clock: For 1 x baudrate, f_{TX} or $f_{RX} \leq 1/(30t_{CY})$: For 16 x and 64 x baud rate, f_{TX} or $f_{RX} \leq 1/(4.5t_{CY})$.
     6. Reset Pulse Width = $6t_{CY}$ minimum; System clock must be running during Reset.
     7. Status update can have a maximum delay of 28 clock periods from the event affecting the status.
     8. Data Bus connected to V_{DD} via loads of 680Ω (minimum).

Mil-Std-883, method 5005, subgroups 9, 10, 11

Figure 23: AC Electrical Characteristics

Symbol	Parameter	Min.	Max.	Units	Condition
-	Clock Frequency (osc)	-	20	MHz	-
f_{Tx}	Transmitter input clock frequency	DC	64	kHz	1 x baud rate
		DC	310	kHz	16 x baud rate
		DC	615	kHz	64 x baud rate
f_{Rx}	Receiver input clock frequency	DC	64	kHz	1x baud rate
		DC	310	kHz	16 x baud rate
		DC	615	kHz	64 x baud rate

Mil-Std-883, method 5005, subgroups 7, 8A, 8B

Figure 24: Operating AC Electrical Characteristics

6. DC CHARACTERISTICS AND RATINGS

Parameter	Min	Max	Units
Supply Voltage	-0.5	7	V
Input Voltage	-0.3	V_{DD}+0.3	V
Current Through Any Pin	-20	+20	mA
Operating Temperature	-55	125	°C
Storage Temperature	-65	150	°C

Figure 25: Absolute Maximum Ratings

Note: Stresses above those listed may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these conditions, or at any other condition above those indicated in the operations section of this specification, is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Symbol	Parameter	Conditions	Total dose radiation not exceeding $3x10^5$ Rad(SI)			Units
			Min	Typ	Max	
V_{DD}	Supply Voltage	-	4.5	5.0	5.5	V
V_{IH}	Input High Voltage	-	2.2	-	-	V
V_{IL}	Input Low Voltage	-	-	-	0.8	V
V_{OH}	Output High Voltage	I_{OH} = -2mA	V_{DD}-0.5	-	-	V
V_{OL}	Output Low Voltage	I_{OL} = 5mA	-	-	V_{SS}+0.4	V
I_{IN}	Input Leakage Current (Note 1)	V_{DD} = 5.5V, V_{IN} = V_{SS} or V_{DD}	-	-	±10	µA
I_{OZ}	Tristate Leakage Current (Note 1)	V_{DD} = 5.5V, V_{IN} = V_{SS} or V_{DD}	-	-	±50	µA
I_{DD}	Power Supply Current	Static, V_{DD} = 5.5V	-	0.1	10	mA

V_{DD} = 5V±10%, over full operating temperature range.
Mil-Std-883, method 5005, subgroups 1, 2, 3
Note 1: Guaranteed but not tested at -55°C

Figure 26: Electrical Characteristics

Subgroup	Definition
1	Static characteristics specified in Figure 26 at +25°C
2	Static characteristics specified in Figure 26 at +125°C
3	Static characteristics specified in Figure 26 at -55°C
7	Functional characteristics specified in Figure 24 at +25°C
8A	Functional characteristics specified in Figure 24 at +125°C
8B	Functional characteristics specified in Figure 24 at -55°C
9	Switching characteristics specified in Figure 23 at +25°C
10	Switching characteristics specified in Figure 23 at +125°C
11	Switching characteristics specified in Figure 23 at -55°C

Figure 27: Definition of Mil-Std-883, Method 5005 Subgroups
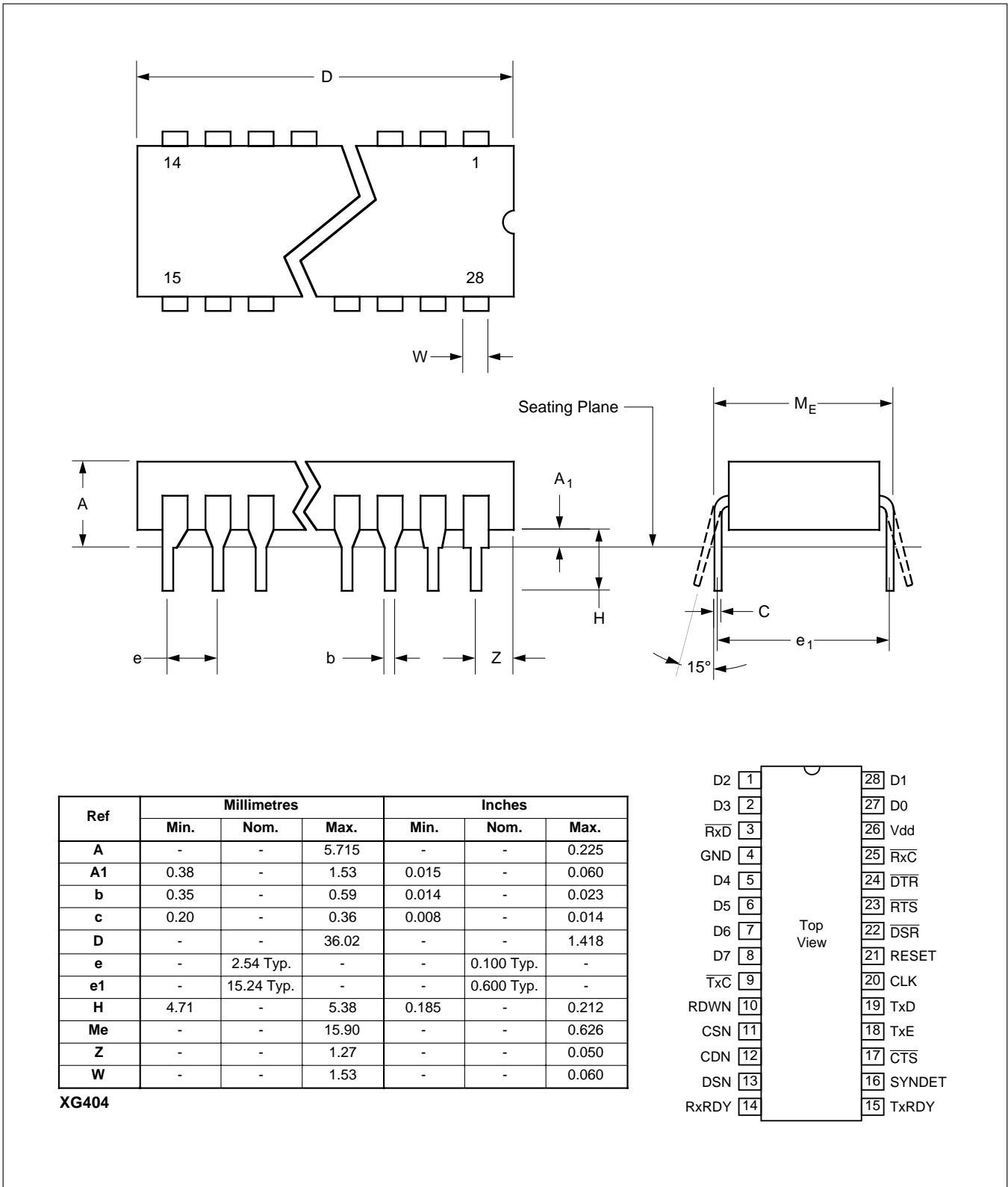
7. OUTLINES AND PIN ASSIGNMENTS

Ref	Millimetres			Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	5.715	-	-	0.225
A1	0.38	-	1.53	0.015	-	0.060
b	0.35	-	0.59	0.014	-	0.023
c	0.20	-	0.36	0.008	-	0.014
D	-	-	36.02	-	-	1.418
e	-	2.54 Typ.	-	-	0.100 Typ.	-
e1	-	15.24 Typ.	-	-	0.600 Typ.	-
H	4.71	-	5.38	0.185	-	0.212
Me	-	-	15.90	-	-	0.626
Z	-	-	1.27	-	-	0.050
W	-	-	1.53	-	-	0.060

XG404

Pin assignments (Top View):

Pin	Signal		Pin	Signal
1	D2		28	D1
2	D3		27	D0
3	$\overline{RxD}$		26	Vdd
4	GND		25	$\overline{RxC}$
5	D4		24	$\overline{DTR}$
6	D5		23	$\overline{RTS}$
7	D6		22	$\overline{DSR}$
8	D7		21	RESET
9	$\overline{TxC}$		20	CLK
10	RDWN		19	TxD
11	CSN		18	TxE
12	CDN		17	$\overline{CTS}$
13	DSN		16	SYNDET
14	RxRDY		15	TxRDY

Figure 28: 28-Lead Ceramic DIL (Solder Seal) - Package Style C

Ref	Millimetres			Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	2.29	-	-	0.090
b1	-	0.51	-	-	0.020	-
D	-	-	14.60	-	-	0.575
E	-	-	14.60	-	-	0.575
e	-	1.02	-	-	0.040	-
Z	-	1.52 Typ.	-	-	0.060 Typ.	-

XG431
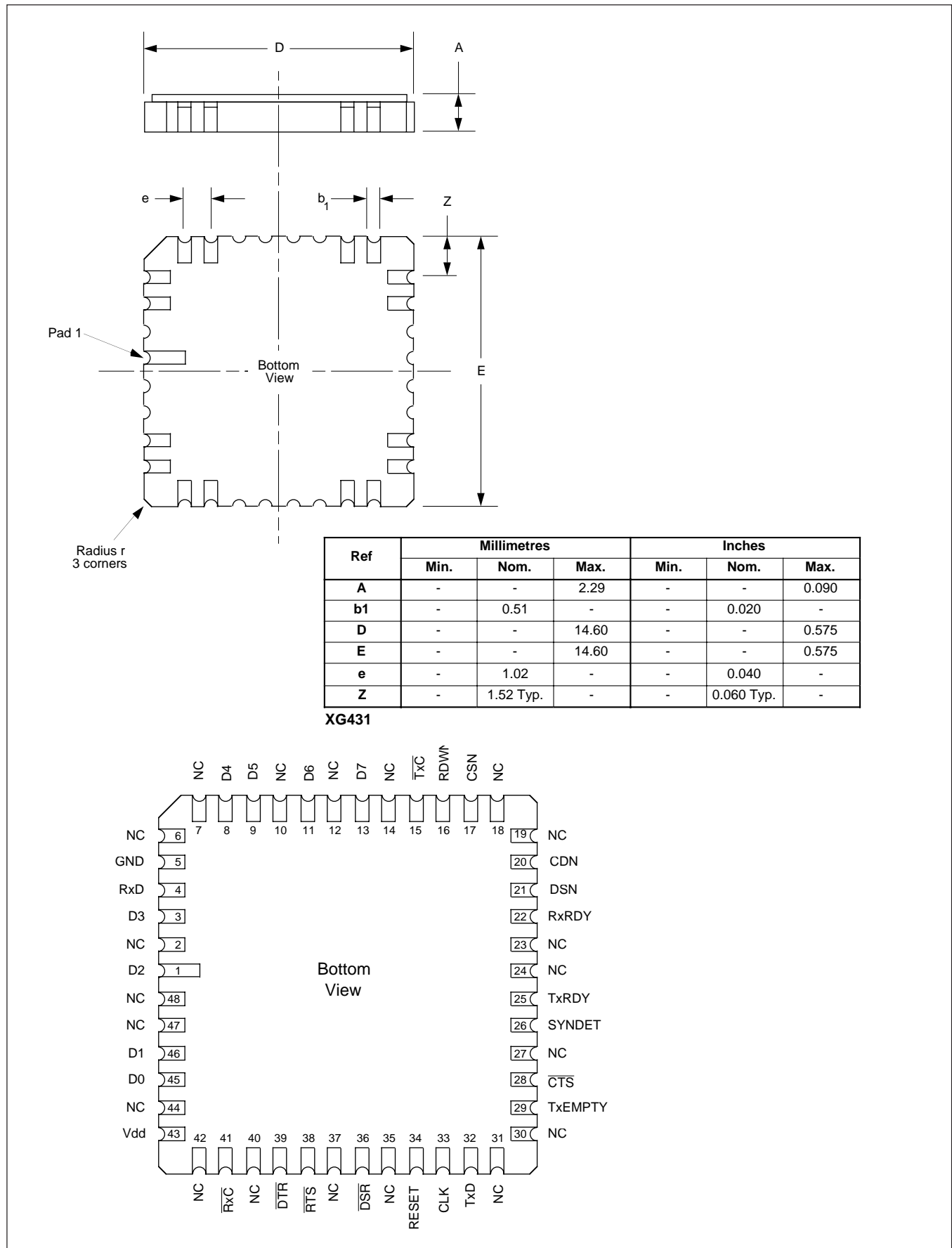
Figure 29: 48-Pad Leadless Chip Carrier - Package Style L
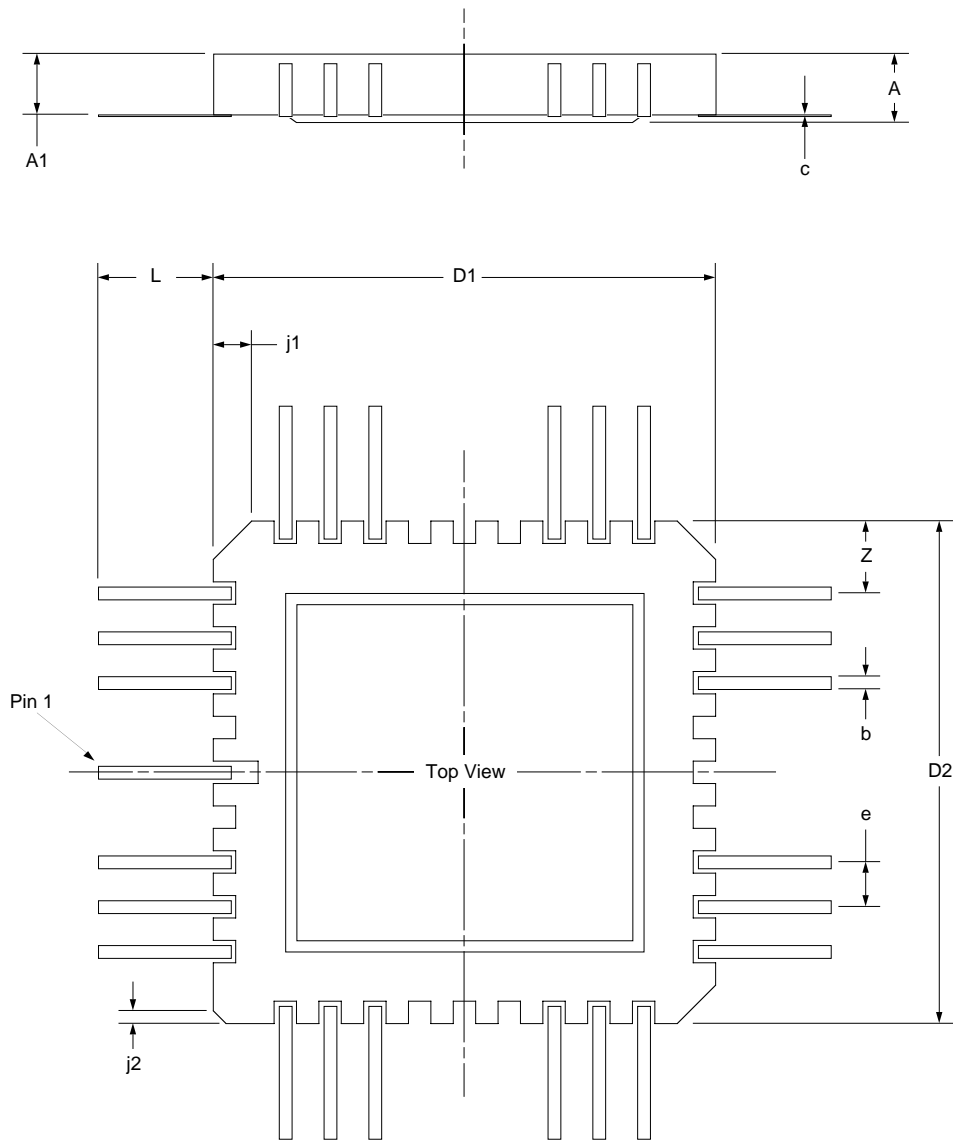
Ref	Millimetres			Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	2.72	-	-	0.107
A1	1.83	-	2.24	0.072	-	0.088
b	0.41	-	0.51	0.016	-	0.020
c	0.20	-	0.30	0.008	-	0.012
D1, D2	23.88	-	24.51	0.940	-	0.960
e	-	2.54	-	-	0.050	-
j1	-	1.02	-	-	0.040	-
j2	-	0.51	-	-	0.020	-
L	10.16	-	10.54	0.400	-	0.415
Z	1.65	-	2.16	0.065	-	0.085

XG540

Figure 30a: 68-Lead Topbraze Flatpack - Package Style F
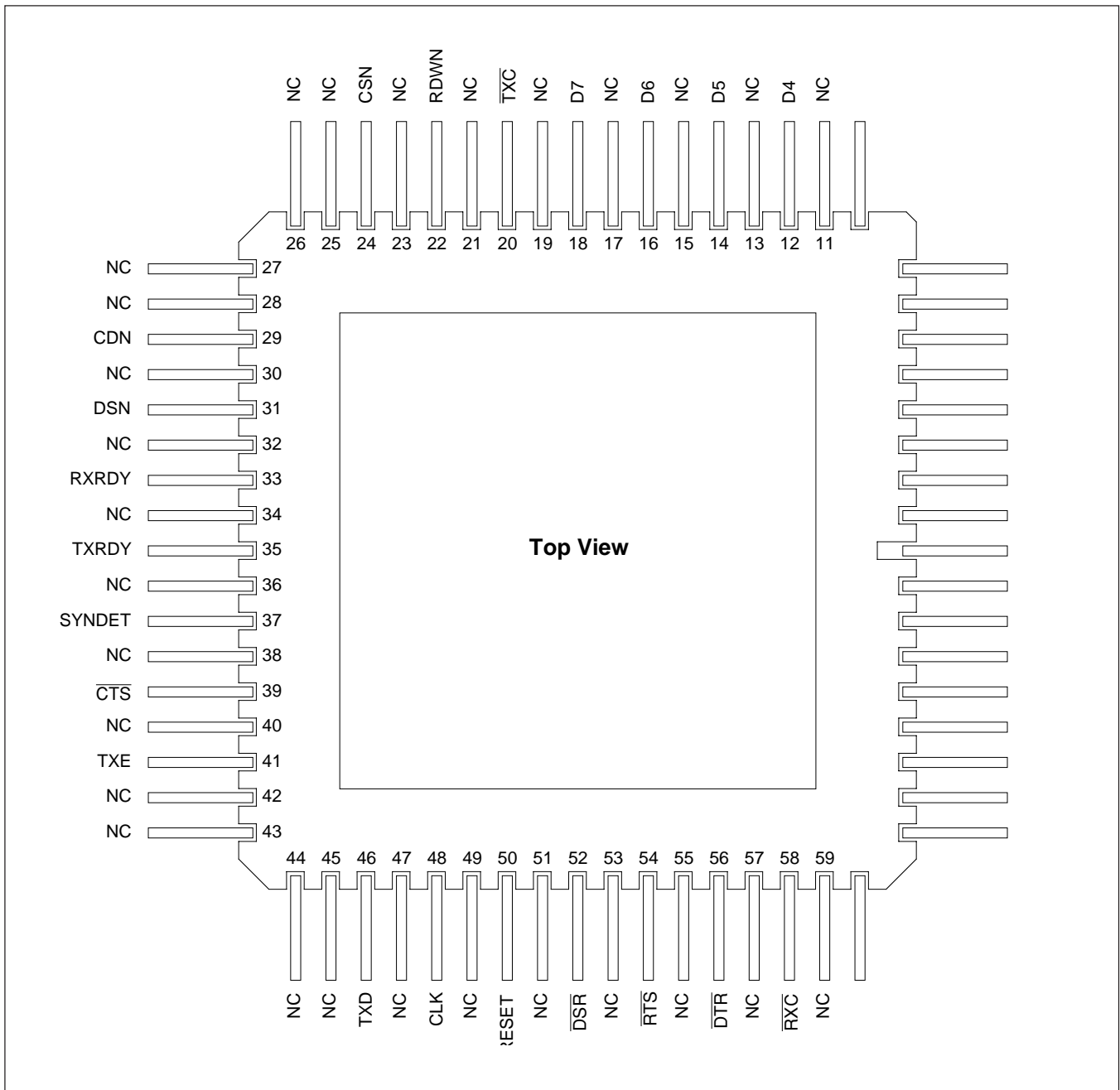
Figure 30b: 68-Lead Topbraze Flatpack - Package Style F

8. RADIATION TOLERANCE

Total Dose Radiation Testing

For product procured to guaranteed total dose radiation levels, each wafer lot will be approved when all sample devices from each lot pass the total dose radiation test.

The sample devices will be subjected to the total dose radiation level (Cobalt-60 Source), defined by the ordering code, and must continue to meet the electrical parameters specified in the data sheet. Electrical tests, pre and post irradiation, will be read and recorded.

Dynex Semiconductor can provide radiation testing compliant with MIL-STD-883 Ionizing Radiation (Total Dose) test 1019.

Total Dose (Function to specification)*	3×10^5 Rad(Si)
Transient Upset (Stored data loss)	5×10^{10} Rad(Si)/sec
Transient Upset (Survivability)	$>1 \times 10^{12}$ Rad(Si)/sec
Neutron Hardness (Function to specification)	$>1 \times 10^{15}$ n/cm^2
Single Event Upset**	$<1 \times 10^{-10}$ Errors/bit day
Latch Up	Not possible

* Other total dose radiation levels available on request
** Worst case galactic cosmic ray upset - interplanetary/high altitude orbit

Figure 31: Radiation Hardness Parameters

9. ORDERING INFORMATION

Unique Circuit Designator

MAx28151xxxxx

Radiation Tolerance

S	Radiation Hard Processing
R	100 kRads (Si) Guaranteed
Q	300 kRads (Si) Guaranteed
H	1000 kRads (Si) Guaranteed

Package Type

C	Ceramic DIL (Solder Seal)
F	Flatpack (Solder Seal)
L	Leadless Chip Carrier

QA/QCI Process
(See Section 9 Part 4)

Test Process
(See Section 9 Part 3)

Assembly Process
(See Section 9 Part 2)

Reliability Level

L	Rel 0
C	Rel 1
D	Rel 2
E	Rel 3/4/5/STACK
B	Class B
S	Class S

For details of reliability, QA/QC, test and assembly options, see 'Manufacturing Capability and Quality Assurance Standards' Section 9.

MA28151

Datasheet Annotations:

Dynex Semiconductor annotate datasheets in the top right hard corner of the front page, to indicate product status. The annotations are as follows:-

Target Information: This is the most tentative form of information and represents a very preliminary specification. No actual design work on the product has been started.

Preliminary Information: The product is in design and development. The datasheet represents the product as it is understood but details may change.

Advance Information: The product design is complete and final characterisation for volume production is well in hand.

No Annotation: The product parameters are fixed and the product is available to datasheet specification.