1.0 SYSTEM OVERVIEW

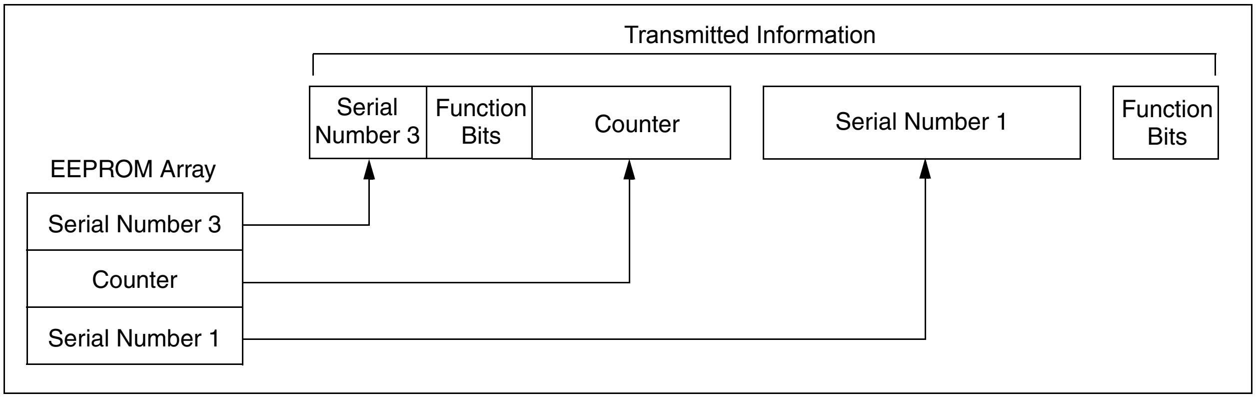
As indicated in the block diagram in Figure 1-1, the HCS101 has a small EEPROM array, which must be loaded with several parameters before use. These parameters include:

- Two 32-bit serial numbers
- 16-bit counter value
- Additional 10-bit serial number
- Configuration data

The EEPROM data for each transmitter is programmed by the manufacturer at the time of production.

Any type of controller may be used as a receiver, but it is typically a microcontroller with compatible firmware that allows the receiver to operate in conjunction with a transmitter, based on the HCS101.

FIGURE 1-1: BASIC OPERATION OF TRANSMITTER ENCODER

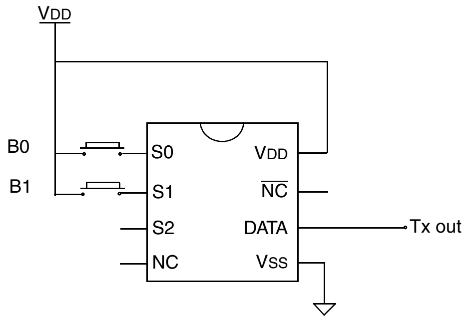


Preliminary

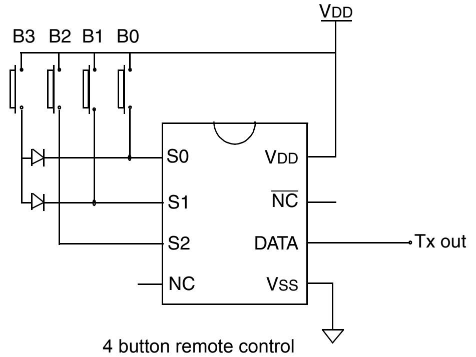
2.0 DEVICE OPERATION

As shown in the typical application circuits in Figure 2-1, the HCS101 is easy to use. It requires only the addition of buttons and RF circuitry for use as the transmitter in your application. A description of each pin is given in Table 2-1.

FIGURE 2-1: TYPICAL CIRCUITS



2 button remote control



4 button remote control

Note: Up to 7 functions can be implemented by pressing more than one button simultaneously or by using a suitable diode array.

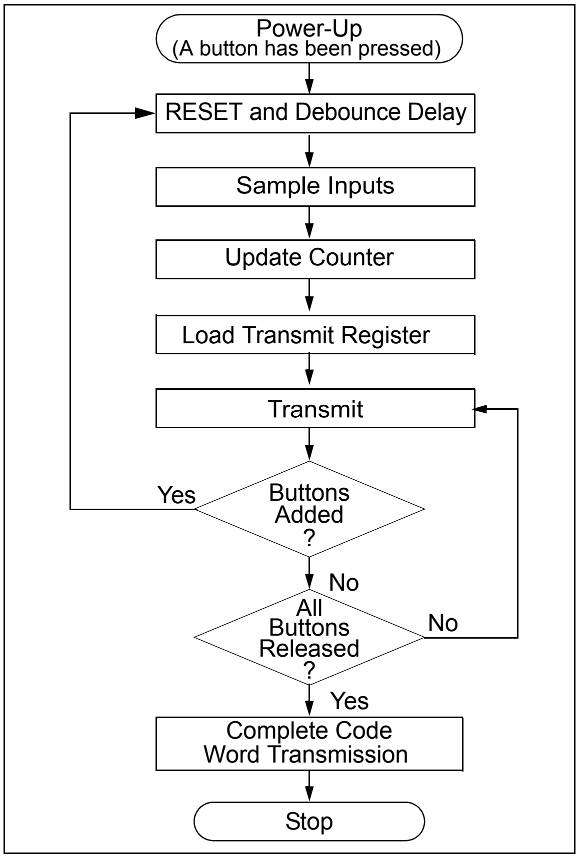
TABLE 2-1: PIN DESCRIPTIONS

Name	Pin Number	Description
S0	1	Switch input 0
S1	2	Switch input 1
S2	3	Switch input 2/Clock pin for Programming mode
NC	4	No connection
VSS	5	Ground reference connection
DATA	6	Pulse Width Modulation (PWM) output pin/Data pin for Programming mode
NC	7	No connection
VDD	8	Positive supply voltage connection

The HCS101 will wake-up upon detecting a switch closure and then delay for a debounce delay (T_{DB}) as shown in Figure 2-2. The device will then update the 16-bit counter before it loads the transmit register. The data is then transmitted serially on the DATA pin in Pulse Width Modulation (PWM) format.

If additional buttons are pressed during a transmission, the current transmission is terminated. The HCS101 restarts and the new transmission will contain the latest button information. When all buttons are released, the device completes the current code word and then powers down. Released buttons do not terminate and/or restart transmissions.

FIGURE 2-2: ENCODER OPERATION



3.0 TRANSMITTED WORD

3.1 Transmission Format (PWM Mode)

The HCS101 transmission is made up of several code words as shown in Figure 3-1. Each code word starts with a preamble and a header, followed by the data. The code word is followed by a guard period before the next code word begins. The same code word is transmitted as long as the button is pressed. Refer to Table 7-3 for transmission timing requirements.

3.2 Code Word Organization

The HCS101 transmits a 66-bit code word. The 66-bit word is constructed from the serial numbers, counter and function information. The code word format is shown in Figure 3-2.

Under normal conditions, serial number 1 is transmitted with the counter and serial number 3. If all the buttons are pressed, serial number 2 is transmitted in place of the counter and serial number 3.

FIGURE 3-1: CODE WORD TRANSMISSION FORMAT

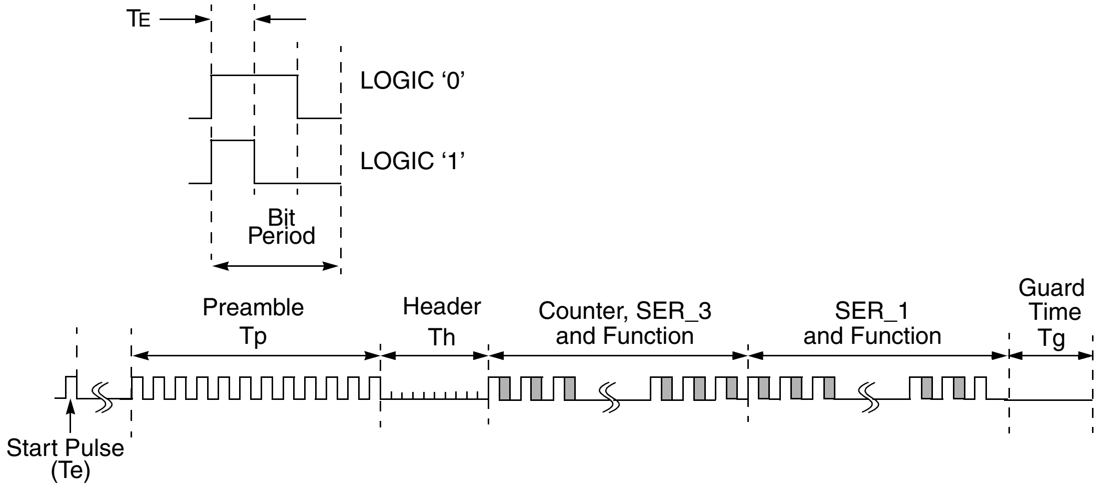


FIGURE 3-2: CODE WORD ORGANIZATION

<table>
<tr><td rowspan="2">'1'
(1 bit)</td><td rowspan="2">VLOW
(1 bit)</td><td>Function**
(0/4 bits)</td><td rowspan="2">Serial Number 1
(32/28 bits)**</td><td>Counter
(16 bits)</td><td>Function
(4 bits)
S2 S1 S0 S3*</td><td>'00'
(2 bits)</td><td>Serial Number 3
(10 bits)</td></tr>
<tr><td>S2 S1 S0 S3*</td><td colspan="4">Serial Number 2***
(32 bits)</td></tr>
</table>

MSb LSb

* See Section 4.3.6, S3 Setting (S3SET)

** See Section 4.3.7 Extended Serial Number (XSER)

*** Serial Number 2 is transmitted when all buttons are pressed

→ Transmission Direction LSb first

4.0 EEPROM MEMORY ORGANIZATION

The HCS101 contains 192 bits (12 x 16-bit words) of EEPROM memory as shown in Table 4-1. Further descriptions of the memory array are given in the following sections.

TABLE 4-1: EEPROM MEMORY MAP

WORD ADDRESS	MNEMONIC	DESCRIPTION
0	RESERVED	Set to 0000H
1	RESERVED	Set to 0000H
2	RESERVED	Set to 0000H
3	RESERVED	Set to 0000H
4	CNTR	Counter
5	RESERVED	Set to 0000H
6	SER_1	Device Serial Number 1 (word 0) 16 LSb's
7	SER_1	Device Serial Number 1 (word 1) 16 MSb's
8	SER_2	Device Serial Number 2 (word 0) 16 LSb's
9	SER_2	Device Serial Number 2 (word 1) 16 MSb's
10	SER_3	Device Serial Number 3
11	CONFIG	Config Word

4.1 CNTR (Counter)

This is the 16-bit gray code counter value that can be used to track the number of times a transmitter has been activated.

4.2 SER_1, SER_2, SER_3 (Encoder Serial Number)

SER_1, and SER_2 are the 32-bit device serial numbers. SER_3 is an additional 10-bit serial number transmitted with every transmission. The most significant 6 bits of the 16-bit SER_3 word are reserved and should be set to zero.

4.3 Configuration Word

The configuration word is a 16-bit word stored in the EEPROM array that is used by the device to store the status configuration options. Further explanations of each of the bits are described in the following sections.

TABLE 4-2: CONFIGURATION WORD

Bit Number	Bit Name
0	OSC0
1	OSC1
2	OSC2
3	OSC3
4	VLOWS
5	BRS
6	MTX4
7	TXEN
8	S3SET
9	XSER
10	RESERVED
11	RESERVED
12	RESERVED
13	RESERVED
14	RESERVED
15	RESERVED

4.3.1 OSCILLATOR TUNING BITS (OSC0 TO OSC3)

These bits are used to tune the nominal frequency of the HCS101 to within ±10% of its nominal value over temperature and voltage.

4.3.2 LOW VOLTAGE TRIP POINT SELECT (VLOWS)

The low voltage trip point select bit (VLOWS) and the S3 setting bit (S3SET) are used to determine the voltage level for the low voltage detector.

VLOWS	S3SET*	Trip Point
0	0	4.4
0	1	4.4
1	0	9
1	1	6.75

* See also Section 4.3.6

4.3.3 BAUD RATE SELECT BITS (BRS)

BRS selects the speed of transmission and the code word blanking. Table 4-3 shows how the bit is used to select the different baud rates and Section 5.2 provides a detailed explanation of code word blanking.

TABLE 4-3: BAUD RATE SELECT

BRS	Basic Pulse Element	Code Words Transmitted
0	400µs	All
1	200µs	1 out of 2

4.3.4 MINIMUM FOUR TRANSMISSIONS (MTX4)

If this bit is cleared, at least one code word is completed when the HCS101 is activated. If this bit is set, at least four complete code words are transmitted.

4.3.5 TRANSMIT PULSE ENABLE (TXEN)

If this bit is cleared, no start pulse occurs before a transmission. If the bit is set, a start pulse (1 TE long) is transmitted before the first code word's preamble.

4.3.6 S3 SETTING (S3SET)

This bit determines the value of S3 in the function code during a transmission and the high trip point selected by VLOWS in Section 4.3.2. If this bit is cleared, S3 mirrors S2 during a transmission. If the S3SET bit is set, S3 in the function code is always set, independent of the value of S2.

4.3.7 EXTENDED SERIAL NUMBER (XSER)

If this bit is cleared, the most significant four bits of the 32-bit Serial Number 1 are replaced with the function code. If this bit is set, the full 32-bit Serial Number 1 is transmitted.

5.0 SPECIAL FEATURES

5.1 Code Word Completion

Code word completion is an automatic feature that ensures the entire code word is transmitted, even if the button is released before the transmission is complete. If the button is held down beyond the time for one code word, multiple code words will result. If another button is activated during a transmission, the active transmission will be aborted and a new transmission will begin using the new button information.

5.2 Blank Alternate Code Word

Federal Communications Commission (FCC) Rules, Part 15 specify the limits on fundamental power and harmonics that can be transmitted. Power is calculated on the worst case average power transmitted in a 100 ms window. It is therefore advantageous to minimize the duty cycle of the transmission by minimizing the duty cycle of the individual bits and by blanking out consecutive words. The transmission duty cycle can be lowered by setting BRS. This reduces the average power transmitted and hence, assists in FCC approval of a transmitter device. Shortening the code word length and transmitting only every other code word (Figure 5-1) also may allow a higher amplitude transmission for greater range.

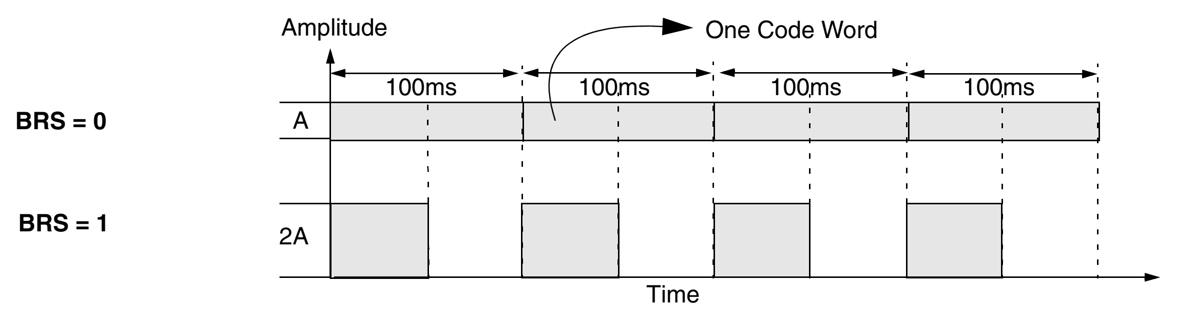
5.3 Auto-Shutoff

The auto-shutoff function automatically stops the device from transmitting if a button inadvertently gets pressed for longer than the time-out period, TTO. This will prevent the device from draining the battery if a button gets pressed while the transmitter is in a pocket or purse.

5.4 VLOW: Voltage LOW Indicator

The VLOW bit is included in every transmission and will be transmitted as a one if the operating voltage has dropped below the low voltage trip point. Refer to Figure 3-2. The trip point is selectable based on the battery voltage being used. See Section 4.3.2 for a description of how the low voltage select option is set.

FIGURE 5-1: CODE WORD TRANSMISSIONS



6.0 PROGRAMMING THE HCS101

When using the HCS101 in a system, the user will have to program some parameters into the device, including the serial number and the counter, before it can be used. The programming cycle allows the user to input a 192-bit serial data stream which is then stored internally in EEPROM. Programming will be initiated by forcing the DATA line high after the S2 line has been held high for the appropriate length of time. Refer to Table 6-1 and Figure 6-1.

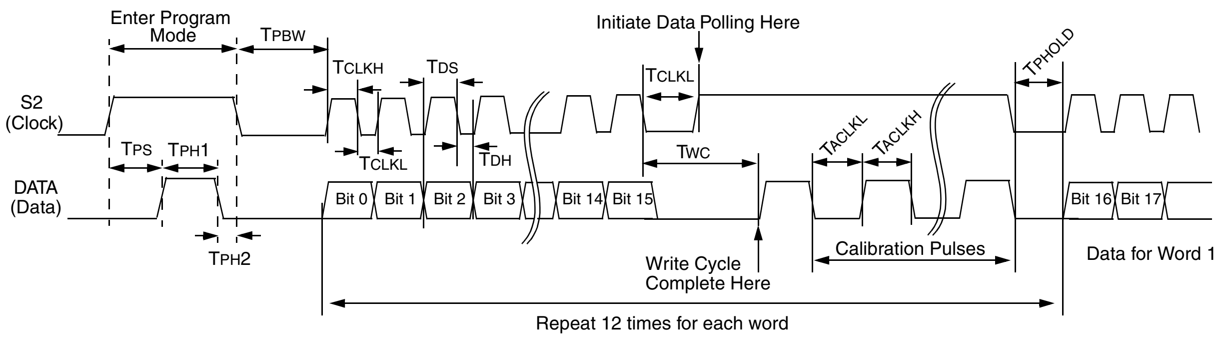
After the Program mode is entered, a delay must be provided to the device for the automatic bulk write cycle to complete. This will write all locations in the EEPROM to all zeros. The device can then be programmed by clocking in 16 bits at a time, using S2 as the clock line and DATA as the data in line. After each 16-bit word is loaded, a programming delay is required for the internal program cycle to complete. This delay can take up to TWC.

The HCS101 will signal that the write is complete by sending out a train of ACK pulses, TACKH high, TACKL low on DATA. The ACK pulses will continue until S2 is dropped. These times can be used to calculate the oscillator calibration value. The first pulse's width should NOT be used for calibration.

At the end of the programming cycle, the device can be verified as shown in Figure 6-2 by reading back the EEPROM. Reading is done by clocking the S2 line and reading the data bits on the DATA pin. **A verify operation can only be done once, immediately following the program cycle**.

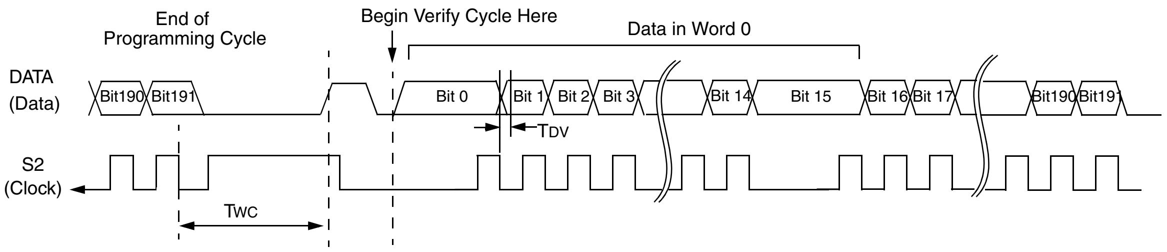
Note:	To ensure that the device does not accidentally enter Programming mode, DATA should never be pulled high by the circuit connected to it. Special care should be taken when driving PNP RF transistors.

FIGURE 6-1: PROGRAMMING WAVEFORMS



Note: S0 and S1 button inputs to be held to ground during the entire programming sequence.

FIGURE 6-2: VERIFY WAVEFORMS



Note: If a Verify operation is to be done, then it must immediately follow the Program cycle.

TABLE 6-1: PROGRAMMING/VERIFY TIMING REQUIREMENTS

VDD = 5.0V ± 10%
25° C ± 5°C

Parameter	Symbol	Min.	Max.	Units
Program mode setup time	TPS	1.5	1.75	ms
Hold time 1	TPH1	4.5	—	ms
Hold time 2	TPH2	50	—	µs
Bulk Write time	TPBW	4.0	—	ms
Program delay time	TPROG	4.0	—	ms
Program cycle time	TWC	50	—	ms
Clock low time	TCLKL	50	—	µs
Clock high time	TCLKH	50	—	µs
Data setup time	TDS	0	—	µs
Data hold time	TDH	30	—	µs
Data out valid time	TDV	—	30	µs
Hold time	TPHOLD	100	—	µs (1)
Acknowledge low time	TACKL	800	—	µs (1)
Acknowledge high time	TACKH	800	—	µs (1)

Note 1: Typical values - not tested in production

7.0 ELECTRICAL CHARACTERISTICS FOR HCS101

Absolute Maximum Ratings†

VDD Supply voltage .... -0.3 to 13.5 V

VIN Input voltage .... -0.3 to VDD + 0.3 V

VOUT Output voltage .... -0.3 to VDD + 0.3 V

IOUT Max Output current .... 50 mA

TSTG Storage temperature **(Note)** .... -55 to +125°C

TLSOL Lead soldering temperature **(Note)** .... 300°C

VESD ESD rating .... 2000 V

† **NOTICE:** Stresses above 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 those or any other conditions above those indicated in the operation listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

TABLE 7-1: DC CHARACTERISTICS

Commercial (C):TAMB = 0°C to +70°C Industrial (I):TAMB = -40°C to +85°C									
		3.5V < VDD < 5.0V			5.0V < VDD < 13.3V				
Parameter	**Sym.**	**Min.**	**Typ[1]**	**Max.**	**Min.**	**Typ[1]**	**Max.**	**Unit**	**Conditions**
Operating Current (avg)(2)	ICC		—	0.5		—	2	mA mA	
Standby Current	ICCS		0.1	1.0		0.1	1.0	µA	
Auto-shutoff Current(3,4)	ICCS		40	75		160	300	µA	
High Level Input Voltage	VIH	0.55VDD		VDD+0.3	2.75		VDD+0.3	V	
Low Level Input Voltage	VIL	-0.3		0.15VDD	-0.3		0.75	V	
High Level Output Voltage	VOH	0.6VDD			3.3			V V	IOH = -1.0 mA VDD = 3.5V IOH = -2.0 mA VDD = 10V
Low Level Output Voltage	VOL			0.08VDD			0.4	V V	IOL = 1.0 mA VDD = 3.5V IOL = 2.0 mA VDD = 10V
Pull-down Resistance; S0-S2	RSO-2	40	60	80	40	60	80	kΩ	VDD = 4.0V
Pull-down Resistance; DATA	RDATA	80	120	160	80	120	160	kΩ	VDD = 4.0V

Note 1: Typical values are at 25°C.

2: No load.

3: Auto-shutoff current specification does not include the current through the input pulldown resistors.

4: Auto-shutoff current is periodically sampled and not 100% tested.

FIGURE 7-1: POWER-UP AND TRANSMIT TIMING

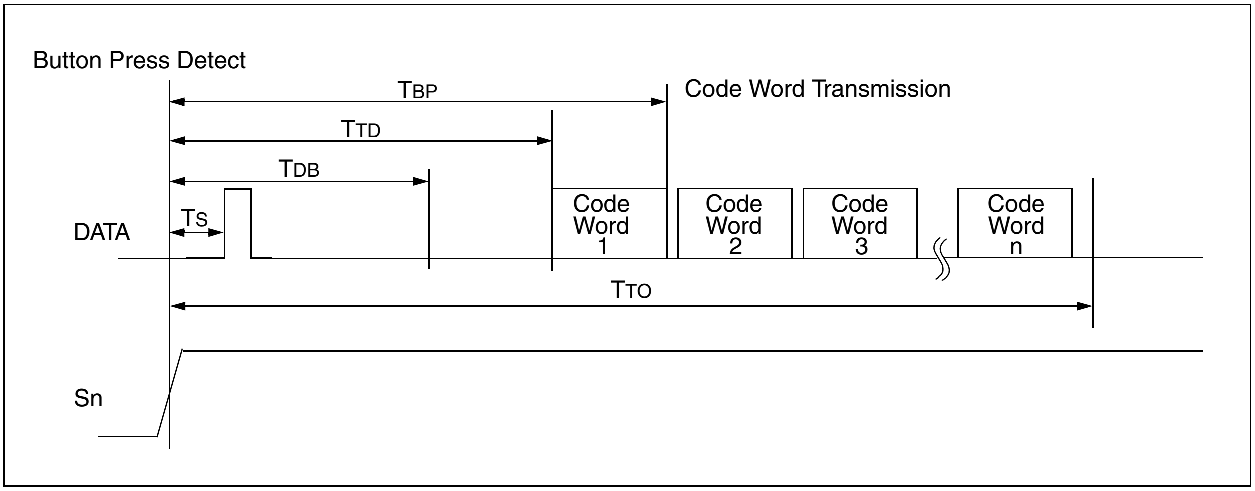


TABLE 7-2: POWER-UP AND TRANSMIT TIMING[2]

		Standard Operating Conditions (unless otherwise specified): Commercial (C): 0°C ≤ TA ≤ +70°C Industrial (I):-40°C ≤ TA ≤ +85°C				
Symbol	**Parameters**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
TBP	Time to second button press	10 + Code Word Time	—	26 + Code Word Time	ms	**(Note 1)**
TTD	Transmit delay from button detect	12	—	26	ms	
TDB	Debounce delay	6	—	20	ms	
TTO	Auto-shutoff time-out period	—	27	—	s	
TS	Start pulse delay	—	4.5	—	ms	

Note 1: TBP is the time in which a second button can be pressed without completion of the first code word and the intention was to press the combination of buttons.

2: Typical values - not tested in production.

FIGURE 7-2: PREAMBLE/HEADER FORMAT

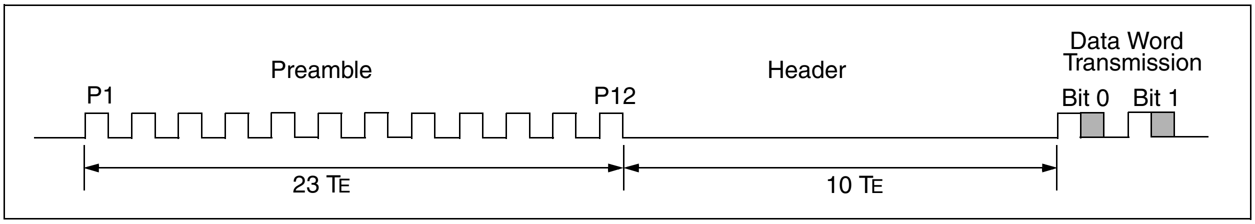


FIGURE 7-3: DATA WORD FORMAT (XSER = 0)

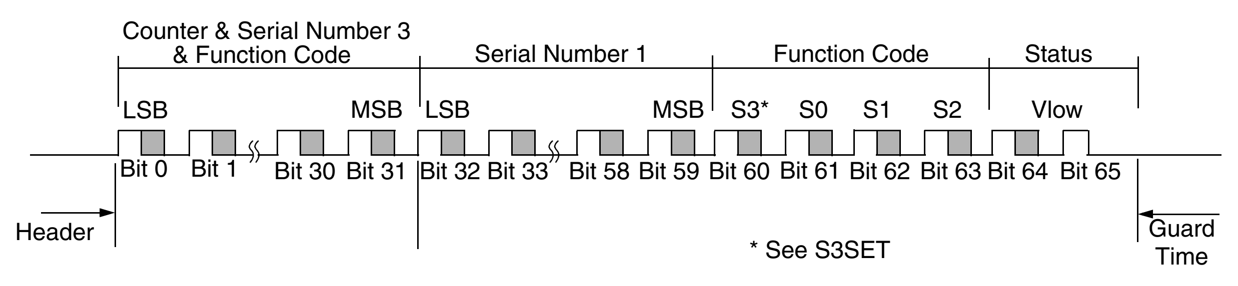


TABLE 7-3: CODE WORD TRANSMISSION TIMING REQUIREMENTS

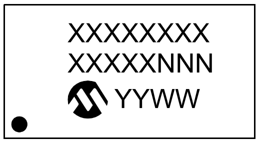
VDD = +3.5 to 13.3V Commercial (C):TAMB = 0°C to +70°C Industrial (I):TAMB = -40°C to +85°C			Code Words Transmitted						
			All			1 out of 2			Units
Symbol	**Characteristic**	**Number of TE**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	
TE	Basic pulse element	1	360	400	440	180	200	220	µs
TBP	PWM bit pulse width	3	—	3	—	—	3	—	ms
TP	Preamble duration	24	8.64	9.6	10.56	4.32	4.8	5.28	ms
TH	Header duration	10	3.6	4.0	4.4	1.8	2.0	2.2	ms
THOP	Hopping code duration	96	34.56	38.4	42.24	17.28	19.2	21.12	ms
TFIX	Fixed code duration	102	36.72	40.8	44.88	18.36	20.4	22.44	ms
TG	Guard Time	39	14.04	15.6	17.16	7.02	7.8	8.58	ms
—	Total Transmit Time	271	97.56	108.4	119.24	48.78	54.2	59.62	ms
—	PWM data rate	—	925	833	757	1851	1667	1515	bps

Note: The timing parameters are not tested but derived from the oscillator clock.

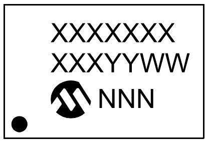
8.0 PACKAGING INFORMATION

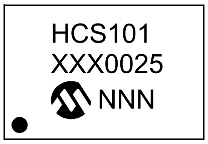
8.1 Package Marking Information

8-Lead PDIP (300 mil)



8-Lead SOIC (150 mil)





Legend:		
	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	ⓔ3	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator (ⓔ3) can be found on the outer packaging for this package.

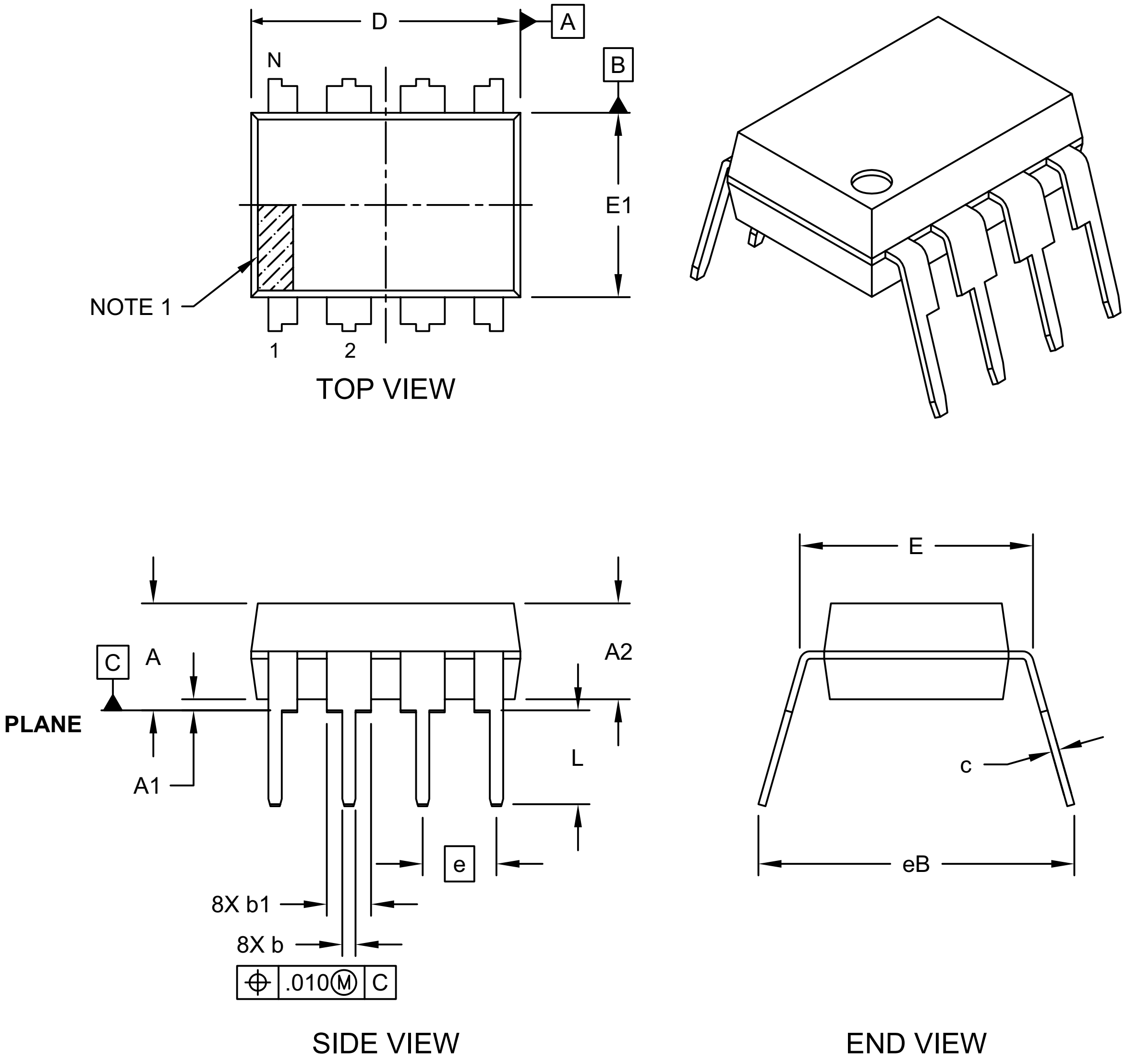
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information.

8.2 Package Details

8-Lead Plastic Dual In-line (P) - 300 mil (PDIP)

8-Lead Plastic Dual In-Line (P) - 300 mil Body [PDIP]

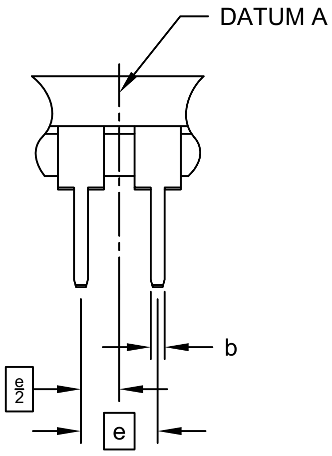
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



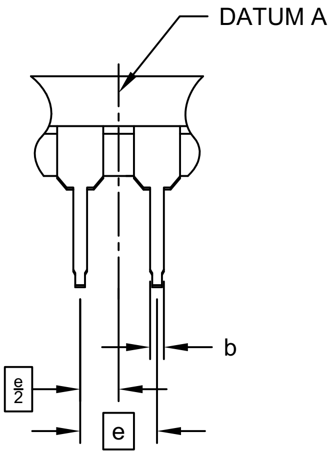
Microchip Technology Drawing No. C04-018D Sheet 1 of 2

8-Lead Plastic Dual In-Line (P) - 300 mil Body [PDIP]

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



ALTERNATE LEAD DESIGN
(VENDOR DEPENDENT)



Units		INCHES		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N	8		
Pitch	e	.100 BSC		
Top to Seating Plane	A	-	-	.210
Molded Package Thickness	A2	.115	.130	.195
Base to Seating Plane	A1	.015	-	-
Shoulder to Shoulder Width	E	.290	.310	.325
Molded Package Width	E1	.240	.250	.280
Overall Length	D	.348	.365	.400
Tip to Seating Plane	L	.115	.130	.150
Lead Thickness	c	.008	.010	.015
Upper Lead Width	b1	.040	.060	.070
Lower Lead Width	b	.014	.018	.022
Overall Row Spacing §	eB	-	-	.430

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
4. Dimensioning and tolerancing per ASME Y14.5M

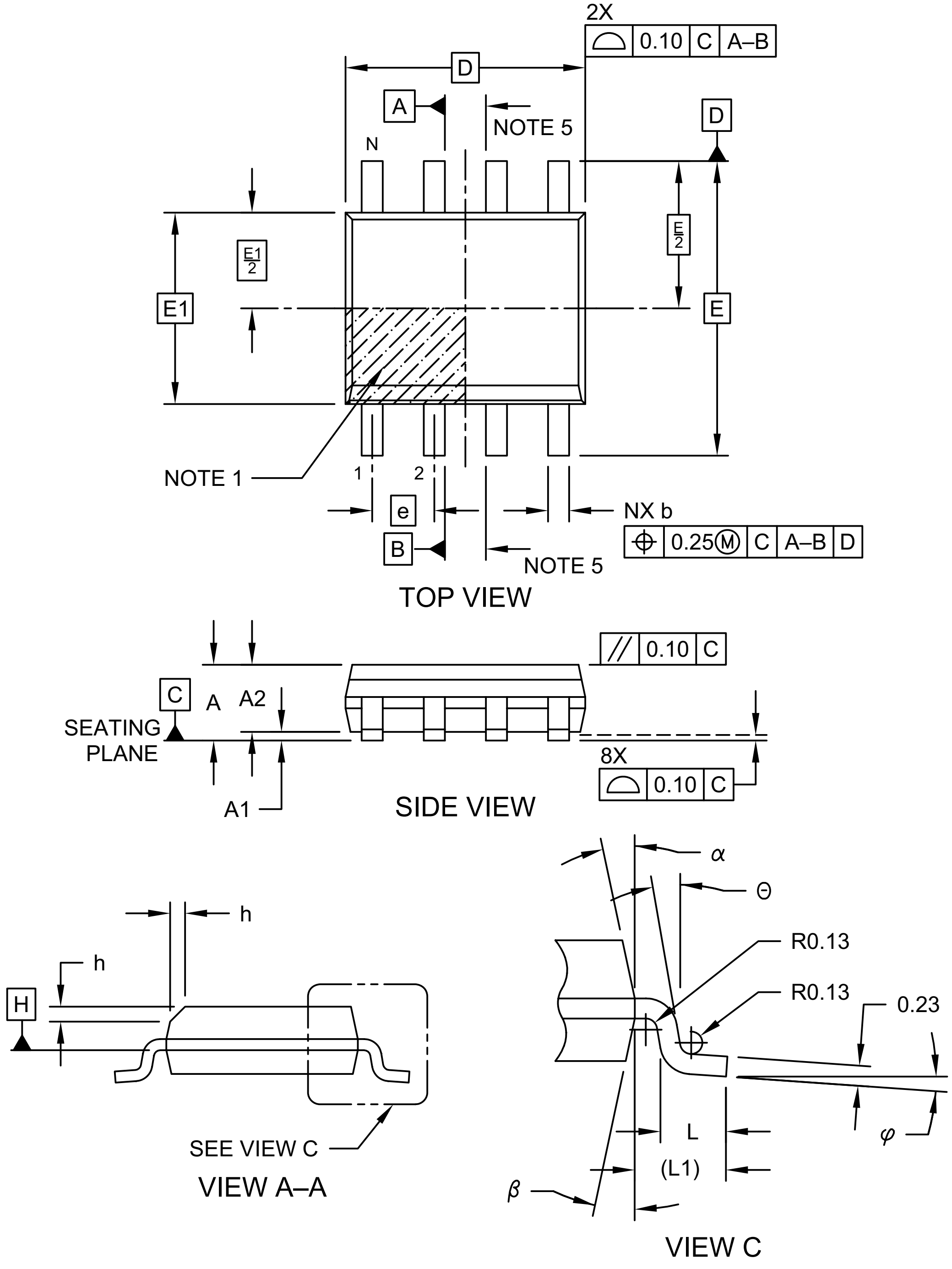
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing No. C04-018D Sheet 2 of 2

8-Lead Plastic Small Outline (SN) - Narrow, 150 mil (SOIC)

8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm (.150 In.) Body [SOIC]

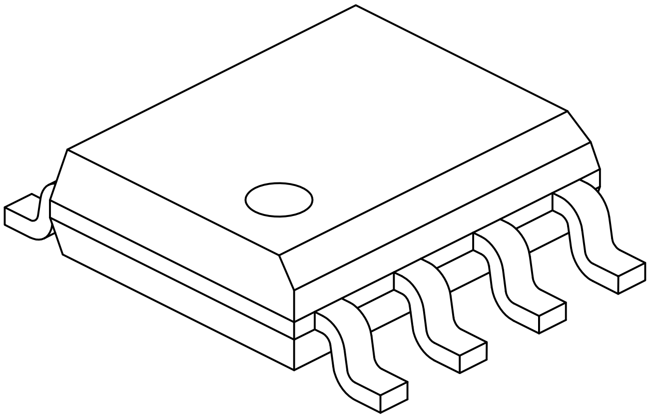
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing No. C04-057-SN Rev D Sheet 1 of 2

8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm (.150 In.) Body [SOIC]

Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N	8		
Pitch	e	1.27 BSC		
Overall Height	A	-	-	1.75
Molded Package Thickness	A2	1.25	-	-
Standoff §	A1	0.10	-	0.25
Overall Width	E	6.00 BSC		
Molded Package Width	E1	3.90 BSC		
Overall Length	D	4.90 BSC		
Chamfer (Optional)	h	0.25	-	0.50
Foot Length	L	0.40	-	1.27
Footprint	L1	1.04 REF		
Foot Angle	φ	0°	-	8°
Lead Thickness	c	0.17	-	0.25
Lead Width	b	0.31	-	0.51
Mold Draft Angle Top	α	5°	-	15°
Mold Draft Angle Bottom	β	5°	-	15°

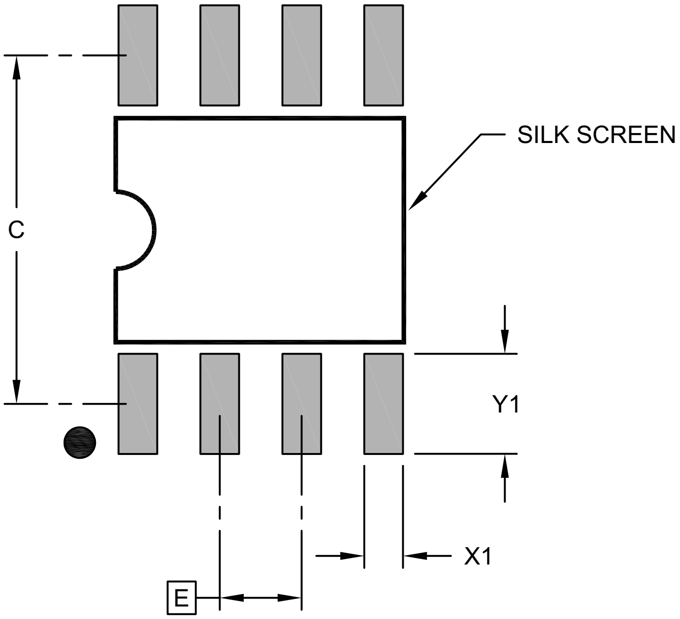
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
4. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.
5. Datums A & B to be determined at Datum H.

Microchip Technology Drawing No. C04-057-SN Rev D Sheet 2 of 2

8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm Body [SOIC]

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	1.27 BSC		
Contact Pad Spacing	C		5.40	
Contact Pad Width (X8)	X1			0.60
Contact Pad Length (X8)	Y1			1.55

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-2057-SN Rev B

HCS101 PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, refer to the factory or the listed sales office.

HCS101 - __ _ /P

Package:
P = Plastic DIP (300 mil Body), 8-lead)
SN = Plastic SOIC (150 mil Body), 8-lead

Temperature Range:
Blank = 0°C to +70°C
I = –40°C to +85°C

Device:
HCS101 = Code Hopping Encoder
HCS101T = Code Hopping Encoder (Tape and Reel)

Sales and Support

Data Sheets

Products supported by a preliminary Data Sheet may have an errata sheet describing minor operational differences and recommended workarounds. To determine if an errata sheet exists for a particular device, please contact one of the following:

1. Your local Microchip sales office.
2. The Microchip Worldwide Web Site. (www.microchip.com)

APPENDIX A: REVISION HISTORY

Revision D (January 2013)

Added a note to each package outline drawing.

Revision E (October 2017)

Updated Table 6-1; Updated Package Drawings; Replaced Reader Response page with On-Line Customer Support page.

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