HCS101

Fixed Code Encoder

FEATURES

Operating

- 2 Programmable 32-bit serial numbers
- 10-bit serial number
- 66-bit transmission code length
- Non-volatile 16-bit counter
- 3.5 -13.3V operation
- 3 inputs, 7 functions available
- Selectable baud rate
- Automatic code-word completion
- Battery low signal transmitted to receiver

Other

- Pin-out compatible with most Keeloq Encoders
- Simple programming interface
- On-chip EEPROM
- On-chip oscillator and timing components
- Button inputs have internal pulldown resistors
- Minimum External Components required

Typical Applications

The HCS101 is ideal for remote control applications. These applications include:

- Low-end automotive alarm systems
- Low-end automotive immobilizers
- Gate and garage door openers
- Identity tokens
- Low-end burglar alarm systems
- Fan and lighting controls
- Toys

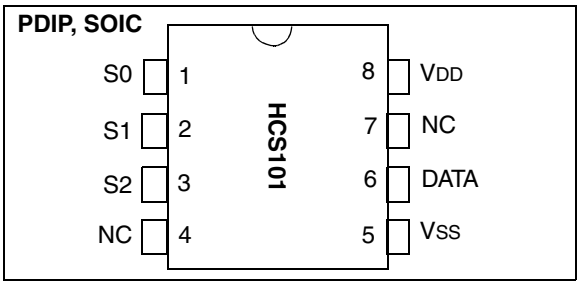
DESCRIPTION

The HCS101 from Microchip Technology Inc. is a fixed code encoder designed for remote control systems. It provides a small package outline and low cost to make this device a perfect solution for unidirectional remote control systems.

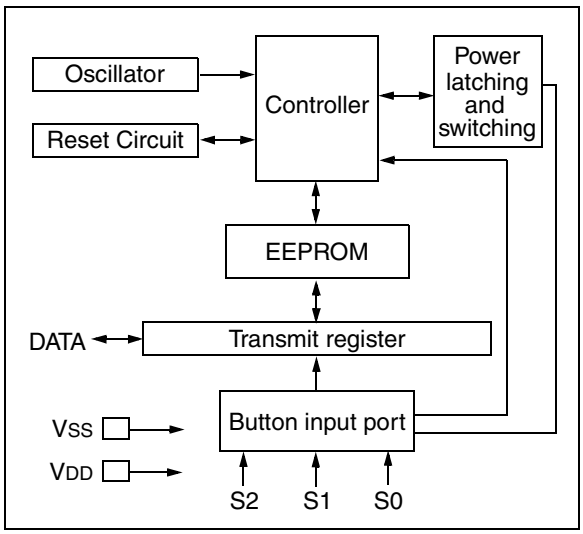
It is also pin compatible with Microchip's HCS201 Code Hopping Encoder allowing easy upgrading to a more secure remote keyless entry (RKE) system.

The HCS101 operates over a wide voltage range of 3.5V to 13.3V and has three button inputs in an 8-pin configuration, which allows the system designer the freedom to utilize up to 7 functions. The only components required for device operation are the buttons and RF circuitry, allowing a very low system cost.

PACKAGE TYPES



HCS101 BLOCK DIAGRAM



1.0 SYSTEM OVERVIEW

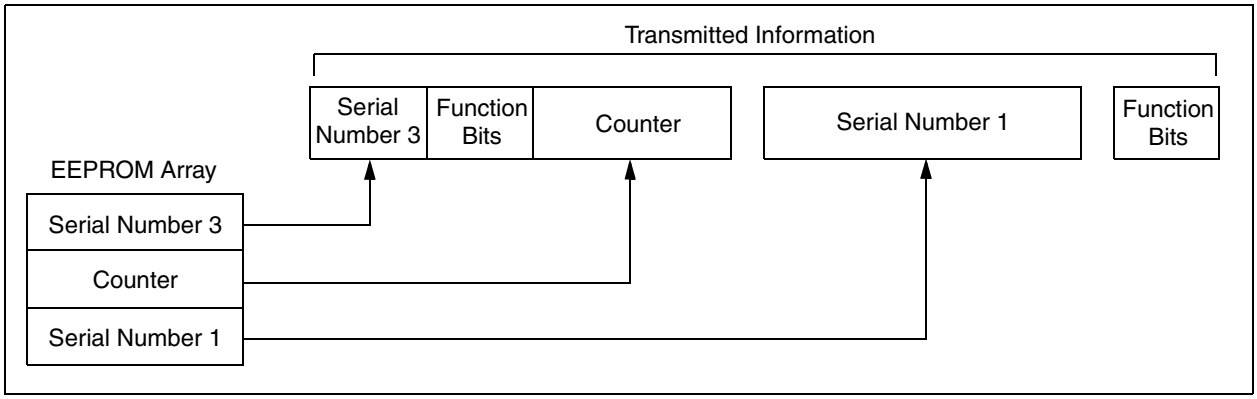
As indicated in the block diagram in Figure 1-1, the HCS101 has a small EEPROM array, which must be loaded with several parameters before use. These parameters include:

- 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.

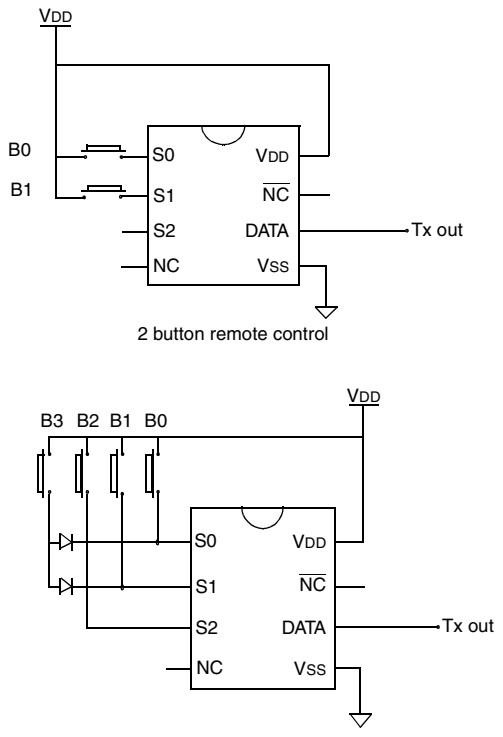
FIGURE 1-1: BASIC OPERATION OF TRANSMITTER ENCODER



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



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

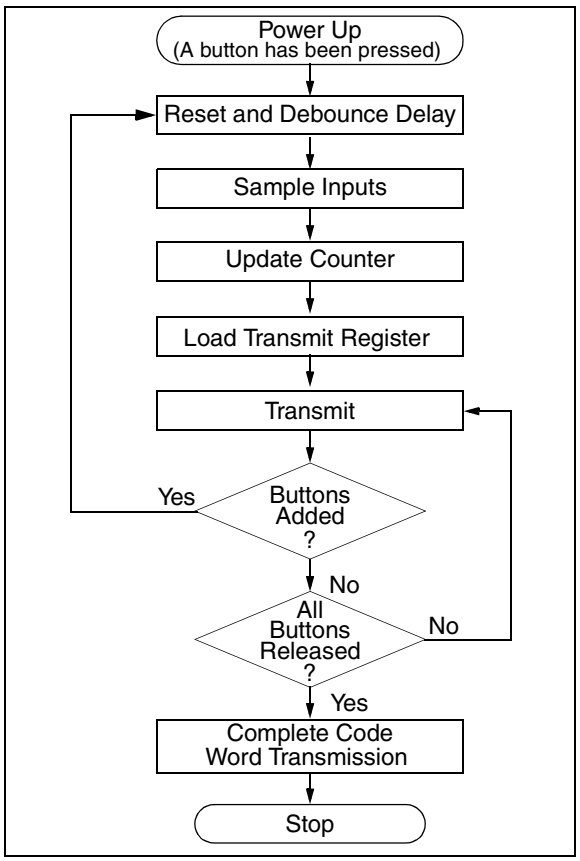
TABLE 2-1: PIN DESCRIPTIONS

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 (TDB) 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 7-4 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

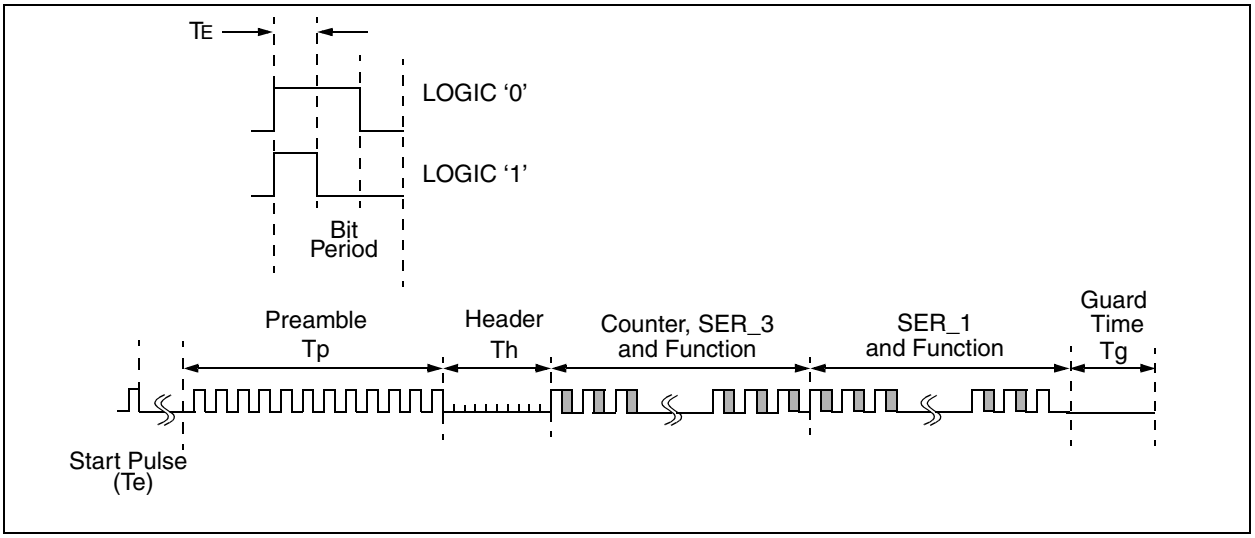
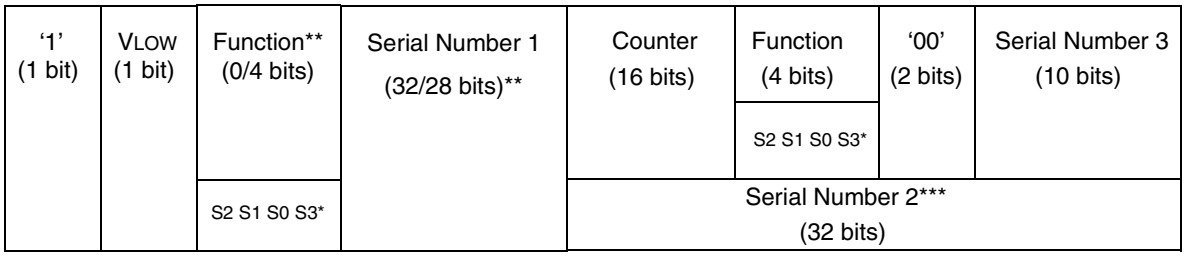


FIGURE 3-2: CODE-WORD ORGANIZATION



* 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)
7	SER_1	Device Serial Number 1 (word 1)
8	SER_2	Device Serial Number 2 (word 0)
9	SER_2	Device Serial Number 2 (word 1)
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 used.

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 SER_3 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 BAUDRATE 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 in code-word blanking.

TABLE 4-3: BAUDRATE 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, a minimum of 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 transmission pulse is transmitted before a transmission. If the bit is set, a start pulse (1 TE long) is transmitted before the preamble of the first code-word.

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 HCS101's serial number are replaced with the function code. If this bit is set, the full 32-bit serial number is transmitted.

5.0 SPECIAL FEATURES

5.1 Code-Word Completion

Code-word completion is an automatic feature that ensures that 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 the new code will be generated 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 100ms window. It is therefore advantageous to minimize the duty cycle of the transmission. This can be achieved 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 allows the user to transmit a higher amplitude transmission, if the code-word length is shorter. This reduces the average power transmitted and hence, assists in FCC approval of a transmitter device. When the higher baud rate is selected, alternate code-words are not transmitted as shown in Figure 5-1.

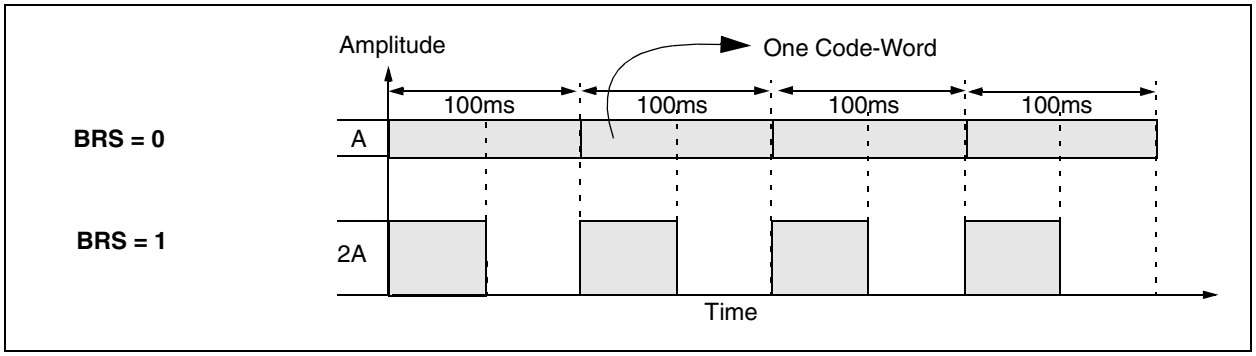
5.3 Auto-Shutoff

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 transmitted with 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 192 bits in a serial data stream, which are 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.

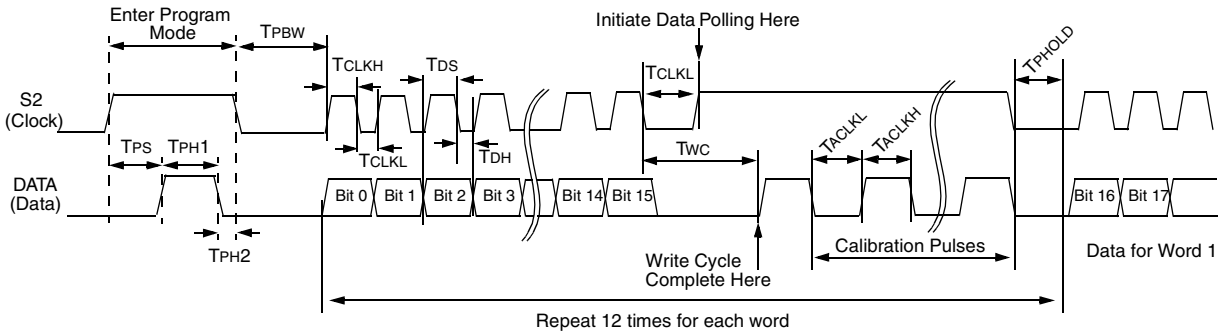
After the program mode is entered, a delay must be provided to the device for the automatic bulk write cycle to complete. This will write all locations in the EEPROM to an all zeros pattern. The device can then be programmed by clocking in 16 bits at a time, using S2 as the clock line and DATA as the 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**.

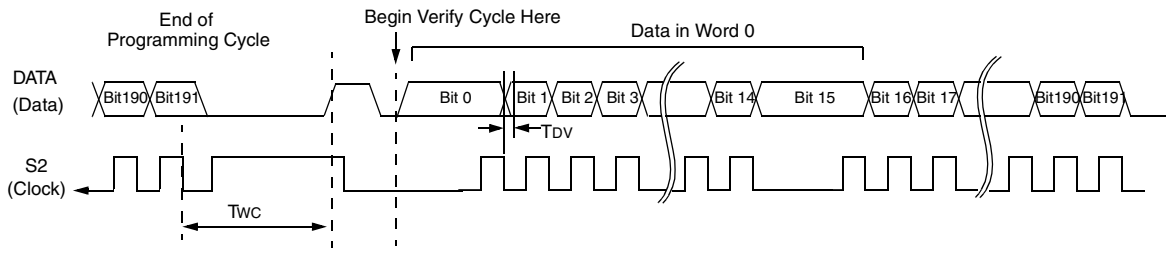
Note:	To ensure that the device does not accidentally enter programming mode, DATA should never be pulled high by the circuit connected to it. Special care should be taken when driving PNP RF transistors.

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

V_{DD} = 5.0V ± 10% 25° C ± 5°C				
Parameter	**Symbol**	**Min.**	**Max.**	**Units**
Program mode setup time	T_{PS}	2	—	ms
Hold time 1	T_{PH1}	5.0	—	ms
Hold time 2	T_{PH2}	50	—	µs
Bulk Write time	T_{PBW}	—	2.2	ms
Program delay time	T_{PROG}	—	2.2	ms
Program cycle time	T_{WC}	—	36	ms
Clock low time	T_{CLKL}	25	—	µs
Clock high time	T_{CLKH}	25	—	µs
Data setup time	T_{DS}	0	—	µs
Data hold time	T_{DH}	30	—	µs
Data out valid time	T_{DV}	10	30	µs
Hold time	T_{PHOLD}	100	—	µs
Acknowledge low time	T_{ACKL}	800	—	µs
Acknowledge high time	T_{ACKH}	800	—	µs

7.0 ELECTRICAL CHARACTERISTICS

TABLE 7-1: ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Units
V_{DD}	Supply voltage	-0.3 to 13.5	V
V_{IN}	Input voltage	-0.3 to V_{DD} + 0.3	V
V_{OUT}	Output voltage	-0.3 to V_{DD} + 0.3	V
I_{OUT}	Max output current	50	mA
T_{STG}	Storage temperature	-55 to +125	C **(Note**)
T_{LSOL}	Lead soldering temp	300	C **(Note)**
V_{ESD}	ESD rating	2000	V

Note: Stresses above those listed under “ABSOLUTE MAXIMUM RATINGS” may cause permanent damage to the device.

TABLE 7-2: DC CHARACTERISTICS

Commercial (C): T_{AMB} = 0°C to +70°C Industrial (I): T_{AMB} = -40°C to +85°C									
		3.5V < V_{DD} < 5.0V			5.0V < V_{DD} < 13.3V				
Parameter	**Sym.**	**Min.**	**Typ[1]**	**Max.**	**Min.**	**Typ[1]**	**Max.**	**Unit**	**Conditions**
Operating current (avg)**(2)**	I_{CC}		—	0.5		—	2	mA mA	
Standby current	I_{CCS}		0.1	1.0		0.1	1.0	µA	
Auto-shutoff current**(3,4)**	I_{CCS}		40	75		160	300	µA	
High level Input voltage	V_{IH}	0.55V_{DD}		V_{DD}+0.3	2.75		V_{DD}+0.3	V	
Low level input voltage	V_{IL}	-0.3		0.15V_{DD}	-0.3		0.75	V	
High level output voltage	V_{OH}	0.6V_{DD}			3.3			V V	I_{OH} = -1.0 mA V_{DD} = 3.5V I_{OH} = -2.0 mA V_{DD} = 10V
Low level output voltage	V_{OL}			0.08V_{DD}			0.4	V V	I_{OL} = 1.0 mA V_{DD} = 3.5V I_{OL} = 2.0 mA V_{DD} = 10V
Resistance; S0-S2	R_{SO-2}	40	60	80	40	60	80	kΩ	V_{DD} = 4.0V
Resistance; DATA	R_{DATA}	80	120	160	80	120	160	kΩ	V_{DD} = 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.

TABLE 7-3: AC CHARACTERISTICS

		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	**(Note 2)**
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: The auto shutoff timeout period is not tested.

FIGURE 7-1: POWER UP AND TRANSMIT TIMING

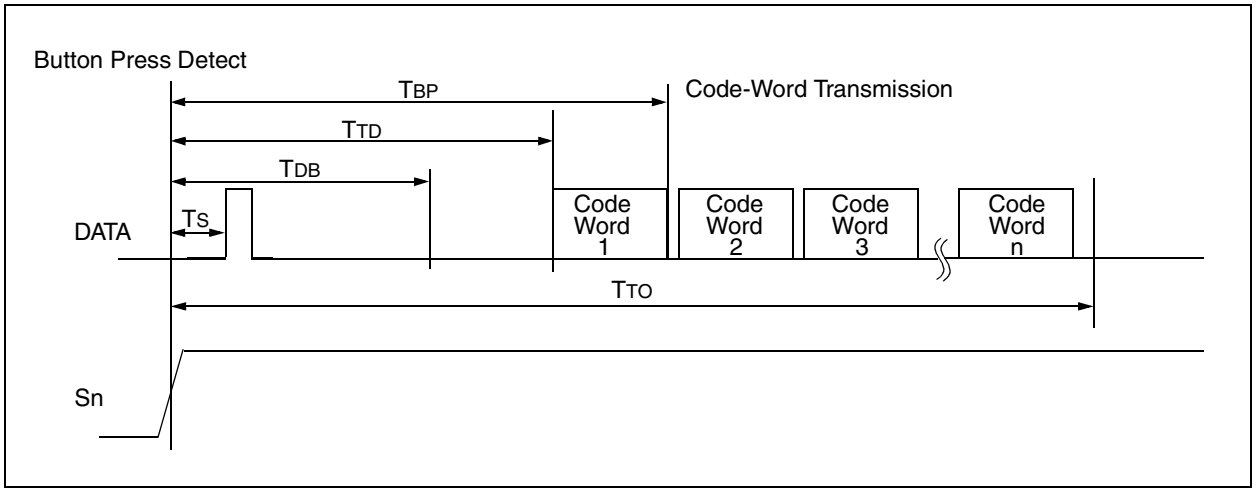


FIGURE 7-2: PREAMBLE/HEADER FORMAT

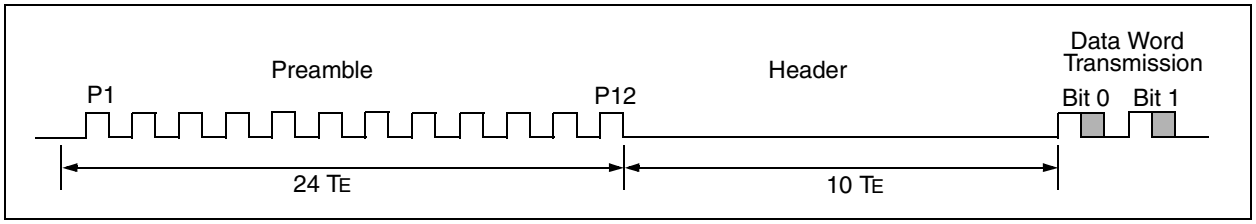


FIGURE 7-3: DATA WORD FORMAT (XSER = 0)

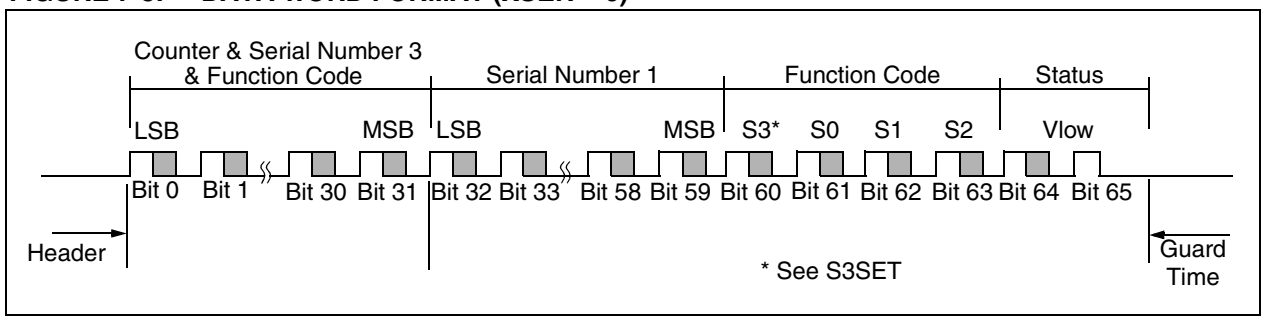


TABLE 7-4: CODE-WORD TRANSMISSION TIMING REQUIREMENTS

V_{DD} = +3.5 to 13.3V Commercial (C): T_{AMB} = 0°C to +70°C Industrial (I): T_{AMB} = -40°C to +85°C			Code-Words Transmitted						
			All			1 out of 2			
Symbol	**Characteristic**	**Number of T_E**	**Min.**	**Typ.**	**Max.**	**Min.**	**Typ.**	**Max.**	**Units**
T_E	Basic pulse element	1	360	400	440	180	200	220	µs
T_{BP}	PWM bit pulse width	3	—	3	—	—	3	—	ms
T_P	Preamble duration	24	8.64	9.6	10.56	4.32	4.8	5.28	ms
T_H	Header duration	10	3.6	4.0	4.4	1.8	2.0	2.2	ms
T_{HOP}	Hopping code duration	96	34.56	38.4	42.24	17.28	19.2	21.12	ms
T_{FIX}	Fixed code duration	102	36.72	40.8	44.88	18.36	20.4	22.44	ms
T_G	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.

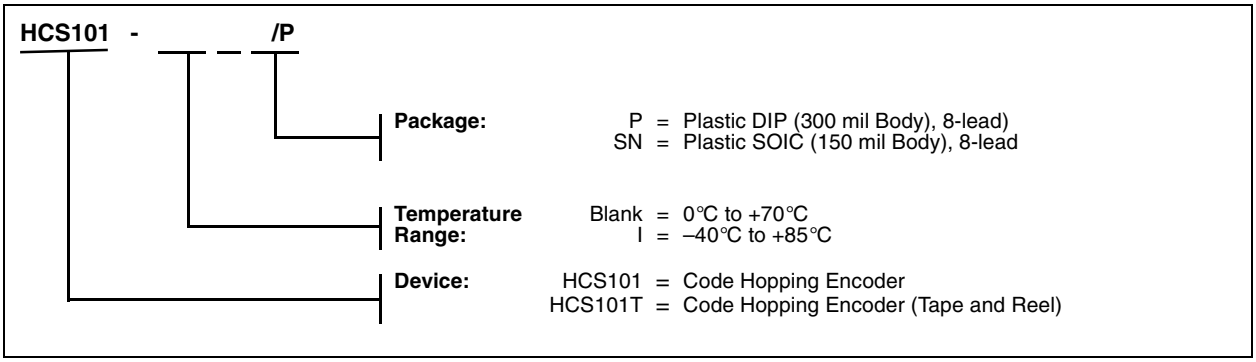
NOTES:

NOTES:

NOTES:

HCS101 PRODUCT IDENTIFICATION SYSTEM

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



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 Corporate Literature Center U.S. FAX: (480) 786-7277.
3. The Microchip Worldwide Site. (www.microchip.com)

Please specify which device, revision of silicon and Data Sheet (include Literature #) you are using.

New Customer Notification System
Register on our web site (www.microchip.com/cn) to receive the most current information on our products.

WORLDWIDE SALES AND SERVICE

AMERICAS

Corporate Office
Microchip Technology Inc.
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-786-7200 Fax: 480-786-7277
Technical Support: 480-786-7627
Web Address: http://www.microchip.com

Atlanta
Microchip Technology Inc.
500 Sugar Mill Road, Suite 200B
Atlanta, GA 30350
Tel: 770-640-0034 Fax: 770-640-0307

Boston
Microchip Technology Inc.
5 Mount Royal Avenue
Marlborough, MA 01752
Tel: 508-480-9990 Fax: 508-480-8575

Chicago
Microchip Technology Inc.
333 Pierce Road, Suite 180
Itasca, IL 60143
Tel: 630-285-0071 Fax: 630-285-0075

Dallas
Microchip Technology Inc.
4570 Westgrove Drive, Suite 160
Addison, TX 75248
Tel: 972-818-7423 Fax: 972-818-2924

Dayton
Microchip Technology Inc.
Two Prestige Place, Suite 150
Miamisburg, OH 45342
Tel: 937-291-1654 Fax: 937-291-9175

Detroit
Microchip Technology Inc.
Tri-Atria Office Building
32255 Northwestern Highway, Suite 190
Farmington Hills, MI 48334
Tel: 248-538-2250 Fax: 248-538-2260

Los Angeles
Microchip Technology Inc.
18201 Von Karman, Suite 1090
Irvine, CA 92612
Tel: 949-263-1888 Fax: 949-263-1338

New York
Microchip Technology Inc.
150 Motor Parkway, Suite 202
Hauppauge, NY 11788
Tel: 631-273-5305 Fax: 631-273-5335

San Jose
Microchip Technology Inc.
2107 North First Street, Suite 590
San Jose, CA 95131
Tel: 408-436-7950 Fax: 408-436-7955

AMERICAS (continued)

Toronto
Microchip Technology Inc.
5925 Airport Road, Suite 200
Mississauga, Ontario L4V 1W1, Canada
Tel: 905-405-6279 Fax: 905-405-6253

ASIA/PACIFIC

Hong Kong
Microchip Asia Pacific
Unit 2101, Tower 2
Metroplaza
223 Hing Fong Road
Kwai Fong, N.T., Hong Kong
Tel: 852-2-401-1200 Fax: 852-2-401-3431

Beijing
Microchip Technology, Beijing
Unit 915, 6 Chaoyangmen Bei Dajie
Dong Erhuan Road, Dongcheng District
New China Hong Kong Manhattan Building
Beijing 100027 PRC
Tel: 86-10-85282100 Fax: 86-10-85282104

India
Microchip Technology Inc.
India Liaison Office
No. 6, Legacy, Convent Road
Bangalore 560 025, India
Tel: 91-80-229-0061 Fax: 91-80-229-0062

Japan
Microchip Technology Intl. Inc.
Benex S-1 6F
3-18-20, Shinyokohama
Kohoku-Ku, Yokohama-shi
Kanagawa 222-0033 Japan
Tel: 81-45-471- 6166 Fax: 81-45-471-6122

Korea
Microchip Technology Korea
168-1, Youngbo Bldg. 3 Floor
Samsung-Dong, Kangnam-Ku
Seoul, Korea
Tel: 82-2-554-7200 Fax: 82-2-558-5934

Shanghai
Microchip Technology
RM 406 Shanghai Golden Bridge Bldg.
2077 Yan'an Road West, Hong Qiao District
Shanghai, PRC 200335
Tel: 86-21-6275-5700 Fax: 86 21-6275-5060

ASIA/PACIFIC (continued)

Singapore
Microchip Technology Singapore Pte Ltd.
200 Middle Road
#07-02 Prime Centre
Singapore 188980
Tel: 65-334-8870 Fax: 65-334-8850

Taiwan, R.O.C
Microchip Technology Taiwan
10F-1C 207
Tung Hua North Road
Taipei, Taiwan, ROC
Tel: 886-2-2717-7175 Fax: 886-2-2545-0139

EUROPE

United Kingdom
Arizona Microchip Technology Ltd.
505 Eskdale Road
Winnersh Triangle
Wokingham
Berkshire, England RG41 5TU
Tel: 44 118 921 5858 Fax: 44-118 921-5835

Denmark
Microchip Technology Denmark ApS
Regus Business Centre
Lautrup hoj 1-3
Ballerup DK-2750 Denmark
Tel: 45 4420 9895 Fax: 45 4420 9910

France
Arizona Microchip Technology SARL
Parc d'Activite du Moulin de Massy
43 Rue du Saule Trapu
Batiment A - ler Etage
91300 Massy, France
Tel: 33-1-69-53-63-20 Fax: 33-1-69-30-90-79

Germany
Arizona Microchip Technology GmbH
Gustav-Heinemann-Ring 125
D-81739 München, Germany
Tel: 49-89-627-144 0 Fax: 49-89-627-144-44

Italy
Arizona Microchip Technology SRL
Centro Direzionale Colleoni
Palazzo Taurus 1 V. Le Colleoni 1
20041 Agrate Brianza
Milan, Italy
Tel: 39-039-65791-1 Fax: 39-039-6899883

11/15/99

DNV Certification, Inc. USA — ANSI-RAB QMS ACCREDITED — DNV — DNV MSC The Netherlands Accredited by the RvA
ISO 9001 / QS-9000 REGISTERED FIRM

Microchip received QS-9000 quality system certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona in July 1999. The Company's quality system processes and procedures are QS-9000 compliant for its PICmicro® 8-bit MCUs, KEELOQ® code hopping devices, Serial EEPROMs and microperipheral products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001 certified.