HCS365

KEELOQ® Code Hopping Encoder

FEATURES

Security

- Two programmable 32-bit serial numbers
- Two programmable 64-bit encoder keys
- Two programmable 60-bit seed values
- Each transmission is unique
- 67/69-bit transmission code length
- 32-bit hopping code
- Encoder keys are read protected

Operating

- 2.0-5.5V operation
- Four button inputs
- 15 functions available
- Four selectable baud rates
- Selectable minimum code word completion
- Battery low signal transmitted to receiver
- Nonvolatile synchronization data
- PWM, VPWM, PPM and Manchester modulation
- Button queue information transmitted
- Dual Encoder functionality

Other

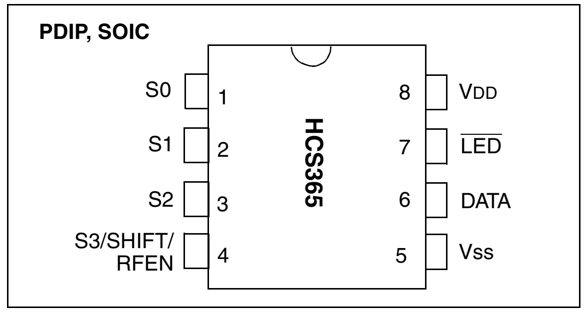
- On-chip EEPROM
- On-chip tuned oscillator (±10%)
- Button inputs have internal pull-down resistors
- $\overline{\text{LED}}$ output
- PLL control for ASK and FSK
- Low external component count

Typical Applications

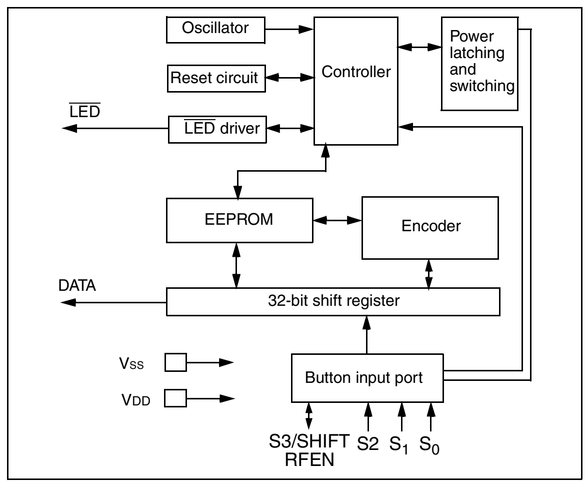
The HCS365 is ideal for Remote Keyless Entry (RKE) applications. These applications include:

- Automotive RKE systems
- Automotive alarm systems
- Automotive immobilizers
- Gate and garage door openers
- Identity tokens
- Burglar alarm systems

PACKAGE TYPES



HCS365 BLOCK DIAGRAM



GENERAL DESCRIPTION

The HCS365 is a code hopping encoder designed for secure Remote Keyless Entry (RKE) and secure remote control systems. The HCS365 utilizes the KEELOQ® code hopping technology, which incorporates high security, a small package outline and low cost, to make this device a perfect solution for unidirectional authentication systems and access control systems.

The HCS365 combines a hopping code generated by a nonlinear encryption algorithm, with a serial number and status bits to create a secure transmission code. The length of the transmission effectively eliminates the threat of code scanning and the code hopping resists code grabbing access techniques.

The encoder key, serial number, and configuration data are stored in EEPROM which is not accessible via any external connection. This makes the HCS365 a very

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Microchip's Secure Data Products are covered by some or all of the following patents:
Code hopping encoder patents issued in Europe, U.S.A., and R.S.A. — U.S.A.: 5,517,187; Europe: 0459781; R.S.A.: ZA93/4726
Secure learning patents issued in the U.S.A. and R.S.A. — U.S.A.: 5,686,904; R.S.A.: 95/5429

secure unit. The HCS365 provides an easy to use serial interface for programming the necessary security keys, system parameters, and configuration data.

The HCS365 can be configured to function as two totally separate encoders allowing easy integration of two KEELOQ systems into a single transmitter. This, for example, enables the user to use the same transmitter to open a car and garage door.

The encoder keys and code combinations are programmable but read-protected. The keys can only be verified after an automatic erase and programming operation. This protects against attempts to gain access to keys and manipulate synchronization values.

The HCS365 operates over a wide voltage range of 2.0V to 5.5V and has four button inputs in an 8-pin configuration. This allows the system designer the freedom to utilize up to 15 functions. The only components required for device operation are the buttons and RF circuitry, allowing a very low system cost.

1.0 SYSTEM OVERVIEW

1.1 Important Terminology

The following is a list of key terms used throughout this datasheet. For additional information of KEELOQ and Code Hopping, refer to Technical Brief 3 (TB003).

- Code Hopping - A method by which a code changes in a predictable way each time it is transmitted.
- Code-word - A block of data that is repeatedly transmitted during a ***transmission***.
- Decoder - A device that can decode data sent by an ***encoder***.
- Decryption algorithm - A recipe whereby scrambled data can be unscrambled using the same ***encryption key*** used to scramble the data.
- Encoder - A device that can generate and encode data.
- Encoder key - A unique and secret digital number used to encrypt and decrypt data. (***encryption key***)
- Encryption Algorithm - A recipe whereby data is scrambled using an ***encryption key*** before it becomes public. The data can only be interpreted by using a ***decryption algorithm*** using the same ***encryption key***.
- Learn – The KEELOQ product family facilitates several learning strategies to be implemented on the decoder. The following are examples of what can be done.
  - Normal Learning
    The receiver uses the same information that is transmitted during normal operation to derive the transmitter's encoder key, decrypt the discrimination value and the synchronization counter.
  - Secure Learn
    The transmitter is activated through a special button combination to transmit a stored 60-bit value (random seed) that can be used for key generation or be part of the key. Transmission of the random seed can be disabled after learning is completed.
- Manufacturer's code – A unique and secret code used to generate unique ***encryption keys*** for each ***encoder***.
- RKE - Remote Keyless Entry
- Transmission - A stream of data consisting of repeating ***code-words***.

As indicated in the block diagram on page one, the HCS365 has a small EEPROM array which must be loaded with several parameters before use. The most important values for each encoder are:

- A 32-bit serial number which is meant to be unique for every encoder
- An encoder key
- A 16/20-bit synchronization value
- Configuration options

This information is programmed by the manufacturer at the time of production. The generation of the encoder keys is done using a key generation algorithm, as shown in Figure 1-1. Typically, inputs to the key generation algorithm are the serial number of the transmitter or seed value, and a 64-bit manufacturer's code. The manufacturer's code is chosen by the system manufacturer and must be carefully controlled. The manufacturer's code is a pivotal part of the overall system security.

The synchronization value is the basis for the transmitted code changing with each transmission, and is updated each time a button is pressed. Because of the complexity of the code hopping encryption algorithm, a change in one bit of the synchronization value will result in a large change in the actual transmitted code. Once the encoder detects that a button has been pressed, the encoder reads the button and updates the synchronization counter. The synchronization value is then combined with the encoder key in the encryption algorithm and the output is 32 bits of encrypted information. This data will change with every button press, hence, it is referred to as the hopping portion of the code word. The 32-bit hopping code is combined with the button information and the serial number to form the code word transmitted to the receiver. The code word format is explained in detail in Section 3.2.

Any type of controller may be used as a decoder, but it is typically a microcontroller with compatible firmware that allows the decoder to operate in conjunction with a encoder, based on the HCS365.

Before an encoder can be used with a particular decoder, the encoder must be 'learned' by the decoder. Upon learning an encoder, information is stored by the decoder so that it may track the encoder, including the serial number of the encoder, the current synchronization value for that encoder and the same encoder key that is used on the encoder. If a decoder receives a message of valid format, the serial number is checked. If it is from a learned encoder, the message is decrypted and the decrypted synchronization counter is checked against what is stored. If the synchronization value is verified, then the button status is checked to see what operation is needed. Figure 1-3 shows the relationship between some of the values stored by the decoder and the values received from the encoder.

FIGURE 1-1: CREATION AND STORAGE OF ENCODER KEY DURING PRODUCTION

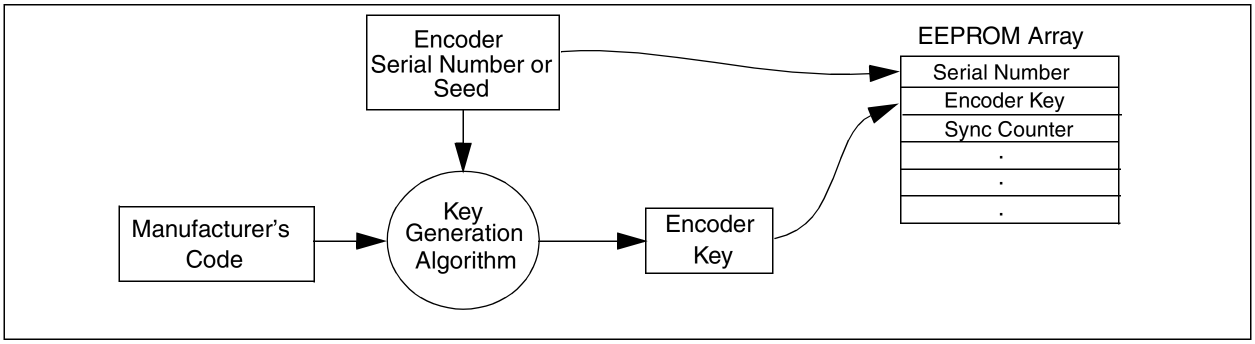


FIGURE 1-2: BASIC OPERATION OF ENCODER

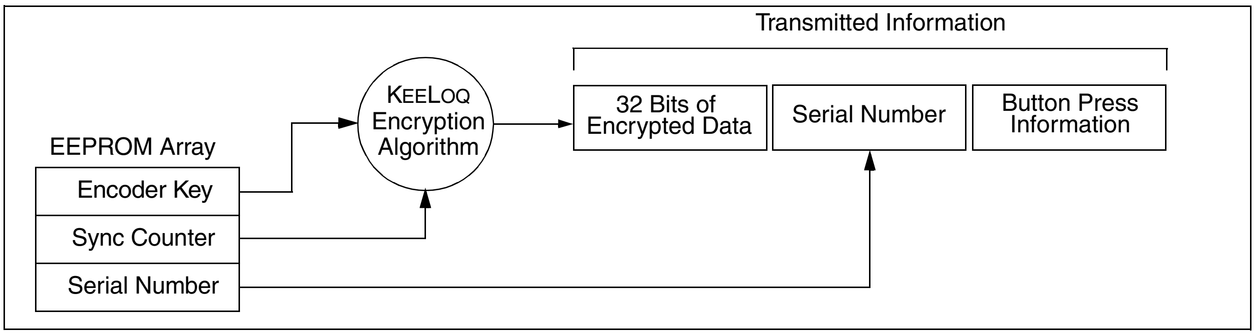
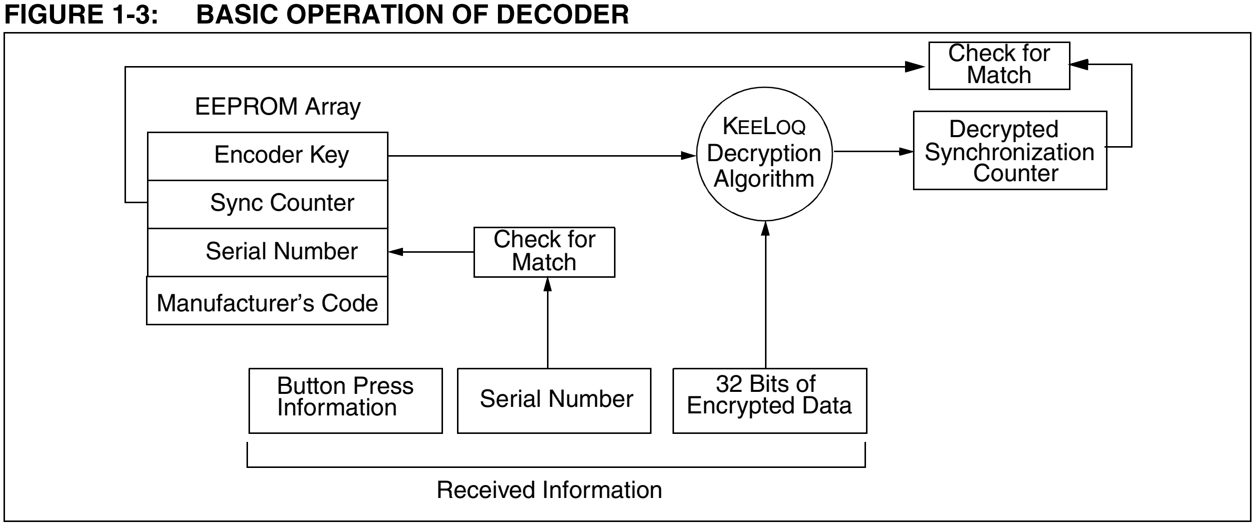


FIGURE 1-3: BASIC OPERATION OF DECODER



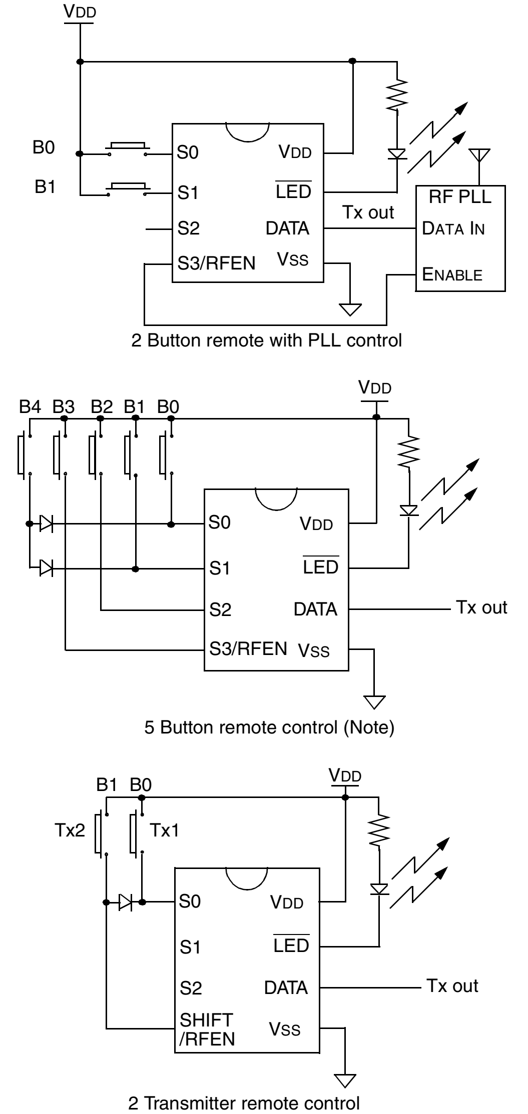
2.0 DEVICE DESCRIPTION

As shown in the typical application circuits (Figure 2-1), the HCS365 is an easy device to use. It requires only the addition of buttons and RF circuitry for use as the encoder in your security application. A description of each pin is described in Table 2-1. Refer to Figure 2-2 for information on the I/O pins.

TABLE 2-1: PIN DESCRIPTIONS

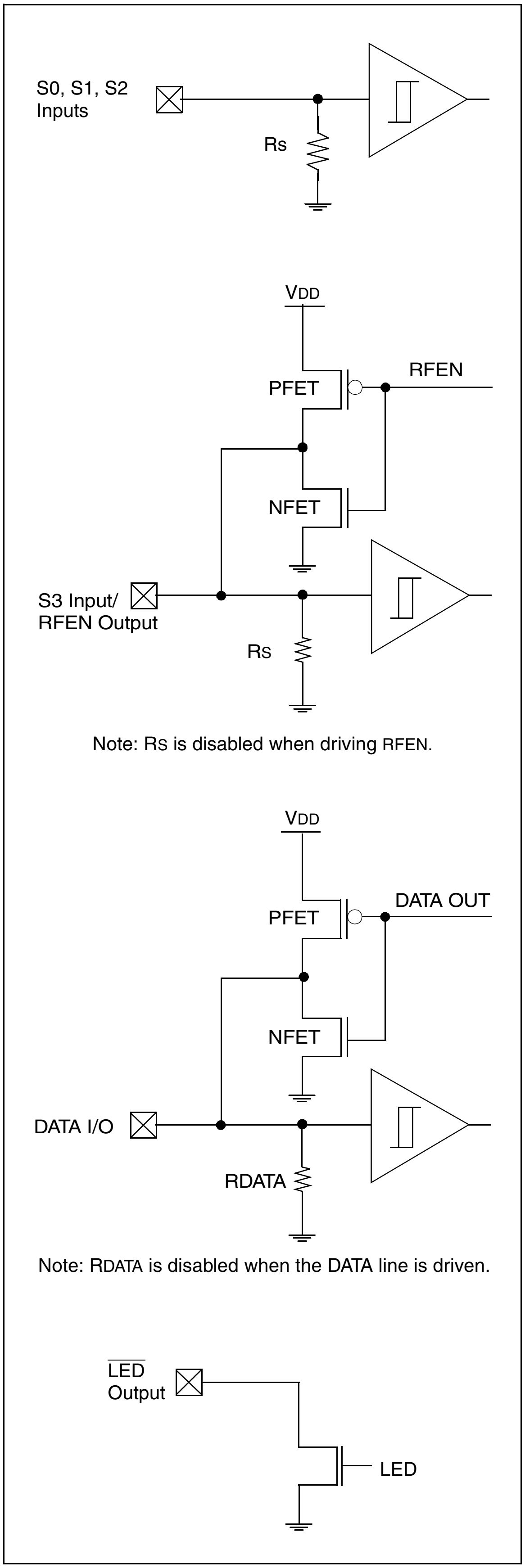
Name	Pin Number	Description
S0	1	Switch input 0
S1	2	Switch input 1
S2	3	Switch input 2
S3/SHIFT/ RFEN	4	Switch input 3, SHIFT button or RF Enable output
VSS	5	Ground reference connection
DATA	6	Data output pin/Data pin for programming mode
$\overline{\text{LED}}$	7	Open drain output for $\overline{\text{LED}}$ configuration
VDD	8	Positive supply voltage connection

FIGURE 2-1: TYPICAL CIRCUITS



Note: Up to 15 functions can be implemented by pressing more than one button simultaneously or by using a suitable diode array.

FIGURE 2-2: I/O CIRCUITS



2.1 Architectural Overview

2.1.1 ONBOARD EEPROM

The HCS365 has an onboard nonvolatile EEPROM, which is used to store user programmable data. The data is programmed at the time of production and include the security-related information such as encoder keys, serial numbers, discrimination and seed values. All the security related options are read protected.

The initial counter value is also programmed at the time of production. From then on the device maintains the counter itself. The HCS365 has build in protection against counter corruption. Before every EEPROM write the internal circuitry also ensures that the High Voltage required to write to the EEPROM is at an acceptable level.

2.1.2 INTERNAL RC OSCILLATOR

The HCS365 has an onboard RC oscillator that controls all the logic output timing characteristics. The oscillator frequency varies within ±10% of the nominal value. All the timing values specified in this document are subject to the oscillator variation.

2.1.3 LOW VOLTAGE DETECTOR

A low battery voltage detector onboard the HCS365 can indicate when the operating voltage drops below a predetermined value. There are two options available depending on the Low Voltage Trip Point Select (VLOWSEL) configuration option. The two options provided are:

- A 2.2 V nominal level for 3V operation
- A 3.2 V nominal level for 5V operation

The output of the low voltage detector is transmitted in each code-word, so the decoder can give an indication to the user that the transmitter battery is low. Operation of the LED changes as well to further indicate that the battery is low and needs replacing.

The output of the Low Voltage Detector can also be latched once it has dropped below the selected value. The Low Voltage Latch (VLOWL) configuration option enables this option. If this option is enabled, the detector level is raised to 3V or 5V once a low battery voltage has been detected. The original value is reinstated, if the VDD voltage is raised above this level, indicating that a new battery has been installed.

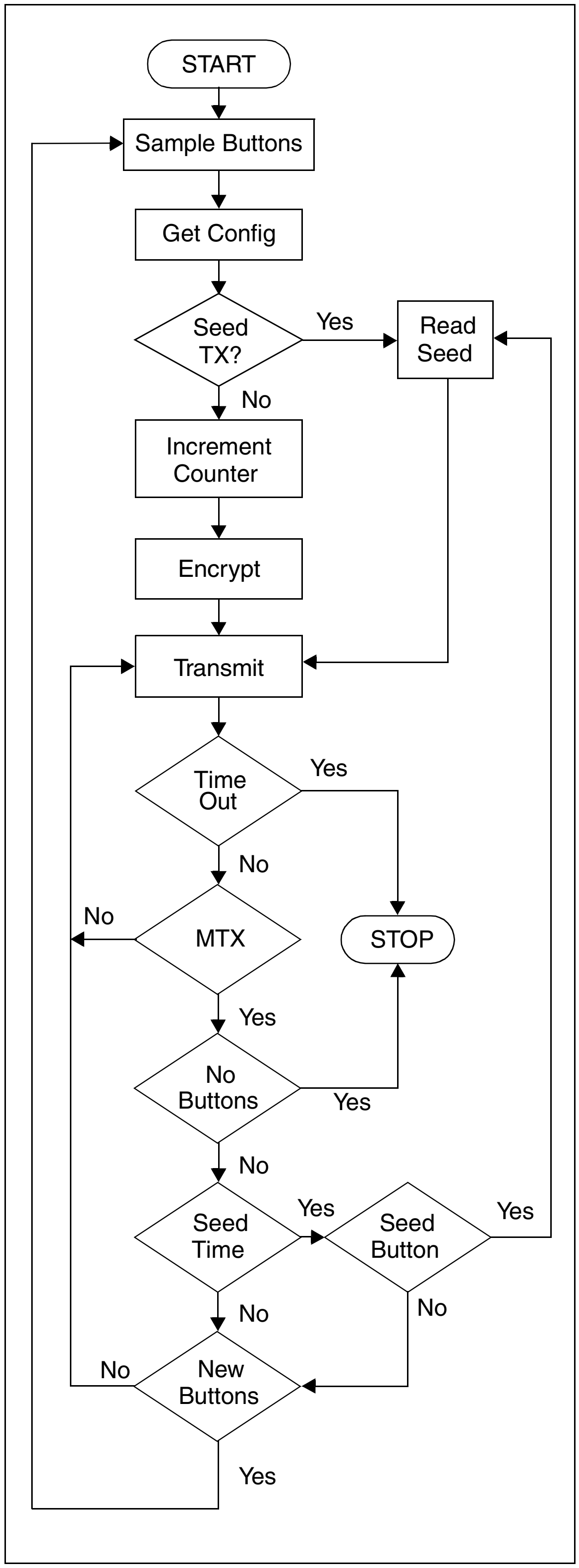
3.0 DEVICE OPERATION

The HCS365 will normally be in a low power sleep mode. When a button input is taken high, the device will wakeup, go through debounce delay of 20ms (T_{DB}) before the button code is latched. The device will then read the configuration options and depending on the configuration options and the button code, it will determine what the data and modulation format will be for the transmission. The transmission will consist of a stream of code-words and will be transmitted T_{DU} after the button is pressed and as long as the buttons are held down or a time-out occurs. The code-word format can be either a code hopping format or a seed format.

The time-out time can be selected with the Time-out Select (TSEL) configuration option. This option allows the time-out to be disabled or set to 0.8s, 3.2s or 25.6s. When a timeout occurs, the device will go into sleep mode to protect the battery from draining when a button gets stuck.

If in the transmit process it is detected that a new button is pressed, the current code-word will be aborted, a new code-word will be transmitted and the time-out counter will reset. If all the buttons are released, the minimum code-words will be completed. The minimum code-words can be set to 1,2,4 or 8 using the minimum code words (MTX) configuration option. If the time for transmitting the minimum code-words is longer than the time-out time, the device will not complete the minimum code-words.

FIGURE 3-1: BASIC FLOW DIAGRAM OF THE DEVICE OPERATION



 Preliminary

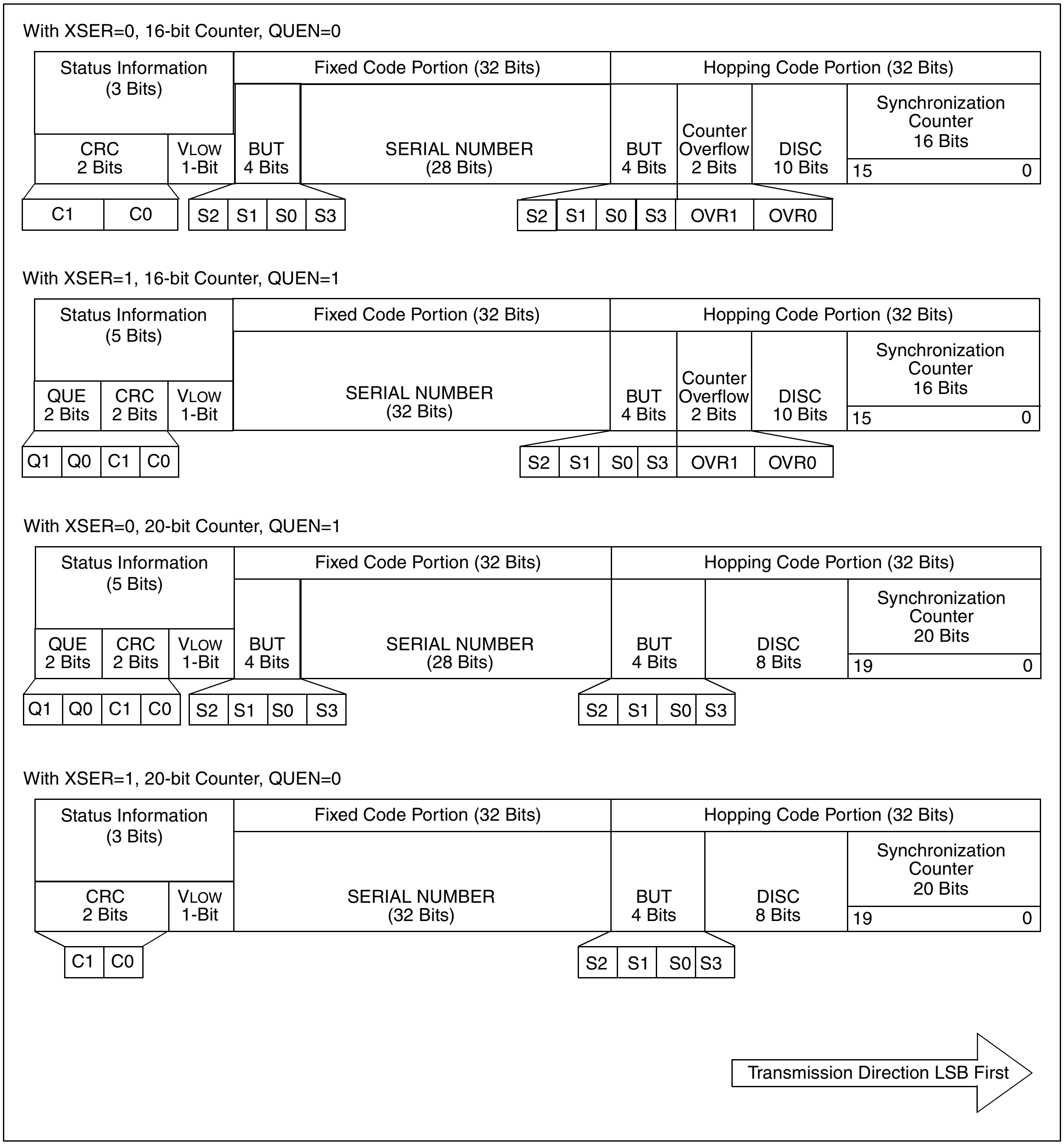
3.1 Dual Encoder Operation

The HCS365 contains two transmitter configuration words, serial numbers, encoder keys, discrimination values, counters and seed values. This implies that the HCS365 can be used as two independent encoders. The code-word is calculated using one of two possible encoder configurations. The Dual mode enable (DUAL) configuration option is used to enable the dual encoder transmissions. If this option is enabled, the SHIFT input pin is used to select between the encoder configurations. A low on the SHIFT pin will select Encoder 1 and a high will select Encoder 2. If the DUAL option is disabled, Encoder 1 is always selected.

3.2 Code Hopping Code-Word Data Format

A Code hopping code-word consists of 32 bits of code hopping data, 32 bits of fixed code and between 3 and 5 bits of status information. Various code-word formats are shown in Figure 3-2.

FIGURE 3-2: CODE-WORD DATA FORMAT



3.2.1 CODE HOPPING PORTION

The hopping portion is calculated by encrypting the counter, discrimination value and function code with the Encoder Key (KEY). The counter can be either a 16 or 20 bit counter, depending on the Counter select (CNTSEL) configuration option. If the 16 bit counter is selected, the discrimination value is 10 bits long and there are 2 counter overflow bits (OVR) that are cleared when the counter wraps to 0. If the counter is 20 bits, the discrimination value is 8 bits long. The rest of the 32 bits are made up of the function code also known as the button inputs.

3.2.2 FIXED CODE PORTION

The 32 bits of fixed code consist of 28 bits of the serial number (SER) and another copy of the function code. This can be changed to contain the whole 32-bit serial number with the Extended Serial Number (XSER) configuration option. This option can be different for Encoder 1 and Encoder 2.

3.2.3 STATUS INFORMATION

The status bits will always contain the output of the Low Voltage detector (VLOW) and a Cyclic Redundancy Check (CRC). Button queue information can also be included in the code-words, if enabled.

3.2.3.1 LOW VOLTAGE DETECTOR STATUS (VLOW)

The output of the low voltage detector is transmitted with each code-word. If VDD drops below the selected voltage, a logic '1' will be transmitted. The output of the detector is sampled before each code-word is transmitted.

3.2.3.2 CYCLIC REDUNDANCY CHECK (CRC)

The CRC bits are calculated on the 65 previously transmitted bits. The decoder can use the CRC bits to check the data integrity before processing starts. The CRC can detect all single bit errors and 66% of double bit errors. The CRC is computed as follows:

EQUATION 3-1: CRC CALCULATION

$$CRC[1]_{n+1} = CRC[0]_n \oplus Di_n$$

and

$$CRC[0]_{n+1} = (CRC[0]_n \oplus Di_n) \oplus CRC[1]_n$$

with

$$CRC[1, 0]_0 = 0$$

and Di_n the nth transmission bit $0 \le n \le 64$

3.2.3.3 BUTTON QUEUE INFORMATION (QUEUE)

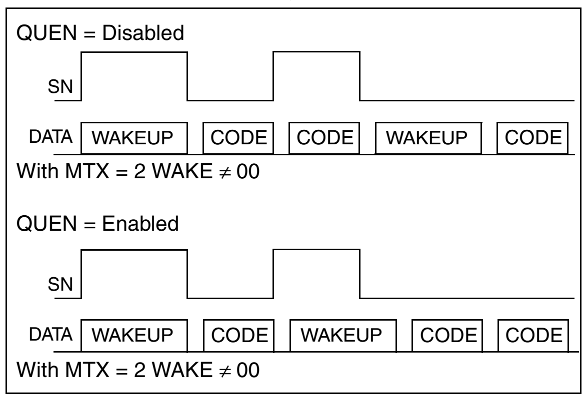
The queuing or repeated pressing of the same buttons can be handled in two ways on the HCS365. This is controlled with the Queue Counter Enable (QUEN) configuration option. This option can be different for Encoder 1 and Encoder 2.

When the QUEN option is disabled, the device will register up to two sequential button presses. In this case, the device will complete the minimum code words selected with the MTX option before the second codeword is calculated and transmitted. The code-word will be 67 bits in this case, with no additional queue bits transmitted.

If the QUEN option is enabled, the queue bits are added to the standard code-word. The queue bits are a 2-bit counter that does not wrap. The counter value starts at 00b and is incremented, if a button is pushed within 2 seconds of the previous button press. The current code-word is terminated when the buttons are queued. This allows additional functionality for repeated button presses.

Figure 3-3 shows code-word completion with the different QUEN settings.

FIGURE 3-3: CODE WORD COMPLETION WITH QUEN SETTINGS



3.3 Seed Code-word Data Format

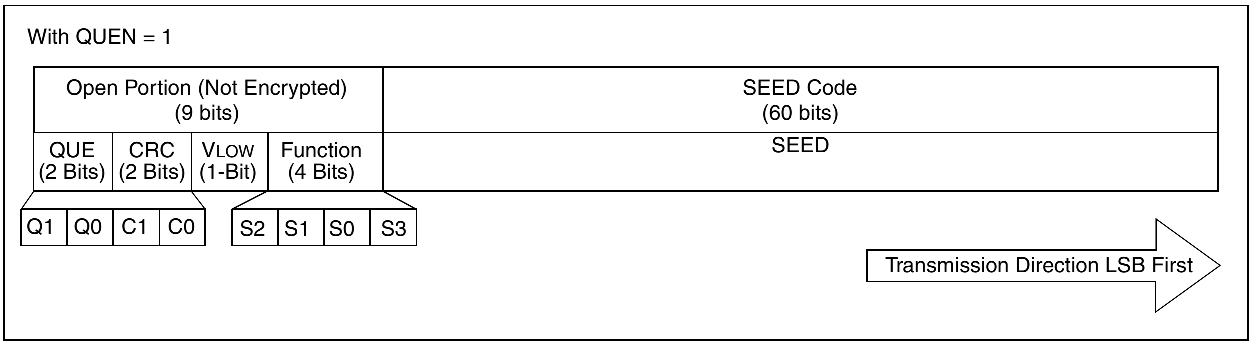
A seed transmission transmits a code-word that consists of 60-bits of fixed data that is stored in the EEPROM. This can be used for secure learning of encoders or whenever a fixed code transmission is required. The seed code-word further contains the function code and the status information (VLOW, CRC and QUEUE) as configured for normal code hopping code-words. The Seed code-word format is shown in Figure 3-4. The function code for seed code-words is always 1111b.

Seed code-words for Encoder 1 and Encoder 2 can be configured as follows:

- Enabled or disabled with the Seed Enable (SDEN) configuration option.

- Enabled until the synchronization counter is bigger than 7Fh with the Limited Seed (SDLM) configuration option.
- The time before the seed transmission is transmitted can be set to 0.0s, 0.8s, 1.6s and 3.2s with the Seed Time (SDTM) configuration option. When it is set to a value other than 0.0s, the HCS365 will transmit a code-hopping transmission until the selected time expires, before the seed code-words are transmitted.
- The button code for transmitting a Seed code-word can be selected with the Seed Button (SDBT) configuration option.
- The Seed mode can be changed between production and user mode with the Seed Mode (SDMD) configuration option. During user mode, the previous options directly control the Seed transmissions, as stated. However, Production mode overrides the Seed Time (SDTM) configuration option, if the synchronization counter is smaller than 7Fh. In Production mode, the HCS365 will transmit normal hopping code code-words for the selected minimum code-words (MTX), and then transmit the same amount of seed code-words.

FIGURE 3-4: SEED CODE-WORD FORMAT



3.4 Transmission Modulation Format

The HCS365 transmission is made up of several code-words. Each code-word starts with a preamble and a header, followed by the data. The code-words are separated by a guard time that can be set to 0ms, 6.4ms, 51.2ms or 102.4ms with the Guard Time Select (GSEL) configuration option. All other timing specifications for the modulation formats are based on a basic timing element (T_E). This Timing Element can be set to 100us, 200us, 400us or 800us with the Baud Rate Select (BSEL) configuration option. The Header time can be set to 4TE or 10TE with the Header Select (HSEL) Configuration option. These options can all be set individually for Encoder 1 and Encoder 2.

There are four different modulation formats available on the HCS365 that can be set individually for Encoder 1 or Encoder 2. The Modulation Select (MSEL) Configuration Option is used to select between:

- Pulse Width Modulation (PWM)
- Manchester Encoding
- Variable Pulse Width Modulation (VPWM)
- Pulse Position Modulation (PPM)

The various formats are shown in Figures 3-5 to 3-8.

FIGURE 3-5: PWM TRANSMISSION FORMAT

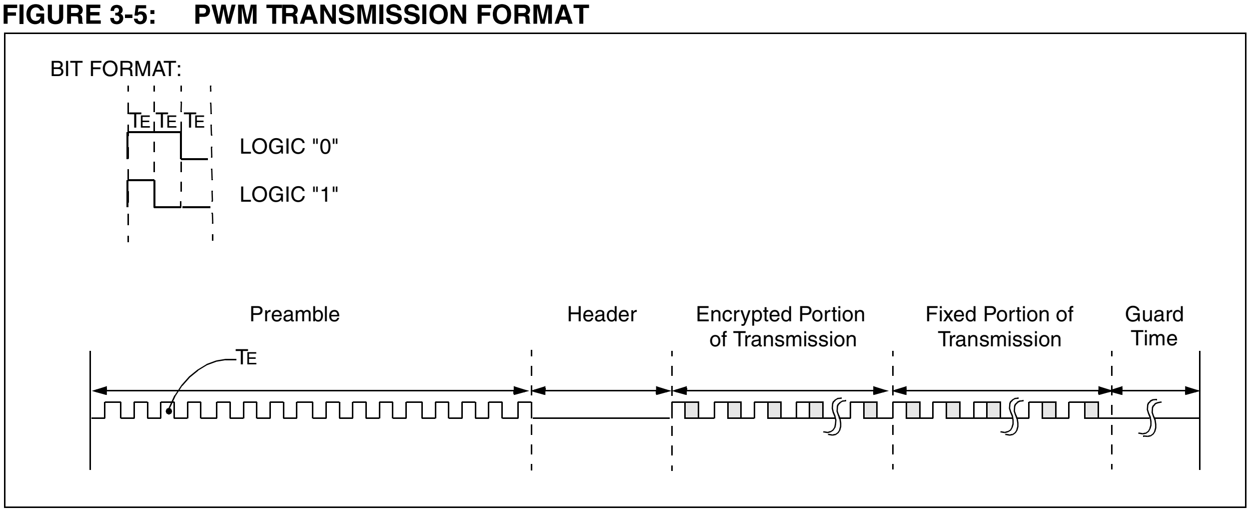


FIGURE 3-6: MANCHESTER FORMAT

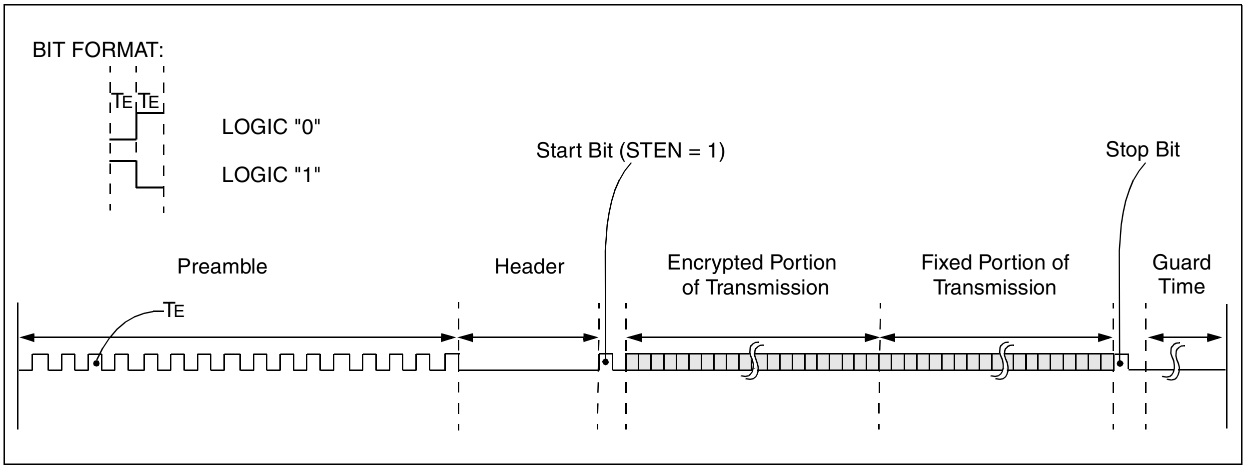


FIGURE 3-7: VPWM FORMAT SUMMARY

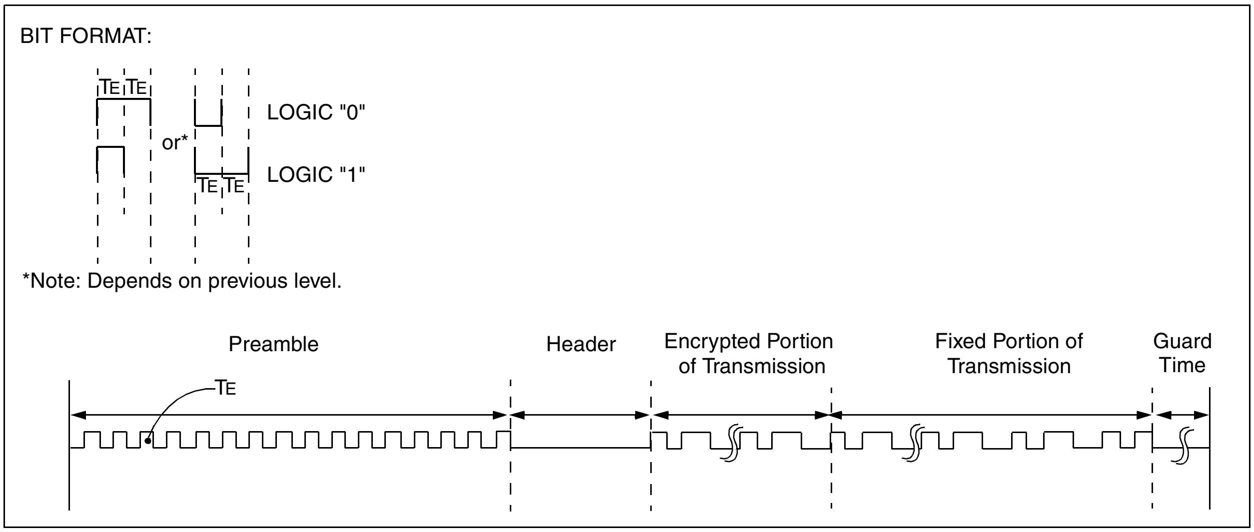
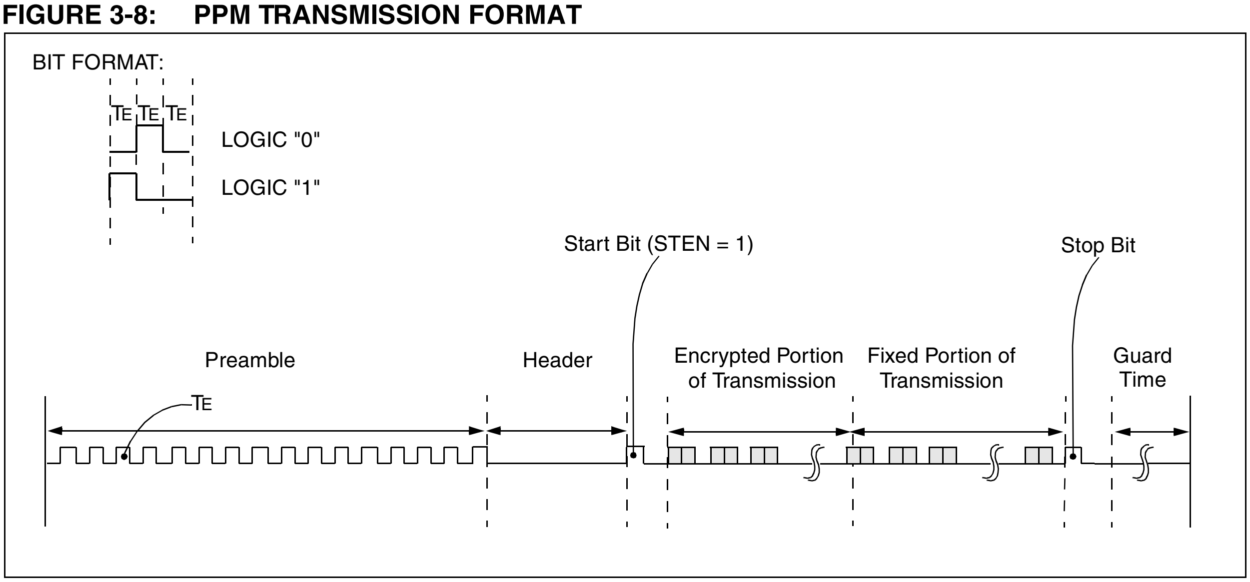


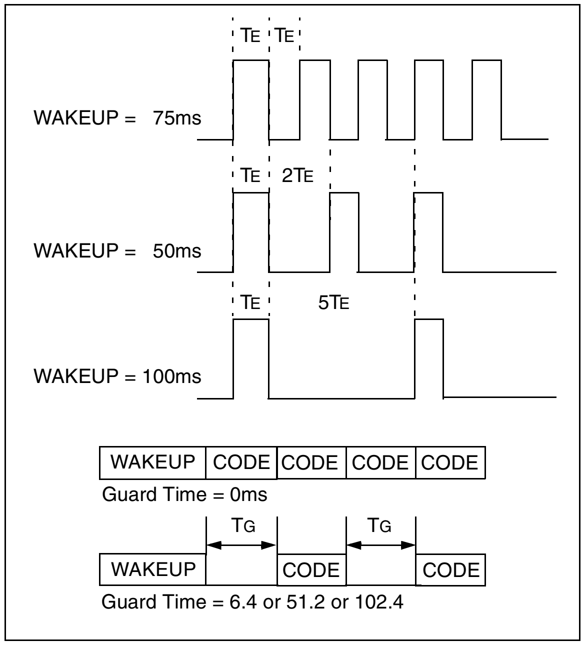
FIGURE 3-8: PPM TRANSMISSION FORMAT



In addition to the Modulation Format, Guard Time and Baud Rate, the following options are also available to change the Transmission Format:

- If the Start/Stop pulse Enable (STEN) configuration option is enabled, the HCS365 will append a leading and trailing '1' to each code word. This is necessary for modulation formats such as Manchester and PPM Encoding to interpret the first and last data bit. This option can be different for Encoder 1 and Encoder 2.
- A wakeup sequence can be transmitted before the transmission starts. The wakeup sequence is configured with the Wakeup (WAKE) configuration Option and can be disabled or set to 50ms, 75ms or 100ms as indicated in Figure 3-9.

FIGURE 3-9: WAKEUP ENABLE

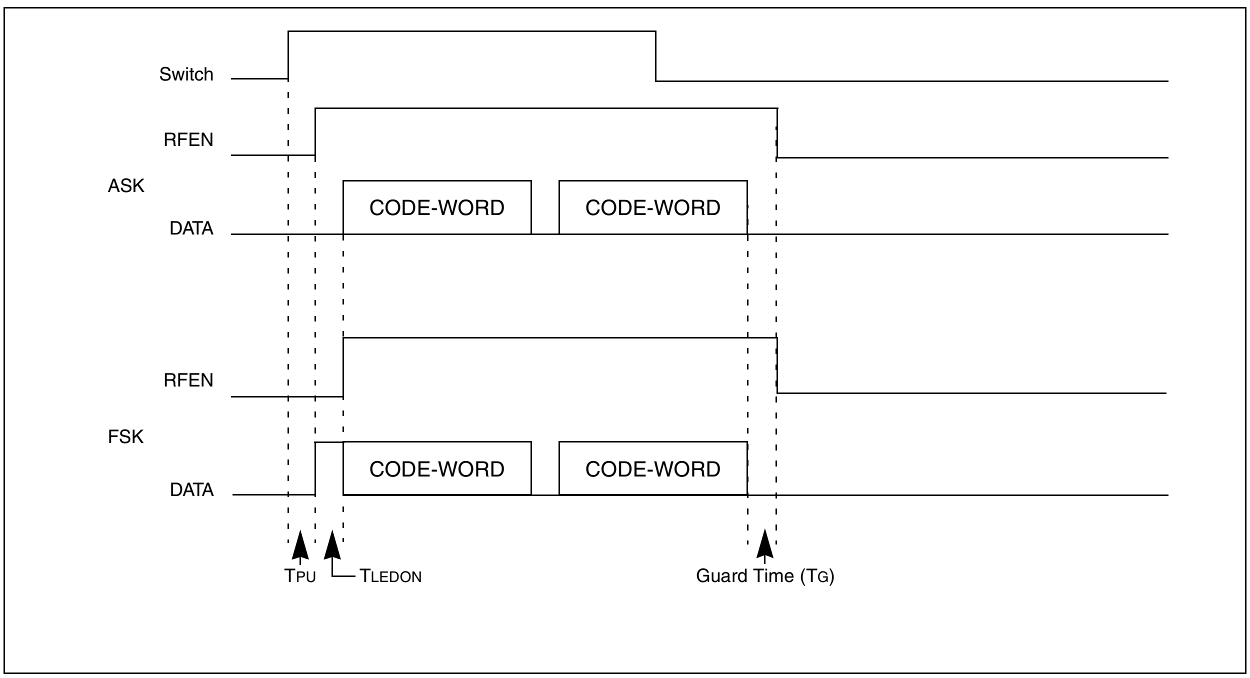


3.5 RF Enable and PLL Interface

The S3/SHIFT/RFEN pin of the HCS365 can be configured to function as a RF enable output signal. This is done with the RF Enable Output (RFENO) Configuration Option. When enabled, this pin will be driven high whenever data is transmitted through the DATA pin. Because this pin is used to select between Encoder 1 and Encoder 2, it will not be possible to utilize the dual encoder functionality, if the RFEN output is enabled.

The RF Enable and DATA output also interfaces with RF PLL's. The PLL interface select (PLLSEL) configuration option selects between the ASK and FSK interface. Figure 3-10 show the startup sequence for both ASK and FSK interface options. The RFEN signal will go low at the end of the last code-word, including the guard time.

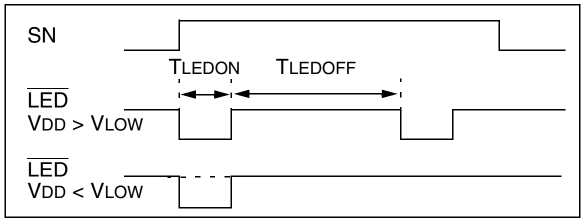
FIGURE 3-10: ASK/FSK INTERFACE



3.6 LED Output

The LED pin will be driven low periodically while the HCS365 is transmitting data, in order to switch on an external LED. The LED on time (T_{LEDON}) can be selected between 50ms and 100ms with the LED on Time Select (LEDOS) configuration option. The LED off time (T_{LEDOFF}) is fixed at 500ms. When the V_{DD} Voltage drops below the selected V_{LOW} trip point, the LED can be configured to blink only once instead of blinking continuously with the LED Blink (LEDBL) configuration option. Waveforms of the LED behavior are shown in Figure 3-11.

FIGURE 3-11: $\overline{\text{LED}}$ OPERATION



 Preliminary

4.0 EEPROM ORGANIZATION

A summary of the HCS365 EEPROM organization is shown in the table below. Data stored in the EEPROM can be classified as Encoder configuration (E) or Device specific (D). In the case of dual Encoder Operation, two copies of the Encoder configuration must be stored for Encoder 1 and Encoder 2.

Symbol	Length (Bits)	Class	Description (Note 1)			Reference Section
KEY	64	E	Encoder Key			1.1, 3.2.1
SEED	60	E	Encoder Seed Value			1.1, 3.3
SYNC	20 16	E E	Encoder Synchronization Counter (CNTSEL=1) Encoder Synchronization Counter (CTNSEL=0)			1.1, 2.1.1, 3.2, 3.2.1
SER	32	E	Encoder Serial Number			1.1, 3.2, 3.2.2
DISC	10	E	Encoder Discrimination value			3.2, 3.2.1
OVR	2	E	Encoder Counter Overflow Bits			3.2.1
MSEL	2	E	Transmission Modulation Format	Value	Format	3.4
				00b	PWM	
				01b	Manchester	
				10b	VPWM	
				11b	PPM	
HSEL	1	E	Header Select	4 TE = 0	10 TE = 1	3.4
XSER	1	E	Extended Serial Number	28 bits = 0	32 bits = 1	3.2
QUEN	1	E	Queue counter Enable	Disable = 0	Enable = 1	3.2.3.3
STEN	1	E	Start/Stop Pulse Enable	Disable = 0	Enable = 1	3.4
LEDBL	1	E	Low Voltage LED Blink	Continuous = 0	Once = 1	3.6
LEDOS	1	E	LED On Time Select	50 ms = 0	100 ms = 1	3.6
SDLM	1	E	Limited Seed	Disable = 0	Enable = 1	3.3
SDEN	1	E	Seed Enable	Disable = 0	Enable = 1	3.3
SDMD	1	E	Seed Mode	User = 0	Production = 1	3.3
SDBT	4	E	Seed Button Code			3.3
SDTM	2	E	Time Before Seed code-word	Value	Time (s)	3.3
				00b	0.0	
				01b	0.8	
				10b	1.6	
				11b	3.2	
BSEL	2	E	Transmission Baud Rate Select	Value	TE (us)	3.4
				00b	100	
				01b	200	
				10b	400	
				11b	800	
GSEL	2	E	Guard Time Select	Value	Time (ms)	3.4
				00b	0.0	
				01b	6.4	
				10b	51.2	
				11b	102.4	
WAKE	2	D	Wakeup	Value	Value	3.4
				00b	No Wakeup	
				01b	75ms 50%	
				10b	50ms 33.3%	
				11b	100ms 16.6%	
CNTSEL	1	D	Counter Select	16 bits = 0	20 bits = 1	3.2.1
VLOWL	1	D	Low Voltage Latch Enable	Disable = 0	Enable = 1	2.1.3
VLOWSEL	1	D	Low Voltage Trip Point Select	2.2 V = 0	3.2V = 1	2.1.3

Symbol	Length (Bits)	Class	Description (Note 1)			Reference Section
PLLSEL	1	D	PLL Interface Select	ASK = 0	FSK = 1	3.5
MTX	2	D	Minimum Code-words	Value	Value	3.2; 3.2.3.3
				00b	1	
				01b	2	
				10b	4	
				11b	8	
DUAL	1	D	Dual Encoder Enable	Disable = 0	Enable = 1	3.1; 3.5
RFENO	1	D	RF Enable Output Select	Disable = 0	Enable = 1	3.5
TSEL	2	D	Timeout Select	Value	Time (s)	3.0
				00b	Disabled	
				01b	0.8	
				10b	3.2	
				11b	25.6	

Note 1: All Timing values vary ±10%.

5.0 ELECTRICAL CHARACTERISTICS

TABLE 5-1: ABSOLUTE MAXIMUM RATINGS

Symbol	Item	Rating	Units
VDD	Supply voltage	-0.3 to 7.5	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	25	mA
TSTG	Storage temperature	-55 to +125	°C (**Note**)
TLSOL	Lead soldering temp	300	°C (**Note**)

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

TABLE 5-2: DC CHARACTERISTICS

Commercial (C): TAMB = 0°C to +70°C
Industrial (I): TAMB = -40°C to +85°C

		2.0V < VDD < 5.5				
Parameter	**Sym.**	**Min.**	**Typ.[1]**	**Max.**	**Unit**	**Conditions**
Operating voltage	VDD	2.0	—	5.5	V	
Operating current (avg)	ICC	— —	5 2	7 3	mA	VDD = 5.5V VDD = 3.3V
Standby current	ICCS	—	—	1	µA	VDD = 5.5V
High level Input voltage	VIH	0.55VDD	—	VDD+0.3	V	
Low level input voltage	VIL	-0.3	—	0.15VDD	V	
High level output voltage	VOH	0.7Vdd	—	—	V	IOH = -1.0mA, VDD = 2.0V
Low level output voltage	VOL	—	—	0.08VDD	V	IOL = 1.0mA, VDD = 2.0V
RFEN pin high drive	IRFEN	—	3	—	mA	VRFEN = 0.7 VDD
LED sink current	ILED	—	—	10	mA	VDD = 5.5V
Pulldown Resistance; S0-S3	RS0-3	40	60	80	kΩ	VDD=4.0V
Pulldown Resistance, RDATA	RDATA	40	60	80	kΩ	VDD=4.0V
Low battery detect	VLOW	—	2.2 3.2	—	V	VLOWSEL = 0 VLOWSEL=0 (See **Note 2**)
Power on/off reset	VPOR	—	1.8	—	V	All HCS365 function stops and device held in reset. **Note 2**

Note 1: Typical values are at 25°C.
2: This value is characterized and not tested

TABLE 5-3: AC CHARACTERISTICS

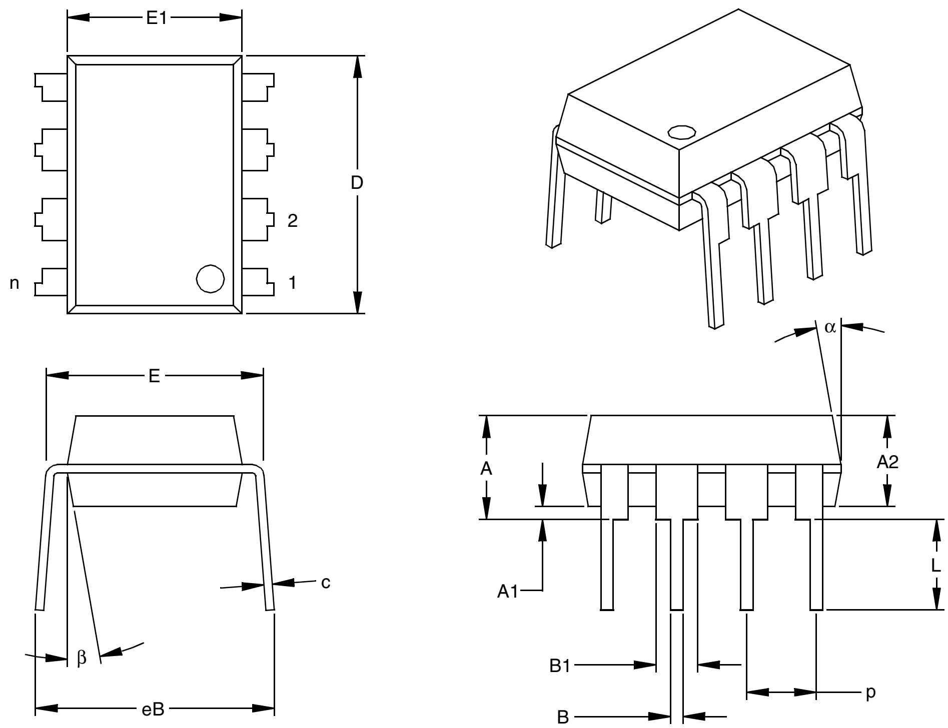
Commercial (C): TAMB = 0°C to +70°C
Industrial (I): TAMB = -40°C to +85°C

		2.0V < VDD < 5.5				
Parameter	**Sym.**	**Min.**	**Typ.[1]**	**Max.**	**Unit**	**Conditions**
Timing Element	TE	—	100	—	µs	BSEL = '00'
POwer Up Time	TPU	—	25	—	ms	
Debounce Time	TDB	—	20	—	ms	
LED On Time	TLEDON	—	50	—	ms	LEDOS = '0'
LED Off Time	TLEDOFF	—	500	—	ms	
Guard Time	TG	—	102.4	—	ms	GSEL = '11'

Note 1: All Timing values are subject to the oscillator variance.

6.0 PACKAGING INFORMATION

Package Type: 8-Lead Plastic Dual In-line (P) – 300 mil (PDIP)

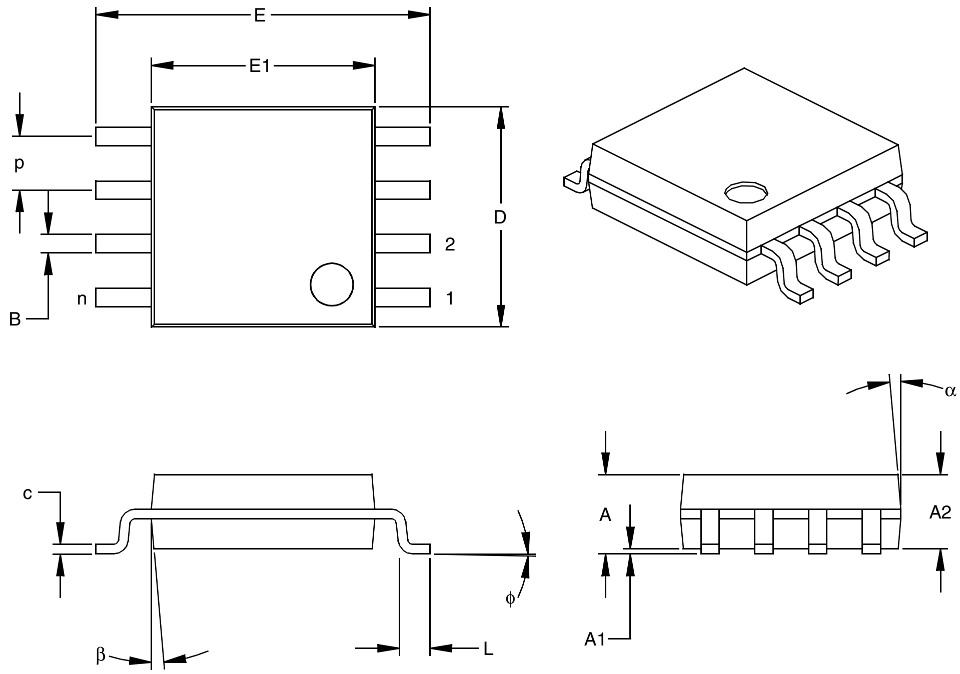


	Units	INCHES*			MILLIMETERS		
	Dimension Limits	MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		8			8	
Pitch	p		.100			2.54	
Top to Seating Plane	A	.140	.155	.170	3.56	3.94	4.32
Molded Package Thickness	A2	.115	.130	.145	2.92	3.30	3.68
Base to Seating Plane	A1	.015			0.38		
Shoulder to Shoulder Width	E	.300	.313	.325	7.62	7.94	8.26
Molded Package Width	E1	.240	.250	.260	6.10	6.35	6.60
Overall Length	D	.360	.373	.385	9.14	9.46	9.78
Tip to Seating Plane	L	.125	.130	.135	3.18	3.30	3.43
Lead Thickness	c	.008	.012	.015	0.20	0.29	0.38
Upper Lead Width	B1	.045	.058	.070	1.14	1.46	1.78
Lower Lead Width	B	.014	.018	.022	0.36	0.46	0.56
Overall Row Spacing §	eB	.310	.370	.430	7.87	9.40	10.92
Mold Draft Angle Top	α	5	10	15	5	10	15
Mold Draft Angle Bottom	β	5	10	15	5	10	15

* Controlling Parameter
§ Significant Characteristic

Notes:
Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010” (0.254mm) per side.
JEDEC Equivalent: MS-001
Drawing No. C04-018

Package Type: 8-Lead Plastic Small Outline (SM) – Medium, 208 mil (SOIC)



Units		INCHES*			MILLIMETERS		
Dimension Limits		MIN	NOM	MAX	MIN	NOM	MAX
Number of Pins	n		8			8	
Pitch	p		.050			1.27	
Overall Height	A	.070	.075	.080	1.78	1.97	2.03
Molded Package Thickness	A2	.069	.074	.078	1.75	1.88	1.98
Standoff	A1	.002	.005	.010	0.05	0.13	0.25
Overall Width	E	.300	.313	.325	7.62	7.95	8.26
Molded Package Width	E1	.201	.208	.212	5.11	5.28	5.38
Overall Length	D	.202	.205	.210	5.13	5.21	5.33
Foot Length	L	.020	.025	.030	0.51	0.64	0.76
Foot Angle	ϕ	0	4	8	0	4	8
Lead Thickness	c	.008	.009	.010	0.20	0.23	0.25
Lead Width	B	.014	.017	.020	0.36	0.43	0.51
Mold Draft Angle Top	α	0	12	15	0	12	15
Mold Draft Angle Bottom	β	0	12	15	0	12	15

*Controlling Parameter

Notes:

Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010” (0.254mm) per side.

Drawing No. C04-056

6.1 Package Marking Information

8-Lead PDIP (300 mil)

```
XXXXXXXX
XXXXXNNN
    YYWW
```

Example

```
HCS365
XXX/NNN
   9925
```

8-Lead SOIC (208 mil)

```
XXXXXXXX
XXXXXXXX
YYWWNNN
```

Example

```
HCS365
XXXXXXXX
9925NNN
```

Legend:	MM...M	Microchip part number information
	XX...X	Customer specific information*
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code

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.

* Standard marking consists of Microchip part number, year code, week code and traceability code. For marking beyond this, certain price adders apply. Please check with your Microchip Sales Office. For SQTP devices, any special marking adders are included in SQTP price.

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NOTES:

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NOTES:

7.0 HCS365 PRODUCT IDENTIFICATION SYSTEM

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

HCS365 — /X

Package:	P	=	Plastic DIP (300 mil body), 8-lead
	SM	=	Plastic SOIC (208 mil body), 8-lead
Temperature Range:	-	=	0°C to +70°C
	I	=	–40°C to +85°C
Device:	HCS365	=	Code Hopping Encoder
	HCS365T	=	Code Hopping Encoder (Tape and Reel - SM only)

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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:

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

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