

## Haptics Controller

### Description:

The MTCH810 provides an easy way to add Haptic feedback to any button/sliders capacitive touch interface. The device integrates a single-channel Haptic driver output with an industry standard I<sup>2</sup>C™ slave interface to create a simple Haptic feedback peripheral.

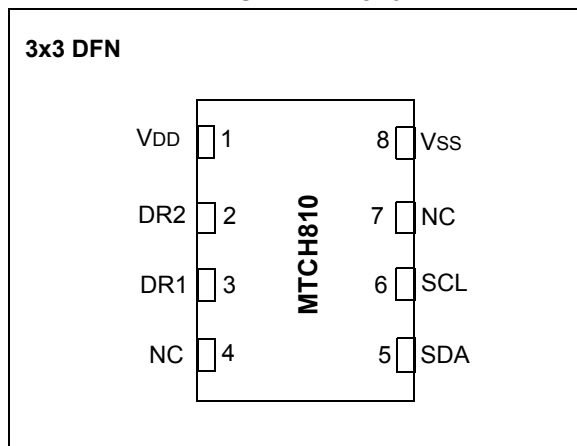
### Features:

- Internal Library of Effects:
  - 14 Haptic effect commands
  - Firmware revision query command
  - Abort Playback command
- I<sup>2</sup>C Control Interface:
  - 7-bit Addressing mode (address = 0x10)
  - Supports 100 kHz and 400 kHz transfer rate
- Wide Operating Voltage: 2.3V-5.5V
- Minimal Number of External Components
- Low-Power Consumption when Idle
- Operating Temperature: -40°C to +85°C

### Package Type:

The device is only offered in an 8-pin 3x3 DFN package (see [Figure 1](#)).

**FIGURE 1: 8-PIN DFN DIAGRAM FOR MTCH810**



**TABLE 1: 8-PIN DFN PINOUT DESCRIPTION**

Name	8-Pin DFN	Description
VDD	1	Power supply input
DR2	2	Drive output 2
DR1	3	Drive output 1
NC	4	No connection
SDA	5	I <sup>2</sup> C™ Data
SCL	6	I <sup>2</sup> C™ Clock
NC	7	No connection
VSS	8	Ground

### Pin Description:

#### DR1

This is the non-inverting PWM Haptics drive output. It should be connected to the non-inverting input of a Haptic driver circuit designed for Eccentric Rotating Mass Actuators (ERMs).

#### DR2

It should be connected to the inverting input of a Haptic driver circuit designed for ERM Actuators.

#### SDA

This pin is the serial data connection of the I<sup>2</sup>C interface. It should be connected to the I<sup>2</sup>C master SDA signal with a pull-up resistor to VDD.

#### SCL

This pin is the serial clock connection of the I<sup>2</sup>C interface. It should be connected to the I<sup>2</sup>C master SCL signal with a pull-up resistor to VDD.

## Table of Contents

1.0	Device Overview .....	3
2.0	I <sup>2</sup> C™ Serial Interface .....	7
3.0	Electrical Characteristics .....	13
4.0	Packaging Information .....	20
	Index .....	25
	The Microchip Web Site .....	26
	Customer Change Notification Service .....	26
	Customer Support .....	26
	Reader Response .....	27
	Product Identification System .....	28

## TO OUR VALUED CUSTOMERS

It is our intention to provide our valued customers with the best documentation possible to ensure successful use of your Microchip products. To this end, we will continue to improve our publications to better suit your needs. Our publications will be refined and enhanced as new volumes and updates are introduced.

If you have any questions or comments regarding this publication, please contact the Marketing Communications Department via E-mail at [docerrors@microchip.com](mailto:docerrors@microchip.com) or fax the **Reader Response Form** in the back of this data sheet to (480) 792-4150. We welcome your feedback.

### Most Current Data Sheet

To obtain the most up-to-date version of this data sheet, please register at our Worldwide Web site at:

<http://www.microchip.com>

You can determine the version of a data sheet by examining its literature number found on the bottom outside corner of any page. The last character of the literature number is the version number, (e.g., DS30000A is version A of document DS30000).

### Errata

An errata sheet, describing minor operational differences from the data sheet and recommended workarounds, may exist for current devices. As device/documentation issues become known to us, we will publish an errata sheet. The errata will specify the revision of silicon and revision of document to which it applies.

To determine if an errata sheet exists for a particular device, please check with one of the following:

- Microchip's Worldwide Web site; <http://www.microchip.com>
- Your local Microchip sales office (see last page)

When contacting a sales office, please specify which device, revision of silicon and data sheet (include literature number) you are using.

### Customer Notification System

Register on our web site at [www.microchip.com](http://www.microchip.com) to receive the most current information on all of our products.

## 1.0 DEVICE OVERVIEW

The Microchip mTouch™ MTCH810 Haptics feedback controller provides an easy way to add tactile feedback to any application. The device implements all the digital functions for a Haptics feedback system. The Haptic effects are designed to provide feedback for a “Button and Slider” type capacitive touch interface. When combined with an analog power driver and an Eccentric Rotating Mass (ERM) style actuator, the resulting circuit comprises a complete tactile feedback Haptic system.

The device is controlled through an I<sup>2</sup>C slave interface. In response to a two-byte command, the MTCH810 (in combination with the driver and ERM) generates one of 13 different Haptic vibration effects. The effects are 180-220 Hz vibrations with different amplitude envelopes and durations. The effects create a variety of different ‘feels’ to provide feedback for different capacitive touch commands, status and error conditions. Several effects are similar with different power levels in order to allow the users to compensate for the variations in the coupling of the vibrations to the user’s finger tip.

Two additional commands allow the termination of an effect early and the ability to read the effects table revision.

### 1.1 Communications

- I<sup>2</sup>C, Slave mode

### 1.2 Drive Outputs

- DR1 is a dedicated PWM output
- DR2 is a dedicated inverted PWM output

### 1.3 PWM Resolution

- 10 bits

## 1.4 Pin Description

### 1.4.1 DR1

This is the enable/non-inverting digital PWM Haptics drive output. It should be connected to the non-inverting input of a Haptic power driver circuit design for ERM actuators. The PWM output should only be active when an effect is in progress.

### 1.4.2 DR2

This is the inverting digital PWM Haptics driver output. It should be connected to the inverting input of a Haptic power driver circuit designed for ERM actuators. The PWM output should only be active when an effect is in progress.

### 1.4.3 I<sup>2</sup>C – SERIAL DATA PIN (SDA)

The SDA pin is the serial data pin of the I<sup>2</sup>C interface. The SDA pin is used to write or read the registers and Configuration bits. The SDA pin is an open-drain N-channel driver. Therefore, it needs an external pull-up resistor from the VDD line to the SDA pin. Except for the Start and Stop conditions, the data on the SDA pin must be stable during the high period of the clock. The high or low state of the SDA pin can only change when the clock signal on the SCL pin is low. Refer to [Section 2.1.2 “I<sup>2</sup>C Operation”](#) for more details on the I<sup>2</sup>C serial interface communication.

### 1.4.4 I<sup>2</sup>C – SERIAL CLOCK PIN (SCL)

The SCL pin is the serial clock pin of the I<sup>2</sup>C interface. The I<sup>2</sup>C interface only acts as a slave and the SCL pin accepts only external serial clocks. The input data from the master device is shifted into the SDA pin on the rising edges of the SCL clock, and the output from the device occurs at the falling edges of the SCL clock. The SCL pin is an open-drain N-channel driver. Therefore, it needs an external pull-up resistor from the VDD line to the SCL pin. Refer to [Section 2.1.2 “I<sup>2</sup>C Operation”](#) for more details on I<sup>2</sup>C serial interface communication. For more details, see [Figure 1-1](#) and [Table 1-1](#).

## 1.4.4.1 Clock Stretching

A feature of the SCL pin is clock stretching. This allows the I<sup>2</sup>C slave to hold communications at the end of each byte from the master. Its purpose is to allow the slave sufficient time to process the data before the next byte is sent. It accomplishes the clock hold by turning on the open-drain output, holding the clock line low. This prevents the master from starting the transmission of the next byte in the packet. For proper operation, the I<sup>2</sup>C master must be capable of recognizing a clock stretch condition, and suspending transmission until the MTCH810 releases the SCL pin.

**Note:** The MTCH810 includes a time-out function on the clock stretching function that will reset the I<sup>2</sup>C interface in the event that the I<sup>2</sup>C interface hangs in a clock stretch condition.

## 1.5 Haptic Commands

The commands are transmitted via the I<sup>2</sup>C serial interface as a Start condition, address plus write bit, two successive bytes and a Stop condition. For the effect table revision number, the Write command is followed by an I<sup>2</sup>C read of two bytes. [Table 2-2](#) and [Table 2-3](#) list all the commands supported by the MTCH810.

## 1.6 Hardware

To build a complete Haptic system, the two digital PWM outputs must be filtered to produce a DC drive signal, and amplified to produce a minimum of 300 mA of drive at 3V. This output is then used to drive an ERM actuator. [Figure 1-1](#) below shows a typical controller, driver and actuator combination for a Haptic system.

The MTCH810 is the controller in the system, accepting I<sup>2</sup>C commands and generating the appropriate PWM signals to create the Haptic effect. The outputs from the MTCH810 are then filtered and amplified by the DRV8601. The amplifier stage is essentially an audio frequency amplifier configured for differential inputs and outputs. The output of the amplifier then drives the ERM.

The RC network in the feedback path provides a pole in the transfer function at 160 Hz to roll off the high frequency gain and attenuate the ripple at the PWM frequency. The connection between the DR1 output and the enable of the amplifier allows the controller to generate an output for the ERM with a drive/coast format, rather than a drive/brake control. Using a differential output eliminates the need for a large capacitor on the output to AC couple the drive signal to the ERM.

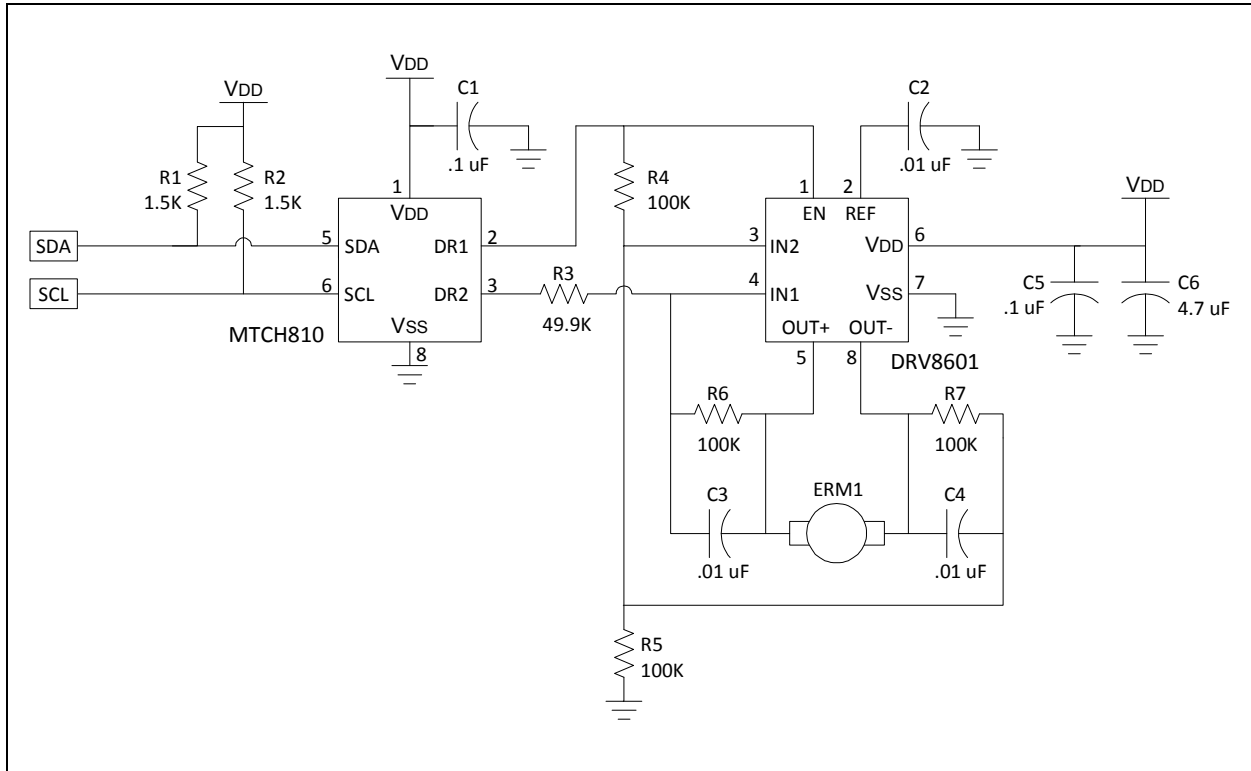
**Note:** Any audio frequency drive circuits will work in the application, provided it can supply 300 mA at 3V and turn on in less than 1 mS. Amplifiers with built-in “click and pop” elimination have soft-start enables which have a turn on time of >10 mS and are not suitable for a Haptic driver.

[Table 1-1](#) lists the qualified ERM actuators and their manufacturers.

**TABLE 1-1: APPROVED ACTUATORS AND SPECIFICATIONS**

Actuator	Dimensions (mm)	Rated Voltage	Haptic Transient Overdrive Voltage	Impedance
Nidec NRS-3388i	4.6 ± 0.2D 15.6 ± 0.9L	1.3V ± 0.2V	3.3V	10.6Ω ± 20%
Johnson Electric 1999-1MB0037EP	6.0H x 8.0W 21.5L	4.5V	5.0V	10Ω - typical

**FIGURE 1-1: TYPICAL SCHEMATIC**



# MTCH810

---

NOTES:

## 2.0 I<sup>2</sup>C™ SERIAL INTERFACE

This device supports the I<sup>2</sup>C serial protocol. The I<sup>2</sup>C module operates in Slave mode, so it does not generate the serial clock.

### 2.1 Overview

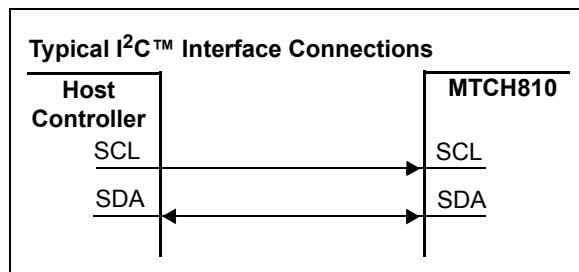
This I<sup>2</sup>C interface is a two-wire interface. Figure 2-1 shows a typical I<sup>2</sup>C Interface connection.

The I<sup>2</sup>C interface specifies different communication bit rates. These are referred to as Standard, Fast or High Speed modes. The MTCH810 device supports these three modes. The bit rates of these modes are:

- Standard mode: Bit Rates up to 100 kbit/s
- Fast mode: Bit Rates up to 400 kbit/s

A device that sends data onto the bus is defined as a transmitter, and a device receiving data is defined as a receiver. The bus has to be controlled by a master device which generates the serial clock (SCL), controls the bus access and generates the Start and Stop conditions. The MTCH810 device works as slave. Both master and slave can operate as transmitter or receiver, but the master device determines which mode is activated. Communication is initiated by the master (microcontroller) which sends the Start bit, followed by the slave address byte. The first byte transmitted is always the slave address byte, which contains the device code, the address bits and the R/W bit.

**FIGURE 2-1: TYPICAL I<sup>2</sup>C™ INTERFACE**



The I<sup>2</sup>C serial protocol only defines the field types, field lengths, timings, etc. of a frame. The frame content defines the behavior of the device. For details on the frame content (commands/data) refer to Section 2.3 "I<sup>2</sup>C Commands".

Refer to the *NXP User Manual* (UM10204\_3) for more details on the I<sup>2</sup>C specifications.

#### 2.1.1 SIGNAL DESCRIPTIONS

The I<sup>2</sup>C interface uses up to two pins (signals). These are:

- SDA (Serial Data) (see Section 1.4.3 "I<sup>2</sup>C – Serial Data Pin (SDA)")
- SCL (Serial Clock) (see Section 1.4.4 "I<sup>2</sup>C – Serial Clock Pin (SCL)")

#### 2.1.2 I<sup>2</sup>C OPERATION

The MTCH810 device I<sup>2</sup>C module is compatible with the NXP I<sup>2</sup>C specification. The following lists some of the module's features:

- 7-bit Slave Addressing
- Supports Three Clock Rate modes:
  - Standard mode, clock rates up to 100 kHz
  - Fast mode, clock rates up to 400 kHz
- Support Multi-Master Applications

The I<sup>2</sup>C 10-bit addressing mode is not supported.

The NXP I<sup>2</sup>C specification only defines the field types, field lengths, timings, etc. of a frame. The frame content defines the behavior of the device. The frame content for this device is defined in Section 2.3 "I<sup>2</sup>C Commands".

#### 2.1.3 I<sup>2</sup>C BIT STATES AND SEQUENCE

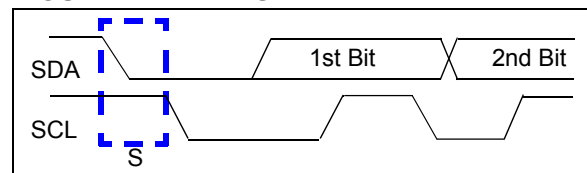
Figure 2-8 shows an I<sup>2</sup>C 8-bit transfer sequence, while Figure 2-7 shows the bit definitions. The serial clock is generated by the master. The following definitions are used for the bit states:

- Start bit (S)
- Data bit
- Acknowledge (A) bit (driven low)/  
No Acknowledge ( $\bar{A}$ ) bit (not driven low)
- Repeated Start bit (Sr)
- Stop bit (P)

#### 2.1.4 START BIT

The Start bit (see Figure 2-2) indicates the beginning of a data transfer sequence. The Start bit is defined as the SDA signal falling when the SCL signal is high.

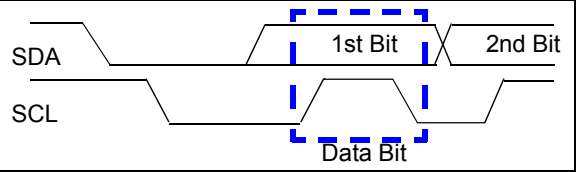
**FIGURE 2-2: START BIT**



2.1.5 DATA BIT

The SDA signal may change state while the SCL signal is low. While the SCL signal is high, the SDA signal MUST be stable (see [Figure 2-3](#)).

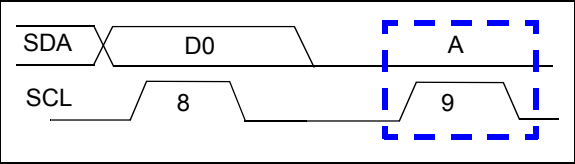
FIGURE 2-3: DATA BIT



2.1.6 ACKNOWLEDGE (A) BIT

The A bit (see [Figure 2-4](#)) is typically a response from the receiving device to the transmitting device. Depending on the context of the transfer sequence, the A bit may indicate different things. Typically, the slave device will supply an A response after the Start bit and eight data bits have been received. An A bit has the SDA signal low.

FIGURE 2-4: ACKNOWLEDGE WAVEFORM



2.1.7 NOT A ( $\bar{A}$ ) RESPONSE

The  $\bar{A}$  bit has the SDA signal high. [Table 2-1](#) shows the conditions where the slave device will issue a Not A ( $\bar{A}$ ).

TABLE 2-1: MTCH810 A /  $\bar{A}$  RESPONSES

Event	Acknowledge Bit Response	Comment
General Call	$\bar{A}$	
Slave Address valid	A	
Slave Address not valid	$\bar{A}$	
Bus Collision	N/A	Treated as "Don't Care" if the collision occurs on the Start bit. Otherwise, I <sup>2</sup> C™ resets.



## 2.1.8 REPEATED START BIT

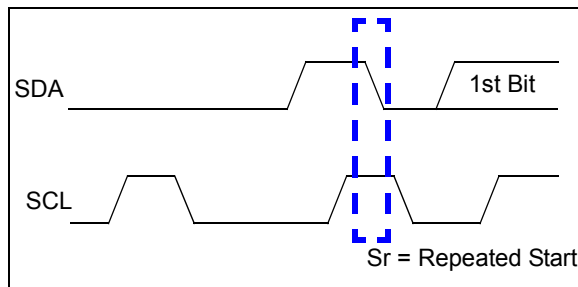
The Repeated Start bit (see [Figure 2-5](#)) indicates that the current master device wishes to continue communicating with the current slave device without releasing the I<sup>2</sup>C bus. The Repeated Start condition is the same as the Start condition, except that the Repeated Start bit follows a Start bit (with the Data bits + A bit) and not a Stop bit.

The Start bit is the beginning of a data transfer sequence and is defined as the SDA signal falling when the SCL signal is high.

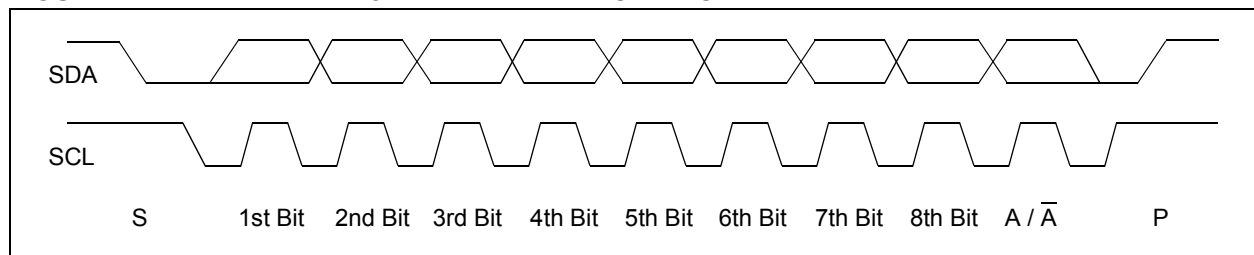
**Note 1:** A bus collision during the Repeated Start condition occurs if:

- SDA is sampled low when SCL goes from low-to-high.
- SCL goes low before SDA is asserted low. This may indicate that another master is attempting to transmit a data '1'.

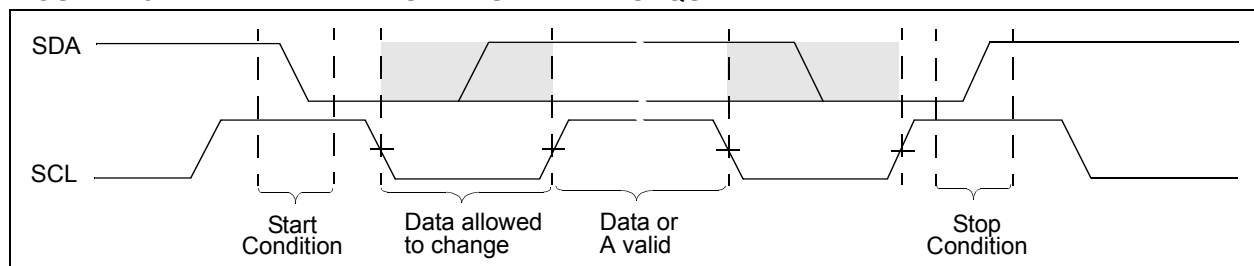
**FIGURE 2-5: REPEAT START CONDITION WAVEFORM**



**FIGURE 2-7: TYPICAL 8-BIT I<sup>2</sup>C™ WAVEFORM FORMAT**



**FIGURE 2-8: I<sup>2</sup>C™ DATA STATES AND BIT SEQUENCE**

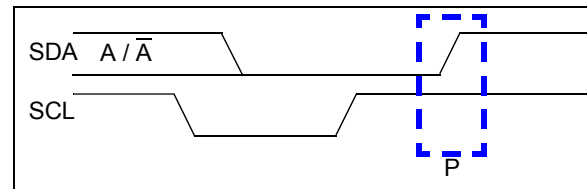


## 2.1.9 STOP BIT

The Stop bit (see [Figure 2-6](#)) indicates the end of the I<sup>2</sup>C data transfer sequence. The Stop bit is defined as the SDA signal rising when the SCL signal is high.

A Stop bit resets the I<sup>2</sup>C interface of the MTCH810 device.

**FIGURE 2-6: STOP CONDITION RECEIVE OR TRANSMIT MODE**



### 2.1.9.1 Aborting a Transmission

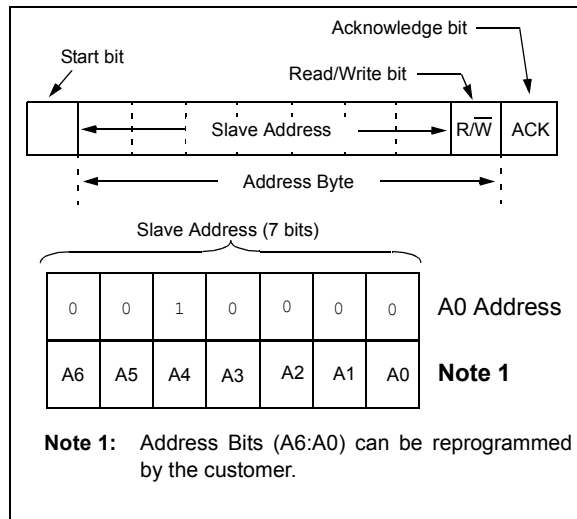
If any part of the I<sup>2</sup>C transmission does not meet the command format, it is aborted. This can be intentionally accomplished with a Start or Stop condition. This is done so that noisy transmissions (usually an extra Start or Stop condition) are aborted before they corrupt the device.

## 2.1.9.2 Device Addressing

The address byte is the first byte received following the Start condition from the master device. The full seven bits of the I<sup>2</sup>C slave address is “0010000”.

Figure 2-9 shows the I<sup>2</sup>C slave address byte format, which contains the seven address bits and a Read/Write (R/W) bit.

**FIGURE 2-9: SLAVE ADDRESS BITS IN THE I<sup>2</sup>C™ CONTROL BYTE**



## 2.2 Device Commands

This section documents the commands that the device supports.

The commands can be grouped into the following categories:

- Effect Commands
- Revision and Control Commands

**TABLE 2-2: EFFECT COMMANDS**

Index	I <sup>2</sup> C™ Message	Haptic Effect Description
0	0x00 0x00	Strong click
1	0x01 0xFF	Med. strong click 60%
2	0x02 0xFE	Low strong click 30%
3	0x03 0xFD	Sharp click
4	0x04 0xFC	Sharp click 60%
5	0x05 0xFB	Sharp click 30%
6	0x06 0xFA	Soft bump
7	0x07 0xF9	Med. soft bump 60%
8	0x08 0xF8	Soft bump 30%
9	0x09 0xF7	Double click
10	0x0A 0xF6	Double click 60%
11	0x0B 0xF5	Triple click
12	0x0C 0xF4	Soft buzz
13	0x0D 0xF3	Strong buzz

**TABLE 2-3: REVISION AND CONTROL COMMANDS**

Index	I <sup>2</sup> C™ Message	Haptic Effect Description
14	0x0E 0xF2	Read effect library version number
15	0x0F 0xF1	Abort effect playback

## 2.3 I<sup>2</sup>C COMMANDS

The I<sup>2</sup>C protocol does not specify how commands are formatted, so this section specifies the MTCH810 device I<sup>2</sup>C command formats and operation.

The commands can be grouped into the following categories:

- Effect Commands
- Revision and Control Commands

The supported commands are shown in [Table 2-2](#) and [Table 2-3](#).

### 2.3.1 EFFECT COMMANDS

Effect commands are used to initiate a specific Haptic effect. The command consists of two bytes which are the XOR of one another. The effect begins with the completion of the I<sup>2</sup>C Stop condition.

### 2.3.2 REVISION AND CONTROL COMMANDS

Revision and Control commands are used to either retrieve the current revision of the effects table within the controller, or to terminate early a Haptic effect. Just like the Effect commands, the command codes are two's compliments of one another. The Terminate-early command is executed at the completion of the I<sup>2</sup>C Stop condition. When the Revision command is sent, the controller then formats the revision data and waits for an I<sup>2</sup>C read from the master.

### 2.3.3 ABORTING A COMMAND TRANSMISSION

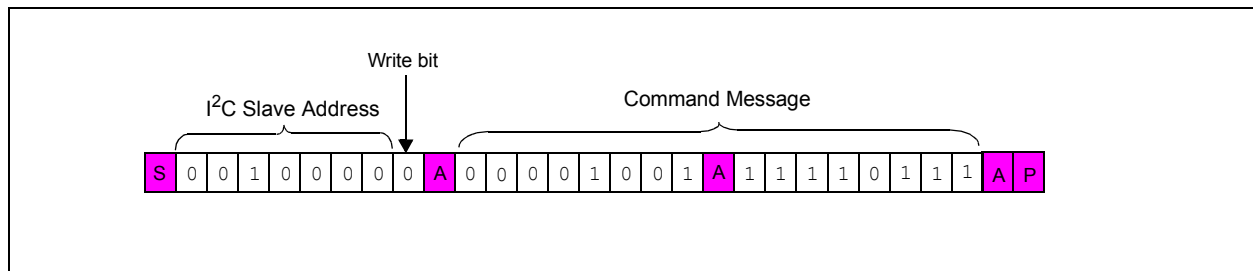
A Restart or Stop condition in an expected data bit position will abort the current command sequence and data will not be written to the MTCH810. Write commands are automatically aborted if the binary XOR checksum is not valid.

### 2.3.4 WRITE COMMAND (NORMAL AND HIGH VOLTAGE)

The format of the command is shown in [Figure 2-10](#). The MTCH810 generates the A /  $\bar{A}$  bits.

A Write command will only start a write cycle after a properly formatted Write command has been received and the Stop condition has occurred.

**FIGURE 2-10: WRITE RANDOM ADDRESS COMMAND**



## 2.3.5 REVISION COMMAND

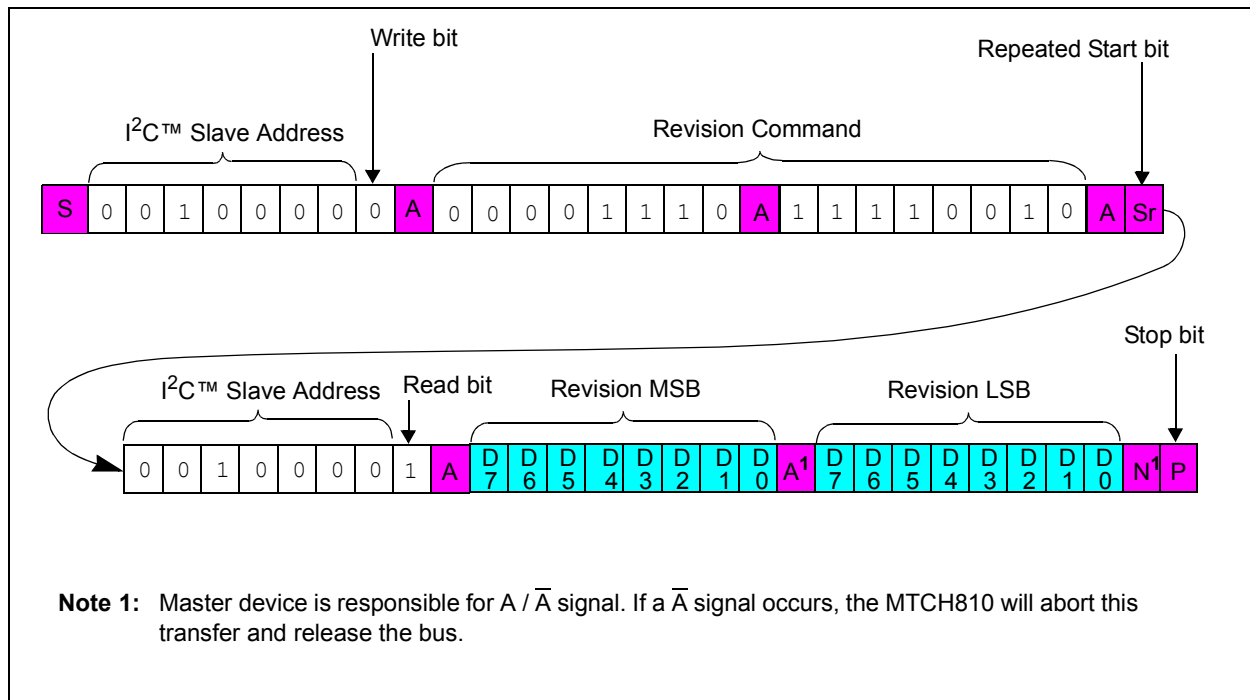
The format of the Revision command (see Figure 2-11) includes the Start condition, I<sup>2</sup>C control byte (with R/W bit set to 0), A bit, the first command byte, A bit, followed by the two's complement of the command byte, a Repeated Start bit, I<sup>2</sup>C control byte (with R/W bit set to 1) and the MTCH810 device transmitting the requested data bytes one at a time, until the master sends a Stop condition.

The I<sup>2</sup>C control byte requires the R/W bit to be equal to a logic one (R/W = 1) in order to generate a read sequence. The data read will start with the Most Significant Byte (MSB) of the revision date and automatically increment to the next byte after each byte request. The sequence is ended with the master generating a Stop or Restart condition. Figure 2-11 shows the waveforms for a single read.

### 2.3.5.1 Ignoring an I<sup>2</sup>C Transmission and "Falling Off" the Bus

The MTCH810 device expects to receive complete, valid I<sup>2</sup>C commands and will assume that any command not defined as a valid command is due to a bus corruption and will enter a passive high condition on the SDA signal. All signals will be ignored until the next valid Start condition and control byte are received.

**FIGURE 2-11: READ REVISION COMMAND**



## 3.0 ELECTRICAL SPECIFICATIONS

### Absolute Maximum Ratings<sup>(†)</sup>

Ambient temperature under bias .....	-40°C to +125°C
Storage temperature .....	-65°C to +150°C
Voltage on VDD with respect to VSS .....	-0.3V to +4.0V
Voltage on all other pins with respect to VSS .....	-0.3V to (VDD + 0.3V)
Total power dissipation <sup>(1)</sup> .....	800 mW
Maximum current out of VSS pin, -40°C ≤ TA ≤ +85°C for industrial.....	85 mA
Maximum current into VDD pin, -40°C ≤ TA ≤ +85°C for industrial.....	80 mA
Clamp current, IK (VPIN < 0 or VPIN > VDD).....	± 20 mA
Maximum output current sunk by any DR pin .....	25 mA
Maximum output current sourced by any DR pin .....	25 mA

**Note 1:** Power dissipation is calculated as follows:  $P_{DIS} = V_{DD} \times \{I_{DD} - \sum I_{OH}\} + \sum \{(V_{DD} - V_{OH}) \times I_{OH}\} + \sum (V_{OL} \times I_{OL})$ .

† **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.

# MTCH810

## 3.1 DC Characteristics: MTCH810

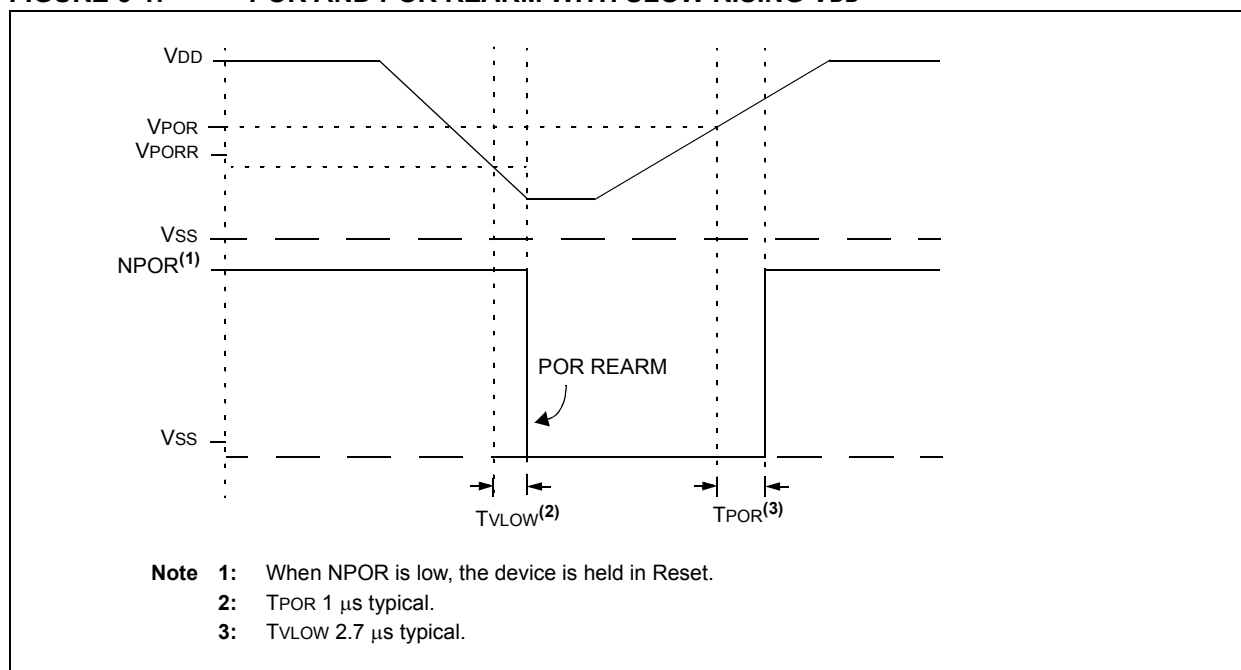
MTCH810			Standard Operating Conditions (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for industrial				
Param. No.	Sym.	Characteristic	Min.	Typ†	Max.	Units	Conditions
D001	VDD	Supply Voltage	1.8	—	3.6	V	
D002	VPOR*	Power-on Reset Release Voltage	—	1.6	—	V	
D003	VPORR*	Power-on Reset Rearm Voltage	—	0.8	—	V	Device in Sleep mode
D004*	SVDD	VDD Rise Rate to ensure internal Power-on Reset signal	0.05	—	—	V/ms	

\* These parameters are characterized but not tested.

† Data in "Typ" column is at 3.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

**Note 1:** This is the limit to which VDD can be lowered in Sleep mode without losing RAM data.

**FIGURE 3-1: POR AND POR REARM WITH SLOW RISING VDD**



## 3.2 DC Characteristics: MTCH810-I/E

DC CHARACTERISTICS			Standard Operating Conditions (unless otherwise stated) Operating temperature $-40^{\circ}\text{C} \leq T_A \leq +85^{\circ}\text{C}$ for industrial				
Param. No.	Sym.	Characteristic	Min.	Typ†	Max.	Units	Conditions
D030A	V <sub>IL</sub>	<b>Input Low Voltage</b>					
		DR PORT:					
		with TTL buffer	—	—	0.15 V <sub>D</sub>	V	$1.8\text{V} \leq V_{DD} \leq 3.6\text{V}$
D031		with I <sup>2</sup> C™ levels	—	—	0.3 V <sub>DD</sub>	V	
D040A	V <sub>IH</sub>	<b>Input High Voltage</b>					
		DR Ports:					
		with TTL buffer	0.25 V <sub>DD</sub> + 0.8	—	—	V	$1.8\text{V} \leq V_{DD} \leq 3.6\text{V}$
D041		with I <sup>2</sup> C™ levels	0.7 V <sub>DD</sub>	—	—	V	
D060	I <sub>IL</sub>	<b>Input Leakage Current<sup>(1)</sup></b>					
		DR Ports	—	± 5	± 125	nA	V <sub>SS</sub> ≤ V <sub>PIN</sub> ≤ V <sub>DD</sub> , Pin at high-impedance at 85°C
			—	± 5	± 1000	nA	125°C
D080	V <sub>OL</sub>	<b>Output Low Voltage<sup>(3)</sup></b>					
		DR Ports	—	—	0.6	V	I <sub>OL</sub> = 6 mA, V <sub>DD</sub> = 3.3V I <sub>OL</sub> = 1.8 mA, V <sub>DD</sub> = 1.8V
D090	V <sub>OH</sub>	<b>Output High Voltage<sup>(3)</sup></b>					
		DR Ports	V <sub>DD</sub> - 0.7	—	—	V	I <sub>OH</sub> = 3 mA, V <sub>DD</sub> = 3.3V I <sub>OH</sub> = 1 mA, V <sub>DD</sub> = 1.8V
D101A*	C <sub>IO</sub>	<b>Capacitive Loading Specs on Output Pins</b>					
		All DR pins	—	—	50	pF	

\* These parameters are characterized but not tested.

† Data in "Typ" column is at 3.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

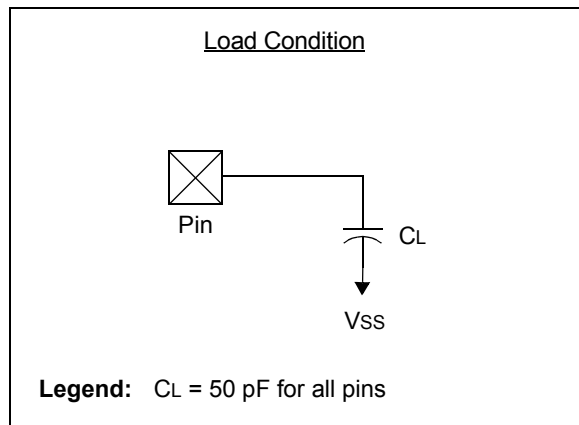
**Note 1:** Negative current is defined as current sourced by the pin.

**2:** The leakage current on the MCLR pin is strongly dependent on the applied voltage level. The specified levels represent normal operating conditions. Higher leakage current may be measured at different input voltages.

**3:** Including OSC2 in CLKOUT mode.

# MTCH810

**FIGURE 3-2: LOAD CONDITIONS**



**TABLE 3-1: DR TIMING PARAMETERS**

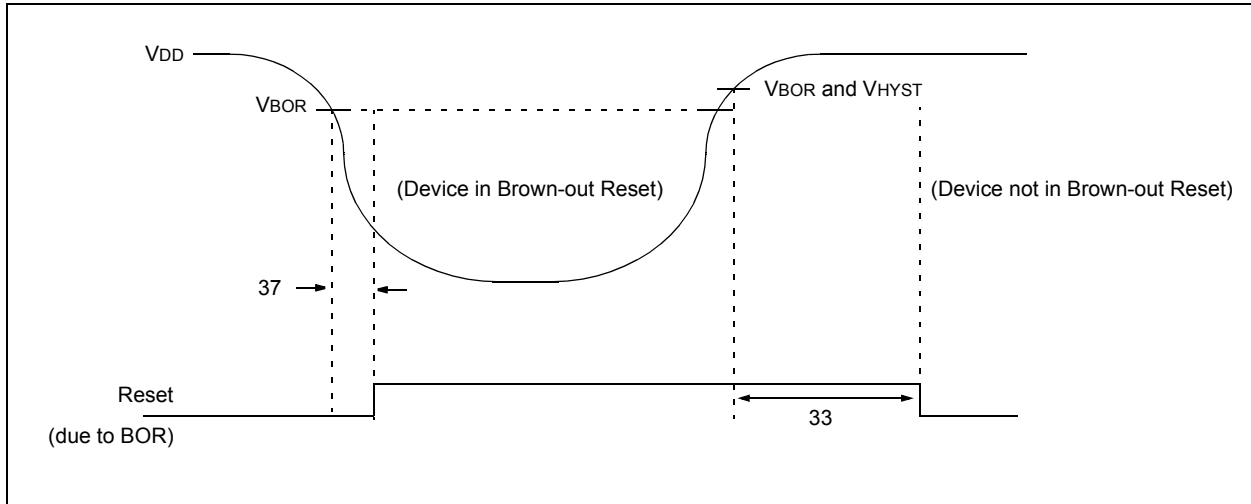
Standard Operating Conditions (unless otherwise stated)							
Operating Temperature $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$							
Param. No.	Sym.	Characteristic	Min.	Typ†	Max.	Units	Conditions
OS18*	TioR	DR output rise time	—	90 55	140 80	ns	VDD = 1.8V VDD = 3.0-3.6V
OS19*	TioF	DR output fall time	—	60 44	80 60	ns	VDD = 1.8V VDD = 3.0-3.6V

\* These parameters are characterized but not tested.

† Data in "Typ" column is at 3.0V, 25°C unless otherwise stated.



**FIGURE 3-3: BROWN-OUT RESET TIMING AND CHARACTERISTICS**



**TABLE 3-2: RESET, WATCHDOG TIMER, OSCILLATOR START-UP TIMER, POWER-UP TIMER AND BROWN-OUT RESET PARAMETERS**

Standard Operating Conditions (unless otherwise stated) Operating Temperature $-40^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$							
Param. No.	Sym.	Characteristic	Min.	Typ†	Max.	Units	Conditions
31	TWDTLP	Watchdog Timer Time-out Period	205	256	305	ms	V <sub>DD</sub> = 1.8V-3.6V, 1:1 Prescaler used
33*	TPWRT	Power-up Timer Period	40	65	140	ms	

\* These parameters are characterized but not tested.

† Data in "Typ" column is at 3.0V, 25°C unless otherwise stated. These parameters are for design guidance only and are not tested.

FIGURE 3-4: I<sup>2</sup>C™ BUS START/STOP BITS TIMING

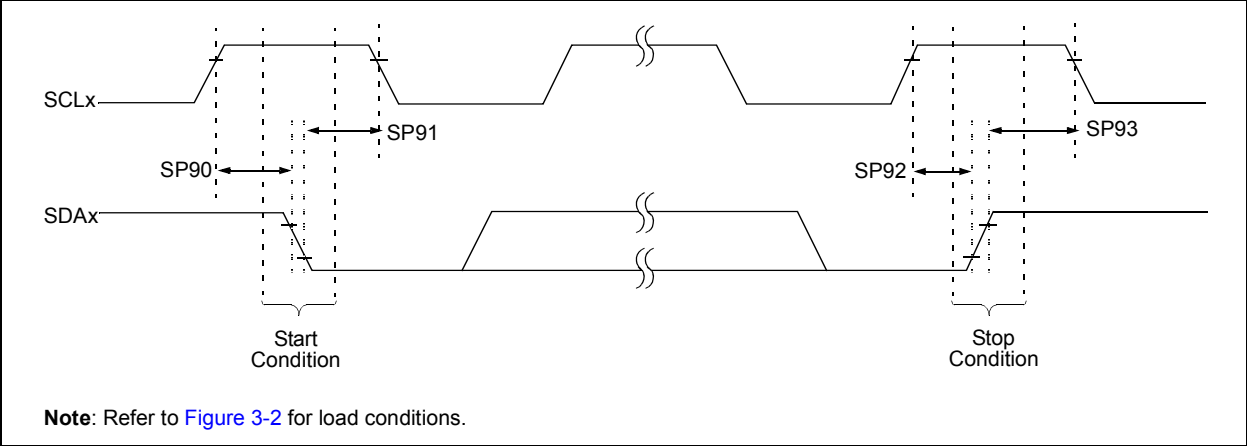
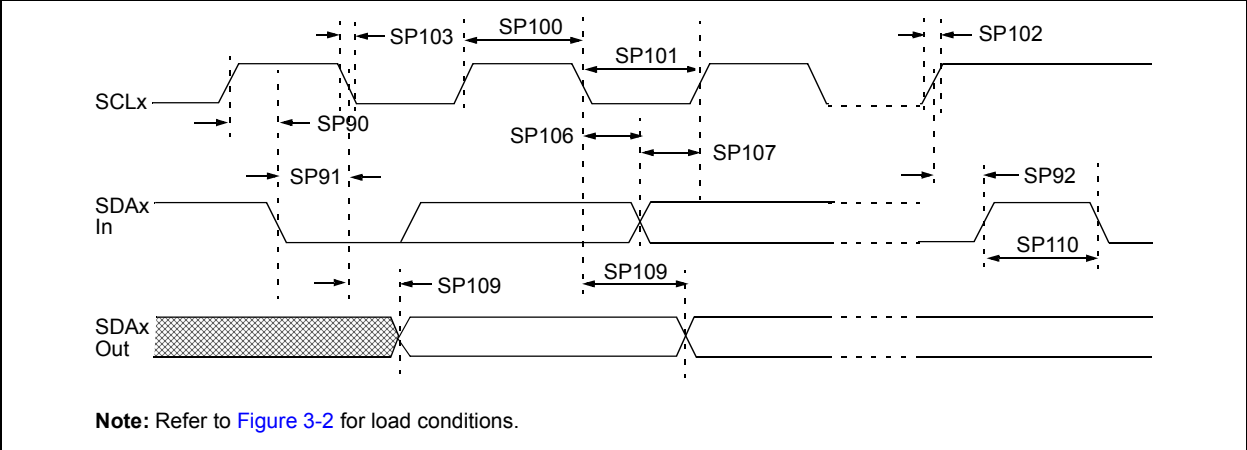


FIGURE 3-5: I<sup>2</sup>C™ BUS DATA TIMING



**TABLE 3-3: I<sup>2</sup>C™ BUS DATA REQUIREMENTS**

Param. No.	Symbol	Characteristic		Min.	Max.	Units	Conditions
SP100*	THIGH	Clock high time	400 kHz mode	0.6	—	μs	
SP101*	TLOW	Clock low time	400 kHz mode	1.3	—	μs	
SP102*	TR	SDAx and SCLx rise time	400 kHz mode	20 + 0.1CB	300	ns	CB is specified to be from 10-400 pF
SP103*	TF	SDAx and SCLx fall time	400 kHz mode	20 + 0.1CB	250	ns	CB is specified to be from 10-400 pF
SP106*	THD:DAT	Data input hold time	400 kHz mode	0	0.9	μs	
SP107*	TSU:DAT	Data input setup time	400 kHz mode	100	—	ns	
SP109*	TAA	Output valid from clock	400 kHz mode	—	—	ns	
SP110*	TBUF	Bus free time	400 kHz mode	1.3	—	μs	Time the bus must be free before a new transmission can start
SP111*	CB	Bus capacitive loading		—	400	pF	
SP112*	TTIMEOUT	Maximum message time	400 kHz mode	29.5	36.0	ms	

\* These parameters are characterized but not tested.

## 4.0 PACKAGING INFORMATION

### 4.1 Package Marking Information

8-Lead DFN (3x3x0.9 mm)

Example

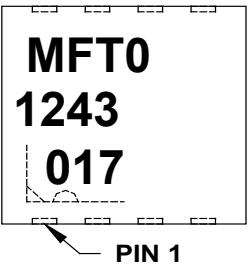
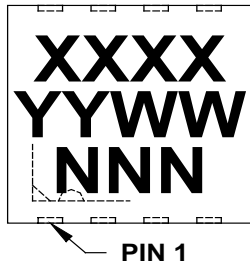


TABLE 4-1: 8-LEAD 3x3x0.9 DFN (MF) TOP MARKING

Part Number	Marking
MTCH810-I/MF	MFT0

<b>Legend:</b>	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
(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
*	This package is Pb-free. The Pb-free JEDEC designator (e3) can be found on the outer packaging for this package.
<b>Note:</b>	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.

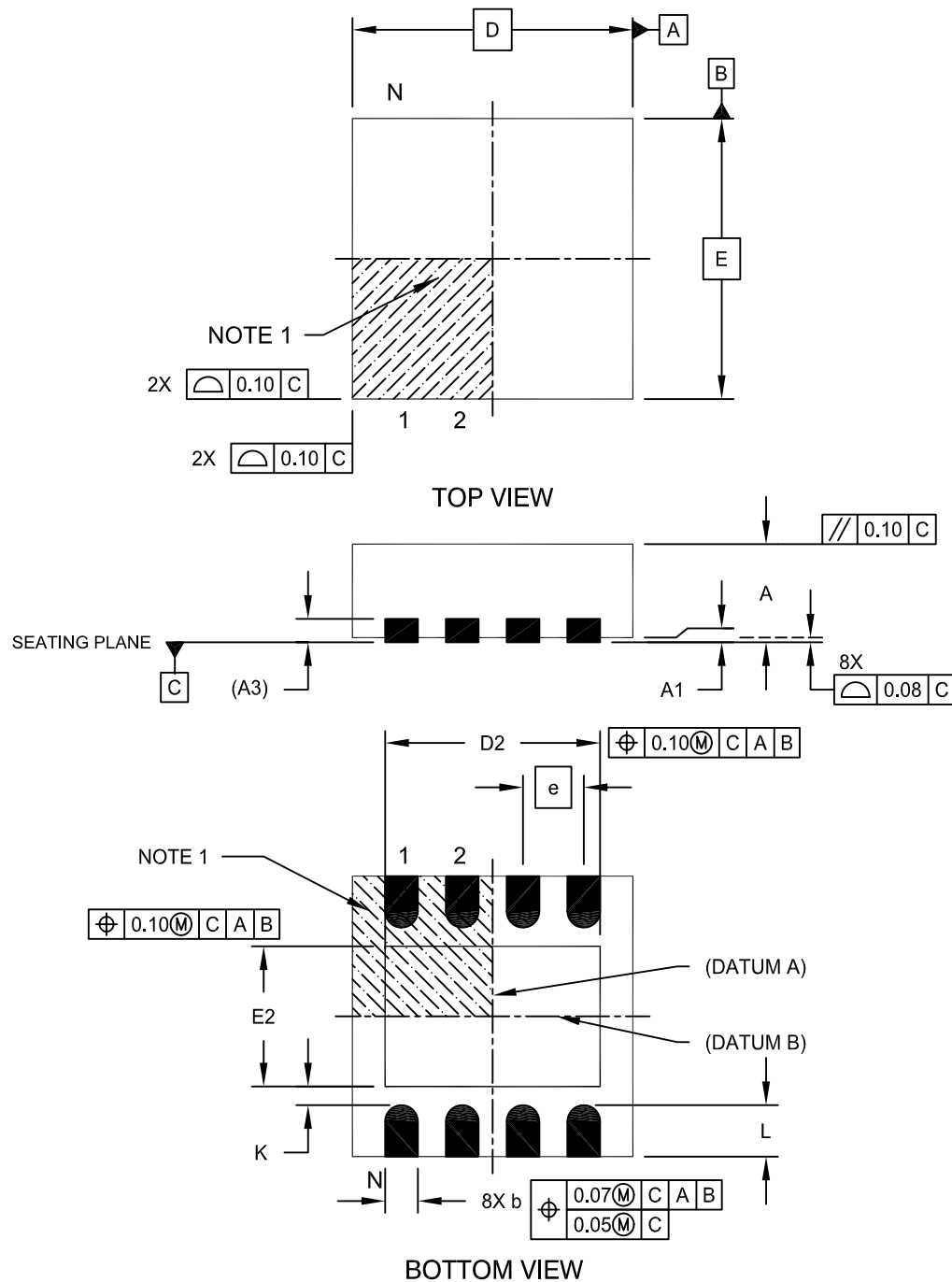
\* Standard PIC® device marking consists of Microchip part number, year code, week code, and traceability code. For PIC device marking beyond this, certain price adders apply. Please check with your Microchip Sales Office. For QTP devices, any special marking adders are included in QTP price.

## 4.2 Package Details

The following sections give the technical details of the packages.

### 8-Lead Plastic Dual Flat, No Lead Package (MF) - 3x3x0.9mm Body [DFN]

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

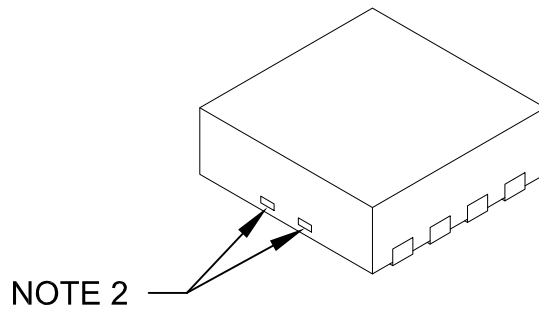


Microchip Technology Drawing No. C04-062C Sheet 1 of 2

# MTCH810

## 8-Lead Plastic Dual Flat, No Lead Package (MF) - 3x3x0.9mm Body [DFN]

**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	0.65 BSC		
Overall Height	A	0.80	0.90	1.00
Standoff	A1	0.00	0.02	0.05
Contact Thickness	A3	0.20 REF		
Overall Length	D	3.00 BSC		
Exposed Pad Width	E2	1.34	-	1.60
Overall Width	E	3.00 BSC		
Exposed Pad Length	D2	1.60	-	2.40
Contact Width	b	0.25	0.30	0.35
Contact Length	L	0.20	0.30	0.55
Contact-to-Exposed Pad	K	0.20	-	-

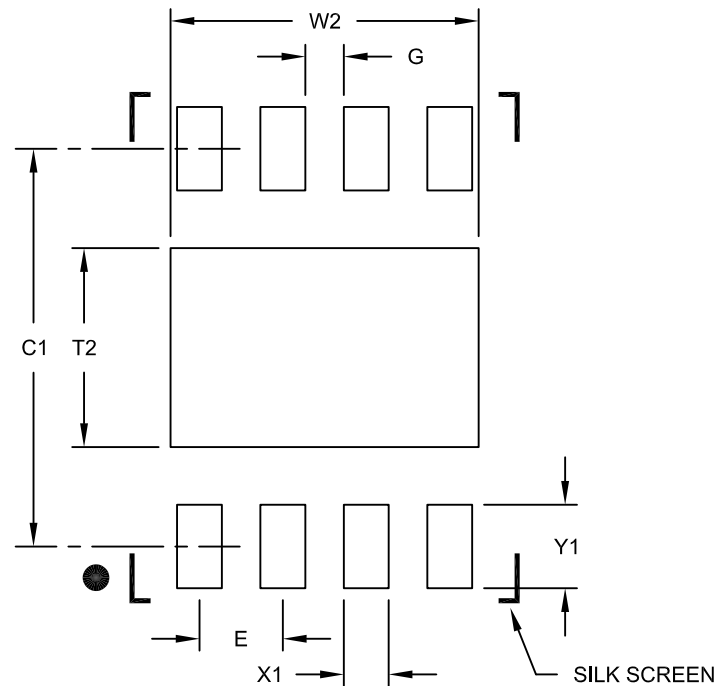
**Notes:**

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package may have one or more exposed tie bars at ends.
3. Package is saw singulated
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.

Microchip Technology Drawing No. C04-062C Sheet 2 of 2

## 8-Lead Plastic Dual Flat, No Lead Package (MF) - 3x3x0.9mm Body [DFN]

**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	0.65 BSC		
Optional Center Pad Width	W2			2.40
Optional Center Pad Length	T2			1.55
Contact Pad Spacing	C1		3.10	
Contact Pad Width (X8)	X1			0.35
Contact Pad Length (X8)	Y1			0.65
Distance Between Pads	G	0.30		

**Notes:**

1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2062B

## APPENDIX A: DATA SHEET REVISION HISTORY

### Revision A (12/2012)

Initial release.



## INDEX

### Symbols

I2C Hardware Interface ..... 7

### A

Absolute Maximum Ratings ..... 13

### B

Brown-out Reset (BOR)

    Specifications ..... 17

    Timing and Characteristics ..... 17

### C

Communications ..... 3

Customer Change Notification Service ..... 26

Customer Notification Service ..... 26

Customer Support ..... 26

### D

DC Characteristics

    MTCH810 ..... 14

Description ..... 1

Device Overview ..... 3

DR1 ..... 3

DR2 ..... 3

Drive Outputs ..... 3

### E

Electrical Specifications ..... 13

Errata ..... 2

### F

Features ..... 1

### I

I2C™ Communications and Protocol ..... 7

Internet Address ..... 26

### M

Microchip Internet Web Site ..... 26

### O

Oscillator Start-up Timer (OST)

    Specifications ..... 17

### P

Package Type ..... 1

Packaging

    DFN ..... 21

Packaging Information ..... 20

Pin Description ..... 1, 3

Power-up Timer (PWRT)

    Specifications ..... 17

PWM Resolution ..... 3

### R

Reader Response ..... 27

Revision History ..... 24

### T

Timing Diagrams

    Brown-out Reset (BOR) ..... 17

    I<sup>2</sup>C Bus Data ..... 18

### W

WWW Address ..... 26

WWW, On-Line Support ..... 2

## THE MICROCHIP WEB SITE

Microchip provides online support via our WWW site at [www.microchip.com](http://www.microchip.com). This web site is used as a means to make files and information easily available to customers. Accessible by using your favorite Internet browser, the web site contains the following information:

- **Product Support** – Data sheets and errata, application notes and sample programs, design resources, user's guides and hardware support documents, latest software releases and archived software
- **General Technical Support** – Frequently Asked Questions (FAQ), technical support requests, online discussion groups, Microchip consultant program member listing
- **Business of Microchip** – Product selector and ordering guides, latest Microchip press releases, listing of seminars and events, listings of Microchip sales offices, distributors and factory representatives

## CUSTOMER CHANGE NOTIFICATION SERVICE

Microchip's customer notification service helps keep customers current on Microchip products. Subscribers will receive e-mail notification whenever there are changes, updates, revisions or errata related to a specified product family or development tool of interest.

To register, access the Microchip web site at [www.microchip.com](http://www.microchip.com). Under "Support", click on "Customer Change Notification" and follow the registration instructions.

## CUSTOMER SUPPORT

Users of Microchip products can receive assistance through several channels:

- Distributor or Representative
- Local Sales Office
- Field Application Engineer (FAE)
- Technical Support
- Development Systems Information Line

Customers should contact their distributor, representative or field application engineer (FAE) for support. Local sales offices are also available to help customers. A listing of sales offices and locations is included in the back of this document.

**Technical support is available through the web site at:** <http://microchip.com/support>

## READER RESPONSE

It is our intention to provide you with the best documentation possible to ensure successful use of your Microchip product. If you wish to provide your comments on organization, clarity, subject matter, and ways in which our documentation can better serve you, please FAX your comments to the Technical Publications Manager at (480) 792-4150.

Please list the following information, and use this outline to provide us with your comments about this document.

TO: Technical Publications Manager Total Pages Sent \_\_\_\_\_

RE: Reader Response

From: Name \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

City / State / ZIP / Country \_\_\_\_\_

Telephone: (\_\_\_\_\_) \_\_\_\_\_ - \_\_\_\_\_ FAX: (\_\_\_\_\_) \_\_\_\_\_ - \_\_\_\_\_

Application (optional):

Would you like a reply? \_\_\_ Y \_\_\_ N

Device: MTCH810

Literature Number: DS41672A

Questions:

1. What are the best features of this document?

---

---

2. How does this document meet your hardware and software development needs?

---

---

3. Do you find the organization of this document easy to follow? If not, why?

---

---

4. What additions to the document do you think would enhance the structure and subject?

---

---

5. What deletions from the document could be made without affecting the overall usefulness?

---

---

6. Is there any incorrect or misleading information (what and where)?

---

---

7. How would you improve this document?

---

---

# MTCH810

## PRODUCT IDENTIFICATION SYSTEM

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

<u>PART NO.</u>	<u>[X]<sup>(1)</sup></u>	-	<u>X</u>	<u>/XX</u>	<u>XXX</u>
Device	Tape and Reel Option		Temperature Range	Package	Pattern
Device:	MTCH810				
Tape and Reel Option:	Blank = Standard packaging (tube or tray) T = Tape and Reel <sup>(1)</sup>				
Temperature Range:	I = -40°C to +85°C (Industrial)				
Package: <sup>(2)</sup>	MF = DFN				
Pattern:	QTP, SQTP, Code or Special Requirements (blank otherwise)				

**Examples:**

a) MTCH810 - I/MF  
Industrial temperature,  
DFN package

**Note 1:** Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.

**2:** For other small form-factor package availability and marking information, please visit [www.microchip.com/packaging](http://www.microchip.com/packaging) or contact your local sales office.

---

**Note the following details of the code protection feature on Microchip devices:**

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

---

Information contained in this publication regarding device applications and the like is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION, INCLUDING BUT NOT LIMITED TO ITS CONDITION, QUALITY, PERFORMANCE, MERCHANTABILITY OR FITNESS FOR PURPOSE. Microchip disclaims all liability arising from this information and its use. Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights.

#### **Trademarks**

The Microchip name and logo, the Microchip logo, dsPIC, FlashFlex, KEELOQ, KEELOQ logo, MPLAB, PIC, PICmicro, PICSTART, PIC<sup>32</sup> logo, rPIC, SST, SST Logo, SuperFlash and UNI/O are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

FilterLab, Hampshire, HI-TECH C, Linear Active Thermistor, MTP, SEEVAL and The Embedded Control Solutions Company are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Silicon Storage Technology is a registered trademark of Microchip Technology Inc. in other countries.

Analog-for-the-Digital Age, Application Maestro, BodyCom, chipKIT, chipKIT logo, CodeGuard, dsPICDEM, dsPICDEM.net, dsPICworks, dsSPEAK, ECAN, ECONOMONITOR, FanSense, HI-TIDE, In-Circuit Serial Programming, ICSP, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, mTouch, Omniclient Code Generation, PICC, PICC-18, PICDEM, PICDEM.net, PICKit, PICtail, REAL ICE, rLAB, Select Mode, SQL, Serial Quad I/O, Total Endurance, TSHARC, UniWinDriver, WiperLock, ZENA and Z-Scale are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

GestIC and ULPP are registered trademarks of Microchip Technology Germany II GmbH & Co. & KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.

© 2012, Microchip Technology Incorporated, Printed in the U.S.A., All Rights Reserved.



Printed on recycled paper.

ISBN: 9781620768174

**QUALITY MANAGEMENT SYSTEM**  
**CERTIFIED BY DNV**  
**== ISO/TS 16949 ==**

*Microchip received ISO/TS-16949:2009 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.*

## Worldwide Sales and Service

### AMERICAS

**Corporate Office**  
2355 West Chandler Blvd.  
Chandler, AZ 85224-6199  
Tel: 480-792-7200  
Fax: 480-792-7277  
Technical Support:  
<http://www.microchip.com/support>  
Web Address:  
[www.microchip.com](http://www.microchip.com)

**Atlanta**  
Duluth, GA  
Tel: 678-957-9614  
Fax: 678-957-1455

**Boston**  
Westborough, MA  
Tel: 774-760-0087  
Fax: 774-760-0088

**Chicago**  
Itasca, IL  
Tel: 630-285-0071  
Fax: 630-285-0075

**Cleveland**  
Independence, OH  
Tel: 216-447-0464  
Fax: 216-447-0643

**Dallas**  
Addison, TX  
Tel: 972-818-7423  
Fax: 972-818-2924

**Detroit**  
Farmington Hills, MI  
Tel: 248-538-2250  
Fax: 248-538-2260

**Indianapolis**  
Noblesville, IN  
Tel: 317-773-8323  
Fax: 317-773-5453

**Los Angeles**  
Mission Viejo, CA  
Tel: 949-462-9523  
Fax: 949-462-9608

**Santa Clara**  
Santa Clara, CA  
Tel: 408-961-6444  
Fax: 408-961-6445

**Toronto**  
Mississauga, Ontario,  
Canada  
Tel: 905-673-0699  
Fax: 905-673-6509

### ASIA/PACIFIC

**Asia Pacific Office**  
Suites 3707-14, 37th Floor  
Tower 6, The Gateway  
Harbour City, Kowloon  
Hong Kong  
Tel: 852-2401-1200  
Fax: 852-2401-3431

**Australia - Sydney**  
Tel: 61-2-9868-6733  
Fax: 61-2-9868-6755

**China - Beijing**  
Tel: 86-10-8569-7000  
Fax: 86-10-8528-2104

**China - Chengdu**  
Tel: 86-28-8665-5511  
Fax: 86-28-8665-7889

**China - Chongqing**  
Tel: 86-23-8980-9588  
Fax: 86-23-8980-9500

**China - Hangzhou**  
Tel: 86-571-2819-3187  
Fax: 86-571-2819-3189

**China - Hong Kong SAR**  
Tel: 852-2943-5100  
Fax: 852-2401-3431

**China - Nanjing**  
Tel: 86-25-8473-2460  
Fax: 86-25-8473-2470

**China - Qingdao**  
Tel: 86-532-8502-7355  
Fax: 86-532-8502-7205

**China - Shanghai**  
Tel: 86-21-5407-5533  
Fax: 86-21-5407-5066

**China - Shenyang**  
Tel: 86-24-2334-2829  
Fax: 86-24-2334-2393

**China - Shenzhen**  
Tel: 86-755-8864-2200  
Fax: 86-755-8203-1760

**China - Wuhan**  
Tel: 86-27-5980-5300  
Fax: 86-27-5980-5118

**China - Xian**  
Tel: 86-29-8833-7252  
Fax: 86-29-8833-7256

**China - Xiamen**  
Tel: 86-592-2388138  
Fax: 86-592-2388130

**China - Zhuhai**  
Tel: 86-756-3210040  
Fax: 86-756-3210049

### ASIA/PACIFIC

**India - Bangalore**  
Tel: 91-80-3090-4444  
Fax: 91-80-3090-4123

**India - New Delhi**  
Tel: 91-11-4160-8631  
Fax: 91-11-4160-8632

**India - Pune**  
Tel: 91-20-2566-1512  
Fax: 91-20-2566-1513

**Japan - Osaka**  
Tel: 81-6-6152-7160  
Fax: 81-6-6152-9310

**Japan - Tokyo**  
Tel: 81-3-6880-3770  
Fax: 81-3-6880-3771

**Korea - Daegu**  
Tel: 82-53-744-4301  
Fax: 82-53-744-4302

**Korea - Seoul**  
Tel: 82-2-554-7200  
Fax: 82-2-558-5932 or  
82-2-558-5934

**Malaysia - Kuala Lumpur**  
Tel: 60-3-6201-9857  
Fax: 60-3-6201-9859

**Malaysia - Penang**  
Tel: 60-4-227-8870  
Fax: 60-4-227-4068

**Philippines - Manila**  
Tel: 63-2-634-9065  
Fax: 63-2-634-9069

**Singapore**  
Tel: 65-6334-8870  
Fax: 65-6334-8850

**Taiwan - Hsin Chu**  
Tel: 886-3-5778-366  
Fax: 886-3-5770-955

**Taiwan - Kaohsiung**  
Tel: 886-7-213-7828  
Fax: 886-7-330-9305

**Taiwan - Taipei**  
Tel: 886-2-2508-8600  
Fax: 886-2-2508-0102

**Thailand - Bangkok**  
Tel: 66-2-694-1351  
Fax: 66-2-694-1350

### EUROPE

**Austria - Wels**  
Tel: 43-7242-2244-39  
Fax: 43-7242-2244-393

**Denmark - Copenhagen**  
Tel: 45-4450-2828  
Fax: 45-4485-2829

**France - Paris**  
Tel: 33-1-69-53-63-20  
Fax: 33-1-69-30-90-79

**Germany - Munich**  
Tel: 49-89-627-144-0  
Fax: 49-89-627-144-44

**Italy - Milan**  
Tel: 39-0331-742611  
Fax: 39-0331-466781

**Netherlands - Drunen**  
Tel: 31-416-690399  
Fax: 31-416-690340

**Spain - Madrid**  
Tel: 34-91-708-08-90  
Fax: 34-91-708-08-91

**UK - Wokingham**  
Tel: 44-118-921-5869  
Fax: 44-118-921-5820

Компания «Life Electronics» занимается поставками электронных компонентов импортного и отечественного производства от производителей и со складов крупных дистрибьюторов Европы, Америки и Азии.

С конца 2013 года компания активно расширяет линейку поставок компонентов по направлению коаксиальный кабель, кварцевые генераторы и конденсаторы (керамические, пленочные, электролитические), за счёт заключения дистрибьюторских договоров

Мы предлагаем:

- Конкурентоспособные цены и скидки постоянным клиентам.
- Специальные условия для постоянных клиентов.
- Подбор аналогов.
- Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.
- Приемлемые сроки поставки, возможна ускоренная поставка.
- Доставку товара в любую точку России и стран СНГ.
- Комплексную поставку.
- Работу по проектам и поставку образцов.
- Формирование склада под заказчика.
- Сертификаты соответствия на поставляемую продукцию (по желанию клиента).
- Тестирование поставляемой продукции.
- Поставку компонентов, требующих военную и космическую приемку.
- Входной контроль качества.
- Наличие сертификата ISO.

В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.

Конструкторский отдел помогает осуществить:

- Регистрацию проекта у производителя компонентов.
- Техническую поддержку проекта.
- Защиту от снятия компонента с производства.
- Оценку стоимости проекта по компонентам.
- Изготовление тестовой платы монтаж и пусконаладочные работы.



Тел: +7 (812) 336 43 04 (многоканальный)

Email: [org@lifeelectronics.ru](mailto:org@lifeelectronics.ru)

[www.lifeelectronics.ru](http://www.lifeelectronics.ru)