MCP2003/4

LIN J2602 Transceiver

Features

- The MCP2003 and MCP2004 are compliant with LIN Bus Specifications 1.3, 2.0 and 2.1 and are compliant to SAE J2602
- Support Baud Rates up to 20 Kbaud with LIN-compatible output driver
- 43V load dump protected
- Very low EMI meets stringent OEM requirements
- Very high ESD immunity:
  - >20kV on VBB (IEC 61000-4-2)
  - >14kV on LBUS (IEC 61000-4-2)
- Very high immunity to RF disturbances meets stringent OEM requirements
- Wide supply voltage, 6.0V-27.0V continuous
- Extended Temperature Range: -40 to +125°C
- Interface to PIC® MCU EUSART and standard USARTs
- Local Interconnect Network (LIN) bus pin:
  - Internal pull-up resistor and diode
  - Protected against battery shorts
  - Protected against loss of ground
  - High current drive
- Automatic thermal shutdown
- Low-power mode:
  - Receiver monitoring bus and transmitter off, (≅ 5 µA)

LOCAL INTERCONNECT NETWORK

Description

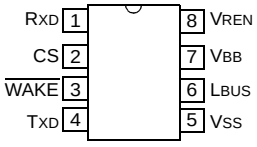
This device provides a bidirectional, half-duplex communication physical interface to automotive and industrial LIN systems to meet the LIN bus specification Revision 2.1 and SAE J2602. The device is short circuit and overtemperature protected by internal circuitry. The device has been specifically designed to operate in the automotive operating environment and will survive all specified transient conditions while meeting all of the stringent quiescent current requirements.

MCP200X family members:

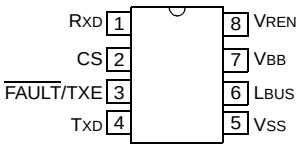
- 8-pin PDIP, DFN and SOIC packages:
  - MCP2003, LIN-compatible driver, with $\overline{\text{WAKE}}$ pins
  - MCP2004, LIN-compatible driver, with $\overline{\text{FAULT}}$/TXE pins

Package Types

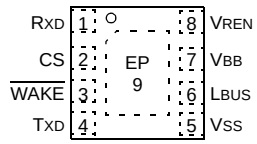
MCP2003
PDIP, SOIC



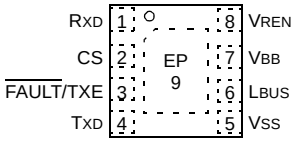
MCP2004
PDIP, SOIC



MCP2003
4x4 DFN*



MCP2004
4x4 DFN*



* Includes Exposed Thermal Pad (EP); see Table 1-1.

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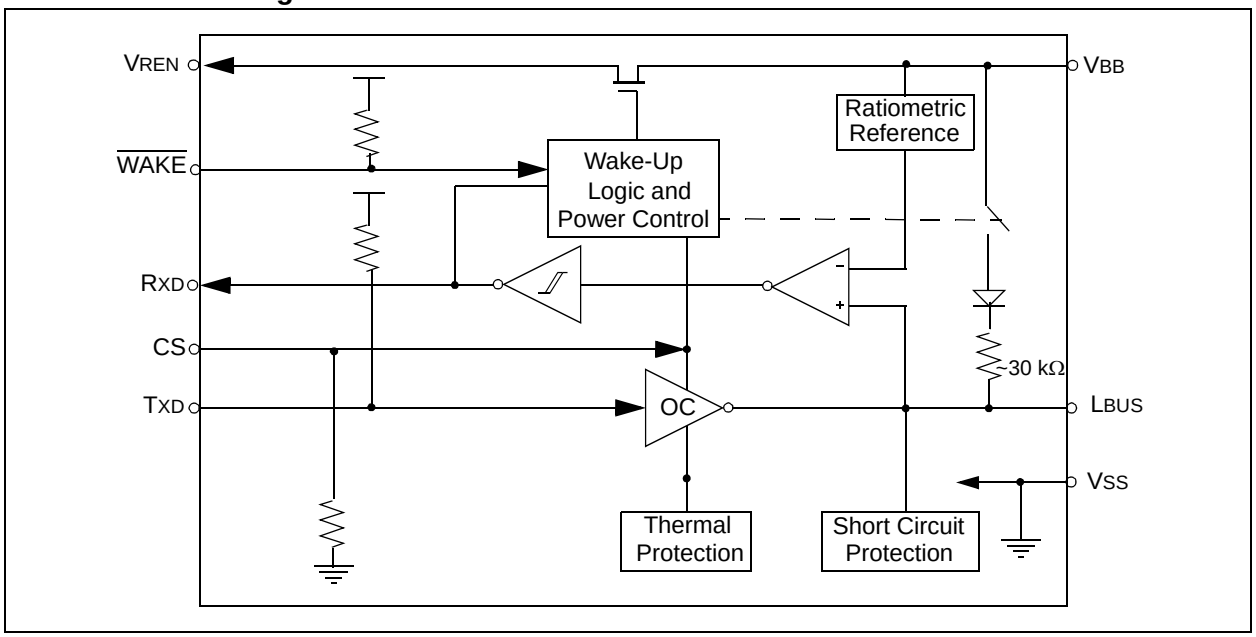
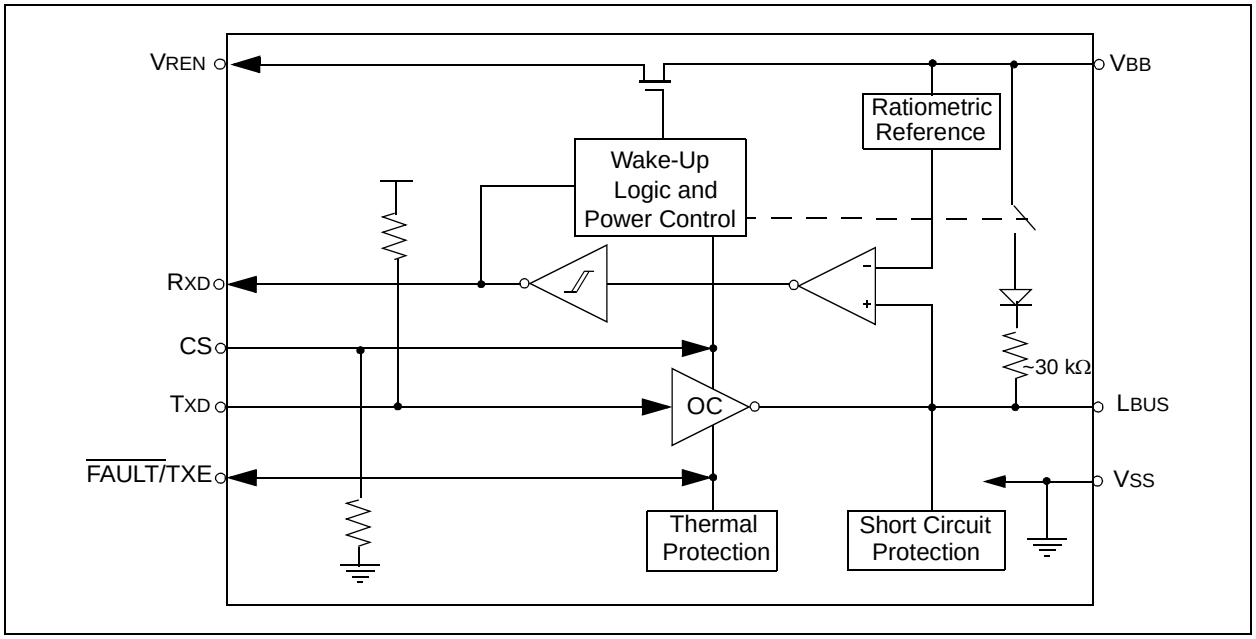
MCP2003 Block Diagram



MCP2004 Block Diagram



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1.0 DEVICE OVERVIEW

The MCP2003/4 provides a physical interface between a microcontroller and a LIN bus. This device will translate the CMOS/TTL logic levels to LIN logic level, and vice versa. It is intended for automotive and industrial applications with serial bus speeds up to 20 Kbaud.

LIN specification 2.1 requires that the transceiver of all nodes in the system is connected via the LIN pin, referenced to ground and with a maximum external termination resistance of 510Ω from LIN bus to battery supply. The 510Ω corresponds to 1 master and 15 slave nodes.

The VREN pin can be used to drive the logic input of an external voltage regulator. This pin is high in all modes except for Power-Down mode.

1.1 External Protection

1.1.1 REVERSE BATTERY PROTECTION

An external reverse-battery-blocking diode should be used to provide polarity protection (see Example 1-1).

1.1.2 TRANSIENT VOLTAGE PROTECTION (LOAD DUMP)

An external 43V transient suppressor (TVS) diode, between VBB and ground, with a 50Ω transient protection resistor (RTP) in series with the battery supply and the VBB pin serve to protect the device from power transients (see Example 1-1) and ESD events. While this protection is optional, it is considered good engineering practice.

1.2 Internal Protection

1.2.1 ESD PROTECTION

For component-level ESD ratings, please refer to the maximum operation specifications.

1.2.2 GROUND LOSS PROTECTION

The LIN Bus specification states that the LIN pin must transition to the recessive state when ground is disconnected. Therefore, a loss of ground effectively forces the LIN line to a high-impedance level.

1.2.3 THERMAL PROTECTION

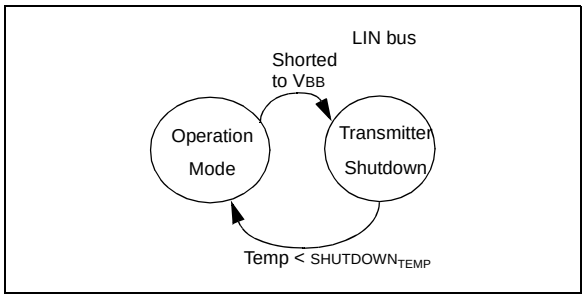
The thermal protection circuit monitors the die temperature and is able to shut down the LIN transmitter.

There are two causes for a thermal overload. A thermal shut down can be triggered by either, or both, of the following thermal overload conditions.

- LIN bus output overload
- Increase in die temperature due to increase in environment temperature

Driving the TXD and checking the RXD pin makes it possible to determine whether there is a bus contention (Rx = low, Tx = high) or a thermal overload condition (Rx = high, Tx = low). After a thermal overload event, the device will automatically recover once the die temperature has fallen below the recovery temperature threshold. See Figure 1-1.

FIGURE 1-1: THERMAL SHUTDOWN STATE DIAGRAM



1.3 Modes of Operation

For an overview of all operational modes, refer to Table 1-1.

1.3.1 POWER-DOWN MODE

In Power-Down mode, the transmitter and VREN are both off. Only the receiver section and the wake-up circuits are operational. This is the lowest power mode.

On bus activity (e.g. a BREAK character), CS going to a high level, or on a falling edge on WAKE, the device will immediately enter Ready mode. If CS is held high as the device transitions from Power-Down to Ready mode, the device will transition to Operation mode as soon as internal voltages stabilize.

Note:	Bus activity is defined as LBUS dropping below VIL(LBUS) for longer than the Bus Activity Debounce time (tBDB)

1.3.2 READY MODE

Upon entering the Ready mode, VREN is enabled and the receiver detect circuit is powered up. The transmitter remains disabled and the device is ready to receive data but not to transmit.

Upon VBB supply pin power-on, the device will remain in Ready mode as long as CS is low. If CS transitions high, the device will enter Operation mode. However, if the TXD pin is held low when CS goes high, the device will transition to Transmitter Off mode instead of Operation mode.

1.3.3 OPERATION MODE

In this mode, all internal modules are operational.

The MCP2003/4 will go into the Power-Down mode on the falling edge of CS. The MCP2003/4 will enter Transmitter Off mode in the event of a Fault condition. These include: thermal overload, bus contention and TXD timer expiration.

The MCP2004 device can also enter Transmitter Off mode if the FAULT/TXE pin is pulled low

1.3.4 TRANSMITTER OFF MODE

Transmitter Off mode is reached whenever the transmitter is disabled either due to a Fault condition or pulling the nFAULT/TXE pin low on the MCP2004. The fault conditions include: thermal overload, bus contention or TXD timer expiration.

The MCP2003/4 will go into Power-Down mode on falling edge of CS, or return to Operation mode if all faults are resolved and the FAULT/TXE pin on the MCP2004 is high.

FIGURE 1-2: OPERATIONAL MODES STATE DIAGRAM – MCP2003

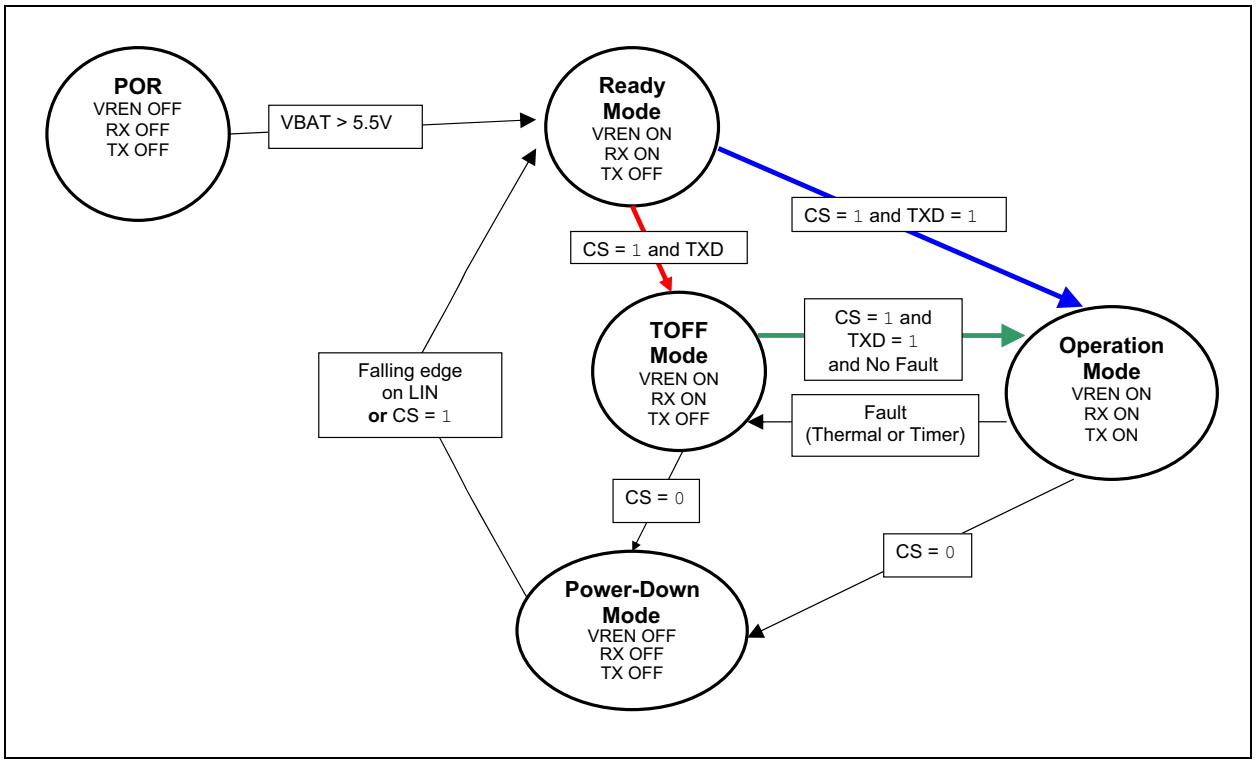


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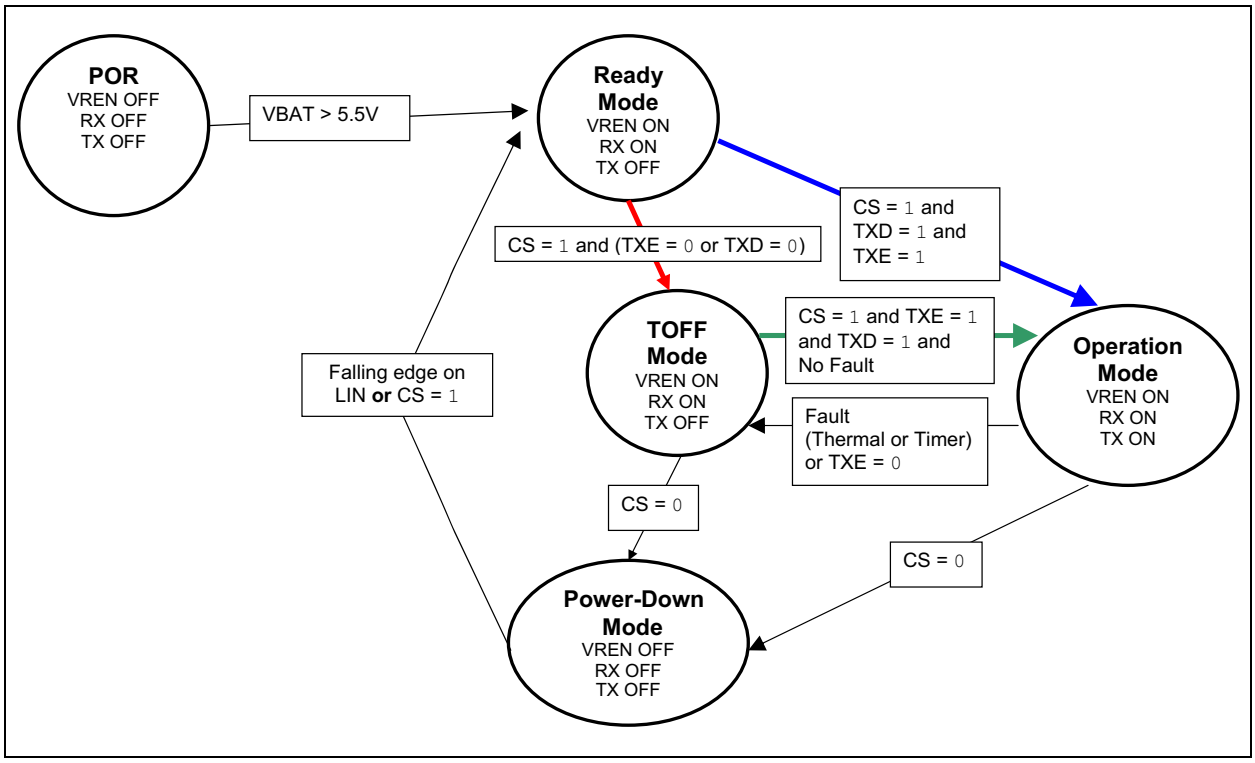
FIGURE 1-3: OPERATIONAL MODES STATE DIAGRAM – MCP2004



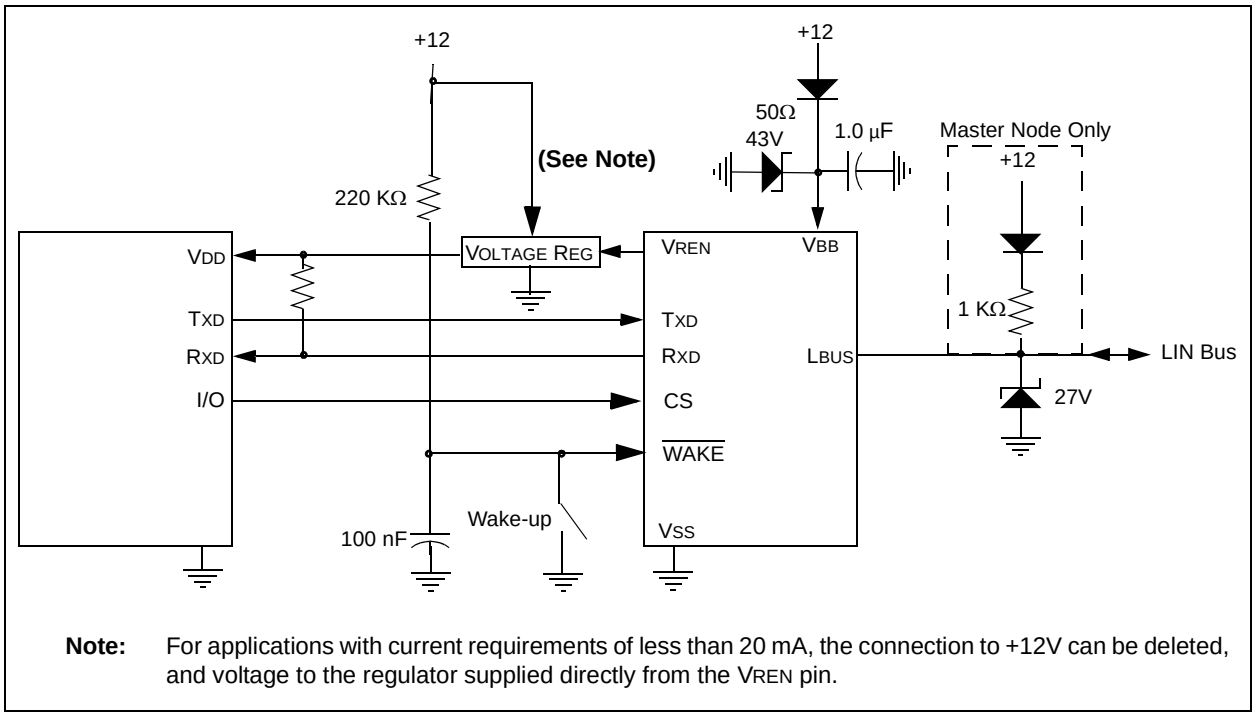
Note: While the MCP2003/4 is in thermal shutdown, TXD should not be actively driven high or it may power internal logic through the ESD diodes and may damage the device.

TABLE 1-1: OVERVIEW OF OPERATIONAL MODES

State	Transmitter	Receiver	Vren	Operation	Comments
POR	OFF	OFF	OFF	Read CS, if low, then Ready; if high, Operational mode	
Ready	OFF	ON	ON	If CS high level, then Operation mode	Bus Off state
Operation	ON	ON	ON	If CS low level, then Power Down; If FAULT/TXE low level, then Transmitter Off mode	Normal Operation mode
Power Down	OFF	Activity Detect	OFF	On LIN bus falling, go to Ready mode. On CS high level, go to Operation mode	Low Power mode
Transmitter Off	OFF	ON	ON	If CS low level, then Power Down; If FAULT/TXE and TXD high, then Operation mode	FAULT/TXE only available on MCP2004

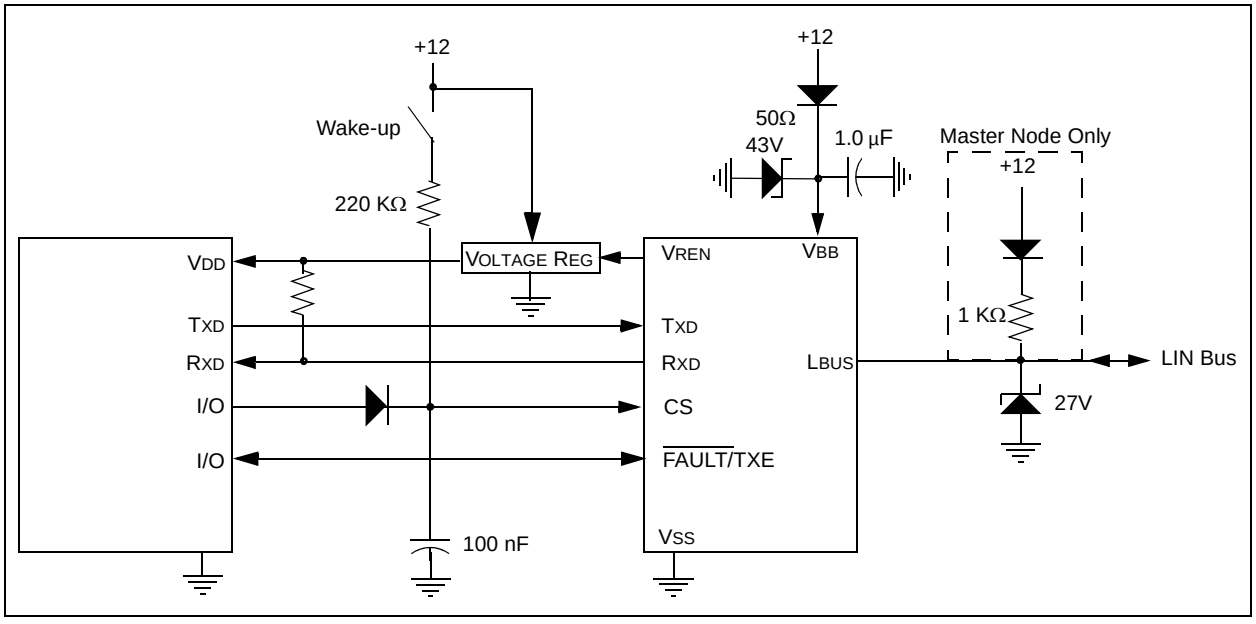
1.4 Typical Applications

EXAMPLE 1-1: TYPICAL MCP2003 APPLICATION



Note: For applications with current requirements of less than 20 mA, the connection to +12V can be deleted, and voltage to the regulator supplied directly from the VREN pin.

EXAMPLE 1-2: TYPICAL MCP2004 APPLICATION



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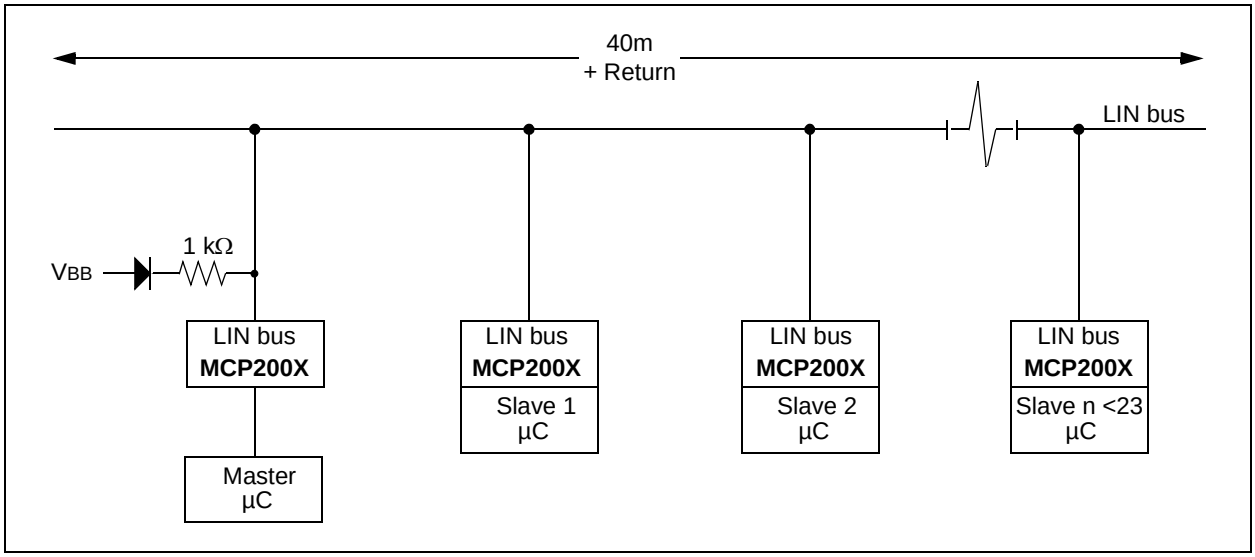
EXAMPLE 1-3: TYPICAL LIN NETWORK CONFIGURATION



1.5 Pin Descriptions

TABLE 1-1: PINOUT DESCRIPTIONS

Pin Name	8-Pin PDIP, SOIC	8-Pin DFN	MCP2003	MCP2004
			Normal Operation	Normal Operation
RXD	1	1	Receive Data Output (OD)	Receive Data Output (OD)
CS	2	2	Chip Select (TTL)	Chip Select/Local WAKE (TTL)
WAKE (MCP2003 only) FAULT/TXE (MCP2004 only)	3	3	Wake up, HV tolerant	Fault Detect Output (OD) Transmitter Enable (TTL)
TXD	4	4	Transmit Data Input (TTL)	Transmit Data Input (TTL)
VSS	5	5	Ground	Ground
LBUS	6	6	LIN bus (bidirectional)	LIN bus (bidirectional)
VBB	7	7	Battery positive	Battery positive
VREN	8	8	Voltage Regulator Enable Output	Voltage Regulator Enable Output
EP	—	9	Exposed Thermal Pad. Do not electrically connect or connect to Vss	Exposed Thermal Pad. Do not electrically connect or connect to Vss

Legend: TTL = TTL Input Buffer; OD = Open-Drain Output

1.5.1 RECEIVE DATA OUTPUT (RXD)

The Receive Data Output pin is a open drain (OD) output and follows the state of the LIN pin.

1.5.2 CS (CHIP SELECT)

Chip Select Input pin. An internal pull-down resistor will keep the CS pin low. This is done to ensure that no disruptive data will be present on the bus while the microcontroller is executing a Power-on Reset and an I/O initialization sequence. The pin must detect a high level to activate the transmitter.

If CS = 0 when the VBB supply is turned on, the device stays in Ready mode. In Ready mode, the receiver is on and the LIN transmitter driver is off.

If CS = 1 when the VBB supply is turned on, the device will proceed to the Operation mode as soon as internal voltages stabilize.

This pin may also be used as a local wake-up input (Refer to Example 1-1). In this implementation, the microcontroller I/O controlling the CS should be converted to a high-impedance input allowing the internal pull-down resistor will keep CS low. An external switch, or other source, can then wake-up both the transceiver and the microcontroller (if powered).

Note:	It is not recommended to tie CS high as this can result the MCP2003/4 entering Operation mode before the microcontroller is initialized and may result in unintentional LIN traffic.

1.5.3 WAKE UP INPUT ($\overline{\text{WAKE}}$)

This pin is only available on the MCP2003.

The $\overline{\text{WAKE}}$ pin has an internal 800K pull up to VBB. A falling edge on the $\overline{\text{WAKE}}$ pin causes the device to wake from Power-Down mode. Upon waking, the MCP2003 will enter Ready mode

1.5.4 $\overline{\text{FAULT}}$/TXE

This pin is only available on the MCP2004. This pin is bidirectional and allows disabling of the transmitter, as well as fault reporting related to disabling the transmitter. This pin is an open-drain output with states as defined in Table 1-2. The transmitter is disabled whenever this pin is low ('0'), either from an internal Fault condition or by an external drive. While the transmitter is disabled, the internal 30 kΩ pull-up resistor on the LBUS pin is also disconnected to reduce current.

Note:	The $\overline{\text{FAULT}}$/TXE pin is true ('0') whenever the internal circuits have detected a short or thermal excursion and have disabled the LBUS output driver.

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TABLE 1-2: $\overline{\text{FAULT}}$/TXE TRUTH TABLE

TXD In	RXD Out	LINBUS I/O	Thermal Override	$\overline{\text{FAULT}}$/TXE		Definition
				External Input	Driven Output	
L	H	VBB	OFF	H	L	FAULT, TXD driven low, LINBUS shorted to VBB **(Note 1)**
H	H	VBB	OFF	H	H	OK
L	L	GND	OFF	H	H	OK
H	L	GND	OFF	H	H	OK, data is being received from the LINBUS
x	x	VBB	ON	H	L	FAULT, Transceiver in thermal shutdown
x	x	VBB	x	L	x	NO FAULT, the CPU is commanding the transceiver to turn off the transmitter driver

Legend: x = don't care

Note 1: The $\overline{\text{FAULT}}$/TXE is valid after approximately 25 µs after TXD falling edge. This is to eliminate false fault reporting during bus propagation delays.

1.5.5 TRANSMIT DATA INPUT (TXD)

The Transmit Data Input pin has an internal pull-up. The LIN pin is low (dominant) when TXD is low, and high (recessive) when TXD is high.

For extra bus security, TXD is internally forced to '1' whenever the transmitter is disabled regardless of external TXD voltage.

1.5.5.1 TXD Dominant Timeout

If TXD is driven low longer than approximately 10ms, the LBUS pin is switched to recessive mode and the part enters TOFF Mode. This is to prevent the LIN node from permanently driving the LIN Bus dominant. The transmitter is re-enabled on TXD rising edge.

1.5.6 GROUND (VSS)

This is the Ground pin.

1.5.7 LIN BUS (LBUS)

The bidirectional LIN Bus pin (LBUS) is controlled by the TXD input. LBUS has a current limited open collector output. To reduce EMI, the edges during the signal changes are slope controlled and include corner rounding control for both falling and rising edges.

The internal LIN receiver observes the activities on the LIN bus, and matches the output signal RXD to follow the state of the LBUS pin.

1.5.7.1 Bus Dominant Timer

The Bus Dominant Timer is an internal timer that deactivates the LBUS transmitter after approximately 25 milliseconds of dominant state on the LBUS pin. The timer is reset on any recessive LBUS state.

The LIN bus transmitter will be re-enabled after a recessive state on the LBUS pin as long as CS is high. Disabling can be caused by the LIN bus being externally held dominant, or by TXD being driven low. Additionally, on the MCP2004, the $\overline{\text{FAULT}}$ pin will be driven low to indicate the Transmitter Off state.

1.5.8 BATTERY (VBB)

This is the Battery Positive Supply Voltage pin.

1.5.9 VOLTAGE REGULATOR ENABLE OUTPUT (VREN)

This is the External Voltage Regulator Enable pin. Open source output is pulled high to VBB in all modes, except Power Down.

1.5.10 EXPOSED THERMAL PAD (EP)

Do not electrically connect, or connect to Vss.

NOTES:

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2.0 ELECTRICAL CHARACTERISTICS

2.1 Absolute Maximum Ratings†

VIN DC Voltage on RXD, TXD, $\overline{\text{FAULT}}$/TXE ..... -0.3 to +30V
VIN DC Voltage on CS, $\overline{\text{WAKE}}$ and VREN ..... -0.3 to +30V
VBB Battery Voltage, continuous, non-operating (**Note 1**) ..... -0.3 to +40V
VBB Battery Voltage, non-operating (LIN bus recessive) (**Note 2**) ..... -0.3 to +43V
VBB Battery Voltage, transient ISO 7637 Test 1 ..... -200V
VBB Battery Voltage, transient ISO 7637 Test 2a ..... +150V
VBB Battery Voltage, transient ISO 7637 Test 3a ..... -300V
VBB Battery Voltage, transient ISO 7637 Test 3b ..... +200V
VLBUS Bus Voltage, continuous ..... -18 to +30V
VLBUS Bus Voltage, transient (**Note 3**) ..... -27 to +43V
ILBUS Bus Short Circuit Current Limit ..... 200 mA
ESD protection on LIN, VBB, $\overline{\text{WAKE}}$ (IEC 61000-4-2) (**Note 4**) ..... ±8 KV
ESD protection on LIN, VBB (Human Body Model) (**Note 5**) ..... ±8 KV
ESD protection on all other pins (Human Body Model) (**Note 5**) ..... ±4 KV
ESD protection on all pins (Charge Device Model) (**Note 6**) ..... ±2 KV
ESD protection on all pins (Machine Model) (**Note 7**) ..... ±200V
Maximum Junction Temperature ..... 150°C
Storage Temperature ..... -65 to +150°C

Note 1: LIN 2.x compliant specification.

2: SAE J2602 compliant specification.

3: ISO 7637/1 load dump compliant (t < 500 ms).

4: According to IEC 61000-4-2, 330 ohm, 150 pF and Tranceiver EMC Test Specifications [2] to [4]. For $\overline{\text{WAKE}}$ pin to meet the specification, series resistor must be in place (refer to Example 1-2).

5: According to AEC-Q100-002 / JESD22-A114.

6: According to AEC-Q100-011B.

7: According to AEC-Q100-003 / JESD22-A115.

† **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 operational listings of this specification is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

2.2 Nomenclature used in this document

Some terms and names used in this data sheet deviate from those referred to in the LIN specifications. Equivalant values are shown below.

LIN 2.1 Name	Term used in the following tables	Definition
V_{BAT}	*not used*	ECU operating voltage
V_{SUP}	VBB	Supply voltage at device pin
I_{BUS_LIM}	ISC	Current Limit of Driver
V_{BUSREC}	VIH(LBUS)	Recessive state
V_{BUSDOM}	VIL(LBUS)	Dominant state

2.3 DC Specifications

DC Specifications	**Electrical Characteristics:** Unless otherwise indicated, all limits are specified for: V_{BB} = 6.0V to 27.0V T_A = -40°C to +125°C					
Parameter	**Sym**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
Power						
V_{BB} Quiescent Operating Current	I_{BBQ}		90	150	µA	Operating Mode, bus recessive (**Note 1**)
V_{BB} Transmitter-off Current	I_{BBTO}	—	75	120	µA	Transmitter off, bus recessive (**Note 1**)
V_{BB} Power Down Current	I_{BBPD}	—	5	15	µA	Transmitter off, bus recessive (**Note 1**)
V_{BB} Current with V_{SS} Floating	$I_{BBNOGND}$	-1	—	1	mA	V_{BB} = 12V, GND to V_{BB}, V_{LIN} = 0-27V
Microcontroller Interface						
High Level Input Voltage (T_{XD}, $\overline{FAULT}$/TXE)	V_{IH}	2.0	—	5.3	V	
Low Level Input Voltage (T_{XD}, $\overline{FAULT}$/TXE)	V_{IL}	-0.3	—	0.8	V	
High Level Input Current (T_{XD}, $\overline{FAULT}$/TXE)	I_{IH}	-2.5	—	—	µA	Input voltage = 4.0V
Low Level Input Current (T_{XD}, $\overline{FAULT}$/TXE)	I_{IL}	-10	—	—	µA	Input voltage = 0.5V
High Level Voltage (V_{REN})	V_{HVREN}	-0.3	—	V_{BB}+0.3		
High Level Output Current (V_{REN})	I_{HVREN}	-20	—	-10	mA	Output voltage = V_{BB}-0.5V
High Level Input Voltage (CS)	V_{IH}	2.0	—	V_{BB}	V	Through a current limiting resistor
Low Level Input Voltage (CS)	V_{IL}	-0.3	—	0.8	V	
High Level Input Current (CS)	I_{IH}	-10.0	—	10.0	µA	Input voltage = 4.0V
Low Level Input Current (CS)	I_{IL}	-5.0	—	5.0	µA	Input voltage = 0.5V
Low Level Input Voltage ($\overline{WAKE}$)	V_{IL}	V_{BB} – 4.0V	—	—	V	
Low Level Output Voltage (R_{XD})	V_{OL}	—	—	0.4	V	I_{IN} = 2 mA
High Level Output Current (R_{XD})	I_{OH}	-1	—	-1	µA	V_{LIN} - V_{BB}, V_{RXD} = 5.5V

Note 1: Internal current limited. 2.0 ms maximum recovery time (R_{LBUS} = 0Ω, TX = 0.4 V_{REG}, V_{LBUS} = V_{BB}).

2: Node has to sustain the current that can flow under this condition; bus must be operational under this condition.

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2.3 DC Specifications (Continued)

DC Specifications	**Electrical Characteristics:** Unless otherwise indicated, all limits are specified for: V_{BB} = 6.0V to 27.0V T_A = -40°C to +125°C					
Parameter	**Sym**	**Min.**	**Typ.**	**Max.**	**Units**	**Conditions**
Bus Interface						
High Level Input Voltage	$V_{IH(LBUS)}$	0.6 V_{BB}	—	—	V	Recessive state
Low Level Input Voltage	$V_{IL(LBUS)}$	-8	—	0.4 V_{BB}	V	Dominant state
Input Hysteresis	V_{HYS}	—	—	0.175 V_{BB}	V	$V_{IH(LBUS)} – V_{IL(LBUS)}$
Low Level Output Current	$I_{OL(LBUS)}$	40	—	200	mA	Output voltage = 0.1 V_{BB}, V_{BB} = 12V
Pull-up Current on Input	$I_{PU(LBUS)}$	5	—	180	µA	~30 kΩ internal pull-up @ V_{IH} (L_{BUS}) = 0.7 V_{BB}
Short Circuit Current Limit	I_{SC}	50	—	200	mA	**(Note 1)**
High Level Output Voltage	$V_{OH(LBUS)}$	0.9 V_{BB}	—	V_{BB}	V	
Driver Dominant Voltage	$V_{\_LOSUP}$	—	—	1.2	V	V_{BB} = 7V, R_{LOAD} = 500Ω
Driver Dominant Voltage	$V_{\_HISUP}$	—	—	2.0	V	V_{BB} = 18V, R_{LOAD} = 500Ω
Driver Dominant Voltage	$V_{\_LOSUP-1K}$	0.6	—	—	V	V_{BB} = 7V, R_{LOAD} = 1 kΩ
Driver Dominant Voltage	$V_{\_HISUP-1K}$	0.8	—	—	V	V_{BB} = 18V, R_{LOAD} = 1 kΩ
Input Leakage Current (at the receiver during dominant bus level)	$I_{BUS\_PAS\_DOM}$	-1	-0.4	—	mA	Driver off, V_{BUS} = 0V, V_{BB} = 12V
Input Leakage Current (at the receiver during recessive bus level)	$I_{BUS\_PAS\_REC}$	—	12	20	µA	Driver off, 8V < V_{BB} < 18V 8V < V_{BUS} < 18V $V_{BUS} \geq V_{BB}$
Leakage Current (disconnected from ground)	$I_{BUS\_NO\_GND}$	-10	1.0	+10	µA	GND_{DEVICE} = V_{BB}, 0V < V_{BUS} < 18V, V_{BB} = 12V
Leakage Current (disconnected from V_{BB})	I_{BUS}	—	—	10	µA	V_{BB} = GND, 0 < V_{BUS} < 18V, **(Note 2)**
Receiver Center Voltage	V_{BUS_CNT}	0.475 V_{BB}	0.5 V_{BB}	0.525 V_{BB}	V	V_{BUS_CNT} = (V_{IL} (L_{BUS}) + V_{IH} (L_{BUS}))/2
Slave Termination	R_{SLAVE}	20	30	47	kΩ	
Capacitance of Slave Node	C_{SLAVE}			50	pF	

Note 1: Internal current limited. 2.0 ms maximum recovery time (R_{LBUS} = 0Ω, TX = 0.4 V_{REG}, V_{LBUS} = V_{BB}).

2: Node has to sustain the current that can flow under this condition; bus must be operational under this condition.

2.4 AC Specifications

AC CHARACTERISTICS	V_{BB} = 6.0V to 27.0V; T_A = -40°C to +125°C					
Parameter	**Sym**	**Min.**	**Typ.**	**Max.**	**Units**	**Test Conditions**
Bus Interface – Constant Slope Time Parameters						
Slope Rising and Falling Edges	tslope	3.5	—	22.5	µs	7.3V <= V_{BB} <= 18V
Propagation Delay of Transmitter	ttranspd	—	—	4.0	µs	ttranspd = max (ttranspdr or ttranspdf)
Propagation Delay of Receiver	trecpd	—	—	6.0	µs	trecpd = max (trecpdr or trecpdf)
Symmetry of Propagation Delay of Receiver Rising Edge w.r.t. Falling Edge	trecsym	-2.0	—	2.0	µs	trecsym = max (trecpdf – trecpdr) R_{RXD} 2.4Ω TO V_{CC}, C_{RXD} 20 pF
Symmetry of Propagation Delay of Transmitter Rising Edge w.r.t. Falling Edge	ttrans-sym	-2.0	—	2.0	µs	ttranssym = max (ttranspdf - ttranspdr)
Time to Sample of FAULT/ TXE for Bus Conflict Report-ing	tfault	—	—	32.5	µs	tfault = max (ttranspd + tslope + trecpd)
Duty Cycle 1 @20.0 kbit/sec		.396	—	—		Cbus; Rbus conditions: 1 nF; 1 kΩ | 6.8 nF; 660Ω | 10 nF; 500Ω THrec(max) = 0.744 x V_{BB}, THdom(max) = 0.581 x V_{BB}, V_{BB} =7.0V – 18V; tbit = 50 µs D1 = tbus_rec(min)/2 x tbit)
Duty Cycle 2 @20.0 kbit/sec		—	—	.581		Cbus; Rbus conditions: 1 nF; 1 kΩ | 6.8 nF; 660Ω | 10 nF; 500Ω THrec(max) = 0.284 x V_{BB}, THdom(max) = 0.422 x V_{BB}, V_{BB} =7.6V – 18V; tbit = 50 µs D2 = tbus_rec(max)/2 x tbit)
Duty Cycle 3 @10.4 kbit/sec		.417	—	—		Cbus; Rbus conditions: 1 nF; 1 kΩ | 6.8 nF; 660Ω | 10 nF; 500Ω THrec(max) = 0.778 x V_{BB}, THdom(max) = 0.616 x V_{BB}, V_{BB} =7.0V – 18V; tbit = 96 µs D3 = tbus_rec(min)/2 x tbit)
Duty Cycle 4 @10.4 kbit/sec		—	—	.590		Cbus; Rbus conditions: 1 nF; 1 kΩ | 6.8 nF; 660Ω | 10 nF; 500Ω THrec(max) = 0.251 x V_{BB}, THdom(max) = 0.389 x V_{BB}, V_{BB} =7.6V – 18V; tbit = 96 µs D4 = tbus_rec(max)/2 x tbit)
Wake-up Timing						
Bus Activity Debounce time	tBDB	5		20	µs	Bus debounce time, 10 µs typical
Bus Activity to Vren on	tBACTVE	35		150	µs	After Bus debounce time, 52 µs typical
WAKE to Vren on	tWAKE			150	µs	
Chip Select to Vren on	tCSOR	—		150	µs	Vren floating
Chip Select to Vren off	tCSPD	—		80	µs	Vren floating

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2.5 Thermal Specifications

THERMAL CHARACTERISTICS					
Parameter	**Symbol**	**Typ**	**Max**	**Units**	**Test Conditions**
Recovery Temperature	$\theta_{RECOVERY}$	+140	—	°C	
Shutdown Temperature	$\theta_{SHUTDOWN}$	+150	—	°C	
Short Circuit Recovery Time	t_{THERM}	1.5	5.0	ms	
Thermal Package Resistances					
Thermal Resistance, 8L-DFN	θ_{JA}	35.7	—	°C/W	
Thermal Resistance, 8L-PDIP	θ_{JA}	89.3	—	°C/W	
Thermal Resistance, 8L-SOIC	θ_{JA}	149.5	—	°C/W	

Note 1: The maximum power dissipation is a function of T_{JMAX}, Θ_{JA} and ambient temperature T_A. The maximum allowable power dissipation at an ambient temperature is $P_D = (T_{JMAX} - T_A)\ \Theta_{JA}$. If this dissipation is exceeded, the die temperature will rise above 150°C and the MCP2003/4 will go into thermal shutdown.

2.6 Typical Performance Curves

Note:	The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

Note: Unless otherwise indicated, V_{BB} = 6.0V to 18.0V, T_A = -40°C to +125°C.

FIGURE 2-1: TYPICAL IBBQ

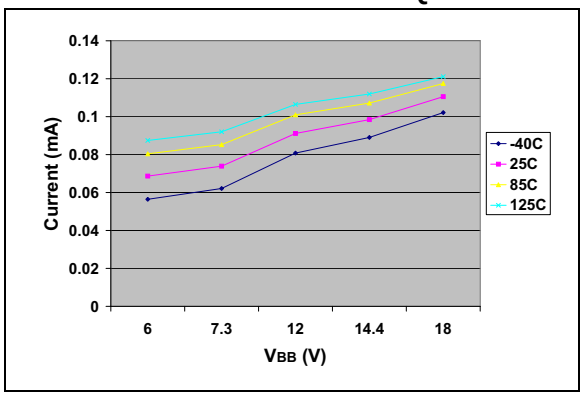


FIGURE 2-2: TYPICAL IBBPD

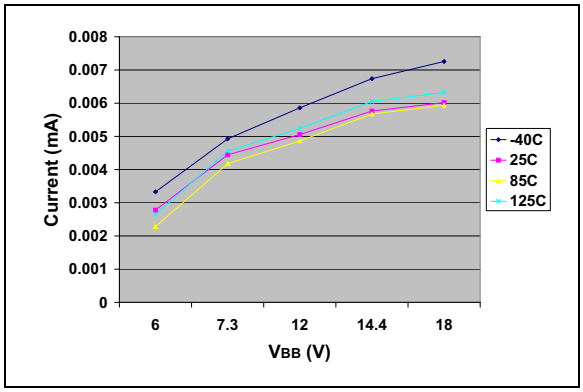
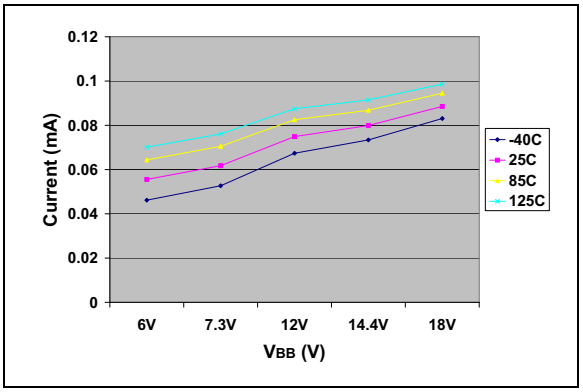


FIGURE 2-3: TYPICAL IBBTO



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2.7 Timing Diagrams and Specifications

FIGURE 2-4: BUS TIMING DIAGRAM

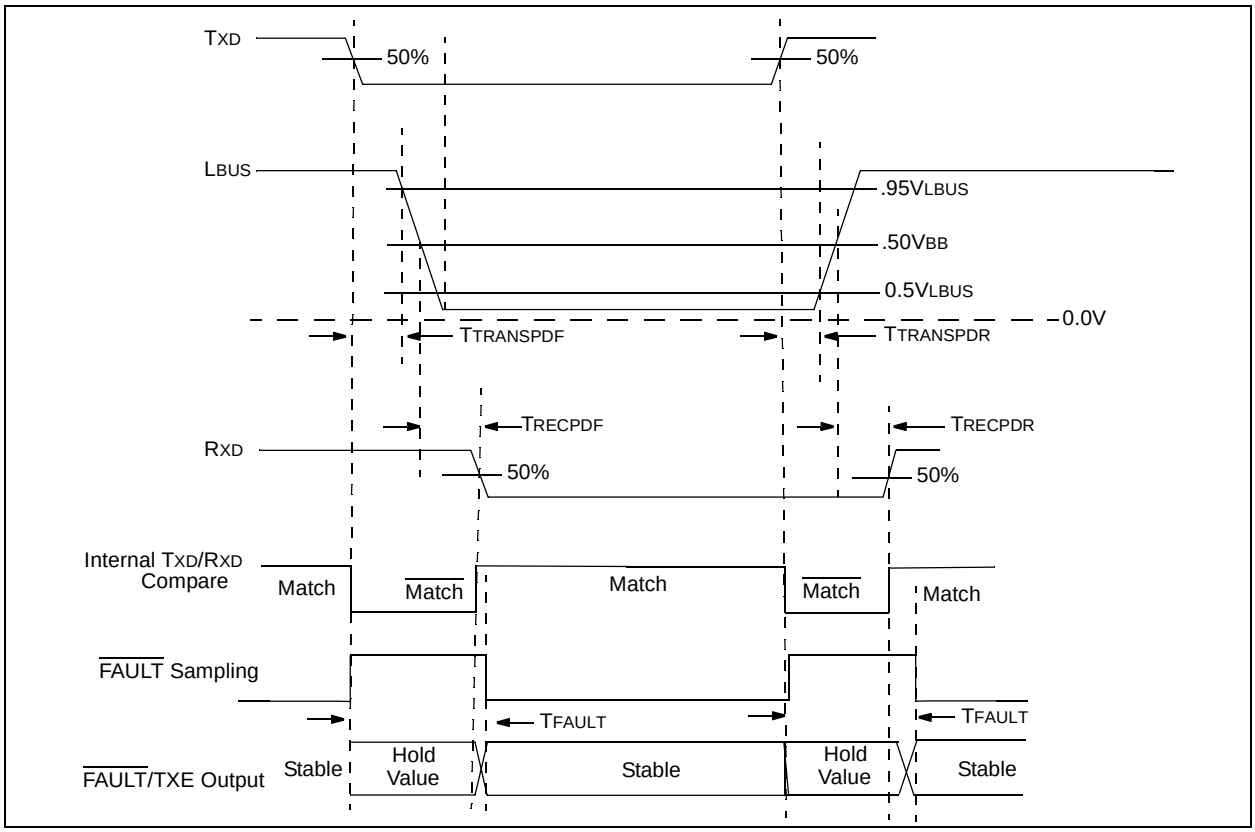


FIGURE 2-5: CS TO VREN TIMING DIAGRAM

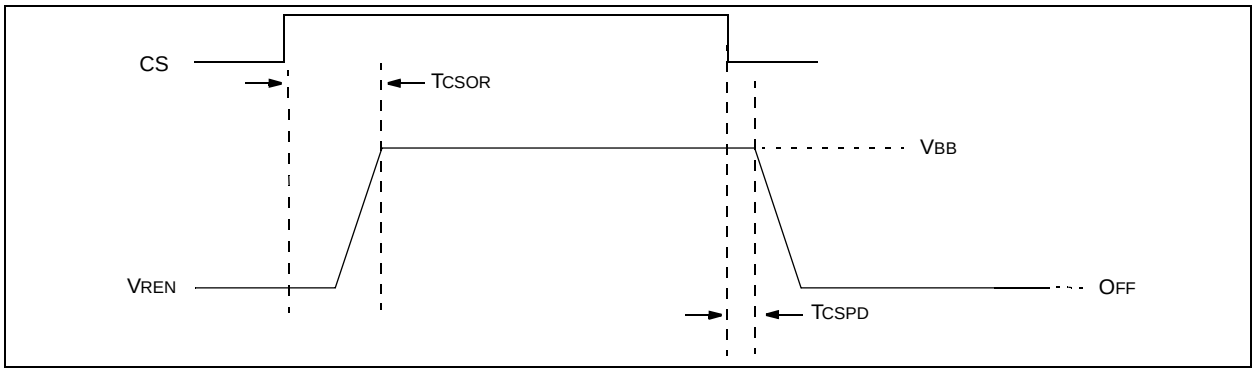
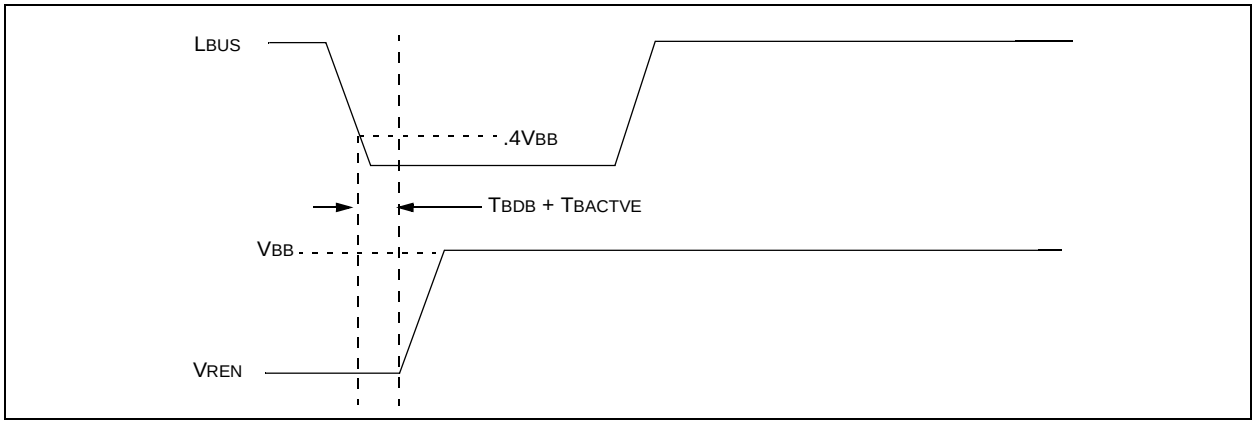


FIGURE 2-6: BUS TO VREN WAKE TIMING DIAGRAM



NOTES:

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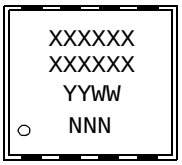
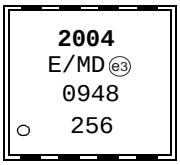
3.0 PACKAGING INFORMATION

3.1 Package Marking Information

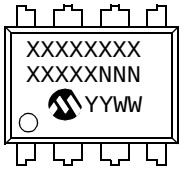
8-Lead DFN (4x4)



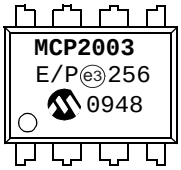
Example:



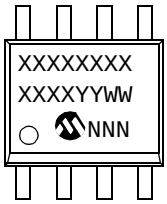
8-Lead PDIP (300 mil)



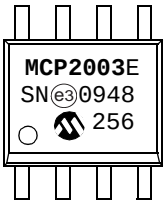
Example:



8-Lead SOIC (150 mil)



Example:

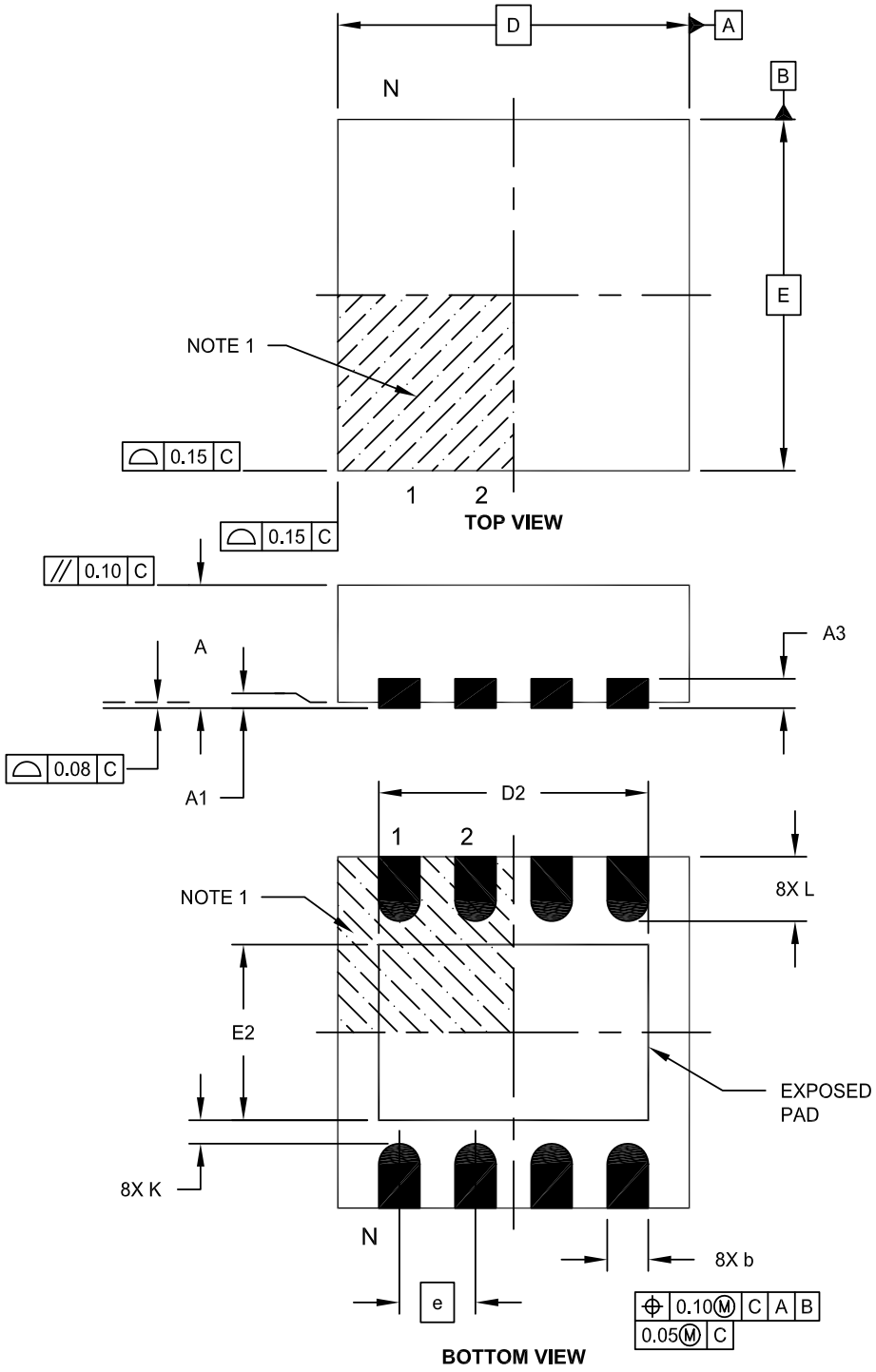


Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package.

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

8-Lead Plastic Dual Flat, No Lead Package (MD) – 4x4x0.9 mm 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 C04-131E Sheet 1 of 2

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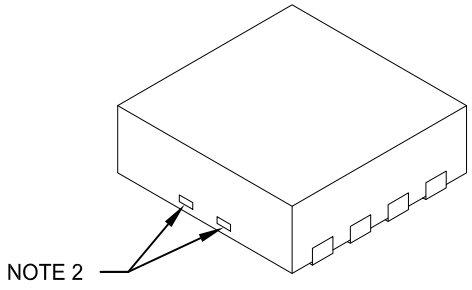
8-Lead Plastic Dual Flat, No Lead Package (MD) – 4x4x0.9 mm Body [DFN]

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		0.80 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		4.00 BSC	
Exposed Pad Width	E2	2.60	2.70	2.80
Overall Width	E		4.00 BSC	
Exposed Pad Length	D2	3.40	3.50	3.60
Contact Width	b	0.25	0.30	0.35
Contact Length	L	0.30	0.40	0.50
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

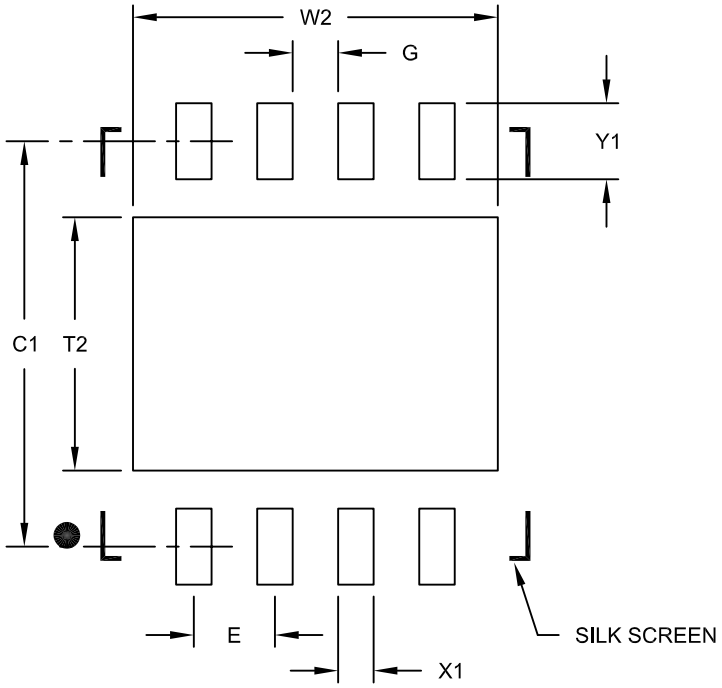
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-131E Sheet 2 of 2

8-Lead Plastic Dual Flat, No Lead Package (MD) - 4x4x0.9 mm 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	0.80 BSC		
Optional Center Pad Width	W2			3.60
Optional Center Pad Length	T2			2.50
Contact Pad Spacing	C1		4.00	
Contact Pad Width (X8)	X1			0.35
Contact Pad Length (X8)	Y1			0.75
Distance Between Pads	G	0.45		

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2131C

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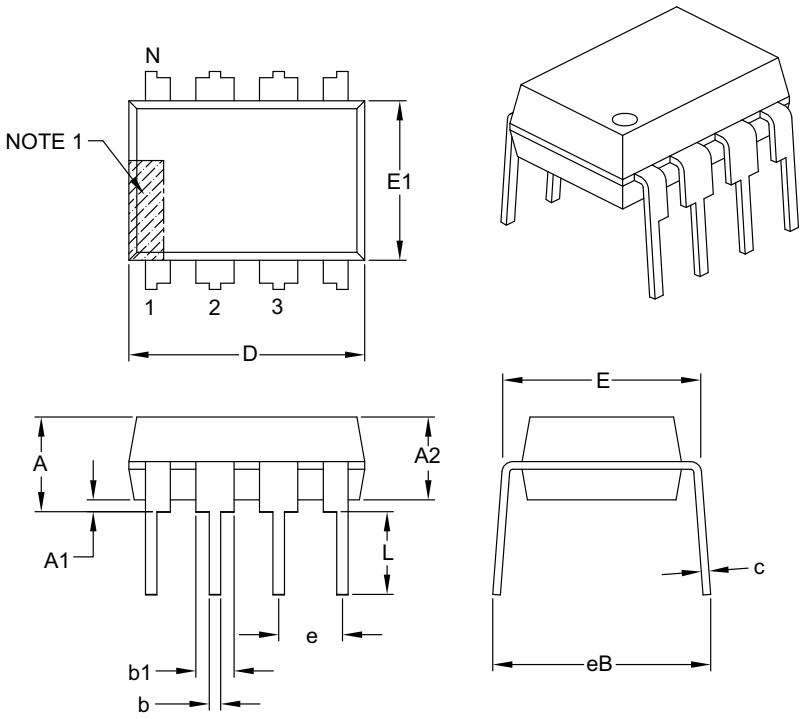
8-Lead Plastic Dual In-Line (P) – 300 mil Body [PDIP]

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



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

Notes:

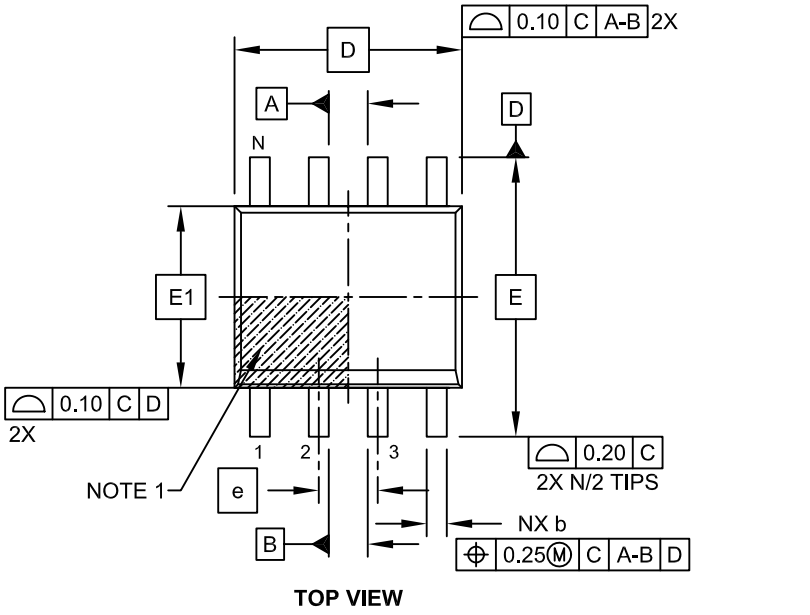
1. Pin 1 visual index feature may vary, but must be located with the hatched area.
2. § Significant Characteristic.
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
4. Dimensioning and tolerancing per ASME Y14.5M.

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

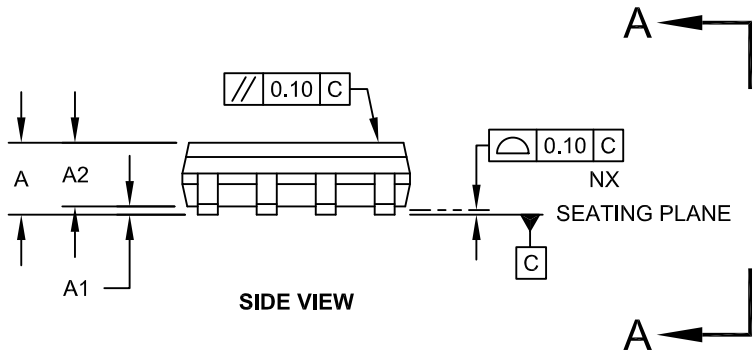
Microchip Technology Drawing C04-018B

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

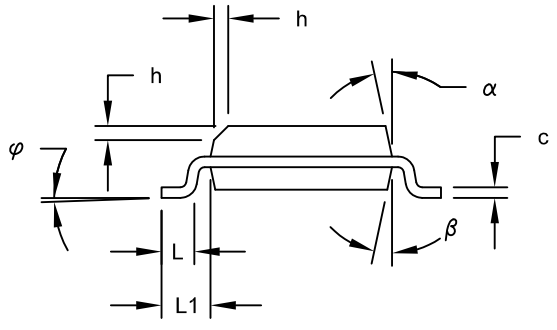
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



TOP VIEW



SIDE VIEW



VIEW A-A

Microchip Technology Drawing No. C04-057C Sheet 1 of 2

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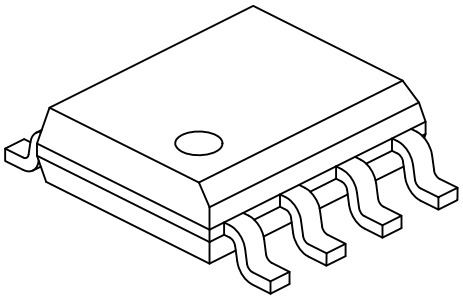
8-Lead Plastic Small Outline (SN) - Narrow, 3.90 mm Body [SOIC]

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



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

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
4. Dimensioning and tolerancing per ASME Y14.5M

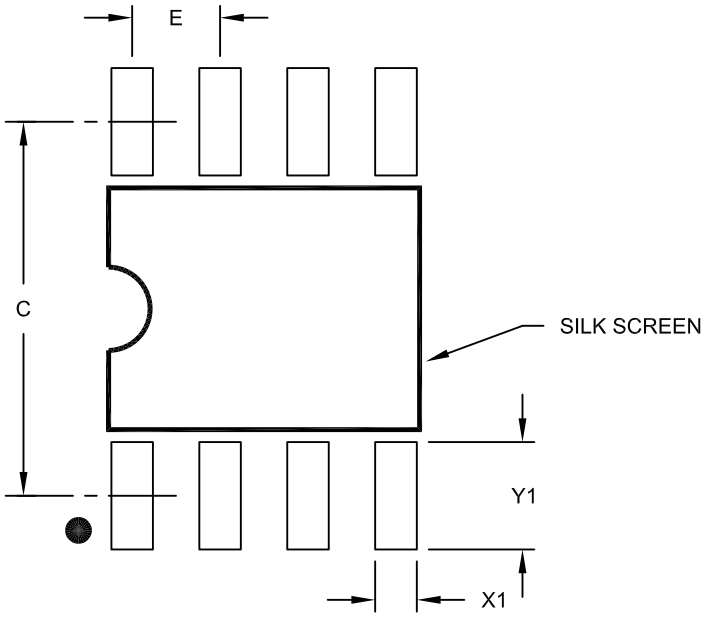
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing No. C04-057C Sheet 2 of 2

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

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



RECOMMENDED LAND PATTERN

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

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2057A

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APPENDIX A: REVISION HISTORY

Revision A (March 2010)

- Original Release of this Document.

Revision B (July 2010)

- Added **Section 2.2 “Nomenclature used in this document”**, and added the “Capacitance of Slave Node” parameter to Table 2.3.

Revision C (August 2010)

- Updated all references of Sleep mode to Power-Down mode, and updated the Max. parameter for Duty Cycle 2 in **Section 2.4 “AC Specifications”**.

NOTES:

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PRODUCT IDENTIFICATION SYSTEM

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

PART NO.	X	/XX
Device	Temperature Range	Package

Device:	MCP2004:	LIN Transceiver with Voltage Regulator
	MCP2004T:	LIN Transceiver with Voltage Regulator (Tape and Reel) (DFN and SOIC)
	MCP2003:	LIN Transceiver with Voltage Regulator
	MCP2003T:	LIN Transceiver with Voltage Regulator (Tape and Reel) (DFN and SOIC)
Temperature Range:	E =	-40°C to +125°C
Package:	MD =	Plastic Micro Small Outline (4x4), 8-lead
	P =	Plastic DIP (300 mil Body), 8-lead, 14-lead
	SN =	Plastic SOIC, (150 mil Body), 8-lead

Examples:

a)	MCP2004-E/MD:	Extended Temperature, 8L-DFN pkg.
b)	MCP2004-E/P:	Extended Temperature, 8L-PDIP pkg.
c)	MCP2004-E/SN:	Extended Temperature, 8L-SOIC pkg.
d)	MCP2004T-E/MD:	Tape and Reel, Extended Temperature, 8L-DFN pkg.
e)	MCP2004T-E/SN:	Tape and Reel, Extended Temperature, 8L-SOIC pkg.
a)	MCP2003-E/MD:	Extended Temperature, 8L-DFN pkg.
b)	MCP2003-E/P:	Extended Temperature, 8L-PDIP pkg.
c)	MCP2003-E/SN:	Extended Temperature, 8L-SOIC pkg.
d)	MCP2003T-E/MD:	Tape and Reel, Extended Temperature, 8L-DFN pkg.
e)	MCP2003T-E/SN:	Tape and Reel, Extended Temperature, 8L-SOIC pkg.

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