

LIN Transceiver with Voltage Regulator

Features

- The MCP2025 is compliant with:
 - LIN Bus Specifications Version 1.3, and 2.x
 - SAE J2602-2
- Supports Baud Rates up to 20 kBaud
- 43V Load Dump Protected
- Maximum Continuous Input Voltage of 30V
- Wide LIN Compliant Supply Voltage: 6.0-18.0V
- Extended Temperature Range: -40 to +125°C
- Interface to PIC® EUSART and Standard USARTs
- Wake-up on LIN Bus Activity or Local Wake Input
- LIN Bus Pin
 - Internal Pull-up Termination Resistor and Diode for Slave Node
 - Protected Against VBAT Shorts
 - Protected Against Loss of Ground
 - High Current Drive
- TXD and LIN Bus Dominant Time-out Function
- Two Low-power Modes
 - TRANSMITTER-OFF: 90 μ A (typical)
 - POWER-DOWN mode: 4.5 μ A (typical)
- MCP2025 On-chip Voltage Regulator
 - Output Voltage of 5.0V or 3.3V 70 mA Capability with Tolerances of $\pm 3\%$ Over Temperature Range.
 - Internal Short Circuit Current Limit
 - Only External Filter and Load Capacitors Needed
- Automatic Thermal Shutdown
- High Electromagnetic Immunity (EMI), Low Electromagnetic Emission (EME)
- Robust ESD Performance: ± 15 kV for LBUS and VBB Pin (IEC61000-4-2)
- Transient Protection for LBUS and VBB pins in Automotive Environment (ISO7637)
- Meets stringent automotive design requirements including "OEM Hardware Requirements for LIN, CAN and FlexRay Interfaces in Automotive Applications", Version 1.2, March 2011
- Multiple Package Options Including Small 4x4 mm DFN

Description

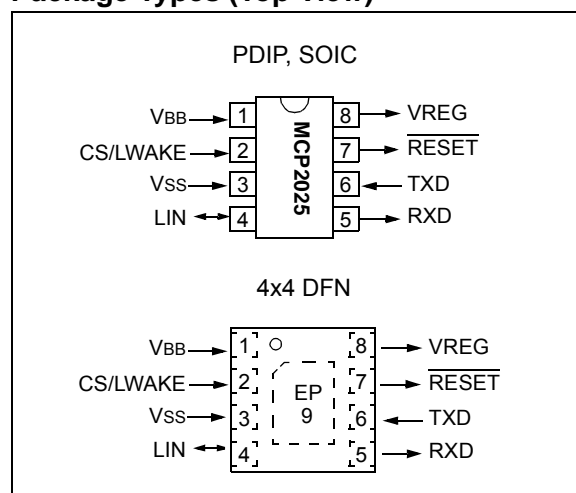
The MCP2025 provides a bidirectional, half-duplex communication physical interface to meet the LIN bus specification Revision 2.1 and SAE J2602-2. The device incorporates a voltage regulator with 5V or 3.3V 70 mA regulated power supply output.

The device has been designed to meet the stringent quiescent current requirements of the automotive industry and will survive +43V load dump transients, and double battery jumps.

MCP2025 family members include:

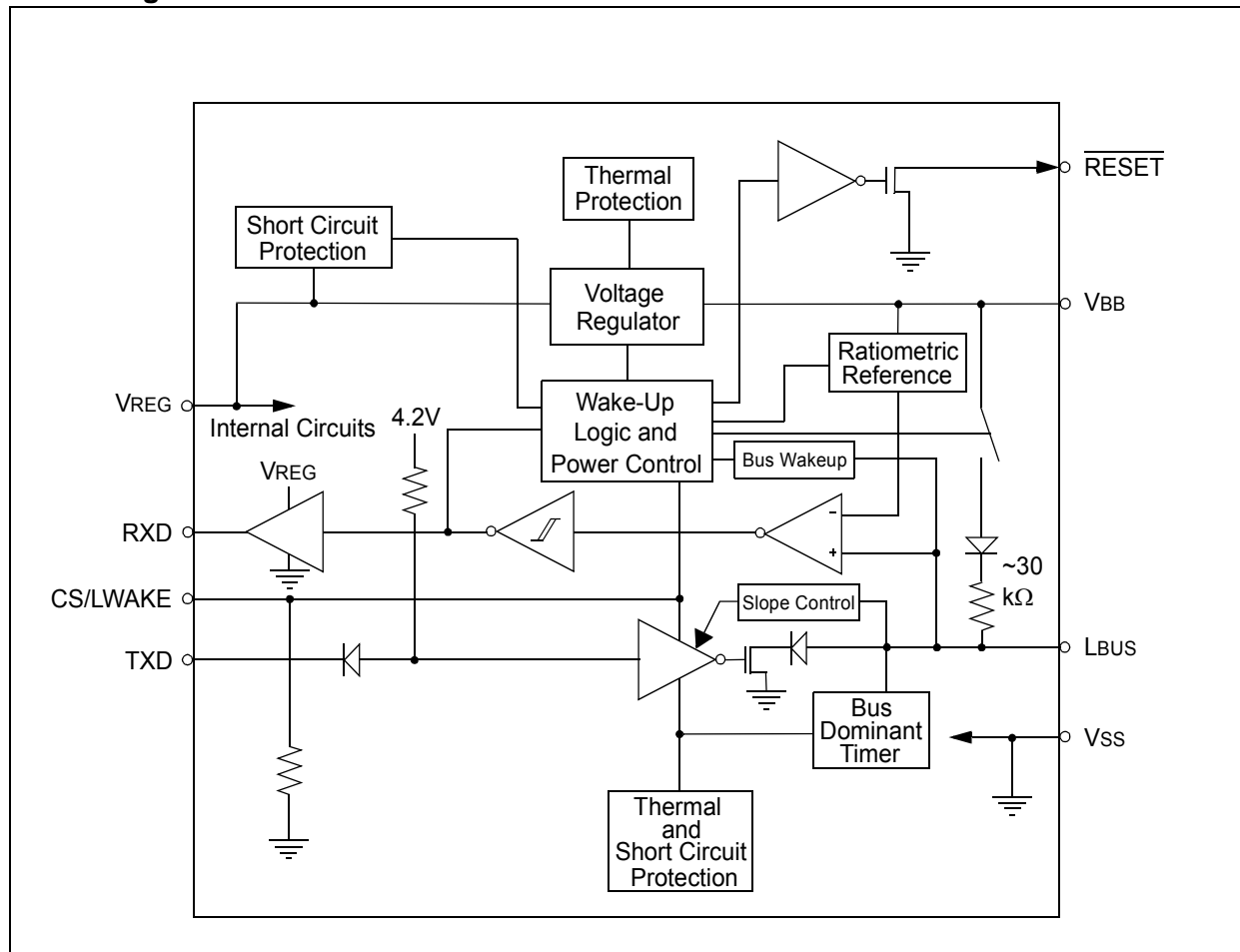
- MCP2025-500, 8-pin, LIN driver with 5.0V regulator
- MCP2025-330, 8-pin, LIN driver with 3.3V regulator

Package Types (Top View)



MCP2025

Block Diagram



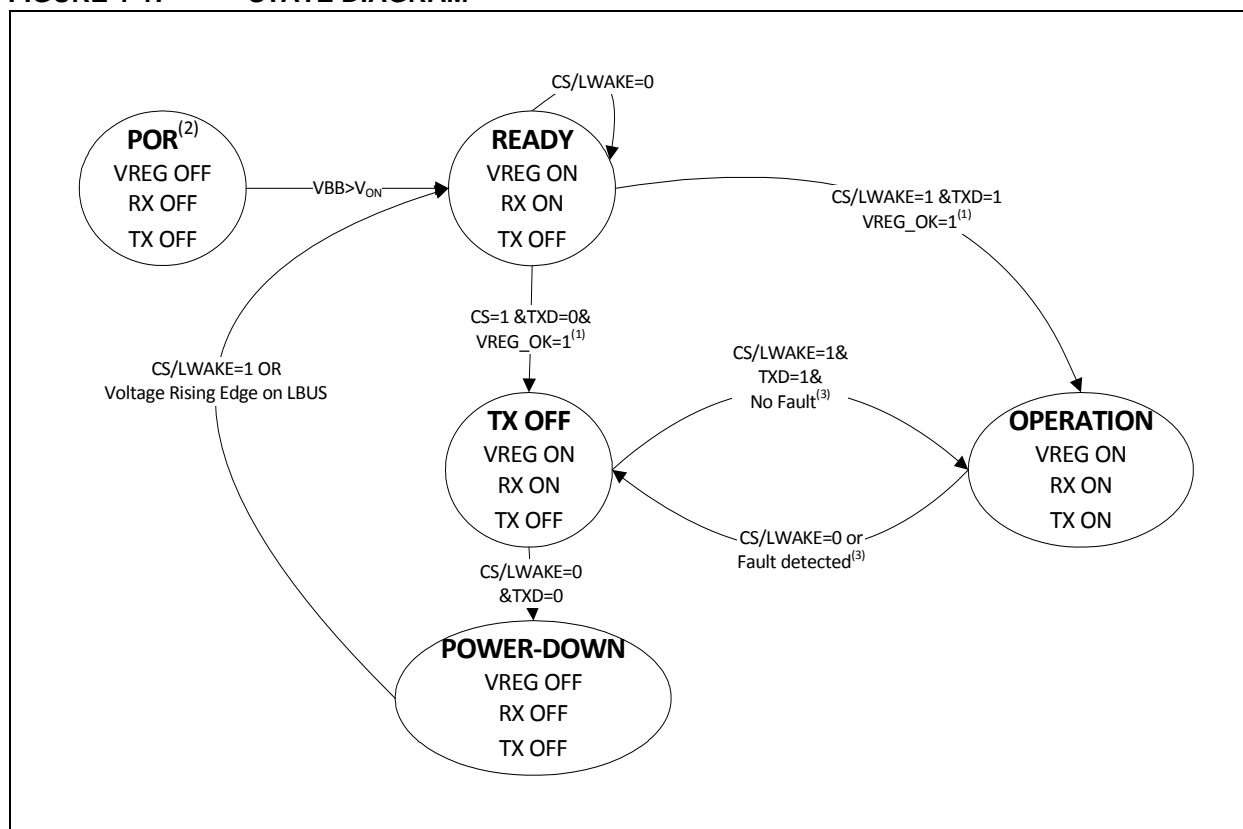
1.0 FUNCTION DESCRIPTION

The MCP2025 provides a physical interface between a microcontroller and a LIN half-duplex bus. It is intended for automotive and industrial applications with serial bus baud rates up to 20 kbaud. This device will translate the CMOS/TTL logic levels to LIN logic levels, and vice versa. The device offers optimum EMI and ESD performance; it can withstand high voltage on the LIN bus. The device supports two low-power modes to meet automotive industry power consumption requirements. The MCP2025 also provides a +5V or 3.3V 70 mA regulated power output.

1.1 Modes of Operation

The MCP2025 works in five modes: POWER-ON-RESET mode, POWER-DOWN mode, READY mode, OPERATION mode, and TRANSMITTER-OFF mode. For an overview of all operational modes, please refer to [Table 1-1](#). For the operational mode transition, please refer to [Figure 1-1](#).

FIGURE 1-1: STATE DIAGRAM



Note 1: VREG_OK : Regulator Output Voltage > 0.8V_{REG_NOM}.

- 2:** If the voltage on pin VBB falls below V_{OFF}, the device will enter POWER-ON RESET mode from all other modes, which is not shown in the figure.
- 3:** Faults include TXD/LBUS permanent dominant, LBUS short to VBB, thermal protection, and VREG_OK is false.

1.1.1 POWER-ON-RESET MODE

Upon application of VBB, or whenever the voltage on VBB is below the threshold of regulator turn off voltage V_{OFF} (typically 4.50V), the device enters POWER-ON-RESET mode (POR). During this mode, the device maintains the digital section in a reset mode and waits until the voltage on pin VBB rises above the threshold of regulator turn on voltage V_{ON} (typically 5.75V) to

enter READY mode. In POWER-ON-RESET mode, the LIN physical layer and voltage regulator are disabled, and the RESET pin is switched to ground.

1.1.2 READY MODE

The device enters READY mode from POR mode after the voltage on VBB rises above the threshold of regulator turn on voltage V_{ON} or from POWER-DOWN mode when a remote or local wake-up event happens.

Upon entering READY mode, the voltage regulator and receiver section of the transceiver are powered up. The transmitter remains in an off state. The device is ready to receive data but not to transmit. In order to minimize the power consumption, the regulator operates in a reduced power mode. It has a lower GBW product and thus is slower. However, the 70 mA drive capability is unchanged.

The device stays in READY mode until the output of the voltage regulator has stabilized and CS/LWAKE pin is HIGH ('1').

1.1.3 OPERATION MODE

If the CS/LWAKE pin changes to high while VREG is OK ($V_{REG} > 0.8 \cdot V_{REG_NOM}$) and TXD pin is HIGH, the part enters OPERATION mode from either READY or TRANSMITTER-OFF mode.

In this mode, all internal modules are operational. The internal pull-up resistor between LBUS and VBB is connected only in this mode.

The device goes to TRANSMITTER-OFF mode at the falling edge on the CS/LWAKE pin or when a fault is detected.

Note: The TXD pin needs to be set high before setting the CS/LWAKE pin to low in order to jump and stay in TRANSMITTER-OFF mode. If the TXD pin is set or maintained low before setting the CS/LWAKE pin to low, the part will transit to TRANSMITTER-OFF mode and then jump to POWER-DOWN mode after a deglitch delay of about 20 μ s.

1.1.4 TRANSMITTER OFF MODE

If VREG is OK ($V_{REG} > 0.8 \cdot V_{REG_NOM}$), the TRANSMITTER-OFF mode can be reached by setting CS/LWAKE to HIGH when TXD pin is LOW from READY mode; or by pulling down CS/LWAKE to low from OPERATION mode.

In TRANSMITTER-OFF mode, the receiver is enabled but the LBUS transmitter is off. It is a lower power mode.

In order to minimize the power consumption, the regulator operates in a reduced power mode. It has a lower GBW product and thus is slower. However, the 70 mA drive capability is unchanged.

The transmitter is also turned off whenever the voltage regulator is unstable or recovering from a fault. This prevents unwanted disruption on the bus during times of uncertain operation.

1.1.5 POWER-DOWN MODE

POWER-DOWN mode is entered by pulling down both the CS/LWAKE pin and TXD to low from TRANSMITTER-OFF mode. In POWER-DOWN mode, the transceiver and the voltage regulator are both off. Only the Bus Wake-up section and the CS/LWAKE pin wake-up circuits are in operation. This is the lowest power mode.

If any bus activity (e.g. a BREAK character) occurs or CS/LWAKE is set to HIGH during POWER-DOWN mode, the device will immediately enter READY mode and enable the voltage regulator. Then, once the regulator output has stabilized (approximately 0.3 ms to 1.2 ms) it can go to either the OPERATION mode or TRANSMITTER-OFF mode. Refer to [Section 1.1.6 "Remote Wake-up"](#) for more details.

1.1.6 REMOTE WAKE-UP

The remote wake-up sub module observes the LBUS in order to detect bus activity. In POWER-DOWN mode, the normal LIN recessive/dominant threshold is disabled, and the LIN bus Wake-Up Voltage Threshold $V_{WK}(LBUS)$ is used to detect bus activities. Bus activity is detected when the voltage on the LBUS falls below the LIN bus Wake-Up Voltage Threshold $V_{WK}(LBUS)$ (approximately 3.4V) for at least t_{BDB} (a typical duration of 80 μ s) followed by a rising edge. Such a condition causes the device to leave POWER-DOWN mode.

TABLE 1-1: OVERVIEW OF OPERATIONAL MODES

State	Transmitter	Receiver	Internal Wake Module	Voltage Regulator	Operation	Comments
POWER-ON-RESET	OFF	OFF	OFF	OFF	Transfer to READY mode after $V_{BB} > V_{ON}$	
READY	OFF	ON	OFF	ON	If CS/LWAKE is high, then proceed to OPERATION or TRANSMITTER-OFF mode	Bus Off state
OPERATION	ON	ON	OFF	ON	If CS/LWAKE is low level, then TRANSMITTER-OFF mode	Normal operation mode
POWER-DOWN	OFF	OFF	ON Activity Detect	OFF	On LIN bus rising edge or CS/LWAKE high level, go to READY mode	Lowest power mode
TRANSMITTER-OFF	OFF	ON	OFF	ON	If TXD and CS/LWAKE low level, then POWER-DOWN If TXD and CS/LWAKE high level, then OPERATION	Bus Off state, lower power mode

1.2 Pin Descriptions

Please refer to [Table 1-2](#) for the pinout overview.

1.2.1 VBB

Battery Positive Supply Voltage pin. An external diode is connected in series to prevent the device from being reversely powered (refer to [Figure 1-9](#)).

1.2.2 VREG

Positive Supply Voltage Regulator Output pin. An on-chip Low Dropout Regulator (LDO) gives +5.0 or +3.3V 70 mA regulated voltage on this pin.

1.2.3 VSS

Ground pin.

1.2.4 TXD

Transmit data input pin (TTL level, HV compliant, adaptive pull-up). The transmitter reads the data stream on the TXD pin and sends it to the LIN bus. The LBUS pin is low (dominant) when TXD is low, and high (recessive) when TXD is high.

The Transmit Data Input pin has an internal adaptive pull-up to an internally-generated 4.2V (approximately). When TXD is '0', a weak pull-up (~900 kΩ) is used to reduce current. When TXD is '1' a stronger pull-up (~300 kΩ) is used to maintain the logic level. A series reverse-blocking diode allows applying TXD input voltages greater than the internally generated 4.2V and renders the TXD pin HV compliant up to 30V (see [Block Diagram](#)).

1.2.5 RXD

Receive Data Output pin. The RXD pin is a standard CMOS output pin and it follows the state of the LBUS pin.

1.2.6 LBUS

LIN Bus pin. LBUS is a bidirectional LIN bus Interface pin and is controlled by the signal TXD. It has an open collector output with a current limitation. To reduce

ElectroMagnetic Emission, the slopes during signal changes are controlled, and the LBUS pin has corner-rounding control for both falling and rising edges.

The internal LIN receiver observes the activities on the LIN bus, and generates the output signal RXD that follows the state of the LBUS. A first degree 160 KHz, low-pass input filter optimizes ElectroMagnetic immunity.

1.2.7 CS/LWAKE

Chip Select and Local Wake-up Input pin (TTL level, high voltage tolerant). This pin controls the device state transition. Refer to [Figure 1-1](#).

An internal pull-down resistor will keep the CS/LWAKE pin low to ensure that no disruptive data will be present on the bus while the microcontroller is executing a POWER-ON RESET and I/O initialization sequence. When CS/LWAKE is '1', a weak pull-down (~600 kΩ) is used to reduce current. When CS/LWAKE is '0' a stronger pull-down (~300 kΩ) is used to maintain the logic level.

This pin may also be used as a local wake-up input (See [Figure 1-9](#)). The microcontroller will set the I/O pin to control the CS/LWAKE. An external switch, or other source, can then wake-up both the transceiver and the microcontroller.

Note: CS/LWAKE should NOT be tied directly to pin VREG as this could force the MCP2025 into OPERATION mode before the microcontroller is initialized.

1.2.8 RESET

RESET OUTPUT pin. This is an open drain output pin. It indicates the internal voltage has reached a valid, stable level. As long as the internal voltage is valid (above 0.8VREG), this pin will present high impedance; otherwise the RESET pin switches to ground.

TABLE 1-2: PINOUT OVERVIEW

PIN Name	PIN Number	PIN Type	Function
VREG	8	Output	Voltage regulator output
VSS	3	Power	Ground
VBB	1	Power	Battery
TXD	6	Input, HV-tolerant	Transmit data input
RXD	5	Output	Receive data output
LBUS	4	I/O, HV	LIN Bus
CS/LWAKE	2	TTL Input, HV-tolerant	Chip Select and Local Wake-up input
RESET	7	Open Drain Output, HV-tolerant	Reset output

1.3 Fail-Safe Features

1.3.1 GENERAL FAIL-SAFE FEATURES

- An internal pull-down resistor on the CS/LWAKE pin disables the transmitter if the pin is floating.
- An internal pull-up resistor on the TXD pin places TXD in HIGH, thus the LBUS is recessive if the TXD pin is floating.
- High-impedance and low leakage current on LBUS during loss of power or ground.
- The current limit on LBUS protects the transceiver from being damaged if the pin is shorted to VBB.

1.3.2 THERMAL PROTECTION

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

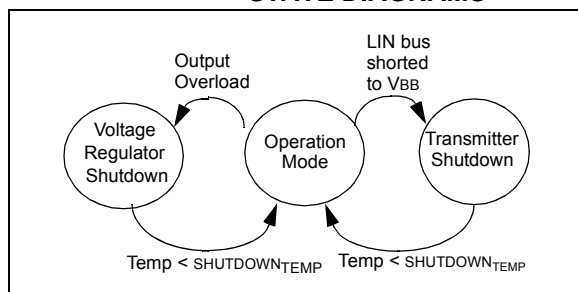
There are three causes for a thermal overload. A thermal shut down can be triggered by any one, or a combination of, the following thermal overload conditions:

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

The recovery time from the thermal shutdown is equal to adequate cooling time.

Driving the TXD and checking the RXD pin makes it possible to determine whether there is a bus contention (TXD = high, RXD = low) or a thermal overload condition (TXD = low, RXD = high).

FIGURE 1-2: THERMAL SHUTDOWN STATE DIAGRAMS



1.3.3 TXD/LBUS TIME-OUT TIMER

The LIN bus can be driven to a dominant level either from the TXD pin or externally. An internal timer deactivates the LBUS transmitter if a dominant status (LOW) on the LIN bus lasts longer than Bus Dominant Time-out Time $t_{TO(LIN)}$ (approximately 20 milliseconds); at the same time, RXD output is put in recessive (HIGH) and the internal pull-up resistor between LBUS and VBB is disconnected. The timer is reset on any recessive LBUS status or POR mode. The recessive

status on LBUS can be caused either by the bus being externally pulled up or by the TXD pin being returned high.

1.4 Internal Voltage Regulator

The MCP2025 has a positive regulator capable of supplying +5.00 or +3.30 VDC $\pm 3\%$ at up to 70mA of load current over the entire operating temperature range of -40°C to $+125^{\circ}\text{C}$. The regulator uses an LDO design, is short-circuit-protected and will turn the regulator output off if its output falls below the Shutdown Voltage Threshold V_{SD} .

With a load current of 70mA, the minimum input to output voltage differential required for the output to remain in regulation is typically +0.5V (+1V maximum over the full operating temperature range). Quiescent current is less than 100 μA with a full 70mA load current when the input to output voltage differential is greater than +3.00V.

Regarding the correlation between V_{BB} , V_{REG} and I_{DD} , please refer to [Figure 1-6](#) and [Figure 1-7](#). When the input voltage (V_{BB}) drops below the differential needed to provide stable regulation, the voltage regulator output V_{REG} will track the input down to approximately V_{OFF} . The regulator will turn off the output at this point. This will allow PIC microcontrollers, with internal POR circuits, to generate a clean arming of the POWER-ON RESET trip point. The MCP2025 will then monitor V_{BB} and turn on the regulator when V_{BB} is above the threshold of regulator turn on voltage V_{ON} .

Under specific ambient temperature and battery voltage range, the voltage regulator can output as high as 150 mA current. For current load capability of the voltage regulator, refer to [Figure 1-4](#) and [Figure 1-5](#).

In POWER-DOWN mode, the V_{BB} monitor is turned off (see [Section 1.1.5 "Power-down Mode"](#) for details).

Note: The regulator overload current limit is approximately 250 mA. The regulator output voltage V_{REG} is monitored. If output voltage V_{REG} is lower than V_{SD} , the voltage regulator will turn off. After a recovery time of about 3mS, the V_{REG} will be checked again. If there is no short circuit, ($V_{REG} > V_{SD}$) then the voltage regulator remains on.

The regulator requires an external output bypass capacitor for stability. See [FIGURE 2-1: "ESR Curves For Load Capacitor Selection"](#) for correct capacity and ESR for stable operation.

FIGURE 1-3: VOLTAGE REGULATOR BLOCK DIAGRAM

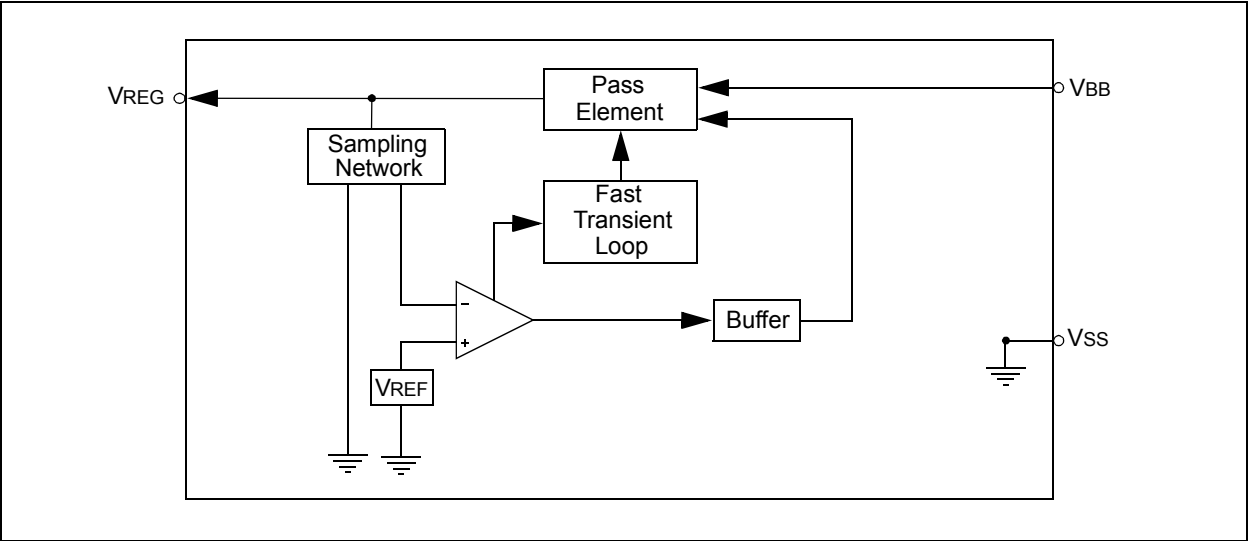


FIGURE 1-4: 5.0V V_{REG} VS. I_{REG} AT $V_{BB} = 12V$

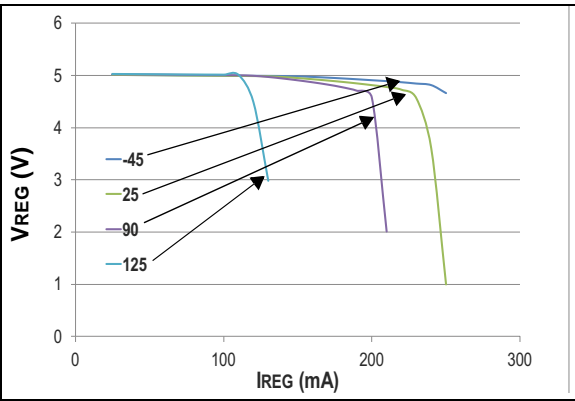


FIGURE 1-5: 3.3V V_{REG} VS. I_{REG} AT $V_{BB} = 12V$

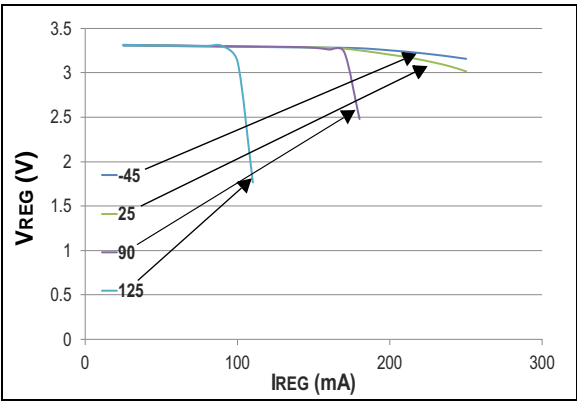


FIGURE 1-6: VOLTAGE REGULATOR OUTPUT ON POWER-ON RESET

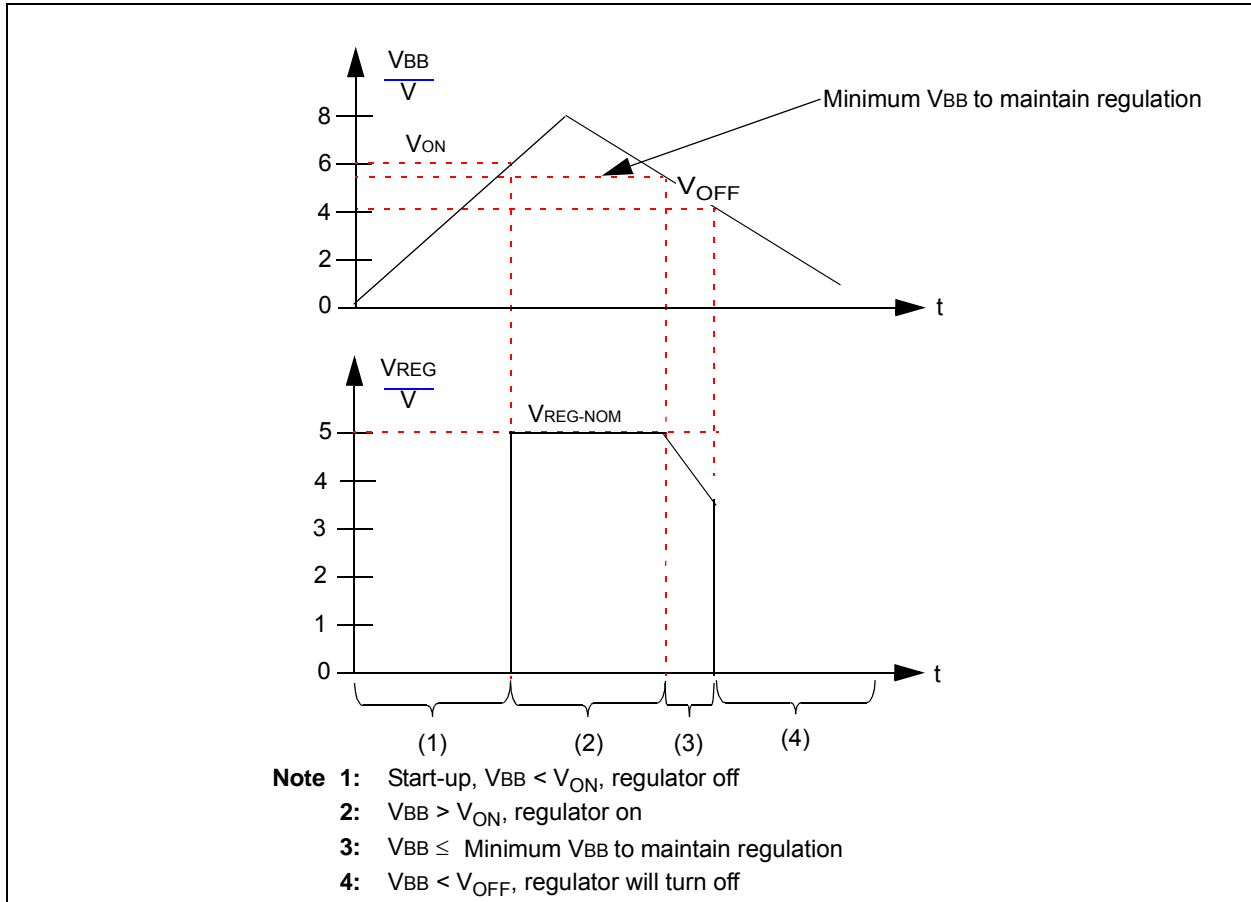
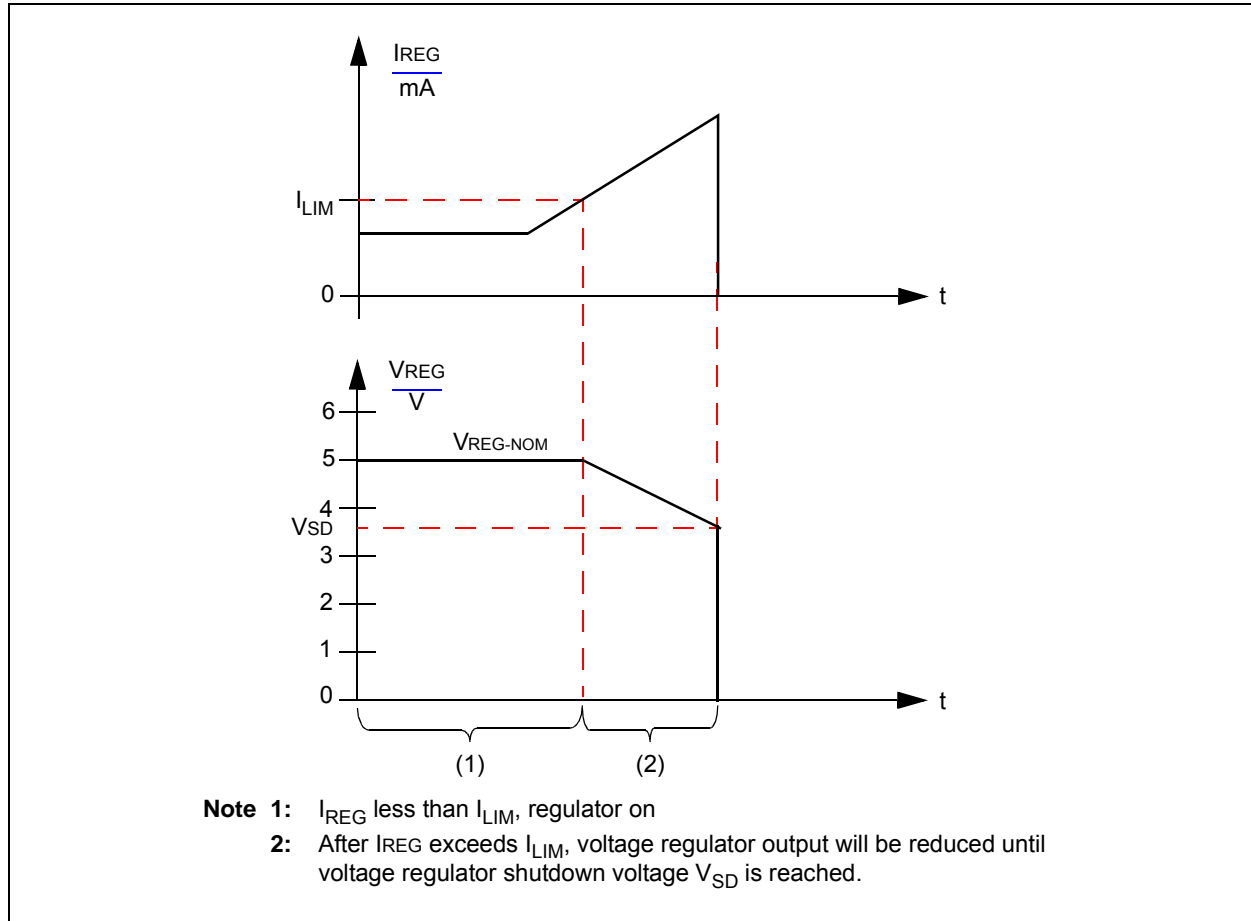


FIGURE 1-7: VOLTAGE REGULATOR OUTPUT ON OVER CURRENT SITUATION



1.5 Optional External Protection

1.5.1 REVERSE BATTERY PROTECTION

An external reverse-battery-blocking diode should be used to provide polarity protection (see [Figure 1-9](#)).

1.5.2 TRANSIENT VOLTAGE PROTECTION (LOAD DUMP)

An external 43V transient suppressor (TVS) diode, between V_{BB} and ground, with a transient protection resistor (RTP) in series with the battery supply and the V_{BB} pin protects the device from power transients and ESD events greater than 43V (see [Figure 1-9](#)). The maximum value for the RTP protection resistor depends upon two parameters: the minimum voltage the part will start at, and the impacts of this RTP resistor on the V_{BB} value, thus on the Bus recessive level and slopes.

This leads to a set of three equations to fulfill.

[Equation 1-1](#) provides a max RTP value, according to the minimum battery voltage the user wants the part to start with.

[Equation 1-2](#) provides a max RTP value according to the maximum error on the recessive level, thus V_{BB} , since the part uses V_{BB} as the reference value for the recessive level.

[Equation 1-3](#) provides a max RTP value according to the maximum relative variation the user can accept on the slope when I_{REG} varies.

Since both [Equation 1-1](#) and [Equation 1-2](#) must be fulfilled, the maximum allowed value for RTP is the smaller of the two values found when solving [Equation 1-1](#) and [Equation 1-2](#).

Usually, [Equation 1-1](#) gives the higher constraint (smaller value) for RTP as shown in the example where V_{BATmin} is 8V.

However, the user needs to verify that the value found in [Equation 1-1](#) also satisfies [Equation 1-2](#) and [Equation 1-3](#).

While this protection is optional, it should be considered as good engineering practice.

EQUATION 1-1:

$$R_{TP} \leq \frac{V_{BATmin} - 5.5V}{250mA}$$

$$5.5V = V_{OFF} + 1.0V$$

250 mA is the peak current at power-on when
VBB = 5.5V

Assume that V_{BATmin} = 8V. Equation 1-1 gives 10Ω.

EQUATION 1-2:

$$R_{TP} \leq \Delta V_{RECESSIVE} / I_{REGMAX}$$

$\Delta V_{RECESSIVE}$ is the maximum variation tolerated on
the recessive level

Assume that $\Delta V_{RECESSIVE}$ = 1V and I_{REGMAX}=50 mA.
Equation 1-2 gives 20Ω.

EQUATION 1-3:

$$R_{TP} \leq \frac{\Delta Slope \times (V_{BATmin} - 1V)}{I_{regmax}}$$

$\Delta Slope$ is the maximum variation tolerated on the
slope level and I_{regmax} is the maximum current the
regulator will provide to the load.
V_{BATmin} > V_{OFF} + 1.0V,

Assume that $\Delta Slope$ =15%, V_{BATmin}=8V and
I_{REGMAX} = 50 mA. Equation 1-3 gives 20Ω.

1.5.3 CBAT CAP

Selecting CBAT = 10* CREG is recommended, however
this leads to a high value cap. Lower values for CBAT
cap can be used, but certain rules must be followed. In
any case, the voltage at the VBB pin should remain
above V_{OFF} when the device is turned on.

The current peak at start-up (due to the fast charge of
the CREG and CBAT capacitor) may induce a significant
drop on the VBB pin. This drop is proportional to the
impedance of the VBAT connection (see Figure 1-9).

Let's assume that the VBAT connection is mainly induc-
tive and resistive, and that the customer knows the
resistive and inductive values of the connection.

The following formula gives an indication of the
minimum value the customer should use for CBAT:

EQUATION 1-4:

$$\frac{C_{BAT}}{C_{REG}} = \sqrt{\frac{100L^2 + R_{tot}^2}{1 + L^2 + \frac{R_{tot}^2}{100}}}$$

where L is in mH and RTOT in Ω.
RTOT = R_{LINE} + R_{TP}

Equation 1-4 allows lower CBAT/CREG values than the
10* ratio we recommend.

Assume that we have a good quality connection with
RTOT = 0.1Ω and L = 0.1 mH.

Solving the equation results in CBAT/CREG = 1.

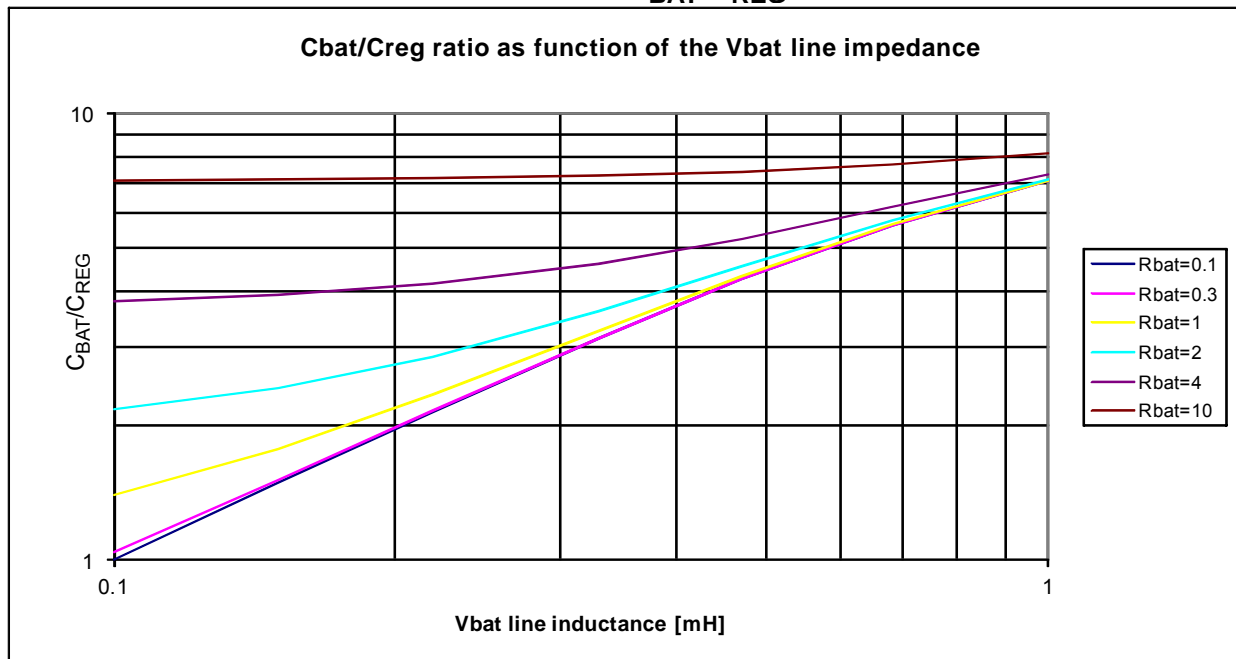
If RTOT is increased to 1Ω, the result becomes CBAT/
CREG = 1.4

But if the connection is highly resistive or highly induc-
tive (poor connection), the CBAT/CREG ratio greatly
increases.

For a highly inductive connection: RTOT = 0.1Ω and L =
1 mH; the CBAT/CREG ratio increases to 7.

For a highly resistive connection: RTOT = 10Ω and
L = 0.1 mH; again, the CBAT/CREG ratio increases to 7.

Figure 1-8 shows the minimum recommended CBAT/
CREG ratio as a function of the impedance of the VBAT
connection.

FIGURE 1-8: Minimum Recommended C_{BAT}/C_{REG} Ratio

1.6 Typical Applications

FIGURE 1-9: TYPICAL APPLICATION CIRCUIT

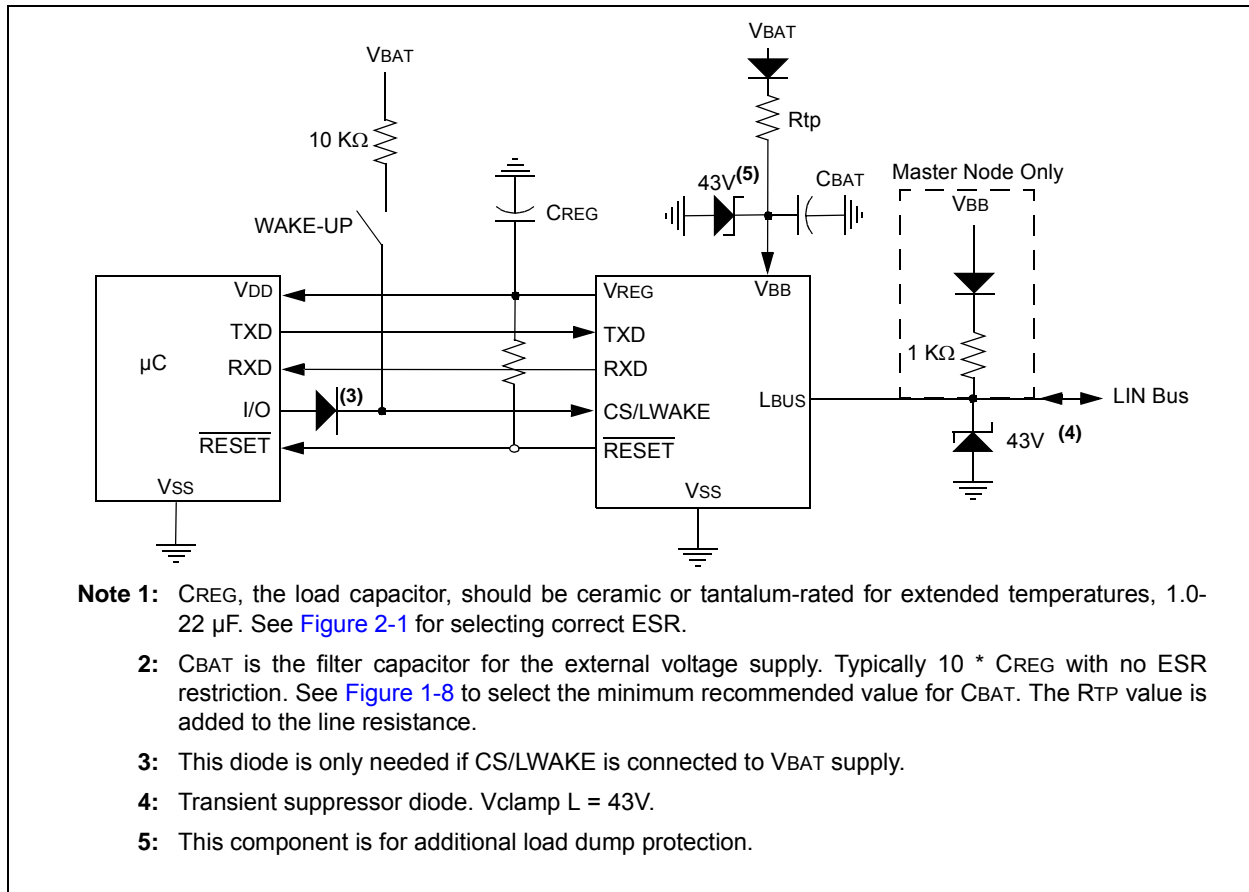
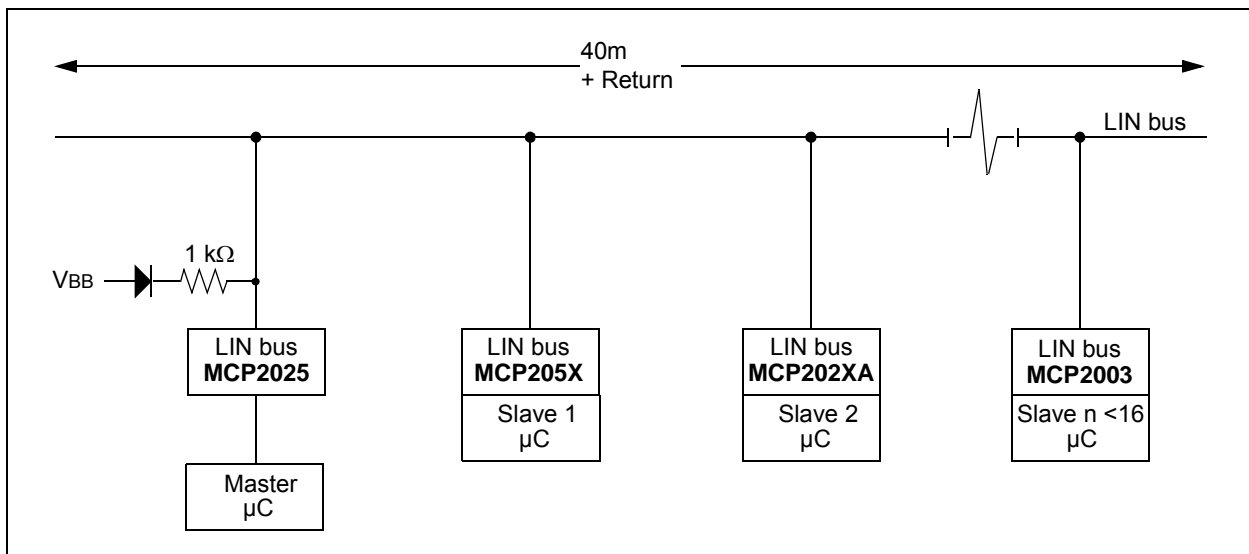


FIGURE 1-10: TYPICAL LIN NETWORK CONFIGURATION



2.0 ELECTRICAL CHARACTERISTICS

2.1 Absolute Maximum Ratings†

V _{IN} DC Voltage on RXD, and $\overline{\text{RESET}}$	-0.3V to V _{REG} +0.3
V _{IN} DC Voltage on TXD, CS/LWAKE	-0.3 to +40V
V _{BB} Battery Voltage, continuous, non-operating (Note 1)	-0.3 to +40V
V _{BB} Battery Voltage, non-operating (LIN bus recessive, no regulator load, t < 60s) (Note 2)	-0.3 to +43V
V _{BB} Battery Voltage, transient ISO 7637 Test 1	-100V
V _{BB} Battery Voltage, transient ISO 7637 Test 2a	+75V
V _{BB} Battery Voltage, transient ISO 7637 Test 3a	-150V
V _{BB} Battery Voltage, transient ISO 7637 Test 3b	+100V
V _{LBUS} Bus Voltage, continuous	-18 to +30V
V _{LBUS} Bus Voltage, transient (Note 3)	-27 to +43V
I _{LBUS} Bus Short Circuit Current Limit	200 mA
ESD protection on LIN, V _{BB} (IEC 61000-4-2) (Note 4)	±15 kV
ESD protection on LIN, V _{BB} (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)	±1500V
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 immunity against transients (t < 500 ms).

4: According to IEC 61000-4-2, 330Ω, 150 pF and Transceiver EMC Test Specifications [2] to [4].

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 “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. Equivalent values are shown below.

LIN 2.1 Name	Term used in the following tables	
V _{BAT}	<i>not used</i>	ECU operating voltage
V _{SUP}	V _{BB}	Supply voltage at device pin
V _{BUS_LIM}	I _{SC}	Current limit of driver
V _{BUSREC}	V _{IH} (L _{BUS})	Recessive state
V _{BUSDOM}	V _{IL} (L _{BUS})	Dominant state

2.3 DC Specifications

DC Specifications		Electrical Characteristics: Unless otherwise indicated, all limits are specified for: V _{BB} = 6.0V to 18.0V T _A = -40°C to +125°C				
Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
Power						
V _{BB} Quiescent Operating Current	I _{BBQ}	—	—	200	μA	I _{OUT} = 0 mA, L _{BUS} recessive V _{REG} = 5.0V
		—	—	200	μA	I _{OUT} = 0 mA, L _{BUS} recessive V _{REG} = 3.3V
V _{BB} Ready Current	I _{BBRD}	—	—	100	μA	I _{OUT} = 0 mA, L _{BUS} recessive V _{REG} = 5.0V
		—	—	100	μA	I _{OUT} = 0 mA, L _{BUS} recessive V _{REG} = 3.3V
V _{BB} Transmitter-off Current with Watchdog Disabled	I _{BBTO}	—	—	100	μA	With voltage regulator on, transmitter off, receiver on, CS = V _{IH} , V _{REG} = 5.0V
		—	—	100	μA	With voltage regulator on, transmitter off, receiver on, CS = V _{IH} , V _{REG} = 3.3V
V _{BB} Power-down Current	I _{BBPD}	—	4.5	8	μA	With voltage regulator powered off, receiver on and transmitter off, CS = V _{IL} .
V _{BB} Current with V _{SS} Floating	I _{BBNOGND}	-1	—	1	mA	V _{BB} = 12V, GND to V _{BB} , V _{LIN} = 0-18V
Microcontroller Interface						
High-level Input Voltage (TXD)	V _{IH}	2.0	—	30	V	
Low-level Input Voltage (TXD)	V _{IL}	-0.3	—	0.8	V	
High-level Input Current (TXD)	I _{IH}	-2.5	—	0.4	μA	Input voltage = 4.0V. ~800 kΩ internal adaptive pull-up
Low-level Input Current (TXD)	I _{IL}	-10	—	—	μA	Input voltage = 0.5V. ~800 kΩ internal adaptive pull-up
High-level Input Voltage (CS/LWAKE)	V _{IH}	2	—	30	V	Through a current-limiting resistor
Low-level Input Voltage (CS/LWAKE)	V _{IL}	-0.3	—	0.8	V	
High-level Input Current (CS/LWAKE)	I _{IH}	—	—	8.0	μA	Input voltage = 0.8V _{REG} ~1.3 MΩ internal pull-down to V _{SS}
Low-level Input Current (CS/LWAKE)	I _{IL}	—	—	5.0	μA	Input voltage = 0.2V _{REG} ~1.3 MΩ internal pull-down to V _{SS}
Low-level Output Voltage (RXD)	V _{OLRXD}	—	—	0.2V _{REG}	V	I _{OL} = 2 mA
High-level Output Voltage (RXD)	V _{OHRXD}	0.8 V _{REG}	—	—	V	I _{OH} = 2 mA

- Note 1:** Internal current limited. 2.0 ms maximum recovery time (R_{LBUS} = 0Ω, TX = 0, V_{LBUS} = V_{BB}).
- 2:** For design guidance only, not tested.
- 3:** In POWER-DOWN mode, normal LIN recessive/dominant threshold is disabled; V_{WK}(L_{BUS}) is used to detect bus activities.

2.3 DC Specifications (Continued)

DC Specifications	Electrical Characteristics:					
	Unless otherwise indicated, all limits are specified for: V _{BB} = 6.0V to 18.0V T _A = -40°C to +125°C					
Parameter	Sym.	Min.	Typ.	Max.	Units	Conditions
Bus Interface (DC specifications are for a V _{BB} range of 6.0 to 18.0V)						
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)	-180	—	-72	μA	~30 kΩ internal pull-up @ V _{IH} (LBUS) = 0.7 V _{BB} , V _{BB} =12V
Short Circuit Current Limit	I _{SC}	50	—	200	mA	(Note 1)
High-level Output Voltage	V _{OH} (LBUS)	0.8 V _{BB}	—	V _{BB}	V	
Driver Dominant Voltage	V _{_LOSUP}	—	—	1.1	V	V _{BB} = 7.3V, R _{LOAD} = 1000Ω
Driver Dominant Voltage	V _{_HISUP}	—	—	1.2	V	V _{BB} = 18V, R _{LOAD} = 1000Ω
Input Leakage Current (at the receiver during dominant bus level)	I _{BUS_PAS_} DOM	-1	—	—	mA	Driver off, V _{BUS} = 0V, V _{BB} = 12V
Input Leakage Current (at the receiver during recessive bus level)	I _{BUS_PAS_} REC	-20	—	20	μA	Driver off, 8V < V _{BB} < 18V 8V < V _{BUS} < 18V V _{BUS} ≥ V _{BB}
Leakage Current (disconnected from ground)	I _{BUS_NO_G} ND	-10	—	+10	μA	GND _{DEVICE} = V _{BB} , 0V < V _{BUS} < 18V, V _{BB} = 12V
Leakage Current (disconnected from V _{BB})	I _{BUS_NO_P} WR	-10	—	+10	μA	V _{BB} = GND, 0 < V _{BUS} < 18V
Receiver Center Voltage	V _{BUS_CNT}	0.475 V _{BB}	0.5 V _{BB}	0.525 V _{BB}	V	V _{BUS_CNT} = (V _{IL} (LBUS) + V _{IH} (LBUS))/2
Slave Termination	R _{SLAVE}	20	30	47	kΩ	(Note 2)
Capacitance of slave node	C _{SLAVE}			50	pF	(Note 2)
Wake-Up Voltage Threshold on LIN Bus	V _{WK} (LBUS)	—	—	3.4	V	Wake up from POWER-DOWN mode (Note 3)

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

2: For design guidance only, not tested.

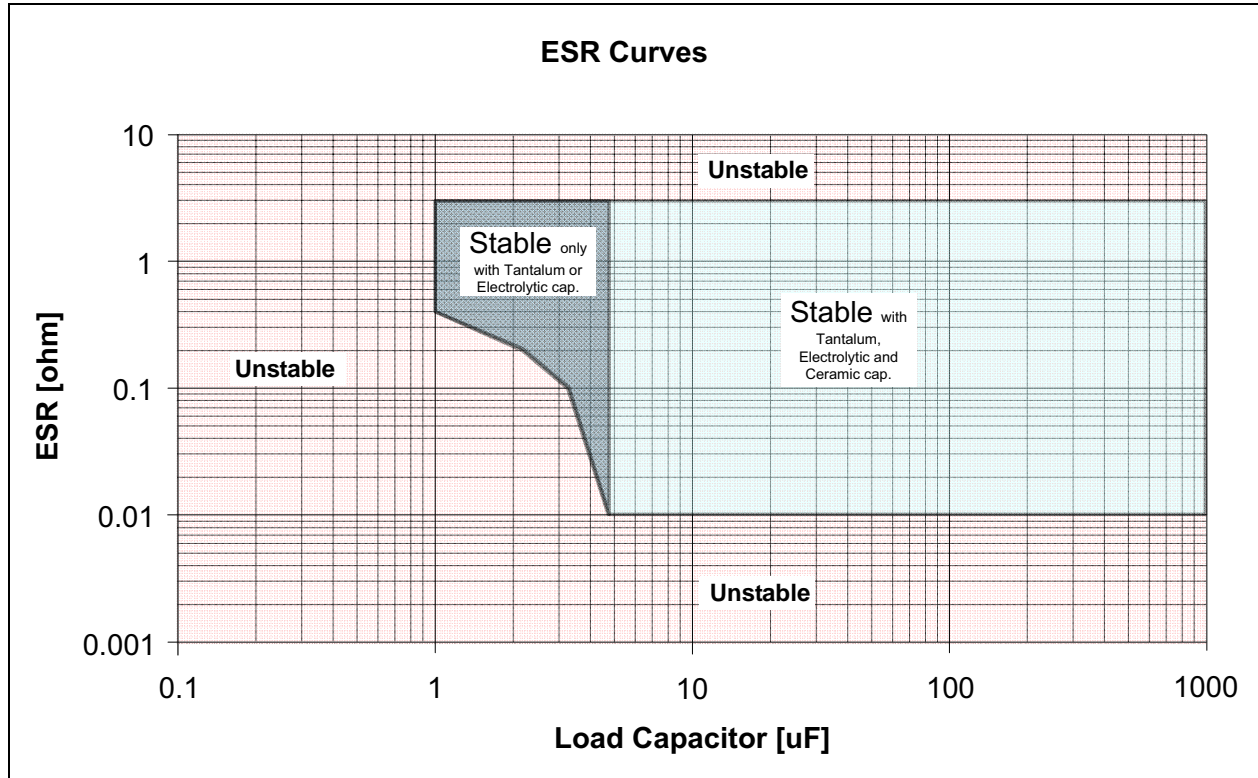
3: In POWER-DOWN mode, normal LIN recessive/dominant threshold is disabled; V_{WK}(LBUS) is used to detect bus activities.

MCP2025

2.3 DC Specification (Continued)

DC Specifications	Electrical Characteristics: Unless otherwise indicated, all limits are specified for: $V_{BB} = 6.0V$ to $18.0V$ $T_A = -40^{\circ}C$ to $+125^{\circ}C$ $C_{LOADREG} = 10 \mu F$					
	Parameter	Sym.	Min.	Typ.	Max.	Units
Voltage Regulator - 5.0V						
Output Voltage Range	V_{REG}	4.85	5.00	5.15	V	$0 \text{ mA} < I_{OUT} < 70 \text{ mA}$
Line Regulation	ΔV_{OUT1}	—	10	50	mV	$I_{OUT} = 1 \text{ mA}$, $6.0V < V_{BB} < 18V$
Load Regulation	ΔV_{OUT2}	—	10	50	mV	$5 \text{ mA} < I_{OUT} < 70 \text{ mA}$ $6.0V < V_{BB} < 12V$
Power Supply Ripple Reject	PSRR	—	—	50	dB	1 VPP @10-20 kHz $I_{LOAD} = 20 \text{ mA}$
Output Noise Voltage	eN	—	—	100	μV_{RMS}	10 Hz – 40 MHz $C_{FILTER} = 10 \mu f$, $CBP = 0.1 \mu f$, $I_{LOAD} = 20 \text{ mA}$
Shutdown Voltage Threshold	V_{SD}	3.5	—	4.0	V	See Figure 1-7 (Note 1)
Input Voltage to Turn-off Output	V_{OFF}	3.9	—	4.5	V	
Input Voltage to Turn-on Output	V_{ON}	5.25	—	6.0	V	
Voltage Regulator - 3.3V						
Output Voltage	V_{REG}	3.20	3.30	3.40	V	$0 \text{ mA} < I_{OUT} < 70 \text{ mA}$
Line Regulation	ΔV_{OUT1}	—	10	50	mV	$I_{OUT} = 1 \text{ mA}$, $6.0V < V_{BB} < 18V$
Load Regulation	ΔV_{OUT2}	—	10	50	mV	$5 \text{ mA} < I_{OUT} < 70 \text{ mA}$, $6.0V < V_{BB} < 12V$
Power Supply Ripple Reject	PSRR	—	50	—	dB	1 VPP @10-20 kHz , $I_{LOAD} = 20 \text{ mA}$
Output Noise Voltage	eN	—	—	100	μV_{RMS} /√Hz	10 Hz – 40 MHz $C_{FILTER} = 10 \mu F$, $CBP = 0.1 \mu F$, $I_{LOAD} = 20 \text{ mA}$
Shutdown Voltage	V_{SD}	2.5	—	2.7	V	See Figure 1-7 (Note 2)
Input Voltage to Turn-off Output	V_{OFF}	3.9	—	4.5	V	
Input Voltage to Turn-on Output	V_{ON}	5.25	—	6	V	

FIGURE 2-1: ESR CURVES FOR LOAD CAPACITOR SELECTION



2.4 AC Specification

AC CHARACTERISTICS		V _{BB} = 6.0V to 18.0V; T _A = -40°C to +125°C				
Parameter	Sym.	Min.	Typ.	Max.	Units	Test Conditions
Bus Interface - Constant Slope Time Parameters (DC specifications are for a V_{BB} range of 6.0 to 18.0V)						
Slope rising and falling edges	t _{SLOPE}	3.5	—	22.5	μs	7.3V ≤ V _{BB} ≤ 18V
Propagation Delay of Transmitter	t _{TRANSPD}	—	—	6.0	μs	t _{TRANSPD} = max (t _{TRANSPDR} or t _{TRANSPDF})
Propagation Delay of Receiver	t _{RECPD}	—	—	6.0	μs	t _{RECPD} = max (t _{RECPDR} or t _{RECPDF})
Symmetry of Propagation Delay of Receiver rising edge w.r.t. falling edge	t _{RECSYM}	-2.0	—	2.0	μs	t _{recsym} = max (t _{recpdf} – t _{recpdr}) R _{RXD} 2.4KΩ to V _{CC} , C _{RXD} 20pF
Symmetry of Propagation Delay of Transmitter rising edge w.r.t. falling edge	t _{TRANSSYM}	-2.0	—	2.0	μs	t _{TRANSSYM} = max (t _{TRANSPDF} – t _{TRANSPDR})
Bus dominant time-out time	t _{TO(LIN)}	—	25	—	mS	
Duty Cycle 1 @20.0 kbit/sec		.396	—	—	%t _{BIT}	CBUS;R _{BUS} conditions: 1 nF; 1 kΩ 6.8 nF; 660Ω 10 nF; 500Ω T _{HREC} (MAX) = 0.744 x V _{BB} , T _{HDOM} (MAX) = 0.581 x V _{BB} , V _{BB} = 7.0V - 18V; t _{BIT} = 50 μs. D1 = t _{BUS_REC} (MIN) / 2 x t _{BIT})
Duty Cycle 2 @20.0 kbit/sec		—	—	.581	%t _{BIT}	CBUS;R _{BUS} conditions: 1 nF; 1 kΩ 6.8 nF; 660Ω 10 nF; 500Ω T _{HREC} (MAX) = 0.284 x V _{BB} , T _{HDOM} (MAX) = 0.422 x V _{BB} , V _{BB} = 7.6V - 18V; t _{BIT} = 50 μs. D2 = t _{BUS_REC} (MAX) / 2 x t _{BIT})
Duty Cycle 3 @10.4 kbit/sec		.417	—	—	%t _{BIT}	CBUS;R _{BUS} conditions: 1 nF; 1 kΩ 6.8 nF; 660Ω 10 nF; 500Ω T _{HREC} (MAX) = 0.778 x V _{BB} , T _{HDOM} (MAX) = 0.616 x V _{BB} , V _{BB} = 7.0V - 18V; t _{BIT} = 96 μs. D3 = t _{BUS_REC} (MIN) / 2 x t _{BIT})
Duty Cycle 4 @10.4 kbit/sec		—	—	.590	%t _{BIT}	CBUS;R _{BUS} conditions: 1 nF; 1 kΩ 6.8 nF; 660Ω 10 nF; 500Ω T _{HREC} (MAX) = 0.251 x V _{BB} , T _{HDOM} (MAX) = 0.389 x V _{BB} , V _{BB} = 7.6V - 18V; t _{BIT} = 96 μs. D4 = t _{BUS_REC} (MAX) / 2 x t _{BIT})

Note 1: Time depends on external capacitance and load. Test condition: C_{REG} = 4.7uF, no resistor load.

2: For design guidance only, not tested.

2.4 AC Specification (Continued)

AC CHARACTERISTICS		V _{BB} = 6.0V to 18.0V; T _A = -40°C to +125°C				
Parameter	Sym.	Min.	Typ.	Max.	Units	Test Conditions
Voltage Regulator						
Bus Activity Debounce time	t _{BDB}	30	80	250	μs	
Bus Activity to Voltage Regulator Enabled	t _{BACTIVE}	35	—	200	μs	
Voltage Regulator Enabled to Ready	t _{VEVR}	300	—	1200	μs	(Note 1)
Chip Select to Ready Mode	t _{CSR}	—	—	230	μs	(Note 2)
Chip Select to Power-down	t _{CSPD}	—	—	300	μs	(Note 2)
Short circuit to shut-down	t _{SHUTDOWN}	20	—	100	μs	
RESET Timing						
VREG OK detect to RESET inactive	t _{RPU}	—	—	60.0	μs	(Note 2)
VREG not OK detect to RESET active	t _{RPD}	—	—	60.0	μs	(Note 2)

Note 1: Time depends on external capacitance and load. Test condition: C_{REG} = 4.7μF, no resistor load.

2: For design guidance only, not tested.

2.5 Thermal Specifications

THERMAL CHARACTERISTICS					
Parameter	Symbol	Typ.	Max.	Units	Test Conditions
Recovery Temperature	θ _{RECOVERY}	+140	—	°C	
Shutdown Temperature	θ _{SHUTDOWN}	+150	—	°C	
Short Circuit Recovery Time	t _{THERM}	1.5	5.0	ms	
Thermal Package Resistances					
Thermal Resistance, 8-PDIP	θ _{JA}	89.3	—	°C/W	
Thermal Resistance, 8-SOIC	θ _{JA}	149.5	—	°C/W	
Thermal Resistance, 8-QFN	θ _{JA}	48.0	—	°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) θ_{JA}. If this dissipation is exceeded, the die temperature will rise above 150°C and the MCP2025 will go into thermal shutdown.

2.6 Timing Diagrams and Specifications

FIGURE 2-2: BUS TIMING DIAGRAM

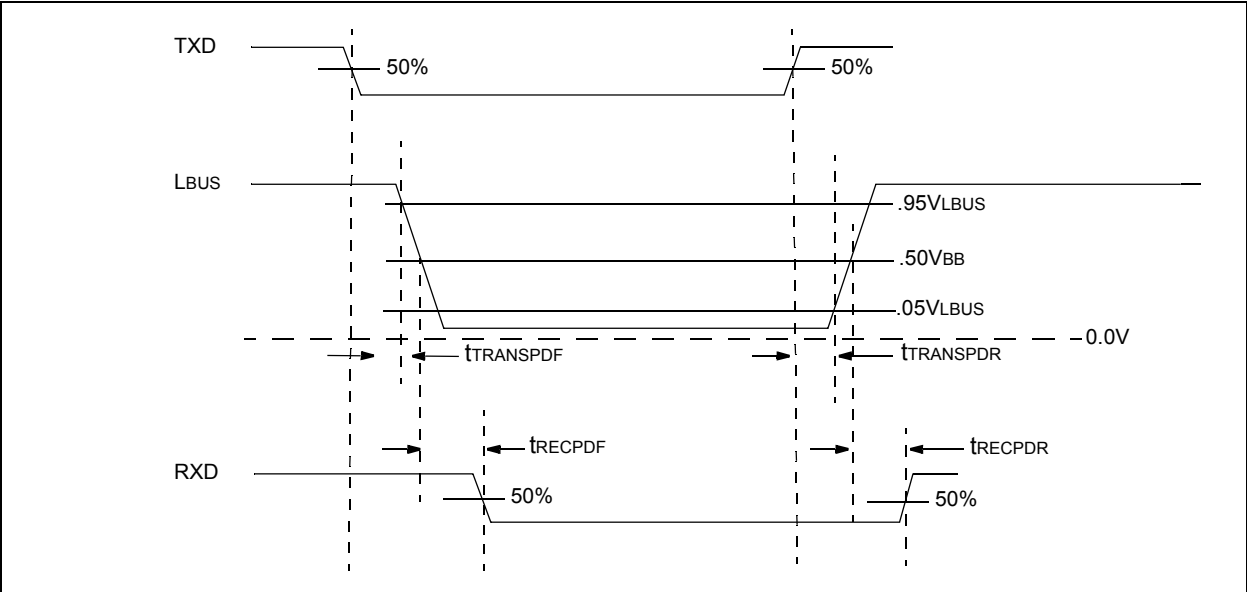


FIGURE 2-3: REGULATOR BUS WAKE TIMING DIAGRAM

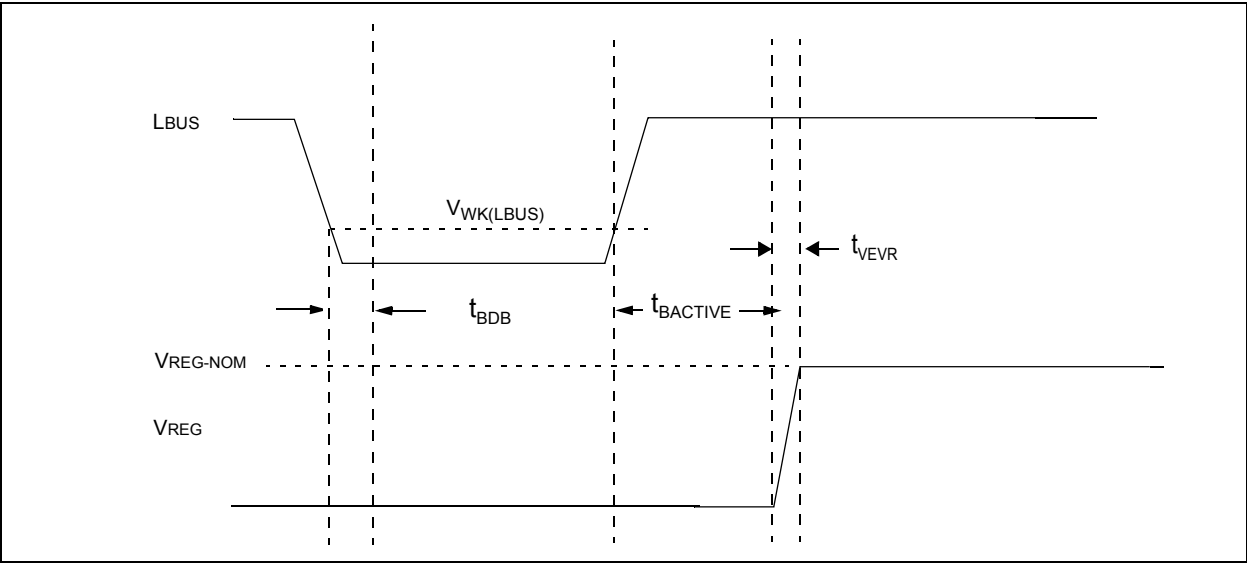


FIGURE 2-4: CS/LWAKE, REGULATOR AND RESET TIMING DIAGRAM

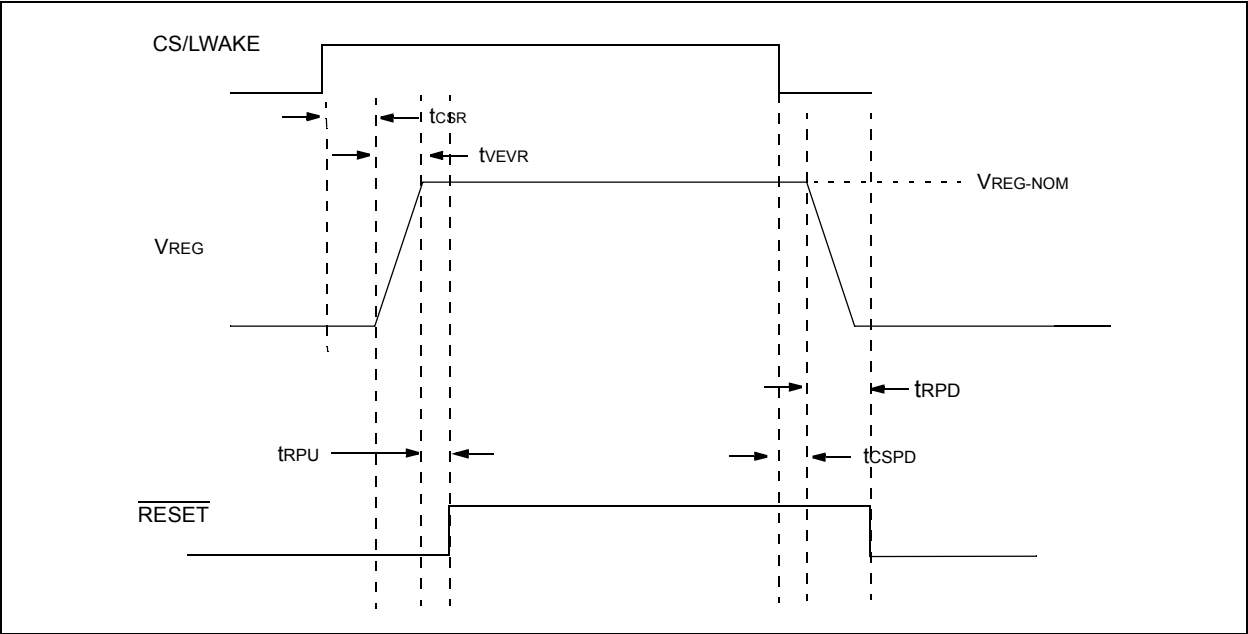


FIGURE 2-5: TYPICAL I_{BBQ} VS. TEMPERATURE - 5.0V

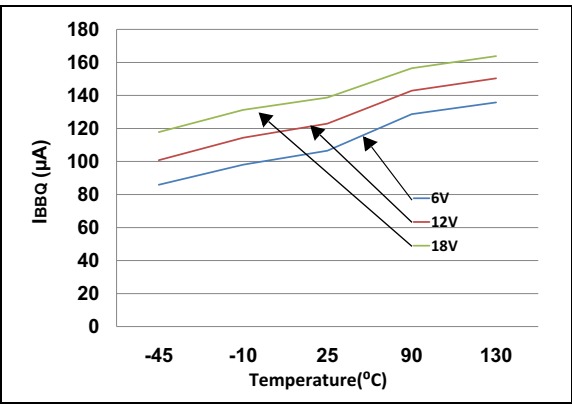


FIGURE 2-7: I_{BBQ} POWER-DOWN VS. TEMPERATURE - 5.0V

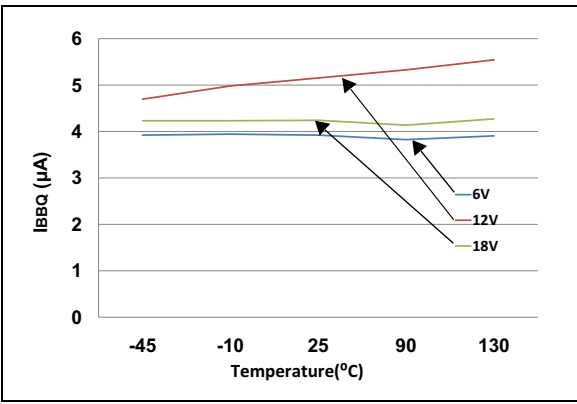


FIGURE 2-6: I_{BBQ} TRANS-OFF VS. TEMPERATURE - 5.0V

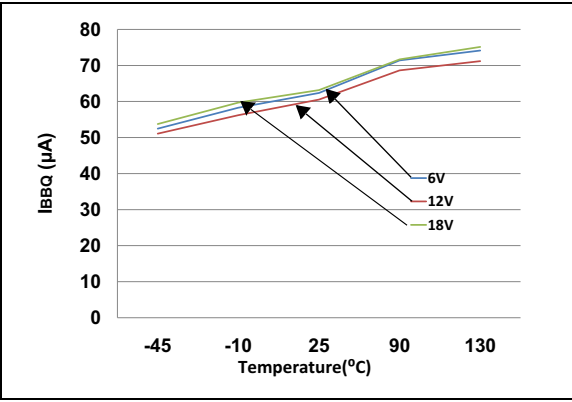


FIGURE 2-8: TYPICAL I_{BBQ}VS. TEMPERATURE - 3.3V

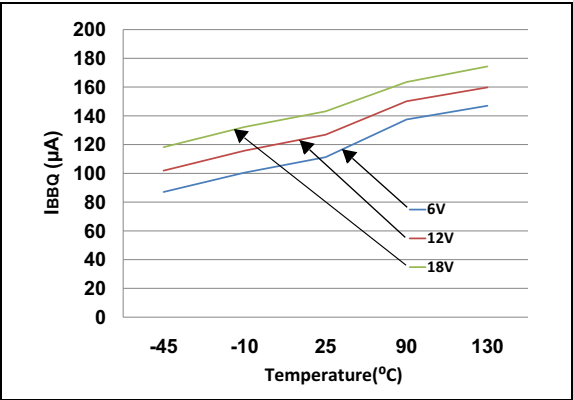


FIGURE 2-10: I_{BBQ} POWER-DOWN VS. TEMPERATURE - 3.3V

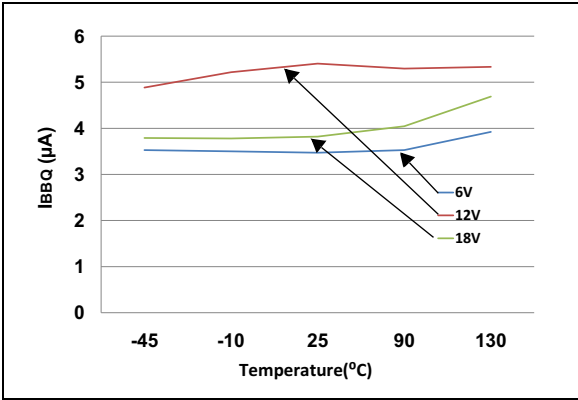
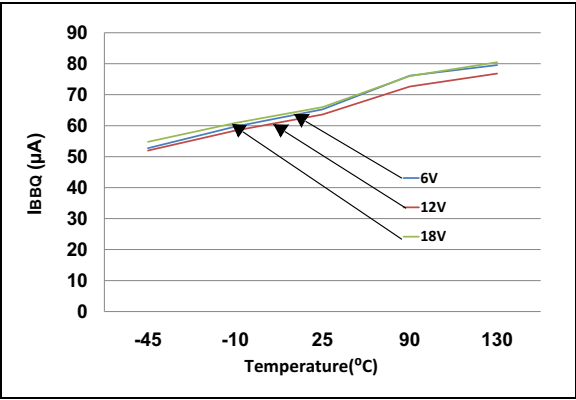


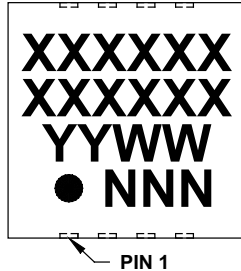
FIGURE 2-9: I_{BBQ} TRANS-OFF VS. TEMPERATURE - 3.3V



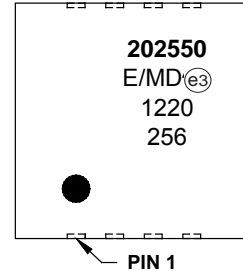
3.0 PACKAGING INFORMATION

3.1 Package Marking Information

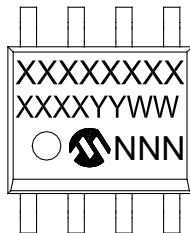
8-Lead DFN (4x4x0.9 mm)



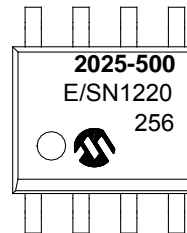
Example



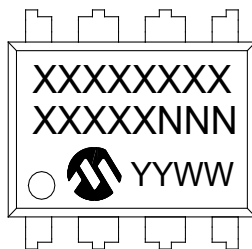
8-Lead SOIC (150 mil)



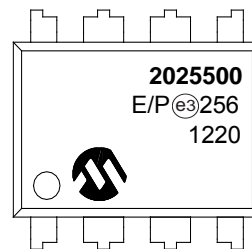
Example:



8-Lead PDIP (300 mil)



Example

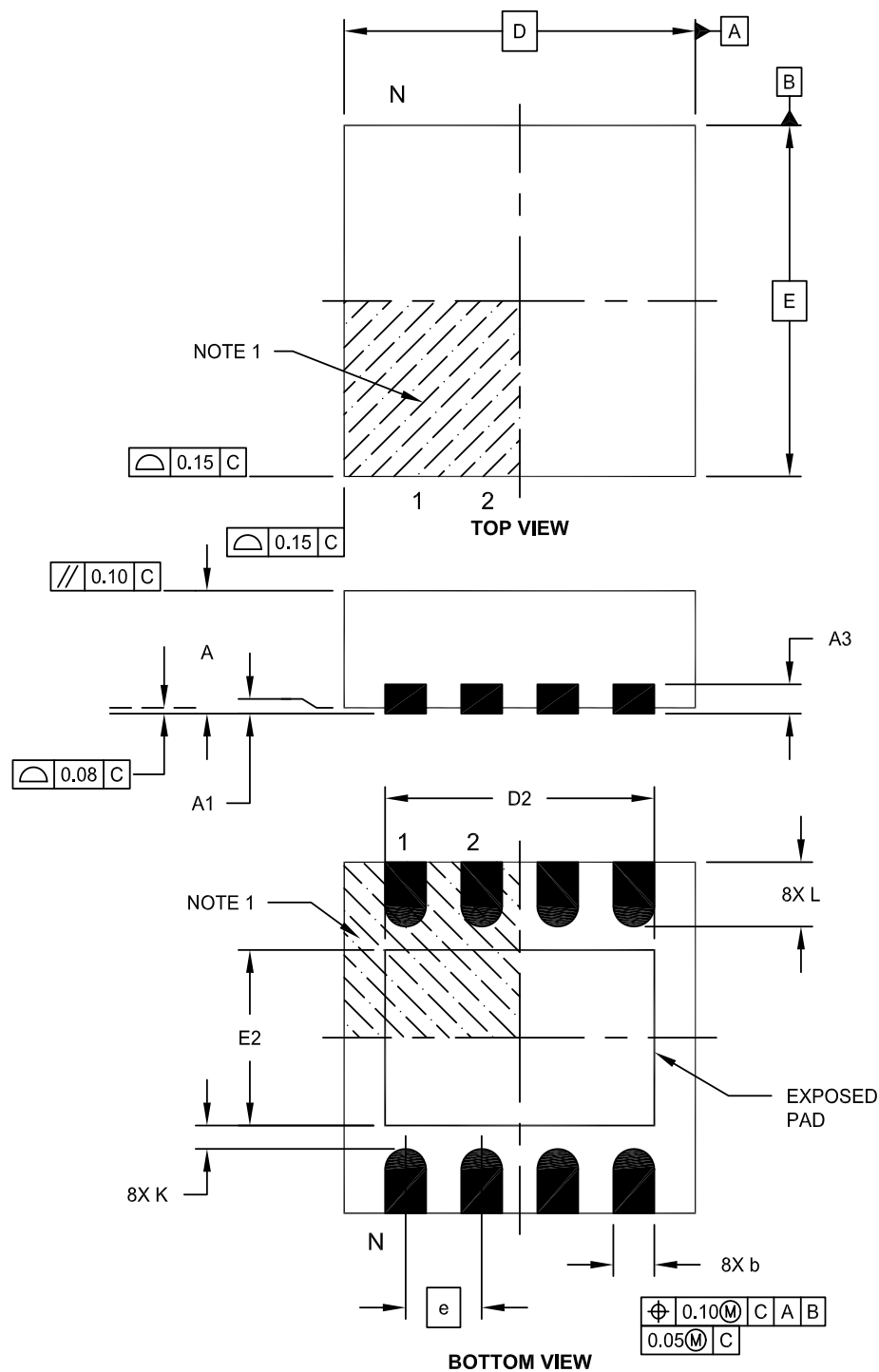


Legend:	XX...X	Customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week '01')
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC designator for Matte Tin (Sn)
	*	This package is Pb-free. The Pb-free 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]

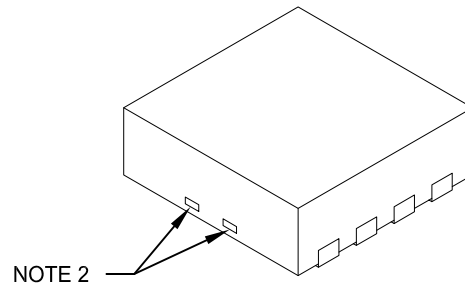
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



Microchip Technology Drawing C04-131E Sheet 1 of 2

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>



Dimension Limits	Units	MILLIMETERS		
		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:

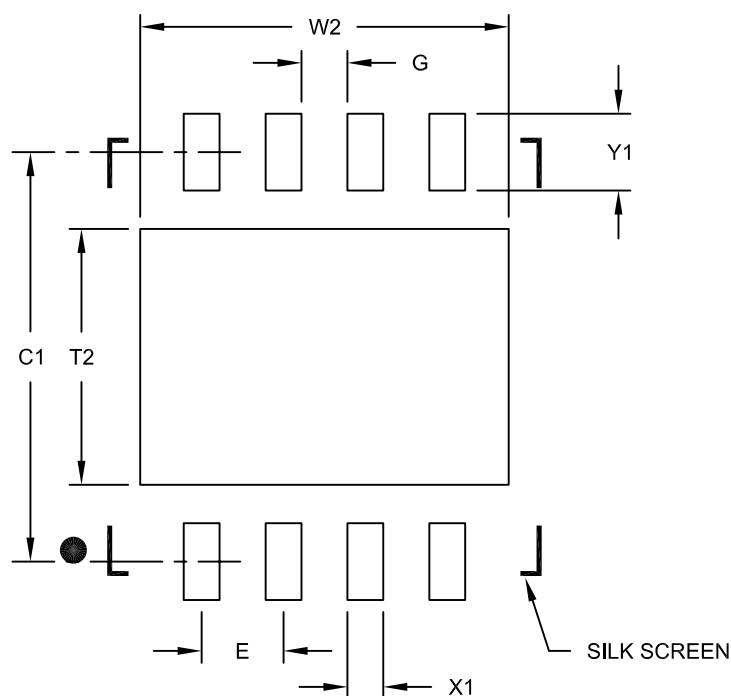
- Pin 1 visual index feature may vary, but must be located within the hatched area.
- Package may have one or more exposed tie bars at ends.
- Package is saw singulated
- Dimensioning and tolerancing per ASME Y14.5M
 - BSC: Basic Dimension. Theoretically exact value shown without tolerances.
 - REF: Reference Dimension, usually without tolerance, for information purposes only.

Microchip Technology Drawing C04-131E Sheet 2 of 2

MCP2025

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:

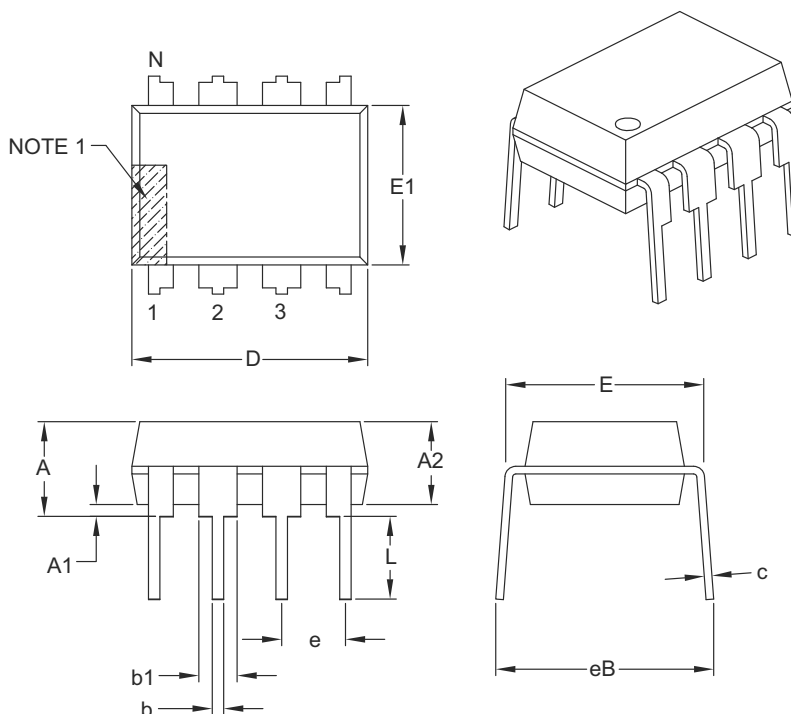
1. Dimensioning and tolerancing per ASME Y14.5M

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

Microchip Technology Drawing No. C04-2131C

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/packageing>



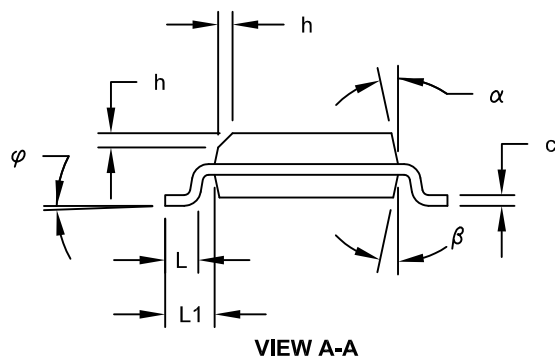
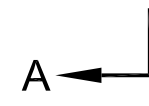
Dimension Limits	Units	INCHES		
		MIN	NOM	MAX
Number of Pins	N	8		
Pitch	e	.100 BSC		
Top to Seating Plane	A	–	–	.210
Molded Package Thickness	A2	.115	.130	.195
Base to Seating Plane	A1	.015	–	–
Shoulder to Shoulder Width	E	.290	.310	.325
Molded Package Width	E1	.240	.250	.280
Overall Length	D	.348	.365	.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:

- Pin 1 visual index feature may vary, but must be located with the hatched area.
- § Significant Characteristic.
- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed .010" per side.
- Dimensioning and tolerancing per ASME Y14.5M.
BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-018B

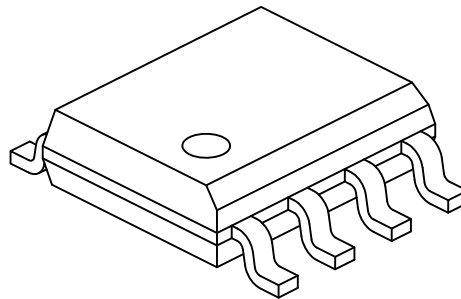
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



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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>



Dimension Limits	Units	MILLIMETERS		
		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:

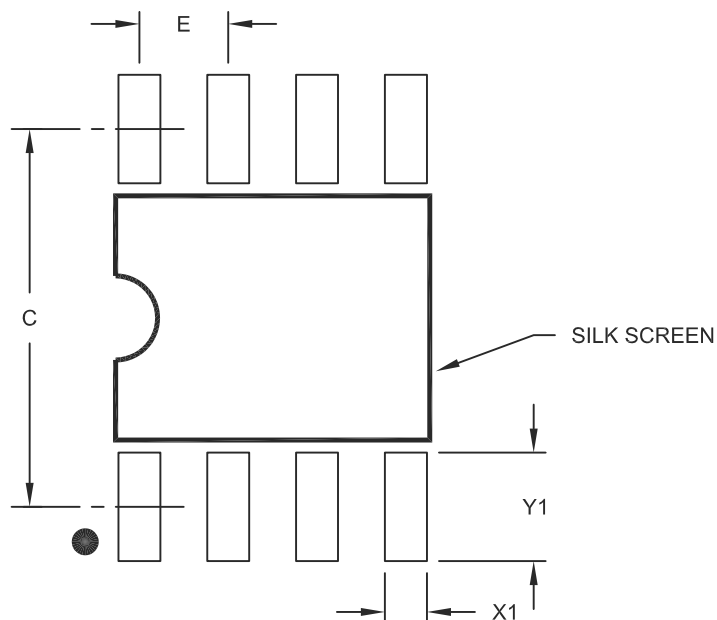
- Pin 1 visual index feature may vary, but must be located within the hatched area.
- § Significant Characteristic
- Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
- Dimensioning and tolerancing per ASME Y14.5M
 - BSC: Basic Dimension.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

MCP2025

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

APPENDIX A: REVISION HISTORY

Revision A (June 2012)

- Original Release of this Document.

NOTES:

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</u>	<u>/XX</u>	Examples:
Device	Temperature Range	Package	
<div>Device: MCP2025: LIN Transceiver with Voltage Regulator MCP2025T: LIN Transceiver with Voltage Regulator (Tape and Reel) (SOIC and DFN only)</div> <div>Temperature Range: E = -40°C to +125°C</div> <div>Package: P = Plastic DIP (300 mil Body), 8-lead SN = Plastic Small Outline SOIC, 8-lead MD = Plastic Dual Flat DFN, 8-lead</div>			<div>a) MCP2025-330E/SN: 3.3V, 8L-SOIC package</div> <div>b) MCP2025-330E/P: 3.3V, 8L-PDIP package</div> <div>c) MCP2025-330E/MD: 3.3V, 8L-DFN package</div> <div>d) MCP2025-500E/SN: 5.0V, 8L-SOIC package</div> <div>e) MCP2025-500E/P: 5.0V, 8L-PDIP package</div> <div>f) MCP2025-500E/MD: 5.0V, 8L-DFN package</div> <div>g) MCP2025T-330E/SN: Tape and Reel, 3.3V, 8L-SOIC package</div> <div>h) MCP2025T-500E/SN: Tape and Reel, 5.0V, 8L-SOIC package</div> <div>i) MCP2025T-330E/MD: Tape and Reel, 3.3V, 8L-DFN package</div> <div>j) MCP2025T-500E/MD: Tape and Reel, 5.0V, 8L-DFN package</div>

NOTES:

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