MOTOROLA
SEMICONDUCTOR
TECHNICAL DATA

MC33388

Prototype Information

CAN Interface

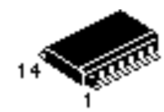
The MC33388 is a CAN physical interface device, dedicated to automotive body electronic multiplexing applications. It operates in differential mode, allowing ground shifts up to 1,5V, reducing RFI disturbances. It offers very low standby current in sleep and standby mode operation, and supports communication speeds up to 125kBauds.

It is fully protected against harsh automotive environments and the driver is able to detect fault conditions and automatically switches into appropriate default mode. Under fault condition, it continuously monitors bus failures in order to switch back to normal bus operation as soon as faults disappeared.

- Dedicated to 12 V systems
- Ambient temperature range from -40°C to 125°C.
- Baud rate from 10 kBaud up to 125kBaud
- Bus line short-circuit protected to battery, VDD and ground
- Thermal protection of bus line drivers
- Automatic switching to single wire mode in case of bus failures and reset to differential mode if bus failures are disappeared
- Supports one wire transmission modes with ground offset up to 1.5V
- Internal bus driver slope control function to minimize RFI
- Bus line protected against transients in an automotive environment
- Very low sleep/standby current (15µA)
- Wake-up capability from bus and dedicated wake-up pin
- Supports unshielded bus wires and up to 32 nodes
- An unpowered node does not disturb the bus lines
- Battery fail flag on NERR output

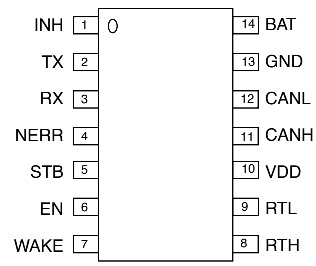
CAN Interface

SILICON MONOLITHIC INTEGRATED CIRCUIT

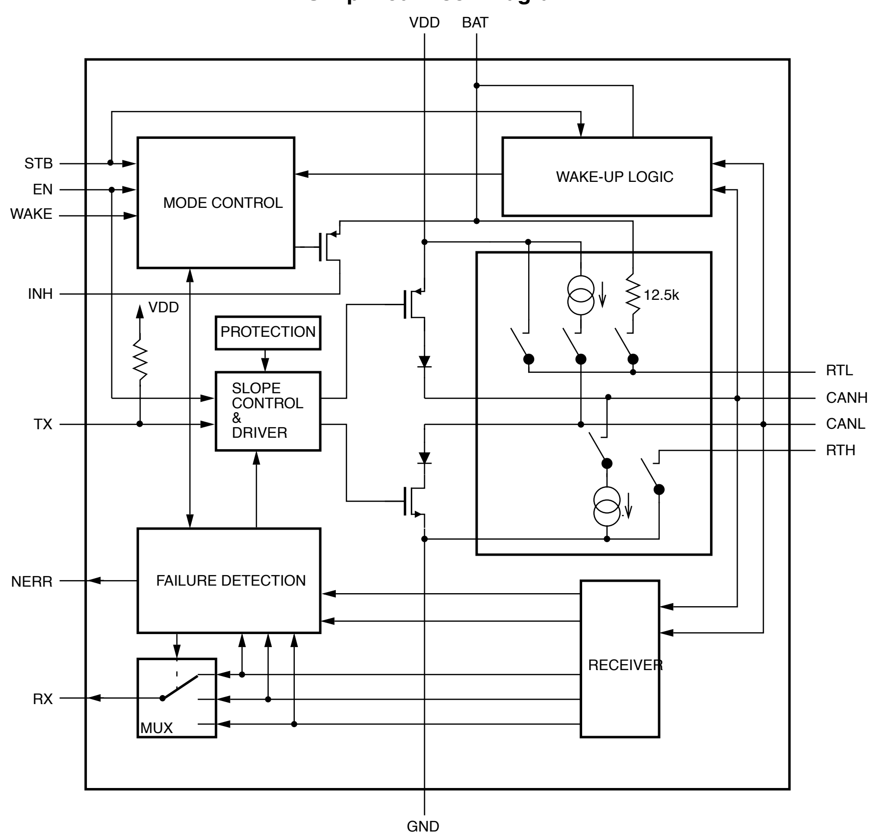


D SUFFIX
PLASTIC PACKAGE
CASE 751A-02
SO-14

PIN CONNECTIONS



Simplified Block Diagram



MAXIMUM RATING

Ratings	Symbol	Min	Typ	Max	Unit
DC supply voltage pin 10	V_{DD}	-0.3		6	V
DC voltage on pins 2, 3, 4, 5, 6 and 7	V_{DD}	-0.3		V_{DD} + 0.3	V
DC voltage on pins 11, 12	V_{BUS}	-10		+27	V
Transient voltage at pins 11, 12 $0 < V_{DD} < 5.5V$; $V_{BAT} \geq 0$; $t < 500ms$	V_{CANH}/V_{CANL}	-40		40	V
Transient voltage on pins 11, 12 (coupled through 1nF capacitor)	V_{tr}	-150		100	V
DC voltage on pin 7	V_{wake}			V_{BAT} +0.3	V
Current in pin 7	I_{wake}	-15			mA
DC voltage on pins 1, 8, 9	V_{rtl}, V_{rth}, V_{inn}	-0.3		V_{BAT} + 0.3	V
DC voltage on pins 14	V_{BAT}	-0.3		27	V
Voltage on pins 14 (Load dump, 500ms)	V_{BAT}			40	V
ESD voltage on any pins (HBM.100pF ; 1.5kΩ)	V_{esc}	-2.0		2.0	kV
ESD voltage on any pins (MM.200pF ; 0Ω)	V_{esc}	-200		200	V
Junction temperature	T_j	-40		150	°C
Storage temperature	T_{stg}	-55		150	°C
RTH, RTL termination resistance	Rt	500		16000	Ω

THERMAL RATINGS

Ratings	Symbol	Value	Unit
Thermal resistance from junction to ambient	$R_{th\ j/a}$	120	°C/W

CHARACTERISTICS V_{DD} = 4,75 to 5,25 ; V_{STB}=VDD ; V_{BAT}=6 to 27V ; T_{amb} = -40 to 125°C unless otherwise specified

Conditions	Symbol	Min	Typ	Max	Unit
SUPPLY					
Supply current (recessive) TX = V_{DD}, normal operating mode	I_{VDD}		2	3	mA
Supply current (dominant) TX = 0V, no load, normal operating mode	I_{VDD}		3.5	5	mA
Supply current (recessive) TX = V_{DD}, normal operating mode	I_{BAT}		190	300	µA
Supply current (receive only) V_{DD} = 5V ; V_{BAT} = 12V ; T_{amb} < 90°C	$I_{VDD} + I_{BAT}$		0.85	1.2	mA
Supply current (VBAT standby) V_{DD} = 5V ; V_{BAT} = 12V ; T_{amb} < 90°C	$I_{VDD} + I_{BAT}$		15	30	µA
Supply current (sleep) V_{DD} = 0V ; V_{BAT} = 12V ; T_{amb} < 90°C	I_{BAT}		12	30	µA
STB, EN, TX Pins					
High level input voltage		0.7*V_{DD}		V_{DD}+0.3V	V

CHARACTERISTICS V_{DD} = 4,75 to 5,25 ; V_{STB}=VDD ; V_{BAT}=6 to 27V ; T_{amb} = -40 to 125°C unless otherwise specified

Conditions	Symbol	Min	Typ	Max	Unit
Low level input voltage		-0.3		0.3 * V_{DD}	V
High level input current (STB, EN) (V_i = 4V)			20	40	µA
Low level input current (STB, EN) (V_i = 1V)		10	20		µA
TX high level input current (V_i = 4V)	I_{TX}	-25	-80	-200	µA
TX low level input current (V_i = 1V)	I_{TX}	-100	-320	-800	µA
Forced V_{BAT} standby mode (Fail Safe)	V_{DD}	3		4.5	V
Battery voltage for setting power on flag	V_{BAT}			4	V
RX, NERR Pins					
High level output voltage NERR (I_0 = -100µA)		V_{DD} - 0.9		V_{DD}	V
High level output voltage RX (I_0 = -250µA)		V_{DD} - 0.9		V_{DD}	V
Low level output voltage (I_0 = 1.5mA)		0		0.9	V
WAKE Pin (must be connected to gnd or BAT if not used)					
Wake up threshold (V_{STB} = 0V)		0.4 V_{BAT}	0.5 V_{BAT}	0.6 V_{BAT}	V
INH Pin					
High level voltage Drop (I_{INH} = -0.2mA)	V_{drop}			0.8	V
Leakage current (Sleep mode ; V_{INH} = 0V)	$I_{l\ inh}$			5	µA
CANH, CANL Pins					
Differential receiver, threshold voltage (by definition, Vdiff=Vcanh-Vcanl)		-3.25		-2.65	V
Differential receiver, dominant to recessive threshold (bus failures 1, 2, 5)		-3.25		-2.65	V
CANH recessive output voltage TX = VDD ; $R_{(RTH)}$ < 4k	V_{CANH}			0.2	V
CANL recessive output voltage TX = VDD ; $R_{(RTL)}$ < 4k	V_{CANL}	V_{DD} - 0.2			V
CANH output voltage, dominant TX = 0V ; I_{CANH} = -40mA ; normal operating mode	V_{CANH}	V_{DD} - 1.4			V
CANL output voltage, dominant TX = 0V ; I_{CANL} = 40mA ; normal operating mode	V_{CANL}			1.4	V
CANH output current (V_{CANH} = 0 ; TX = 0)	I_{CANH}		75	100	mA
CANL output current (V_{CANL} = 14V; TX = 0)	I_{CANL}		95	150	mA
Detection threshold for short-circuit to battery voltage (normal mode)	V_{CANH}, V_{CANL}	7.2	8	8.7	V
Detection threshold for short-circuit to battery voltage (standby/sleep mode)	V_{CANH}	V_{BAT}/2 +3		V_{BAT} /2+5	V
CANH output current (sleep mode ; V_{CANH} = 12V, failure3)			5		µA

CHARACTERISTICS V_{DD} = 4,75 to 5,25 ; V_{STB}=VDD ; V_{BAT}=6 to 27V ; T_{amb} = -40 to 125°C unless otherwise specified

Conditions	Symbol	Min	Typ	Max	Unit
CANL output current (sleep Mode ; V_{CANL} = 0V ; VBAT = 12V, failure4)			0		µA
CANL wake up voltage threshold	$V_{wake,L}$	2.4	3.1	3.8	V
CANH wake up voltage threshold	$V_{wake,H}$	1.2	1.9	2.7	V
Wake up threshold difference	V_{wakeL}-V_{wakeH}	0.2			V
CANH single ended receiver threshold (Failures 4, 6, 7)	V_{CANH}	1.5	1.85	2.15	V
CANL single ended receiver threshold (Failures 3, 8)	V_{CANL}	2.8	3.05	3.4	V
CANL pull up current (Normal mode, failures 4, 6 and 7)	$I_{CANL,pu}$		75		µA
CANH pull down current (Normal mode, failure 3)	$I_{CANH,pd}$		75		µA
Receiver differential input impedance CANH / CANL	R_{diff}	100			kΩ
Differential receiver common mode voltage range	V_{com}	-10		10	V
CANH to ground capacitance	C_{CANH}			50	pF
CANL to ground capacitance	C_{CANL}			50	pF
C_{CANL} to C_{CANH} capacitor difference (Absolute value)	DC_{can}			10	pF

RTH, RTL Pins

Conditions	Symbol	Min	Typ	Max	Unit
RTL to VDD switch on resistance (I_{out} < -10mA ; Normal operating Mode)	R_{rtl}		25	50	Ω
RTL to BAT switch series resistance (VBAT Standby mode or sleep mode)	R_{rtl}	8	12.5	23	kΩ
RTH to ground Switch On resistance (I_{out} <10mA ; Normal operating mode)	R_{rth}		25	50	Ω

Thermal Shutdown

Conditions	Symbol	Min	Typ	Max	Unit
Shutdown Temperature	T_{sd}		165		°C

AC Characteristics

Conditions	Symbol	Min	Typ	Max	Unit
CANL and CANH slew rates (10% to 90%). Rising or falling edges		3.5	5	6.5	V/µs
Propagation delay TX to RX low (C_{load} = 10nF)	T_{pdlow}		1	2	µs
Propagation delay TX to RX high (C_{load} = 10nF)	T_{pdhigh}		1	2	µs
Min. dominant time for wake-up on CANL or CANH (low power modes ; V_{BAT} = 12V)	T_{wake}	8		38	µs
Min. WAKE time for wake-up (low power modes ; V_{BAT}= 12V)	T_{wake}	8		38	µs
Failure 3 detection time (Normal mode)		10		60	µs
Failure 6 detection time (Normal mode)		50		400	µs
Failure 3 recovery time (Normal mode)		10		60	µs
Failure 6 recovery time (Normal mode)		150		1000	µs

CHARACTERISTICS V_{DD} = 4,75 to 5,25 ; V_{STB}=VDD ; V_{BAT}=6 to 27V ; T_{amb} = -40 to 125°C unless otherwise specified

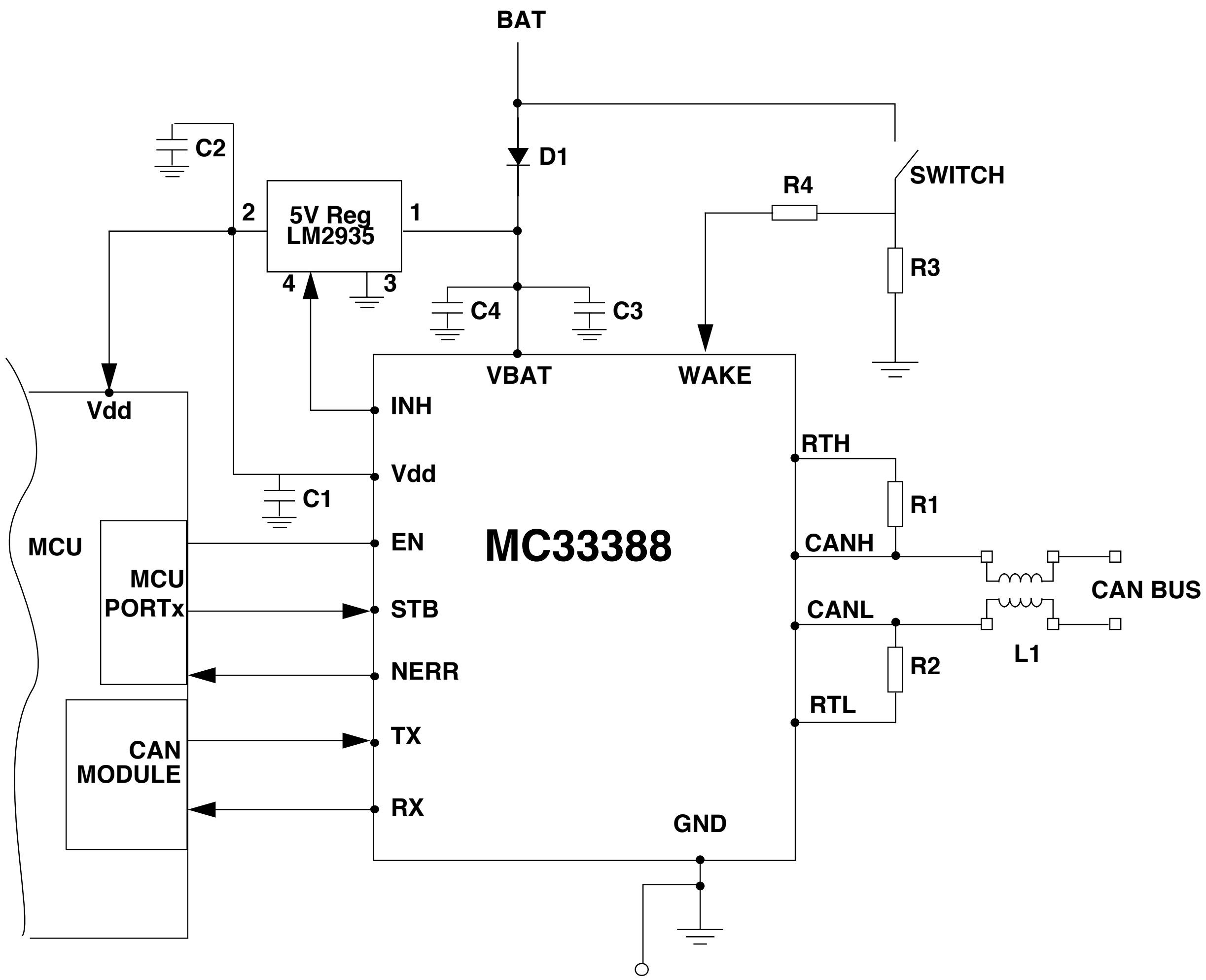
Conditions	Symbol	Min	Typ	Max	Unit
Failure 4, 7, 8 detection time (Normal mode)		0.75		4	ms
Failure 4, 7, 8 recovery time (Normal mode)		10		60	µs
Failure 3, 4, 7 detection time (Low Power Modes ; V_{BAT} = 12V)		0.8		8	ms
Failure 3, 4, 7 recovery time (Low Power Modes ; V_{BAT} = 12V)			2.5		ms
Min. holdtime go to sleep command		4		38	µs
Edge count difference between CANH and CANL for failures 1, 2, 5 detection (NERR becomes Low) (Normal Mode)			3		
Edge count difference between CANH and CANL for failures 1, 2, 5 recovery (Normal Mode)			3		
TX permanent dominant timer disable time (Normal mode and Failure mode)	$t_{TX,d}$	0.75		4	ms

TRUTH TABLE

<table>
<tr><th>STB</th><th>EN</th><th>Mode</th><th>INH</th><th>NERR</th><th>RX</th><th>RTL</th></tr>
<tr><td>0</td><td>0</td><td>VBAT Standby[1]</td><td>High</td><td colspan="2" rowspan="3">Active LOW wake-up interrupt signal if V_{DD} is present</td><td>Switched to V_{BAT}</td></tr>
<tr><td>0</td><td>0</td><td>Sleep[2]</td><td>Floating</td><td>Switched to V_{BAT}</td></tr>
<tr><td>0</td><td>1</td><td>Go to sleep command</td><td>Floating</td><td>Switched to V_{BAT}</td></tr>
<tr><td>1</td><td>0</td><td>Receive only[3]</td><td>High</td><td>Active LOW V_{BAT} power-on flag</td><td rowspan="2">High=receive ; Low=dominant received data</td><td>Switched to V_{DD}</td></tr>
<tr><td>1</td><td>1</td><td>Normal operation mode</td><td>High</td><td>Active LOW error flag</td><td>Switched to V_{DD}</td></tr>
</table>

NOTES:
1. Wake-up interrupts are released when entering normal operating mode.
2. If go to sleep command was used before (EN may turn LOW as Vdd drops, without affecting internal functions because of fail safe functionality.
3. VBAT power-on flag will be reset when entering normal operation mode.

Figure 1. Application Schematic



Components Value :

R1=R2=R ; R / nb of nodes > 133Ω
R3 : TBD
R4 : 22KΩ
500Ω<R<16kΩ

L1 : optional
C1=100nF
C2>4.7uF
C3=100nF
C4>10uF
D1=1N4007 type

DEVICE DESCRIPTION

Introduction

The MC33388 is a CAN physical interface device, dedicated to automotive body electronic multiplexing applications. It operates in differential mode, allowing ground shifts up to 1,5V, reducing RFI disturbance. It offers very low standby current in sleep and standby mode operation, and supports communication speeds up to 125kBauds.

It is fully protected against harsh automotive environments and the driver is able to detect fault conditions and automatically switches into appropriate default mode. Under fault condition, it continuously monitors bus failure in order to switch back to normal bus operation as soon as faults disappeared.

Bus line slew rates are controlled in order to minimize the RFI, and this allows use of unshielded cables for the bus. In normal operation (no bus failures), RX is the image of the differential bus state. The differential receiver inputs are connected to CANH and CANL through integrated filters. The filtered input signals are also used for the single wire receivers.

The CANH and CANL receivers have threshold voltages that assure maximum noise margin in single wire modes.

Failure Detector

The failure detector is active in normal operation mode and in Receive_only mode. It detects the following single bus failures and switches to an appropriate mode.

- Failure # 1: CANH wire interrupted
- Failure # 2: CANL wire interrupted
- Failure # 3: CANH short-circuited to battery
- Failure # 4: CANL short-circuited to ground
- Failure # 5: CANH short-circuited to ground
- Failure # 6: CANL short-circuited to battery
- Failure # 7: CANL mutually shorted to CANH
- Failure # 8: CANH short-circuited to V_{DD}

The differential receiver threshold is set at -2,8V. This assures a proper reception in the normal operating modes and in case of failures 1, 2 and 5 with noise margin as high as possible. These failures or recovery from them, do not destroy ongoing transmissions.

Failures 3 and 6 are detected by comparators respectively connected to CANH and CANL. If the comparator threshold is exceeded for a certain time, the reception is switched to single wire mode. This time is needed to avoid false triggering by external RF fields. Recovery from these failures is detected automatically after a certain time-out (filtering) and no transmission is lost.

Failures 4, 7 and 8 initially result in a permanent dominant level at the internal comparator outputs. If failure 4 and 7 appear, the CANL driver and the RTL pin are switched off after a time out, only a weak pull up at RTL remains. Reception continues by switching to single wire mode through CANH. When the failures 4 or 7 are removed, the recessive bus levels are restored. If the receiver voltages remain in the recessive state for a certain time, reception and transmission switch back to the differential mode.

If the internal logic recognizes failure 8, the CANH driver is switched off after a time out and the reception is switched to single wire mode through CANL. If the receiver voltages remain in the recessive state for a certain time, reception and transmission switch back automatically to the differential mode.

If any of the 8 wiring failure occurs, the output NERR will be made low. On error recovery, NERR will be made high again.

During all single wire transmissions, the EMC performance (both immunity and emission) is worse than in differential mode. Integrated receiver filters suppress any HF noise induced into the bus wires. The cut-off frequency of these filters is a compromise between propagation delay and HF suppression. In single wire mode, low frequency noise can not be distinguished from the wanted signal.

In the event of a permanent dominant TX state (for more than 2ms) the output drivers are disabled. That assures the operation of the complete system in case of a permanent dominant TX state of one control unit. A defect control unit autonomous go to receive only mode.

Low power modes

The transceiver provides 3 low power modes which can be entered and exited by STB and EN.

The mode with the lowest power consumption is the sleep mode. The INH pin is switched to high impedance for desactivation of external voltage regulators. CANL is biassed to the battery voltage via the RTL output. If the VDD voltage is provided, the RX and NERR will signal the wake-up interrupt.

The VBAT standby mode will react the same as the sleep mode with an active INH output.

In the receive only mode, the transmitter is disabled but the receive part of the device remains active. In this mode, NERR output signals the VBAT power-on flag and RX reports bus activity. Failure detection and management is the same as normal mode.

Wake-up requests are recognized by the transceiver, either when a dominant state is detected on either bus lines (remote wake-up) or if the WAKE pin changes its state (local wake-up). Under power-up conditions when VBAT is superior to 5V, the state voltage on the WAKE pin is considered to be the reference state for the wake-up function. On leaving normal mode, the current WAKE pin state becomes the new reference state.

On a wake-up request the transceiver will set the INH output which can be used for activation the external VDD voltage regulator. If VDD is provided the wake-up request can be read on the NERR or RX outputs by the microcontroller.

To prevent false wake-up due to transients or RF fields, wake-up threshold levels have to be maintained for a certain time. In the low power modes, failure detection circuit remains partly active to prevent increased power consumption in cases of error 3, 4 and 7.

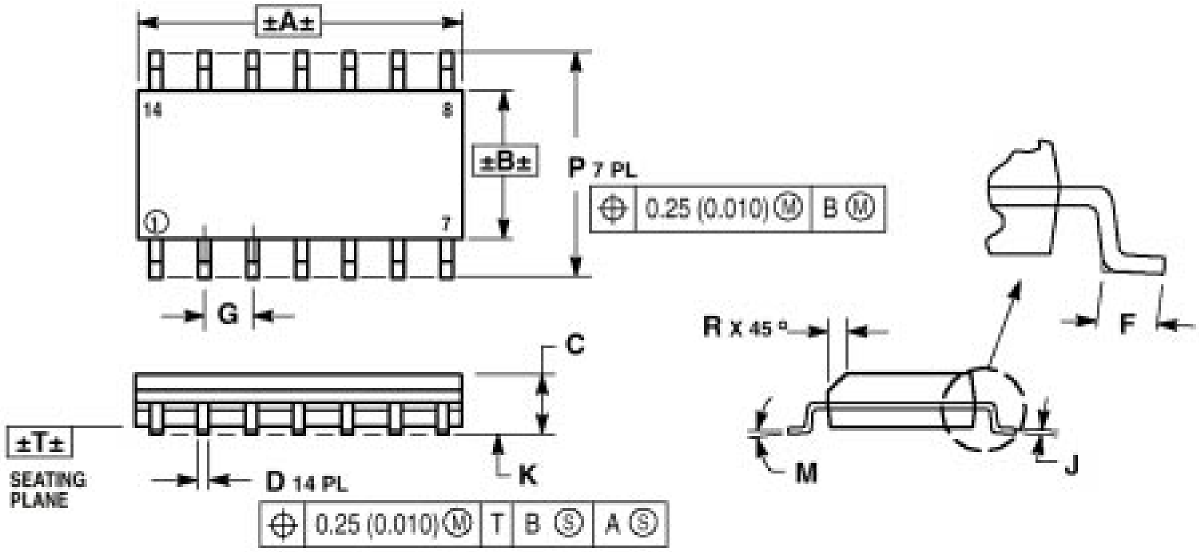
Power on

After the power VBAT is switched on the INH pin will become high and an internal power-on flag will be set. This flag can be read via the NERR pin (STB=1, EN = 0) and will be reset by entering normal operation mode.

The EN and STB will internally be set to low level if the V_{DD} voltage is below a certain threshold to provide fail safe functionality.

Protection

A current limiting circuit protects the transmitter output stages against short-circuit to positive and negative battery voltage. If the junction temperature exceeds a maximum value, the transmitter output stages are disabled. Because the transmitter is responsible for the major part of the power dissipation, this will result in a reduced power dissipation and hence a lower chip temperature. All other parts of the circuit will remain operating.



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	8.55	8.75	0.337	0.344
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0°	7°	0°	7°
P	5.80	6.20	0.228	0.244
R	0.25	0.50	0.010	0.019