



# Automotive ISO 9141 Serial Link Driver

The MC33199 is a serial interface circuit used in diagnostic applications. It is the interface between the microcontroller and the special K and L lines of the ISO diagnostic port. The MC33199 has been designed to meet the «Diagnosis System ISO9141» specification.

The device has a bi-directional bus K line driver, fully protected against short circuits and over temperature. It also includes the L line receiver, used during the wake up sequence in the ISO transmission.

The MC33199 has a unique feature which allow transmission Baud rate up to 200kBaud.

## Features

- Electrically Compatible with Specification “Diagnosis System ISO9141”
- Transmission speed up to 200kBaud
- Internal Voltage Reference Generator for Line Comparator Thresholds
- TXD, RXD and LO pins are 5V CMOS Compatible
- High Current Capability of DIA pin (K line)
- Short Circuit Protection for the K Line Input
- Over Temperature Shutdown with Hysteresis
- Large Operating Range of Driver Supply Voltage
- Large Operating Temperature Range
- ESD Protected pins
- Pb-Free Packaging Designated by Suffix Code EF

**33199**

**LIN, ISO-9141 J-1850 PHYSICAL INTERFACES**



ORDERING INFORMATION		
Device	Temperature Range (T <sub>A</sub> )	Package
MC33199D	-40°C to 125°C	14 SOIC
MCZ33199EF/R2		

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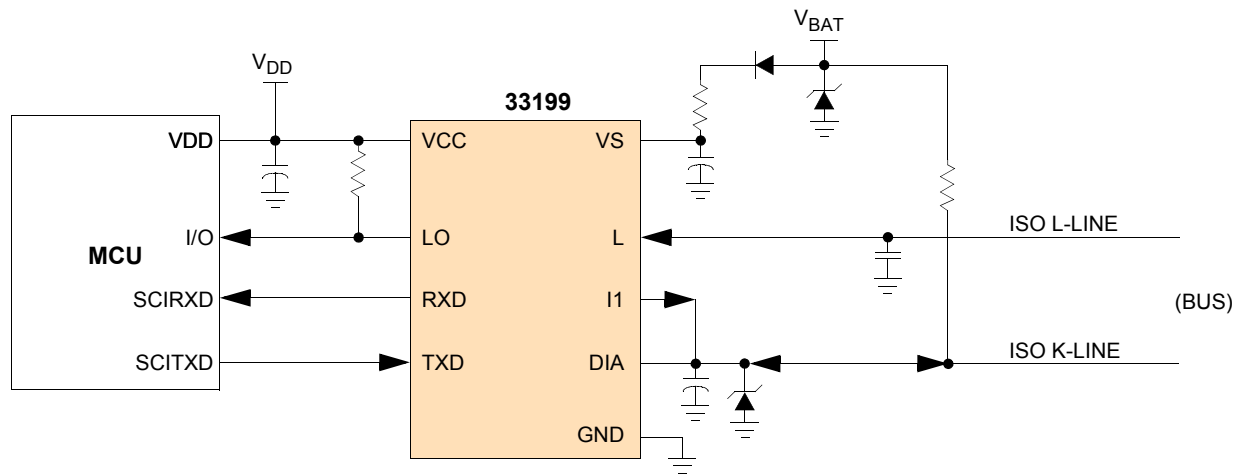


Figure 1. Simplified Application Diagram

### INTERNAL BLOCK DIAGRAM

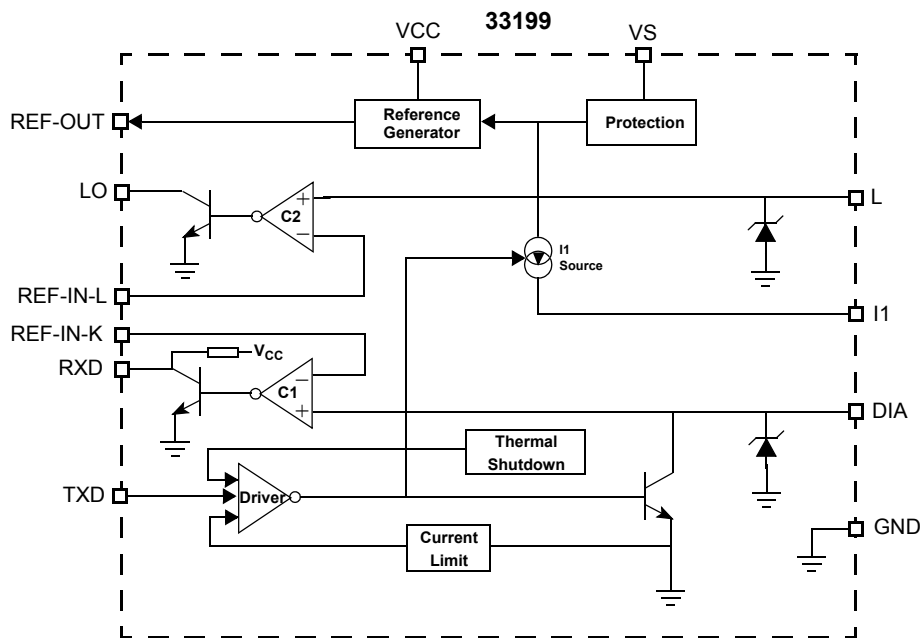
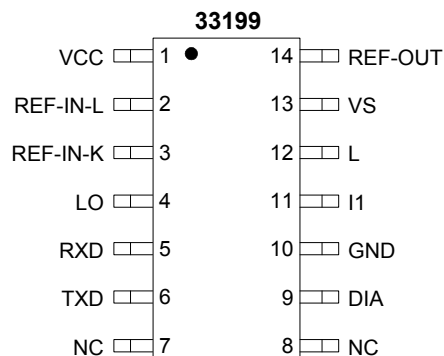


Figure 2. 33199 Simplified Internal Block Diagram

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## PIN CONNECTIONS



**Figure 3. 33199 Pin Connections**

**Table 1. Pin Definitions**

A functional description of each pin can be found in the Functional Pin Description section, beginning on page [12](#).

Pin Number	Pin Name	Definition
1	VCC	5V typical power supply pin. typical supply current is less than 1.5mA
2	REF-IN-L	Input reference for C2 comparator.
3	REF-IN-K	Input reference for C1 comparator.
4	LO	This pin control Sleep Mode, Transmit Level, and Speed. It has a weak pulldown.
5	RXD	Open drain output of the data on BUS. A recessive bus = a logic [1], a dominant bus = logic [0]. An external pullup is required.
6	TXD	Data input here will appear on the BUS pin. A logic [0] will assert the bus, a logic [1] will make the bus go to the recessive state.
7, 8	NC	No internal connection to these pins.
9	DIA	Provides a battery-level logic signal.
10	GND	Electrical Common Ground and Heat removal. A good thermal path will also reduce the die temperature.
11	I1	Power input. An external diode is needed for reverse battery protection.
12	L	The external bus load resistor connects here to prevent bus pullup in the event of loss of module ground.
13	VS	This pin connects to the bus through external components.
14	REF-OUT	Internal reference voltage generator output pin.

## ELECTRICAL CHARACTERISTICS

### MAXIMUM RATINGS

**Table 2. Maximum Ratings**

All voltages are with respect to ground unless otherwise noted. Exceeding these ratings may cause a malfunction or permanent damage to the device.

Ratings	Symbol	Value	Unit
<b>ELECTRICAL RATINGS <sup>(1)</sup></b>			
VS Supply Pin	$V_S$	0.5 to + 40	V
DC Voltage Range			
Transient Pulse <sup>(2)</sup>	$V_{PULSE}$	2 to + 40	
VCC Supply DC Voltage Range	$V_{CC}$	0.3 to + 6.0	V
<b>DIA and L Pins <sup>(2)</sup></b>			
DC Voltage Range		- 0.5 TO + 38	V
Transient Pulse (clamped by internal diode)		-2	V
DC Source Current		- 50	mA
DIA Low Level Sink Current		INT. LIMIT	mA
TXD DC Voltage Range		-0.3 TO $V_{CC} + 0.3$	V
<b>REF-IN DC Voltage Range</b>			
VS < VCC		-0.3 TO $V_{CC}$	V
VS > VCC		-0.3 TO $V_S$	
ESD Voltage Capability	$V_{ESD}$	+/-2000	V
<b>THERMAL RATINGS</b>			
Storage Temperature	$T_{STG}$	55 to + 150	°C
Operating Junction Temperature	$T_J$	40 to + 150	°C
Thermal Resistance, Junction to air	$R_{TJA}$	180	C/W
Max Power Dissipation (@ $T_A=105$ °C)	$P_D$	250	mW
Peak Package Reflow Temperature During Reflow <sup>(3), (4)</sup>	$T_{PPRT}$	Note 4.	°C

**Notes**

- The device is compatible with Specification: "Diagnosis System ISO9141"
- See the test Circuit ([Figure 26](#)). Transient test pulse according to ISO76371 and DIN 40839, highest test levels
- Pin soldering temperature limit is for 10 seconds maximum duration. Not designed for immersion soldering. Exceeding these limits may cause malfunction or permanent damage to the device.
- Freescale's Package Reflow capability meets Pb-free requirements for JEDEC standard J-STD-020C. For Peak Package Reflow Temperature and Moisture Sensitivity Levels (MSL), Go to [www.freescale.com](http://www.freescale.com), search by part number [e.g. remove prefixes/suffixes and enter the core ID to view all orderable parts. (i.e. MC33xxx enter 33xxx), and review parametrics.

### STATIC ELECTRICAL CHARACTERISTICS

**Table 3. Static Electrical Characteristics**

Characteristics noted under conditions  $V_{CC}$  from 4.5V to 5.5V,  $V_S$  from 4.5V to 20V unless otherwise note. Typical values reflect approximate mean at 25°C, nominal VCC and VS, at time of device characterization. Typical values noted reflect the approximate parameter means at  $T_A = 25^\circ\text{C}$  under nominal conditions unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
<b>VCC PIN 1</b>					
VCC Supply Voltage Range	$V_{CC}$	4.5		5.5	V
VCC Supply Current <sup>(6)</sup>	$I_{CC}$	0.5	1.0	1.5	V
<b>REF-IN-L PIN 2 AND REF-IN-K PIN 3</b>					
REF-IN-L & REF-IN-K Input Voltage Range: for $0 < V_S < V_{CC}$ for $V_{CC} < V_S < 40V$	$V_{INREF}$	2.0 2.0		$V_{CC} - 2.0$ $V_S - 1.0$	V
REF-IN-L & REF-IN-K Inputs Currents	$I_{VIN}$	-5.0		5.0	$\mu\text{A}$
<b>LO PIN 4</b>					
LO open Collector Output Low Level Voltage @ $I_{OUT} = 1\text{mA}$ Low Level Voltage @ $I_{OUT} = 4\text{mA}$	$V_{OL}$		0.34	0.7 0.8	V
<b>RXD PIN 5</b>					
Pull up resistor to VCC	$R_{RXD}$	1.5	2.0	2.5	$k\Omega$
Low Level Voltage @ $I_{OUT} = 1\text{mA}$	$V_{OL}$		0.3	0.7	V
<b>TXD PIN 6</b>					
High Level Input Voltage	$V_{IH}$	$0.7V_{CC}$	2.8		V
Low Level Input Voltage	$V_{IL}$		2.0	$0.3V_{CC}$	V
Input Current @ $0 < V_S < 40V$ TXD at High Level TXD at Low Level	$I_H$ $I_L$	-200 -600		30 -100	$\mu\text{A}$
<b>DIA INPUT / OUTPUT PIN 9</b>					
Low Level Output Voltage @ $I = 30\text{mA}$	$V_{OL}$	0.0	0.35	0.8	V
Drive Current Limit	$I_{LIM}$	40		120	mA
High Level Input Threshold Voltage (REF-IN-K connected to REF-OUT)	$V_{IH}$	$V_{REF MIN}$ 0.25V	$V_{REF}$ 0.325V	$V_{REF MAX}$ 0.4V	V
Low Level Input Threshold Voltage (REF-IN-K connected to REF-OUT)	$V_{IL}$	$V_{REF MIN}$ -0.2V	$V_{REF}$ -0.125V	$V_{REF MAX}$ -0.05V	V
Input Hysteresis	$V_{HYST}$	300	450	600	mV
Leakage Current	$I_{LEAK}$	4.0	10	16	$\mu\text{A}$
Over temperature Shutdown	$T_{LIM}$	155			$^\circ\text{C}$

**Notes**

5. Measured with TXD=Vcc, I1=Vs, DIA & L high, no load, REF-IN-L and REF-IN-K connected to REF-OUT

**Table 3. Static Electrical Characteristics (continued)**

Characteristics noted under conditions  $V_{CC}$  from 4.5V to 5.5V,  $V_S$  from 4.5V to 20V unless otherwise note. Typical values reflect approximate mean at 25°C, nominal VCC and VS, at time of device characterization. Typical values noted reflect the approximate parameter means at  $T_A = 25^\circ\text{C}$  under nominal conditions unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
<b>L INPUT PIN 12</b>					
High Level Input Threshold Voltage (REF-IN-L connected to REF-OUT)	$V_{IH}$	$V_{REF\ MIN}$ 0.25V	$V_{REF}$ 0.325V	$V_{REF\ MAX}$ 0.4V	V
Low Level Input Threshold Voltage (REF-IN-L connected to REF-OUT)	$V_{IL}$	$V_{REF\ MIN}$ -0.2V	$V_{REF}$ -0.125V	$V_{REF\ MAX}$ -0.05V	V
Input Hysteresis	$V_{HYST}$	300	450	600	mV
Leakage Current	$I_{LEAK}$	4.0	10	16	$\mu\text{A}$
<b>L1 INPUT PIN 11</b>					
Static Source Current	$I_{1S}$	-4.0	-3.0	-2.0	mA
Static Saturation Voltage @ $I_{1S}=-2\text{mA}$	$V_{I1SAT}$	$V_S - 1.2$	$V_S - 0.8$	$V_S$	V
Dynamic Source Current	$I_{1D}$	-120	-80	-40	mA
Dynamic Saturation Voltage @ $I_{1S}=-40\text{mA}$	$V_{I1DSAT}$	$V_S - 2.7$	$V_S - 0.85$	$V_S$	V
<b>VS PIN 13</b>					
VS Supply Voltage Range	$V_S$	4.5		20	V
VS Supply Current	$I_S$	0.5	1.3	2.0	mA
<b>REF-OUT PIN 14</b>					
Output Voltage : @ $3 < V_S < 5.6\text{V}$ & $I_{RO} = +10\mu\text{A}$ @ $5.6 < V_S < 18\text{V}$ & $I_{RO} = +10\mu\text{A}$ @ $18 < V_S < 40\text{V}$ & $I_{RO} = +10\mu\text{A}$	$V_{REF}$	2.7 $0.5 \times V_S$ 8.5		3.3 $0.56 \times V_S$ 10.8	V
Maximum output current	$I_{OUT}$	-50		50	$\mu\text{A}$
Pull-up resistor to VCC	$R_{PU}$	3.0	8.0	12	$\text{k}\Omega$

6. Measured with TXD=VCC, I1=VS, DIA & L high, no load, REF-IN-L and REF-IN-K connected to REF-OUT

### DYNAMIC ELECTRICAL CHARACTERISTICS

**Table 4. Dynamic Electrical Characteristics**

Characteristics noted under conditions  $V_{CC}$  from 4.5V to 5.5V,  $V_S$  from 4.5V to 20V unless otherwise noted. Typical values noted reflect the approximate parameter means at  $T_A = 25^\circ\text{C}$  under nominal conditions unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
<b>DELAY TIMING</b>					
Transmission Speed	1/T BIT	0.0		200k	Baud
High or Low Bit Time	T BIT	5.0			$\mu\text{s}$
Rxd Output :					ns
Low to High Transition Delay Time	$t_{RDR}$			450	
High to Low Transition Delay Time	$t_{DRF}$			450	
LO Output :					$\mu\text{s}$
Low to High Transition Delay Time	$t_{LDR}$			2.0	
High to Low Transition Delay Time	$t_{LDF}$			2.0	
DIA Output :					ns
Low to High Transition Delay Time	$t_{DDR}$			650	
High to Low Transition Delay Time	$t_{DDF}$			650	
I1 Output @ $V_S - I1 > 2.7V$ :					$\mu\text{s}$
Rise time	$t_{1R}$			0.3	
Hold Time	$t_{1F}$	1.5		4.5	

TIMING DIAGRAMS

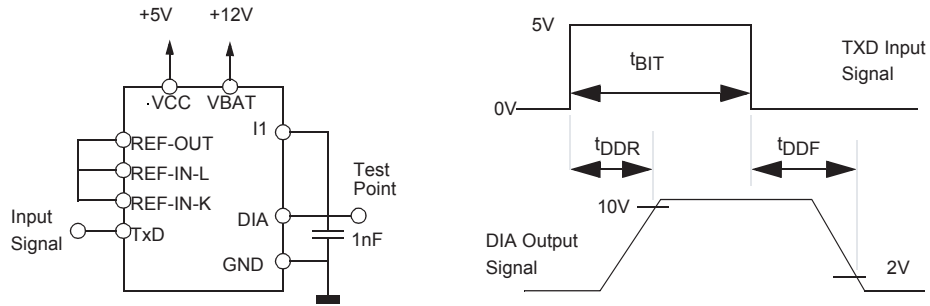


Figure 4. TXD to DIA AC Characteristic

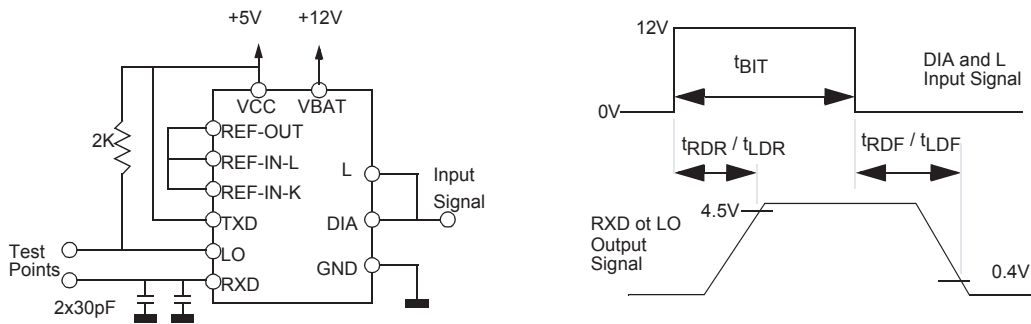


Figure 5. DIA to TxD and L to LO AC Characteristics

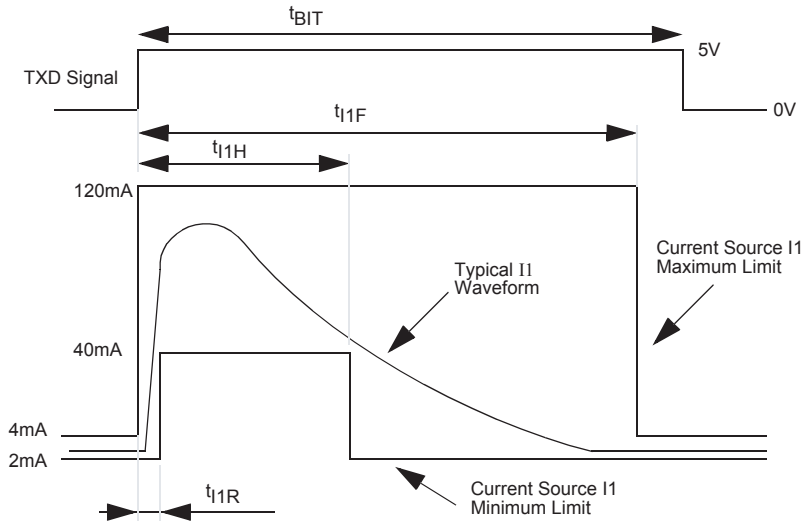


Figure 6. Current Source I1 AC Characteristics

At static HIGH or LOW level TXD, the current source I1 delivers a current of 3mA (typ). Only during LOW to HIGH transition, does this current increase to a higher value in order to charge the K Line capacitor ( $C_k < 4nF$ ) in a short time.

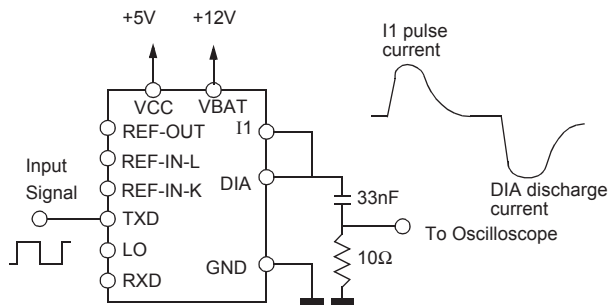


Figure 7. Current Source I1 and DIA Discharge current test schematic

**ELECTRICAL PERFORMANCE CURVES**

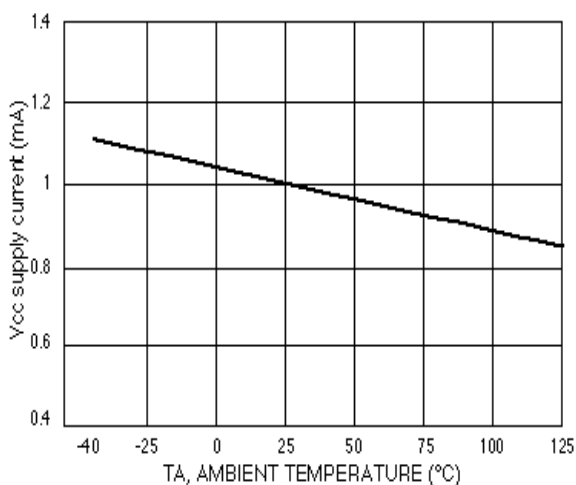


Figure 8. ICC Supply Current versus Temperature

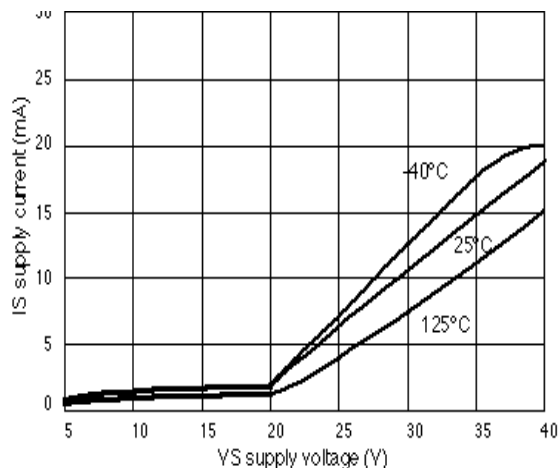


Figure 10. IS Supply Current versus VS Supply Voltage

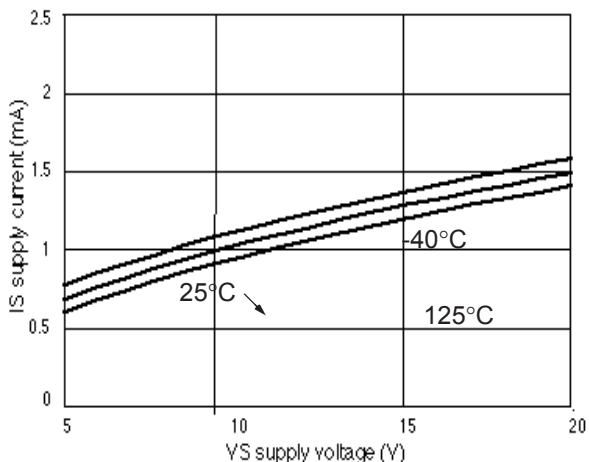


Figure 9. VS Supply Current versus VS Supply Voltage

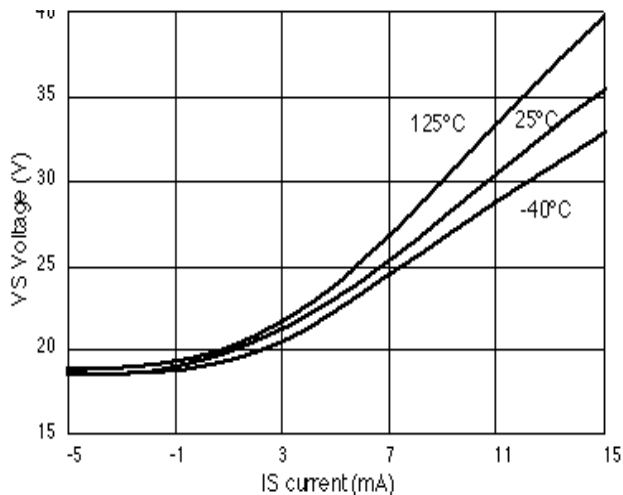


Figure 11. VS Voltage versus IS Current  
( $V_{CC}=5.5V$ ,  $V_{DIA}$ , L, I1=20V)

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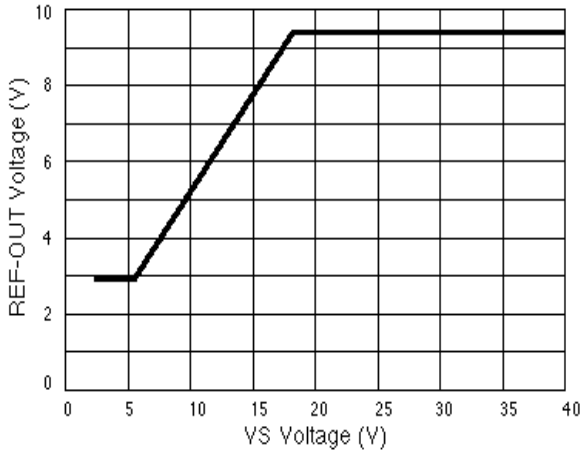


Figure 12. REF-OUT Voltage versus VS Supply Voltage

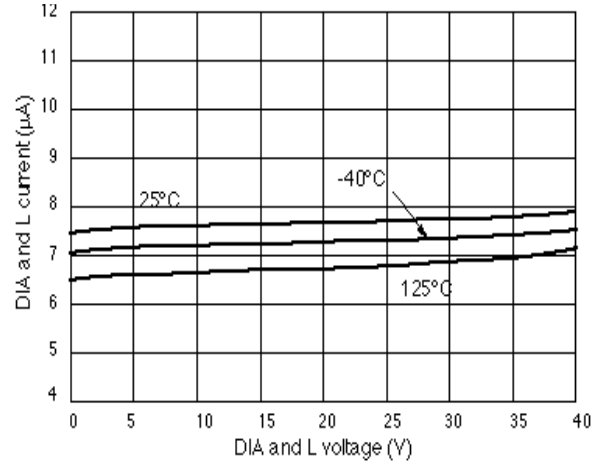


Figure 15. L and DIA Current versus L and DIA Voltage

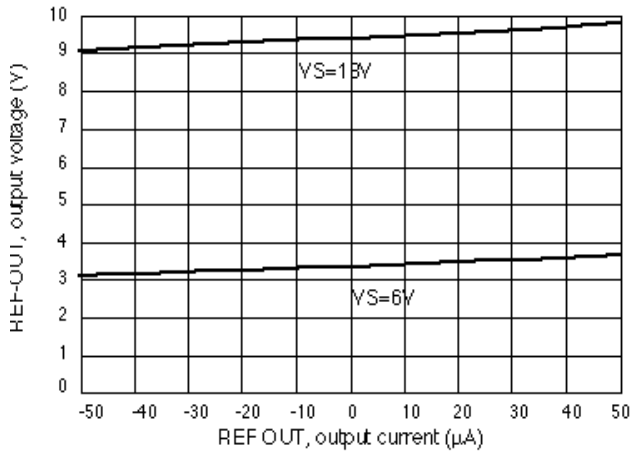


Figure 13. REF-OUT Voltage versus REF-OUT Current

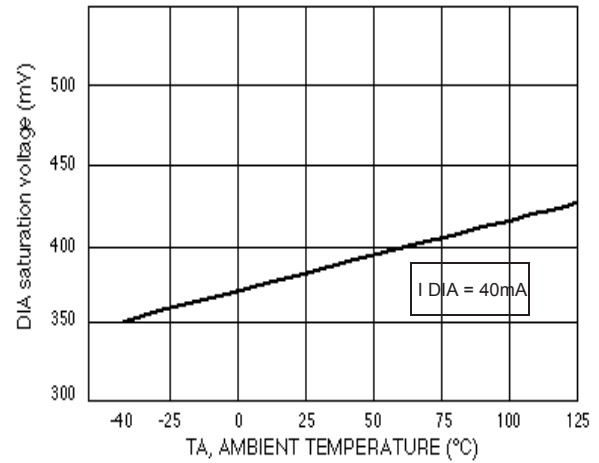


Figure 16. DIA Saturation Voltage versus Temperature

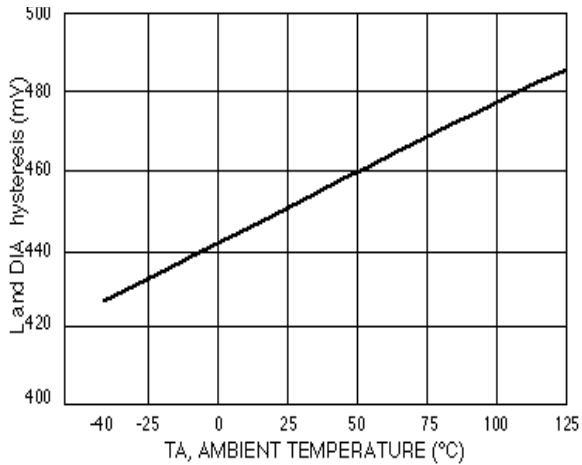


Figure 14. L and DIA Hysteresis versus Temperature

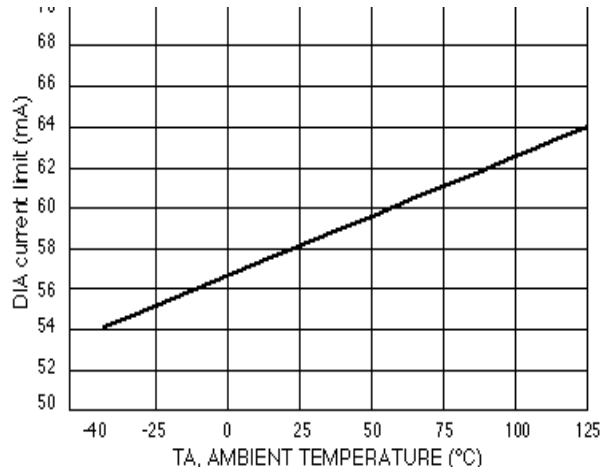


Figure 17. DIA Current Limit versus Temperature

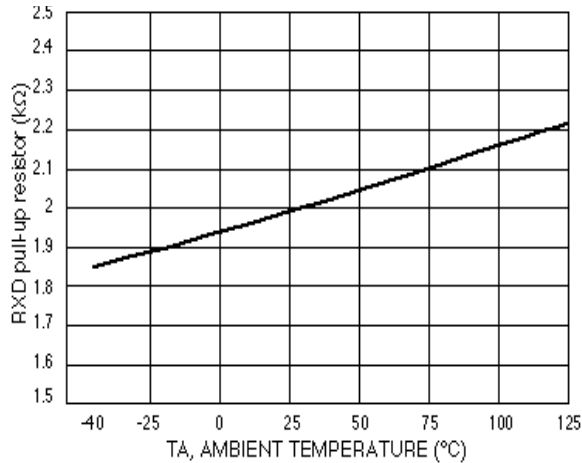


Figure 18. RXD Pull-up Resistor versus Temperature

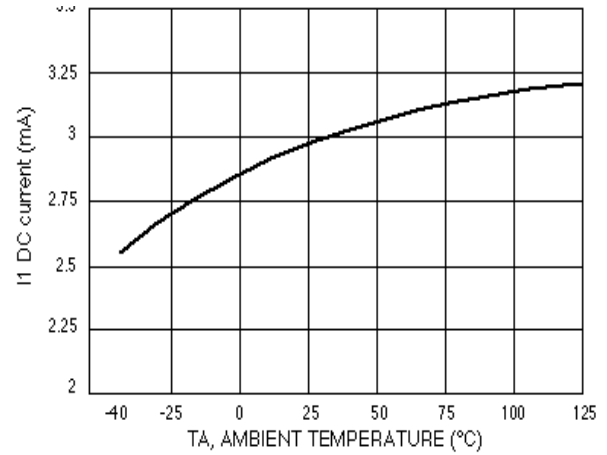


Figure 21. I1 Output DC Current versus Temperature

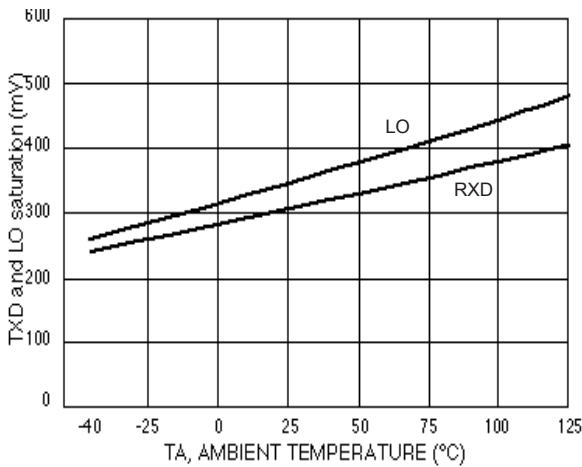


Figure 19. TXD and LO Saturation Voltage versus Temperature

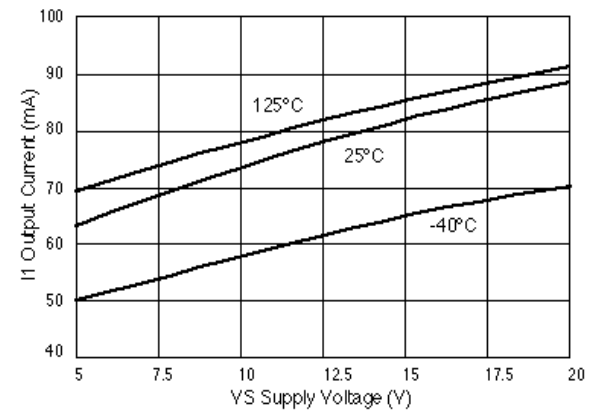


Figure 22. I1 Output Pulse Current versus VS Supply Voltage

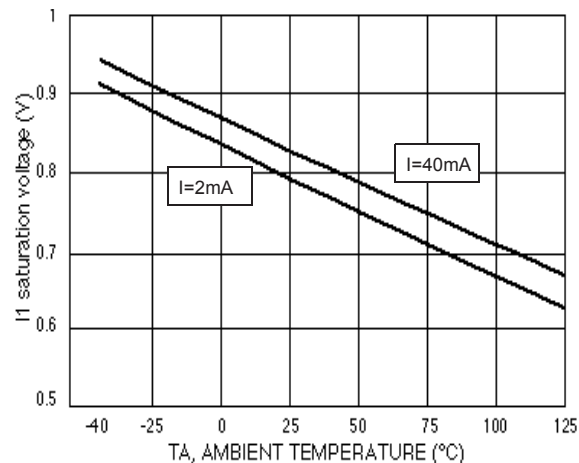


Figure 20. I1 Saturation Voltage versus Temperature

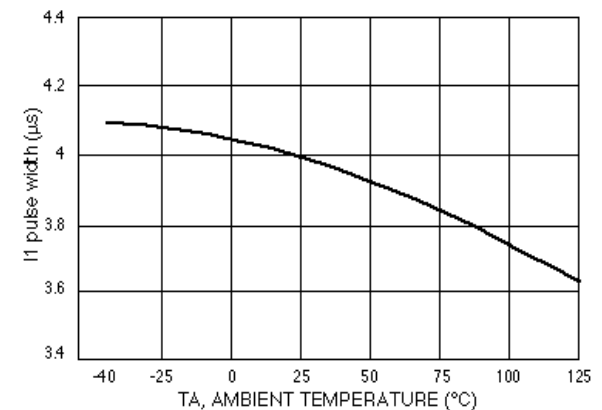


Figure 23. I1 Pulse Current Width versus Temperature

## FUNCTIONAL DESCRIPTION

## INTRODUCTION

The MC33199 is a serial interface circuit used in diagnostic applications. It is the interface between the microcontroller and the special K and L lines of the ISO diagnostic port. The MC33199 has been designed to meet the «Diagnosis System ISO9141» specification.

This product description will detail the functionality of the device (see [Figure 2. 33199 Simplified Internal Block Diagram](#)). First, the power supply and reference voltage generator will be discussed, then the paths functions between MCU, K and L lines will be detailed. A dedicated paragraph will tell about the special functionality of the I1 pin, which allow high Baud rates transmission.

## FUNCTIONAL PIN DESCRIPTION

**VCC (VCC)**

5V typical power supply pin. Typical supply current is less than 1.5mA.

**REF-IN-L (REF-IN-L)**

Input reference for C2 comparator. This input can be connected directly to REF-OUT, with or without a resistor network, or to an external reference.

**REF-IN-K (REF-IN-K)**

Input reference for C1 comparator. This input can be connected directly to REF-OUT, with or without a resistor network, or to an external reference.

**LO (LO)**

Output of C2 comparator, normally connected to a microcontroller I/O. If L input > (REF-IN-L + Hyst/2) then output LO is in high state. If L < (REF-IN-L - Hyst/2) then output LO is in low state, output transistor ON.

This pin is an open collector structure. A Pull up resistor should be added to VCC.

Drive capability of this output is 5mA.

**RXD (RXD)**

Receive output, normally connected to a microcontroller I/O.

If DIA input > (REF-IN-L + Hyst/2) then output LO is in high state.

If DIA < (REF-IN-L - Hyst/2) then output LO is in low state, output transistor ON. This pin has an internal pull up resistor to VCC (2Kohm typ). Drive capability of this output is 5mA

**TXD (TXD)**

Transmission input, is normally connected to a microcontroller I/O. This pin controls DIA output. If Txd is high, the output DIA transistor is OFF. If Txd is low the DIA output transistor is ON.

**DIA (DIA)**

Input / Output Diagnosis Bus line pin. This pin is an open collector structure, protected against over current and short

circuit to VBAT (VS). When turning ON (TXD low), this pin will pull the Bus line to Gnd, the current into DIA will be internally limited to 60mA typ.

The internal power transistor has a thermal shutdown circuit, which forces the DIA output OFF in case of over temperature.

DIA is also the C1 comparator input. It is protected against both positive and negative over voltage by a 38V zener diode. This pin exhibits a constant input current of 7.5?A.

**GND (GND)**

Gnd reference for the entire device.

**I1 (I1)**

Bus source current pin. It is normally tied to DIA pin and to the Bus line.

At static HIGH or LOW level Txd, the current source I1 delivers a current of 3mA (typ). Only during LOW to HIGH transition, does this current increase to a higher value in order to charge the key line capacitor (C<4nF) in a short time (see fig 3 and 4).

**L (L)**

Input for C2 comparator. This pin is protected against both positive and negative over voltage by a 38V zener diode.

This L line is a second independent input. It can be used for wake up sequence in ISO diagnosis or as an additional input bus line.

This pin exhibits a constant input current of 7.5?A.

**VS (VS)**

12V typical, or Vbat supply pin for the device. This pin is protected against over voltage transients.

**REF-OUT (REF-OUT)**

Internal reference voltage generator output pin. Its value depends on Vs (Vbat) values. This output can be directly connected to REF-IN L and REF-IN-K, or through a resistor network. Maximum current capability is 50?A.

## FUNCTIONAL DEVICE OPERATION

### POWER SUPPLIES AND REFERENCE VOLTAGE

The device has two power supplies :

A 5V supply, VCC, normally connected to the MCU supply voltage. This pin sinks typically 1mA during operation. A VBAT supply voltage, VS, normally tied to the car battery voltage. This pin can sustain up to 40V DC. Care should be taken for reverse battery protection and transient voltages higher than 40V.

The voltage reference generator is supplied from both VCC and VBAT. It provides reference voltage for the K and L lines comparators thresholds. The reference voltage is dependant on VBAT voltage : it is linear versus VBAT voltage, for VBAT from 5.6V to 18V. Below 5.6V and over 18V the reference voltage is clamped (see [Figure 12](#)). The reference is connected externally to the device, through REF-OUT pin. It is available for other needs. It can supplied 50µA max (see [Figure 13](#)).

### PATH FUNCTIONS BETWEEN MCU, K AND L LINES

The path function from the MCU to the K line is composed of a driver interfacing directly with the MCU through the TXD pin. The TXD pin is CMOS compatible. This driver controls a power transistor which can be turned ON or OFF. When it is ON, it pull the DIA pin low. This pin is known as K line in the ISO 9141 specification. The DIA pin structure is open collector, without pull up component. This allow the connection of several MC33199 on the K line and the use of a single pull up resistor per system (see [Figure 25](#)). In order to protect the DIA pin against short circuits to VBAT, the device incorporates a current limitation (see [Figure 17](#)) and a thermal shutdown. This current limitation will also act when the device drives a K line bus exhibiting large parasitic capacitor value (see [Special functionality of I1 pin](#)).

The path from this DIA pin, or K line, to the MCU is done through a comparator. The comparator threshold voltage is connected to REF-IN-K pin. It can be tied to the REF-OUT voltage, if the VBAT dependant threshold is to be achieved. The second input of this comparator is internally connected to DIA pin. The output of the comparator is available on RXD output pin, normally connected to a MCU I/O port. RXD pin has a 2kOhms internal pull up resistor.

The path from the L line, used during wake-up sequence of the transmission, to the MCU is done through a second comparator. The comparator threshold voltage is connected to REF-IN-L pin. As the REF-IN-K pin, it can be tied to the REFOUT voltage, if the VBAT dependant threshold need to be achieved. The second input of this comparator is internally

connected to L pin. The output of the comparator is available on LO output pin, which is an open collector structure. LO is normally connected to a MCU I/O port.

The DIA, and L pins can sustain up to 38V DC. Care should be taken for reverse battery protection and transient voltages higher than 38V.

The DIA and L pins both have internal pull down current source of typically 7.5µA (see [Figure 15](#)). So the L line exhibits a 10µA pull down current. The DIA pin has the same behavior when it is in OFF state, that is when TXD is at logic high level.

### SPECIAL FUNCTIONALITY OF I1 PIN

The MC33199 has a unique feature which allows the transmission Baud rate to be up to 200kbaud. In practice, the K line can be several meters long, and thus can have a large parasitic capacitor value. This parasitic capacitor value will slow down the low to high transition of the K line, and indeed will limit the Baud rate transmission. For the K line to go from low to high level, the parasitic capacitor need to be charged, and it can only be charged by the pull up resistor. A low pull up resistor value would result in fast charge time of the capacitor, but also in large output current, and large power dissipation in the driver.

To avoid this problem, the MC33199 incorporates a dynamic current source, which is temporary activated at the low to high transition of the TXD pin, that is when the DIA pin or K line should switch from low to high level (see [Figure 6](#) & [Figure 7](#)).

This current source is available at I1 pin. It has a typical value of 80mA. It is activated for 4µs (see [Figure 22](#) & [Figure 23](#)) and is automatically disabled after this time. During that time it will charge the K line parasitic capacitor. This extra current will quickly rise the K line voltage up to the Vbat, and will result in reduce rise time on the K line. With this feature the MC33199 can ensure Baud rate transmission of up to 200kbaud.

During high to low transition on the K line, the parasitic capacitor of the bus line will be discharged by the output transistor of the DIA pin. In this case, the total current may exceed the internal current limitation of the DIA pin. If so, the current limitation will act, and discharge current will be limited to typically 60mA (See [Figure 7](#) & [Figure 17](#)).

If a high Baud rate is necessary, the I1 pin need to be connected to the DIA as shown in the typical application [Figure 24](#). The I1 pin can also be left open, if the I1 functionality and high Baud rate are not suited in the application.



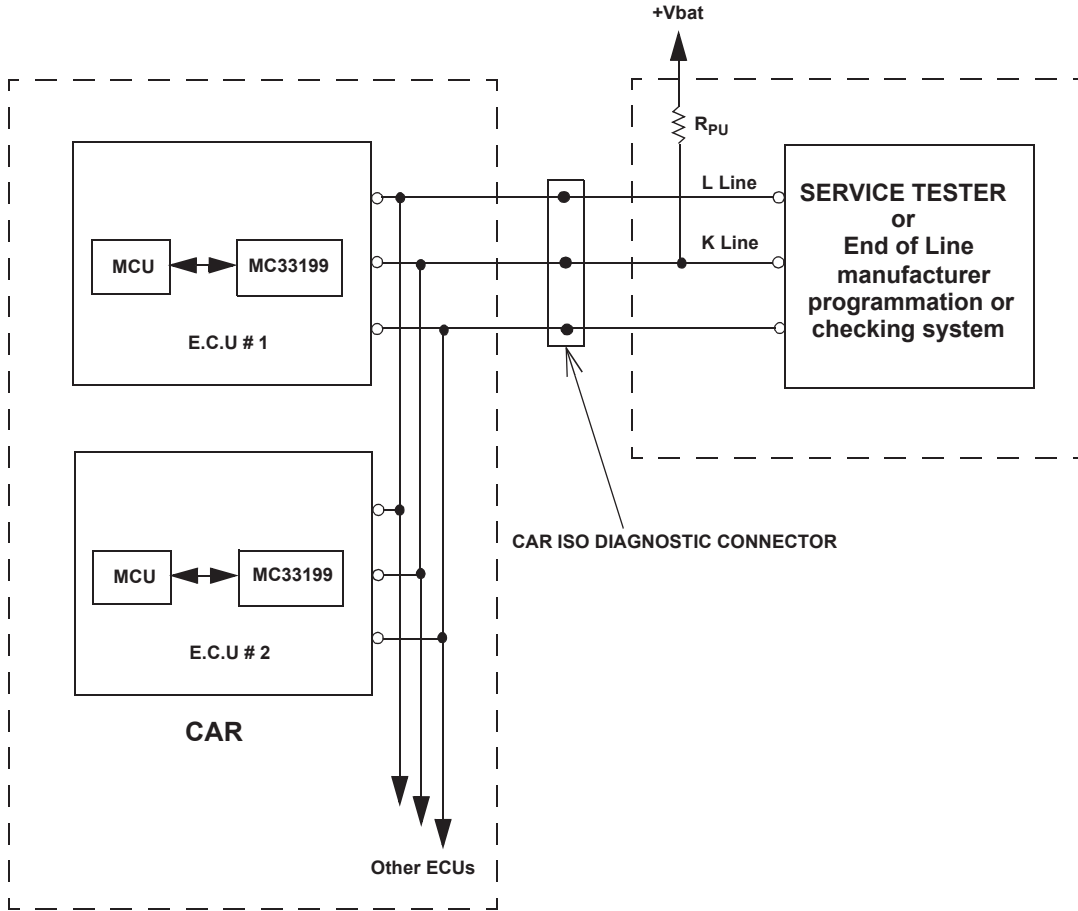


Figure 25. Typical Application with Several ECUs

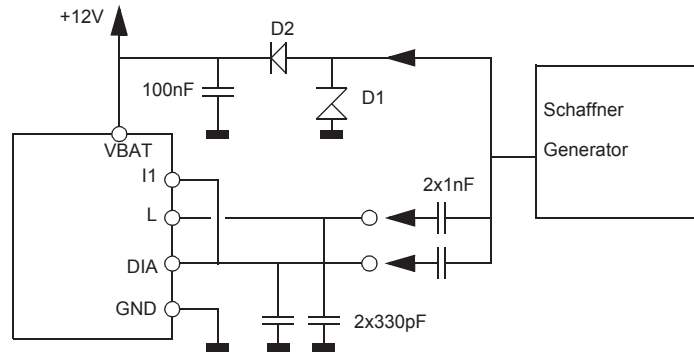


Figure 26. Test Circuit for Transient Schaffner Pulses

Test pulses are directly applied to VS and via a capacitor of 1nF to DIA and L. The voltage VS is limited to -2V/38V by the transient suppressor diode D1. Pulses can occur simultaneously or separately.



## REVISION HISTORY

Revision	Date	Description of Changes
2.0	8/2006	<ul style="list-style-type: none"> <li>• Implemented Revision History page</li> <li>• Added EF Pb-FREE suffix</li> <li>• Revised Figure 1, Simplified Application Drawing.</li> <li>• Converted to Freescale format and updated to the prevailing form and style</li> <li>• Removed MC33199EF/R2 and replaced with MCZ33199EF/R2 in the Ordering Information block</li> </ul>
	9/2006	<ul style="list-style-type: none"> <li>• Made unit label corrections on <a href="#">Transmission Speed</a>, <a href="#">High or Low Bit Time</a>, <a href="#">LO Output</a> :, and <a href="#">I1 Output @ VS-I1 &gt; 2.7V</a> : on page 7.</li> </ul>
	10/2006	<ul style="list-style-type: none"> <li>• Removed Peak Package Reflow Temperature During Reflow (solder reflow) parameter from <a href="#">Maximum Ratings on page 4</a>. Added note with instructions to obtain this information from <a href="http://www.freescale.com">www.freescale.com</a>.</li> </ul>

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