Advance Information

Automotive “Local Interconnect Network” Physical Interface

MC33399

LIN INTERFACE

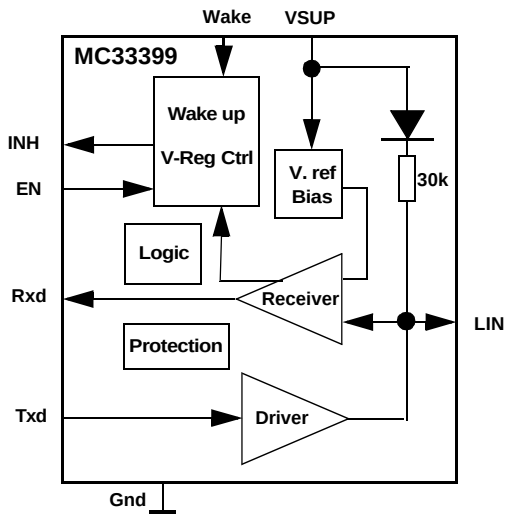
SILICON MONOLITHIC INTEGRATED CIRCUIT

The MC33399 is a Physical Layer component dedicated to automotive sub bus applications. The device is compliant to LIN specification. Its main features are:

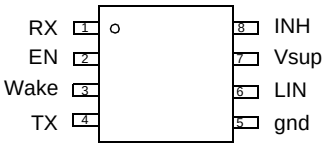
- Speed Communication from 1 to 20Kb/s
- Nominal Operation from VSUP 8 to 18V DC
- Fully Functional up to 27V DC battery voltage.
- 40V maximum Voltage during Load Dump
- Handle from +40V to -18V DC voltage at LIN pin
- Gnd disconnection fail safe at module level
- An Unpowered Node does not disturb the network
- GND Shift Operation at system level
- Two Operation Modes: Normal and Sleep Mode
- Very Low Standby Current during Sleep Mode 20uA
- Wake-up Capability from LIN bus, MCU command and dedicated high voltage wake up input (interface to external switch)
- Interface to MCU with CMOS compatible I/O pins
- Control of External Voltage Regulator
- LIN bus Threshold Voltage fully Compatible with LIN protocol specification
- Bus slew rate control according to LIN protocol specification recommendations (2V/us typ.)
- Internal pull up resistor
- Handle Automotive Transients per ISO9137 Specification
- ESD 4KV on LIN bus Pin
- High EMC Immunity

D SUFFIX
PLASTIC PACKAGE
CASE 751
(SO-8)

Simplified Block Diagram



PIN CONNECTIONS



(Top view)

ORDERING INFORMATION		
Device	**Operating Temperature Range**	**Package**
–	- 40°C to+125°C	SO-8

This document contains information on a new product. Specifications and information herein are subject to change without notice.

MAXIMUM RATINGS

Ratings	Symbol	Min	Typ	Max	Unit
ELECTRICAL RATINGS					
VSUP - Continuous Supply Voltage - Transient Voltage (Load dump)	 VSUP VSUP			 +27 +40	V
Wake DC & Transient Voltage (Through a 33kohms serial resistor)	Vwake	-18V		+40	V
Logic pins (Rx, Tx, EN)	Vlog	- 0.3		5.5	V
LIN - DC voltage - Transient (coupled through 1nF capacitor)	Vbus	 -18 -150		 +40 +100	V
INH - DC Voltage - Transient Voltage	Vinh	 -0.3 tbd		 Vsup+0.3 tbd	V
ESD Human Body Model (100pF, 1.5 kOhms) - All Pins, Except LIN Pin - LIN Pin	VHesd	 -2 -4		 +2 +4	 kV
ESD Machine Model (220pF, 0 Ohms) - All Pins	VMesd	 -200		 +200	 V
THERMAL RATINGS					
Junction Temperature	T_j	- 40		+150	°C
Storage Temperature	T_s	- 55		+165	°C
Ambient Temperature	T_a	- 40		+125	°C
Thermal Resistance Junction to Ambient	Rtja			150	°C/W
Thermal Shutdown	Tshut	150	170	200	°C
Thermal Shutdown Hysteresis	Thyst	8	10	20	°C

ELECTRICAL CHARACTERISTICS (VSUP = FROM 7 TO 18V, and T_j FROM -40 TO 150°C UNLESS OTHERWISE NOTED)

Description	Symbol	Characteristics			Unit	Conditions
		Min	Typ	Max		
VSUP pin (Device power supply)						
Nominal DC Voltage Range	VSUP	7	13.5	18	V	
Supply Current in Sleep Mode	Is1		20	50	µA	Sleep mode Vlin>Vsup-0.5V Vsup<14V
Supply Current in Sleep Mode and Vsup>14V	Is2			300	µA	14V<Vsup<27V
Supply Current in Normal Mode	Is(n-rec)			2	mA	Bus recessive
Supply Current in Normal Mode	Is(n-dom)			3	mA	Bus dominant Total bus load >500 Ohms
Vsup Undervolatage Threshold	Vsup_low	5.8	6.4	6.8	V	
Rx output pin (logic)						
Low Level Voltage Output	Vol	0		0.9	V	I out ≤ +1.5mA
High Level Voltage Output	Voh	3.75		5.25	V	I out ≥ -250uA
Tx input pin (logic)						
Low Level Voltage Input	Vil			1.5	V	
High Level Voltage Input	Vih	3.5			V	
Input Threshold Hysteresis	Vinhyst	50	400		mV	

ELECTRICAL CHARACTERISTICS (VSUP = FROM 7 TO 18V, and T_J FROM -40 TO 150°C UNLESS OTHERWISE NOTED)

Description	Symbol	Characteristics			Unit	Conditions
		Min	Typ	Max		
Pull-up Current Source	Is	-50		-25	uA	1v <V(Tx) < 4v
Enable Input Pin (Logic)						
Low Level Voltage Input	Vil			1.5	V	
High Level Voltage Input	Vih	3.5			V	
Input Threshold Hysteresis	Vinhyst	50	400		mV	
Low Level Input Current (Vin 1V)	Iil	10	20		uA	
High Level Input Current (Vin = 4V)	Iih		20	40	uA	
Pull-down Current	Idw		20		uA	1V<EN<4V
LIN Bus Pin (Voltage Expressed versus Vsup Voltage)						
Low Level Voltage (Tx low, Iout =40mA)	Vlin-low	0		1.4	V	Dominant state
High Level Voltage (Tx high, Iout = 10uA)	Vlin-high	V_{SUP}-1V			V	Recessive state
Pull up Resistor to Vsup (NOTE 1)	Ipu	20	30	40	kohms	
Current Limitation (Tx low, LIN = Vsup)	Ilim	50	200		mA	
Leakage Current to GND (NOTE 1)	Ileak1	0		10	uA	Recessive state, Vlin from Vsup-0.5V to +VBAT
Leakage Current to GND, Vsup Disconnected	Ileak2	-40		40	uA	Vsup disconnected Vlin from -18 to +18V Excluding internal pull up source
Leakage Current to GND, Vsup Disconnected VLin at -18V	Ileak3		-600		uA	Vsup disconnected Vlin from -18V Including internal pull up source
Leakage Current to GND Vsup Disconnected VLin at +18V	Ileak4		25		uA	Vsup disconnected Vlin from +18V Including internal pull up source
Lin Receiver Vil (Tx high, Rx low)	Lin-vil	0		$0.4V_{SUP}$		
Lin Receiver Vih (Tx high, Rx high)	Lin-vih	0.6 V_{SUP}		V_{SUP}		
LIN Receiver Threshold			Vsup/2		V	
LIN Receiver Input Hysteresis	LIN hyst	$0.05V_{SUP}$		0.1 V_{SUP}	V	
Inhibit Output Pin						
High Level Voltage	Vwuh	V_{SUP}-0.8		V_{SUP}	V	Normal mode
Leakage Current	Ileak	0		5	uA	Sleep mode 0<Vinh <Vsup
WAKE Pin						
Typical Wake Up Threshold (EN = 0V), High to Low Transition, V_{SUP}=7V to 18V. NOTE 2.	$Wu_{threshl}$		0.44 V_{SUP}		V	
Typical Wake Up Threshold (EN = 0V), Low To High Transition, V_{SUP}=7V to 18V. NOTE 2.	$Wu_{threslh}$		0.57 V_{SUP}		V	
Wake Up Threshold Hysteresis	Wu_{hyst}	500			mV	
Wake Up Threshold, High to Low Transition at V_{SUP}=12V	Wu_{hl}	3.6		6.5	V	
Wake Up Threshold, Low To High Transition at V_{SUP}=12V	Wu_{lh}	6.2		7.5	V	
Wake Input Current (V<14V)	Win1		tbd	20	µA	V<14V
Wake Input Current (V>14V)	Win2			100	µA	V<27V

NOTE:
1: A diode structure is inserted with the pull resistor to avoid parasitic current path from LIN to Vsup
2. When VSUP is greater than 18V, the wake up thresholds remain identical to the wake up thresholds at 18V

ELECTRICAL CHARACTERISTICS (VSUP = FROM 7 TO 18V, and T_J FROM -40 TO 150°C UNLESS OTHERWISE NOTED)

Description	Symbol	Characteristics			Unit	Conditions
		Min	Typ	Max		
Timing characteristics						
LIN Falling Edge Slew Rate	Tfall	1	2	3	V/us	Measured from 80 to 20%
LIN Rising Edge Slew Rate, Rbus>1k, Cbus<10nF	Trise	1	2	3	V/us	Measured from 20 to 80%
LIN rise/fall Symmetry (Trise-tfall)	Tlin sym	-2		+2	us	Measured from 20 to 80%
Propagation Delay (Tx low to Lin low) (Driver propagation delay)	TtxLinL			1	us	Measured from Tx H->L to LIN crossing 90%Vsup
Propagation Delay (Tx high to Lin high) (Driver propagation delay)	TtxLinH			1	us	Measured from Tx L->H to LIN crossing 10%Vsup
Propagation Delay (LIN low to Rx low) (Receiver propagation delay)	TLinRxL		4	6	us	
Propagation Delay (LIN high to Rx high) (Receiver propagation delay)	TLinRxH		4	6	us	
Propagation Delay (bus wake-up -> INH high)	TpropWL		50		us	

Figure 1. Timing Description

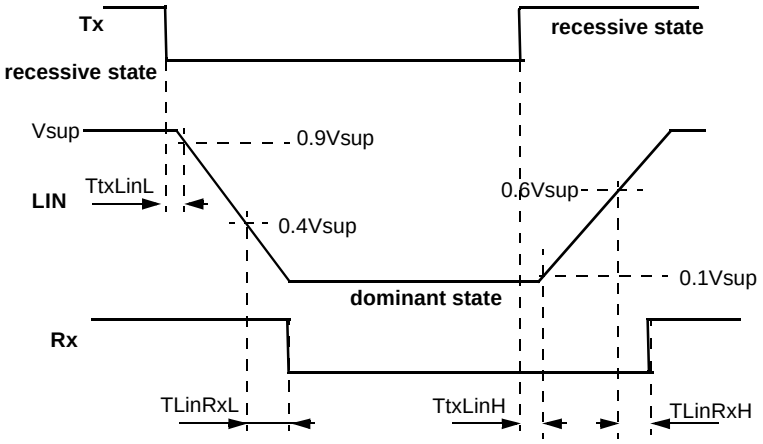


Figure 2. Rise and Fall Time Description

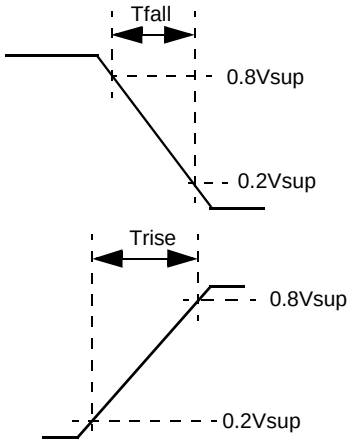
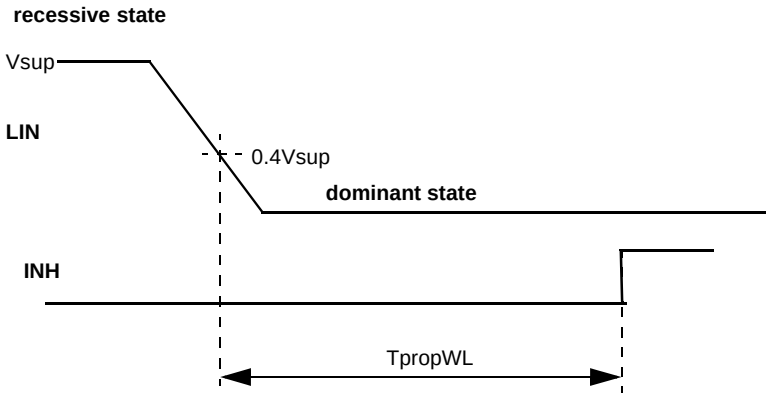


Figure 3. Bus Wake up Timing Description



VSUP Supply Pin

Device power supply pin. It is connected to battery through a serial diode for reverse battery protection. The DC operating voltage is from 7 to 27V. This pin sustains standard automotive voltage conditions such as 27V DC during jump start conditions and 40V during load dump. An under voltage reset circuitry is implemented to disable the transmission path (from Tx to LIN) when Vsup is falling below 7V in order to avoid false bus message. Supply current in sleep mode is 20uA typical.

GND Ground Pin

Device gnd connection.

In case ground disconnection at the module level, the MC33399 does not have significant current consumption on the LIN bus pin when in recessive state (less than 100uA is sourced from LIN bus pin, which create 100mV drop voltage from the 1 kohms LIN bus pull up resistor), for dominant state the pull up resistor should be always active.

Gnd shift: the MC33399 handle ground shift up to 3V for Vsup>9V. Below 9V Vsup, ground shift can reduce Vsup value below the minimum Vsup operation of 7V.

LIN Bus Pin

This I/O pin represents the single-wire bus transmitter and receiver.

Transmitter Characteristics

The driver is a low side transistor with internal current limitation and thermal shutdown. An internal pull up resistor with a serial diode structure is integrated, so no external pull-up components are required for the application in a slave node. An additional pull up resistor of 1kΩ must be added when the device is used in the master node.

Voltage can go from +40V down to 18V DC below GND (-18V) without no current other than the pull up resistance. This pin exhibit no reverse current from the LIN bus line to VSUP, even in case of GND shift or Vbat disconnection. LIN thresholds are compatible LIN Protocol Specification.

The fall time, from recessive to dominant and the rise time from dominant to recessive are controlled to 2V/us typical. The symmetry between rise and fall time is also guaranteed.

When going from dominant to recessive the bus impedance parasitic capacitor has to be charged up to Vsup, and this is done by the total system pull up current resistors. In order to guarantee the rise time is within the specification, maximum bus capacitance should not exceed 10nF with bus total pull up resistance less than 1kOhm.

Receiver Characteristics

The receiver thresholds are ratiometric with the device supply pin. Typical threshold is 50%, with a hysteresis between 5 and 10% of Vsupply.

Tx Input Pin

This pin is the MCU interface to control the state of the LIN output. When Tx is low, LIN output is low, when Tx is high, LIN output transistor is turned off.

This pin has an internal pull up current source internal 5V in order to set the bus in recessive state in case the micron controller could not control it during system power up or down for instance. During the Sleep mode the pull-up is turned off.

Rx Output Pin

This pin is the MCU interface which reports the state of the LIN bus voltage. LIN high (recessive) is reported by a high level on Rx, LIN low (dominant) is reported by a low voltage on Rx. Rx output structure is a CMOS type push-pull output stage.

EN Input Pin (Enable)

This pin controls the operation mode of the interface. If EN=1, the interface is in normal mode, with transmission path from Tx to LIN and from LIN to Rx both active.

If EN=0, the device is turned into sleep mode or low power mode, and no transmission is possible. In sleep mode the LIN bus pin is hold at Vsup through the bus pull up resistors and pull up current sources. The device can transmit only after being waked up (see INH pin description).

During sleep mode the device is still supplied from the battery voltage (through VSUP pin). Supply current is 20uA typical. Setting the ENABLE pin to low will turn the INHIBIT to high impedance. EN pin has an internal 20uA pull down current source to ensure the device is in sleep mode if EN floats.

INH Output Pin

This pin is used to control an external switchable voltage regulator having an inhibit input. The inhibit pin is a high side switch structure to Vsup. When the device is in normal mode, inhibit high side switch is turned on and the external voltage regulator is activated. When the device is in sleep mode, the inhibit switch is turned off and disables the voltage regulator (if this feature is used).

A wake-up event on the LIN bus line will switch the inhibit pin to Vsup level. Wake up output current capability is limited to 280uA. INH pin can also drive an external transistor connected to an MCU IRQ or XIRQ input to generate an interrupt. Refer to typical application, figure 7.

Wake Input Pin

This pin is a high voltage input used to wake up the device from Sleep mode. Wake is usually connected to an external switch in the application. The typical wake thresholds are Vsup/2.

Wake pin has special design structure and allows wake up from both high to low or low to high transitions. When entering into the Sleep mode, the LIN monitors the state of the wake pin and stores it as reference state. The opposite state of this reference state will be the wake up event used by the device to enter again into normal mode.

An internal filter is implemented, (50 µs typical filtering time delay). Wake pin input structure exhibits a high impedance, with extremely low input current when voltage at this pin is below 14V. When voltage at Wake pin exceed 14V input current start to sink into the device. A serial resistor should be inserted in order to limit the input current mainly during transient pulses. Recommended resistor value is 33kohms.

CAUTION : The Wake pin should not be left open. If wake up function is not used, wake should be connected to GND to avoid false wake up.

Device Wake-up Events

The device can be waked up from sleep mode from three wake-up events:

- LIN bus activity
- Internal node wake-up described below (EN pin).
- Wake up from Wake pin

Fig 5, 6, 7, 8 and 9 show device application circuit and detail of wake up operations.

Wake-up From LIN Bus

A wake-up from LIN pin switched from recessive state to dominant (switch from Vsup to GND) can occur. This is achieved by a node sending a wake-up frame on the bus. This condition will internally wake-up the interface, which will switch high the INH pin to enable the voltage regulator.The device will switch into the “wait for normal mode”. The microcontroller and the complete application will be powered up. The microcontroller will have to switch the EN pin to a high level to allow the device to leave the “wait for normal mode” and turn it into “normal mode” in order to allow communication on the bus.

Wake-up From Internal Node Activity

The application can internally wake-up. In this case the micro controller of the application will set the device enable pin in the high state. The device will switch into ”normal mode”.

Wake-up From Wake Pin

The application can wake up with the activation of an external switch. Refer to pin description.

Mode of Operation

The device has two main modes of operation:

Normal Mode

This is the normal transmitting and receiving mode. All features are available.

Sleep Mode

In this mode the transmission path is disabled and the device is in low power mode. Supply current from Vsup is 20uA typical. Wake-up can occur from LIN bus activity, from node internal wake-up through the EN pin and from Wake input pin.

Device Power Up

At system power up (Vsup rises from zero) the device automatically switches into the “wait for normal mode”. It switches the INH pin in high state to Vsup level. The microcontroller of the application will then confirm the normal mode by setting the EN pin high.

Special Automotive Requirements

ESD

The LIN pin has high Human Body Model ESD immunity and handle more than +-4kV.

Electromagnetic Compatibility

Emission on LIN Bus Output Line

Emission level on LIN bus output is internally limited and reduced by active slew rate control of the output bus driver.

Susceptibility

On the LIN bus pin: The device offers high susceptibility immunity level from external disturbance occurring at the LIN bus pin in order to guarantee communication during external disturbance. On the Wake input pin:an internal filter is implemented to reduce the false wake up during external disturbance.

Noise Filtering

Noise filtering is used to protect the electronic module against illegal wake-up spikes on the bus. 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.

Figure 4. Device State Machine

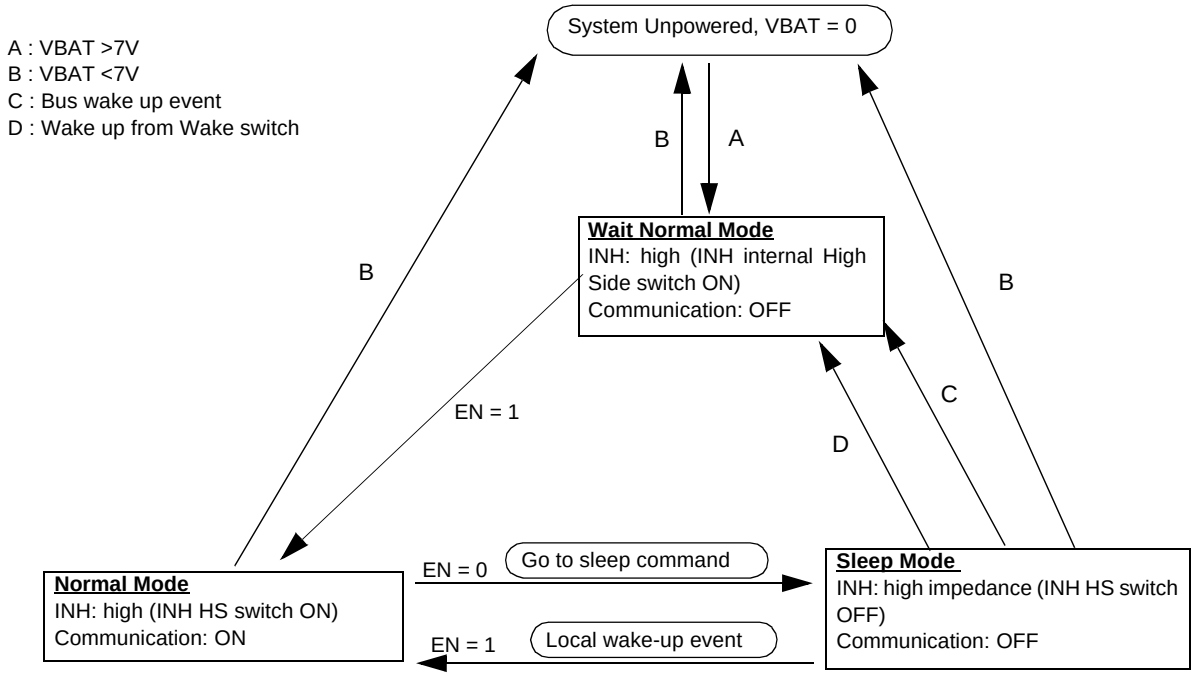


Figure 5. Typical Device Application with Wake Input Switch and INH (Switchable 5V Regulator)

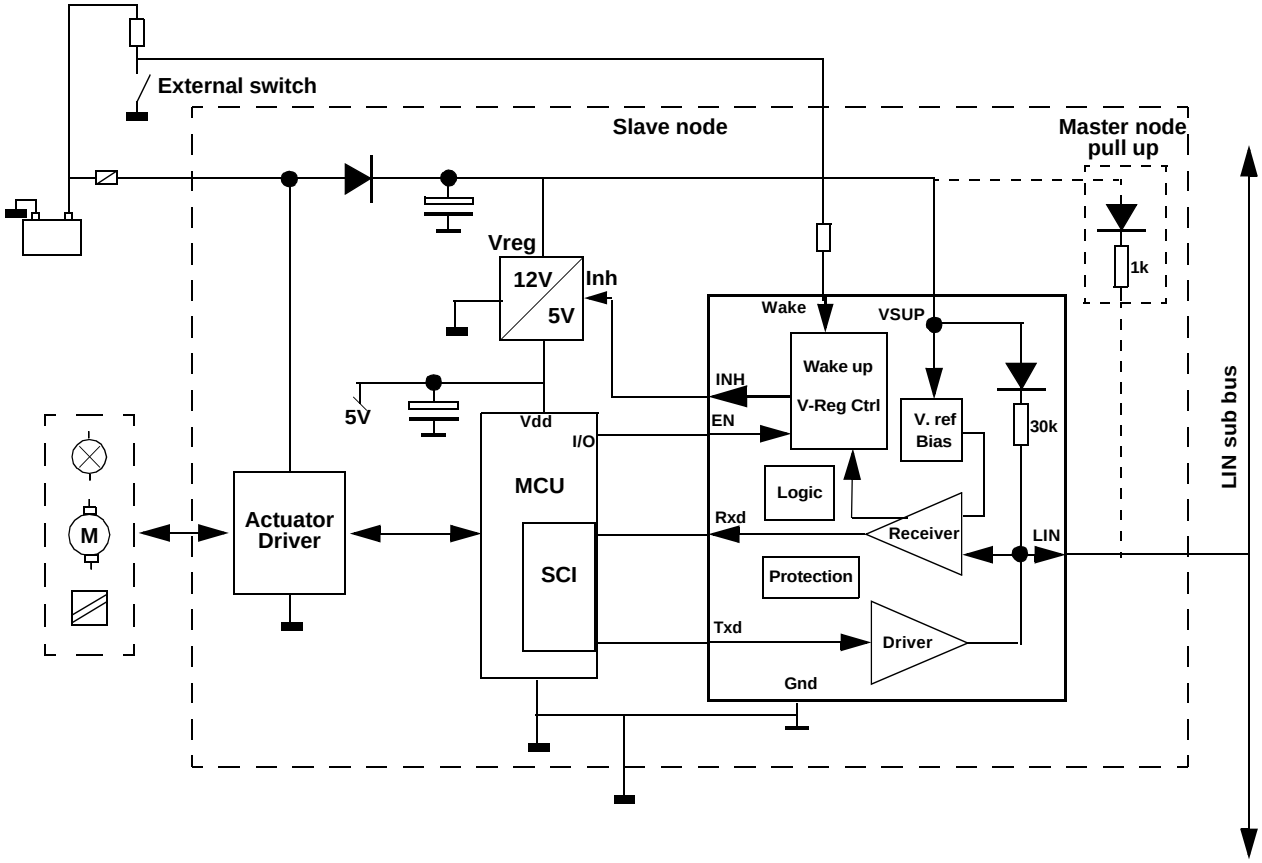


Figure 6. LIN Wake up Wavefrom Diagram with INH Option

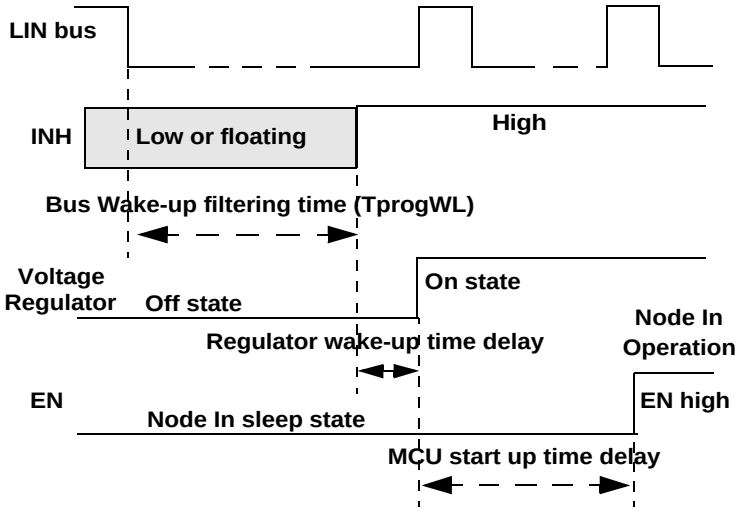


Figure 7. LIN Wake up from Wake up Switch

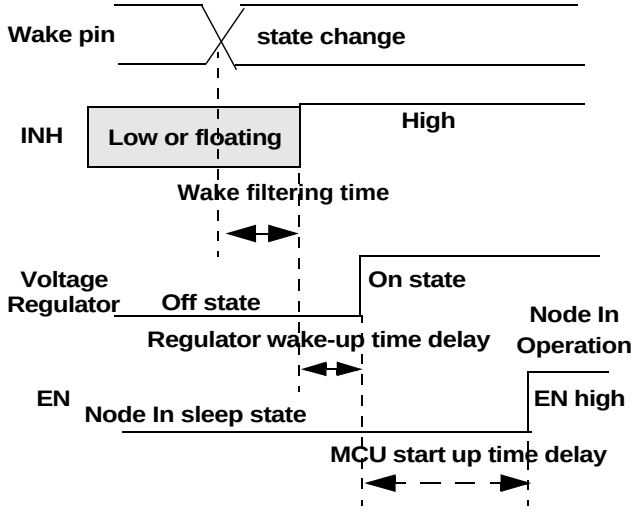


Figure 8. Typical Device Application with MCU Wake up from Stop Mode (Non Switchable 5V Regulator, MCU Stop Mode)

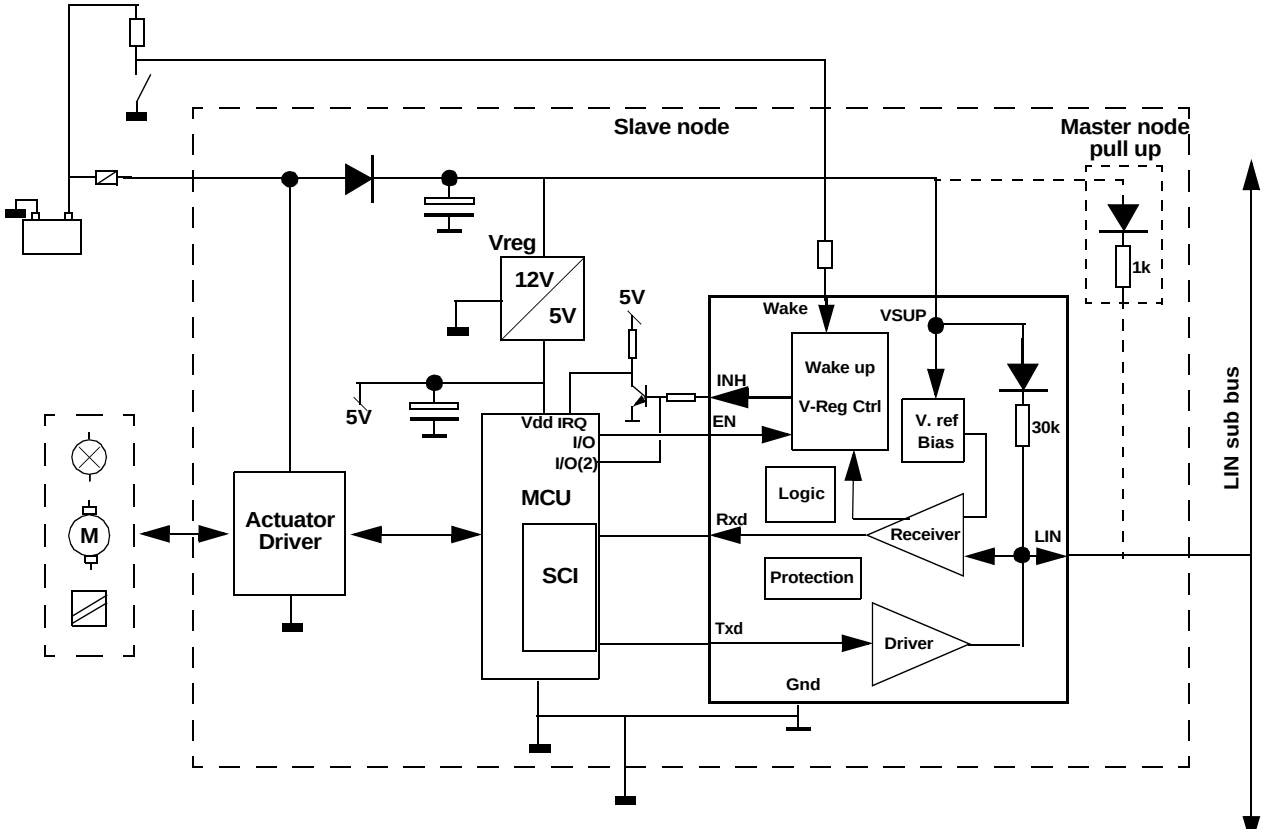
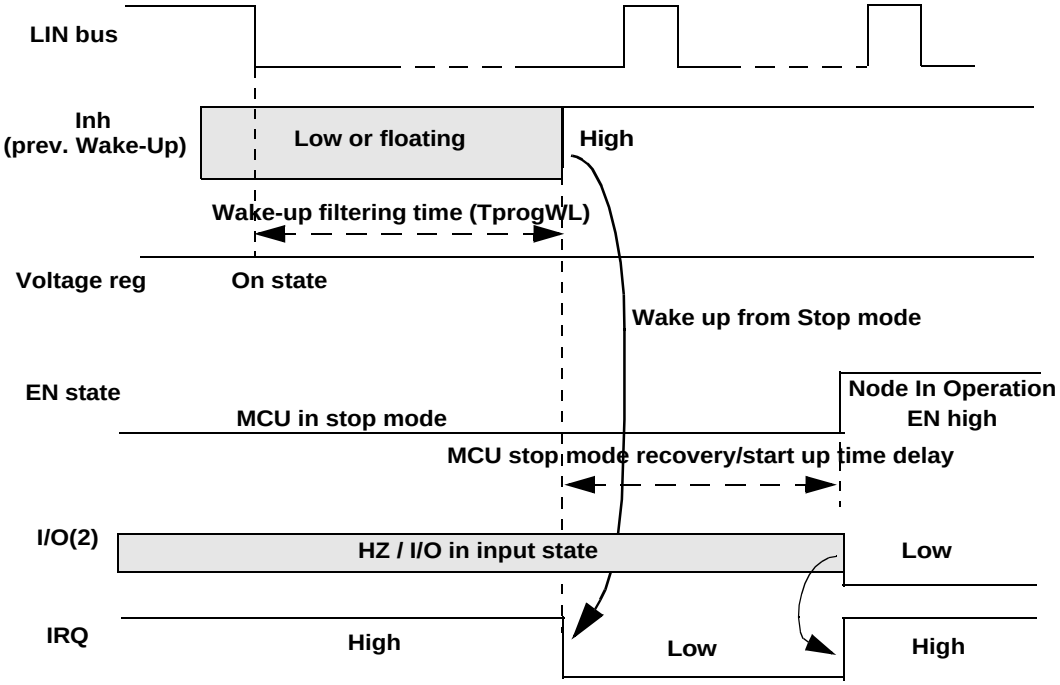


Figure 9. LIN Wake-up Waveform Diagram with MCU in Stop Mode



How to reach us:
USA / EUROPE / Locations Not Listed: Motorola Literature Distribution; P.O. Box 5405, Denver, Colorado 80217. 1-303-675-2140 or 1-800-441-2447

Technical Information Center: 1-800-521-6274

HOME PAGE: http://www.motorola.com/semiconductors

JAPAN: Motorola Japan Ltd.; SPS, Technical Information Center, 3-20-1, Minami-Azabu, Minato-ku, Tokyo 106-8573 Japan. 81-3-344-3569

ASIA / PACIFIC: Motorola Semiconductors H.K. Ltd.; Silicon Harbour Centre, 2, Dai King Street, Tai Po Industrial Estate, Tai Po, N.T., Hong Kong. 852-26668334