

Prototype Information

**Bus Interface IC for  
Automotive Application**

The MC33188D is a bus interface circuit especially designed to operate in the harsh automotive environment. It can be directly connected to a microcontroller and to the bus line. It is capable of interfacing several bus types, with single and multi wire configurations, including MIBus.

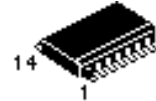
The bus line is internally short-circuit protected. The circuit has an automatic standby mode to minimize the current consumption. Receiving path remains active during sleep mode.

Several MC33188D can be connected to the same bus line and the device also includes a transmission monitoring circuit.

- Large Vbat Operating Range from 6 to 16 Volts
- Automatic Sleep Mode with Low Standby Current
- Load Dump and Jump Start Protected
- MIBus Application
- Single, Multi wires and Full Duplex Operation Allowed
- 5V or 12V Bus High Voltage Level
- 2.2KΩ Bus Pull up Resistor
- Bus Line Short-circuit Protected
- -40°C to +85°C Operating Temperature Range
- CMOS Compatible Levels for Direct Microprocessor Interface
- Bus Line Thresholds Dependent on Vbat

**BUS INTERFACE**

**SILICON MONOLITHIC  
INTEGRATED CIRCUIT**

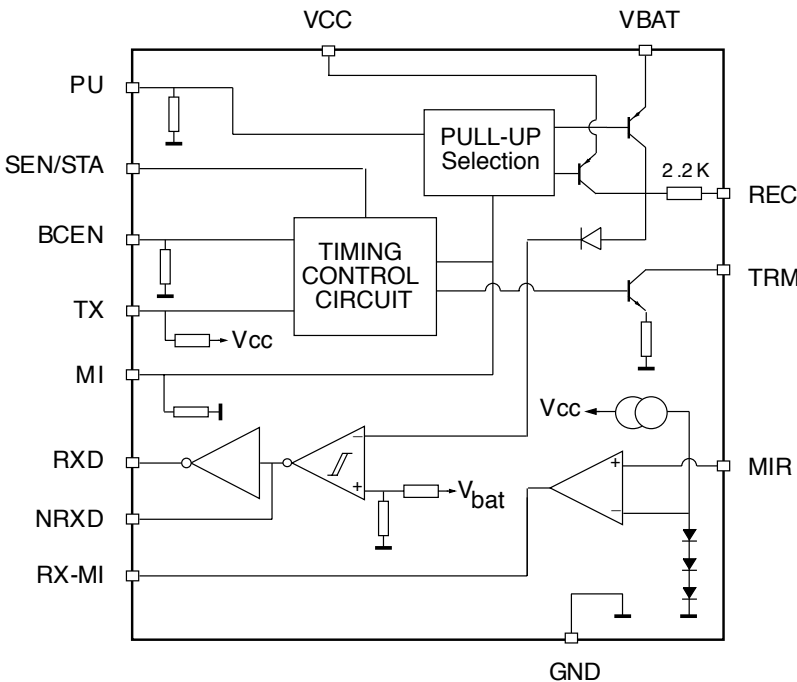


**D SUFFIX**  
**PLASTIC PACKAGE**  
**CASE 751 A-02**  
**SO-14**

**ORDERING INFORMATION**

| Device   | Temperature Range | Package |
|----------|-------------------|---------|
| XC33188D | -40°C to +85°C    | SO14    |

**Simplified Application Schematic**



**PIN CONNECTIONS**

- Pin 1 : RX-MI
- Pin 2 : MIR
- Pin 3 : GND
- Pin 4 : VCC
- Pin 5 : TRM
- Pin 6 : REC
- Pin 7 : VBAT
- Pin 8 : PU
- Pin 9 : MI
- Pin 10 : SEN/STA
- Pin 11 : TX
- Pin 12 : BCEN
- Pin 13 : RXD
- Pin 14 : NRXD

**MAXIMUM RATINGS**

| Ratings   | Symbol | Value                  | Unit |
|---|--------|------------------------|------|
| Continuous Supply Voltage on Vcc  | Vcc    | 5.5                    | V    |
| Power Supply Voltage on Vbat<br>- Continuous<br>- During 15 seconds (jump start)<br>- During 0.4 second (load dump) | Vbat   | 16<br>25<br>40         | V    |
| REC, TRM, MIR Voltage<br>- Continuous<br>- During 15 seconds (jump start)<br>- During 0.4 second (load dump)        | Vmax   | -0.5 to 16<br>25<br>40 | V    |
| ESD Voltage : Human Body Model<br>- All pins except pins 2 and 6<br>- Pins 2 and 6                                  | Vesd   | 2000<br>1500           | V    |
| Storage Temperature   | Tstg   | -55 to 150             | °C   |
| Operating Junction Temperature  | Tj     | -40 to 150             | °C   |
| Operating Ambient Temperature   | Tamb   | -40 to 85              | °C   |

**ELECTRICAL CHARACTERISTICS** Vcc from 4.75 to 5.25V, Vbat from 6 to 16V, Tamb from -40°C to 85°C unless otherwise noted

| Description  | Symbol   | Min         | Typ               | Max            | Unit |
|--|----------|-------------|-------------------|----------------|------|
| <b>RX-MI</b>   |          |             |                   |                |      |
| RX-MI Low Voltage at I = 5μA   | VOL rxmi | -0.3        |                   | 0.2 * Vcc      | V    |
| RX-MI High Voltage at I = -70μA  | VOH rxmi | 0.7 * Vcc   |                   | Vcc + 0.3      | V    |
| <b>MIR</b>   |          |             |                   |                |      |
| MIR Threshold  | THmir    | 1.5         | 2                 | 3              | V    |
| MIR Input Current<br>- Vmir = 0V<br>- Vmir = 14.8V   | Imir     | -200<br>-20 | -100<br>0         | 0<br>20        | μA   |
| <b>Vcc</b>   |          |             |                   |                |      |
| Vcc Supply Current : Vcc = 5V  | Icc      | 0           |                   | 1              | mA   |
| Vbat and Vcc Supply Current in Sleep Mode<br>at Vcc = 5V and Vbat = 12V                            | Ism      | 50          | 100               | 135            | μA   |
| <b>TRM</b>   |          |             |                   |                |      |
| TRM Saturation Voltage<br>- At Vbat = 12V and I = 20mA<br>- At Vbat = 16V and I = 25mA             | SAT trm  | 0<br>0      | 0.3<br>0.36       | 0.7<br>1       | V    |
| TRM Current Limit at Vtrm = 16V, Vtx = 0V  | ICCtrm   | 25          | 50                | 100            | mA   |
| TRM Leakage Current at Vtrm = 16V, Vtx = 5V  | ILtrm    | 0           | —                 | 100            | μA   |
| <b>REC</b>   |          |             |                   |                |      |
| REC Pull Up Resistor   | Rrec     | 1400        | 2200              | 3000           | Ohms |
| REC Input Current<br>- Vrec = 4.2V, Vbat = 12V<br>- Vrec = Vbat = 12V<br>- Vrec = 14.8V, Vbat = 1V | Irec     | 0<br>0<br>0 | —<br>—<br>—       | 60<br>10<br>10 | μA   |
| REC High Threshold:<br>- Vbat = 6V<br>- Vbat = 12V<br>- Vbat = 16V                                 | HTH rec  | 2<br>6      | 3.6<br>6.6<br>8.6 | 4<br>9.5       | V    |

**ELECTRICAL CHARACTERISTICS** Vcc from 4.75 to 5.25V, Vbat from 6 to 16V, Tamb from -40°C to 85°C unless otherwise noted

| Description   | Symbol  | Min        | Typ               | Max        | Unit |
|---|---------|------------|-------------------|------------|------|
| REC Low Threshold:<br>- Vbat = 6V<br>- Vbat = 12V<br>- Vbat = 16V               | LTH rec | 2.7<br>6.1 | 2.9<br>5.8<br>7.1 | 4<br>9     | V    |
| REC Hysteresis:<br>- Vbat = 6V<br>- Vbat = 12V<br>- Vbat = 16V                  | HYS rec | 0.3<br>1   | 0.6<br>0.8<br>1.5 | 1.5<br>2.2 | V    |
| REC Output Level High<br>Vbat = 12V, I = -100μA, TX = 5V                        | HLrec   | 10.8       | 11.6              | 12         | V    |
| REC Output Level High in MIBus mode<br>Vbat = 12V, I = -50μA, MIsel = 1, PU = 0 | HLrecmi | 4.5        | 4.8               | –          | V    |

**Vbat**

|                                 |      |  |  |    |    |
|---------------------------------|------|--|--|----|----|
| Vbat Supply Current Pull up OFF | Ibat |  |  | 1  | mA |
| Vbat Supply Current Pull up ON  | Ibat |  |  | 15 | mA |

**PU**

|                       |       |           |    |           |   |
|-----------------------|-------|-----------|----|-----------|---|
| PU Pull Down Resistor | Rpu   | 10        | 20 | 30        | K |
| PU Input Voltage High | VIHpu | 0.7 * Vcc |    | Vcc + 0.3 | V |
| PU Input Voltage Low  | VILpu | -0.3      |    | 0.3 * Vcc | V |
| PU Hysteresis         | HYSpu | 0.3       | 1  | 1.5       | V |

**MI**

|                       |        |           |    |           |   |
|-----------------------|--------|-----------|----|-----------|---|
| MI Pull Down Resistor | Rmi    | 10        | 20 | 30        | K |
| MI Input Voltage High | VIHmis | 0.7 * Vcc |    | Vcc + 0.3 | V |
| MI Input Voltage Low  | VILmis | -0.3      |    | 0.3 * Vcc | V |
| MI Hysteresis         | HYSmis | 0.3       | 1  | 1.5       | V |

**SEN/STA**

|  |                      |              |           |            |    |
|--|----------------------|--------------|-----------|------------|----|
| SEN/STA Input Voltage High   | VIHss                | 0.7 * Vcc    |           | Vcc + 0.3  | V  |
| SEN/STA Input Voltage Low  | VILss                | -0.3         |           | 0.3 * Vcc  | V  |
| SEN/STA Hysteresis   | HYSss                | 0.3          | 1         | 1.5        | V  |
| SEN/STA Output Voltage High at I = -20μA   | VOHss                | 0.7 * Vcc    |           |            | V  |
| SEN/STA Output Voltage Low at I = 10μA   | VOLss                |              |           | 0.2 * Vcc  | V  |
| SEN/STA Input Current. Vcc = 5.5V<br>- At VSEN/STA = 1.65V<br>- At VSEN/STA = 5.5V | I <sub>sen/sta</sub> | -400<br>-200 | -160<br>0 | 200<br>400 | μA |

**TX**

|                       |                   |           |   |           |   |
|-----------------------|-------------------|-----------|---|-----------|---|
| TX Input Voltage High | VIHtx             | 0.7 * Vcc |   | Vcc + 0.3 | V |
| TX Input Voltage Low  | VILtx             | -0.3      |   | 0.3 * Vcc | V |
| TX Hysteresis         | HYS <sub>tx</sub> | 0.3       | 1 | 1.5       | V |

**ELECTRICAL CHARACTERISTICS** Vcc from 4.75 to 5.25V, Vbat from 6 to 16V, Tamb from -40°C to 85°C unless otherwise noted

| Description             | Symbol  | Min       | Typ | Max       | Unit |
|-------------------------|---------|-----------|-----|-----------|------|
| <b>BCEN</b>             |         |           |     |           |      |
| BCEN Pull Down Resistor | Rbcen   | 10        | 20  | 30        | K    |
| BCEN Input Voltage High | VIHbcen | 0.7 * Vcc |     | Vcc + 0.3 | V    |
| BCEN Input voltage Low  | VILbcen | -0.3      |     | 0.3 * Vcc | V    |
| BCEN Hysteresis         | HYSbcen | 0.3       | 1   | 1.5       | V    |

**RXD and NRXD**

|  |         |           |  |           |   |
|--|---------|-----------|--|-----------|---|
| RXD Low Voltage at I = 220 $\mu$ A (note 1)    | VOLrxd  | -0.3      |  | 0.3 * Vcc | V |
| RXD High Voltage at I = -220 $\mu$ A (note 1)  | VOHrxd  | 0.7 * Vcc |  | Vcc + 0.3 | V |
| NRXD Low Voltage at I = 220 $\mu$ A (note 1)   | VOLnrxd | -0.3      |  | 0.3 * Vcc | V |
| NRXD High Voltage at I = -220 $\mu$ A (note 1) | VOHnrxd | 0.7 * Vcc |  | Vcc + 0.3 | V |

NOTE 1 : These values are not affected even if REC Voltage is down to -10V.

**DYNMIC CHARACTERISTICS** (AT V<sub>BAT</sub> = 12V and T<sub>A</sub> = 25°C)

| Ratings  | Symbol | Min                  | Typ                 | Max                  | Unit       |
|--|--------|----------------------|---------------------|----------------------|------------|
| T Sleep  | Tsl    | 10                   | 40                  | 200                  | ms         |
| T Low  | Tl     | 3                    | 6                   | 12                   | ms         |
| T Bit_compare  | Tbc    | 25                   | 40                  | 60                   | $\mu$ s    |
| TSperr   | Tsp    | 0.9                  | 1.36                | 1.8                  | ms         |
| TRecovery  | Tr     | 30                   | 50                  | 75                   | $\mu$ s    |
| Twake  | Tw     | –                    | –                   | 2                    | $\mu$ s    |
| TRM time. C=40pF. REC&TRM connected. Pu=1<br>- Rise Time<br>- Fall Time  | TRMt   | 1<br>1               | 1.6<br>1.6          | 2<br>2               | V/ $\mu$ s |
| Delay time. C = 12pF<br>- TX rise time to RXD rise time<br>- TX fall time to RXD fall time<br>- TX rise time to RXMI rise time<br>- TX fall time to RXMI fall time | TD     | 5<br>5<br>0.5<br>0.5 | 10<br>8<br>3<br>1.3 | 20<br>20<br>4<br>2.5 | $\mu$ s    |

## PIN DESCRIPTION

| Pin Number | Pin Name | Description   |
|------------|----------|---|
| 1          | RXMI     | This pin reflects the logical value of the MIR input pin.   |
| 2          | MIR      | This pin receives the data from the MIBus single line wire when the interface is in MIBus mode configuration.   |
| 3          | GND      | Gnd pin.  |
| 4          | Vcc      | 5V typical power supply pin. Supply current is 0.8mA typical and down to 135 $\mu$ A in sleep mode.   |
| 5          | TRM      | Bus line transmission pin. It has the same phase as the input TX, it is an open collector structure, short-circuit protected.   |
| 6          | REC      | Bus line reception pin. The voltage level of the bus is determined through a selectable pull-up resistor connected to either Vcc or Vbat.<br>Soothed depends on Vbat voltage, it is approximately : $K \times Vbat + Vbe$ .   |
| 7          | Vbat     | 12V typical power supply pin. It supplies REC pull-up resistors and comparators.  |
| 8          | PU       | Pull-up selection for REC output.<br>- PU = 0, pull-up resistor OFF<br>- PU=1, pull-up resistor ON<br>In the MIBus mode (MI=1), the bus line REC can be supplied at 5 or 12V, with pull-up resistor ON :<br>- PU = 0 and MI = 1, REC is supplied at 5V (normal MIBus mode)<br>- PU = 1 and MI = 1, REC is supplied at 12V (MIBus programming mode)  |
| 9          | MI       | MIBus selection.<br>- MI = 1, the circuit is configured in the MIBus mode.<br>- MI = 0, the circuit is configured for other bus applications.<br>This pin has an internal pull down resistor.<br>When MIBus is selected, the internal timing control circuit is disabled.<br>MIBus = 1 switches on the pull-up resistor.  |
| 10         | SEN/STA  | Sender status pin is an input/output pin.<br>As an input, if SEN/STA is forced at 0, the timing control circuit is disabled : output cannot be blocked, sending path is always free.<br>If SEN/STA is forced at 1, output TRM and the sending path are blocked.<br>As an output : the MCU can read back the status of the timing control circuit by reading the SEN/STA voltage level.<br>- SEN/STA = 0 means that the sending path is free.<br>- SEN/STA = 1 means that the sending path is blocked.<br>In the MIBus mode (MI=1) the timing control circuit status is reported on SEN/STA but the sending path is always free. |
| 11         | TX       | Transmission input. The logical state of TX is transmitted to output TRM. The logical state 1 forces the output transistor OFF and the logical state 0 forces the output transistor ON. It has an internal pull-up resistor.  |
| 12         | BCEN     | Bit Compare Enable. When BCEN = 1 the compare circuit for TX and REC is disabled. This pin has an internal pull down resistor.  |
| 13         | RXD      | Receive output. The logical state of REC is transmitted to RXD and NRXD. The input comparator threshold are adapted to Vbat voltage.  |
| 14         | NRXD     | This pin exhibit the complemented value of the data presented at RXD.   |

**Timing Control Circuit**

The purpose of this portion of the circuit is to monitor the transmission and to report the status to the microcontroller. If a special condition occurs, the timing control circuit will block the output and set the SEN/STA pin to 1.

Four special conditions exist :

- 1) TX = 0 for a time greater than Tlow (Tlow = 6 ms typical). In this case the control circuit blocks TRM output and set SEN/STA to 1.
- 2) TX = 1 and REC = 0 for a time greater than Tbit-compare (Tbit-compare = 40 μs typical). In this case, the control circuit blocks TRM output and set SEN/STA to 1.
- 3) TX = 1 and REC = 1 for a time greater than Tsperr (Tsperr = 1.36 ms typical). In this case, if the output has been previously blocked by one of the above condition, the sending path will be set free and SEN/STA set back to 0.
- 4) If condition TX = 0 less than Tlow with output not blocked by the timing control circuit is followed by condition TX = 1 and REC = 1 during min. Trecovey (Trecovey = 50 μs typical), then the timing control circuit is totally reseted (internal

capacitor discharged). The sending path stays free and SEN/STA remains at 0.

When condition 1 or 2 occurs, the timing control circuit switches OFF the output transistor and set SEN/STA to 1. If BCEN = 1, the bit compare function condition 2 is disabled.

When MIBus is selected (MIsel = 1), the timing control circuit action is disabled. This means that the circuit operates and report its status on SEN/STA but doesn't block TRM output.

**Sleep Mode Function**

If TXD = 1 and no transition occurs on REC for a time greater than Tsleep (Tsleep = 40 ms typical) and if the circuit is not in MIBus mode (MI = 0), the circuit will be switched into the sleep mode.

In this mode the Vcc current is reduced to 135μA maximum, the receiving path from REC to RXD and NRXD remains active.

A transition on REC or a high to low transition on TXD will wake up the circuit within Twake.

**TRUTH TABLE for PULL-UP and BUS MODE**

| MI          | PU          | Effect On Bus                               |
|-------------|-------------|---|
| Open or Low | Open or Low | No pull-up active                           |
| Open or Low | High        | 12V pull-up active                          |
| High        | Open or Low | 5V pull-up active - MIBus mode              |
| High        | High        | 12V pull-up active - MIBus programming mode |

**Figure 1. Single Wire MIBus Configuration**

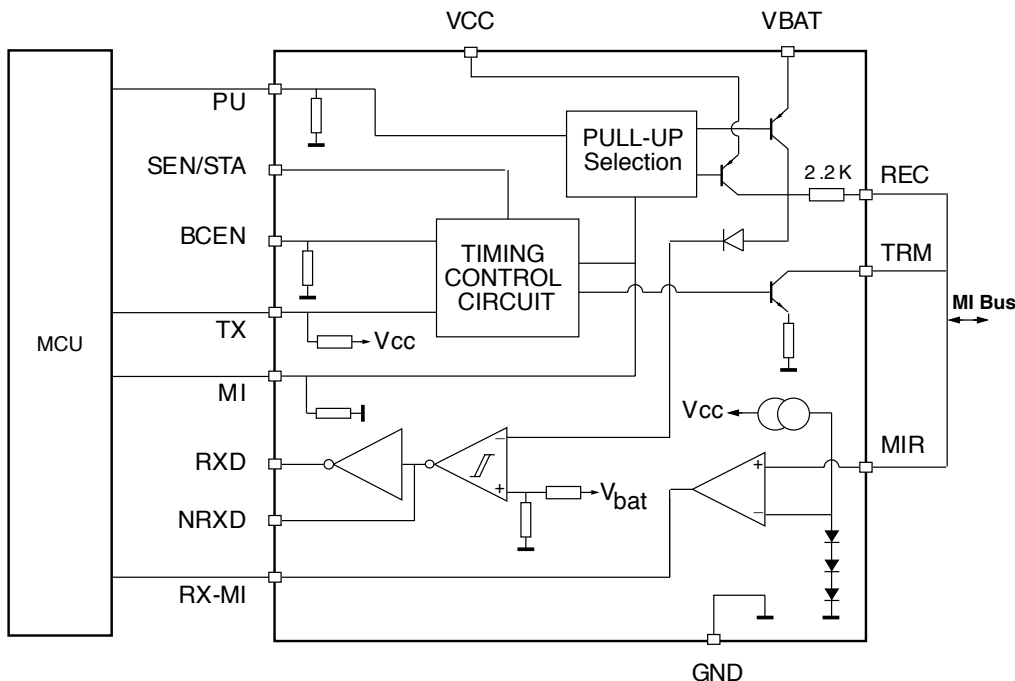


Figure 2. Single Wire Configuration

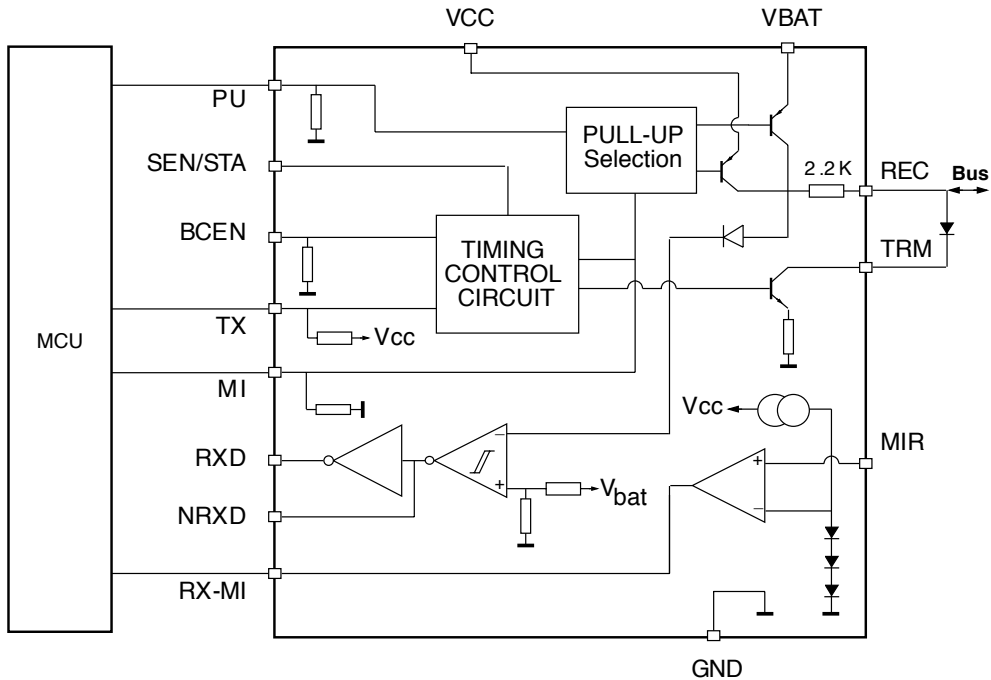
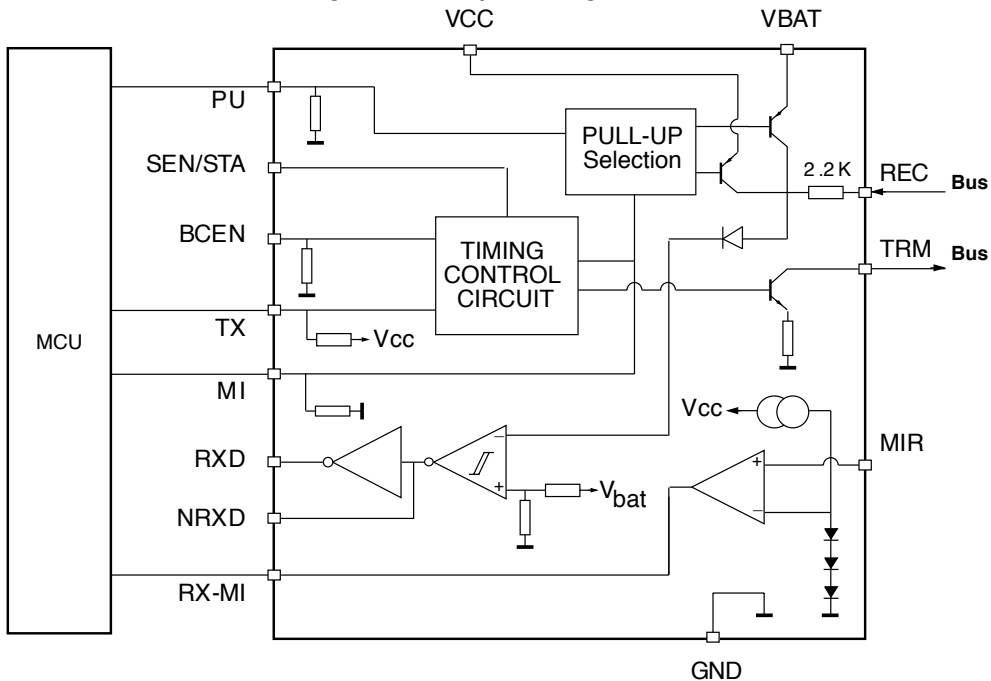



Figure 3. Full Duplex Configuration



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