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## MAX22088

## Home Bus System (HBS) Compatible Transceiver with Active Inductor

### General Description

The MAX22088 Home Bus System (HBS) compatible transceiver can be used in the Home Bus System, where data and power are passed on a single pair of wires, while minimizing the need for external components. The MAX22088 eliminates the large external AC-blocking inductor typically required in bus powered applications and improves the signal quality to allow for longer cables. Additionally, the MAX22088 features an integrated 5V linear regulator to power system loads up to 70mA (max).

The MAX22088 supports passing data with speed up to 200kbps. The MAX22088 features dynamic cable termination to improve the signal quality for applications with high data rates.

Additional features include adjustable receiver hysteresis, receiver thresholds and driver slew rate allow the MAX22088 to be used in a wide variety of systems.

Integrated protection (IEC 61000-4-2  $\pm 8$ kV Contact and  $\pm 15$ kV Air-Gap ESD) ensures robust communication in harsh industrial environments. The MAX22088 is specified for operation over the  $-40^{\circ}\text{C}$  to  $+105^{\circ}\text{C}$  temperature range and is available in a compact 24-pin 4mm x 4mm TQFN package.

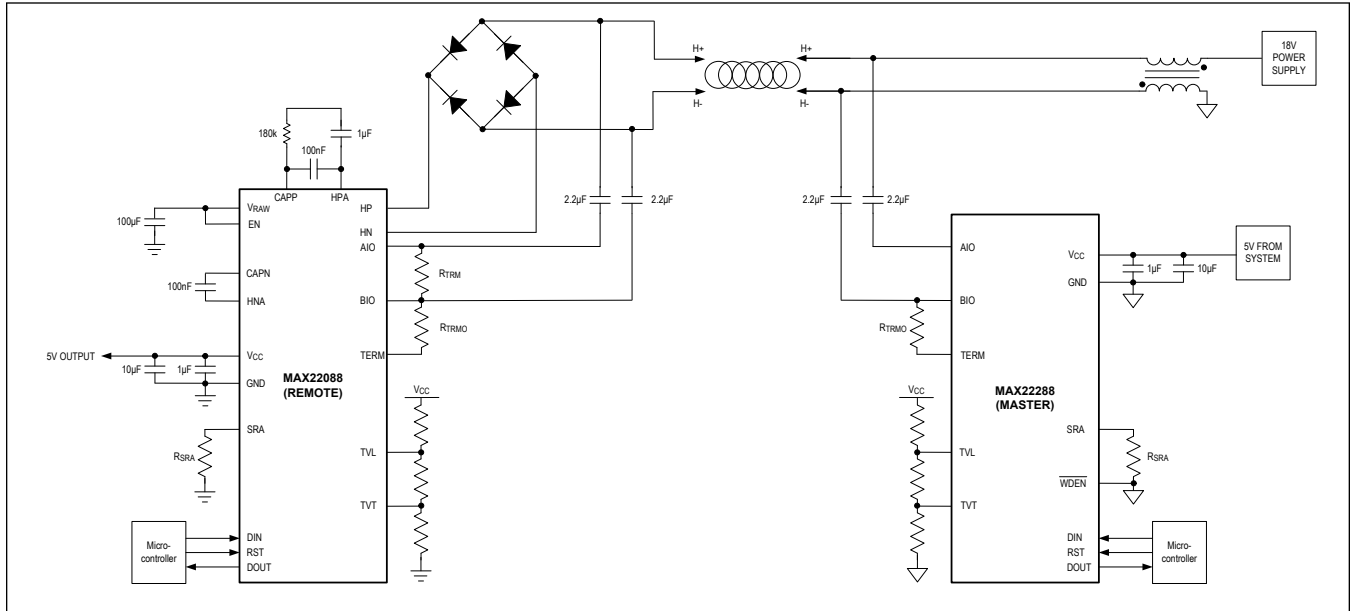
### Applications

- HVAC
- Data over Power Applications
- Digital Signage
- Remote Monitoring and Sensing

### Benefits and Features

- High Integration Reduces BOM and Footprint
  - Eliminates the Need for Large AC-blocking Inductor
  - Compact 4mm x 4mm TQFN Package
  - Supports External DC-DC Converter for System Loads More Than 70mA
- Configurability Enables Flexible Design
  - Adjustable Receiver Thresholds
  - Switched Cable Termination
  - Adjustable Slew Rate on Transmit Signals
  - Large Receiver Hysteresis
  - Data Rates from 9600bps to 200kbps
  - Dynamic Cable Termination Improves Signal Quality for High Speed Applications
- Integrated Protection for Robust Communication
  - IEC 61000-4-2  $\pm 8$ kV Contact and  $\pm 15$ kV Air-Gap ESD Protection
  - IEC 61000-4-5  $\pm 1$ kV Surge Protection with Selected External Components
  - $-40^{\circ}\text{C}$  to  $+105^{\circ}\text{C}$  Operating Temperature Range
  - Thermal Shutdown Protection

Simplified Home Bus System (HBS)



## Absolute Maximum Ratings

|  |                                |  |                 |
|--|--------------------------------|--|-----------------|
| HP to HN .....                             | -0.3V to +28.0V                | CAPP, CAPN.....  | ±10mA           |
| HP to GND.....                             | -0.3V to +28.0V                | All Other Pins .....   | ±50mA           |
| HN to GND .....                            | -6.0V to +6.0V                 | Continuous Power Dissipation   |                 |
| HPA to CAPP .....                          | -0.3V to +6.0V                 | Single-Layer Board (T <sub>A</sub> = +70°C, derate 20.8mW/°C above +70°C)..... | 1666.70mW       |
| CAPN to HNA.....                           | -0.3V to +6.0V                 | Multilayer Board (T <sub>A</sub> = +70°C, derate 27.8mW/°C above +70°C).....   | 2222.20mW       |
| V <sub>RAW</sub> , EN to GND.....          | -0.3V to +28.0V                | Operating Temperature Range .....  | -40°C to +105°C |
| V <sub>CC</sub> to GND.....                | -0.3V to +6.0V                 | Junction Temperature .....   | +150°C          |
| AIO, BIO, TERM, SRA to GND.....            | -0.3V to V <sub>CC</sub> +0.3V | Storage Temperature Range .....  | -40°C to +150°C |
| DIN, DOUT, RST, TVL, TVT, HPEN to GND..... | -0.3V to +6.0V                 | Soldering Temperature (reflow) .....   | +260°C          |
| Continuous Current Into Any Pin            |                                |  |                 |
| HP, HN, V <sub>RAW</sub> , GND .....       | ±250mA                         |  |                 |
| V <sub>CC</sub> , AIO, BIO, TERM .....     | ±100mA                         |  |                 |

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## Package Information

### 24-TQFN

|  |                         |
|--|-------------------------|
| Package Code                                   | T2444+4C                |
| Outline Number                                 | <a href="#">21-0139</a> |
| Land Pattern Number                            | <a href="#">90-0022</a> |
| <b>Thermal Resistance, Single-Layer Board:</b> |                         |
| Junction to Ambient (θ <sub>JA</sub> )         | 48°C/W                  |
| Junction to Case (θ <sub>JC</sub> )            | 3°C/W                   |
| <b>Thermal Resistance, Four-Layer Board:</b>   |                         |
| Junction to Ambient (θ <sub>JA</sub> )         | 36°C/W                  |
| Junction to Case (θ <sub>JC</sub> )            | 3°C/W                   |

For the latest package outline information and land patterns (footprints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maximintegrated.com/thermal-tutorial](http://www.maximintegrated.com/thermal-tutorial).

## Electrical Characteristics

(Global conditions: R<sub>SRA</sub> = 120kΩ, V<sub>TVL</sub> = 1V, V<sub>TVT</sub> = 0.5V, Typical values are at V<sub>HP</sub> - V<sub>HN</sub> = 9V, T<sub>A</sub> = +25°C, unless otherwise noted.) (Note 1)

| PARAMETER  | SYMBOL                            | CONDITIONS   | MIN | TYP | MAX | UNITS |
|--|-----------------------------------|--|-----|-----|-----|-------|
| <b>DC CHARACTERISTICS / POWER SUPPLY (V<sub>CC</sub>, V<sub>RAW</sub>, HP, HN)</b> |                                   |  |     |     |     |       |
| Supply Voltage   | V <sub>HP</sub> - V <sub>HN</sub> | DC input voltage, excluding superimposed HBS data signals        | 9   |     | 24  | V     |
|  | V <sub>RAWI</sub>                 | External voltage applied to V <sub>RAW</sub>                     | 4.6 |     | 24  |       |
| V <sub>RAW</sub> Output Voltage  | V <sub>RAWO</sub>                 | V <sub>HP</sub> - V <sub>HN</sub> = 9V, I <sub>RAW</sub> = 0mA   | 7.4 | 7.7 |     | V     |
|  |                                   | V <sub>HP</sub> - V <sub>HN</sub> = 9V, I <sub>RAW</sub> = 200mA | 6.9 | 7.3 |     |       |
| V <sub>CC</sub> Output Voltage   | V <sub>CC</sub>                   | I <sub>LOAD</sub> = 70mA, V <sub>RAW</sub> ≥ 6V                  | 4.5 | 5.0 | 5.5 | V     |

**Electrical Characteristics (continued)**

(Global conditions:  $R_{SRA} = 120k\Omega$ ,  $V_{TVL} = 1V$ ,  $V_{TVT} = 0.5V$ , Typical values are at  $V_{HP} - V_{HN} = 9V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.) (Note 1)

| PARAMETER   | SYMBOL              | CONDITIONS  | MIN            | TYP | MAX  | UNITS      |
|---|---------------------|---|----------------|-----|------|------------|
| Supply Current  | $I_{HP}, I_{HN}$    | $V_{RST} = V_{CC}$ , $I_{CC} = 0mA$ , $V_{HP} - V_{HN} = 9V$                                    |                | 3   | 5    | mA         |
|   | $I_{RAW}$           | $V_{RST} = V_{CC}$ , $HP = CAPP = V_{RAW}$ , $HN = CAPN = GND$                                  |                | 2.5 | 4.0  |            |
|   |                     | $HP = CAPP = V_{RAW}$ , $V_{RST} = HN = CAPN = GND$ , $DIN$ at 57.6kbps, $R_{LOAD} = 100\Omega$ |                | 25  |      |            |
| Maximum $V_{CC}$ Load Current                                 | $I_{VCCMAX}$        | $V_{HP} - V_{HN} \geq 9V$ , including $I_{RAW}$   |                |     | 70   | mA         |
| Maximum $V_{RAW}$ Load Current                                | $I_{VRAWMAX}$       | $V_{HP} - V_{HN} \geq 9V$ , excluding superimposed HBS data signals                             |                |     | 200  | mA         |
| <b>DC CHARACTERISTICS / TRANSMIT CHANNEL (AIO, BIO, TERM)</b> |                     |   |                |     |      |            |
| Output Voltage High   | $V_{TOH}$           | AIO, BIO to GND, $V_{RAW} \geq 4.6V$ , $I_{LOAD} = 45mA$ to GND                                 | $V_{CC} - 0.6$ |     |      | V          |
| Output Voltage Low  | $V_{TOL}$           | AIO, BIO to GND, $V_{RAW} \geq 4.6V$ , $I_{LOAD} = 45mA$ to $V_{CC}$                            |                |     | 0.6  | V          |
| Termination Switch On Resistance                              | $R_{TERM}$          | TERM to AIO   | 2.5            | 5   | 10   | $\Omega$   |
| AIO, BIO Transmit Input Resistance                            | $R_{IN}$            | Input resistance of AIO and BIO when they are unconnected, $DIN = V_{CC}$                       | 7              | 10  | 13   | k $\Omega$ |
| Bias Voltage Ratio Matching                                   | $V_{AIO} / V_{BIO}$ | AIO, BIO unconnected  | -1             |     | +1   | %          |
| <b>DC CHARACTERISTICS / RECEIVE CHANNEL (TVL, TVT)</b>        |                     |   |                |     |      |            |
| Receive Threshold Leading Edge                                | $V_{LEAD}$          | $V_{TVL} = 1.0V$ , $\overline{HPEN} = V_{CC}$   | 0.85           | 1   | 1.15 | V          |
| Receive Threshold Trailing Edge                               | $V_{TRAIL}$         | $V_{TVT} = 0.5V$ , $\overline{HPEN} = V_{CC}$   | 0.35           | 0.5 | 0.65 | V          |
| TVL and TVT Input Leakage Current                             | $I_{THLEAK}$        | $V_{TVT} = V_{TVL} = 2.5V$  | -1             |     | +1   | $\mu A$    |
| <b>DC CHARACTERISTICS / DIGITAL I/O</b>                       |                     |   |                |     |      |            |
| Input Logic-High  | $V_{IH}$            |   | 1.4            |     |      | V          |
| Input Logic-Low   | $V_{IL}$            |   |                |     | 0.4  | V          |
| Input Leakage Current   | $I_{LEAK}$          |   | -1             |     | +1   | $\mu A$    |
| Open-Drain Logic-Low  | $V_{OL}$            | $I_{SINK} = 2mA$  |                |     | 0.3  | V          |
| Open-Drain Leakage  | $I_{ODL}$           | $V_{OUT} = 5V$ , output not asserted  |                |     | 1    | $\mu A$    |
| <b>AC CHARACTERISTICS / TRANSMIT CHANNEL (Note 3)</b>         |                     |   |                |     |      |            |
| Output Rise Time Leading Edge                                 | $t_{RLD}$           | $R_{SRA} = 120k\Omega$ , $R_{LOAD} = 200\Omega$ , <a href="#">Figure 1</a>                      | 0.8            | 1.4 | 2.0  | $\mu s$    |
| Output Fall Time Leading Edge                                 | $t_{FLD}$           | $R_{SRA} = 120k\Omega$ , $R_{LOAD} = 200\Omega$ , <a href="#">Figure 1</a>                      | 0.8            | 1.4 | 2.0  | $\mu s$    |
| Output Rise Time Trailing Edge                                | $t_{RTR}$           | $R_{SRA} = 120k\Omega$ , $R_{LOAD} = 200\Omega$ , <a href="#">Figure 1</a>                      | 0.8            | 1.4 | 2.0  | $\mu s$    |
| Output Fall Time Trailing Edge                                | $t_{FTR}$           | $R_{SRA} = 120k\Omega$ , $R_{LOAD} = 200\Omega$ , <a href="#">Figure 1</a>                      | 0.8            | 1.4 | 2.0  | $\mu s$    |

**Electrical Characteristics (continued)**

(Global conditions:  $R_{SRA} = 120k\Omega$ ,  $V_{TVL} = 1V$ ,  $V_{TVT} = 0.5V$ , Typical values are at  $V_{HP} - V_{HN} = 9V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.) (Note 1)

| PARAMETER   | SYMBOL           | CONDITIONS   | MIN  | TYP  | MAX      | UNITS      |
|---|------------------|--|------|------|----------|------------|
| Transmit Propagation Delay                            | $t_{TPROP}$      | $R_{SRA} = 120k\Omega$ , $R_{LOAD} = 200\Omega$ , <a href="#">Figure 1</a> |      |      | 1.2      | $\mu s$    |
| Transmission Output Symmetry                          | $t_{SYM}$        | $R_{SRA} = 120k\Omega$ , $R_{LOAD} = 200\Omega$ , <a href="#">Figure 1</a> | -0.4 | 0    | +0.4     | $\mu s$    |
| Termination Switching Delay                           | $t_{TERM}$       | $R_{SRA} = 120k\Omega$ , $R_{LOAD} = 200\Omega$ , <a href="#">Figure 2</a> |      |      | 0.5      | $\mu s$    |
| Termination On-Time                                   | $t_{TRMON}$      | $R_{SRA} = 120k\Omega$ , $R_{LOAD} = 200\Omega$ , <a href="#">Figure 2</a> | 19   | 34   | 63       | $\mu s$    |
| <b>AC CHARACTERISTICS / RECEIVE CHANNEL (Note 3)</b>  |                  |  |      |      |          |            |
| Receive Propagation Delay                             | $t_{RPROP}$      | $\overline{HPEN} = V_{CC}$ , <a href="#">Figure 3</a>                      |      |      | 1        | $\mu s$    |
| Receiver High Pass Filter Time Constant               | $t_{HP}$         | $\overline{HPEN} = GND$  |      | 1200 |          | $\mu s$    |
| <b>PROTECTION</b>                                     |                  |  |      |      |          |            |
| ESD Protection AIO, BIO, TERM, HP, HN to GND (Note 2) |                  | IEC 61000-4-2 air-gap discharge  |      |      | $\pm 15$ | kV         |
|   |                  | IEC 61000-4-2 contact discharge  |      |      | $\pm 8$  |            |
| ESD Protection  | $V_{ESD}$        | Human Body Model   |      |      | $\pm 4$  | kV         |
| Thermal Shutdown                                      | $T_{SHDN}$       | Junction temperature rising  |      |      | +150     | $^\circ C$ |
| Thermal Shutdown Hysteresis                           | $T_{SHDN\_HYST}$ |  |      |      | 20       | $^\circ C$ |

**Note 1:** Limits are 100% tested at  $T_A = +25^\circ C$ . Limits over the operating temperature range are guaranteed by design.

**Note 2:** Both air-gap and contact ESD are tested with no power connected to HP, HN,  $V_{RAW}$ , or  $V_{CC}$ .

**Note 3:** Not production tested. Guaranteed by design.

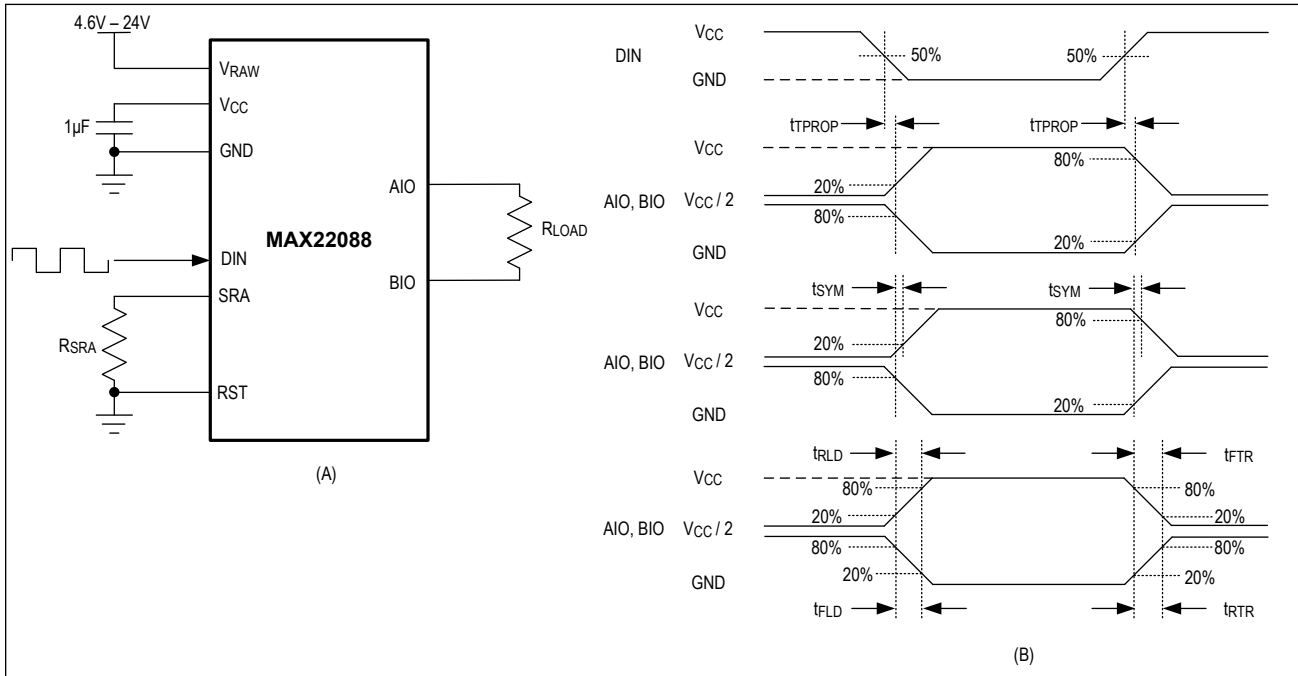


Figure 1. Transmit Channel Timing Diagram

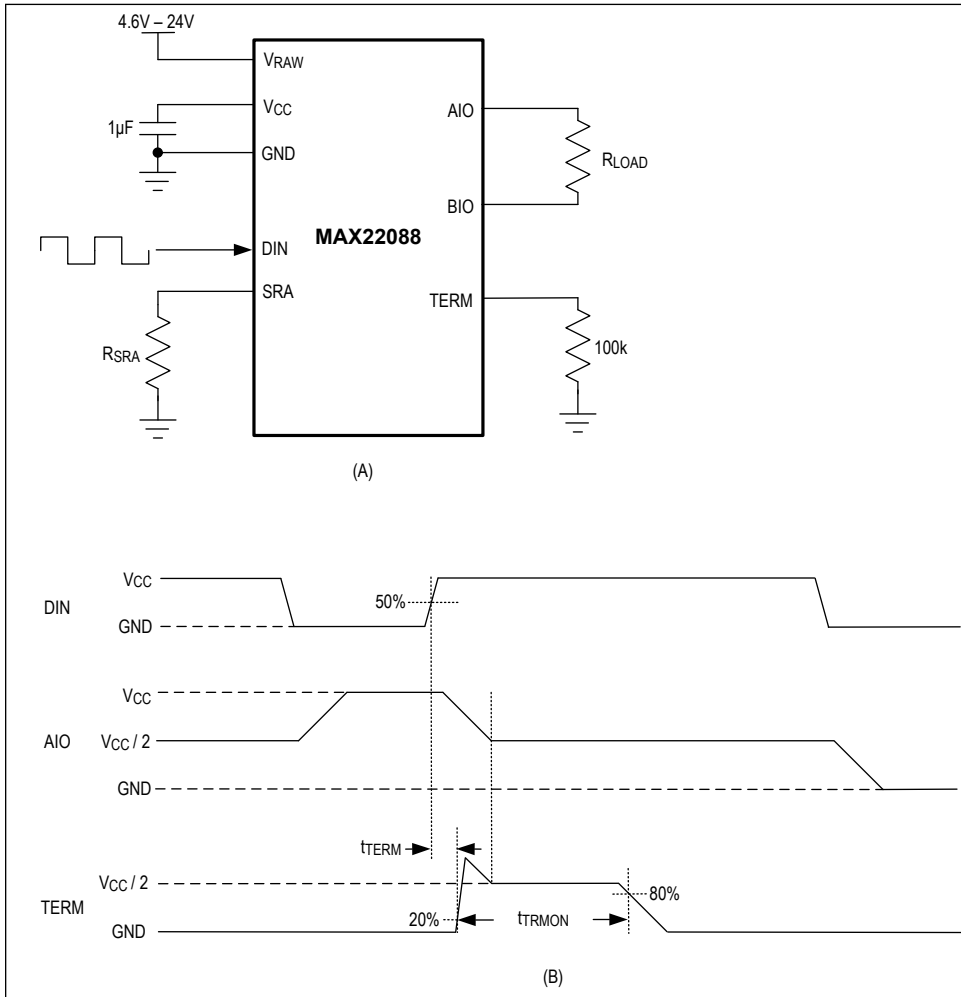


Figure 2. Transmission Switch Delay and Termination On-Time

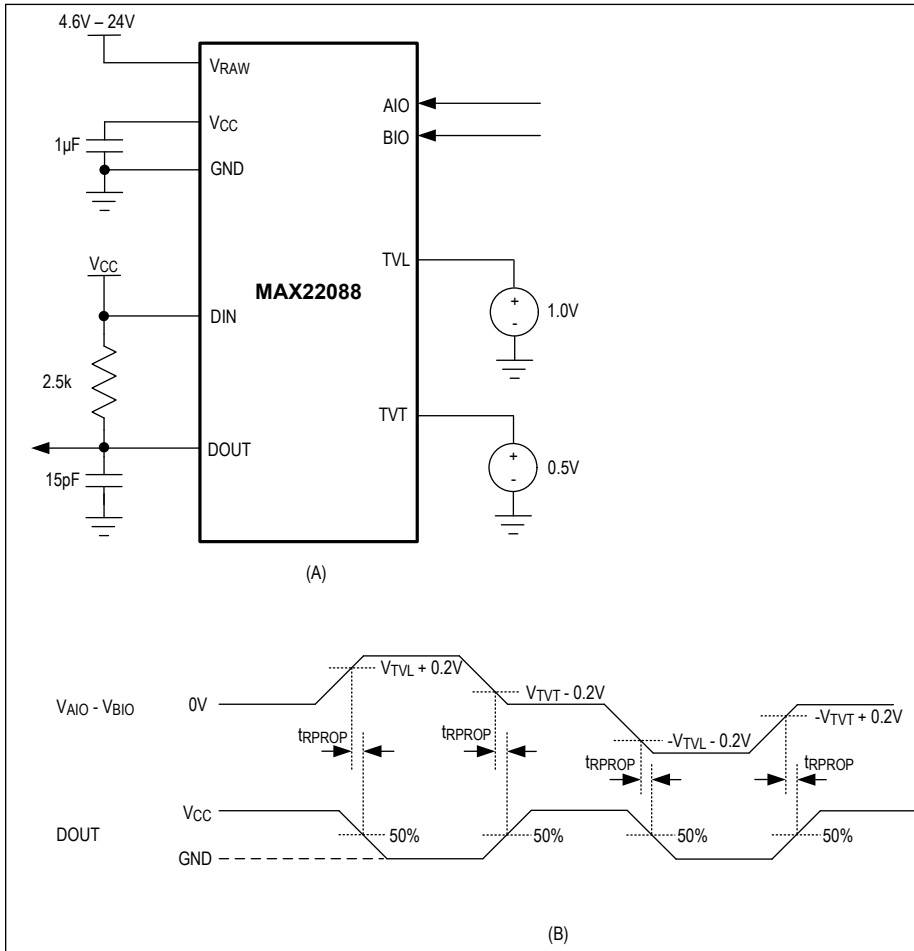
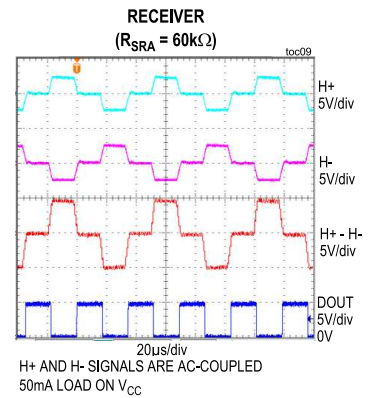
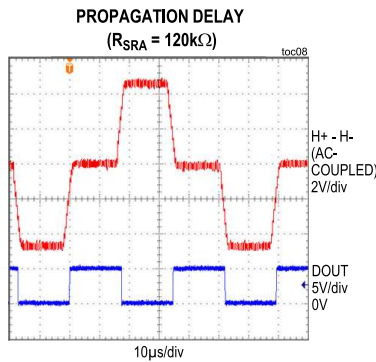
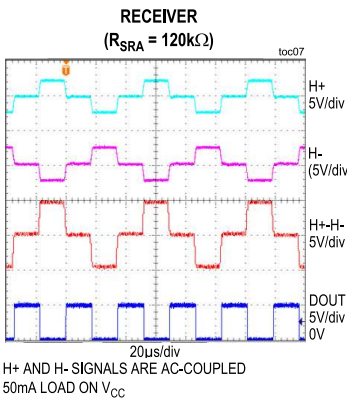
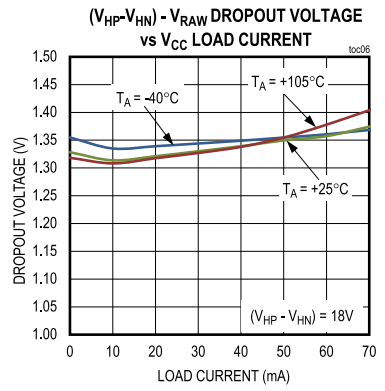
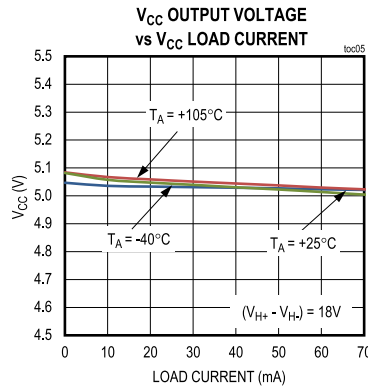
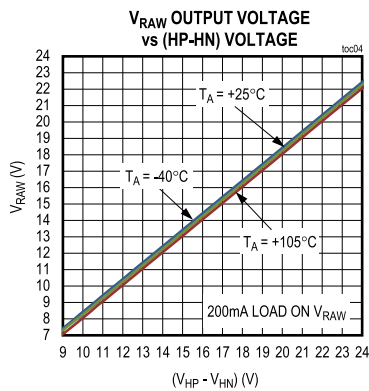
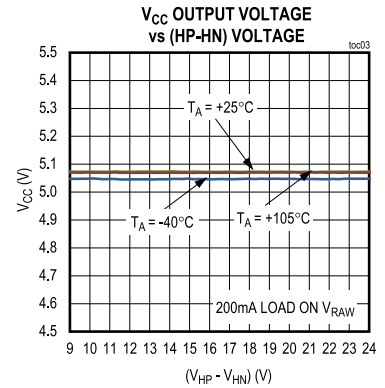
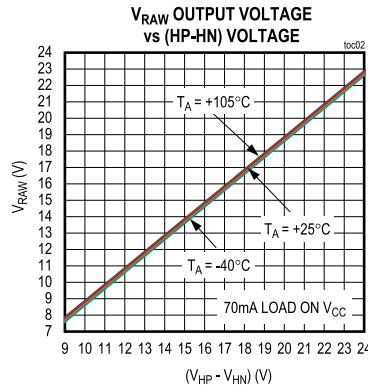
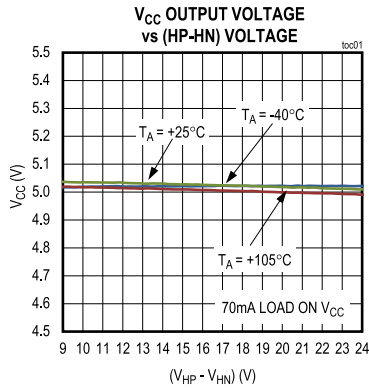


Figure 3. Receive Propagation Delay



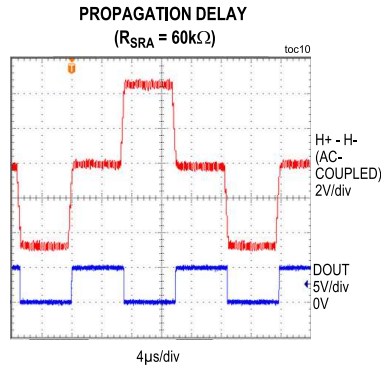
Typical Operating Characteristics

( $T_A = +25^\circ\text{C}$ , unless otherwise noted.)



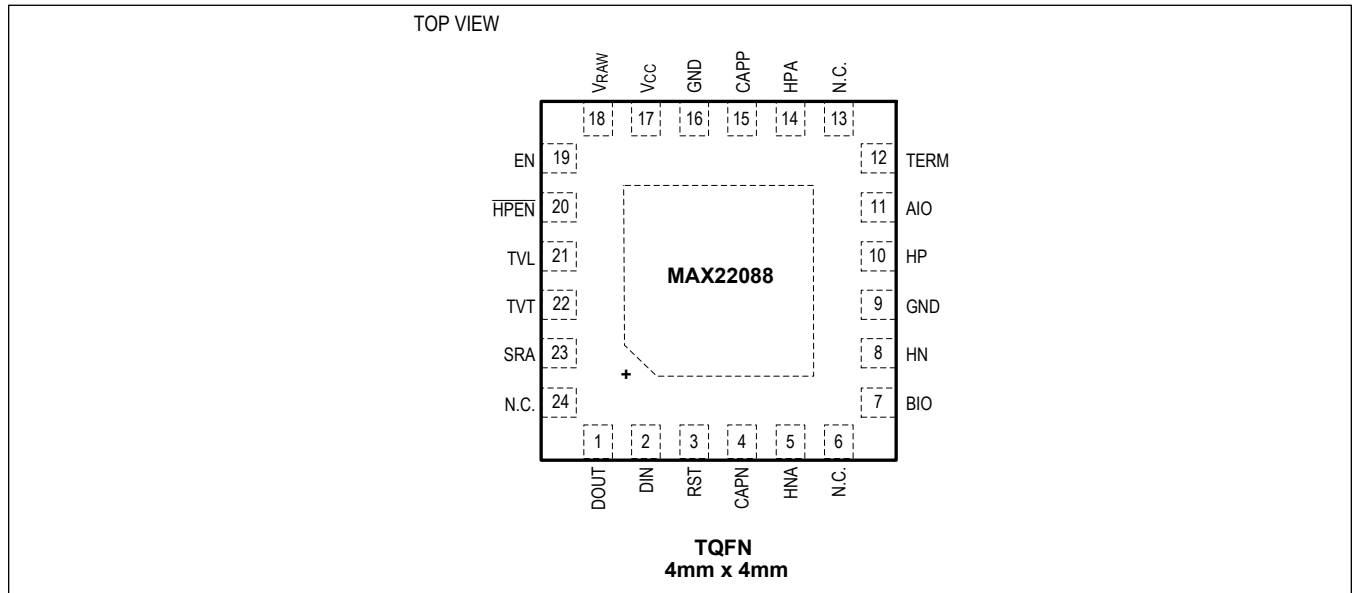
Typical Operating Characteristics (continued)

(T<sub>A</sub> = +25°C, unless otherwise noted.)



Pin Configuration

MAX22088



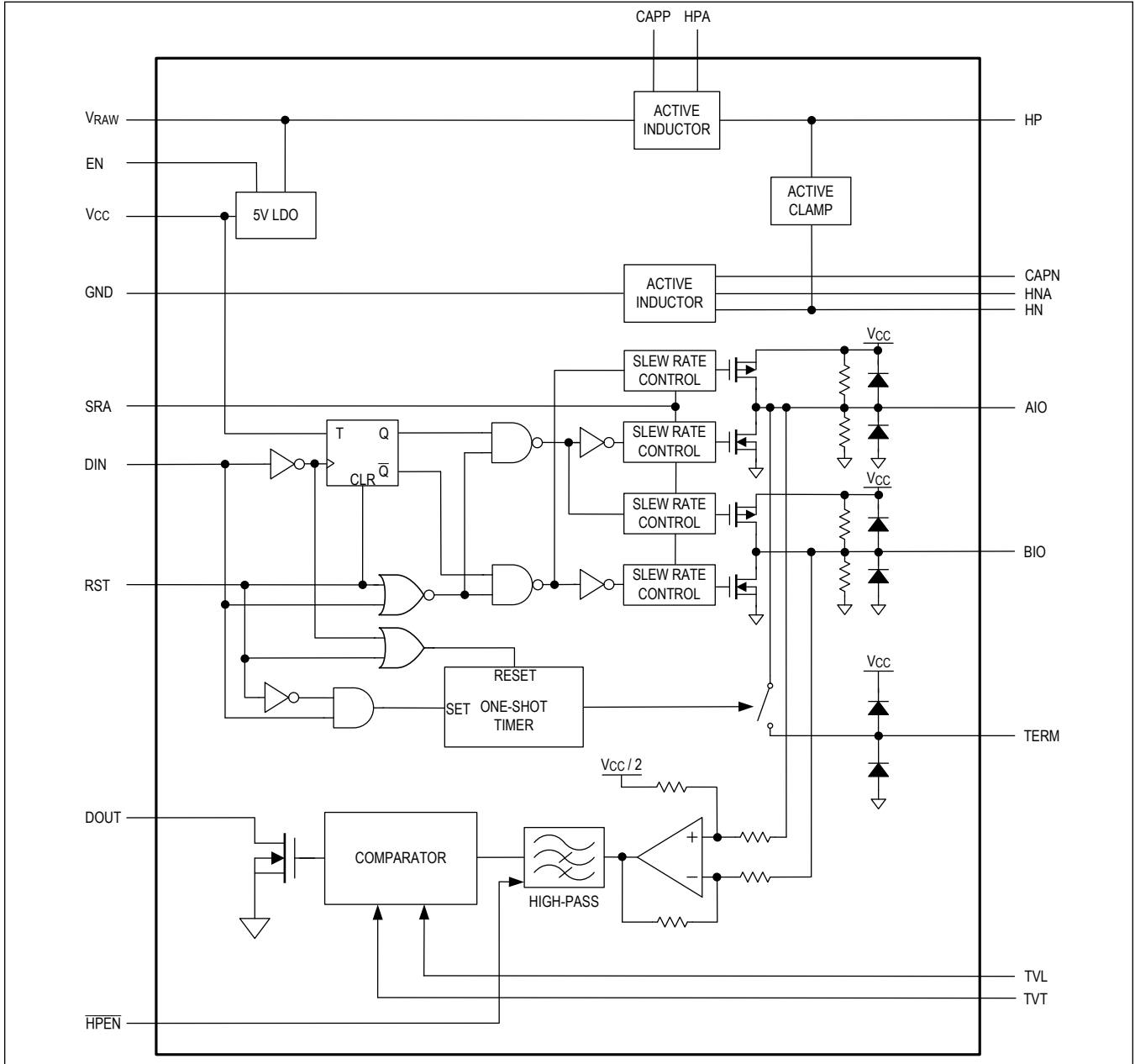
Pin Description

| PIN          | NAME | FUNCTION   |
|--------------|------|--|
| <b>POWER</b> |      |  |
| 4            | CAPN | Active Inductor Bypass Capacitor Connection. For 57.6kbps operation, connect a 100nF ceramic capacitor between CAPN and HNA. Connect CAPN to HNA when the Active Inductor is not used. See the <a href="#">Active Inductor</a> section for more information. |
| 5            | HNA  | Active Inductor Bypass Capacitor Connection. For 57.6kbps operation, connect a 100nF ceramic capacitor between CAPN and HNA. Connect HNA to CAPN when the Active Inductor is not used.   |

## Pin Description (continued)

| PIN             | NAME                     | FUNCTION   |
|-----------------|--------------------------|--|
| 14              | HPA                      | Active Inductor Bypass Capacitor Connection. Connect a 1 $\mu$ F ceramic capacitor in series with a 180k $\Omega$ resistor between CAPP and HPA. In parallel, connect an additional 100nF ceramic capacitor between CAPP and HPA for 57.6kbps operation. Connect HPA to CAPP when the Active Inductor is not used.   |
| 15              | CAPP                     | Active Inductor Bypass Capacitor Connection. Connect a 1 $\mu$ F ceramic capacitor in series with a 180k $\Omega$ resistor between CAPP and HPA. In parallel, connect an additional 100nF ceramic capacitor between CAPP and HPA for 57.6kbps operation. Connect CAPP to HPA when the Active Inductor is not used. See the <a href="#">Active Inductor</a> section for more information. |
| 9, 16           | GND                      | Ground Reference. See the <a href="#">Layout Recommendations</a> section for more information.   |
| 17              | V <sub>CC</sub>          | LDO Power Output. Bypass V <sub>CC</sub> to GND with a 1 $\mu$ F (min) ceramic capacitor as close to the device as possible. V <sub>CC</sub> is able to supply up to 70mA (max) of current to external loads. See the <a href="#">Internal Voltage Regulator</a> section for more information.   |
| 18              | V <sub>RAW</sub>         | Active Inductor Power Output. Bypass V <sub>RAW</sub> to GND with a 100 $\mu$ F (min) capacitor to drive loads less than 70mA (max). Bypass V <sub>RAW</sub> to GND with a 200 $\mu$ F (min) capacitor to drive loads more than 70mA (max). See the <a href="#">V<sub>RAW</sub> Voltage Output</a> section for more information.   |
| EP              | —                        | Exposed pad. Connect EP to GND.  |
| <b>HOME BUS</b> |                          |  |
| 7               | BIO                      | Home Bus Data Input and Output. Connect BIO to Home Bus through an external 2.2 $\mu$ F capacitor in series with a 4.7 $\Omega$ resistor for 57.6kbps operation. See the <a href="#">Operation of MAX22088 Transceiver</a> section for more information.   |
| 8               | HN                       | Power Supply Input from Home Bus. Connect HN to GND when the Active Inductor is not used. See the <a href="#">Power Supply</a> section for more information.   |
| 10              | HP                       | Power Supply Input from Home Bus. Connect HP to V <sub>RAW</sub> when the Active Inductor is not used. See the <a href="#">Power Supply</a> section for more information.  |
| 11              | AIO                      | Home Bus Data Input and Output. Connect AIO to Home Bus through an external 2.2 $\mu$ F capacitor in series with a 4.7 $\Omega$ resistor for 57.6kbps operation. See the <a href="#">Operation of MAX22088 Transceiver</a> section for more information.   |
| 12              | TERM                     | Switched Bus Termination. Connect a resistor between TERM and BIO to adjust Home Bus cable termination for better signal quality. See the <a href="#">Dynamic Cable Termination</a> section for more information.  |
| 21              | TVL                      | Leading Edge Data Threshold. See the <a href="#">Receiver Thresholds</a> section for more information.   |
| 22              | TVT                      | Trailing Edge Data Threshold. See the <a href="#">Receiver Thresholds</a> section for more information.  |
| <b>LOGIC</b>    |                          |  |
| 1               | DOUT                     | Open-Drain Data Output. Connect a pullup resistor to the logic voltage supply.   |
| 2               | DIN                      | Data Input   |
| 3               | RST                      | Bus Reset Control Input. See the <a href="#">RST (Reset) Functionality</a> section for more information.   |
| 19              | EN                       | LDO Enable Input. Always connect EN to V <sub>RAW</sub> to enable the internal voltage regulator.  |
| 20              | $\overline{\text{HPEN}}$ | High Pass Filter Enable Input. Connect $\overline{\text{HPEN}}$ to GND to enable the internal high pass filter on receiver input. Connect HPEN to V <sub>CC</sub> to disable the internal high pass filter. Do not leave HPEN unconnected. See the <a href="#">High Pass Filter</a> section for more information.  |
| 23              | SRA                      | Slew Rate Adjustment Input. Connect SRA to GND through a resistor to adjust the slew rate of the AIO and BIO transmit edges. See the <a href="#">Transmit Slew Rate Adjustment</a> section for more information.   |
| 6, 13, 24       | N.C.                     | Not Connected  |

Functional Diagrams



## Detailed Description

The MAX22088 can be used in the Home Bus System (HBS), where power and data are carried on a single pair of wires. The MAX22088 operates with data rates up to 200kbps for bus-powered applications. For applications where power is consumed, the MAX22088 features an integrated Active Inductor to eliminate the use of external AC-blocking inductor. In applications where only data communication is required or an external power source exists, the MAX22088, the Home Bus System (HBS) compatible transceiver without an Active Inductor can be used. Refer to the MAX22088 data sheet for more information.

The MAX22088 can drive external system loads at 5V up to 70mA using the integrated voltage regulator. The MAX22088 also features dynamic cable termination, configurable receiver hysteresis and thresholds, and transmit driver slew rate adjustment for better signal quality and flexible design.

## Power Supply

For applications where power is sourced, the MAX22088 is powered by the system voltage supplied at  $V_{RAW}$ . In this configuration, an external AC-blocking inductor is required to superimpose the data on the Home Bus cable. Bypass the integrated Active Inductor by connecting CAPN to HNA, HN to GND, CAPP to HPA, and HP to  $V_{RAW}$ .

For applications where power is consumed, the MAX22088 is powered by the voltage carried on the Home Bus cable. In this configuration, the MAX22088 eliminates the need for an external AC-blocking inductor and uses the integrated Active Inductor to separate data from power. Power is passed from the Home Bus cable to  $V_{RAW}$  to supply the MAX22088 and drive external system loads.

## $V_{RAW}$ Voltage Output

$V_{RAW}$  is the output of the integrated Active Inductor. The integrated Active Inductor can source up to 200mA (max) to  $V_{RAW}$  to power the external loads, minus internal load current. Bypass  $V_{RAW}$  to GND with a 100 $\mu$ F (min) capacitor to drive loads less than 70mA (max). Bypass  $V_{RAW}$  to GND with a 200 $\mu$ F (min) capacitor to drive loads more than 70mA (max). To drive larger loads, or for a regulated output, connect a DC-DC converter, or an LDO, to  $V_{RAW}$ . See the [Typical Application Circuits](#) section for more information.

## Internal Voltage Regulator

The MAX22088 features an internal 5V linear regulator, powered by  $V_{RAW}$ , capable of driving external loads up to 70mA (max), minus internal load current. Always connect EN to  $V_{RAW}$  to enable the 5V output at  $V_{CC}$ . Do not use  $V_{CC}$  to power external loads if an external LDO or DC-DC converter is connected at  $V_{RAW}$ . See the [Typical Application Circuits](#) section for more information.

## Active Inductor

The MAX22088 features an integrated Active Inductor to eliminate the need for an external AC-blocking inductor in applications where power is consumed. The differential inputs, HP and HN, to the integrated Active Inductor maintain a balanced termination for the Home Bus cable. The equivalent value of the integrated Active Inductor ( $L_{ACT}$ ) is set by the values of the two capacitors ( $C_{ACT}$ ) connected between CAPP and HPA, and between CAPN and HNA. Use the following approximate formula to calculate the typical value of the integrated Active Inductor:

$$L_{ACT} = \frac{C_{ACT}}{6 \times 10^{-7}} \times \left( \frac{1}{10 \times \sqrt{I_{LOAD}}} - \frac{1}{3 + 25 \times I_{LOAD}} \right)$$

where  $L_{ACT}$  is in Henry,  $C_{ACT}$  is in Farad,  $I_{LOAD}$  is in Ampere ([Figure 4](#)).

For 57.6kbps operation, the recommended value for  $C_{ACT}$  is 100nF. Ensure that the  $C_{ACT}$  is in the range from 100nF to 500nF.

In parallel to  $C_{ACT}$ , connect a 180k $\Omega$  resistor and a 1 $\mu$ F ceramic capacitor in series between CAPP and HPA to provide dampening for the LC network formed by the integrated Active Inductor and the bypass capacitor on  $V_{RAW}$ . This LC network also limits the inrush current that charges the bypass capacitor on  $V_{RAW}$ .

The transient load current, in series with the output inductance, can cause fluctuations on output voltage at  $V_{RAW}$ . In a Home Bus system, the total inductance is the serial combination of the passive inductor on the power-sourcing side (host)

and the integrated Active Inductor on the power-consuming side (device). Limit the load current and carefully select the  $C_{ACT}$  value to avoid excessive voltage fluctuations at  $V_{RAW}$ , as shown in [Table 1](#).

**Table 1. Capacitor Value and Maximum Transient Load Current**

| $C_{ACT}$ (nF) | MAXIMUM TRANSIENT $I_{LOAD}$ (mA) |
|----------------|-----------------------------------|
| 100            | 200                               |
| 200            | 160                               |
| 300            | 120                               |
| 400            | 100                               |
| 500            | 90                                |

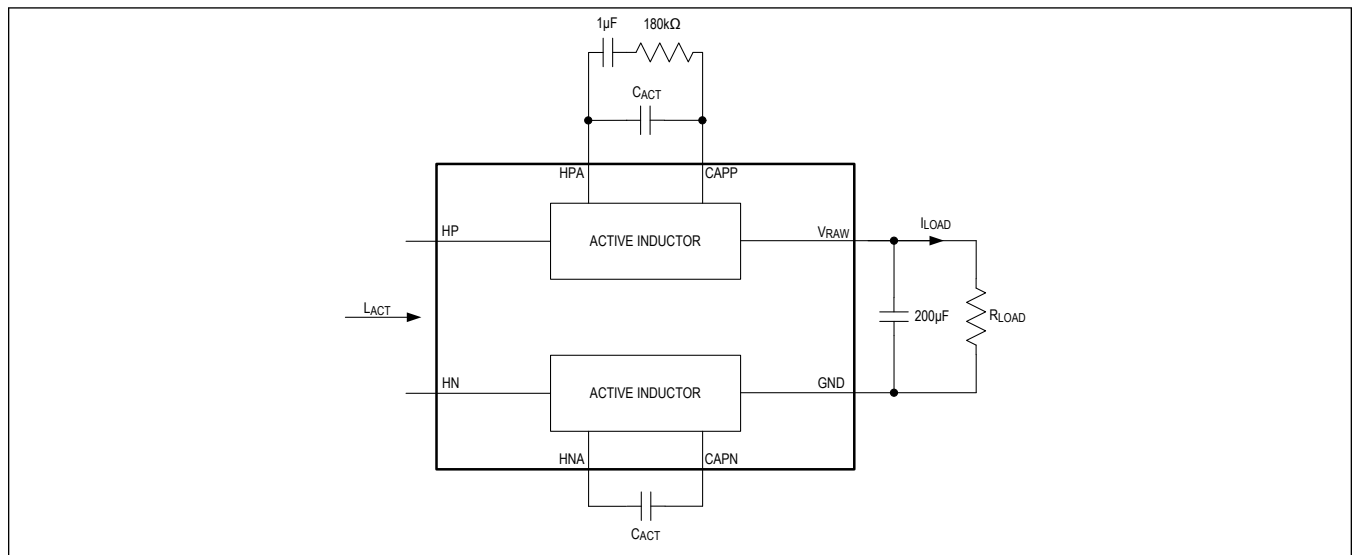


Figure 4. Integrated Active Inductor Circuit

**Operation of MAX22088 Transceiver**

The MAX22088 uses three pins for the logic interface: RST, DIN, and DOUT. AIO, BIO, and TERM are connected to the Home Bus network. RST is the bus reset control input. Drive RST low to enable the transmitter on AIO and BIO. Drive RST high to disable the transmitter. The MAX22088 Home Bus receiver is always enabled.

DIN is the logic input of the MAX22088. DOUT is the logic output. When DIN goes from high to low, the polarities of AIO and BIO invert. When DIN goes from low to high, AIO and BIO are set to high-impedance ([Figure 5](#)).

DOUT asserts low when the leading edge of  $V_{AIO} - V_{BIO}$  crosses  $V_{TVL}$  or  $-V_{TVL}$ . DOUT is high-impedance when the trailing edge of  $V_{AIO} - V_{BIO}$  crosses  $V_{TVT}$  or  $-V_{TVT}$ . See the [Receiver Threshold Adjustment](#) section for more information.

To improve signal quality, the MAX22088 features an internal switch that connects TERM to AIO for 34µs (typ) after the driver transitions to high-impedance. See the [Dynamic Cable Termination](#) section for more information. For a typical data rate of 57.6kbps, the recommended value for coupling capacitors is 2.2µF (min).

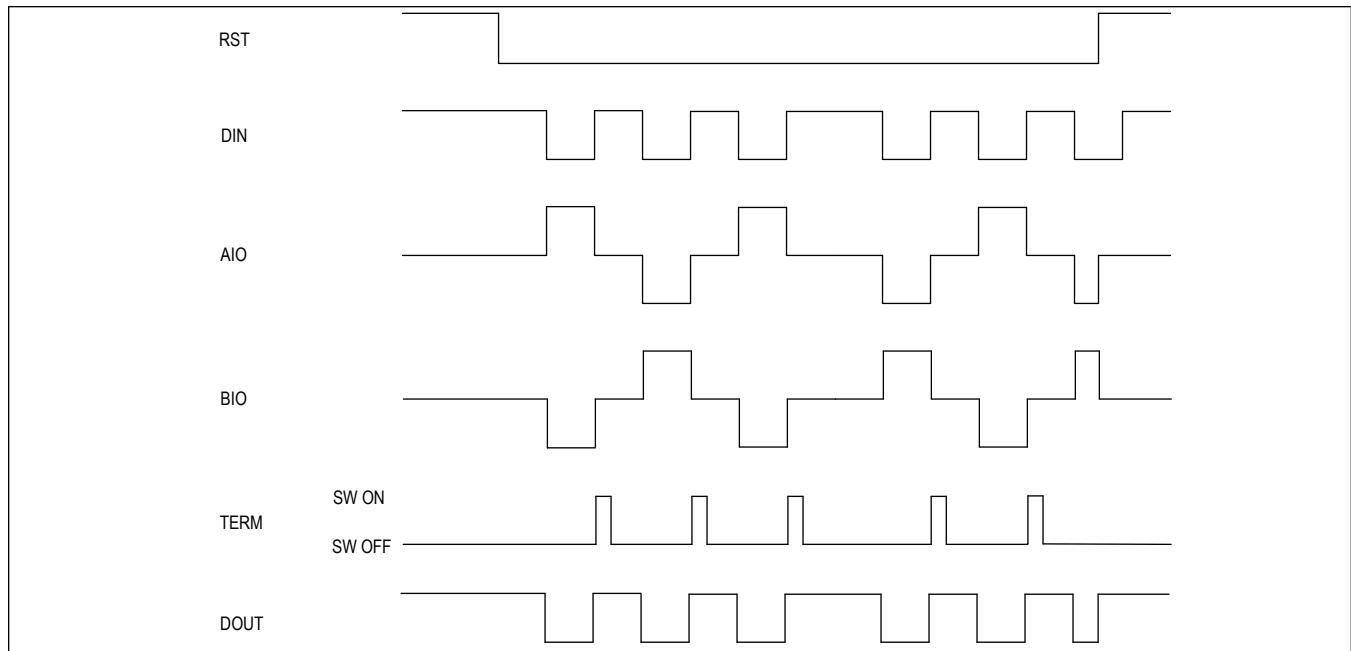


Figure 5. Operation of MAX22088 Transceiver

### Dynamic Cable Termination

The MAX22088 supports Home Bus signals at data rates up to 200kbps. When operating at high data rates, the mismatch between the Home Bus cable impedance and cable termination resistor can negatively affect the signal quality. The MAX22088 features dynamic cable termination to improve the signal quality with longer cables. When DIN asserts high, and the driver transitions to high impedance, an internal switch connects AIO to TERM. The external termination resistor at TERM is then connected between AIO and BIO in parallel with the static cable termination resistor. The internal switch opens after 34 $\mu$ s (typ), when DIN asserts low or when RST is driven high. The optimized value of the dynamic termination resistor depends on the application. For typical applications, the value of the dynamic termination resistor is between 50 $\Omega$  and 240 $\Omega$ .

### Transmit Slew Rate Adjustment

Connect an external resistor,  $R_{SRA}$ , from SRA to GND to control the slew rate of the transmit signals at AIO and BIO. The transmit rise/fall time ( $t_{RLD}$ ,  $t_{FLD}$ ,  $t_{RTR}$ ,  $t_{FTR}$ ) is proportional to  $R_{SRA}$  and is calculated using the following equation:

$$t_{\text{rise/fall}}(\text{ns}) = 17(\text{pF}) \times R_{SRA}(\text{k}\Omega)$$

For most applications, it is recommended to use  $R_{SRA} = 62\text{k}\Omega$  resulting in 1 $\mu$ s (typ) output rise/fall time. Ensure that  $R_{SRA}$  is in the range from 33k $\Omega$  to 470k $\Omega$ .

### Receiver Threshold Adjustment

The threshold levels for the receiving signals are set by the voltages at TVL and TVT. The voltage at TVL sets the threshold for the leading edge of the pulse on the Home Bus signal ( $V_{AIO} - V_{BIO}$ ). The voltage at TVT sets the threshold for the trailing edge of the pulse. Ensure that  $V_{TVL} > V_{TVT}$ .

DOUT asserts low when  $V_{AIO} - V_{BIO}$  crosses  $V_{TVL}$  or  $-V_{TVL}$ . DOUT is high-impedance when  $V_{AIO} - V_{BIO}$  crosses  $V_{TVT}$  or  $-V_{TVT}$  (Figure 6). Connect a pullup resistor from DOUT to a logic voltage supply. Ensure the pullup resistor is in the range from 1k $\Omega$  to 100k $\Omega$ .

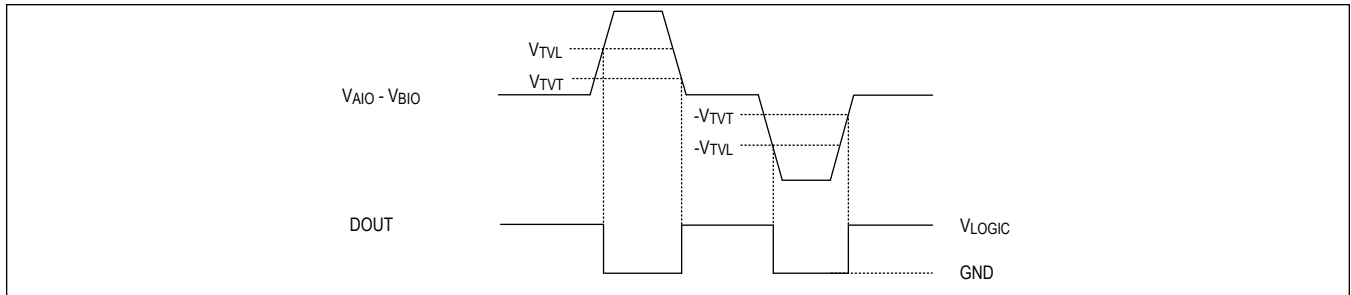


Figure 6. Receiver Thresholds

### RST (Reset) Functionality

The MAX22088 features a bus reset control input. Drive RST low to enable the transmitter. Drive RST high to disable the transmitter. RST also controls the internal switch used for dynamic cable termination. Ensure that RST remains low for at least 34 $\mu$ s (typ) after the internal switch is closed when the driver transitions to high-impedance. The internal switch opens when RST is driven high.

### High-Pass Filter

The MAX22088 features an internal high pass filter on the receiver to filter out the low frequency voltage fluctuations at AIO and BIO. Connect  $\overline{\text{HPEN}}$  to GND to enable the internal high-pass filter on the receiver input. Connect  $\overline{\text{HPEN}}$  to  $V_{CC}$  to disable the internal high pass filter. Ensure that  $\overline{\text{HPEN}}$  is always connected.



## Applications Information

### Surge Protection

External components are required to protect the MAX22088 Home Bus pins (HP, HN, AIO, BIO, and TERM) from high-voltage transient events. The [Typical Application Circuits](#) show a recommended protection scheme.

### HP and HN Surge Protection

HP and HN must be protected with external components from surge transients. Connect a TVS diode between the HP and HN lines. Ensure that the maximum standoff voltage of the TVS diode does not exceed 24V (max). Connect a 1 $\Omega$  current limiting resistor between the TVS diode and HP to force the current sharing between an internal Active Clamp and the external TVS diode ([Figure 7](#)).

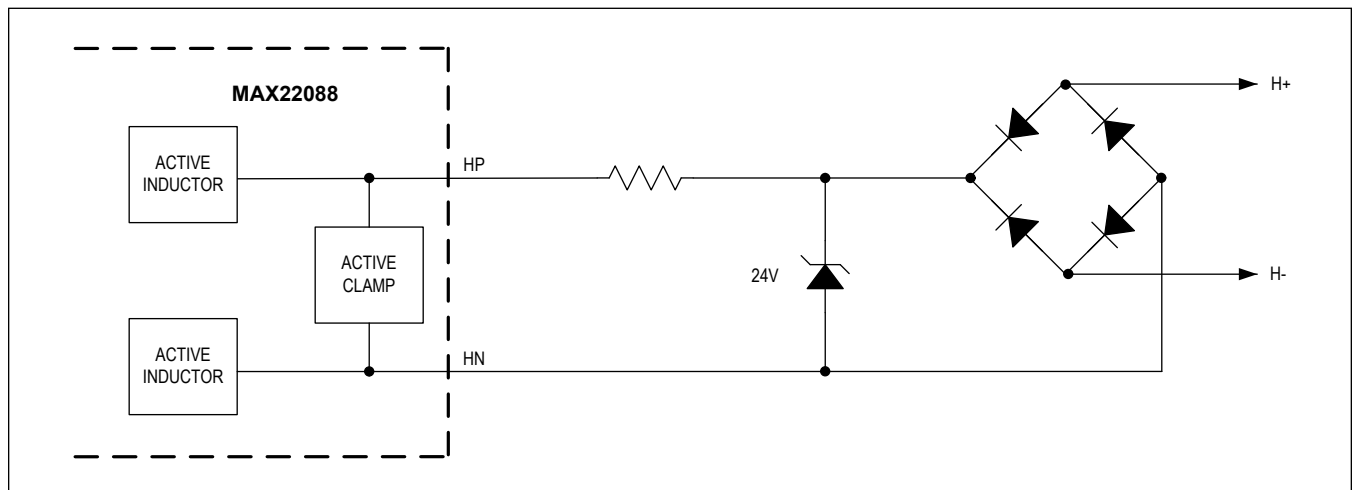


Figure 7. HP and HN Surge Protection

### AIO, BIO, and TERM Surge Protection

AIO, BIO, and TERM must be protected with external components from surge transients. Connect TVS diodes with a 5.8V (max) standoff voltage from AIO and BIO to GND. Connect a 4.7 $\Omega$  serial resistor between each TVS diode and AIO/BIO to limit the current flows into AIO/BIO during the surge transients. Depending on the surge transients polarities, the residual current after the 4.7 $\Omega$  resistor flows from AIO/BIO through the internal ESD clamping diodes to  $V_{CC}$  or GND. Connect a 1 $\mu$ F (min) ceramic capacitor as close to  $V_{CC}$  as possible, and a 10 $\mu$ F (min) bulk capacitor on the  $V_{CC}$  bus to absorb this current and limit the voltage overshoot on  $V_{CC}$  during surge transients.

### Layout Recommendations

Although impedance matching is not required on H+ and H- lines, route them together as much as possible. To reduce the parasitic capacitance on signal lines, do not route H+ and H- lines, or their connected components, over the ground planes.

To ensure proper protection, connect the ground return of the protection diodes directly to the ground plane. Use a star configuration to connect all grounds together as close to the GND (pin 9) as possible. Place the external protection TVS diodes and the diode bridge as close to the Home Bus connector as possible.

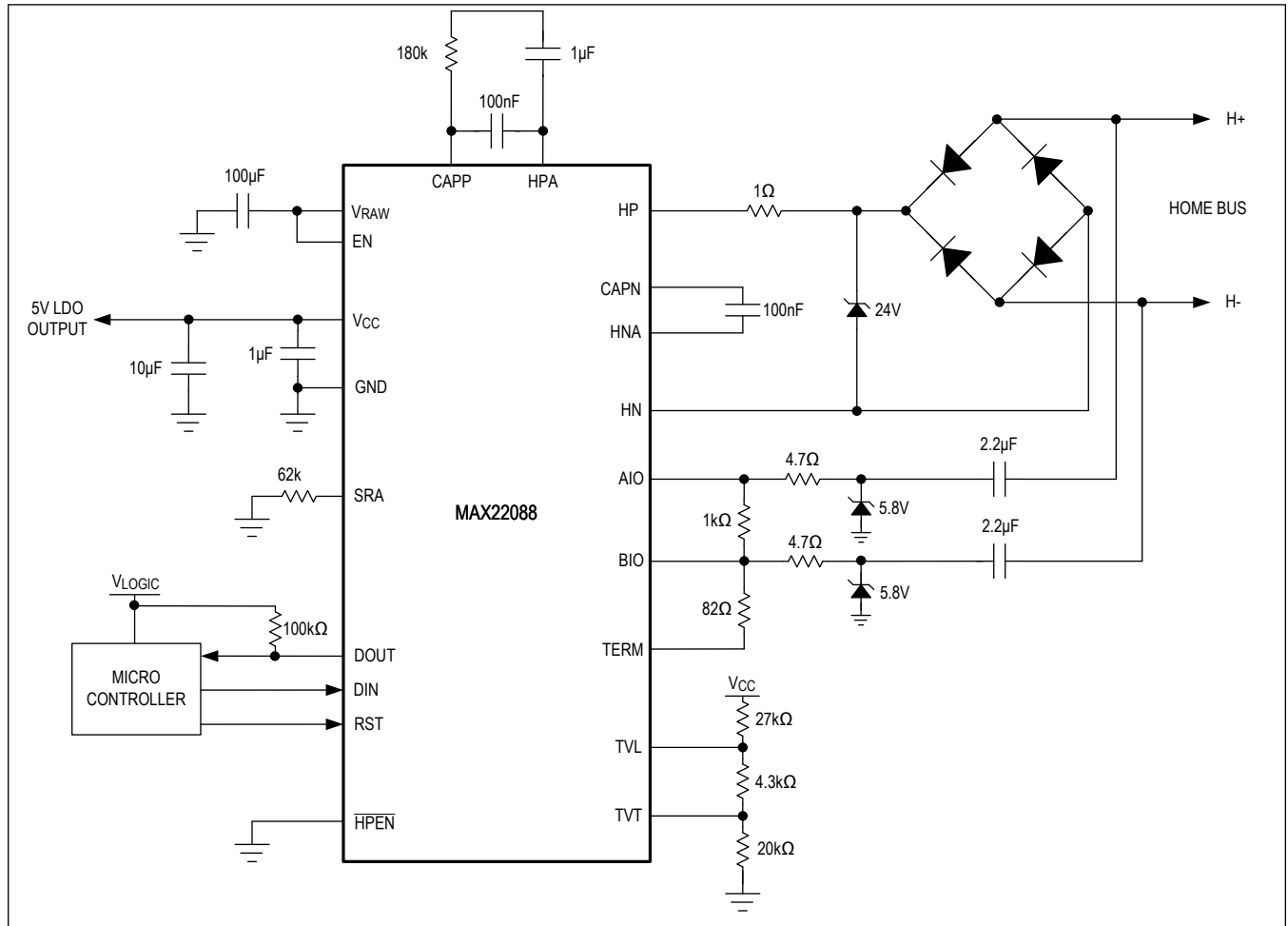
### Application Notes

Refer to [AN7224](#), Introduction to Home Bus, for Home Bus System (HBS) standard and communication protocols.

Refer to [AN7226](#), How to Transmit UART Packets Using Home Bus System (HBS) Compatible Transceiver, for data packet processing examples in microcontroller in the Home Bus System.

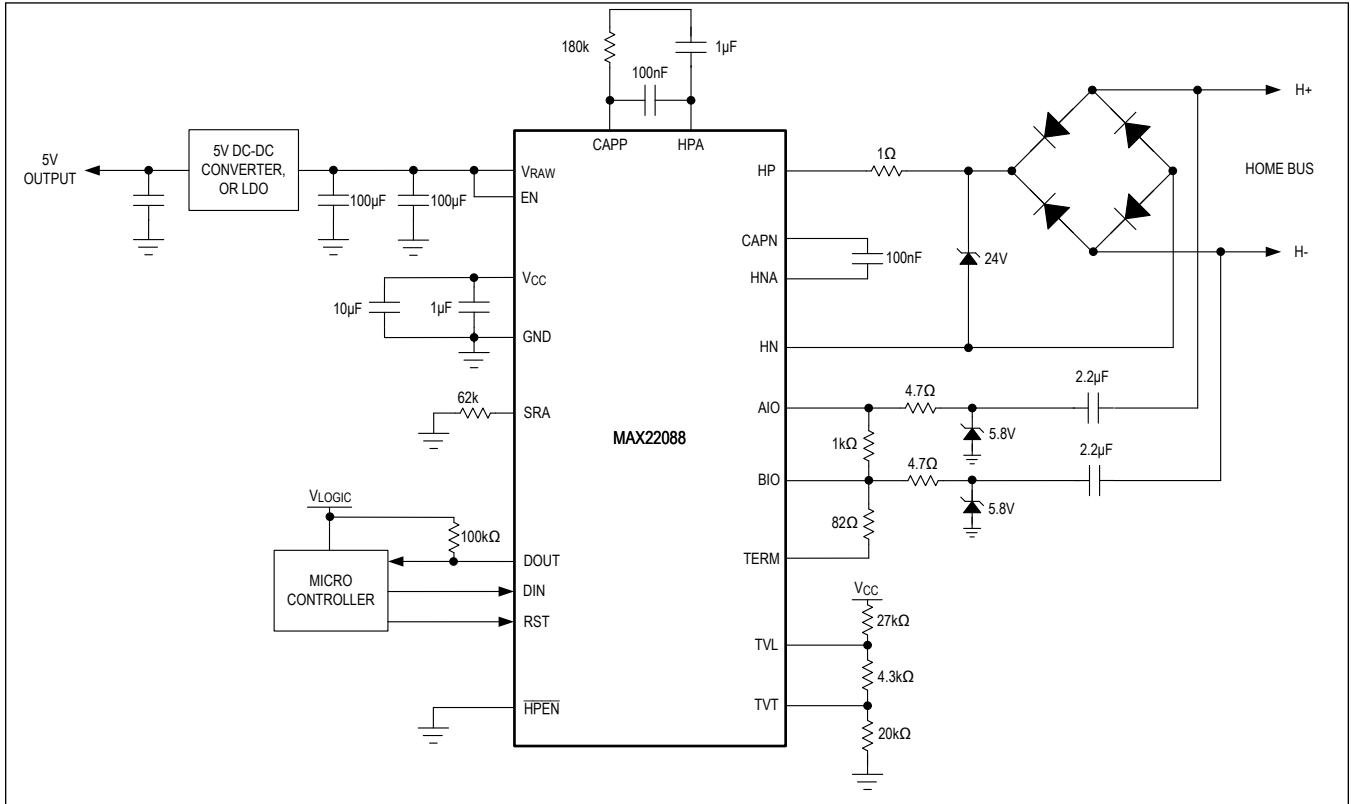
Typical Application Circuits

Low-Power Application with Internal LDO Output (57.6kbps)



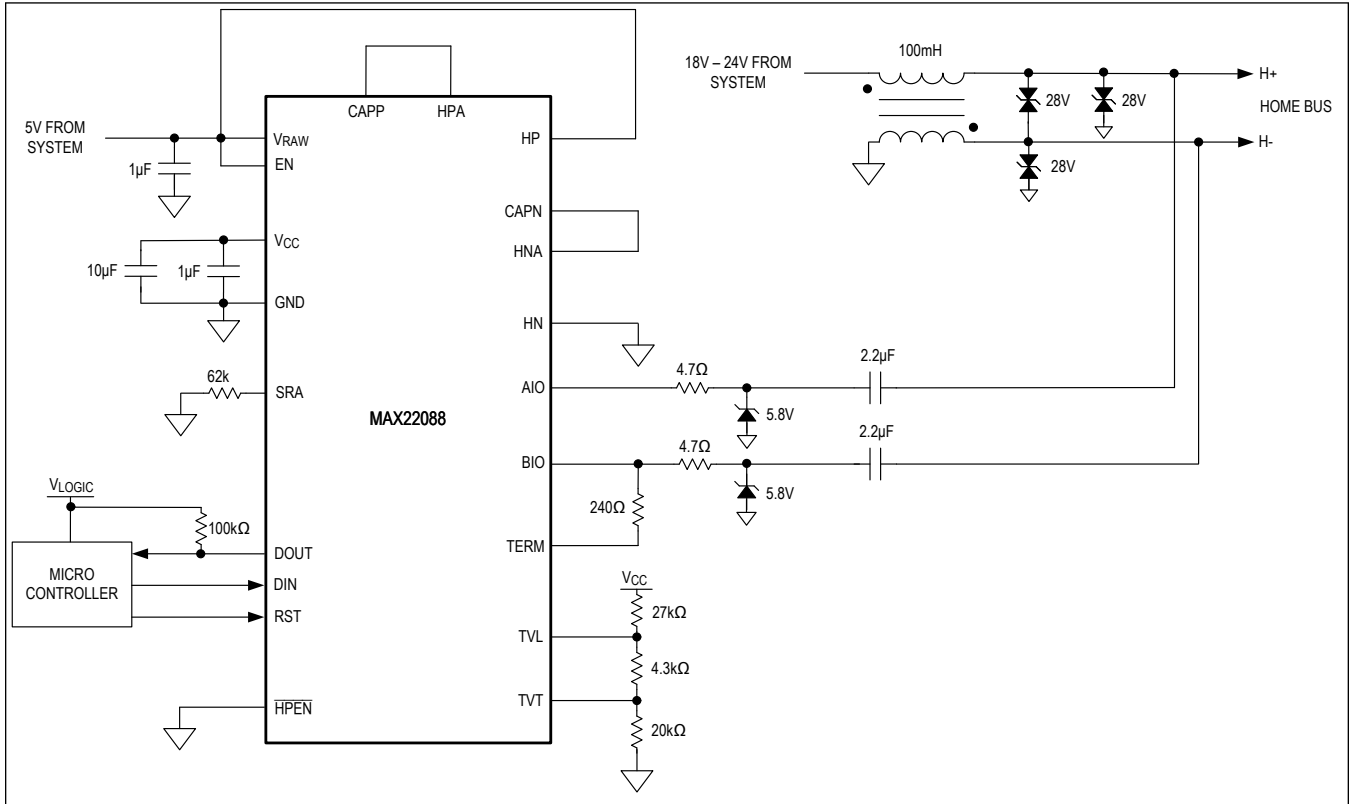
Typical Application Circuits (continued)

Medium-Power Application with External DC-DC Converter (57.6kbps)



Typical Application Circuits (continued)

Application Where Power is Sourced from Unit (57.6kbps)



Ordering Information

| PART NUMBER   | TEMPERATURE RANGE |
|---------------|-------------------|
| MAX22088GTG+  | -40°C to +105°C   |
| MAX22088GTG+T | -40°C to +105°C   |

+Denotes a lead(Pb)-free/RoHS-compliant package.

T = Tape and reel.

**Revision History**

| REVISION NUMBER | REVISION DATE | DESCRIPTION   | PAGES CHANGED   |
|-----------------|---------------|---|-----------------|
| 0               | 1/20          | Initial release   | —               |
| 1               | 6/20          | Updated Homebus to Home Bus in title and all sections   | 1–21            |
| 2               | 2/21          | Updated the <i>Electrical Characteristics</i> section   | 3               |
| 3               | 2/22          | Updated title, <i>Benefits and Features</i> , <i>Functional Diagrams</i> , <i>Detailed Description</i> , <i>Active Inductor</i> , and <i>Dynamic Cable Termination</i> sections, <i>Pin Description</i> , <i>Simplified Home Bus System</i> diagram, and <i>Typical Application Circuits</i> ; Added <i>Application Notes</i> section | 1, 12–16, 18–21 |
| 4               | 6/23          | Update <i>Simplified Home Bus System (HBS)</i> diagram, <i>Pin Description</i> section, <i>Detailed Description Overview</i> section, <i>Internal Voltage Regulator</i> Section and <i>Dynamic Cable Termination</i> section.   | 2, 14, 16, 18   |