## Overview

The GM485E is a high-speed, half-duplex transceiver for RS-485/RS-422 communication that contains one driver and one receiver. With a fail-safe circuit, when the receiver input is open or shorted, it ensures that the receiver outputs a logic high level. This means that if all transmitters connected to the terminated bus are disabled (high impedance), the receiver will output a logic high level. GM485E has a limited slew rate driver, which can reduce EMI and reflections caused by improper cable termination, and achieve error-free data transmission up to 500kbps. In addition, the receiver of GM485E has 1/8 unit load input impedance, and up to 256 transceivers can be connected to the bus.

## Features

- 1nA low current shutdown mode
- Industry standard 8-pin SOP package
- Allows up to 256 transceivers to be connected to the bus
- A true fail-safe receiver compatible with EIA/TIA-485
- Powerful slew rate control function helps to achieve error-free data transmission
- Provides enhanced ESD protection for RS-485/RS-422 I/O pins

## Enhanced ESD protection for I/O pins

HBM human body model: ±15kV

IEC 61000-4-2:

Contact discharge ±12kV

Air discharge ±15kV

## Pin logic diagram and description

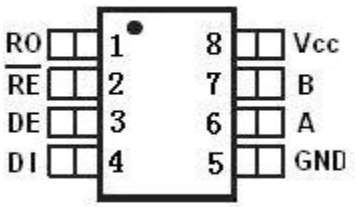



Figure 1: GM485E pin diagram

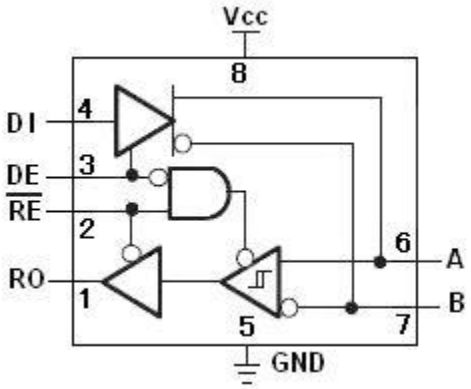



Figure 2: GM485E logic diagram

## Application

- Industrial control
- Electricity meter, water meter, gas meter
- Transceiver applications sensitive to EMI
- Security system
- Lighting system
- Instrumentation

## Ordering information

| Model | Temperature range | Package |
|---|---|---|
| GM485P | -40℃~+85℃ | DIP8 |
| GM485E | -40℃~+85℃ | SOP8 |

## Pin description

| Pin | Name | Features |
|---|---|---|
| 1 | RO | Receiver output.<br>When RE is low, if A-B ≧ -50mV, RO output is high; if A-B ≦ -200mV, RO output is low |
| 2 | RE | Receiver output enable.<br>RO output is valid when RE is connected to low level;<br>RO is in high impedance state when RE is connected to high level;<br>When RE is connected to high level and DE is connected to low level, the device enters low-power shutdown mode |
| 3 | DE | Driver output enable.<br>When DE is connected to high level, the driver output is valid, when DE is low level, the output is in high impedance state;<br>When RE is connected to high level and DE is connected to low level, the device enters low-power shutdown mode |
| 4 | DI | Driver input.<br>When DE is high, the low level on DI forces the non-inverting output low, and the inverting output high. Similarly, a high level on DI will force the non-inverting output to be high, and the inverting output to be low. |
| 5 | GND | Ground |
| 6 | A | Receiver non-inverting input and driver non-inverting output |
| 7 | B | Receiver inverting input and driver inverting output |
| 8 | $V_{CC}$ | Power supply: 3.0≦$V_{CC}$≦5.5V |

## Absolute maximum ratings

| Parameter | Symbol | Value | Unit |
|---|---|---|---|
| Supply voltage | $V_{CC}$ | +7 | V |
| Control input voltage | /RE, DE | -0.3 to $V_{CC}$+0.3 | V |
| Driver input voltage | DI | -0.3 to $V_{CC}$+0.3 | V |
| Driver output voltage | A, B | ±13 | V |
| Receiver input voltage | A, B | ±13 | V |
| Receiver output voltage | RO | -0.3～$V_{CC}$+0.3 | V |
| Continuous power consumption | DIP8 | 727 | mW |
| | SOP8 | 471 | |
| Operating temperature range | | -40～+85 | ℃ |
| Storage temperature | | -65～+150 | ℃ |
| Welding temperature | | 300 | ℃ |

## DC electrical characteristics

(If not otherwise stated, VCC=+5V±5%, $T_A=T_{MIN}\sim T_{MAX}$, the typical value is $V_{CC}$=+5V, $T_A$=25℃) (Note 1)

| Parameter | Symbol | Test conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Driver** | | | | | | | |
| Differential driver output (no load) | $V_{OD1}$ | Figure 4 | | | | 5 | V |
| Differential driver output | $V_{OD2}$ | Figure 4, R=50Ω (RS-422) | | 2.0 | | | V |
| | | Figure 4, R=27Ω (RS-485) | | 1.5 | | | |
| Amplitude change of differential output voltage (Note 2) | $\Delta V_{OD}$ | Figure 4, R=50Ω or R=27Ω | | | | 0.2 | V |
| Driver common mode output voltage | $V_{OC}$ | Figure 4, R=50Ω or R=27Ω | | | | 3 | V |
| Amplitude change of common mode voltage (Note 2) | $\Delta V_{OC}$ | Figure 4, R=50Ω or R=27Ω | | | | 0.2 | V |
| Input high voltage | $V_{IH1}$ | DE, DI, /RE, H/F, TXP, RXP | | 2.0 | | | V |
| Input low voltage | $V_{IL1}$ | DE, DI, /RE, H/F, TXP, RXP | | | | 0.8 | V |
| DI input hysteresis | $V_{HYS}$ | DE, DI, /RE, H/F, TXP, RXP | | | 100 | | mV |
| Input high voltage | $V_{IH2}$ | SRL | | $V_{CC}$-0.8 | | | V |
| Input low voltage | $V_{IL2}$ | SRL | | | | 0.8 | V |
| Input current (A, B) half duplex | $I_{IN4}$ | DE=GND | $V_{IN}$=12V | | | 125 | μA |
| | | $V_{CC}$=GND or 5.25V | $V_{IN}$=-7V | | | -75 | |
| Driver short-circuit output current | $I_{OSD}$ | -7V≦$V_{OUT}$≦$V_{CC}$ | | -250 | | | mA |
| | | 0V≦$V_{OUT}$≦12V | | | | 250 | |
| | | 0V≦$V_{OUT}$≦VCC | | ±25 | | | |
| **Receiver** | | | | | | | |
| Receiver differential threshold voltage | $V_{TH}$ | -7V≦$V_{CM}$≦12V | | -200 | -110 | -50 | mV |
| Receiver input hysteresis | $\Delta V_{TH}$ | | | | 30 | | mV |
| Receiver output high voltage | $V_{OH}$ | $I_O$=-4mA,$V_{ID}$=-50mV | | $V_{CC}$-1.5 | | | V |
| Receiver output low voltage | $V_{OL}$ | $I_O$=4mA,$V_{ID}$=-200mV | | | | 0.4 | V |
| Three-state output current at receiver | $I_{OZR}$ | 0.4V≦$V_O$≦2.4V | | | | ±1 | μA |
| Receiver input impedance | $R_{IN}$ | -7V≦$V_{CM}$≦12V | | 96 | | | kΩ |
| Receiver output short circuit current | $I_{OSR}$ | 0V≦$V_{RO}$≦$V_{CC}$ | | ±7 | | ±95 | mA |
| **Supply current** | | | | | | | |
| Supply current | $I_{CC}$ | No load, /RE=DI=$V_{CC}$, DE= $V_{CC}$ | | | 155 | 900 | μA |
| | | No load, /RE=DI=GND, DE=GND | | | 160 | 600 | μA |
| Shutdown mode current | $I_{SHDN}$ | DE=GND, /RE=$V_{CC}$, DI=$V_{CC}$ or GND | | | 0.001 | 10 | μA |
| **ESD electrostatic protection** | | | | | | | |
| Electrostatic protection (A/B pin) | | HBM Human body model | | ±15 | kV | ±15 | kV |
| | | MM Machine mode | | ±800 | V | ±800 | V |
| | | Contact discharge IEC 61000-4-2 | | ±12 | kV | ±12 | kV |
| | | Air discharge IEC 61000-4-2 | | ±15 | kV | ±15 | kV |
| Electrostatic protection (other pins) | | HBM Human body model | | ±8 | kV | ±8 | kV |
| | | MM Machine mode | | ±400 | V | ±400 | V |

Note 1: All currents into device pins are positive; all currents out of device pins are negative; all voltages are without exception referenced to device ground

Note 2: When DI input changes state, $\triangle V_{OD}$ and $\triangle V_{OC}$ are $V_{OD}$ and $V_{OC}$ changes respectively.

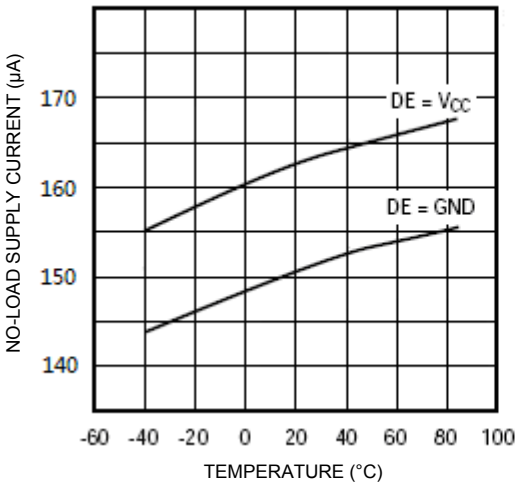
Note 3: Maximum current level applies to peak current just prior to foldback-current limiting; minimum current level applies during current limiting.

(If not otherwise stated, VCC=+5V±5%, $T_A=T_{MIN}\sim T_{MAX}$, the typical value is $V_{CC}$=+5V, $T_A$=25℃)

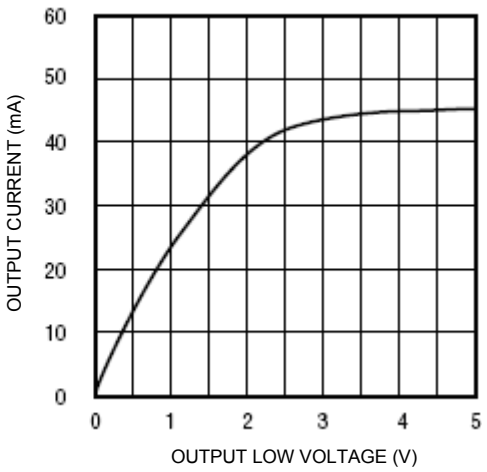
| Parameter | Symbol | Condition | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Driver input to output | $T_{DPLH}$ | Figure 6 and 8, $R_{DIFF}$=54Ω, $C_{L1}=C_{L2}$=100pF | 250 | 720 | 900 | ns |
| | $T_{DPHL}$ | | 250 | 720 | 900 | |
| Driver output skew $\|t_{DPLH} - t_{DPHL}\|$ | $T_{DSKEW}$ | Figure 6 and 8, $R_{DIFF}$=54Ω, $C_{L1}=C_{L2}$=100pF | | -3 | ±100 | ns |
| Driver rise or fall time | $t_{DR}$, $t_{DF}$ | Figure 6 and 8, $R_{DIFF}$=54Ω, $C_{L1}=C_{L2}$=100pF | 200 | 530 | 750 | ns |
| Maximum data rate | $F_{MAX}$ | | | | 500 | kbps |
| Driver enable to output high | $T_{DZH}$ | Figure 7 and 9, $C_L$=100pF, S2 closed | | | 2500 | ns |
| Driver enable to output low | $T_{DZL}$ | Figure 7 and 9, $C_L$=100pF, S1 closed | | | 2500 | ns |
| Driver disable time from high | $T_{DHZ}$ | Figure 7 and 9, $C_L$=15pF, S2 closed | | | 100 | ns |
| Receiver input to output | $T_{RPLH}$ | Figure 10 and 12, $\|V_{ID}\|$≥2.0V, $V_{ID}$≦15ns rise and fall time | | 127 | 200 | ns |
| | $T_{RPHL}$ | | | | | |
| Differential receiver skew $\|t_{DPLH} - t_{DPHL}\|$ | $T_{RSKD}$ | Figure 10 and 12, $\|V_{ID}\|$≥2.0V, $V_{ID}$≦15ns rise and fall time | | 3 | ±30 | ns |
| Receiver enable to output low | $T_{RZL}$ | Figure 5 and 11, $C_L$=100pF, S1 closed | | 20 | 50 | ns |
| Receiver enable to output high | $T_{RZH}$ | Figure 5 and 11, $C_L$=100pF, S2 closed | | 20 | 50 | ns |
| Receiver disable time from low | $T_{RLZ}$ | Figure 5 and 11, $C_L$=100pF, S1 closed | | 20 | 50 | ns |
| Receiver disable time from high | $T_{RHZ}$ | Figure 5 and 11, $C_L$=100pF, S2 closed | | 20 | 50 | ns |
| Time to shutdown | $T_{SHDN}$ | | 50 | 200 | 600 | ns |
| Driver enable from shutdown to output high | $T_{DZH(SHDN)}$ | Figure 7 and 9, $C_L$=15pF, S2 closed | | | 4500 | ns |
| Driver enable from shutdown to output low | $T_{DZL(SHDN)}$ | Figure 7 and 9, $C_L$=15pF, S1 closed | | | 4500 | ns |
| Receiver enable from shutdown to output high | $T_{RZH(SHDN)}$ | Figure 5 and 11, $C_L$=100pF, S2 closed | | | 3500 | ns |
| Receiver enable from shutdown to output low | $T_{RZL(SHDN)}$ | Figure 5 and 11, $C_L$=100pF, S1 closed | | | 3500 | ns |

## Typical operating characteristics

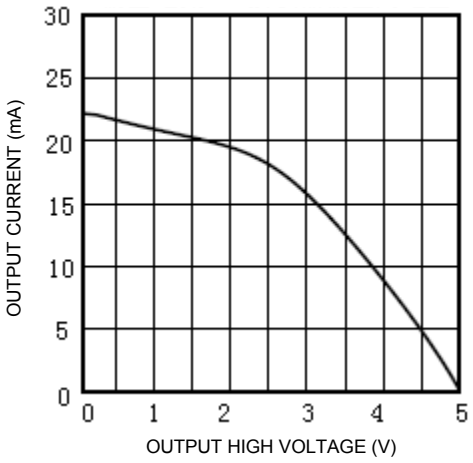
NO LOAD SUPPLY CURRENT
vs. TEMPERATURE



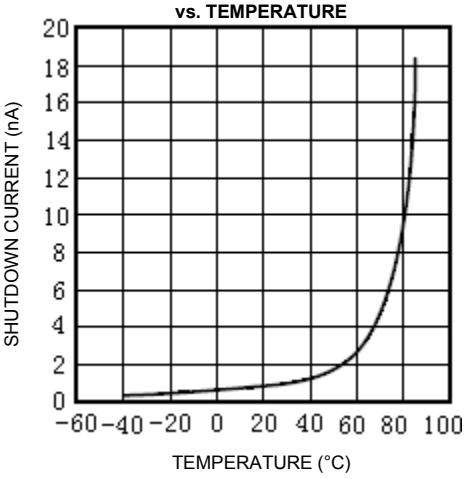

OUTPUT CURRENT
vs. RECEIVER OUTPUT LOW VOLTAGE



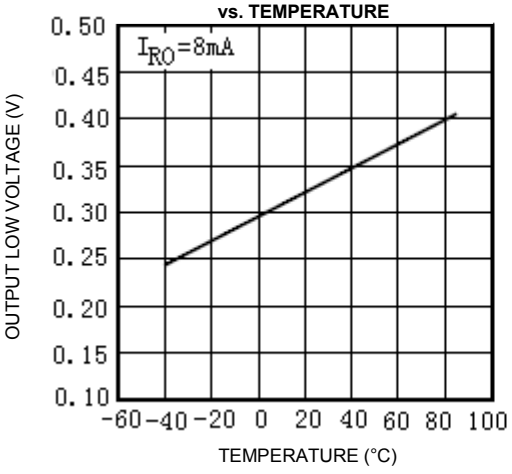

OUTPUT CURRENT
vs. RECEIVER OUTPUT HIGH VOLTAGE



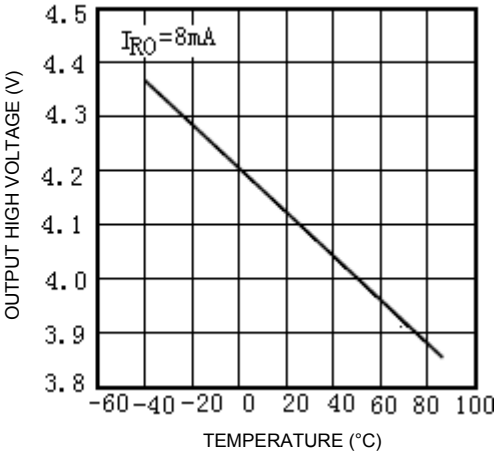

SHUTDOWN CURRENT
vs. TEMPERATURE



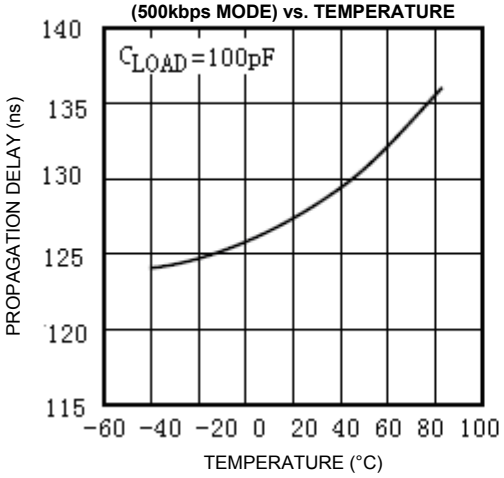

RECEIVER OUTPUT LOW VOLTAGE
vs. TEMPERATURE



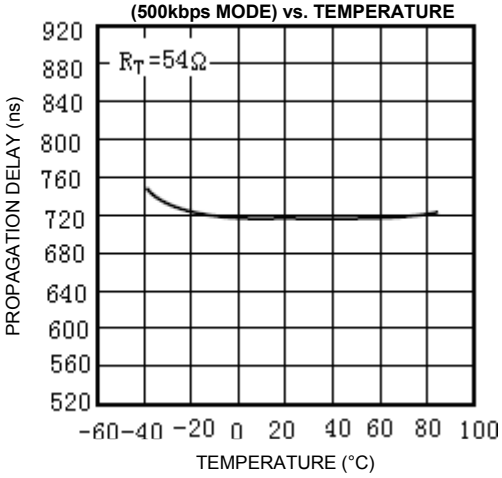

RECEIVER OUTPUT HIGH VOLTAGE
vs. TEMPERATURE



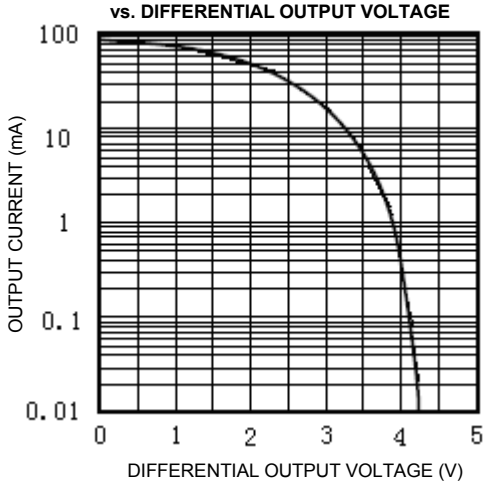
RECEIVER PROPAGATION DELAY
(500kbps MODE) vs. TEMPERATURE



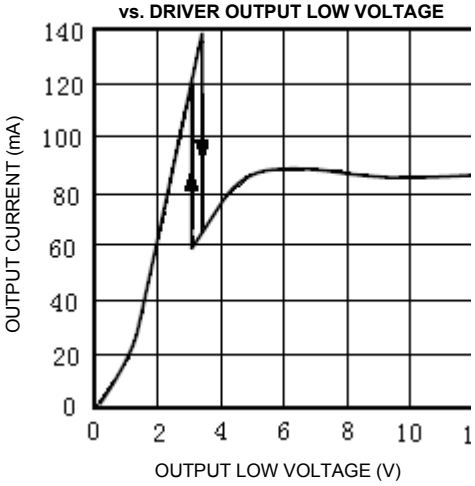

DRIVER PROPAGATION DELAY
(500kbps MODE) vs. TEMPERATURE



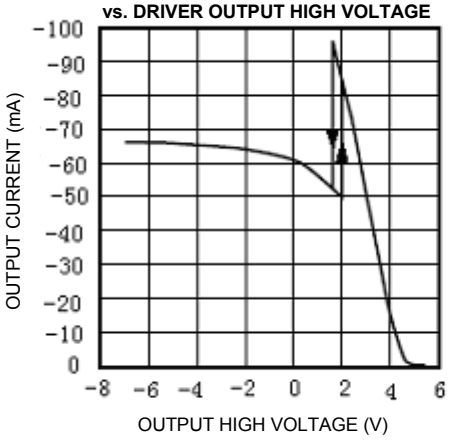

DRIVER OUTPUT CURRENT
vs. DIFFERENTIAL OUTPUT VOLTAGE



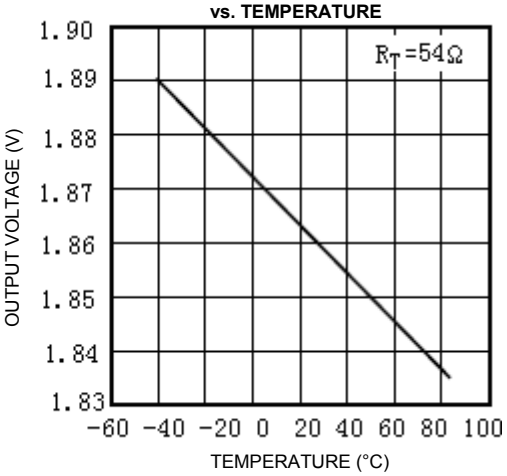

OUTPUT CURRENT
vs. DRIVER OUTPUT LOW VOLTAGE




OUTPUT CURRENT
vs. DRIVER OUTPUT HIGH VOLTAGE




DRIVER DIFFERENTIAL OUTPUT VOLTAGE
vs. TEMPERATURE



## Function table

**GM485E**

| Driver | | | | |
|---|---|---|---|---|
| Input | | | Output | |
| /RE | DE | DI | B/Z | A/Y |
| X | 1 | 1 | 0 | 1 |
| X | 1 | 0 | 1 | 0 |
| 0 | 0 | X | High-Z | High-Z |
| 1 | 0 | X | Shutdown | |

**GM485E**

| Receiver | | | |
|---|---|---|---|
| Input | | Output | |
| /RE | DE | A-B | RO |
| 0 | X | ≥-0.05V | 1 |
| 0 | X | ≤-0.2V | 0 |
| 0 | X | Open/shorted | 1 |
| 1 | 1 | X | High-Z |
| 1 | 0 | X | Shutdown |

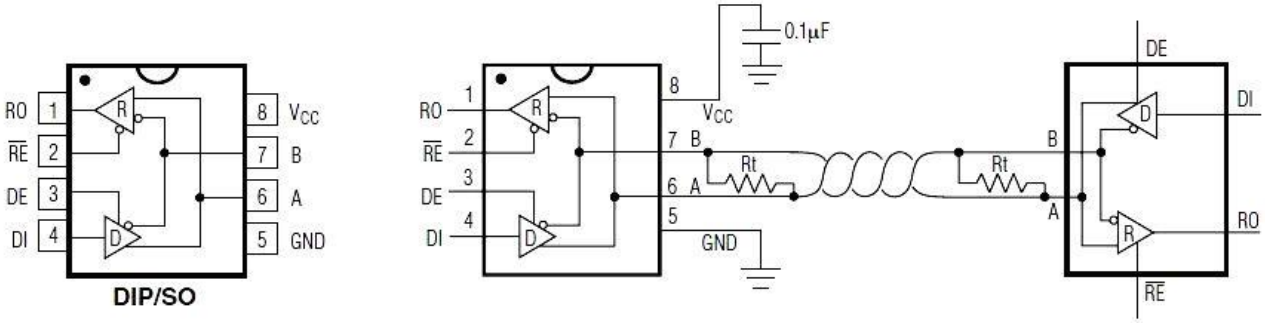



Figure 3: GM485E typical half-duplex application circuit

## 1. Description

The GM485E high-speed transceiver for RS-485/RS-422 communication contains a driver and a receiver. It has a fail-safe circuit to ensure that the receiver outputs a logic high level when the receiver input is open or short-circuited. This means that if all transmitters connected to the terminated bus are disabled (high impedance), the receiver will output a logic high level. GM485E has a limted slew rate driver, which can reduce EMI and reflections caused by improper cable termination, and achieve error-free data transmission up to 500kbps. GM485E is a half-duplex transceiver.

## 2. Receiver input filtering

When the GM3085E operates in above 500kbps mode, its receiver not only has input hysteresis, but also includes input filtering function. This filtering function improves the noise immunity with differential signals that have slow rise and fall times. The filter increases receiver propagation delay by 25%.

## 3. Fail-safe

When the receiver input is short-circuited or open, or when all drivers connected to the terminated transmission line are disabled, GM485E can ensure that the receiver outputs a logic high level. This is achieved by setting the receiver input threshold to -50mV and -200mV respectively. If the differential receiver input voltage (A-B) is greater than or equal to -50mV, RO is logic-high; if the voltage (A-B) is less than or equal to -200mV, RO is logic-low.

When all transmitters connected to the terminated bus are disabled, the receiver differential input voltage will be pulled to 0V by the termination resistor. Depending on the receiver threshold, a logic high level with a minimum noise margin of 50mV can be achieved. Unlike previous fail-safe devices, the -50mV to -200mV threshold voltage complies with the ±200 mV EIA/TIA-485 standard.

## 256 transceivers on the bus

The input impedance of the standard RS-485 receiver is 12kΩ (1 unit load), and the standard driver can drive up to 32 unit loads. The receiver of the GM485E transceiver has 1/8 unit load input impedance (96kΩ), allowing up to 256 transceivers to be connected in parallel on the same communication bus. These devices can be combined arbitrarily, or combined with other RS-485 transceivers, as long as the total load does not exceed 32 unit loads that can be connected to the same bus.

## Reduced EMI and reflections

The limited slew rate driver of GM485E can minimize EMI and reduce reflections caused by improperly terminated cables. Figure 13 shows that the amplitude of high-frequency harmonic components is lower than normal. The rise time of the driver is related to the length of an unterminated stub, and the following equation shows this relationship:

$$Length=t_{RISE}/(10 \times 1.5ns/ft),\ \text{where } t_{RISE} \text{ is the driver's rise time}$$

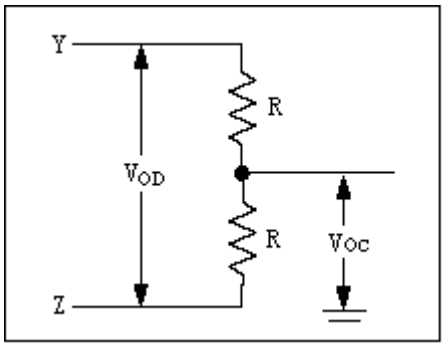



Figure 4: Driver DC test load

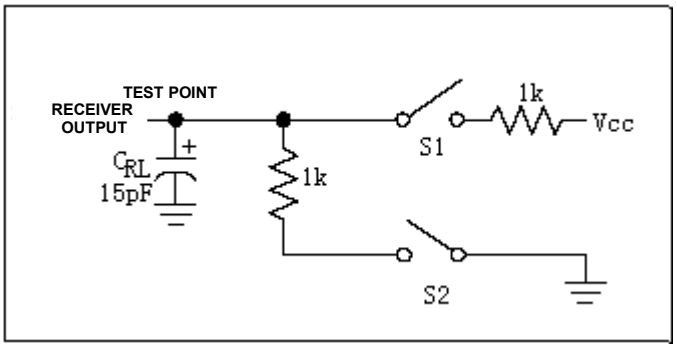



Figure 5: Receiver enable/disable timing test load

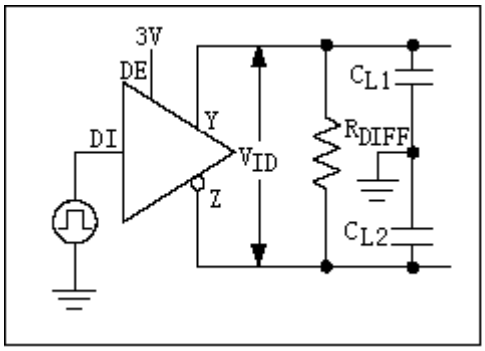



Figure 6: Driver timing test load

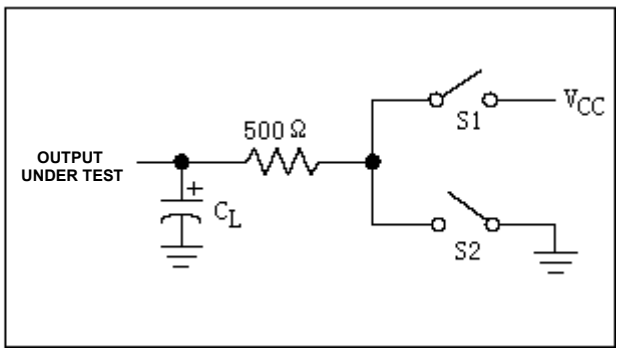



Figure 7: Driver enable/disable timing test load

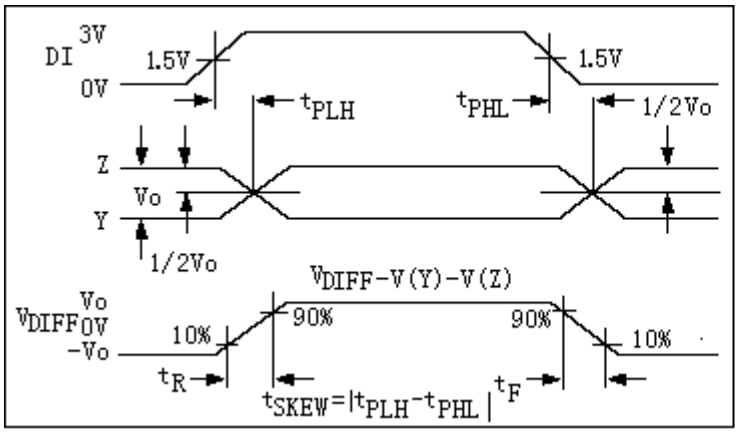



Figure 8: Driver propagation delays

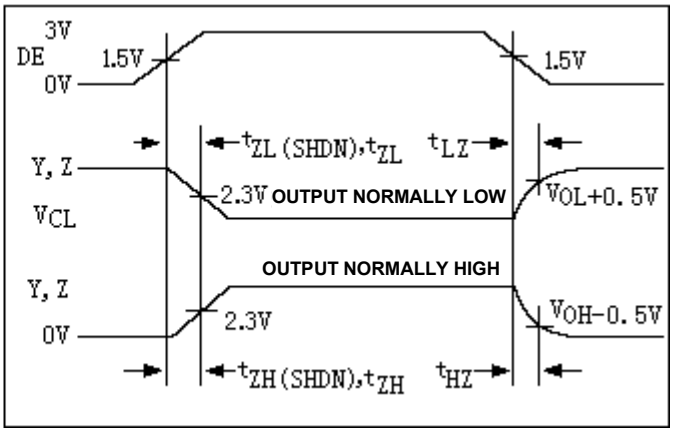



Figure 9: Driver enable and disable times

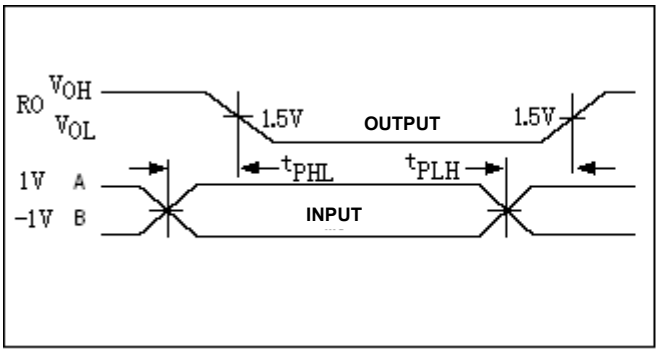



Figure 10: Receiver propagation delays

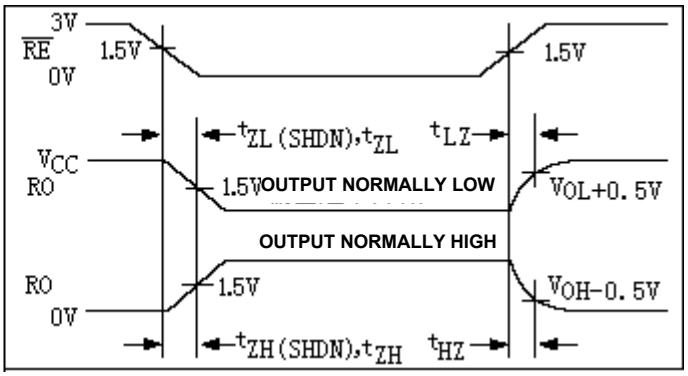



Figure 11: Receiver enable and disable times

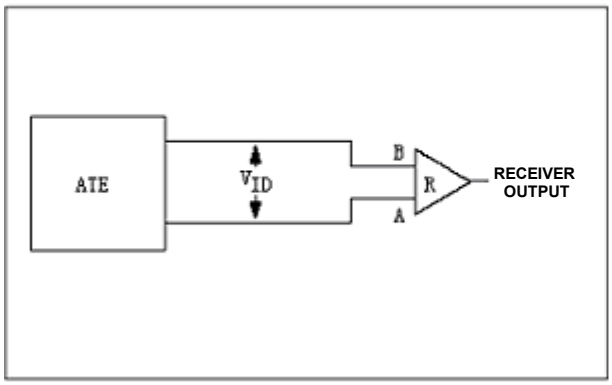



Figure 12: Receiver propagation delay test circuit

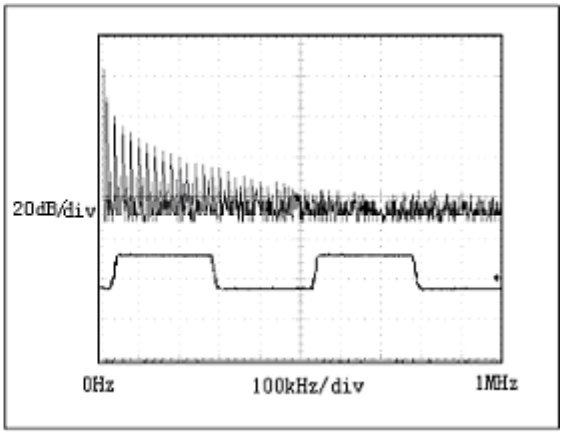



Figure 13: GM485E driver output waveform and FFT diagram when transmitting a 20kHz signal

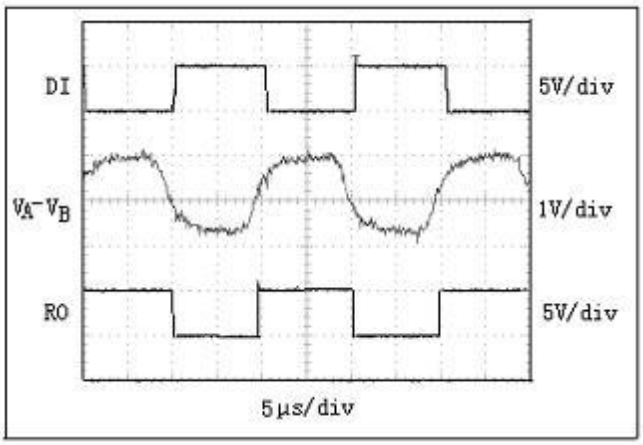



Figure 14: System differential voltage at 50kHz driving 4000 feet of cable

## Drive output protection

A foldback current limit mechanism on the output stage prevents excessive output current and high power dissipation caused by faults or by bus contention. The output stage foldback current limiting provides immediate short-circuit protection over the entire common-mode voltage range (refer to the typical operating characteristics).

## Typical application

The GM485E transceiver is designed for two-way data communication on a multipoint bus transmission line. Figure 15 shows a typical network application circuit. These devices can also be used as linear transponders with cables longer than 4000 feet, as shown in Figure 14. In order to reduce reflections, terminal matching should be performed at both ends of the transmission line with the characteristic impedance of the wire used, and the length of the branch wires outside the main line should be as short as possible.

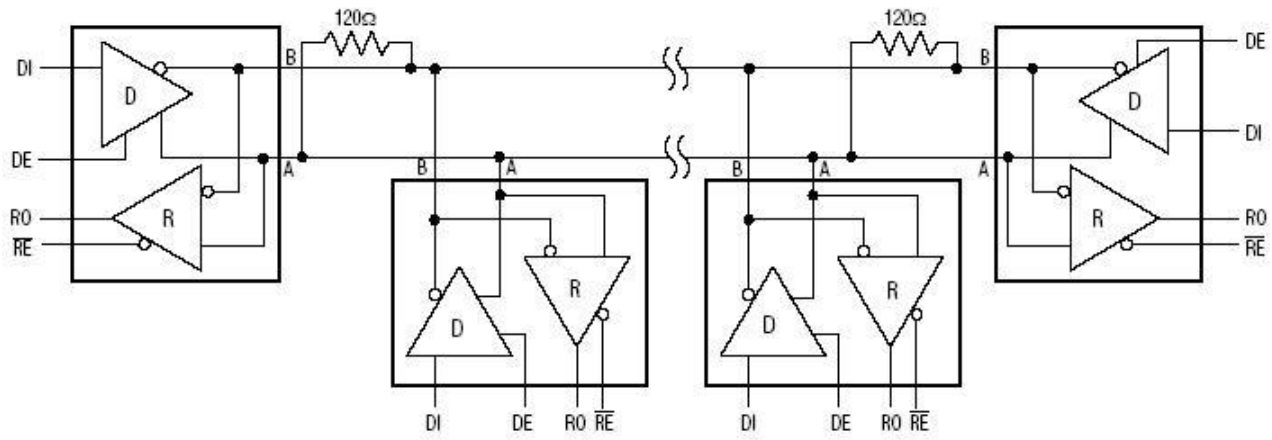



Figure 15: Typical half-duplex RS-485 network

## ESD test instructions

Test ESD under HBM (Human Body Model) to achieve ±15KV, the test diagram is as follows:

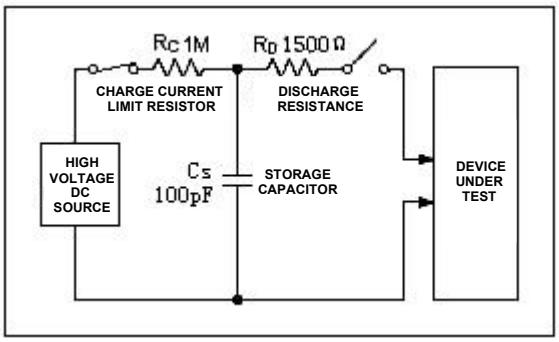



Figure 16: HBM ESD test circuit diagram

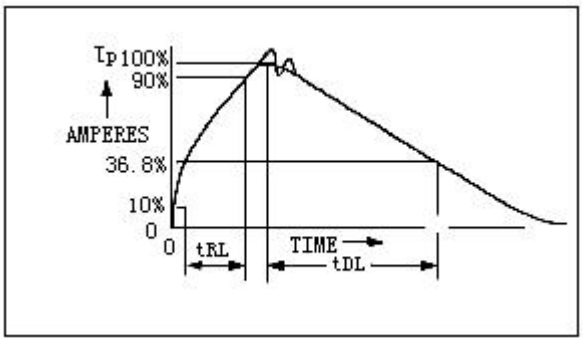



Figure 17: HBM current waveform

Figure 16 shows the Human Body Model, and Figure 17 shows the current waveform it generates when discharged into a low impedance.

Under the condition of no power supply, connect the GND pin or VCC pin of GM485E to the ground, and release ±15KV static electricity to the output port of the driver and the input port of the receiver (A, B port), and the chip can realize the protection function and work normally.

GM485E can surpass the national standard GB/17626.2 level 4 under the IEC61000-4-2 standard test. The test chart and national standard grade table are as follows:

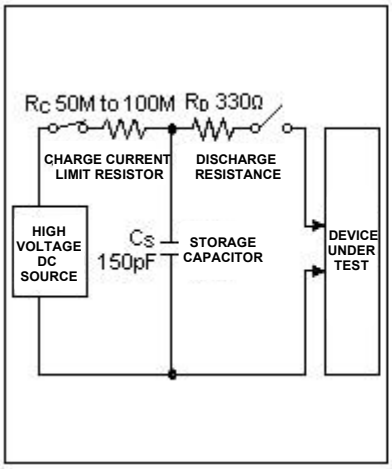



Figure 18: IEC61000-4-2 ESD test model

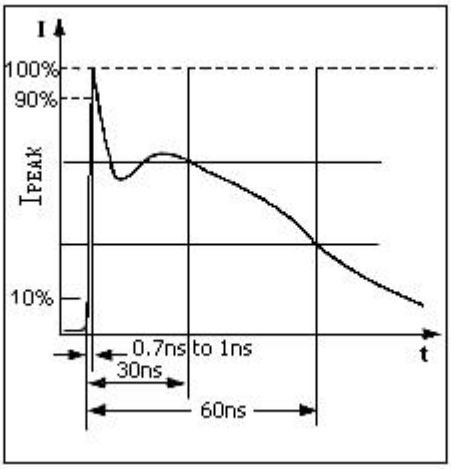



Figure 19: IEC1000-4-2 ESD generator current waveform

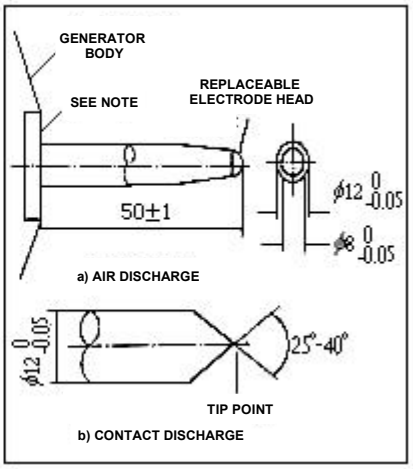



Figure 20: ESD test tips in two modes

| Severity level | Contact discharge test voltage (kV) | Air discharge test voltage (kV) |
|---|---|---|
| 1 | 2 | 2 |
| 2 | 4 | 4 |
| 3 | 6 | 8 |
| 4 | 8 | 15 |

Figure 21: National standard GB/17626.2 severity rating table of electrostatic discharge

Figure 18 shows the IEC61000-4-2 standard test chart, figure 19 shows the current waveform generated by a low impedance discharge, and figure 20 shows the ESD test tip under two different discharge modes. Figure 21 is the national standard GB/17626.2 ESD severity rating table. At a humidity of 30% to 60% and a temperature of 25°C, air discharge and contact discharge are performed on the whole machine. The air discharge of GM485E reaches ±20KV and the contact discharge reaches ±15KV.

# Product information

## 1. Internal structure and materials

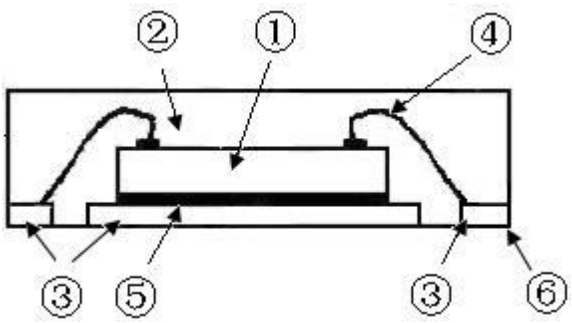



Figure 22: Typical IC internal structure diagram

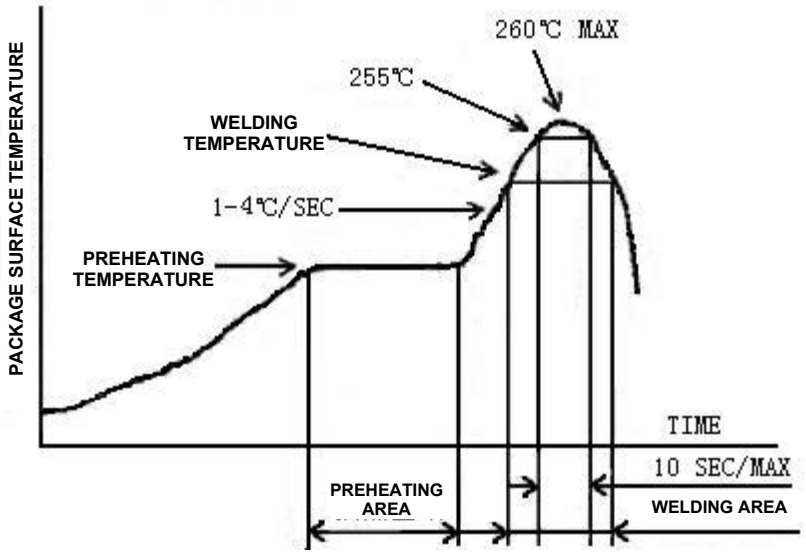
| NO | Item | Materials |
|---|---|---|
| 1 | Die | Silicon |
| 2 | Molding | Silica Fused |
| 3 | Lead frame | Cu-Alloy |
| 4 | Wire | Au or Cu |
| 5 | Die attach | Ag paste |
| 6 | Plating | Sn |

## 2. Storage conditions

Operating temperature range: -40℃~+85℃
Storage temperature range: -65℃~+150℃
The recommended storage conditions are as follows:
——Temperature: +5℃~+30℃
——Humidity: 40% ~70%RH

## 3. Welding temperature

3.1 Recommended reflow soldering temperature




Preheating temperature: 130℃～190℃
Preheating area: 120sec MAX
Welding temperature: 200℃～230℃
Welding area: 60sec MAX

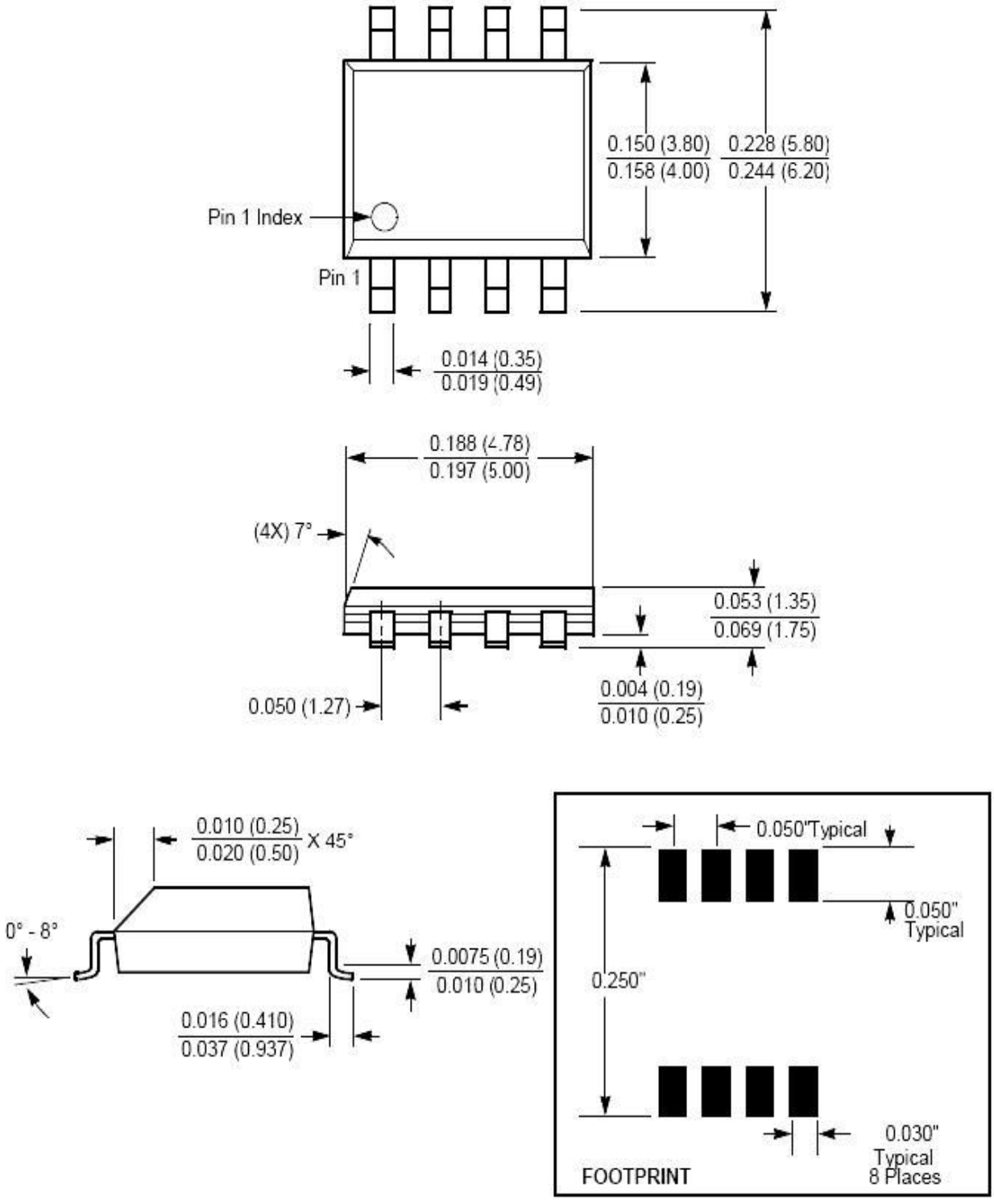
(Note) Number of maximum reflow cycles: twice

Figure 23: IC reflow soldering temperature curve

3.2 DIP8 products are suitable for wave soldering, and the soldering temperature is 235℃ ～260℃.

## 4 Package information

8-pin plastic SOIC, package code SOP8




Note: All dimensions are in inches (millimeters)