GM2410V,GM2412V ±70V Fault-Protected RS-485 Transceivers With Flexible I/O Supply and IEC ESD

1 FEATURES

- Meets or exceeds the requirements of the TIA/EIA-485A and TIA/EIA-422B standards
- 3V to 5.5V supply voltage
- Differential output exceeds 2.1V for PROFIBUS compatibility with 5V supply
- Bus I/O protection
  -- ±70V DC bus fault
  -- ±16kV HBM ESD
  -- Half duplex devices: ±15-kV IEC 61000-4-2 contact and air-gap discharge
  -- Full duplex devices: ±12-kV IEC 61000-4-2 contact and air-gap discharge
  -- ±4kV IEC 61000-4-4 fast transient burst
- SLR Pin Selectable Data Rates:
  -- 250kbps and 1Mbps
- Extended ambient temperature range: -40°C to 125°C
- Extended operational common-mode range: ±25V
- Enhanced receiver hysteresis for noise immunity
- Low power consumption
  -- Low shutdown supply current: < 2µA
  -- Current during operation: < 1mA
- Glitch-free power-up/down for hot plug-in capability
- Open, short, and idle bus failsafe
- Thermal shutdown
- 1/8 unit load (up to 256 bus nodes) in -7V to 12V common mode range
- Small DFN and SOP packages to save board space

2 APPLICATIONS

- Motor drives
- Factory automation and control
- HVAC systems
- Building automation
- Grid infrastructure
- Electricity meters
- Process analytics
- Video surveillance

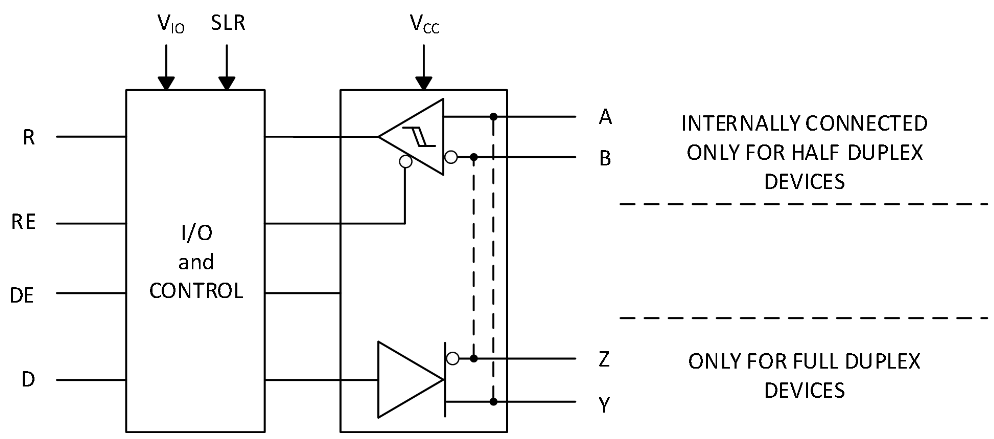
3 DESCRIPTION

GM241xV are ±70-V fault-protected, half and full duplex RS-422/RS-485 transceivers using a 1.65V to 5.5V supply for logic signal interface, and a 3V to 5.5V bus side supply. These devices have slew rate select feature that enables them to be used at two maximum speeds based on the SLR pin setting.

These devices feature integrated IEC ESD protection, eliminating the need for external system level protection components. Extended ±25V input common-mode range makes reliable data communication over longer cable run lengths and/or in the presence of large ground loop voltages.

Enhanced 150mV receiver hysteresis provides high noise rejection. In addition, the receiver fail-safe feature makes sure of a logic high when the inputs are open or shorted together.

Block Diagram



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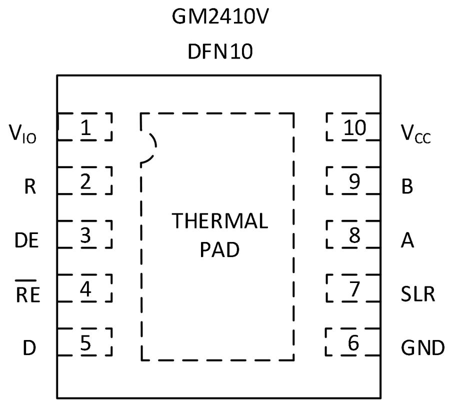
4 Pin Configuration and Functions



Pin		TYPE	Description
NO.	NAME		
1	V_{IO}	Logic supply	1.65V to 5.5V supply for logic I/O signals (R, RE, D, DE and SLR)
2	R	Digital output	Receive data output
4	DE	Digital input	Driver enable input; integrated pull-down
3	$\overline{RE}$	Digital input	Receiver enable input; integrated pull-up
5	D	Digital input	Transmission data input; integrated pull-up
6	GND	Reference potential	Local device ground
7	SLR	Digital input	Slew rate select. For GM2410V: Low = 1Mbps, High = 250kbps. Defaults to 1Mbps if SLR is left floating.
8	A	Bus I/O	RS 485 bus I/O,A
9	B	Bus I/O	RS 485 bus I/O,B
10	V_{CC}	Bus supply	Bus supply
-	Thermal Pad	-	Connect to GND for optimal thermal performance

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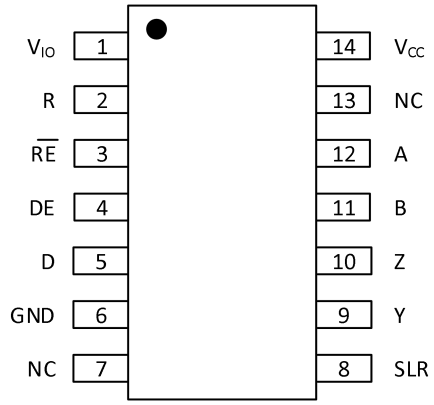
GM2412V
SOP14



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2	R	Digital output	Receive data output
3	$\overline{RE}$	Digital input	Receiver enable input; integrated pull-up
4	DE	Digital input	Driver enable input; integrated pull-down
5	D	Digital input	Transmission data input; integrated pull-up
6	GND	Reference potential	Local device ground
7	NC	No connect	Not connected internally
8	SLR	Digital input	Slew rate select. For GM2412V: Low = 1Mbps, High = 250 kbps. Defaults to 1Mbps if SLR is left floating.
9	Y	Bus output	RS 485 driver non-inverting output
10	Z	Bus output	RS 485 driver inverting output
11	B	Bus input	RS 485 receiver inverting input
12	A	Bus input	RS 485 receiver non-inverting input
13	NC	No connect	Not connected internally
14	V_{CC}	Bus supply	3V to 5.5V bus supply

5 Sepcifications

5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

Parameter		MIN	MAX	UNIT
Logic supply voltage	V_{IO}	-0.5	V_{CC}+0.2	V
Bus supply voltage	V_{CC}	-0.5	6.5	V
Bus voltage	Range at any bus pin as differential or common-mode with respect to GND	-70	70	V
Input voltage	Range at any logic pin (D, DE, SLR or RE)	-0.3	V_{IO}+0.2	V
Receiver output current	I_O	-24	24	mA
Storage temperature	T_{stg}	-65	170	°C

1.Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute maximum ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If briefly operating outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not sustain damage, but it may not be fully functional. Operating the device in this manner may affect device reliability, functionality, performance, and shorten the device lifetime.

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5.2 ESD Ratings

				VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001(1)	Bus terminals and GND	±16,000	V
			All pins except bus terminals and GND	±4,000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)		±1,500	V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

5.3 ESD Ratings[IEC]

SYMBOL	PARAMETER			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge, Half duplex devices GM2410V(1)	Contact discharge, per IEC 61000-4-2	Bus terminals and GND	±15,000	V
		Air-gap discharge, per IEC 61000-4-2	Bus terminals and GND	±15,000	
$V_{(ESD)}$	Electrostatic discharge, Full duplex devices GM2412V	Contact discharge, per IEC 61000-4-2	Bus terminals and GND	±12,000	V
		Air-gap discharge, per IEC 61000-4-2	Bus terminals and GND	±12,000	
$V_{(EFT)}$	Electrical fast transient	Per IEC 61000-4-4	Bus terminals	±4,000	V

(1) For optimised IEC ESD performance, it is recommended to have series resistor (≥ 50 Ω) on all logic inputs to minimize transient currents going into or out of the logic pins.

5.4 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

Symbol	Parameter		MIN	TYP	MAX	UNIT
V_{CC}	Supply Voltage		3		5.5	V
V_{IO}	I/O supply voltage		1.65		V_{CC}	V
V_I	Input voltage at any bus terminal (separately or common mode)(1)		-25		25	V
V_{IH}	High-level input voltage (driver, driver enable, receiver enable and slew rate select inputs)		0.7*V_{IO}		V_{IO}	V
V_{IL}	Low-level input voltage (driver, driver enable, receiver enable and slew rate select inputs)		0		0.3*V_{IO}	V
V_{ID}	Differential input voltage bus pins		-25		25	V
I_O	Output current, driver		-60		60	mA
I_{OR}	Output current, receiver	V_{IO} = 1.8V or 2.5V	-4		4	mA
I_{OR}	Output current, receiver	V_{IO} = 3.3V or 5V	-8		8	mA
R_L	Differential load resistance		54	60		Ω
$1/T_{UI}$	Signaling rate	SLR=V_{IO}			250	kbps
		SLR=GND			1	Mbps
T_A	Operating ambient temperature		-40		125	°C
T_J	Junction temperature		-40		150	°C

(1) The algebraic convention, in which the least positive (most negative) limit is designated as minimum is used in this data sheet

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5.5 Thermal Information

	THERMAL METRIC[1]	GM2410V	GM2412V	UNIT
Symbol	Parameter	DRC	SOIC	
$R_{\Theta JA}$	Junction-to-ambient thermal resistance	46.7	87.5	°C/W
$R_{\Theta JC(TOP)}$	Junction-to-case (top) thermal resistance	47.7	41.8	°C/W
$R_{\Theta JB}$	Junction-to-board thermal resistance	19.1	43.7	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	0.7	8.1	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	19.1	43.3	°C/W
$R_{\Theta JC(BOT)}$	Junction-to-case (bottom) thermal resistance	4.6	N/A	°C/W

(1)For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

5.6 Power Dissipation

Symbol	Parameter	Condition		VALUE	UNIT
P_D	Driver and receiver enabled, loopback for full duplex devices (A connected to Y, B connected to Z) V_{CC} = 5.5V, T_A = 125 °C, square wave at 50% duty cycle	Unterminated R_L = 300Ω, C_L = 50pF (driver)	250kbps	160	mW
			1Mbps	250	
		RS-422 load R_L = 100Ω, C_L = 50pF (driver)	250kbps	170	mW
			1Mbps	250	
		RS-485 load R_L = 54Ω, C_L = 50pF (driver)	250kbps	220	mW
			1Mbps	280	

5.7 Electrical Characteristics

over operating free-air temperature range (unless otherwise noted). All typical values are at 25°C and supply voltage of V_{CC} = 5V, V_{IO} = 3.3V , unless otherwise noted. [1].

Symbol	Parameter	Condition		MIN	TYP	MAX	UNIT
Driver							
$\lvert V_{OD} \rvert$	Driver differential output voltage magnitude	R_L = 60Ω, –25V ≤ V_{test} ≤ 25V (See Figure 1)		1.5	2.6		V
		R_L = 60Ω, –25V ≤ V_{test} ≤ 25V, 4.5V ≤ V_{CC} ≤ 5.5V (See Figure 1)		2.1	2.6		V
		R_L = 100Ω (See Figure 2)		2	3.1		V
		R_L = 54Ω (See Figure 2)		1.5	2.6		V
$\Delta\lvert V_{OD} \rvert$	Change in differential output voltage	R_L = 54Ω or 100Ω (See Figure 2)		-50		50	mV
V_{OC}	Common-mode output voltage	R_L = 54Ω or 100Ω (See Figure 2)		1	$V_{CC}/2$	3	V
$\Delta V_{OC(SS)}$	Change in steady-state common-mode output voltage	R_L = 54Ω or 100Ω (See Figure 2)		-50		50	mV
I_{OS}	Short-circuit output current	DE = V_{IO}, -70V ≤ (V_A or V_B) ≤ 70V,or A shorted to B (A,B are driver terminals for half duplex, Y/Z are for full duplex)		-200		200	mA
Receiver							
I_I	Bus input current	DE = 0V, V_{CC} and V_{IO} = 0V or 5.5V	V_I = 12V		75	125	µA
			V_I = 25V		250	300	
			V_I = -7V	-100	-80		
			V_I = -25V	-350	-300		
V_{TH+}	Positive-going input threshold voltage[2]	Over common-mode range of ±25V			-100	-50	mV
V_{TH-}	Negative-going input threshold voltage[2]			-200	-150		mV

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Symbol	Parameter	Condition	MIN	TYP	MAX	UNIT
V_{HYS}	Input hysteresis	Over common-mode range of ±25V		50		mV
V_{TH_FSH}	Input fail-safe threshold	Over common-mode range of ±25V	-40		40	mV
$C_{A,B}$	Input differential capacitance	Measured between A and B, f=1MHz		50		pF
V_{OH}	Output high voltage	I_{OH} = –8mA,V_{IO} = 3 to 3.6V or 4.5V to 5.5V	V_{IO}-0.4	V_{IO}-0.2		V
V_{OL}	Output low voltage	I_{OL} = 8mA,V_{IO} = 3 to 3.6V or 4.5V to 5.5V		0.2	0.4	V
V_{OH}	Output high voltage	I_{OH} = –4mA, V_{IO} = 1.65 to 1.95V or 2.25V to 2.75V	V_{IO}-0.4	V_{IO}-0.2		V
V_{OL}	Output low voltage	I_{OL} = 4mA, V_{IO} = 1.65 to 1.95V or 2.25V to 2.75V		0.2	0.4	V
I_{OZ}	Output high-impedance current,R pin	V_O=0V or V_{IO}, $\overline{RE}$ = V_{IO}	-1		1	μA
Logic						
I_{IN}	Input current (DE,SLR)	1.65V ≤ V_{IO} ≤ 5.5V, 0V ≤ V_{IN} ≤ V_{CC}			5	μA
I_{IN}	Input current (D,$\overline{RE}$)	1.65V ≤ V_{IO}≤ 5.5V, 0V ≤ V_{IN} ≤ V_{CC}	-5			μA
Thermal Protection						
T_{SHDN}	Thermal shutdown threshold	Temperature rising	150	170		°C
T_{HYS}	Thermal shutdown hysteresis			10		°C
Supply						
UV_{VCC} (RISING)	Rising under-voltage threshold on V_{CC}			2.3	2.6	V
UV_{VCC} (FALLING)	Falling under-voltage threshold on V_{CC}		1.95	2.2		V
$UV_{VCC(HYS}$	Hysteresis on under-voltage of V_{CC}			170		mV
UV_{VIO} (RISING)	Rising under-voltage threshold on V_{IO}			1.4	1.6	V
UV_{VIO} (FALLING)	Falling under-voltage threshold on V_{IO}		1.2	1.3		V
$UV_{VIO(HYS)}$	Hysteresis on under-voltage of V_{IO}			120		mV
I_{CC}	Supply current (quiescent), V_{CC} = 4.5V to 5.5V	Driver and receiver enabled; $\overline{RE}$= 0V, DE = V_{IO}, No load		0.6	1	mA
		Driver enabled, receiver disabled; $\overline{RE}$= V_{CC}, DE = V_{IO}, No load		0.6	1	mA
		Driver disabled, receiver enabled; $\overline{RE}$= 0V, DE = 0V, No load		0.5	0.7	mA
		Driver and receiver disabled; $\overline{RE}$= V_{IO}, DE = 0V, No load		1.6	3	μA
I_{CC}	Supply current (quiescent), V_{CC} = 3V to 3.6V	Driver and receiver enabled; $\overline{RE}$= 0V, DE = V_{IO}, No load		0.4	0.9	mA
		Driver enabled, receiver disabled; $\overline{RE}$= V_{IO}, DE = V_{IO}, No load		0.4	0.9	mA
		Driver disabled, receiver enabled; $\overline{RE}$= 0V, DE = 0V, No load		0.3	0.5	mA
		Driver and receiver disabled; $\overline{RE}$= V_{IO}, DE = 0V, No load		1.6	3	μA

Symbol	Parameter	Conditions		MIN	TYP	MAX	UNIT
I_{IO}	Logic Supply current (quiescent), V_{IO} = 4.5V to 5.5V	Driver disabled, receiver enabled,SLR=GND	$\overline{RE}$= 0V, DE =0V, No load		4.5	8.4	μA
		Driver disabled, receiver enabled, SLR=V_{IO}	$\overline{RE}$=0V, DE = 0V, No load		3.3	8.4	μA
		Driver disabled, receiver disabled, SLR=GND	$\overline{RE}$= V_{IO}, DE = 0V, No load		0.1	1	μA
		Driver disabled, receiver disabled, SLR=V_{IO}	$\overline{RE}$= V_{IO}, DE = 0V, No load		1.8	4	μA

1.A, B are driver output and receiver input terminals for Half duplex devices; A/B are Receiver input, Y/Z are driver output terminals for Full duplex devices

2.Under any specific conditions, V_{TH+} is assured to be at least V_{HYS} higher than V_{TH-}.

5.8 Switching Characteristics_250kbps

250kbps (GM2410V, GM2412V with SLR = V_{IO}) over recommended operating conditions. All typical values are at 25°C and supply voltage of V_{CC} = 5V , V_{IO} = 3.3V, unless otherwise noted. (1)

Symbol	Parameter	Conditions		MIN	TYP	MAX	UNIT
Driver							
t_r, t_f	Differential output rise/fall time	R_L = 54 Ω, C_L = 50pF See Figure3	V_{CC} = 3 to 3.6V, Typical at 3.3V	450	560	1200	ns
			V_{CC} = 4.5 to 5.5V, Typical at 5V	500	625	1200	
t_{PHL}, t_{PLH}	Propagation delay		V_{CC} = 3 to 3.6V, Typical at 3.3V		500	720	ns
			V_{CC} = 4.5 to 5.5V, Typical at 5V		540	770	
$t_{SK(P)}$	Pulse skew, |t_{PHL}–t_{PLH}|		V_{CC} = 3 to 3.6V, Typical at 3.3V		10	70	ns
			V_{CC} = 4.5 to 5.5V, Typical at 5V		10	70	
t_{PHZ}, t_{PLZ}	Disable time	$\overline{RE}$ = X	See Figure 4 and Figure 5		40	75	ns
t_{PZH}, t_{PZL}	Enable time	$\overline{RE}$ = 0V			70	280	ns
		$\overline{RE}$ = V_{IO}			2.5	4.5	μs
t_{SHDN}	Time to shutdown	$\overline{RE}$ = V_{IO}		50		500	ns
Receiver							
t_r, t_f	Output rise/fall time	C_L = 15pF	See Figure 6		7	20	ns
t_{PHL}, t_{PLH}	Propagation delay				800	1270	ns
$t_{SK(P)}$	Pulse skew, |t_{PHL}–t_{PLH}|				5	45	ns
t_{PHZ}, t_{PLZ}	Disable time				30	40	ns
$t_{PZH(1)}$	Enable time	V_{IO} = 3V to 3.6V; DE = V_{IO}	See Figure 7		90	120	ns
		V_{IO} = 1.65V to 1.95V, DE = V_{IO}			100	130	
$t_{PZL(1)}$		V_{IO} = 3V to 3.6V; DE = V_{IO}			900	1320	
		V_{IO} = 1.65V to 1.95V; DE=V_{IO}			900	1320	

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Symbol	Parameter	Condition		MIN	TYP	MAX	UNIT
$t_{PZH(2)}$ $t_{PZL(2)}$	Enable time	DE = 0V	See Figure 8		3.3	5.4	µs
$t_{D(OFS)}$	Delay to enter fail-safe operation	C_L = 15pF	See Figure 9	7	11	18	µs
$t_{D(FSO)}$	Delay to enter fail-safe operation			540	800	1260	ns
t_{SHDN}	Time to shutdown	DE = 0V	See Figure 8	50		500	ns

1.A, B are driver output and receiver input terminals for Half duplex devices; A/B are Receiver input, Y/Z are driver output terminals for Full duplex device

5.9 Switching Characteristics_1Mbps

1Mbps (GM2410V, GM2412V with SLR = 0) over recommended operating conditions. All typical values are at 25°C and supply voltage of V_{CC} = 5V , V_{IO} = 3.3V, unless otherwise noted. (1)

Symbol	Parameter	Conditions		MIN	TYP	MAX	UNIT
Driver							
t_r, t_f	Differential output rise/fall time	R_L = 54Ω, C_L = 50pF See Figure3	V_{CC} = 3 to 3.6V, Typical at 3.3V	125	150	300	ns
			V_{CC} = 4.5 to 5.5V, Typical at 5V	130	160	300	
t_{PHL}, t_{PLH}	Propagation delay		V_{CC} = 3 to 3.6V, Typical at 3.3V		160	240	ns
			V_{CC} = 4.5 to 5.5V, Typical at 5V		185	280	
$t_{SK(P)}$	Pulse skew, $\lvert t_{PHL}-t_{PLH}\rvert$		V_{CC} = 3 to 3.6V, Typical at 3.3V		2	20	ns
			V_{CC} = 4.5 to 5.5V, Typical at 5V		2	15	
t_{PHZ}, t_{PLZ}	Disable time	$\overline{RE}$ = X	See Figure 4 and Figure 5		40	75	ns
t_{PZH}, t_{PZL}	Enable time	$\overline{RE}$ = 0V			70	280	ns
		$\overline{RE}$ = V_{IO}			2.5	4.5	µs
t_{SHDN}	Time to shutdown	$\overline{RE}$ = V_{IO}		50		500	ns
Receiver							
t_r, t_f	Output rise/fall time	C_L = 15pF	See Figure 6		7	15	ns
t_{PHL}, t_{PLH}	Propagation delay				50	85	ns
$t_{SK(P)}$	Pulse skew, $\lvert t_{PHL}-t_{PLH}\rvert$				4	12.5	ns
t_{PHZ}, t_{PLZ}	Disable time	DE=X			30	40	ns
$t_{PZH(1)}$ $t_{PZL(1)}$	Enable time	V_{IO}=3V to 3.6V; DE=V_{IO}	See Figure 7		90	120	ns
		V_{IO} = 1.65V to 1.95V, DE=V_{IO}			90	130	
$t_{PZH(2)}$ $t_{PZL(2)}$	Enable time	DE=0V	See Figure 8		3	4.5	µs
$t_{D(OFS)}$	Delay to enter fail-safe operation	C_L = 15pF	See Figure 9	7	10	18	µs
$t_{D(FSO)}$	Delay to exit fail-safe operation			27	40	60	ns
t_{SHDN}	Time to shutdown	DE=0V	See Figure 8	50		500	ns

1.A, B are driver output and receiver input terminals for Half duplex devices; A/B are Receiver input, Y/Z are driver output terminals for Full duplex device

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6 Parameter Measurement Information

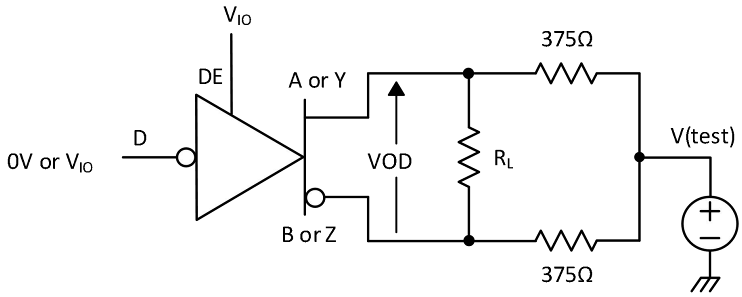

Figure 1. Measurement of Driver Differential Output Voltage With Common-Mode Load

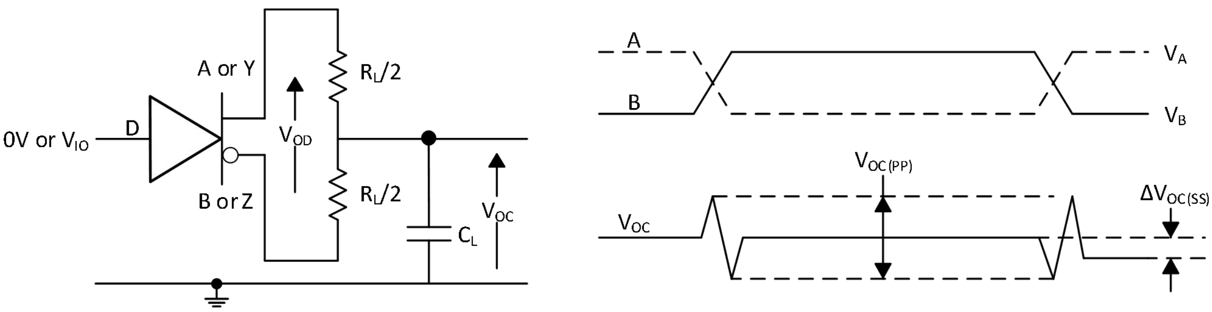

Figure 2. Measurement of Driver Differential and Common-Mode Output With RS-485 Load

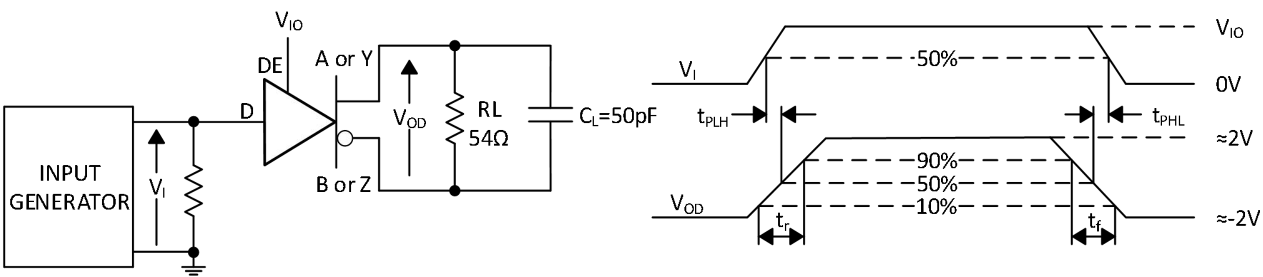

Figure 3. Measurement of Driver Differential Output Rise and Fall Times and Propagation Delays

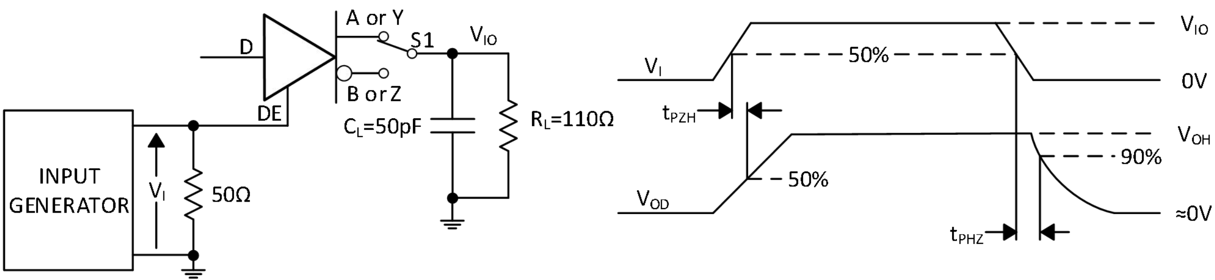

Figure 4. Measurement of Driver Enable and Disable Times With Active High Output and Pull-Down Load

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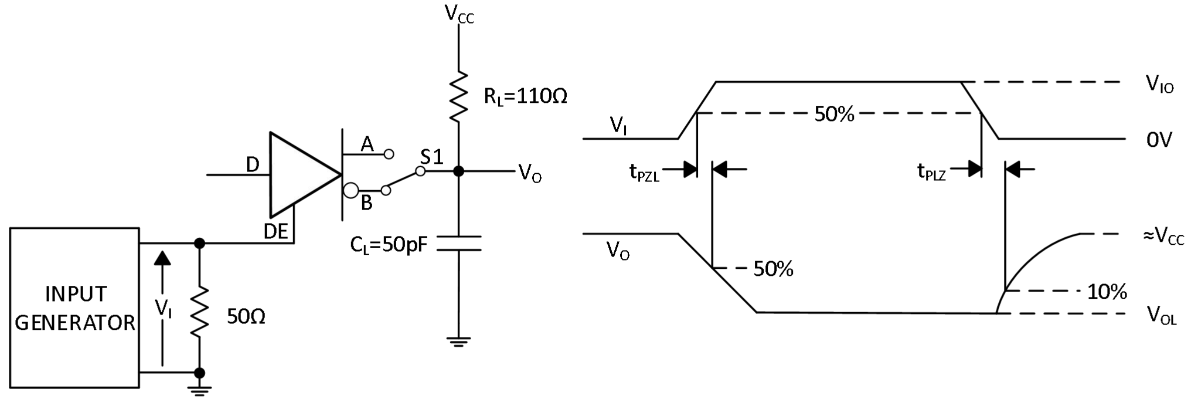

Figure 5. Measurement of Driver Enable and Disable Times With Active Low Output and Pull-up Load

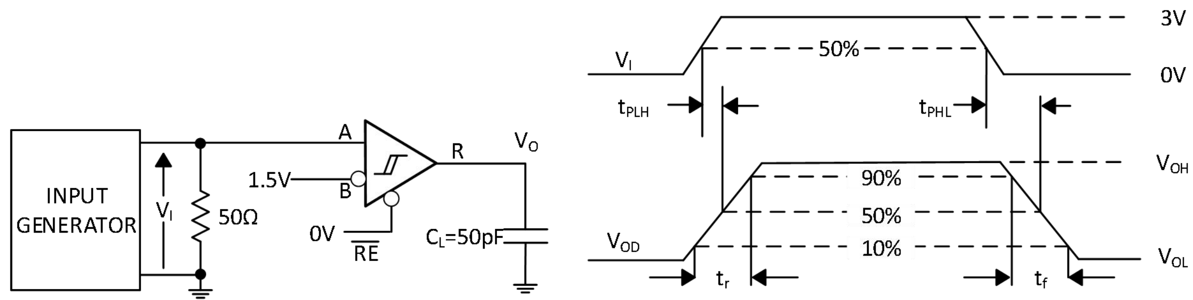

Figure 6. Measurement of Receiver Output Rise and Fall Times and Propagation Delays

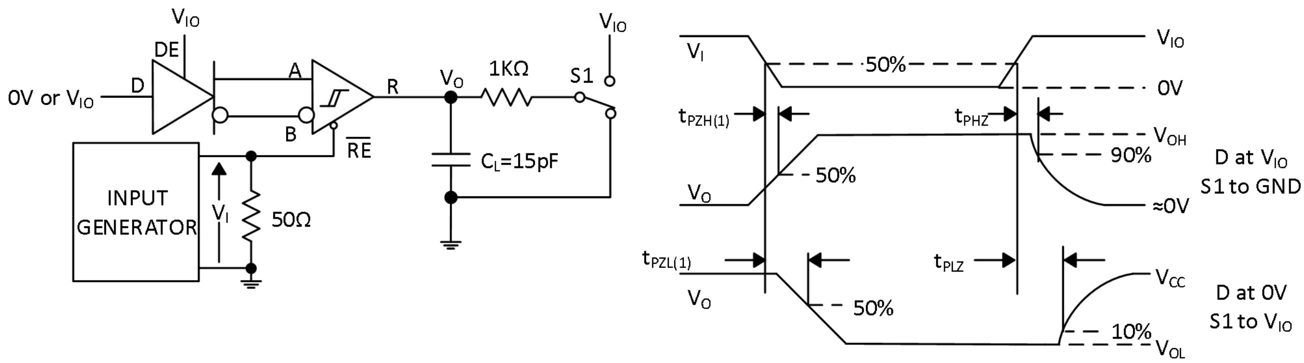

Figure 7. Measurement of Receiver Enable/Disable Times With Driver Enabled

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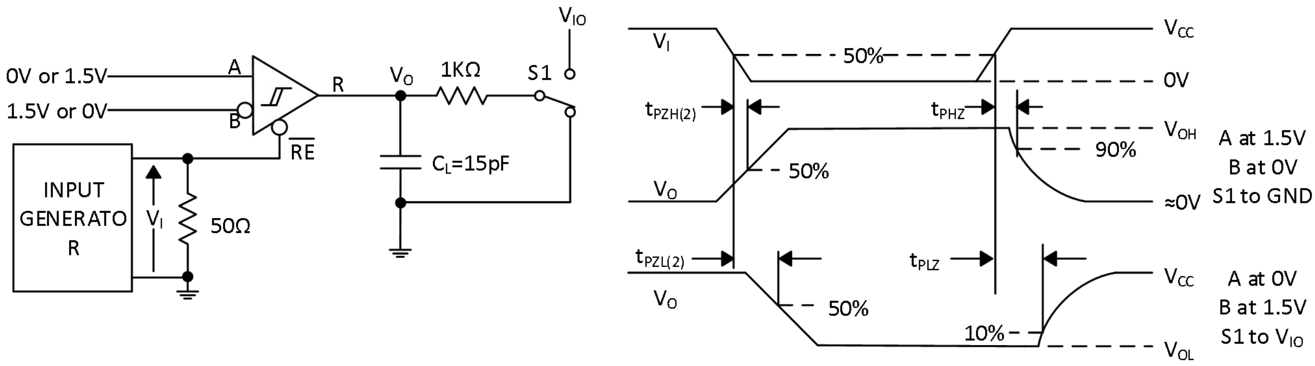

Figure 8. Measurement of Receiver Enable Times With Driver Disabled

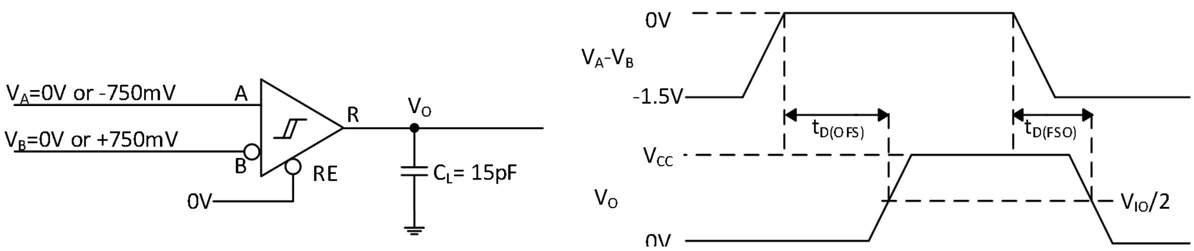

Figure 9. Measurement of Fail-Safe Delay

7 Detailed Description

7.1 Overview

GM241XV are ±70V bus fault-protected, ±25V common-mode voltage range capable half and full-duplex RS-485 transceivers. The devices have active-high driver enable and active-low receiver enable logic. Each device has SLR pin which allows it to be used for two different maximum speed settings. This is beneficial as customers can qualify one device and use it in two different end-applications. The devices also have flexible I/O supply pin V_{IO} which enables digital interface voltage range, from 1.65V to 5.5V, different from bus voltage supply 3V to 5.5V.

7.2 Functional Block Diagrams

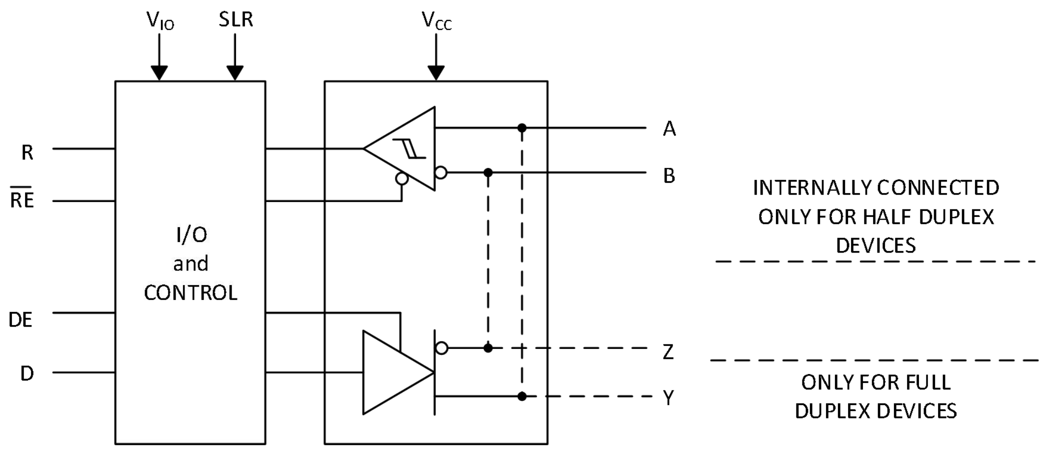

Figure 10. GM241X Block Diagram

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7.3 Feature Description

7.3.1 ±70V Fault Protection

GM241XV transceivers have extended bus fault protection compared to standard RS-485 devices. Transceivers that operate in rugged industrial environments are often exposed to voltage transients greater than the -7V to +12V defined by the TIA/EIA-485A standard. To protect against such conditions, the generic RS-485 devices with lower absolute maximum ratings requires expensive external protection components. To simplify system design and reduce overall system cost, GM241XV devices are protected up to ±70V without the need for any external components.

7.3.2 Integrated IEC ESD and EFT Protection

Internal ESD protection circuits protect the transceivers against electrostatic discharges (ESD) according to IEC 61000-4-2 of up to ±15kV contact and air discharge (for half-duplex devices) and up to ±12kV contact and air discharge (for full-duplex devices). Bus structures also protect against electrical fast transients (EFT) according to IEC 61000-4-4 for up to ±4kV. With careful system design, integrated bus structures can enable EFT Criterion A at the system level (minimum to no data loss when transient noise is present).

7.3.3 Driver Overvoltage and Overcurrent Protection

The GM241XV drivers are protected against any DC supply shorts in the range of -70V to +70V. The devices internally limit the short circuit current to ±200mA in order to comply with the TIA/EIA-485A standard. In addition, a fold-back current limiting circuit further reduces the driver short circuit current to less than ±5mA if the output fault voltage exceeds |±25V|.

All devices feature thermal shutdown protection that disables the driver and the receiver if the junction temperature exceeds the T_{SHDN} threshold due to excessive power dissipation.

7.3.4 Enhanced Receiver Noise Immunity

The differential receivers of GM241XV feature fully symmetric thresholds to maintain duty cycle of the signal even with small input amplitudes. In addition, 100mV (typical) hysteresis ensures excellent noise immunity.

7.3.5 Receiver Fail-Safe Operation

The receivers are fail-safe to invalid bus states caused by the following:

- Open bus conditions, such as a disconnected connector
- Shorted bus conditions, such as cable damage shorting the twisted-pair together
- Idle bus conditions that occur when no driver on the bus is actively driving

In any of these cases, the receiver outputs a fail-safe logic high state if the input amplitude stays for longer than $t_{D(OFS)}$ at less than $|V_{TH\_FSH}|$.

7.3.6 Low-Power Shutdown Mode

Driving DE low and $\overline{RE}$ high for longer than 500ns puts the devices into the shutdown mode. If either DE goes high or $\overline{RE}$ goes low, the counters reset. The devices does not enter the shutdown mode if the enable pins are in disable state for less than 50ns. This feature prevents the devices from accidentally going into shutdown mode due to skew between DE and $\overline{RE}$.

7.4 Device Functional Modes

When the driver enable pin, DE, is logic high (H), the differential outputs A and B follow the logic states at data input D. A logic high at D causes A to turn high and B to turn low. In this case the differential output voltage defined as $V_{OD} = V_A - V_B$ is positive. When D is low (L), the output states reverse: B turns high, A becomes low, and V_{OD} is negative.

When DE is low, both outputs turn high-impedance. In this condition the logic state at D is irrelevant (X). The DE pin has an internal pull-down resistor to ground, thus when left open the driver is disabled (Z= high-impedance) by default. The D pin has an internal pull-up resistor to V_{IO}, thus, when left open while the driver is enabled, output A turns high and B turns low.

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Table 1. Driver Function Table

INPUT	ENABLE		OUTPUTS	FUNCTION
D	DE	A	B	
H	H	H	L	Actively drive bus high
L	H	L	H	Actively drive bus low
X	L	Z	Z	Driver disabled
X	OPEN	Z	Z	Driver disabled by default
OPEN	H	H	L	Actively drive bus high by default

When the receiver enable pin, $\overline{RE}$, is logic low, the receiver is enabled. When the differential input voltage defined as $V_{ID} = V_A - V_B$ is higher than the positive input threshold, V_{TH+}, the receiver output, R, turns high. When V_{ID} is lower than the negative input threshold, V_{TH-}, the receiver output, R, turns low. If V_{ID} is between V_{TH+} and V_{TH-}, the output is indeterminate.

When $\overline{RE}$ is logic high or left open, the receiver output is high-impedance and the magnitude and polarity of V_{ID} are irrelevant. Internal biasing of the receiver inputs causes the output to go failsafe-high when the transceiver is disconnected from the bus (open-circuit), or he bus lines are shorted to one another (short-circuit), or the bus is not actively driven (idle bus).

Table 2. Receiver Function Table

DIFFERENTIAL INPUT	ENABLE	OUTPUTS	FUNCTION
$V_{ID} = V_A – V_B$	$\overline{RE}$	R	
$V_{TH+} < V_{ID}$	L	H	Receive valid bus high
$V_{TH-} < V_{ID} < V_{TH+}$	L	?	Indeterminate bus state
$V_{ID} < V_{TH}$	L	L	Receive valid bus low
X	H	Z	Receiver disabled
X	OPEN	Z	Receiver disabled by default
Open-circuit bus	L	H	Fail-safe high output
Short-circuit bus	L	H	Fail-safe high output
Idle (terminated) bus	L	H	Fail-safe high output

Table 3 shows SLR (slew rate select) pin functionality. SLR has intergated pull-down, so the device remains in higher speed mode until SLR is pulled high which limits the slew rate and puts the device in slower speed mode.

Table 3. SLR Pin Control

DEVICE	FUNCTION
GM2410V	SLR = Low or floating: Both transmitter (TX) and receiver (RX) maximum speed is 1Mbps.SLR = High: Both TX and RX maximum speed is limited to 250kbps
GM2412V	

Table 4 shows the device behavior in undervoltage scenarios:

Table 4.Supply Function Table

V_{CC}	V_{IO}	DRIVER OUTPUT	RECEIVER OUTPUT
$>UV_{VCC(rising)}$	$>UV_{VIO(rising)}$	Determined by DE and D inputs	Determined by RE and A-B
$<UV_{VCC(falling)}$	$>UV_{VIO(rising)}$	High impedance	High impedance
$>UV_{VCC(rising)}$	$<UV_{VIO(falling)}$	High impedance	High impedance
$<UV_{VCC(falling)}$	$<UV_{VIO(falling)}$	High impedance	High impedance

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8 Application and Implementation

8.1 Application Information

GM241XV are fault-protected, half-duplex RS-485 transceivers commonly used for asynchronous data transmissions. For these devices, the driver and receiver enable pins allow for the configuration of different operating modes.

8.2 Typical Application

An RS-485 bus consists of multiple transceivers connecting in parallel to a bus cable. To eliminate line reflections, each cable end is terminated with a termination resistor, R_T, whose value matches the characteristic impedance, Z_0, of the cable. This method, known as parallel termination, generally allows for higher data rates over longer cable length.

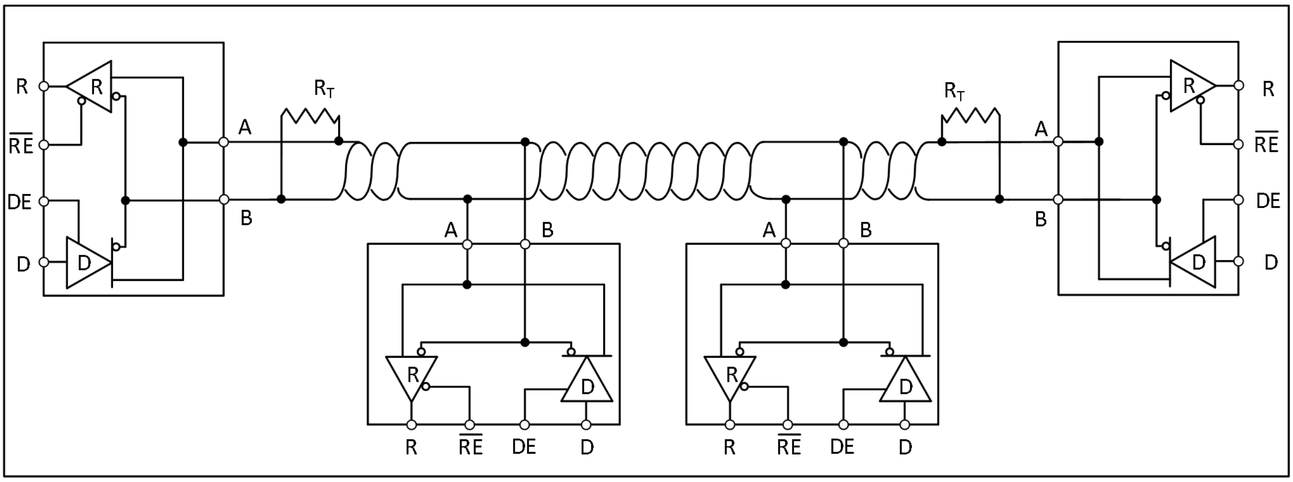

Figure 11. Typical RS-485 Network With Half-Duplex Transceivers

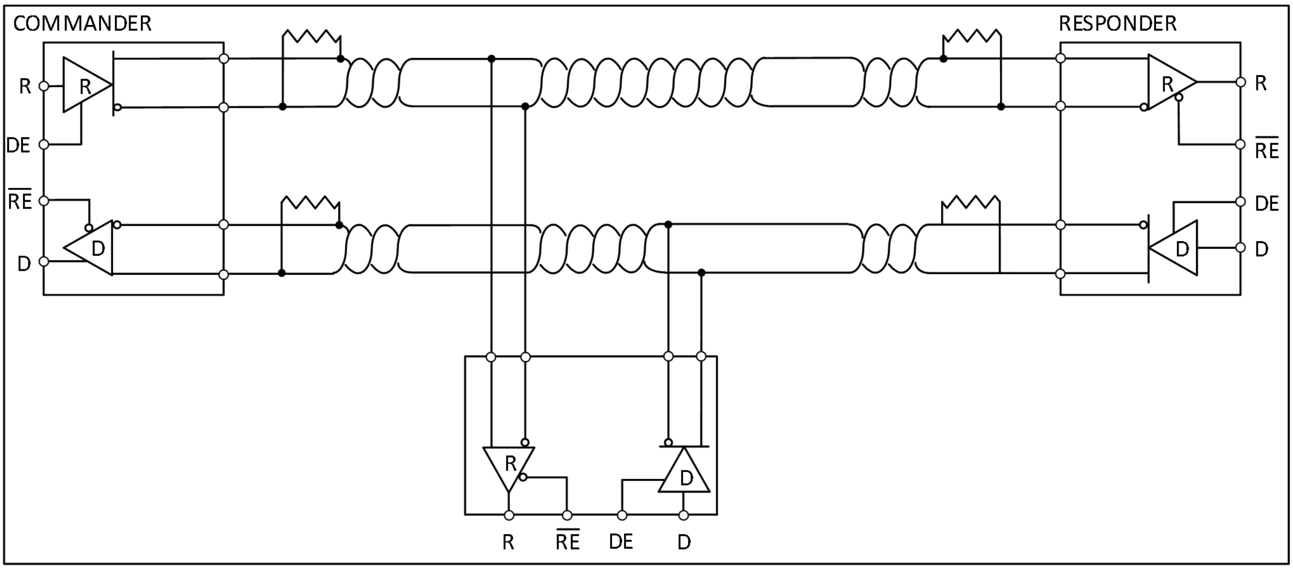

Figure 12. Typical RS-485 Network with Full-Duplex transceivers

8.2.1 Design Requirements

RS-485 is a robust electrical standard suitable for long-distance networking that may be used in a wide range of applications with varying requirements, such as distance, data rate, and number of nodes.

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8.2.1.1 Data Rate and Bus Length

There is an inverse relationship between data rate and cable length, which means the higher the data rate, the short the cable length; and conversely, the lower the data rate, the longer the cable length. While most RS-485 systems use data rates between 10kbps and 100kbps, some applications require data rates up to 250kbps at distances of 4000 feet and longer. Longer distances are possible by allowing for small signal jitter of up to 5 or 10%.

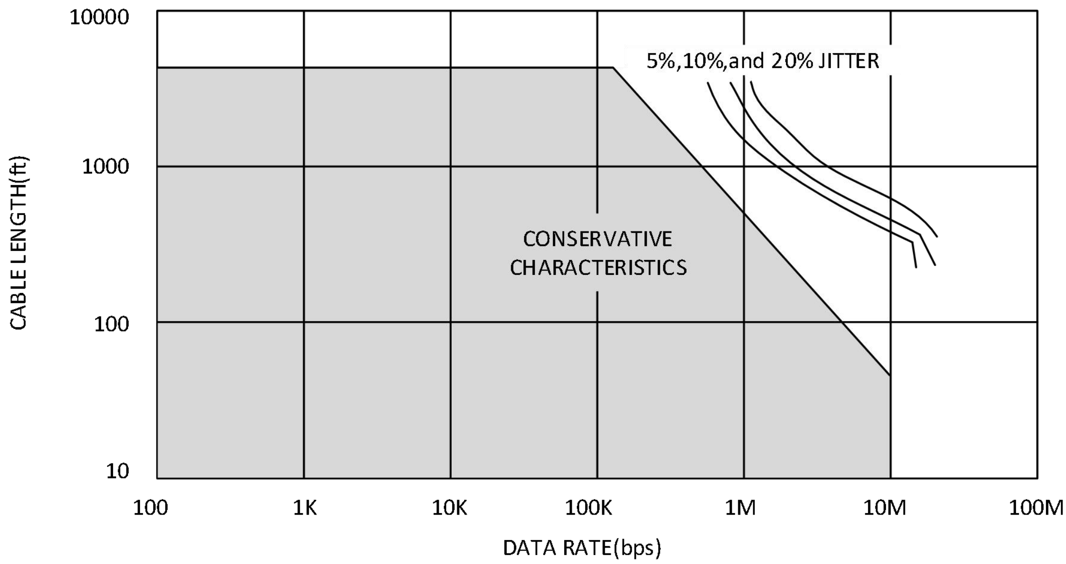

Figure 13. Cable Length vs Data Rate Characteristic

8.2.1.2 Stub Length

When connecting a node to the bus, the distance between the transceiver inputs and the cable trunk, known as the stub, should be as short as possible. Stubs present a non-terminated piece of bus line which can introduce reflections of varying phase as the length of the stub increases. As a general guideline, the electrical length, or round-trip delay, of a stub should be less than one-tenth of the rise time of the driver, thus giving a maximum physical stub length as shown in Equation 1.

$$L_{(STUB)} \le 0.1 \times tr \times v \times c$$

where

- t_r is the 10/90 rise time of the driver
- c is the speed of light (3×10^8m/s)
- v is the signal velocity of the cable or trace as a factor of c

8.2.1.3 Bus Loading

The RS-485 standard specifies that a compliant driver must be able to drive 32 unit loads (UL), where 1 unit load represents a load impedance of approximately 12kΩ. Because the GM241XV devices consist of 1/8 UL transceivers, connecting up to 256 receivers to the bus is possible for a limited common mode range of - 7V to 12V.

8.2.1.4 Transient Protection

The bus pins of the GM241XV transceivers include on-chip ESD protection against ±16kV HBM and ±15kV IEC 61000-4-2 contact discharge for half-duplex devices ±8kV for full-duplex devices. The International Electrotechnical Commission (IEC) ESD test is far more severe than the HBM ESD test. The 50% higher charge capacitance, $C_{(S)}$, and 78% lower discharge resistance, $R_{(D)}$, of the IEC model produce significantly higher discharge currents than the HBM model. As stated in the IEC 61000-4-2 standard, contact discharge is the preferred transient protection test method.

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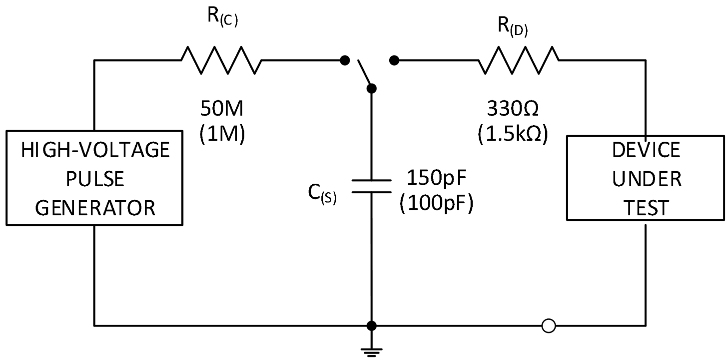

Figure 14. HBM and IEC ESD Models and Currents in Comparison (HBM Values in Parenthesis)

The on-chip implementation of IEC ESD protection significantly increases the robustness of equipment. Common discharge events occur because of human contact with connectors and cables. Designers may choose to implement protection against longer duration transients, typically referred to as surge transients.

EFTs are generally caused by relay-contact bounce or the interruption of inductive loads. Surge transients often result from lightning strikes (direct strike or an indirect strike which induce voltages and currents), or the switching of power systems, including load changes and short circuit switching. These transients are often encountered in industrial environments, such as factory automation and power-grid systems.

Figure 16 compares the pulse-power of the EFT and surge transients with the power caused by an IEC ESD transient. The left side of the diagram shows the relative pulse-power for a 0.5kV surge transient and 4kV EFT transient, both of which exceeds the 10kV ESD transient visible in the lower-left corner. 500V surge transients are representative of events that may occur in factory environments in industrial and process automation.The right side of the diagram shows the pulse power of a 6kV surge transient, relative to the same 0.5kV surge transient. 6kV surge transients are may occur in power generation and power-grid systems.

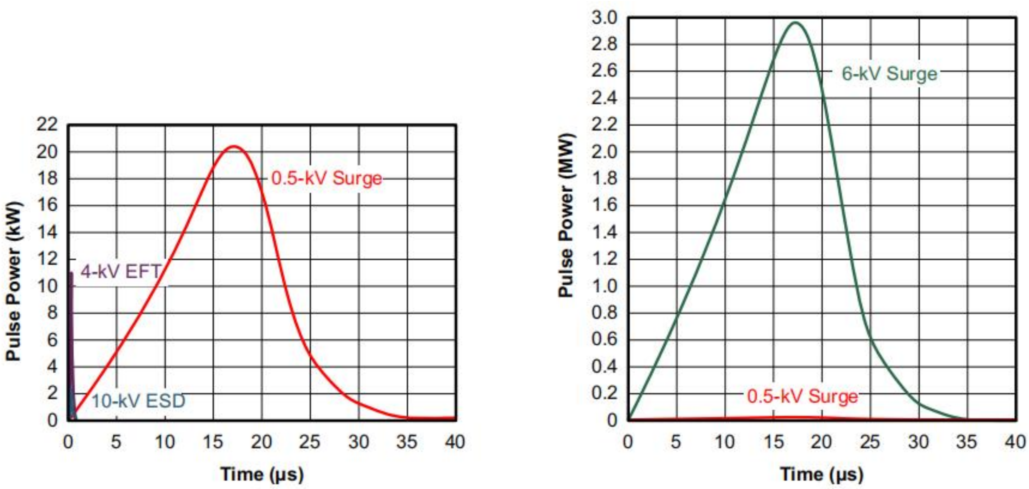

Figure 15. Power Comparison of ESD, EFT, and Surge Transients

For surge transients, high-energy content is characterized by long pulse duration and slow decaying pulse power. The electrical energy of a transient that is dumped into the internal protection cells of a transceiver is converted into thermal energy, which heats and destroys the protection cells, thus destroying the transceiver.

Figure 15 shows the large differences in transient energies for single ESD, EFT, surge transients, and an EFT pulse train that is commonly applied during compliance testing..

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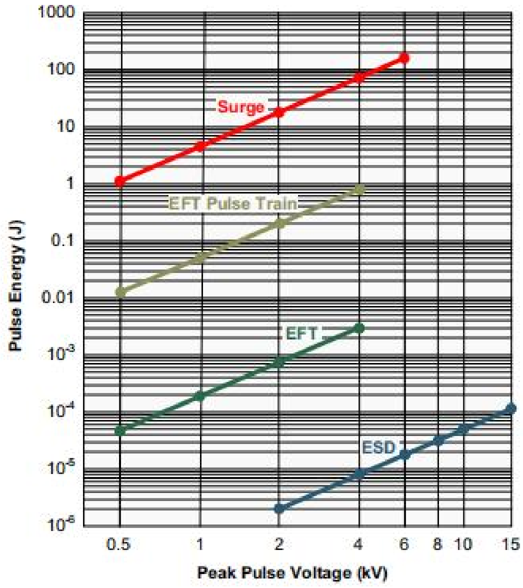

Figure 16. Comparison of Transient Energies

8.2.2 Detailed Design Procedure

Figure 17 suggests a protection circuit against 1kV surge (IEC 61000-4-5) transients. Table 5 shows the associated bill of materials. SMAJ30CA TVS diodes are rated to operate up to 30V. This makes sure the protection diodes do not conduct if a direct RS-485 bus shorts to 24V DC industrial power rail.

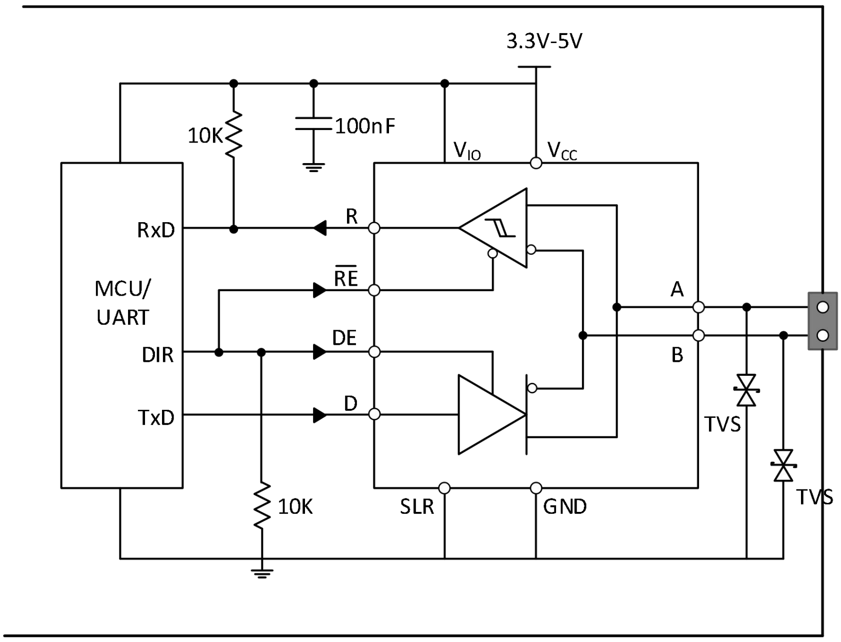

Figure 17. Transient Protection Against Surge Transients for Half-Duplex Devices

Table 5. Components List(5)

DEVICE	FUNCTION	ORDER NUMBER	MANUFACTURER
XCVR	RS-485 transceiver	GM241XV	Gatemode
TVS	Bidirectional 400-W transient suppressor	SMAJ30CA	

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8.3 Power Supply Recommendations

For reliable operation at all data rates and supply voltages, each supply should be decoupled with a minimum of 100nF ceramic capacitor located as close to the supply pins as possible. This helps to reduce supply voltage ripple present on the outputs of switched-mode power supplies and also helps to compensate for the resistance and inductance of the PCB power planes.

9 Layout

9.1 Layout Guidelines

Robust and reliable bus node design often requires the use of external transient protection devices in order to protect against surge transients that may occur in industrial environments. Since these transients have a wide frequency bandwidth (from approximately 3MHz to 300MHz), high-frequency layout techniques should be applied during PCB design.

1.Place the protection circuitry close to the bus connector to prevent noise transients from propagating across the board.

2.Use V_{CC} and ground planes to provide low inductance. Note that high-frequency currents tend to follow the path of least impedance and not the path of least resistance.

3.Design the protection components into the direction of the signal path. Do not force the transient currents to divert from the signal path to reach the protection device.

4.Apply 100nF to 220nF decoupling capacitors as close as possible to the V_{CC} pins of transceiver, UART and/or controller ICs on the board.

5.Use at least two vias for V_{CC} and ground connections of decoupling capacitors and protection devices to minimize effective via inductance.

6.Use 1kΩ to 10kΩ pull-up and pull-down resistors for enable lines to limit noise currents in these lines during transient events.

7.Insert pulse-proof resistors into the A and B bus lines if the TVS clamping voltage is higher than the specified maximum voltage of the transceiver bus pins. These resistors limit the residual clamping current into the transceiver and prevent it from latching up.

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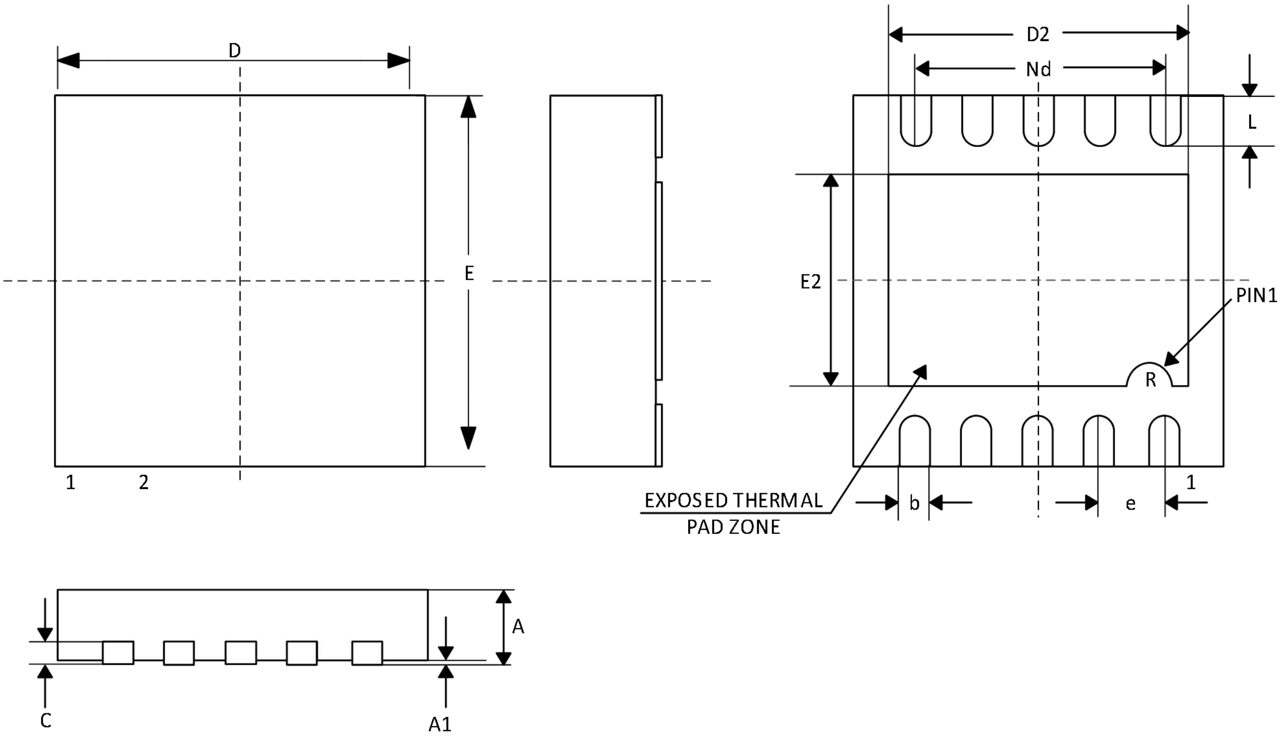
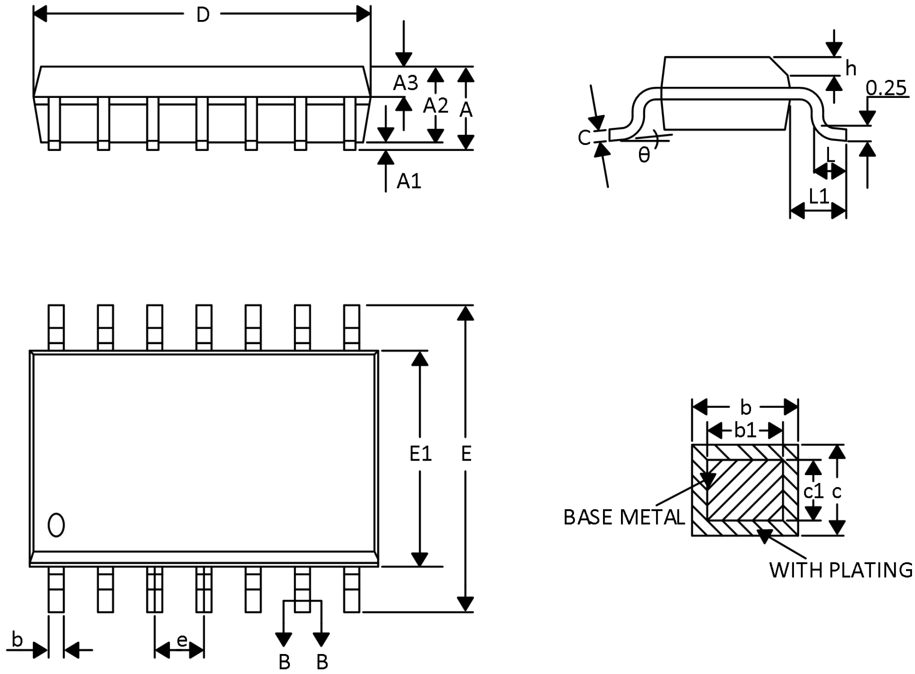
PACKAGE DIMENSION

DFN10



SYMBOL	MIN	NOM	MAX
A	0.70	0.75	0.80
A1	-	0.02	0.05
b	0.18	0.23	0.28
c	0.18	0.20	0.25
D	2.90	3.00	3.10
D2	2.30	2.40	2.50
e	0.50BSC		
Nd	2.00BSC		
E	2.90	3.00	3.10
E2	1.60	1.70	1.80
L	0.30	0.40	0.50
R	0.20BSC		
L/F 载体尺寸	2.6*1.9		

SOP14



SYMBOLS	MILLIMETER		
	MIN	NOM	MAX
A	-	-	1.75
A1	0.05	-	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	-	0.47
b1	0.38	0.41	0.44
c	0.20	-	0.24
c1	0.19	0.20	0.21
D	8.55	8.65	8.75
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
e	1.24BSC		
h	0.25	-	0.50
L	0.50	-	0.80
L1	1.05REF		
θ	0°	-	8°

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Order Information

Order number	Package	Marking information	Operation Temperature Range	MSL Grade	Ship, Quantity	Green
GM2410V	DFN10	GM2410V	-40 to 125°C	3	T&R, 5000	Rohs
GM2412V	SOP14	GM2412V	-40 to 125°C	3	T&R, 2500	Rohs

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