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SP509

Rugged 40Mbps, 8 Channel Multi-Protocol Transceiver with Programmable DCE/DTE and Termination Resistors

FEATURES

- Ultra Fast 40Mbps Differential Transmission Rates
- Improved ESD Tolerance for Analog I/Os with 15kV HBM
- Internal Transceiver Termination Resistors for V.11/V.35
- Interface Modes:
 - RS-232 (V.28) – EIA-530 (V.10 & V.11)
 - X.21 (V.11) – EIA-530A (V.10 & V.11)
 - RS-449/V.36 – V.35
(V.10 & V.11)
- Protocols are Software Selectable with 3-Bit Word
- Eight (8) Drivers and Eight (8) Receivers
- V.35 and V.11 Receiver Termination Network Disable Option
- Internal Line or Digital Loopback for Diagnostic Testing
- Adheres to NET1/NET2 and TBR-1/TBR-2 Requirements
- Easy Flow-Through Pinout
- +5V Only Operation
- Individual Driver and Receiver Enable/Disable Controls
- Operates in either DTE or DCE Mode

Now Available in Lead Free Packaging

Refer to page 7 for pinout

APPLICATIONS

- Router
- Frame Relay
- CSU
- DSU
- PBX
- Secure Communication Terminals

DESCRIPTION

The SP509 is a monolithic device that supports eight (8) popular serial interface standards for Wide Area Network (WAN) connectivity. The SP509 is fabricated using a low power BiCMOS process technology, and incorporates an Exar regulated charge pump allowing +5V only operation. Exar's patented charge pump provides a regulated output of $\pm 5.8V$, which will provide enough voltage for compliant operation in all modes. Eight (8) drivers and eight (8) receivers can be configured via software for any of the above interface modes at any time. The SP509 requires no additional external components for compliant operation for all of the eight (8) modes of operation other than four capacitors used for the internal charge pump. All necessary termination is integrated within the SP509 and is switchable when V.35 drivers and V.35 receivers, or when V.11 receivers are used. The SP509 provides the controls and transceiver availability for operating as either a DTE or DCE.

Additional features with the SP509 include internal loopback that can be initiated in any of the operating modes by use of the LOOPBACK pin. While in loopback mode, receiver outputs are internally connected to driver inputs creating an internal signal path bypassing the serial communications controller for diagnostic testing. The SP509 also includes a latch enable pin with the driver and receiver address decoder. The internal V.11 or V.35 receiver termination can be switched off using a control pin (TERM_OFF) for monitoring applications. All eight (8) drivers and receivers in the SP509 include separate enable pins for added convenience. The SP509 is ideal for WAN serial ports in networking equipment such as routers, access concentrators, network muxes, DSU/CSU's, networking test equipment, and other access devices.

Applicable U.S. Patents-5,306,954; and others patents pending

ABSOLUTE MAXIMUM RATINGS

These are stress ratings only and functional operation of the device at these ratings or any other above those indicated in the operation sections of the specifications below is not implied. Exposure to absolute maximum rating conditions for extended periods of time may affect reliability.

V _{CC}	+7V
Input Voltages:	
Logic	-0.3V to (V _{CC} +0.5V)
Drivers.....	-0.3V to (V _{CC} +0.5V)
Receivers.....	±15.5V
Output Voltages:	
Logic	-0.3V to (V _{CC} +0.5V)
Drivers.....	±12V
Receivers.....	-0.3V to (V _{CC} +0.5V)
Storage Temperature.....	-65°C to +150°C
Power Dissipation.....	1520mW
(derate 19.0mW/°C above +70°C)	
Package Derating:	
θ _{JA}	52.7 °C/W
θ _{JC}	6.5 °C/W

STORAGE CONSIDERATIONS

Due to the relatively large package size, storage in a low humidity environment is preferred. Large high density plastic packages are moisture sensitive and should be stored in Dry Vapor Barrier Bags. Prior to usage, the parts should remain bagged and stored below 40°C and 60%RH. If the parts are removed from the bag, they should be used within 48 hours or stored in an environment at or below 20%RH. If the above conditions cannot be followed, the parts should be baked for four hours at 125°C in order to remove moisture prior to soldering. Exar ships the 100-pin LQFP in Dry Vapor Barrier Bags with a humidity indicator card and desiccant pack. The humidity indicator should be below 30%RH.

ELECTRICAL SPECIFICATIONS

T_A = +25°C and V_{CC} = +4.75V to +5.25V unless otherwise noted.

PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITIONS
LOGIC INPUTS					
V _{IL} V _{IH}	2.0		0.8	Volts Volts	
LOGIC OUTPUTS					
V _{OL} V _{OH}		2.4	0.4	Volts Volts	I _{OUT} = -3.2mA I _{OUT} = 1.0mA
V.28 DRIVER DC Parameters					
Open Circuit Voltage			±15	Volts	per Figure 1
Loaded Voltage	±5.0		±15	Volts	per Figure 2
Short-Circuit Current			±100	mA	per Figure 4, V _{OUT} =0V
Power-Off Impedance	300			Ω	per Figure 5
AC Parameters					V_{CC} = +5V for AC parameters
Transition Time			1.5	μs	per Figure 6; +3V to -3V
Instantaneous Slew Rate			30	V/μs	per Figure 3
Propagation Delay					
t _{PHL}	0.5	1	5	μs	
t _{PLH}	0.5	1	5	μs	
Max. Transmission Rate	120	230		kbps	
V.28 RECEIVER DC Parameters					
Input Impedance	3		7	kΩ	per Figure 7
Open-Circuit Bias			+2.0	Volts	per Figure 8
HIGH Threshold		1.7	3.0	Volts	
LOW Threshold	0.8	1.2		Volts	
AC Parameters					V_{CC} = +5V for AC parameters
Propagation Delay					
t _{PHL}	50	100	500	ns	
t _{PLH}	50	100	500	ns	

$T_A = +25^{\circ}\text{C}$ and $V_{CC} = +4.75\text{V}$ to $+5.25\text{V}$ unless otherwise noted.

PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITIONS
V.28 RECEIVER (cont) AC Parameters (cont.) Max. Transmission Rate	120	235		kbps	
V.10 DRIVER DC Parameters Open Circuit Voltage Test-Terminated Voltage Short-Circuit Current Power-Off Current AC Parameters Transition Time Propagation Delay t_{PHL} t_{PLH} Max. Transmission Rate	± 4.0 $0.9V_{OC}$ 30 30 120	 100 100	 ± 6.0 ± 150 ± 100 200 500 500	Volts Volts mA μA ns ns kbps	per Figure 9 per Figure 10 per Figure 11 per Figure 12 $V_{CC} = +5V$ for AC parameters per Figure 13; 10% to 90%
V.10 RECEIVER DC Parameters Input Current Input Impedance Sensitivity AC Parameters Propagation Delay t_{PHL} t_{PLH} Max. Transmission Rate	 -3.25 4 120		 $+3.25$ ± 0.3 50 50	mA k Ω Volts ns ns kbps	per Figures 14 and 15 $V_{CC} = +5V$ for AC parameters
V.11 DRIVER DC Parameters Open Circuit Voltage Test Terminated Voltage Balance Offset Short-Circuit Current Power-Off Current AC Parameters Transition Time Propagation Delay t_{PHL} t_{PLH} Differential Skew $(t_{phl} - t_{plh})$ Max. Transmission Rate Channel to Channel Skew	 ± 2.0 $0.5V_{OC}$ 40	 30 30 2 2	 ± 6.0 $0.67V_{OC}$ ± 0.4 ± 3.0 ± 150 ± 100 10 50 50 5 	Volts Volts Volts Volts mA μA ns ns ns ns Mbps ns	per Figure 16 per Figure 17 per Figure 17 per Figure 17 per Figure 18 per Figure 19 $V_{CC} = +5V$ for AC parameters per Fig. 21 and 36; 10% to 90% Using $C_L = 50pF$; per Figures 33 and 36 per Figures 33 and 36 per Figures 33 and 36
V.11 RECEIVER DC Parameters Common Mode Range Sensitivity	 -7		 $+7$ ± 0.2	Volts Volts	

ELECTRICAL SPECIFICATIONS

T_A = +25°C and V_{CC} = +4.75V to +5.25V unless otherwise noted.

PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITIONS
V.11 RECEIVER (cont)					
DC Parameters (cont.)					
Input Current	-3.25		±3.25	mA	per Figure 20 and 22; power on or off
Current w/ 100Ω Termination			±60.75	mA	per Figure 23 and 24
Input Impedance	4			kΩ	
AC Parameters					
Propagation Delay					V _{CC} = +5V for AC parameters Using C _L = 50pF;
t _{PHL}		30	50	ns	per Figures 33 and 38
t _{PLH}		30	50	ns	per Figures 33 and 38
Skew(t _{PHL} - t _{PLH})		2	5	ns	per Figure 33
Max. Transmission Rate	40			Mbps	
Channel to Channel Skew		2		ns	
V.35 DRIVER					
DC Parameters					
Test Terminated Voltage	±0.44		±0.66	Volts	per Figure 25
Offset			±0.6	Volts	per Figure 25
Output Overshoot	-0.2V _{ST}		+0.2V _{ST}	Volts	per Figure 25; V _{ST} = Steady state value
Source Impedance	50		150	Ω	per Figure 27; Z _S = V ₂ /V ₁ x 50
Short-Circuit Impedance	135		165	Ω	per Figure 28
AC Parameters					
Transition Time		7	20	ns	per Figure 29; 10% to 90%
Propagation Delay					
t _{PHL}		30	50	ns	per Figure 33 and 36; C _L = 20pF
t _{PLH}		30	50	ns	per Figure 33 and 36; C _L = 20pF
Differential Skew		2	5	ns	per Figure 33 and 36; C _L = 20pF
(t _{PHL} - t _{PLH})					
Max. Transmission Rate	40			Mbps	
Channel to Channel Skew		5		ns	
V.35 RECEIVER					
DC Parameters					
Sensitivity		±50	±200	mV	
Source Impedance	90		110	Ω	per Figure 30; Z _S = V ₂ /V ₁ x 50Ω
Short-Circuit Impedance	135		165	Ω	per Figure 31
AC Parameters					
Propagation Delay					V _{CC} = +5V for AC parameters
t _{PHL}		30	50	ns	per Figure 33 and 38; C _L = 20pF
t _{PLH}		30	50	ns	per Figure 33 and 38; C _L = 20pF
Skew(t _{PHL} - t _{PLH})		2	5	ns	per Figure 33; C _L = 20pF
Max. Transmission Rate	40			Mbps	
Channel to Channel Skew		2		ns	
TRANSCIEVER LEAKAGE CURRENT					
Driver Output 3-State Current		500		μA	per Figure 32; Drivers disabled
Rcvr Output 3-State Current		1	10	μA	T _x & R _x disabled, 0.4V - V _O - 2.4V
POWER REQUIREMENTS					
V _{CC}	4.75	5.00	5.25	Volts	
I _{CC} (Shutdown Mode)		1		μA	All I _{CC} values are with V _{CC} = +5V
(V.28/RS-232)		95		mA	f _{IN} = 120kbps; Drivers active & loaded
(V.11/RS-422)		230		mA	f _{IN} = 10Mbps; Drivers active & loaded
(EIA-530 & RS-449)		270		mA	f _{IN} = 10Mbps; Drivers active & loaded
(V.35)		170		mA	V.35 @ f _{IN} = 10Mbps, V.28 @ 20kbps
(EIA-530A)		200		mA	f _{IN} = 10Mbps; Drivers active & loaded

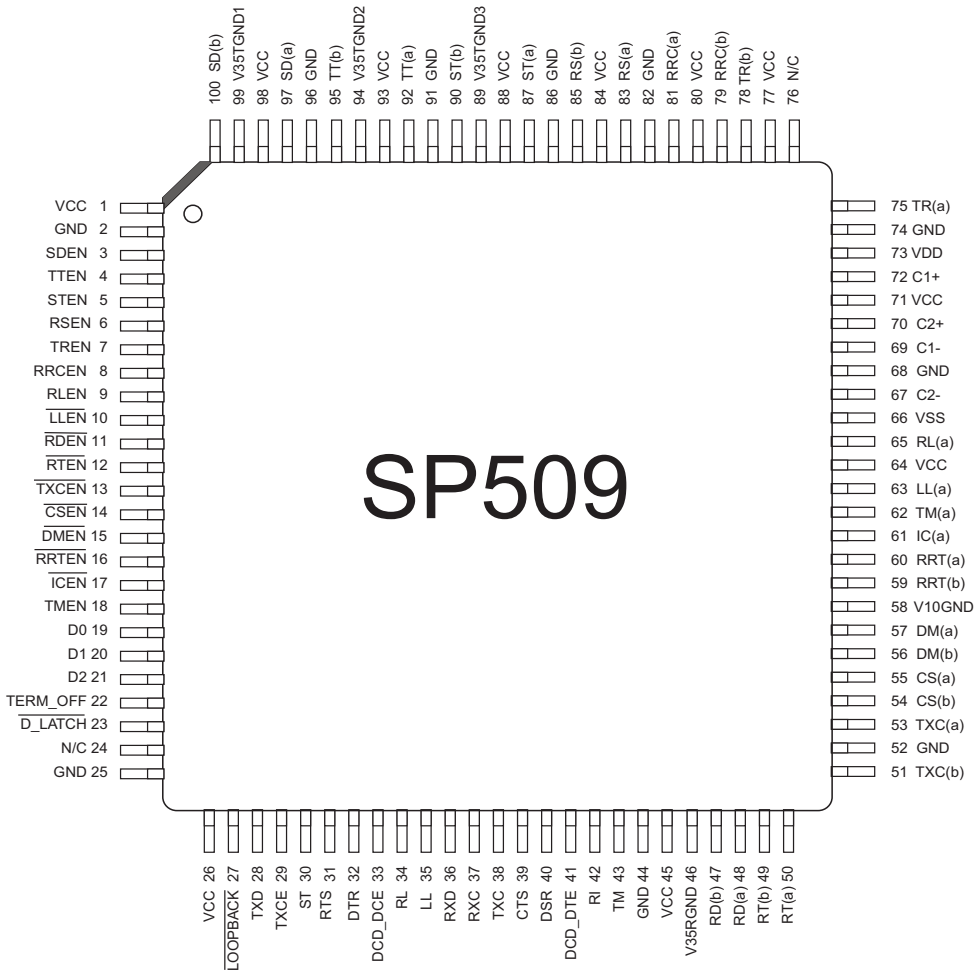
$T_A = +25^\circ\text{C}$ and $V_{CC} = +5.0\text{V}$ unless otherwise noted.

PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITIONS
DRIVER DELAY TIME BETWEEN ACTIVE MODE AND TRI-STATE MODE					
RS-232/V.28					
t_{PZL}^1 : Tri-state to Output LOW		0.11	5.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 40; S_2 closed
t_{PZH}^1 : Tri-state to Output HIGH		0.11	2.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 40; S_2 closed
t_{PLZ}^2 : Output LOW to Tri-state		0.05	2.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 40; S_2 closed
t_{PHZ}^2 : Output HIGH to Tri-state		0.05	2.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 40; S_2 closed
RS-423/V.10					
t_{PZL}^1 : Tri-state to Output LOW		0.07	2.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 40; S_2 closed
t_{PZH}^1 : Tri-state to Output HIGH		0.05	2.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 40; S_2 closed
t_{PLZ}^2 : Output LOW to Tri-state		0.55	2.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 40; S_2 closed
t_{PHZ}^2 : Output HIGH to Tri-state		0.12	2.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 40; S_2 closed
RS-422/V.11					
t_{PZL}^1 : Tri-state to Output LOW		0.04	10.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 37; S_1 closed
t_{PZH}^1 : Tri-state to Output HIGH		0.05	2.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 37; S_2 closed
t_{PLZ}^2 : Output LOW to Tri-state		0.03	2.0	μs	$C_L = 15\text{pF}$, Fig. 34 & 37; S_1 closed
t_{PHZ}^2 : Output HIGH to Tri-state		0.11	2.0	μs	$C_L = 15\text{pF}$, Fig. 34 & 37; S_2 closed
V.35					
t_{PZL}^1 : Tri-state to Output LOW		0.85	10.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 37; S_1 closed
t_{PZH}^1 : Tri-state to Output HIGH		0.36	2.0	μs	$C_L = 100\text{pF}$, Fig. 34 & 37; S_2 closed
t_{PLZ}^2 : Output LOW to Tri-state		0.06	2.0	μs	$C_L = 15\text{pF}$, Fig. 34 & 37; S_1 closed
t_{PHZ}^2 : Output HIGH to Tri-state		0.05	2.0	μs	$C_L = 15\text{pF}$, Fig. 34 & 37; S_2 closed
RECEIVER DELAY TIME BETWEEN ACTIVE MODE AND TRI-STATE MODE					
RS-232/V.28					
t_{PZL}^1 : Tri-state to Output LOW		0.05	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 40; S_1 closed
t_{PZH}^1 : Tri-state to Output HIGH		0.05	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 40; S_2 closed
t_{PLZ}^2 : Output LOW to Tri-state		0.65	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 40; S_2 closed
t_{PHZ}^2 : Output HIGH to Tri-state		0.65	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 40; S_2 closed
RS-423/V.10					
t_{PZL}^1 : Tri-state to Output LOW		0.04	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 40; S_1 closed
t_{PZH}^1 : Tri-state to Output HIGH		0.03	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 40; S_2 closed
t_{PLZ}^2 : Output LOW to Tri-state		0.03	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 40; S_2 closed
t_{PHZ}^2 : Output HIGH to Tri-state		0.03	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 40; S_2 closed

OTHER AC CHARACTERISTICS (Continued)

$T_A = +25^\circ\text{C}$ and $V_{CC} = +5.0\text{V}$ unless otherwise noted.

PARAMETER	MIN.	TYP.	MAX.	UNITS	CONDITIONS
RS-422/V.11					
t_{PZL} : Tri-state to Output LOW		0.04	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 39; S_1 closed
t_{PZH} : Tri-state to Output HIGH		0.03	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 39; S_2 closed
t_{PLZ} : Output LOW to Tri-state		0.03	2.0	μs	$C_L = 15\text{pF}$, Fig. 35 & 39; S_1 closed
t_{PHZ} : Output HIGH to Tri-state		0.03	2.0	μs	$C_L = 15\text{pF}$, Fig. 35 & 39; S_2 close
V.35					
t_{PZL} : Tri-state to Output LOW		0.04	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 39; S_1 closed
t_{PZH} : Tri-state to Output HIGH		0.03	2.0	μs	$C_L = 100\text{pF}$, Fig. 35 & 39; S_2 closed
t_{PLZ} : Output LOW to Tri-state		0.03	2.0	μs	$C_L = 15\text{pF}$, Fig. 35 & 39; S_1 closed
t_{PHZ} : Output HIGH to Tri-state		0.03	2.0	μs	$C_L = 15\text{pF}$, Fig. 35 & 39; S_2 closed
TRANSCEIVER TO TRANSCEIVER SKEW (per Figures 32, 33, 36, 38)					
RS-232 Driver		100		ns	$[(t_{PHL})_{TX1} - (t_{PHL})_{TXn}]$
		100		ns	$[(t_{PLH})_{TX1} - (t_{PLH})_{TXn}]$
RS-232 Receiver		20		ns	$[(t_{PHL})_{RX1} - (t_{PHL})_{RXn}]$
		20		ns	$[(t_{PHL})_{RX1} - (t_{PHL})_{RXn}]$
RS-422 Driver		2		ns	$[(t_{PHL})_{TX1} - (t_{PHL})_{TXn}]$
		2		ns	$[(t_{PLH})_{TX1} - (t_{PLH})_{TXn}]$
RS-422 Receiver		2		ns	$[(t_{PHL})_{RX1} - (t_{PHL})_{RXn}]$
		3		ns	$[(t_{PHL})_{RX1} - (t_{PHL})_{RXn}]$
RS-423 Driver		5		ns	$[(t_{PHL})_{TX2} - (t_{PHL})_{TXn}]$
		5		ns	$[(t_{PLH})_{TX2} - (t_{PLH})_{TXn}]$
RS-423 Receiver		5		ns	$[(t_{PHL})_{RX2} - (t_{PHL})_{RXn}]$
		5		ns	$[(t_{PHL})_{RX2} - (t_{PHL})_{RXn}]$
V.35 Driver		2		ns	$[(t_{PHL})_{TX1} - (t_{PHL})_{TXn}]$
		2		ns	$[(t_{PLH})_{TX1} - (t_{PLH})_{TXn}]$
V.35 Receiver		2		ns	$[(t_{PHL})_{RX1} - (t_{PHL})_{RXn}]$
		2		ns	$[(t_{PHL})_{RX1} - (t_{PHL})_{RXn}]$



Pin Number	Pin Name	Description	Pin Number	Pin Name	Description
1	VCC	5V Power Supply Input	51	TxC(b)	TxC Non-Inverting Input
2	GND	Signal Ground	52	GND	Signal Ground
3	SDEN	TxD Driver Enable Input	53	TxC(a)	TxC Inverting Input
4	TTEN	TxCE Driver Enable Input	54	CS(b)	CTS Non-Inverting Input
5	STEN	ST Driver Enable Input	55	CS(a)	CTS Inverting Input
6	RSEN	RTS Driver Enable Input	56	DM(b)	DSR Non-Inverting Input
7	TREN	DTR Driver Enable Input	57	DM(a)	DSR Inverting Input
8	RRCEN	DCD Driver Enable Input	58	GNDV10	V.10 Rx Reference Node
9	RLEN	RL Driver Enable Input	59	RRT(b)	DCD _{DTE} Non-Inverting Input
10	LLEN#	LL Driver Enable Input	60	RRT(a)	DCD _{DTE} Inverting Input
11	RDEN#	RxD Receiver Enable Input	61	IC	RI Receiver Input
12	RTEN#	RxC Receiver Enable Input	62	TM(a)	TM Receiver Input
13	TxCEN#	TxC Receiver Enable Input	63	LL(a)	LL Driver Output
14	CSEN#	CTS Receiver Enable Input	64	VCC	Power Supply Input
15	DMEN#	DSR Receiver Enable Input	65	RL(a)	RL Driver Output
16	RRTEN#	DCD _{DTE} Receiver Enable Input	66	VSS1	-2xVCC Charge Pump Output
17	ICEN#	RI Receiver Enable Input	67	C2N	Charge Pump Capacitor
18	TMEN	TM Receiver Enable Input	68	GND	Signal Ground
19	D0	Mode Select Input	69	C1N	Charge Pump Capacitor
20	D1	Mode Select Input	70	C2P	Charge Pump Capacitor
21	D2	Mode Select Input	71	VCC	Power Supply Input
22	TERM_OFF	Termination Disable Input	72	C1P	Charge Pump Capacitor
23	D_LATCH#	Decoder Latch Input	73	VDD	2xVCC Charge Pump Output
24	NC	No Connect	74	GND	Signal Ground
25	GND	Signal Ground	75	TR(a)	DTR Inverting Output
26	VCC	5V Power Supply Input	76	NC	No Connect
27	LOOPBACK#	Loopback Mode Enable Input	77	VCC	Power Supply Input
28	TxD	TxD Driver TTL Input	78	TR(b)	DTR Non-Inverting Output
29	TxCE	TxCE Driver TTL Input	79	RRC(b)	DCD Non-Inverting Output
30	ST	ST Driver TTL Input	80	VCC	Power Supply Input
31	RTS	RTS Driver TTL Input	81	RRC(a)	DCD Inverting Output
32	DTR	DTR Driver TTL Input	82	GND	Signal Ground
33	DCD_DCE	DCD _{DCE} Driver TTL Input	83	RS(a)	RTS Inverting Output
34	RL	RL Driver TTL Input	84	VCC	Power Supply Input
35	LL	LL Driver TTL Input	85	RS(b)	RTS Non-Inverting Output
36	RxD	RxD Receiver TTL Output	86	GND	Signal Ground
37	RxC	RxC Receiver TTL Output	87	ST(a)	ST Inverting Output
38	TxC	TxC Receiver TTL Output	88	VCC	Power Supply Input
39	CTS	CTS Receiver TTL Output	89	V35TGND3	ST Termination Reference
40	DSR	DSR Receiver TTL Output	90	ST(b)	ST Non-Inverting Output
41	DCD_DTE	DCD _{DTE} Receiver TTL Output	91	GND	Signal Ground
42	RI	RI Receiver TTL Output	92	TT(a)	TxCE Inverting Output
43	TM	TM Receiver TTL Output	93	VCC	5V Power Supply Input
44	GND	Signal Ground	94	V35TGND2	ST Termination Reference
45	VCC	Power Supply Input	95	TT(b)	TxCE Non-Inverting Output
46	V35RGND	Receiver Termination Reference	96	GND	Signal Ground
47	RD(b)	RxD Non-Inverting Input	97	SD(a)	TxD Inverting Output
48	RD(a)	RxD Inverting Input	98	VCC	5V Power Supply Input
49	RT(b)	RxC Non-Inverting Input	99	V35TGND1	ST Termination Reference
50	RT(a)	RxC Inverting Input	100	SD(b)	TxD Non-Inverting Output

SP509 Driver Table

Driver Output Pin	V.35 Mode	EIA-530 Mode	RS-232 Mode (V.28)	EIA-530A Mode	RS-449 Mode (V.36)	X.21 Mode (V.11)	Shutdown	Suggested Signal
MODE (D0, D1, D2)	001	010	011	100	101	110	111	
T ₁ OUT(a)	V.35	V.11	V.28	V.11	V.11	V.11	High-Z	TxD(a)
T ₁ OUT(b)	V.35	V.11	High-Z	V.11	V.11	V.11	High-Z	TxD(b)
T ₂ OUT(a)	V.35	V.11	V.28	V.11	V.11	V.11	High-Z	TxCE(a)
T ₂ OUT(b)	V.35	V.11	High-Z	V.11	V.11	V.11	High-Z	TxCE(b)
T ₃ OUT(a)	V.35	V.11	V.28	V.11	V.11	V.11	High-Z	TxC_DCE(a)
T ₃ OUT(b)	V.35	V.11	High-Z	V.11	V.11	V.11	High-Z	TxC_DCE(b)
T ₄ OUT(a)	V.28	V.11	V.28	V.11	V.11	V.11	High-Z	RTS(a)
T ₄ OUT(b)	High-Z	V.11	High-Z	V.11	V.11	V.11	High-Z	RTS(b)
T ₅ OUT(a)	V.28	V.11	V.28	V.10	V.11	V.11	High-Z	DTR(a)
T ₅ OUT(b)	High-Z	V.11	High-Z	High-Z	V.11	V.11	High-Z	DTR(b)
T ₆ OUT(a)	V.28	V.11	V.28	V.11	V.11	V.11	High-Z	DCD_DCE(a)
T ₆ OUT(b)	High-Z	V.11	High-Z	V.11	V.11	V.11	High-Z	DCD_DCE(b)
T ₇ OUT(a)	V.28	V.10	V.28	V.10	V.10	High-Z	High-Z	RL
T ₈ OUT(a)	V.28	V.10	V.28	V.10	V.10	High-Z	High-Z	LL

Table 1. Driver Mode Selection

SP509 Receiver Table

Receiver Input Pin	V.35 Mode	EIA-530 Mode	RS-232 Mode (V.28)	EIA-530A Mode	RS-449 Mode (V.36)	X.21 Mode (V.11)	Shutdown	Suggested Signal
MODE (D0, D1, D2)	001	010	011	100	101	110	111	
R ₁ IN(a)	V.35	V.11	V.28	V.11	V.11	V.11	High-Z	RxD(a)
R ₁ IN(b)	V.35	V.11	High-Z	V.11	V.11	V.11	High-Z	RxD(b)
R ₂ IN(a)	V.35	V.11	V.28	V.11	V.11	V.11	High-Z	RxC(a)
R ₂ IN(b)	V.35	V.11	High-Z	V.11	V.11	V.11	High-Z	RxC(b)
R ₃ IN(a)	V.35	V.11	V.28	V.11	V.11	V.11	High-Z	TxC_DTE(a)
R ₃ IN(b)	V.35	V.11	High-Z	V.11	V.11	V.11	High-Z	TxC_DTE(b)
R ₄ IN(a)	V.28	V.11	V.28	V.11	V.11	V.11	High-Z	CTS(a)
R ₄ IN(b)	High-Z	V.11	High-Z	V.11	V.11	V.11	High-Z	CTS(b)
R ₅ IN(a)	V.28	V.11	V.28	V.10	V.11	V.11	High-Z	DSR(a)
R ₅ IN(b)	High-Z	V.11	High-Z	High-Z	V.11	V.11	High-Z	DSR(b)
R ₆ IN(a)	V.28	V.11	V.28	V.11	V.11	V.11	High-Z	DCD_DTE(a)
R ₆ IN(b)	High-Z	V.11	High-Z	V.11	V.11	V.11	High-Z	DCD_DTE(b)
R ₇ IN(a)	V.28	V.10	V.28	V.10	V.10	High-Z	High-Z	RI
R ₈ IN(a)	V.28	V.10	V.28	V.10	V.10	High-Z	High-Z	TM

Table 2. Receiver Mode Selection

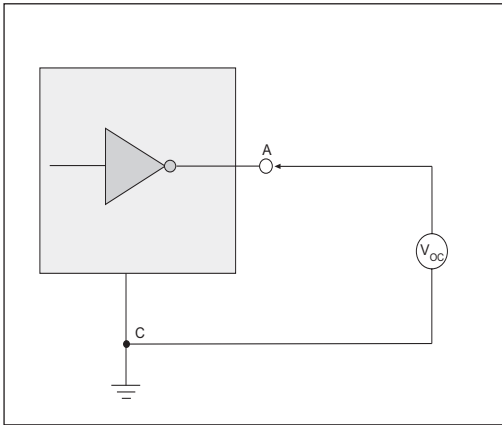


Figure 1. V.28 Driver Output Open Circuit Voltage

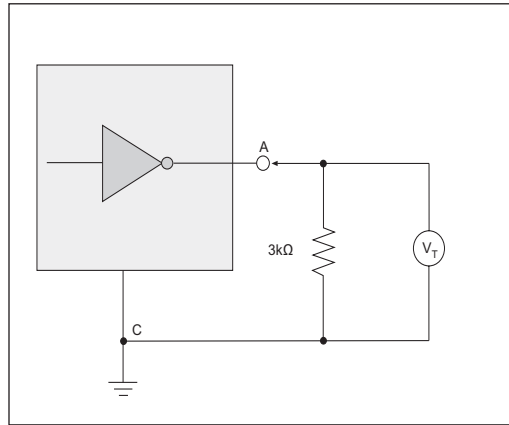


Figure 2. V.28 Driver Output Loaded Voltage

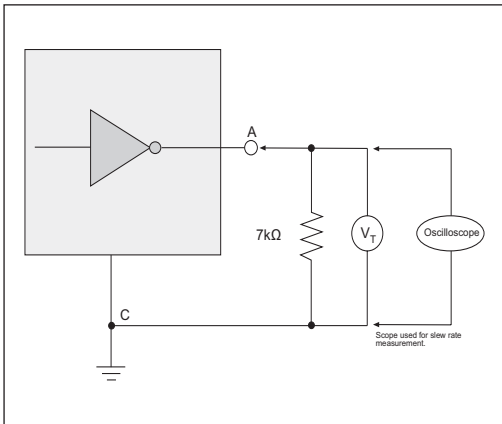


Figure 3. V.28 Driver Output Slew Rate

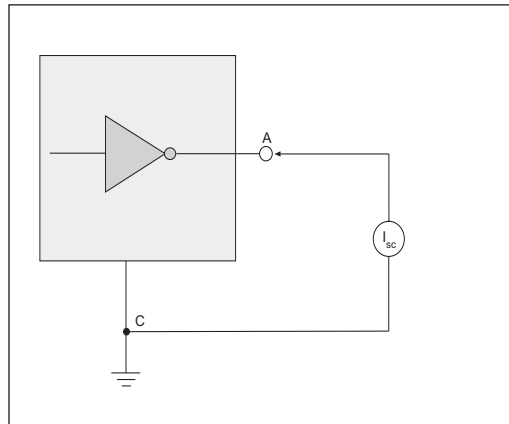


Figure 4. V.28 Driver Output Short-Circuit Current

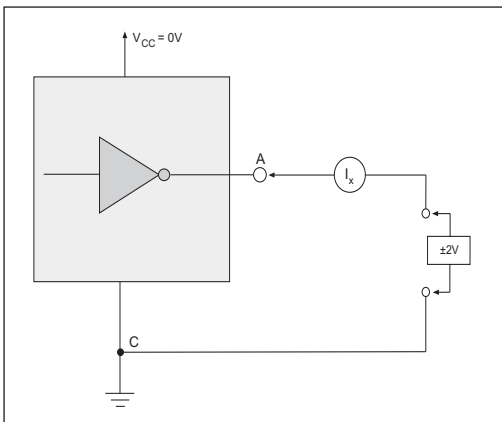


Figure 5. V.28 Driver Output Power-Off Impedance

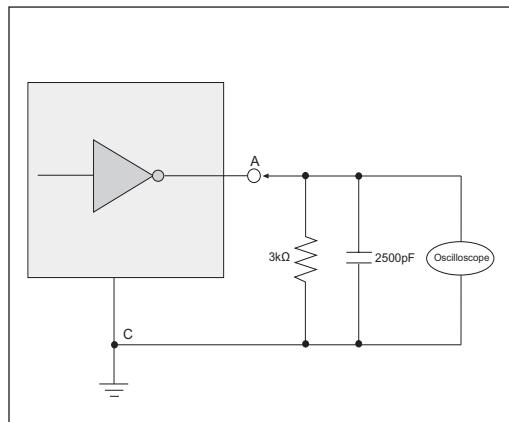


Figure 6. V.28 Driver Output Rise/Fall Times

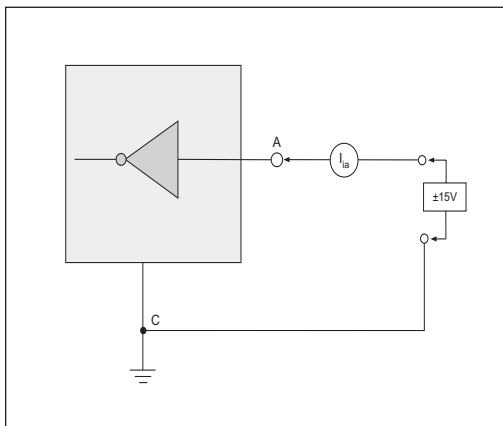


Figure 7. V.28 Receiver Input Impedance

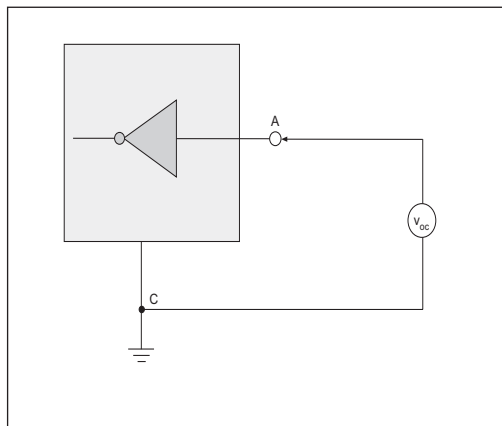


Figure 8. V.28 Receiver Input Open Circuit Bias

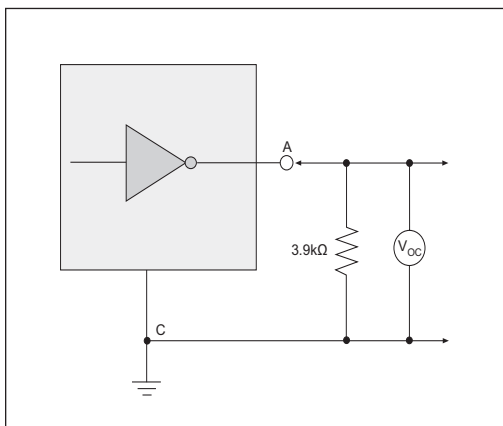


Figure 9. V.10 Driver Output Open-Circuit Voltage

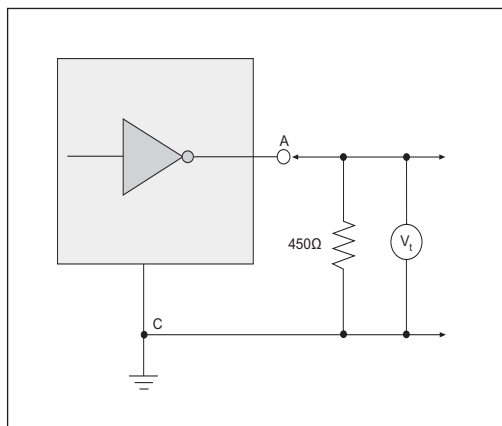


Figure 10. V.10 Driver Output Test Terminated Volt-

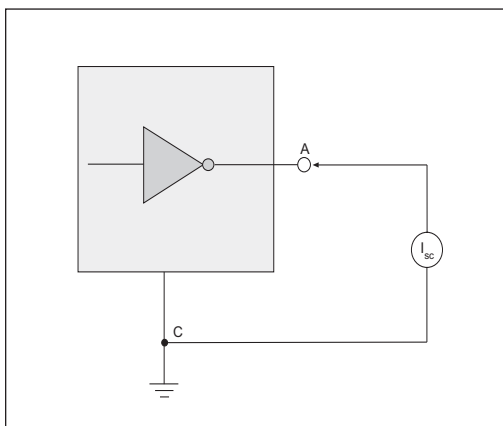


Figure 11. V.10 Driver Output Short-Circuit Current

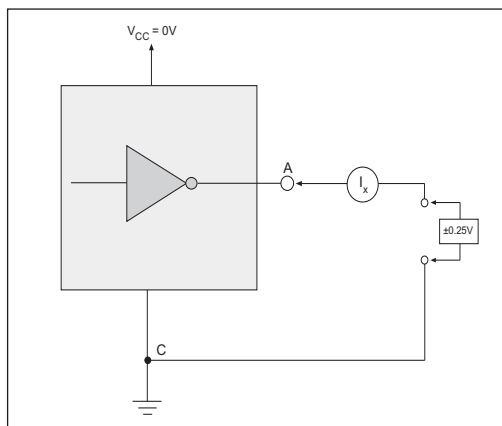


Figure 12. V.10 Driver Output Power-Off Current

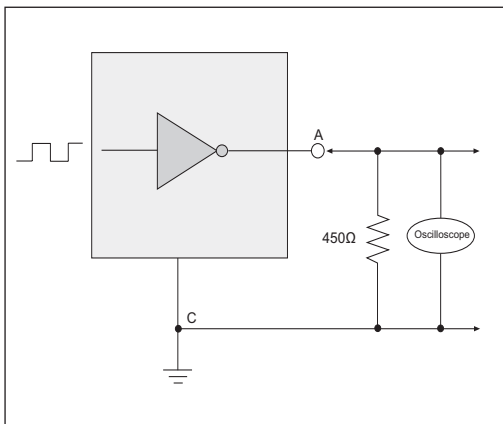


Figure 13. V.10 Driver Output Transition Time

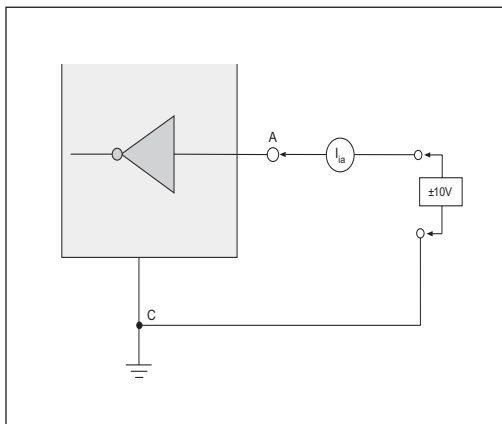


Figure 14. V.10 Receiver Input Current

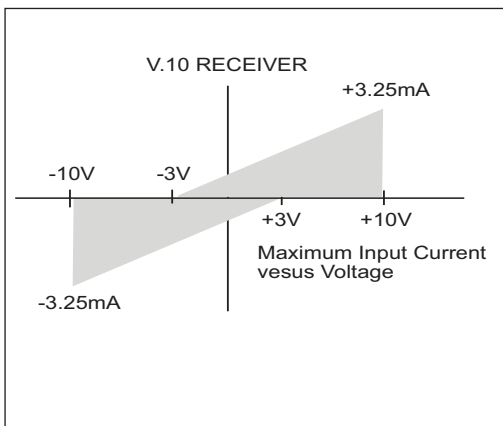


Figure 15. V.10 Receiver Input IV Graph

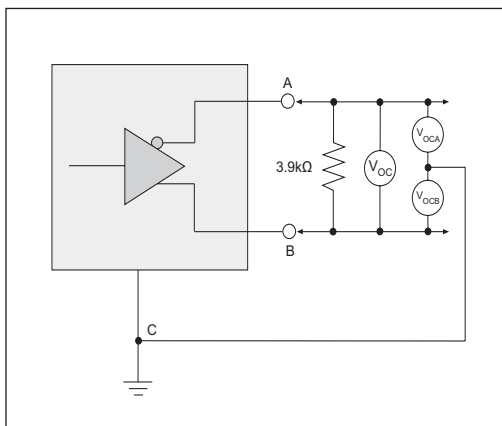


Figure 16. V.11 Driver Output Open-Circuit Voltage

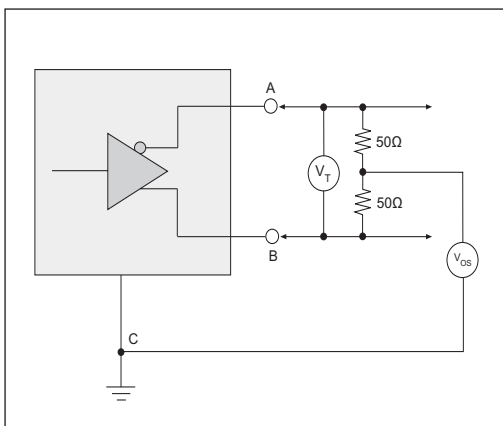


Figure 17. V.11 Driver Output Test Terminated Voltage

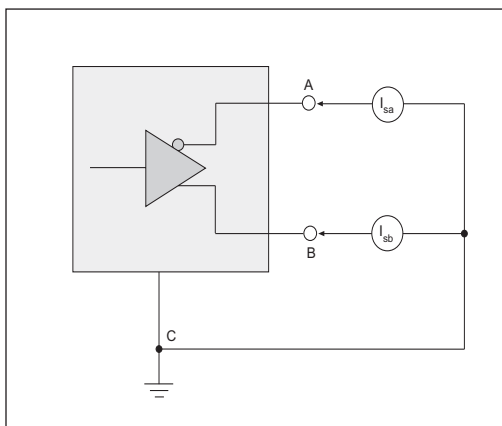


Figure 18. V.11 Driver Output Short-Circuit Current

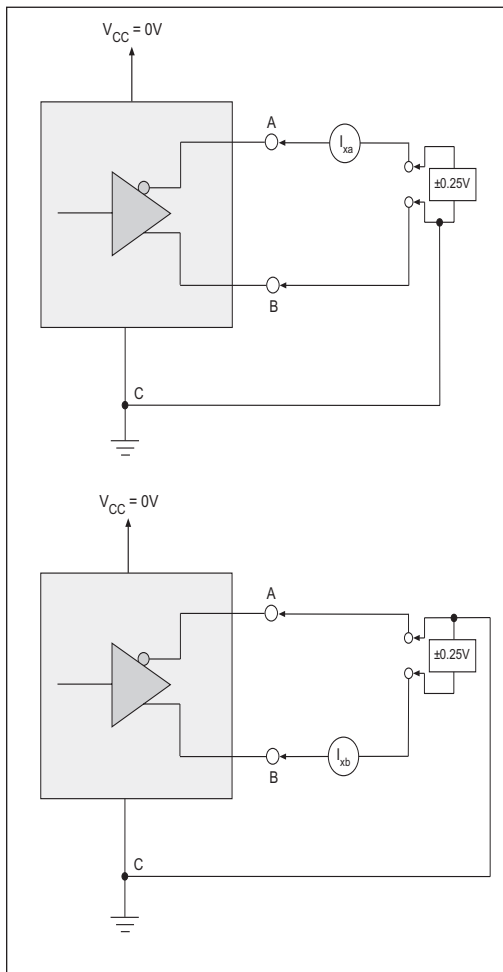


Figure 19. V.11 Driver Output Power-Off Current

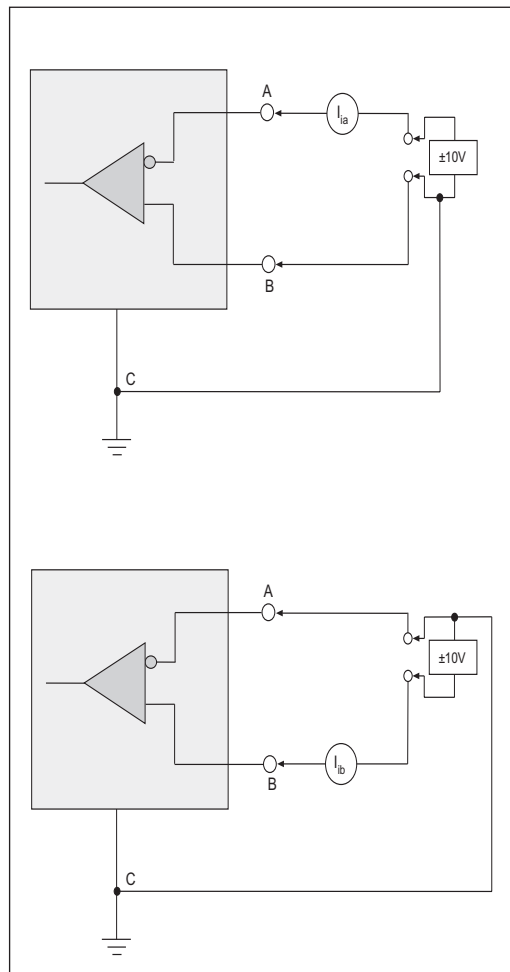


Figure 20. V.11 Receiver Input Current

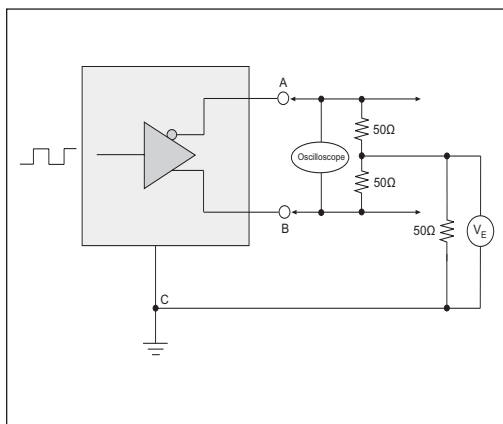


Figure 21. V.11 Driver Output Rise/Fall Time

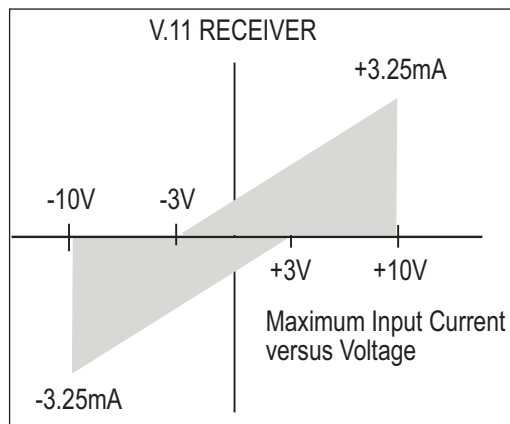


Figure 22. V.11 Receiver Input IV Graph

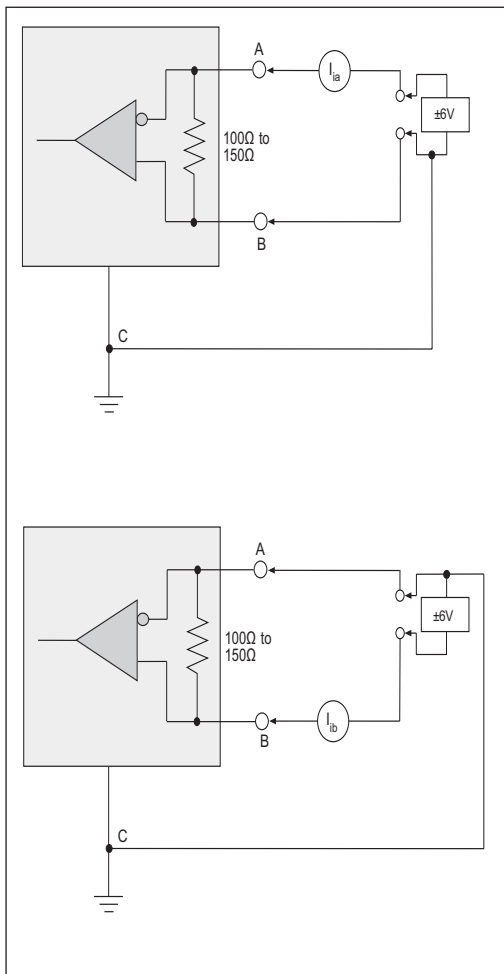


Figure 23. V.11 Receiver Input Current w/ Termination

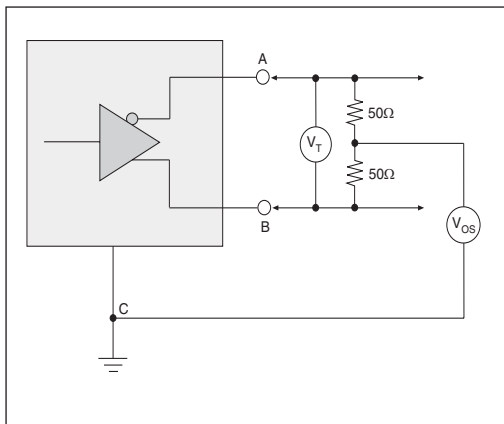


Figure 26. V.35 Driver Output Offset Voltage

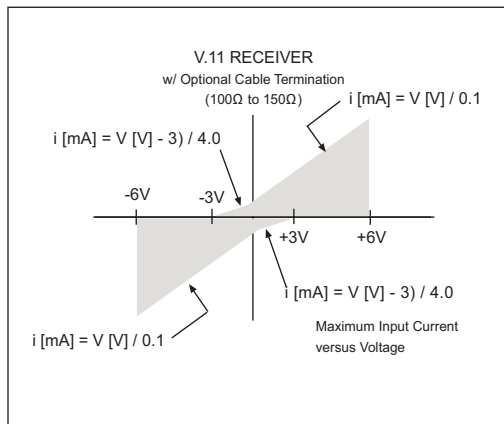


Figure 24. V.11 Receiver Input Graph w/ Termination

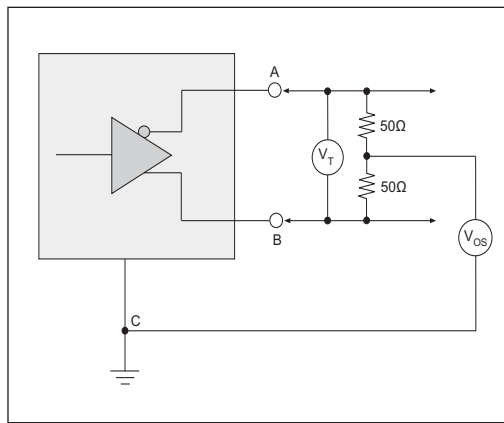


Figure 25. V.35 Driver Output Test Terminated Voltage

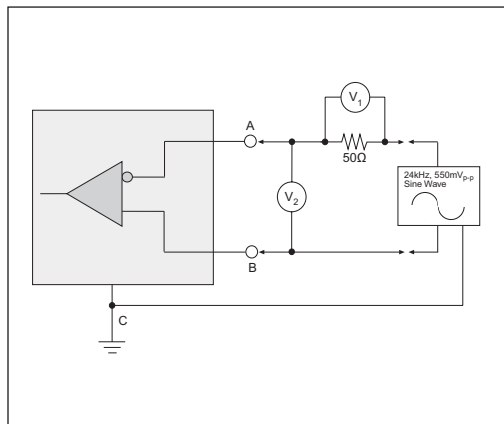


Figure 27. V.35 Driver Output Source Impedance

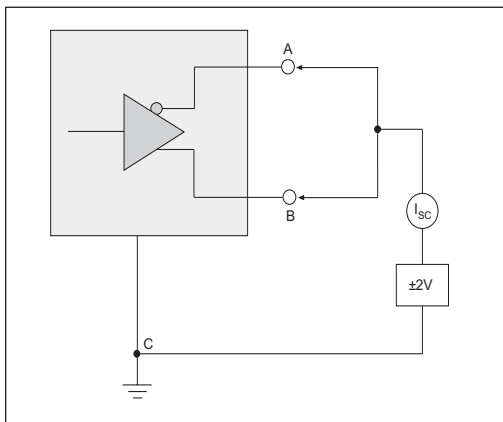


Figure 28. V.35 Driver Output Short-Circuit Impedance

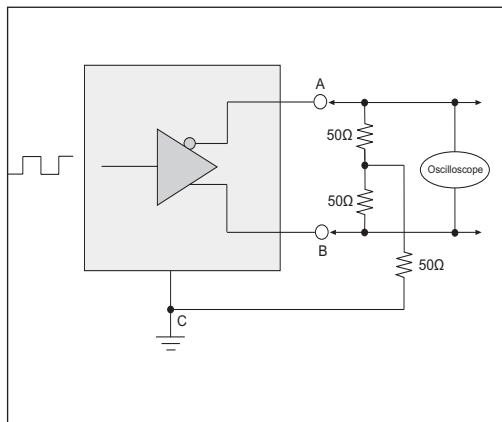


Figure 29. V.35 Driver Output Rise/Fall Time

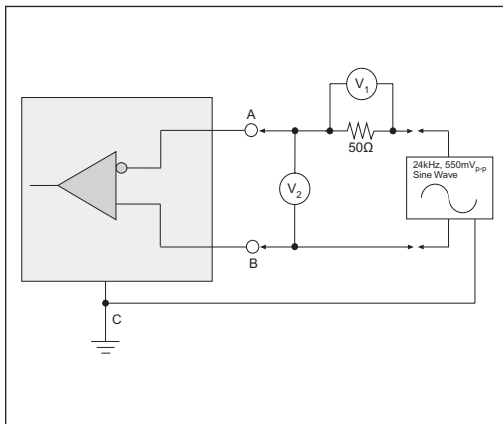


Figure 30. V.35 Receiver Input Source Impedance

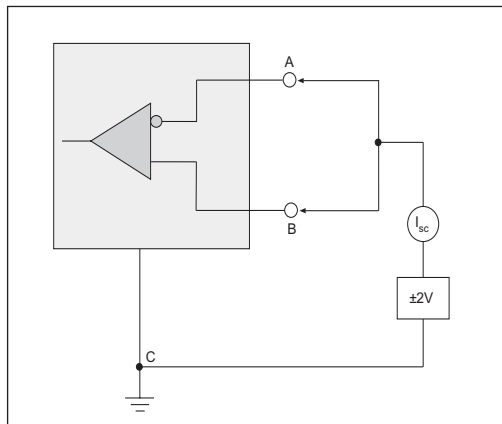


Figure 31. V.35 Receiver Input Short-Circuit Impedance

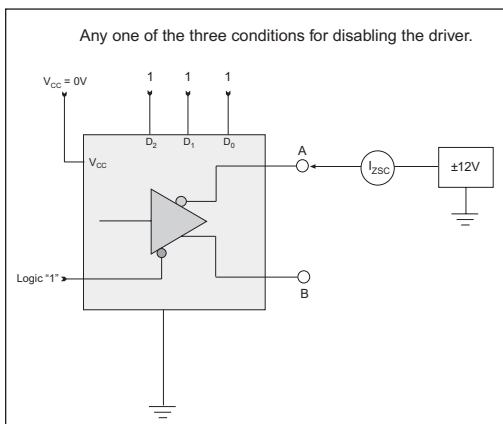


Figure 32. Driver Output Leakage Current Test

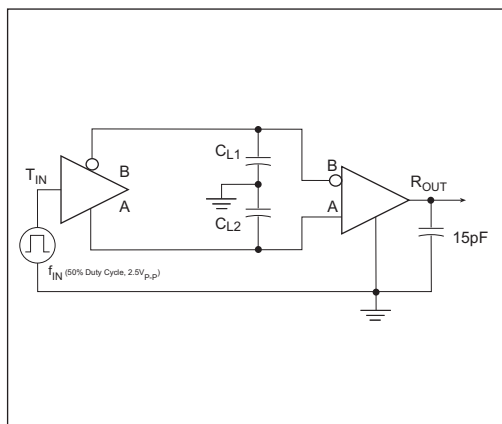


Figure 33. Driver/Receiver Timing Test Circuit

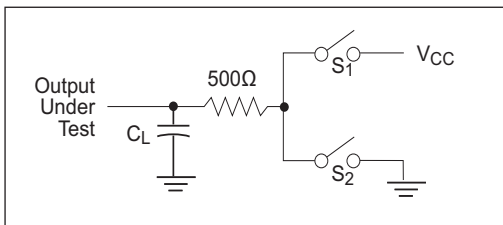


Figure 34. Driver Timing Test Load Circuit

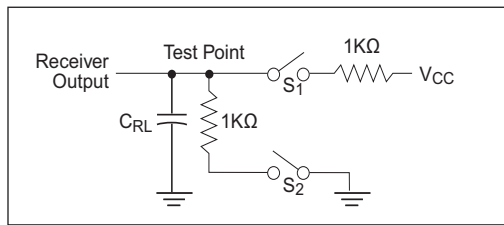


Figure 35. Receiver Timing Test Load Circuit

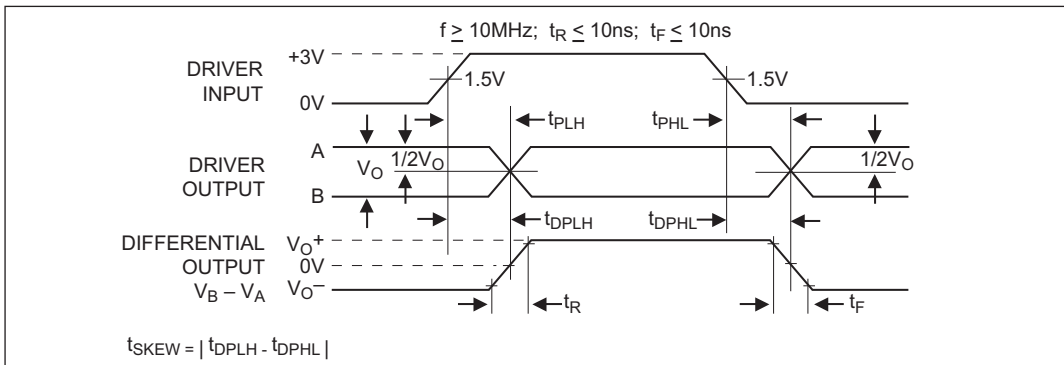


Figure 36. Driver Propagation Delays

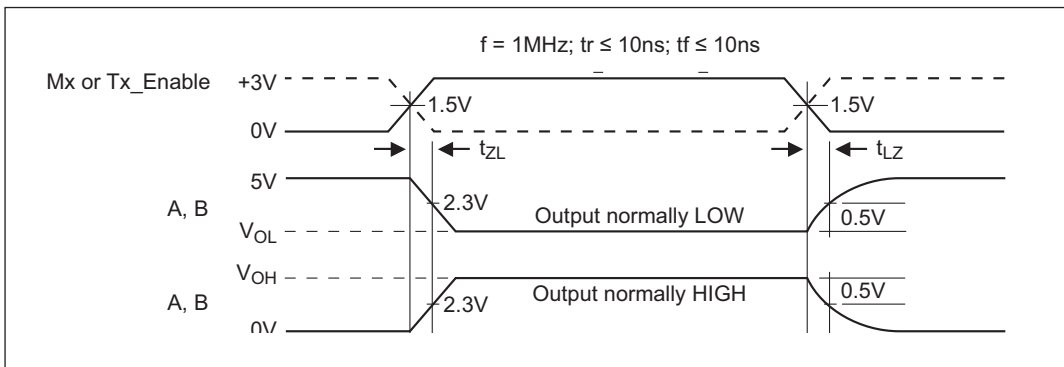


Figure 37. Driver Enable and Disable Times

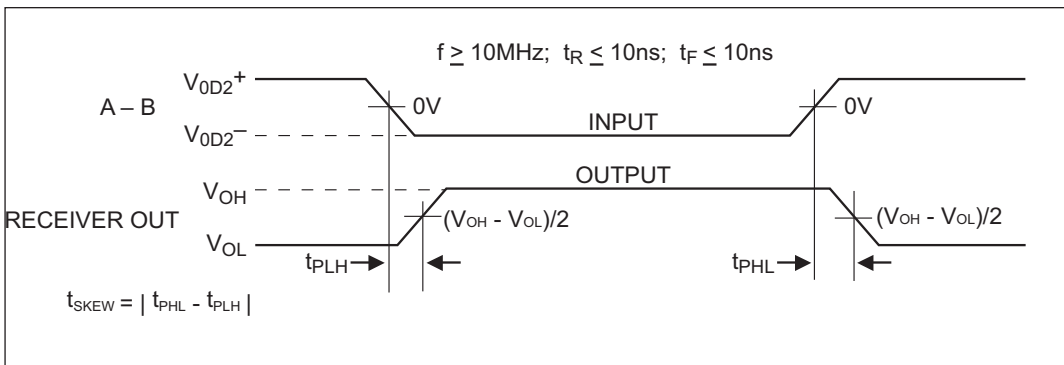


Figure 38. Receiver Propagation Delays

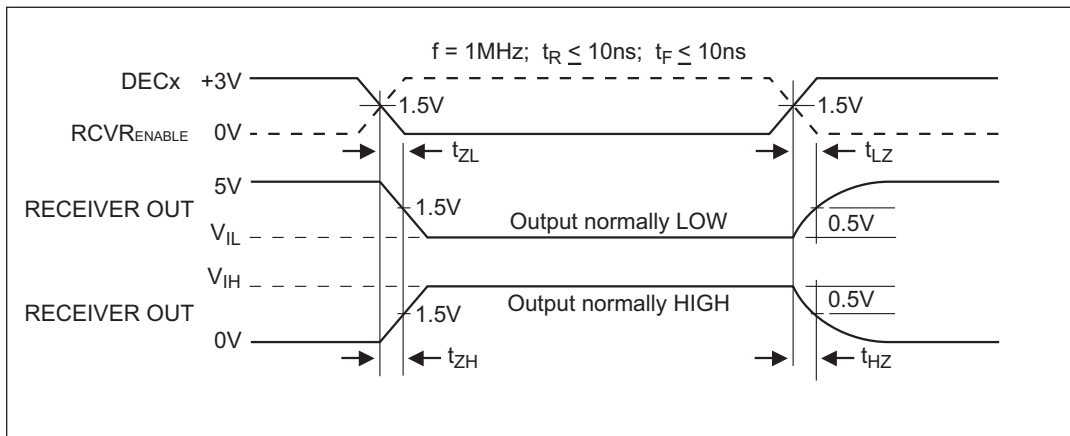


Figure 39. Receiver Enable and Disable Times

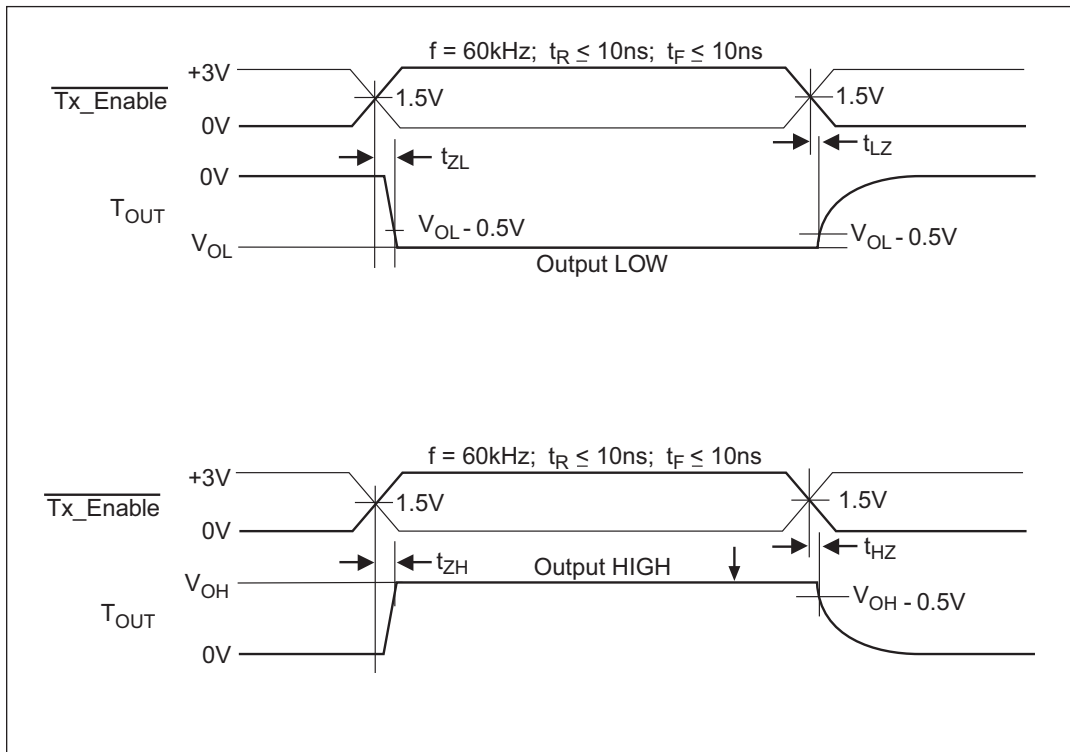


Figure 40. V.28 (RS-232) and V.10 (RS-423) Driver Enable and Disable Times

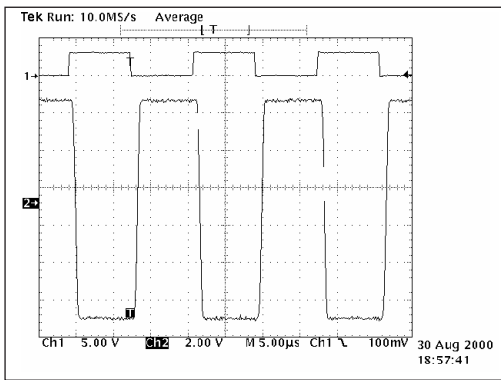


Figure 41. Typical V.28 Driver Output Waveform

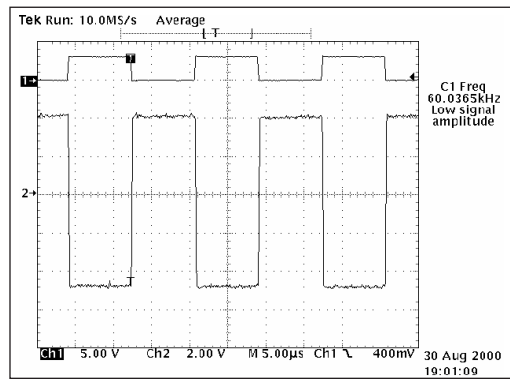


Figure 42. Typical V.10 Driver Output Waveform

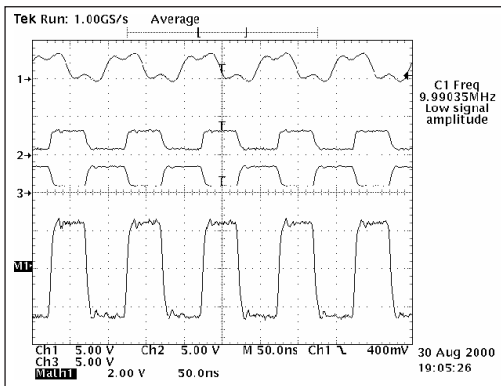


Figure 43. Typical V.11 Driver Output Waveform

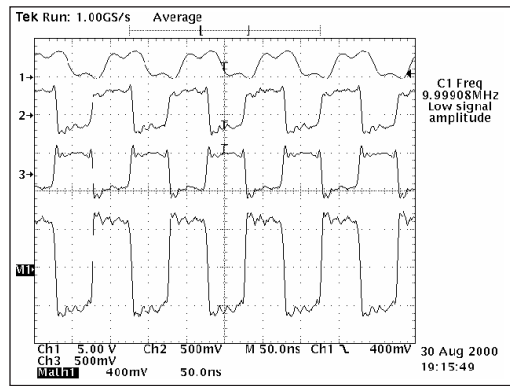


Figure 44. Typical V.35 Driver Output Waveform

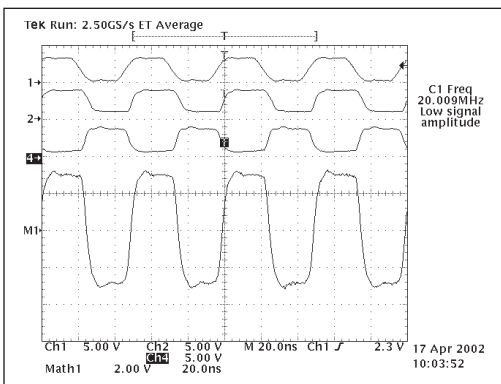


Figure 45. Typical V.11 Driver Output Waveform

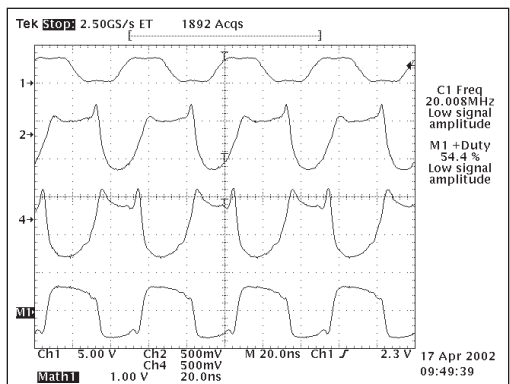


Figure 46. Typical V.35 Driver Output Waveform

VCC pins (1, 26, 45, 64, 71, 77, 80, 84, 88, 93, 98)
 GND pins (2, 25, 44, 52, 68, 74, 82, 86, 91, 96)
 N.C. pins (24 and 76)

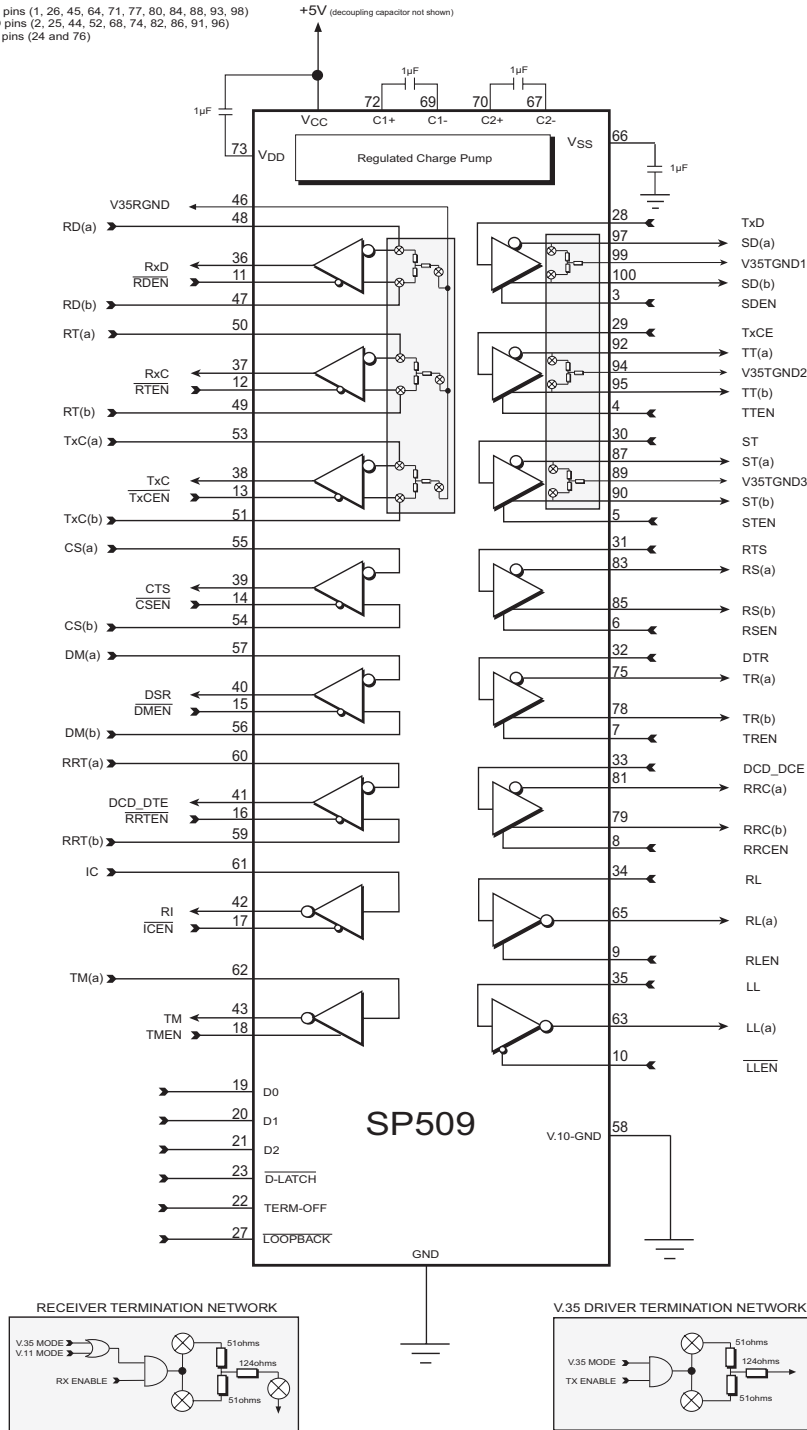


Figure 47. Functional Diagram

The SP509 contains highly integrated serial transceivers that offer programmability between interface modes through software control. The SP509 offers the hardware interface modes for RS-232 (V.28), RS-449/V.36 (V.11 and V.10), EIA-530 (V.11 and V.10), EIA-530A (V.11 and V.10), V.35 (V.35 and V.28) and X.21 (V.11). The interface mode selection is done via three control pins, which can be latched via microprocessor control.

The SP509 has eight drivers, eight receivers, and Exar's patented on-board charge pump (5,306,954) that is ideally suited for wide area network connectivity and other multi-protocol applications. Other features include digital and line loopback modes, individual enable/disable control lines for each driver and receiver, fail-safe when inputs are either open or shorted, individual termination resistor ground paths, separate driver and receiver ground outputs, enhanced ESD protection on driver outputs and receiver inputs.

THEORY OF OPERATION

The SP509 device is made up of 1) the drivers, 2) the receivers, 3) a charge pump, 4) DTE/DCE switching algorithm, and 5) control logic.

Drivers

The SP509 has eight enhanced independent drivers. Control for the mode selection is done via a three-bit control word into D0, D1, and D2. The drivers are prearranged such that for each mode of operation, the relative position and functionality of the drivers are set up to accommodate the selected interface mode. As the mode of the drivers is changed, the electrical characteristics will change to support the required signal levels. The mode of each driver in the different interface modes that can be selected is shown in Table 1.

There are four basic types of driver circuits – ITU-T-V.28 (RS-232), ITU-T-V.10 (RS-423), ITU-T-V.11 (RS-422), and CCITT-V.35.

The V.28 (RS-232) drivers output single-ended signals with a minimum of $\pm 5V$ (with $3k\Omega$ & $2500pF$ loading), and can operate over 120kbps. Since the SP509 uses a charge pump to generate the RS-232 output rails, the driver outputs will never exceed $\pm 10V$. The V.28 driver architecture is similar to Exar's standard line of RS-232 transceivers.

The RS-423 (V.10) drivers are also single-ended signals which produce open circuit V_{OL} and V_{OH} measurements of $\pm 4.0V$ to $\pm 6.0V$. When terminated with a 450Ω load to ground, the driver output will not deviate more than 10% of the open circuit value. This is in compliance of the ITU V.10 specification. The V.10 (RS-423) drivers are used in RS-449/V.36, EIA-530, and EIA-530A modes as Category II signals from each of their corresponding specifications. The V.10 drivers are guaranteed to transmit over 120kbps, but can operate at over 1Mbps if necessary.

The third type of drivers are V.11 (RS-422) differential drivers. Due to the nature of differential signaling, the drivers are more immune to noise as opposed to single-ended transmission methods. The advantage is evident over high speeds and long transmission lines. The strength of the driver outputs can produce differential signals that can maintain $\pm 2V$ differential output levels with a load of 100Ω . The signal levels and drive capability of these drivers allow the drivers to also support RS-485 requirements of $\pm 1.5V$ differential output levels with a 54Ω load. The strength allows the SP509 differential driver to drive over long cable lengths with minimal signal degradation. The V.11 drivers are used in RS-449, EIA-530, EIA-530A and V.36 modes as Category I signals which are used for clock and data. Exar's new driver design over its predecessors allow the SP509 to operate over 40Mbps for differential transmission.

The fourth type of drivers are V.35 differential drivers. There are only three available on the SP509 for data and clock (TxD, TxCE, and TxC in DCE mode). These drivers are current sources that drive loop current through a differential pair resulting in a 550mV differential voltage at the receiver. These drivers also incorporate fixed termination networks for each driver in order to set the V_{OH} and V_{OL} depending on load conditions. This termination network is basically a “Y” configuration consisting of two 51Ω resistors connected in series and a 124Ω resistor connected between the two 50Ω resistors and a V35TGND output. Each of the three drivers and its associated termination will have its own V35TGND output for grounding convenience. Filtering can be done on these pins to reduce common mode noise transmitted over the transmission line by connecting a capacitor to ground.

The drivers also have separate enable pins which simplifies half-duplex configurations for some applications, especially program-mable DTE/DCE. The enable pins will either enable or disable the output of the drivers according to the appropriate active logic illustrated on Figure 47. The enable pins have internal pull-up and pull-down devices, depending on the active polarity of the receiver, that enable the driver upon power-on if the enable lines are left floating. During disabled conditions, the driver outputs will be at a high impedance 3-state.

The driver inputs are both TTL and CMOS compatible. All driver inputs have an internal pull-up resistor so that the output will be at a defined state at logic LOW (“0”). Unused driver inputs can be left floating. The internal pull-up resistor value is approximately 500kΩ.

Receivers

The SP509 has eight enhanced independent receivers. Control for the mode selection is done via a three-bit control word that is the same as the driver control word. Therefore, the modes for the drivers and receivers are identical in the application.

Like the drivers, the receivers are prear-

ranged for the specific requirements of the synchronous serial interface. As the operating mode of the receivers is changed, the electrical characteristics will change to support the required serial interface protocols of the receivers. Table 2 shows the mode of each receiver in the different interface modes that can be selected. There are two basic types of receiver circuits—ITU-T-V.28 (RS-232) and ITU-T-V.11, (RS-422).

The RS-232 (V.28) receiver is single-ended and accepts RS-232 signals from the RS-232 driver. The RS-232 receiver has an operating input voltage range of $\pm 15V$ and can receive signals down to $\pm 3V$. The input sensitivity complies with RS-232 and V.28 at $\pm 3V$. The input impedance is 3kΩ to 7kΩ in accordance to RS-232 and V.28. The receiver output produces a TTL/CMOS signal with a +2.4V minimum for a logic “1” and a +0.4V maximum for a logic “0”. The RS-232 (V.28) protocol uses these receivers for all data, clock and control signals. They are also used in V.35 mode for control line signals: CTS, DSR, LL, and RL. The RS-232 receivers can operate over 120kbps.

The second type of receiver is a differential type that can be configured internally to support ITU-T-V.10 and CCITT-V.35 depending on its input conditions. This receiver has a typical input impedance of 10kΩ and a differential threshold of less than $\pm 200mV$, which complies with the ITU-T-V.11 (RS-422) specifications. V.11 receivers are used in RS-449/V.36, EIA-530, EIA-530A and X.21 as Category I signals for receiving clock, data, and some control line signals not covered by Category II V.10 circuits. The differential V.11 transceiver has improved architecture that allows over 40Mbps transmission rates.

Receivers dedicated for data and clock (Rx D, Rx C, Tx C) incorporate internal termination for V.11. The termination resistor is typically 120Ω connected between the A and B inputs. The termination is essential for minimizing crosstalk and signal reflection over the transmission line. The minimum value is guaranteed to exceed 100Ω, thus complying with the V.11 and RS-422 specifications.

This resistor is invoked when the receiver is operating as a V.11 receiver, in modes EIA-530, EIA-530A, RS-449/V.36, and X.21. The same receivers also incorporate a termination network internally for V.35 applications. For V.35, the receiver input termination is a “Y” termination consisting of two 51Ω resistors connected in series and a 124Ω resistor connected between the two 50Ω resistors and V35RGND output. The V35RGND is usually grounded. The receiver itself is identical to the V.11 receiver.

The differential receivers can be configured to be ITU-T-V.10 single-ended receivers by internally connecting the non-inverting input to ground. This is internally done by default from the decoder. The non-inverting input is rerouted to V10GND and can be grounded separately. The ITU-T-V.10 receivers can operate over 1Mbps and are used in RS-449/V.36, E1A-530, E1A-530A and X.21 modes as Category II signals as indicated by their corresponding specifications. All receivers include an enable/disable line for disabling the receiver output allowing convenient half-duplex configurations. The enable pins will either enable or disable the output of the receivers according to the appropriate active logic illustrated on Figure 47. The receiver’s enable lines include an internal pull-up or pull-down device, depending on the active polarity of the receiver, that enables the receiver upon power up if the enable lines are left floating. During disabled conditions, the receiver outputs will be at a high impedance state. If the receiver is disabled any associated termination is also disconnected from the inputs.

All receivers include a fail-safe feature that outputs a logic high when the receiver inputs are open, terminated but open, or shorted together. For single-ended V.28 and V.10 receivers, there are internal 5kΩ pull-down resistors on the inputs which produces a logic high (“1”) at the receiver outputs. The differential receivers have a proprietary circuit that detect open or shorted inputs and if so, will produce a logic HIGH (“1”) at the receiver output.

CHARGE PUMP

The charge pump is a Exar-patented design (5,306,954) and uses a unique approach compared to older less-efficient designs. The charge pump still requires four external capacitors, but uses four-phase voltage shifting technique to attain symmetrical power supplies. The charge pump V_{DD} and V_{SS} outputs are regulated to +5.8V and -5.8V, respectively. There is a free-running oscillator that controls the four phases of the voltage shifting. A description of each phase follows.

Phase 1

V_{SS} charge storage —During this phase of the clock cycle, the positive side of capacitors C_1 and C_2 are initially charged to V_{CC} . C_1 is then switched to ground and the charge in C_1 is transferred to C_2 . Since C_2 is connected to V_{CC} , the voltage potential across capacitor C_2 is now $2 \times V_{CC}$.

Phase 2

V_{SS} transfer —Phase two of the clock connects the negative terminal of C_2 to the V_{SS} storage capacitor and the positive terminal of C_2 to ground, and transfers the negative generated voltage to C_3 . This generated voltage is regulated to -5.8V. Simultaneously, the positive side of the capacitor C_1 is switched to V_{CC} and the negative side is connected to ground.

Phase 3

V_{DD} charge storage —The third phase of the clock is identical to the first phase—the charge transferred in C_1 produces $-V_{CC}$ in the negative terminal of C_1 which is applied to the negative side of the capacitor C_2 . Since C_2 is at V_{CC} , the voltage potential across C_2 is $2 \times V_{CC}$.

Phase 4

V_{DD} transfer —The fourth phase of the clock connects the negative terminal of C_2 to ground, and transfers the generated 5.8V across C_2 to C_4 , the V_{DD} storage capacitor. This voltage is regulated to +5.8V. At the regulated voltage, the internal oscillator is disabled and simultaneously with this, the positive side of capacitor C_1 is switched to V_{CC} and the negative side is connected to ground, and the cycle begins again.

The charge pump cycle will continue as long as the operational conditions for the internal oscillator are present.

Since both V^+ and V^- are separately generated from V_{CC} ; in a no-load condition V^+ and V^- will be symmetrical. Older charge pump approaches that generate V^- from V^+ will show a decrease in the magnitude of V^- compared to V^+ due to the inherent inefficiencies in the design.

The clock rate for the charge pump typically operates at 250kHz. The external capacitors can be as low as 1 μ F with a 16V breakdown voltage rating.

TERM_OFF FUNCTION

The SP509 contains a TERM_OFF pin that disables all three receiver input termination networks regardless of mode. This allows the device to be used in monitor mode applications that are typically found in networking test equipment. The TERM_OFF pin internally contains a pull-down device with an impedance of over 500k Ω , which will default in a "ON" condition during power-up if V.35 receivers are used. The individual receiver enable line and the SHUTDOWN mode from the decoder will disable the termination regardless of TERM_OFF.

LOOPBACK FUNCTION

The SP509 contains a LOOPBACK pin that invokes a loopback path. This loopback path is illustrated in Figure 48. LOOPBACK has an internal pull-up resistor that defaults to normal mode during power up or if the pin is left floating. During loopback, the driver output and receiver input characteristics will still adhere to its appropriate specifications.

DECODER AND D_LATCH FUNCTION

The SP509 contains a D_LATCH pin that latches the data into the D0, D1, and D2 decoder inputs. If tied to a logic LOW ("0"), the latch is transparent, allowing the data at the decoder inputs to propagate through and program the SP509 accordingly. If tied to a logic HIGH("1"), the latch locks out the data and prevents the mode from changing until this pin is brought to a logic LOW.

There are internal pull-up devices on D0, D1, and D2, which allow the device to be in SHUTDOWN mode ("111") upon power up. However, if the device is powered -up with the D_LATCH at a logic HIGH, the decoder state of the SP509 will be undefined.

ESD TOLERANCE

The SP509 device incorporates ruggedized ESD cells on all driver output and receiver input pins. The ESD structure is improved over our previous family for more rugged applications and environments sensitive to electrostatic discharges and associated transients.

CTR1/CTR2 EUROPEAN COMPLIANCY

As with all of Exar's previous multi-protocol serial transceiver IC's, the drivers and receivers have been designed to meet all the requirements to NET1/NET2 and TBR2 in order to meet CTR1/CTR2 compliancy. The SP509 is also tested in-house at Exar and adheres to all the NET1/2 physical layer testing and the ITU Series V specifications before shipment. Please note that although the SP509, as with its predecessors, adhere to CTR1/CTR2 compliancy testing, any complex or unusual configuration should be double-checked to ensure CTR1/CTR2 compliance. Consult the factory for details.

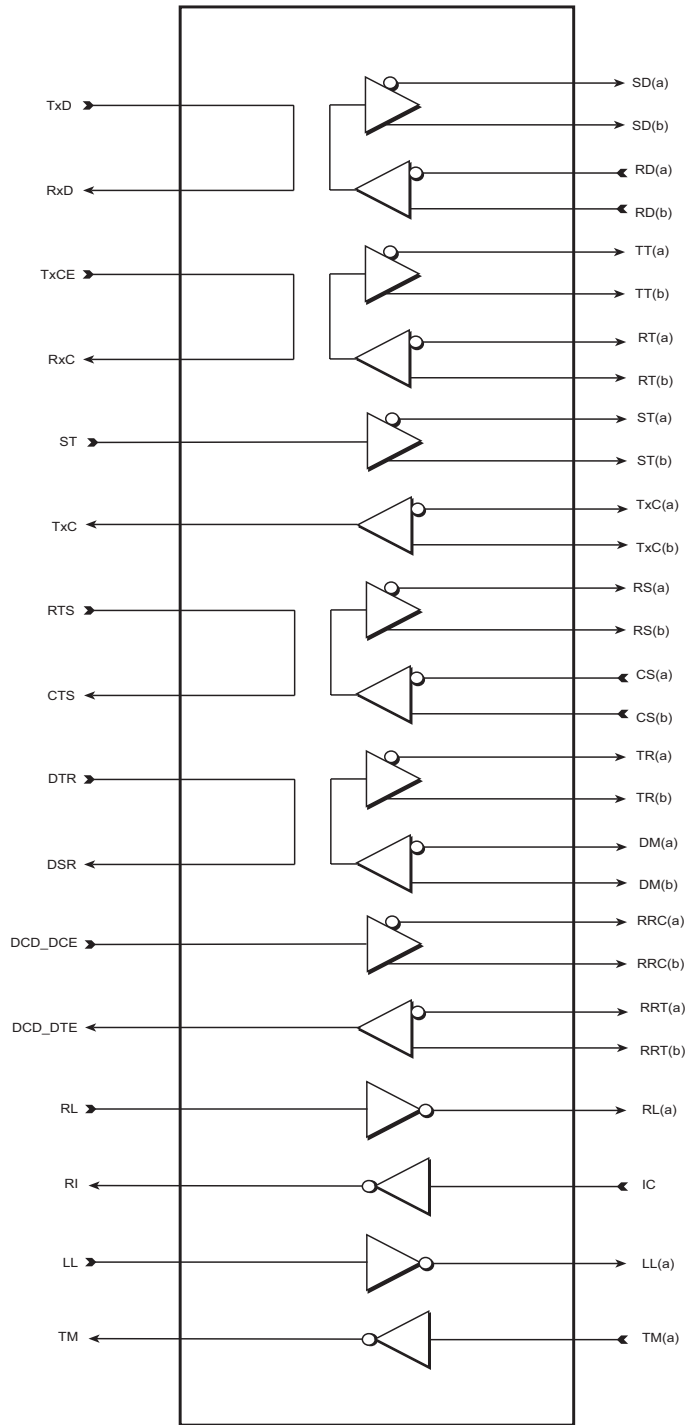


Figure 48. SP509 Loopback Path

