



# +5V Multiprotocol, Software-Selectable Clock Transceiver

MAX13172E

## General Description

The MAX13172E is a four-driver/four-receiver multiprotocol transceiver that operates from a single +5V supply in conjunction with the MAX13170E and MAX13174E. The MAX13172E, along with the MAX13170E and the MAX13174E, form a complete software-selectable data terminal equipment (DTE) or data communication equipment (DCE) interface port that supports the V.28 (RS-232), V.10/V.11 (RS-449/V.36, EIA-530, EIA-530A, X.21, RS-423), and V.35 protocols. The MAX13172E transceiver carries serial-interface control signaling, while the MAX13170E carries the high-speed clock and data signals. Typically, the MAX13170E is terminated using the MAX13174E.

The MAX13172E is available in a 5.3mm x 10.2mm, 28-pin SSOP package and operates over the 0°C to +70°C commercial temperature range.

## Applications

- Data Networking
- CSU/DSU Devices
- Data Routers
- Switches
- PCI Cards
- Telecommunication Equipment

## Features

- ◆ The MAX13170E/MAX13172E/MAX13174E Chipset is a Pin-for-Pin Upgrade to the MXL1544/MAX3175/ MXL1543/MXL1543B Chipset
- ◆ Chipset Operates from a Single +5V Supply
- ◆ Software-Selectable DCE/DTE Configurations
- ◆ Supports V.28 (RS-232), V.10/V.11 (RS-449/V.36, EIA-530, EIA-530A, X.21, RS-423) Protocols
- ◆ Flowthrough Pin Configuration
- ◆ Fail-Safe Receivers While Maintaining V.11 and V.35 Compatibility
- ◆ Extremely Low Maximum Shutdown Current (No-Cable Mode)
- ◆ TUV-Certified NET1/NET2 and TBR1/TBR2 Compliant (Pending)
- ◆ Extended ESD Protection for All Transmitter Outputs and Receiver Inputs to GND  
±10kV Using the Human Body Model  
±3kV Using the Contact Method Specified in IEC 61000-4-2  
±3kV Using the Air Gap Discharge Method Specified in IEC 61000-4-2

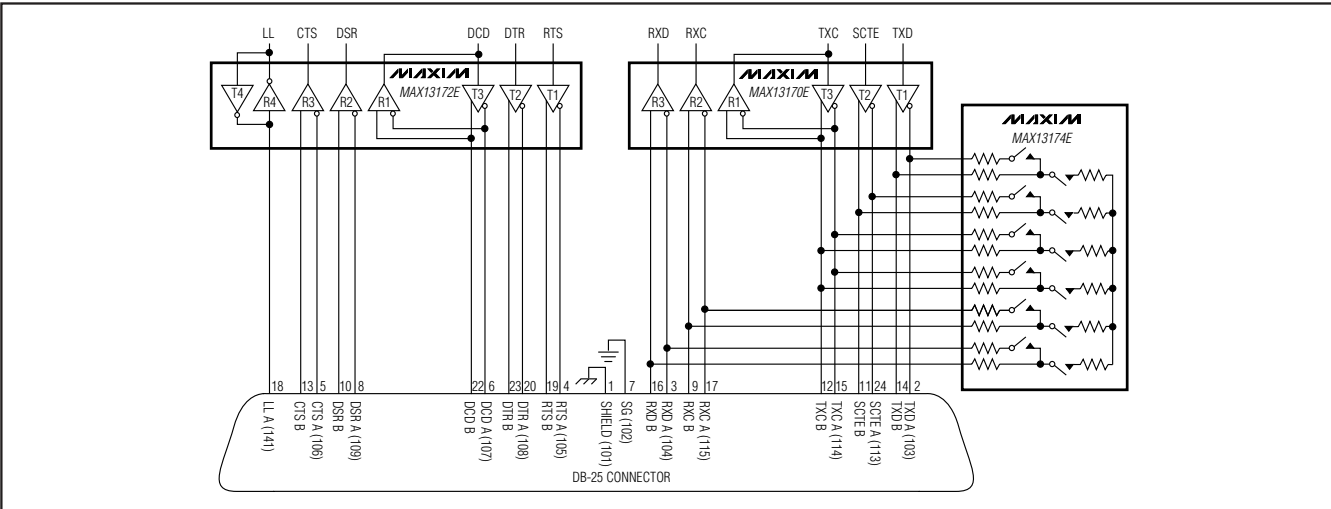
## Ordering Information

PART	TEMP RANGE	PIN-PACKAGE
MAX13172ECAI+	0°C to +70°C	28 SSOP

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

Pin Configuration appears at end of data sheet.

## Typical Operating Circuit



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## ABSOLUTE MAXIMUM RATINGS

(All voltages referenced to GND, unless otherwise noted.)

Supply Voltages	
V <sub>CC</sub> .....	-0.3V to +6V
V <sub>DD</sub> .....	-0.3V to +7.1V
V <sub>EE</sub> .....	+0.3V to -7.1V
V <sub>DD</sub> to V <sub>CC</sub> .....	+0.3 to +6V
Logic Input Voltages	
M0, M1, M2, DCE/DTE, T <sub>IN</sub> , INVERT.....	-0.3V to +6V
Logic Output Voltages	
R <sub>OUT</sub> .....	-0.3V to (V <sub>CC</sub> + 0.3V)
Transmitter Outputs	
T <sub>OUT</sub> , T <sub>OUT</sub> /R <sub>IN</sub> (No-Cable Mode, V.28 only).....	-15V to +15V
Short-Circuit Duration to GND.....	Continuous

Receiver Inputs	
R <sub>IN</sub> , T <sub>OUT</sub> /R <sub>IN</sub> .....	-15V to +15V
R <sub>INA</sub> to R <sub>INB</sub> , T3OUTA/R1INA to T3OUT/R1INB.....	-15V to +15V
Continuous Power Dissipation (T <sub>A</sub> = +70°C)	
28-Pin TSSOP	
Single-Layer Board (derate 9.5mW/°C above +70°C).....	762mW
Multi-Layer Board (derate 14.9mW/°C above +70°C).....	1194mW
Operating Temperature Range.....	0°C to 70°C
Junction Temperature.....	+150°C
Storage Temperature Range.....	-65°C to +150°C
Lead Temperature (soldering, 10s).....	+300°C
Soldering Temperature (reflow).....	+260°C

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

## PACKAGE THERMAL CHARACTERISTICS (Note 1)

SSOP

Junction-to-Ambient Thermal Resistance (θ <sub>JA</sub> ).....	+67°C/W
Junction-to-Case Thermal Resistance (θ <sub>JC</sub> ).....	+25°C/W

**Note 1:** Package thermal resistances were obtained using the method described in JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maxim-ic.com/thermal-tutorial](http://www.maxim-ic.com/thermal-tutorial).

## ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> = 4.5V to 5.5V, T<sub>A</sub> = T<sub>MIN</sub> to T<sub>MAX</sub>. Typical values are at V<sub>CC</sub> = 5V, and T<sub>A</sub> = +25°C, V.28 mode only: V<sub>DD</sub> = +5.6V to +7.1V and V<sub>EE</sub> = -7.1V to -5.4V. Typical values are at V<sub>DD</sub> = +6.9V and V<sub>EE</sub> = -6.7V, no-cable mode: V<sub>DD</sub> = V<sub>CC</sub> and V<sub>EE</sub> = 0V, other modes: V<sub>DD</sub> = +5.15V to +5.7V and V<sub>EE</sub> = -4.84V to -4.16V. Typical value are at V<sub>DD</sub> = +5.3V and V<sub>EE</sub> = -4.5V.) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V <sub>CC</sub> Operating Range	V <sub>CC</sub>		4.5		5.5	V
V <sub>DD</sub> Operating Range	V <sub>DD</sub>	V.28 mode	5.6		7.1	V
		V.10 or V.11 mode	5.15		5.7	
V <sub>EE</sub> Operating Range	V <sub>EE</sub>	V.28 mode	-7.1		-5.4	V
		V.10 or V.11 mode	-4.84		-4.16	
V <sub>CC</sub> Supply Current (DCE Mode) (Digital Inputs = GND or V <sub>CC</sub> ) (Transmitter Outputs Static)	I <sub>CC</sub>	CH1, CH3 = V.11, CH2 = V.10, CH4 = V.10, no load		5.5		mA
		CH1, CH3 = V.11, CH2 = V.10, CH4 = V.10, full load		95	135	
		CH1, CH2, CH3 = V.11, CH4 = V.10, full load		138	180	
		V.28 mode		3.5	9	μA
		No cable mode; M0, M1, M2, DCE/DTE, INVERT, open or at V <sub>CC</sub> (V <sub>DD</sub> = V <sub>CC</sub> and V <sub>EE</sub> = GND)		0	10	
Internal Power Dissipation (DCE Mode)	P <sub>D</sub>	CH1, CH3 = V.11, CH2, CH4 = V.10, no load		300		mW
		V.28 mode, full load		54		

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## ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = 4.5V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 5V$ , and  $T_A = +25^\circ C$ , V.28 mode only:  $V_{DD} = +5.6V$  to  $+7.1V$  and  $V_{EE} = -7.1V$  to  $-5.4V$ . Typical values are at  $V_{DD} = +6.9V$  and  $V_{EE} = -6.7V$ , no-cable mode:  $V_{DD} = V_{CC}$  and  $V_{EE} = 0V$ , other modes:  $V_{DD} = +5.15V$  to  $+5.7V$  and  $V_{EE} = -4.84V$  to  $-4.16V$ . Typical value are at  $V_{DD} = +5.3V$  and  $V_{EE} = -4.5V$ .) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
V <sub>EE</sub> Supply Current	I <sub>EE</sub>	CH1, CH3 = V.11, CH2 = V.10 or V.11, CH4 = V.10, no load		2.1		mA
		CH1, CH2, CH3 = V.11, CH4 = V.10, full load (output low)		13	30	
		CH1, CH3 = V.11, CH2, CH4 = V.10, full load (output low)		22	30	
		V.28 mode, no load		1		
		V.28 mode, full load (output low)		12	18	
		No cable mode (V <sub>DD</sub> = V <sub>CC</sub> and V <sub>EE</sub> = GND)		0	10	μA
V <sub>DD</sub> Supply Current	I <sub>DD</sub>	CH1, CH3 = V.11, CH2 = V.10 or V.11, CH4 = V.10, no load		0.6		mA
		CH1, CH2, CH3 = V.11, CH4 = V.10, full load (output high)		11	30	
		CH1, CH3 = V.11, CH2, CH4 = V.10, full load (output high)		22	30	
		V.28 mode, no load		2.5		
		V.28 mode, full load (output high)		12	10	
		No cable mode (V <sub>DD</sub> = V <sub>CC</sub> and V <sub>EE</sub> = GND)		0	10	μA
Thermal-Shutdown Protection	THSD			+145		°C
<b>LOGIC INPUTS (M0, M1, M2, DCE/DTE, INVERT, T1IN, T2IN, T3IN, T4IN)</b>						
Input High Voltage	V <sub>IH</sub>		0.66 × V <sub>CC</sub>			V
Input Low Voltage	V <sub>IL</sub>		0.33 × V <sub>CC</sub>			V
Logic-Input Current	I <sub>IN</sub>	T1IN, T2IN, T3IN, T4IN	-1		+1	μA
Pullup Resistor	R <sub>PUIN</sub>	M0, M1, M2, DCE/DTE, INVERT to V <sub>CC</sub>	50	100	166	kΩ
<b>LOGIC OUTPUTS (R1OUT, R2OUT, R3OUT, R4OUT)</b>						
Output High Voltage	V <sub>OH</sub>	I <sub>SOURCE</sub> = 4mA	0.66 × V <sub>CC</sub>			V
Output Low Voltage	V <sub>OL</sub>	I <sub>SINK</sub> = 4mA	0.33 × V <sub>CC</sub>			V
Output Pullup Resistor	R <sub>PUY</sub>	No cable mode (to V <sub>CC</sub> )	71.4			kΩ
Transmitter Output Leakage Current	I <sub>Z</sub>	-0.25V < V <sub>OUT</sub> < +0.25V, V <sub>CC</sub> = 0V or no cable mode		±1	±5	μA
<b>V.11 TRANSMITTER</b>						
Open-Circuit Differential Output Voltage	V <sub>ODO</sub>	Open circuit, R = 1.95kΩ, Figure 1	-V <sub>CC</sub>		+V <sub>CC</sub>	V
Loaded Differential Output Voltage (Note 4)	I <sub>VODL</sub>	R = 50Ω, Figure 1	0.5 × V <sub>ODO</sub>			V
		R = 50Ω, Figure 1	2			
Change in Magnitude of Output Differential Voltage	ΔV <sub>OD</sub>	R = 50Ω, Figure 1			0.2	V

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## ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = 4.5V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 5V$ , and  $T_A = +25^\circ C$ , V.28 mode only:  $V_{DD} = +5.6V$  to  $+7.1V$  and  $V_{EE} = -7.1V$  to  $-5.4V$ . Typical values are at  $V_{DD} = +6.9V$  and  $V_{EE} = -6.7V$ , no-cable mode:  $V_{DD} = V_{CC}$  and  $V_{EE} = 0V$ , other modes:  $V_{DD} = +5.15V$  to  $+5.7V$  and  $V_{EE} = -4.84V$  to  $-4.16V$ . Typical value are at  $V_{DD} = +5.3V$  and  $V_{EE} = -4.5V$ .) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Common-Mode Output Voltage	$V_{OC}$	$R = 50\Omega$ , Figure 1			3.0	V
Change in Magnitude of Common-Mode Output Voltage	$\Delta V_{OC}$	$R = 50\Omega$ , Figure 1			0.2	V
Short-Circuit Current	$I_{SC}$	$V_{OUT} = V_{GND}$			150	mA
Rise Time	$t_R$	Figures 2, 5		4	10	ns
Fall Time	$t_F$	Figures 2, 5		6	10	ns
Transmitter Input-to-Output Prop Delay	$t_{PHL}, t_{PLH}$	Figures 2, 5			22	ns
Data Skew	$ t_{PHL} - t_{PLH} $	Figures 2, 5 (Note 5)			3	ns
Output-to-Output Skew	$t_{SKEWT}$	Figures 2, 5 (Notes 5, 6)			3	ns
<b>V.11 RECEIVER</b>						
Differential Threshold Voltage	$V_{TH}$	$-7V \leq V_{CM} \leq +7V$	-200		-50	mV
Input Hysteresis	$\Delta V_{TH}$	$-7V \leq V_{CM} \leq +7V$		15		mV
Receiver Input Current	$I_{IN}$	$-10V \leq V_{A,B} \leq +10V$	-0.66		+0.66	mA
Receiver Input Resistance	$R_{IN}$	$-10V \leq V_{A,B} \leq +10V$	15	30		k $\Omega$
Rise or Fall Time	$t_R, t_F$	Figures 2, 6		3		ns
Receiver Input-to-Output Delay	$t_{PHL}, t_{PLH}$	Figures 2, 6		16	26	ns
Data Skew	$ t_{PHL} - t_{PLH} $	Figures 2, 6 (Note 5)			3.5	ns
Output-to-Output Skew	$t_{SKEWR}$	(Notes 5, 6)			3.5	ns
<b>V.10 TRANSMITTER</b>						
Open-Circuit Output Voltage Swing (Figure 3)	$V_O$	$R_L = 3.9k\Omega$ (out high)	4		6	V
		$R_L = 3.9k\Omega$ (out low)	-6		-4	
Output Voltage Swing (Figure 3)	$V_T$	$R_L = 450\Omega$ (out high)	3.6			V
		$R_L = 450\Omega$ (out low)			-3.6	
		$R_L = 450\Omega$	$0.9 \times  V_O $			
Short-Circuit Current	$I_{SC}$	$V_O = V_{GND}$	-55		+55	mA
Rise or Fall Time	$t_R, t_F$	$R_L = 450\Omega, C_L = 100pF$ (Figure 7)		2		$\mu s$
Transmitter Input-to-Output Delay	$t_{PLH}, t_{PHL}$	$R_L = 450\Omega, C_L = 100pF$ (Figure 7)		1		$\mu s$
<b>V.10 RECEIVER</b>						
Input Threshold Voltage	$V_{TH}$	Measured on inverting input (A)	50		250	mV
Input Hysteresis	$\Delta V_{TH}$			25		mV
Receiver Input Current	$I_{IN}$	$-10V \leq V_A \leq +10V$	-0.66		+0.66	mA
Receiver Input Impedance	$R_{IN}$	$-10V \leq V_A \leq +10V$	15	30		k $\Omega$
Rise or Fall Time	$t_R, t_F$	Figures 4, 8		3		ns
Receiver Input-to-Output Delay from Low to High	$t_{PLH}$	Figures 4, 8		55		ns
Receiver Input-to-Output Delay from High to Low	$t_{PHL}$	Figures 4, 8		109		ns
Data Skew	$ t_{PHL} - t_{PLH} $	Figures 4, 8		60		ns

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## ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} = 4.5V$  to  $5.5V$ ,  $T_A = T_{MIN}$  to  $T_{MAX}$ . Typical values are at  $V_{CC} = 5V$ , and  $T_A = +25^\circ C$ , V.28 mode only:  $V_{DD} = +5.6V$  to  $+7.1V$  and  $V_{EE} = -7.1V$  to  $-5.4V$ . Typical values are at  $V_{DD} = +6.9V$  and  $V_{EE} = -6.7V$ , no-cable mode:  $V_{DD} = V_{CC}$  and  $V_{EE} = 0V$ , other modes:  $V_{DD} = +5.15V$  to  $+5.7V$  and  $V_{EE} = -4.84V$  to  $-4.16V$ . Typical value are at  $V_{DD} = +5.3V$  and  $V_{EE} = -4.5V$ .) (Notes 2, 3)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS	
<b>V.28 TRANSMITTER</b>							
Output-Voltage Swing	$V_{OD}$	Open circuit (output high)	$V_{DD}$			V	
		Open circuit (output low)	$V_{EE}$				
		$R_L = 3k\Omega$	Output high	+5	+6.8		
			Output low	-6.8	-5		
Short-Circuit Current	$ I_{SC} $			85	mA		
Output Slew Rate	$SR_{R/F}$	$R_L = 3k\Omega$ , $C_L = 2500pF$ , Figures 3, 9	4		30	V/ $\mu s$	
Transmitter Input-to-Output Propagation Delay	$t_{PHL}$ , $t_{PLH}$	$R_L = 3k\Omega$ , $C_L = 2500pF$ , Figures 3, 9		1	2	$\mu s$	
<b>V.28 RECEIVER</b>							
Input Threshold Low	$V_{IL}$		0.8			V	
Input Threshold High	$V_{IH}$				2	V	
Input Hysteresis	$V_{Hyst}$			0.25		V	
Input Resistance	$R_{IN}$	$-15V \leq V_{IN} \leq +15V$	3	5	7	$k\Omega$	
Rise or Fall Time	$t_R$ , $t_F$	Figures 4, 10		3		ns	
Receiver Input-to-Output Delay	$t_{PHL}$ , $t_{PLH}$	Figures 4, 10			150	ns	
<b>ESD PROTECTION (T_OUT_, T_OUT_/R_OUT_, R_IN_ to GND)</b>							
ESD Protection		Contact Discharge IEC61000-4-2	$\pm 3$			kV	
		Air Gap Discharge IEC61000-4-2	$\pm 3$				
		Human Body Model	$\pm 10$				

**Note 2:** The MAX13172E is designed to operate with  $V_{DD}$  and  $V_{EE}$  supplied by the MAX13170E charge pump.

**Note 3:** All devices are 100% production tested at  $T_A = +25^\circ C$ , and are guaranteed by design for  $T_A = 0^\circ C$  to  $+70^\circ C$  as specified.

**Note 4:**  $|V_{ODL}|$  is guaranteed at both  $0.5 \times V_{DDO}$  and  $2V$ .

**Note 5:** Guaranteed by design, not production tested.

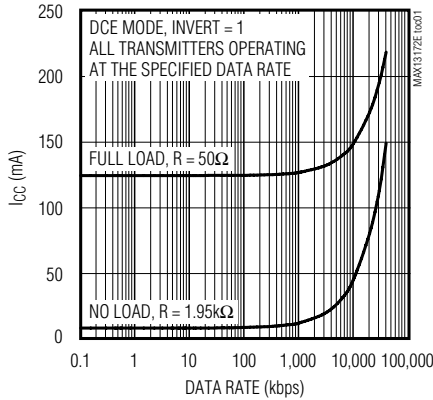
**Note 6:** Output-to-output skews are evaluated as a difference of propagation delays between different channels in the same condition and for the same polarity (LH or HL).

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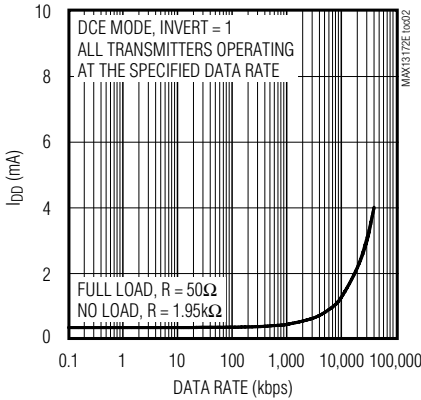
## Typical Operating Characteristics

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

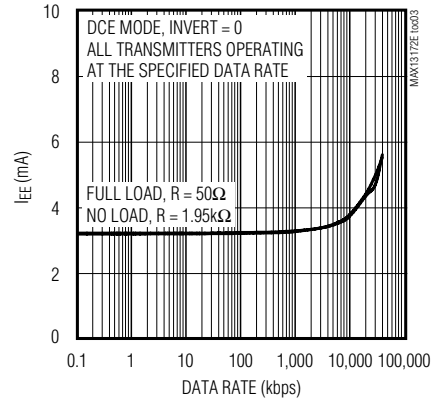
**V.11 MODE SUPPLY CURRENT ( $I_{CC}$ ) vs. DATA RATE**



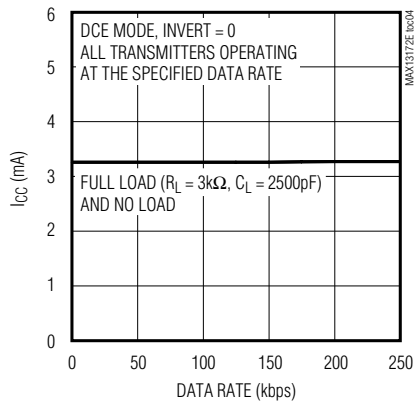
**V.11 MODE SUPPLY CURRENT ( $I_{DD}$ ) vs. DATA RATE**



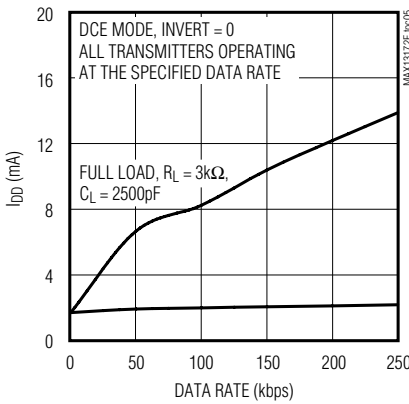
**V.11 MODE SUPPLY CURRENT ( $I_{EE}$ ) vs. DATA RATE**



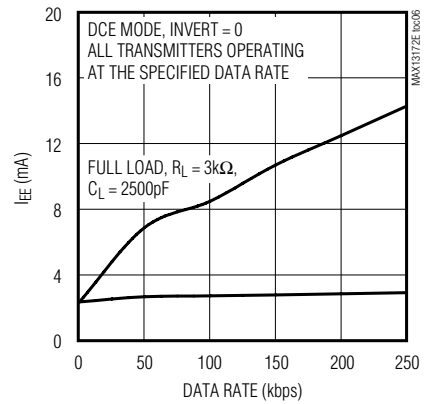
**V.28 MODE SUPPLY CURRENT ( $I_{CC}$ ) vs. DATA RATE**



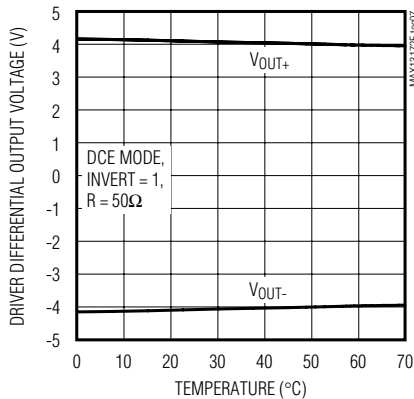
**V.28 MODE SUPPLY CURRENT ( $I_{DD}$ ) vs. DATA RATE**



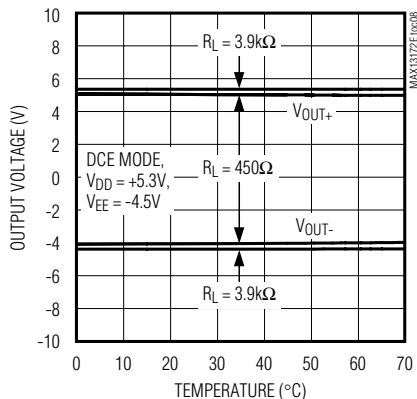
**V.28 MODE SUPPLY CURRENT ( $I_{EE}$ ) vs. DATA RATE**



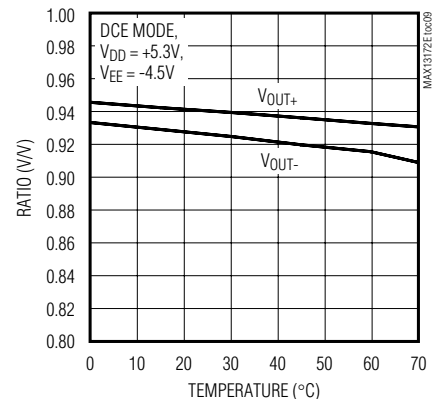
**V.11 LOADED DRIVER DIFFERENTIAL OUTPUT VOLTAGE vs. TEMPERATURE**



**V.10 OUTPUT VOLTAGE vs. TEMPERATURE**



**V.10 RATIO OF LOADED/UNLOADED OUTPUT VOLTAGE vs. TEMPERATURE**



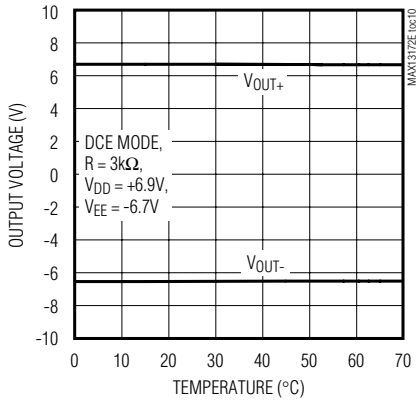
# +5V Multiprotocol, Software-Selectable Clock Transceiver

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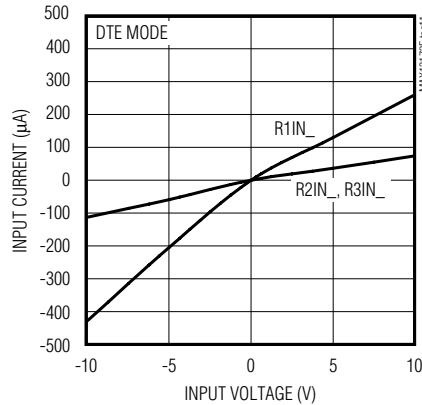
## Typical Operating Characteristics (continued)

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

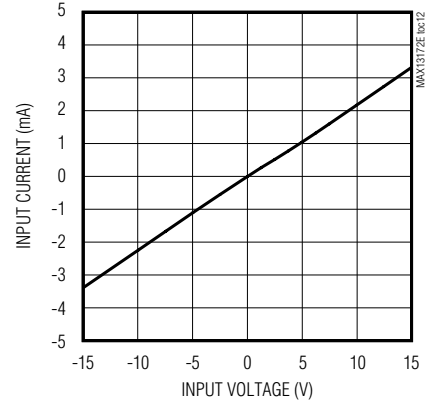
**V.28 LOADED OUTPUT VOLTAGE vs. TEMPERATURE**



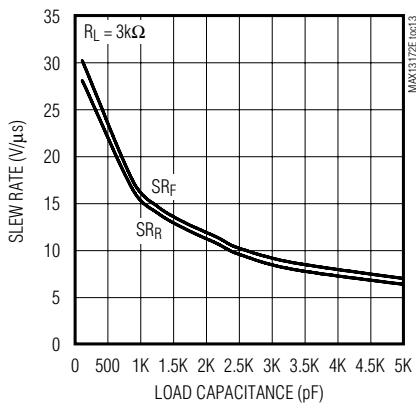
**V.11 RECEIVER INPUT CURRENT vs. INPUT VOLTAGE**



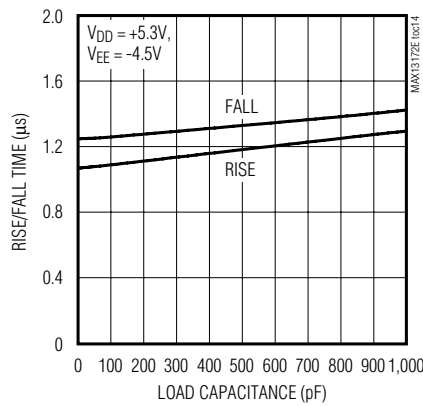
**V.28 RECEIVER INPUT CURRENT vs. INPUT VOLTAGE**



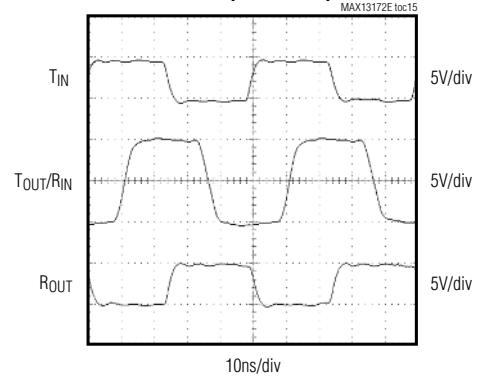
**V.28 SLEW RATE vs. LOAD CAPACITANCE**



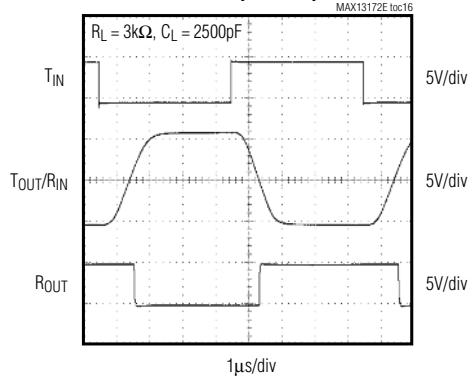
**V.10 TRANSMITTER RISE/FALL TIME vs. LOAD CAPACITANCE**



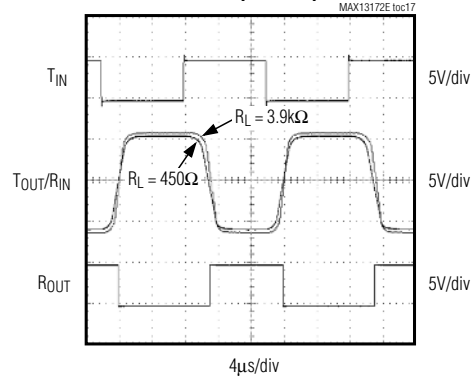
**LOOPBACK SCOPE SHOT PHOTO V.11 MODE (UNLOADED)**



**LOOPBACK SCOPE SHOT PHOTO V.28 MODE (LOADED)**



**LOOPBACK SCOPE SHOT PHOTO V.10 MODE (LOADED)**



# +5V Multiprotocol, Software-Selectable Clock Transceiver

## Pin Description

PIN	NAME	FUNCTION
1	V <sub>CC</sub>	Device Supply Voltage. Bypass V <sub>CC</sub> with a 1μF capacitor-to-ground as close as possible to the device.
2	V <sub>DD</sub>	Positive Supply Voltage Input. V <sub>DD</sub> is generated by the MAX13170E. Bypass V <sub>DD</sub> with a 1μF capacitor to ground.
3	T1IN	Transmitter 1 Logic Input
4	T2IN	Transmitter 2 Logic Input
5	T3IN	Transmitter 3 Logic Input
6	R1OUT	Receiver 1 Logic Output
7	R2OUT	Receiver 2 Logic Output
8	R3OUT	Receiver 3 Logic Output
9	T4IN	Transmitter 4 Logic input
10	R4OUT	Receiver 4 Logic Output
11	M0	Mode Select 0 Input. Internally pullup to V <sub>CC</sub> .
12	M1	Mode Select 1 Input. Internally pullup to V <sub>CC</sub> .
13	M2	Mode Select 2 Input. Internally pullup to V <sub>CC</sub> .
14	DCE/D $\overline{T\overline{E}}$	DCE/D $\overline{T\overline{E}}$ Input. Internally pullup to V <sub>CC</sub> . Logic level high selects DCE interface.
15	INVERT	T4/R4 Select Input. Internally pullup to V <sub>CC</sub> . INVERT reverses the action of DCE/D $\overline{T\overline{E}}$ for Channel 4.
16	T4OUTA/ R4INA	Transmitter 4 Inverting Output/Receiver 4 Inverting Input
17	R3INB	Receiver 3 Noninverting Input
18	R3INA	Receiver 3 Inverting Input
19	R2INB	Receiver 2 Noninverting Input
20	R2INA	Receiver 2 Inverting Input
21	T3OUTB/ R1INB	Transmitter 3 Noninverting Output/Receiver 1 Noninverting Input
22	T3OUTA/ R1INA	Transmitter 3 Inverting Output/Receiver 1 Inverting Input
23	T2OUTB	Transmitter 2 Noninverting Output
24	T2OUTA	Transmitter 2 Inverting Output
25	T1OUTB	Transmitter 1 Noninverting Output
26	T1OUTA	Transmitter 1 Inverting Output
27	GND	Ground
28	V <sub>EE</sub>	Negative Supply Input. V <sub>EE</sub> is generated by the MAX13170E. Bypass V <sub>EE</sub> with a 1μF capacitor to ground.



# +5V Multiprotocol, Software-Selectable Clock Transceiver

MAX13172E

## Test Circuits

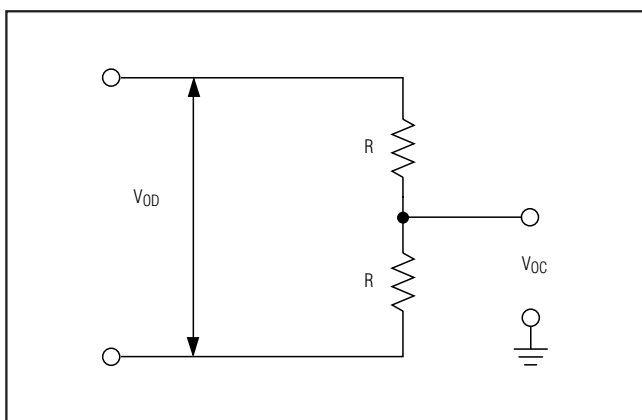


Figure 1. V.11 DC Test Circuit

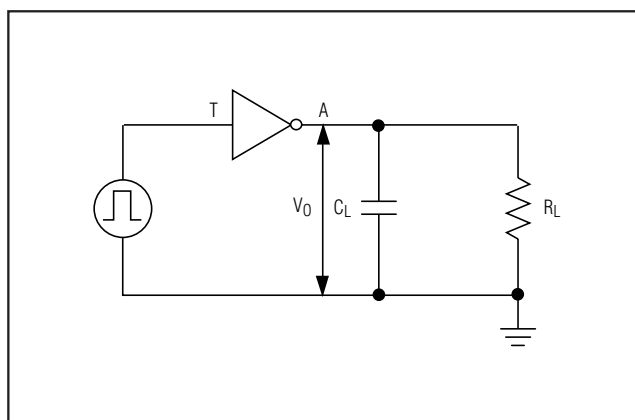


Figure 3. V.10/V.28 Transmitter Test Circuit

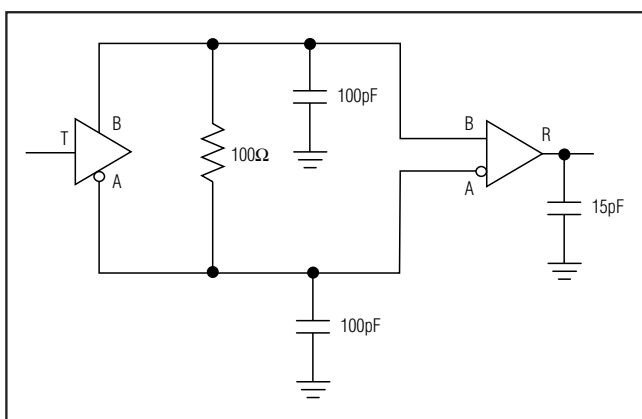


Figure 2. V.11 AC Test Circuit

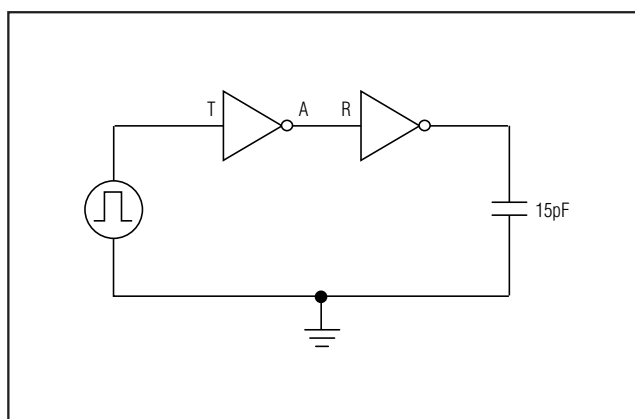


Figure 4. V.10/V.28 Receiver Test Circuit

## Detailed Description

The MAX13172E is a four-driver/four-receiver, multiprotocol transceiver that operates from a single +5V supply. The charge pump operates from the MAX13170E. The MAX13172E along with the MAX13170E and MAX13174E, form a complete software-selectable DTE or DCE interface port that supports the V.28 (RS-232), V.10/V.11 (RS-449/V.36, EIA-530, EIA-530A, X.21, RS-423), and V.35 protocols. The MAX13172E usually carries the control signals. The MAX13170E carries the high-speed clock and data signals, and the MAX13174E provides termination for the clock and data signals.

The MAX13172E features an ultra-low supply current no-cable mode, fail-safe operation, and thermal-shut-

down circuitry. Thermal shutdown protects the transmitter and receiver outputs against excessive power dissipation. When activated, the thermal-shutdown circuitry places the driver outputs into a high-impedance state.

The state of the mode-select inputs M0, M1, and M2 determines which serial-interface protocol is selected (Table 1). The state of the DCE/DTE input determines whether the transceivers are configured as a DTE serial port or a DCE serial port. When the DCE/DTE input is logic-high, driver T3 is activated and receiver R1 is disabled. When the DCE/DTE input is logic-low, driver T3 disabled and receiver R1 is activated. The INVERT input state changes the DCE/DTE functionality regarding T4 and R4 only. M0, M1, M2, INVERT, and DCE/DTE are internally pulled up to V<sub>CC</sub> to ensure logic-high if left unconnected.

# +5V Multiprotocol, Software-Selectable Clock Transceiver

## Switching Time Waveforms

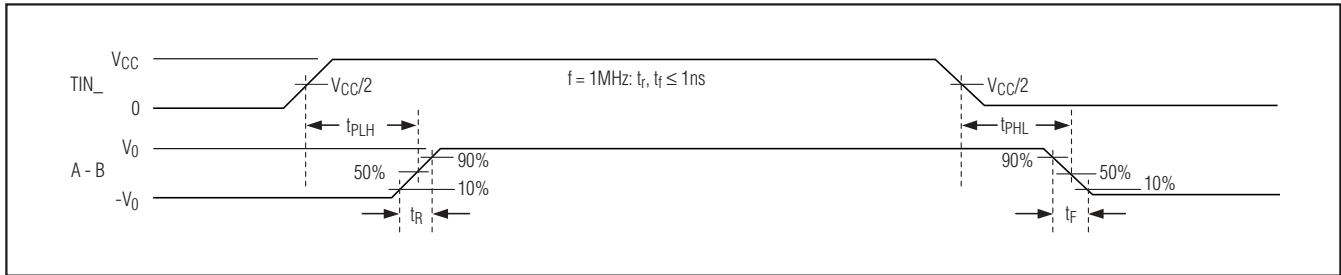


Figure 5. V.11 Transmitter Propagation Delays

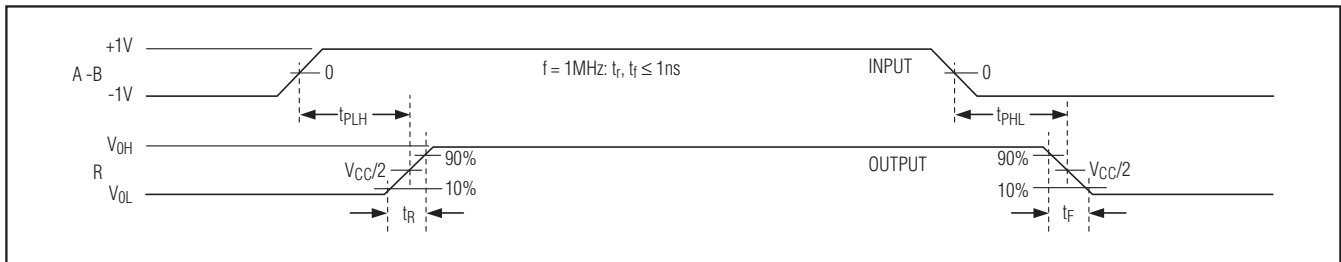


Figure 6. V.11 Receiver Propagation Delays

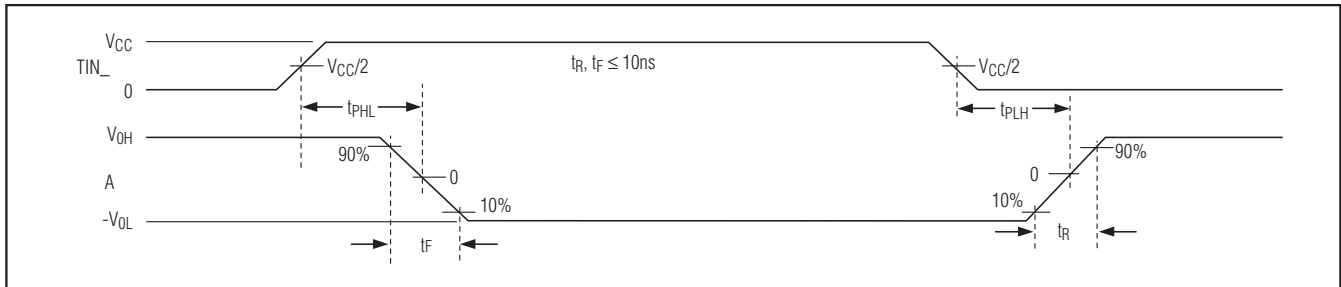


Figure 7. V.10 Transmitter Propagation Delays

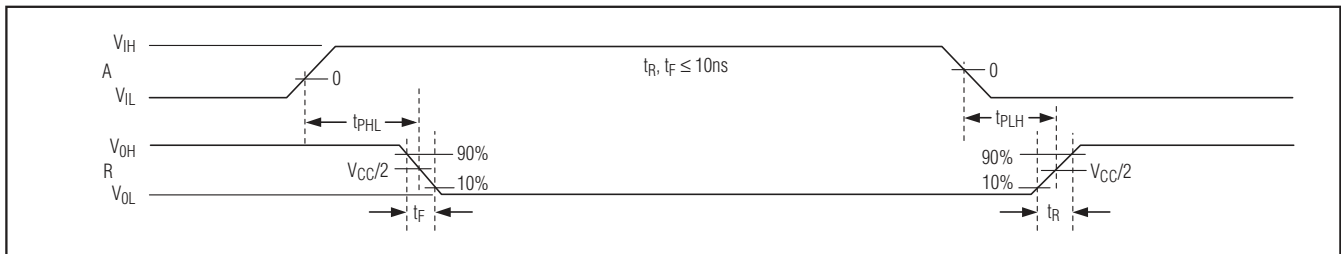


Figure 8. V.10 Receiver Propagation Delays

# +5V Multiprotocol, Software-Selectable Clock Transceiver

MAX13172E

## Switching Time Waveforms (continued)

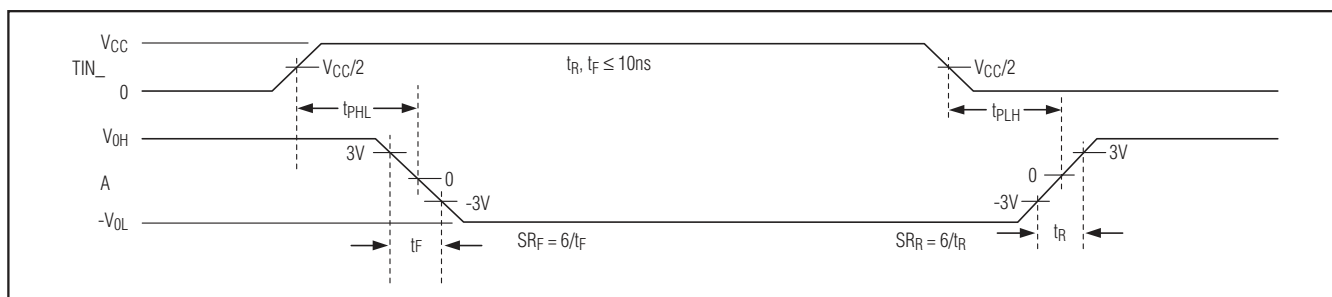


Figure 9. V.28 Transmitter Propagation Delays

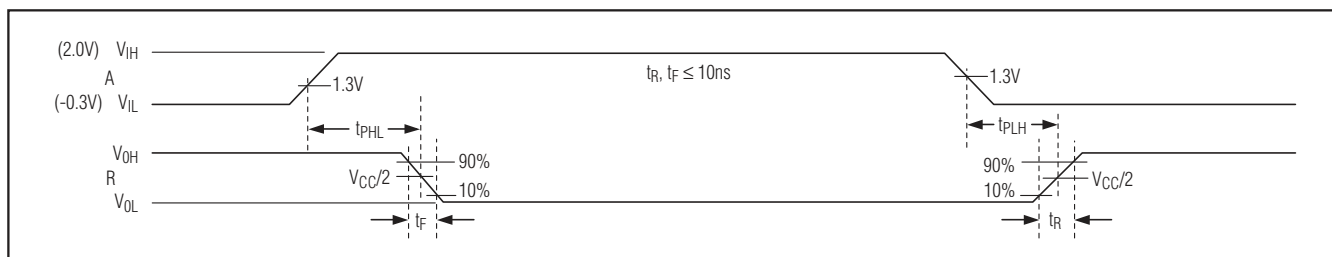


Figure 10. V.28 Receiver Propagation Delays

Table 1. Mode Select Table

PROTOCOL	M2	M1	M0	DCE/ DTE	INVERT	T1	T2	T3	R1	R2	R3	T4	R4
Not Used (Default V.11)	0	0	0	0	0	V.11	V.11	Z	V.11	V.11	V.11	Z	V.10
RS-530A	0	0	1	0	0	V.11	V.10	Z	V.11	V.10	V.11	Z	V.10
RS-530	0	1	0	0	0	V.11	V.11	Z	V.11	V.11	V.11	Z	V.10
X.21	0	1	1	0	0	V.11	V.11	Z	V.11	V.11	V.11	Z	V.10
V.35	1	0	0	0	0	V.28	V.28	Z	V.28	V.28	V.28	Z	V.28
RS-449/V.36	1	0	1	0	0	V.11	V.11	Z	V.11	V.11	V.11	Z	V.10
V.28/RS-232	1	1	0	0	0	V.28	V.28	Z	V.28	V.28	V.28	Z	V.28
No Cable	1	1	1	0	0	Z	Z	Z	Z	Z	Z	Z	Z
Not Used (Default V.11)	0	0	0	0	1	V.11	V.11	Z	V.11	V.11	V.11	V.10	Z
RS-530A	0	0	1	0	1	V.11	V.10	Z	V.11	V.10	V.11	V.10	Z
RS-530	0	1	0	0	1	V.11	V.11	Z	V.11	V.11	V.11	V.10	Z
X.21	0	1	1	0	1	V.11	V.11	Z	V.11	V.11	V.11	V.10	Z
V.35	1	0	0	0	1	V.28	V.28	Z	V.28	V.28	V.28	V.28	Z
RS-449/V.36	1	0	1	0	1	V.11	V.11	Z	V.11	V.11	V.11	V.10	Z
V.28/RS-232	1	1	0	0	1	V.28	V.28	Z	V.28	V.28	V.28	V.28	Z
No Cable	1	1	1	0	1	Z	Z	Z	Z	Z	Z	Z	Z

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Table 1. Mode Select Table (continued)

PROTOCOL	M2	M1	M0	DCE/ DTE	INVERT	T1	T2	T3	R1	R2	R3	T4	R4
Not Used (Default V.11)	0	0	0	1	0	V.11	V.11	V.11	Z	V.11	V.11	V.10	Z
RS-530A	0	0	1	1	0	V.11	V.10	V.11	Z	V.10	V.11	V.10	Z
RS-530	0	1	0	1	0	V.11	V.11	V.11	Z	V.11	V.11	V.10	Z
X.21	0	1	1	1	0	V.11	V.11	V.11	Z	V.11	V.11	V.10	Z
V.35	1	0	0	1	0	V.28	V.28	V.28	Z	V.28	V.28	V.28	Z
RS-449/V.36	1	0	1	1	0	V.11	V.11	V.11	Z	V.11	V.11	V.10	Z
V.28/RS-232	1	1	0	1	0	V.28	V.28	V.28	Z	V.28	V.28	V.28	Z
No Cable	1	1	1	1	0	Z	Z	Z	Z	Z	Z	Z	Z
Not Used (Default V.11)	0	0	0	1	1	V.11	V.11	V.11	Z	V.11	V.11	Z	V.10
RS-530A	0	0	1	1	1	V.11	V.10	V.11	Z	V.10	V.11	Z	V.10
RS-530	0	1	0	1	1	V.11	V.11	V.11	Z	V.11	V.11	Z	V.10
X.21	0	1	1	1	1	V.11	V.11	V.11	Z	V.11	V.11	Z	V.10
V.35	1	0	0	1	1	V.28	V.28	V.28	Z	V.28	V.28	Z	V.28
RS-449/V.36	1	0	1	1	1	V.11	V.11	V.11	Z	V.11	V.11	Z	V.10
V.28/RS-232	1	1	0	1	1	V.28	V.28	V.28	Z	V.28	V.28	Z	V.28
No Cable	1	1	1	1	1	Z	Z	Z	Z	Z	Z	Z	Z

The MAX13172E's mode can be selected through software control of the M0, M1, M2, INVERT, and DCE/DTE inputs. Alternatively, the mode can be selected by shorting the appropriate combination of mode control inputs to GND (the inputs left unconnected will be internally pulled up to  $V_{CC}$  - logic-high). If the M0, M1, and M2 mode inputs are all unconnected, the MAX13172E will enter no-cable mode.

### Fail-Safe

The MAX13172E guarantees a logic-high receiver output when the receiver inputs are open or shorted, or when they are connected to a terminated transmission line with all the drivers disabled. The V.11 receivers threshold is set between -200mV and -50mV to guarantee fail-safe operation. If the differential receiver input voltage (B - A) is  $\geq$  -50mV, ROUT is logic-high. In the case of a terminated bus with all transmitters disabled, the receiver's differential input voltage is pulled to 0 by the termination. With the receiver thresholds of the MAX13172E, this results in ROUT logic-high.

The V.10 receiver threshold is set between +50mV and +250mV. If the V.10 receiver input voltage is less than or equal to +50mV, ROUT is logic-high. The V.28 receiver threshold is set between 0.8V and 2.0V. If the receiver input voltage is less than or equal to 0.8V, ROUT is logic-high. In the case of a terminated bus with transmitters disabled, the receiver's input voltage is pulled to 0 by the termination.

### ESD Protection

As with all Maxim devices, a minimum of  $\pm 2$ kV-to-GND ESD-protection structures are incorporated on all pins to protect against electrostatic discharges encountered during handling and assembly. The driver outputs and receiver inputs of the MAX13172E have extra protection against static electricity. Maxim's engineers have developed state-of-the-art structures to protect these pins against ESD of  $\pm 10$ kV without damage (HBM). The ESD structures withstand high ESD in all states: normal operation, shutdown, and powered down. After an ESD event, the MAX13172E keeps working without latching or damage. ESD protection can be tested in various ways. The transmitter outputs and receiver inputs of the MAX13172E are characterized for protection to the following limits:

- $\pm 10$ kV using the Human Body Model
- $\pm 3$ kV using the Contact Method specified in IEC 61000-4-2
- $\pm 3$ kV using the Air Gap Discharge Method specified in IEC 61000-4-2

### ESD Test Conditions

ESD performance depends on a variety of conditions. Contact Maxim for a reliability report that documents test setup, test methodology, and test results.

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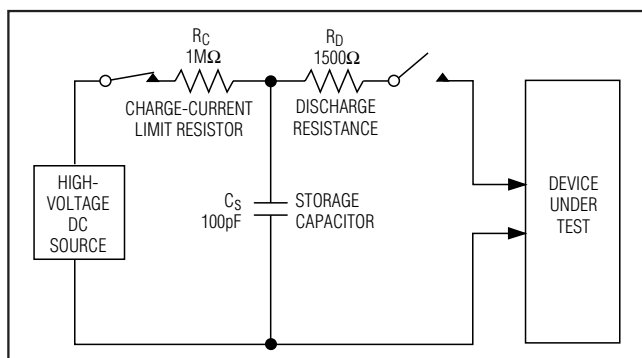


Figure 11a. Human Body ESD Test Model

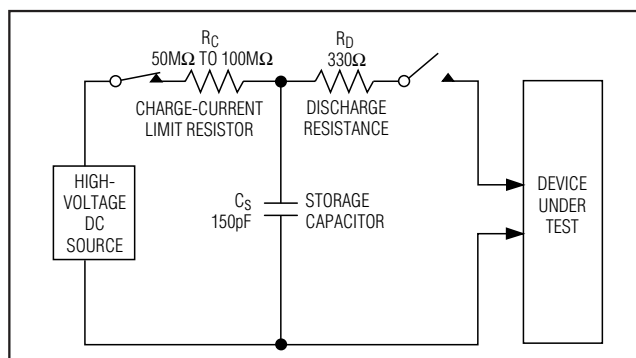


Figure 11c. IEC 61000-4-2 ESD Test Model

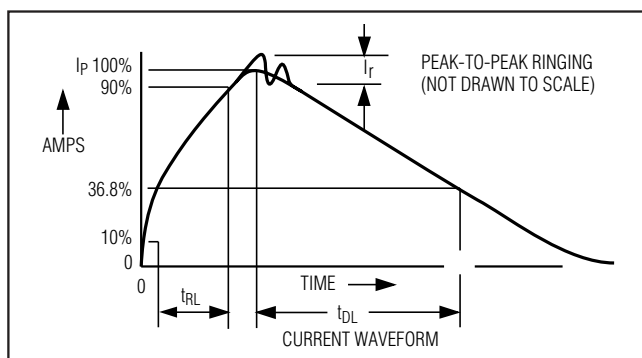


Figure 11b. Human Body Current Waveform

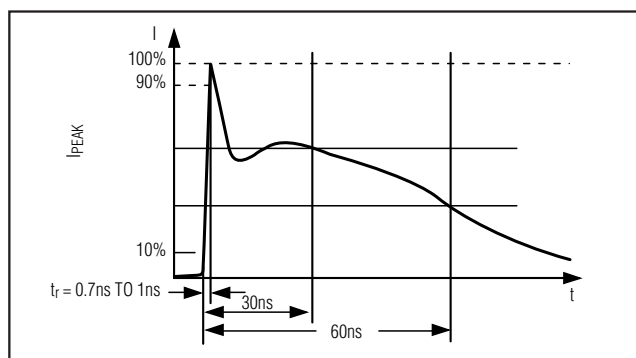


Figure 11d. IEC 61000-4-2 ESD Generator Current Waveform

## Human Body Model

Figure 11a shows the Human Body Model, and Figure 11b shows the current waveform it generates when discharged into a low impedance. This model consists of a 100pF capacitor charged to the ESD voltage of interest, which is then discharged into the test device through a 1.5kΩ resistor.

## IEC 61000-4-2

The IEC 61000-4-2 standard covers ESD testing and performance of finished equipment. However, it does not specifically refer to integrated circuits. The MAX13172E helps equipment designs meet IEC 61000-4-2, without the need for additional ESD-protection components.

The major difference between tests done using the Human Body Model and IEC 61000-4-2 is higher peak current in IEC 61000-4-2 because series resistance is lower in the IEC 61000-4-2 model. Hence, the ESD withstand voltage measured to IEC 61000-4-2 is generally lower than that measured using the Human Body Model. Figure 11c shows the IEC 61000-4-2 model, and Figure 11d shows the current waveform for the IEC 61000-4-2 ESD Contact Discharge test.

# +5V Multiprotocol, Software-Selectable Clock Transceiver

## Applications Information

### Cable-Selectable Configuration Application

A cable-selectable, multiprotocol DTE/DCE interface is shown in Figure 12. The mode control lines M0, M1, and DCE/DTE are wired to the DB-25 connector. To select the serial-interface mode, the appropriate combination of M0, M1, M2, and DCE/DTE are grounded within the cable wiring. The control lines that are not grounded are pulled high by the internal pullups on the MAX13170E. The serial-interface protocol of the MAX13172E is now selected based on the cable that is connected to the DB-25 interface.

#### V.10 (RS-423) Interface

The V.10 interface (Figure 13) is an unbalanced single-ended interface capable of driving a 450Ω load. The V.10 driver generates a minimum  $V_O$  voltage of  $\pm 4V$  across A' and C' when unloaded and a minimum voltage of  $0.9 \times V_O$  when loaded with 450Ω. The V.10 receiver has a single-ended input and does not reject common-mode differences between C and C'. The V.10 receiver input trip threshold is defined between +250mV and -250mV with input impedance characteristic shown in Figure 14.

The MAX13172E V.10 mode receiver has a threshold between +50mV and +250mV. To ensure that the receiver has proper fail-safe operation see the *Fail-Safe* section. To aid in rejecting system noise, the MAX13172E V.10 receiver has a typical hysteresis of 25mV. Switch S3 in Figures 16a and 16b is open in V.10 mode to disable the V.28 5kΩ termination at the receiver input. Switch S2 is closed and switch S1 is open to internally ground the receiver B input.

#### V.11 (RS-422) Interface

As shown in Figure 15, the V.11 protocol is a fully balanced differential interface. The V.11 driver generates a minimum of  $\pm 2V$  between nodes A and B when 100Ω minimum resistance is presented at the load. The V.11 receiver is sensitive to differential signals of  $\pm 200mV$  at receiver inputs A' and B'. The V.11 receiver input must comply with the impedance curve of Figure 14 and reject common-mode signals developed across the cable (referenced from C to C' in Figure 15) of up to  $\pm 7V$ .

The MAX13172E V.11 mode receiver has a differential threshold between -50mV and -200mV. To ensure that the receiver has proper fail-safe operation; see the *Fail-Safe* section. To aid in rejecting system noise, the MAX13172E V.11 receiver has a typical hysteresis of 15mV. Switch S3 in Figure 17 is open in V.11 mode to

disable the V.28 5kΩ termination at the inverting receiver input. Because the control signals are slow (60kbps), 100Ω termination resistance is generally not required for the MAX13172E. The receiver inputs must also be compliant with the impedance curve shown in Figure 14.

#### V.28 (RS-232) Interface

The V.28 interface is an unbalanced single-ended interface (Figure 13). The V.28 generator provides a minimum of  $\pm 5V$  across the 3kΩ load impedance between A' and C'. The V.28 receiver has a single-ended input.

The MAX13172E V.28 mode receiver has a threshold between +0.8V and +2.0V. To aid in rejecting system noise, the MAX13172E V.28 receiver has a typical hysteresis of 0.25V. Switch S3 in Figures 18a and 18b is closed in V.28 mode to enable the 5kΩ V.28 termination at the receiver inputs.

#### No-Cable Mode

The MAX13172E will enter no-cable mode when the mode-select pins are left unconnected or connected high ( $M0 = M1 = M2 = 1$ ). In this mode, the multiprotocol drivers and receivers are disabled and the supply current is less than 10μA. The receiver outputs enter a high-impedance state in no-cable mode, which allows these output lines to be shared with other receiver outputs (the receiver outputs have an internal pullup resistor to pull the outputs high if not driven). Also, in no-cable mode, the transmitter outputs enter a high-impedance state, so these output lines can be shared with other devices.

#### DTE vs. DCE Operation

Figure 19 shows a port with one DB-25 connector that can be configured for either DTE or DCE operation. The configuration requires separate cables for proper signal routing in DTE or DCE operation. Figures 20 and 21 illustrates a DCE or DTE controller-selectable interface. The DCE/DTE and INVERT inputs switch the port's mode of operation (Table 1).

The MAX13170E and MAX13172E can be connected for either DTE or DCE operation in one of two ways: a dedicated DTE or DCE port with an appropriate gender connector or a port with a connector that can be configured for DTE or DCE operation by rerouting the signals to the MAX13170E and MAX13172E using a dedicated DTE cable or dedicated DCE cable. The interface mode is selected by logic outputs from the controller or from jumpers to either VCC or GND on the mode select pins. A dedicated DCE port using a DB-25 female connector is shown in Figure 20. Figure 21 illustrates a dedicated DTE port using a DB-25 male connector.

# +5V Multiprotocol, Software-Selectable Clock Transceiver

**MAX13172E**

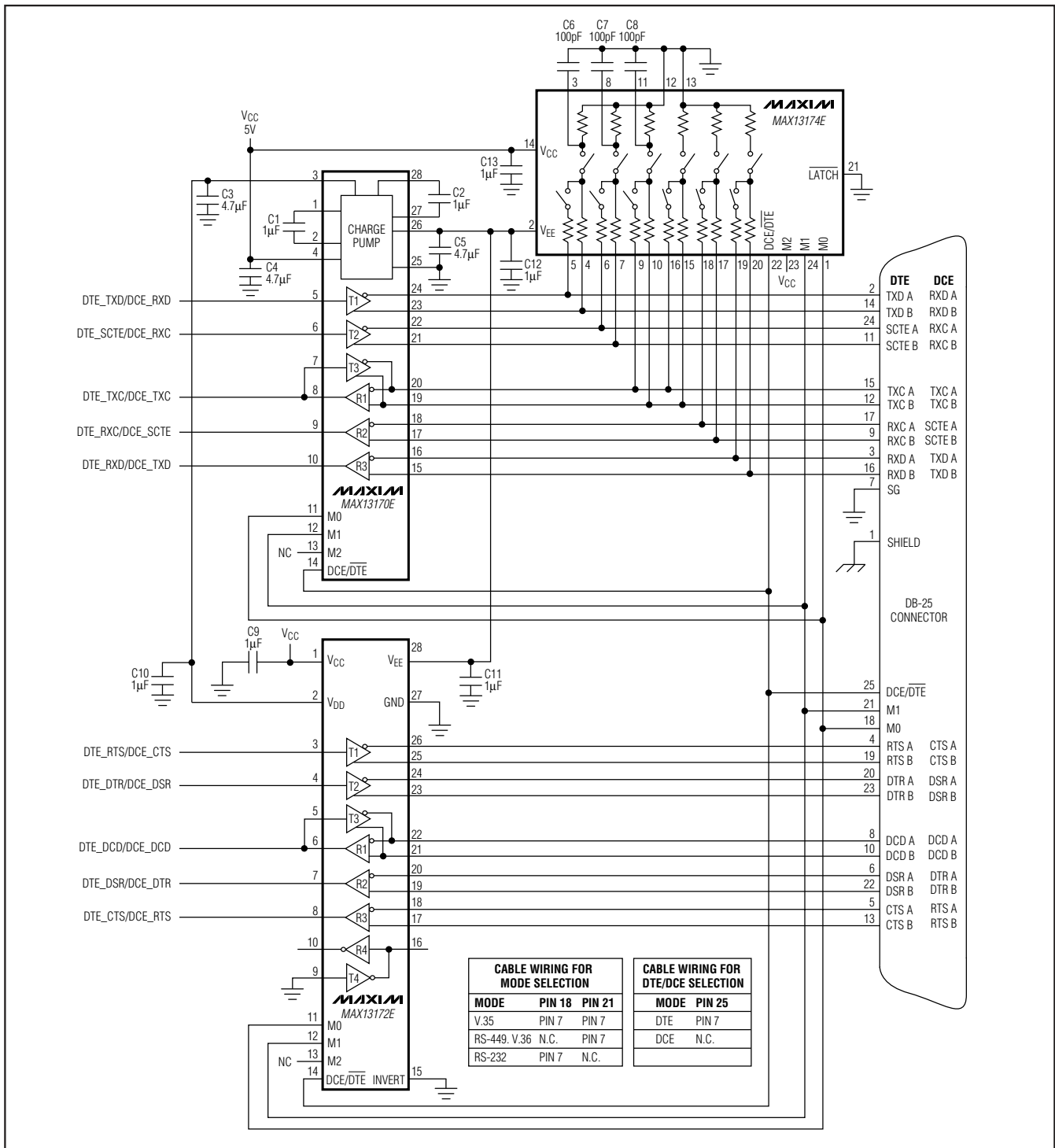


Figure 12. Cable-Selectable Multiprotocol DTE/DCE Port

# +5V Multiprotocol, Software-Selectable Clock Transceiver

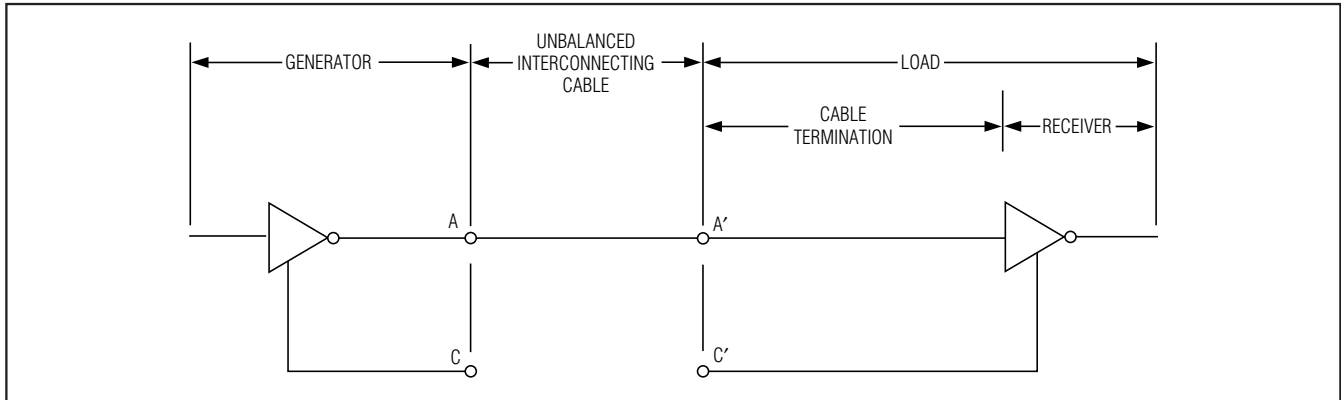


Figure 13. Typical V.10/V.28 Interface

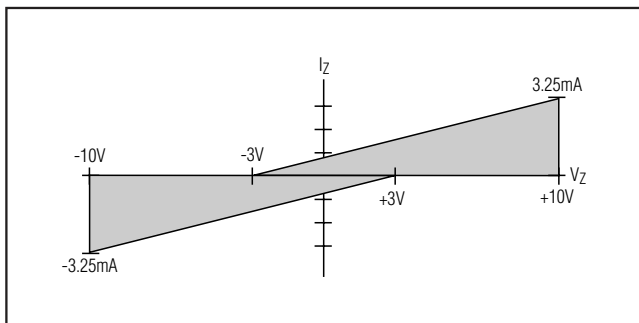


Figure 14. Receiver Input Impedance Curve

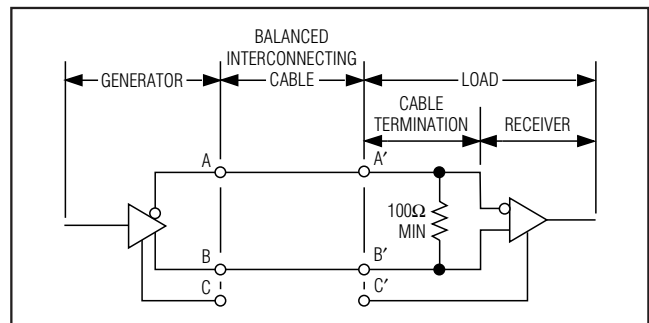


Figure 15. Typical V.11 Interface

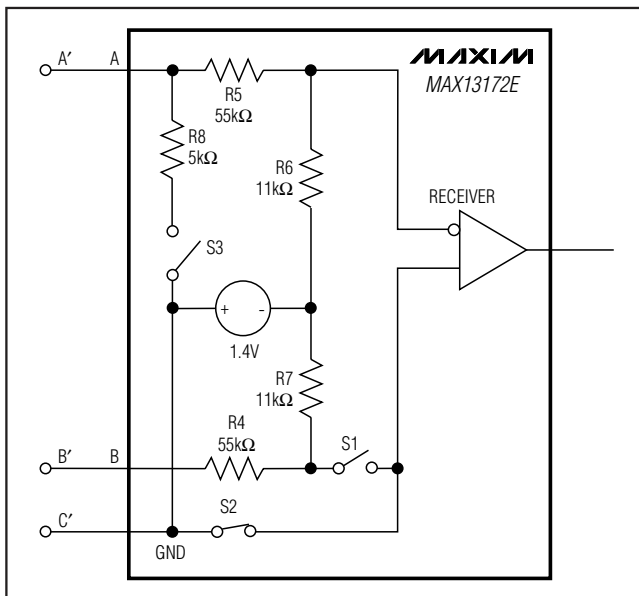


Figure 16a. V.10 Internal Resistance Network for Receivers 1, 2, and 3

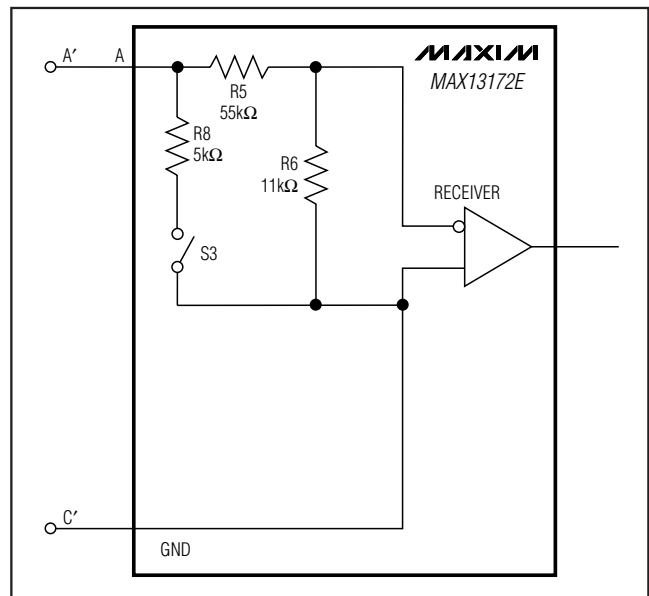


Figure 16b. V.10 Internal Resistance Network for Receiver 4



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**MAX13172E**

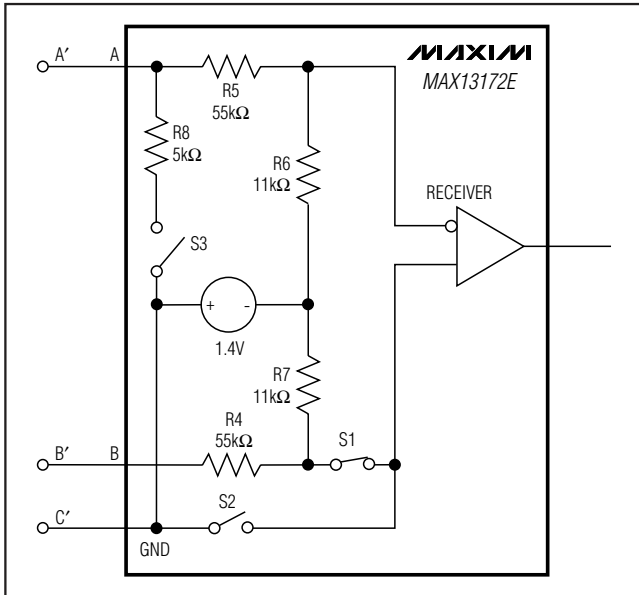


Figure 17. V.11 Internal Resistance Networks

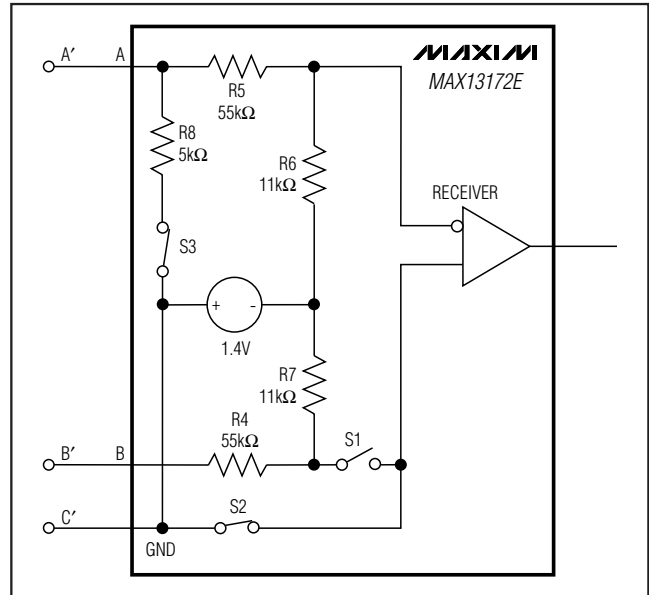


Figure 18a. V.28 Internal Resistance Network for Receiver 1, 2, and 3

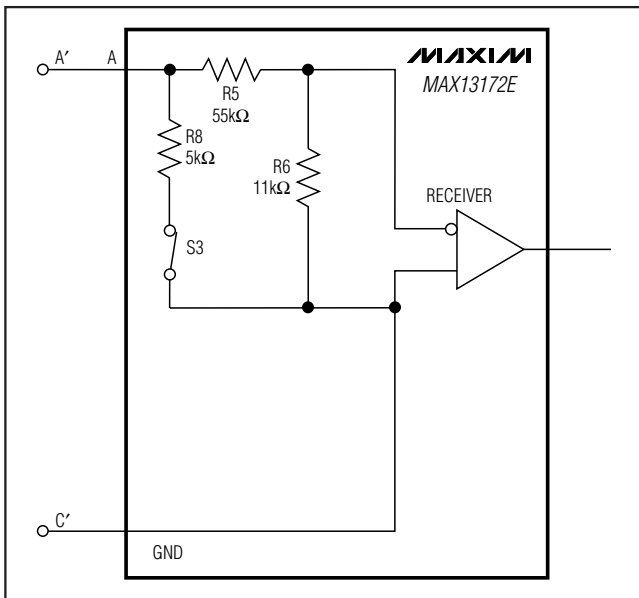


Figure 18b. V.28 Internal Resistance Network for Receiver 4

# +5V Multiprotocol, Software-Selectable Clock Transceiver

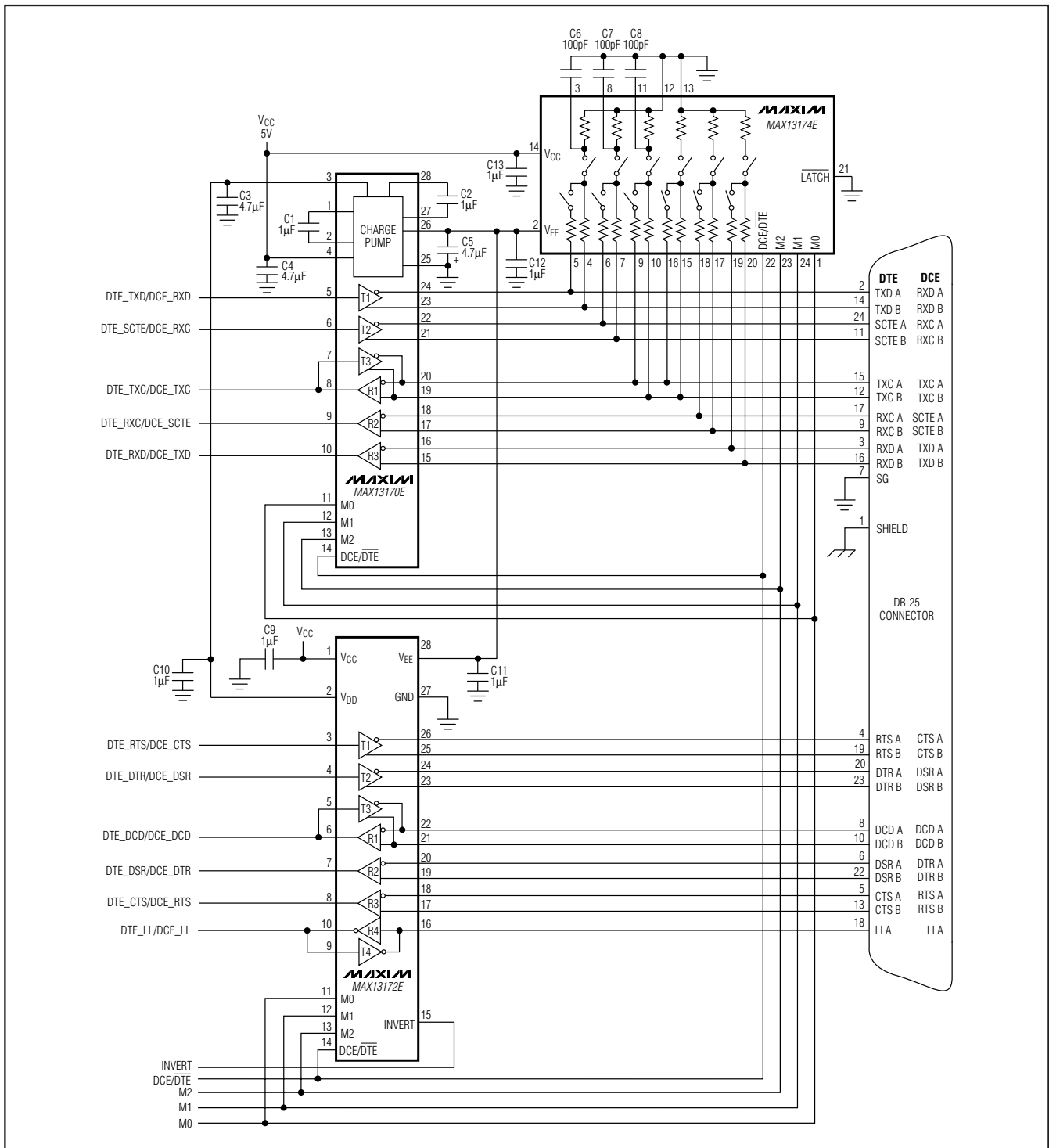


Figure 19. Controller-Selectable Multiprotocol DCE/DTE Port with DB-25 Connector

# +5V Multiprotocol, Software-Selectable Clock Transceiver

**MAX13172E**

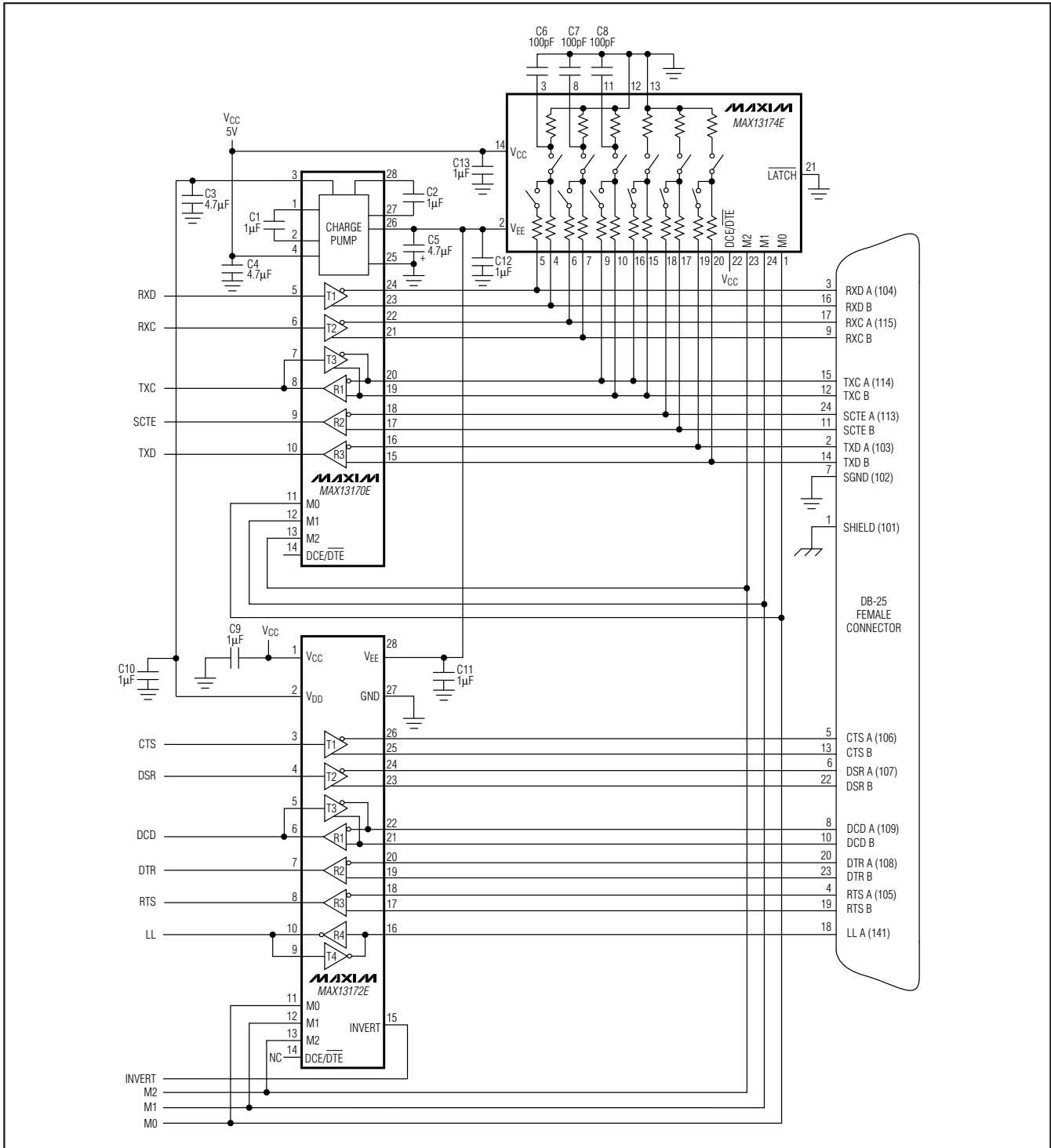


Figure 20. Controller-Selectable DCE Port with DB-25 Connector

# +5V Multiprotocol, Software-Selectable Clock Transceiver

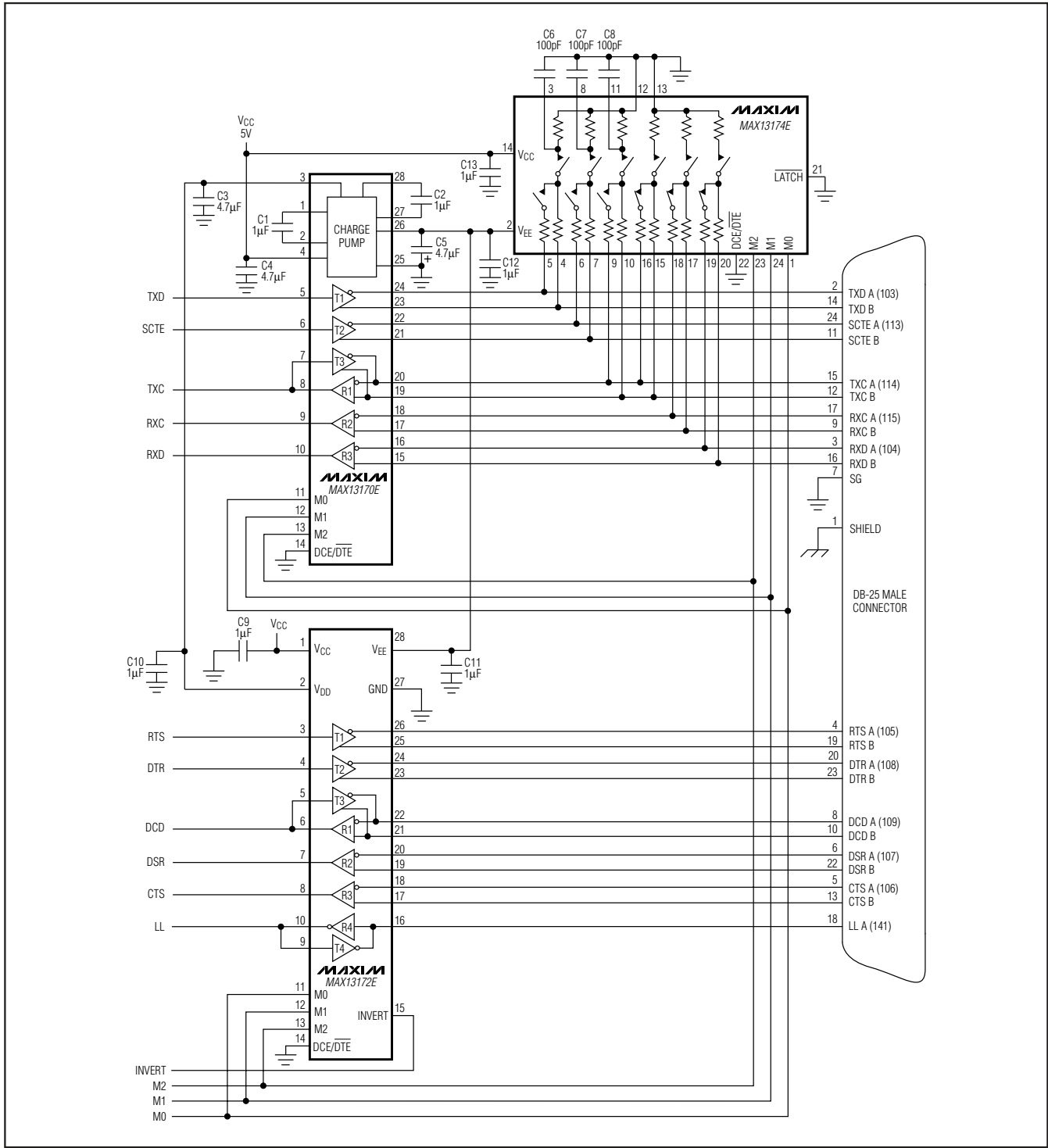
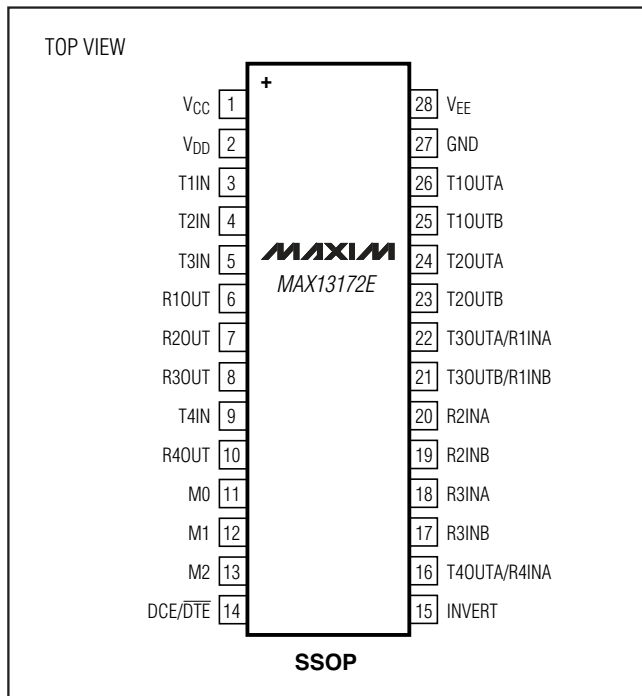


Figure 21. Controller-Selectable Multiprotocol DTE Port with DB-25 Connector

# +5V Multiprotocol, Software-Selectable Clock Transceiver

**MAX13172E**

## Pin Configuration



## Chip Information

PROCESS: BICMOS

## Package Information

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

PACKAGE TYPE	PACKAGE CODE	OUTLINE NO.	LAND PATTERN NO.
28 SSOP	A28+2	<a href="#">21-0056</a>	<a href="#">90-0095</a>

# +5V Multiprotocol, Software-Selectable Clock Transceiver

## Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
0	7/09	Initial release	—
1	8/11	Updated soldering temperature in <i>Absolute Maximum Ratings</i> , updated <i>Fail-Safe</i> section, updated <i>Package Information</i> section, and added lead-free indicator to <i>Pin Configuration</i>	2, 23, 38

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