

JULY 2005

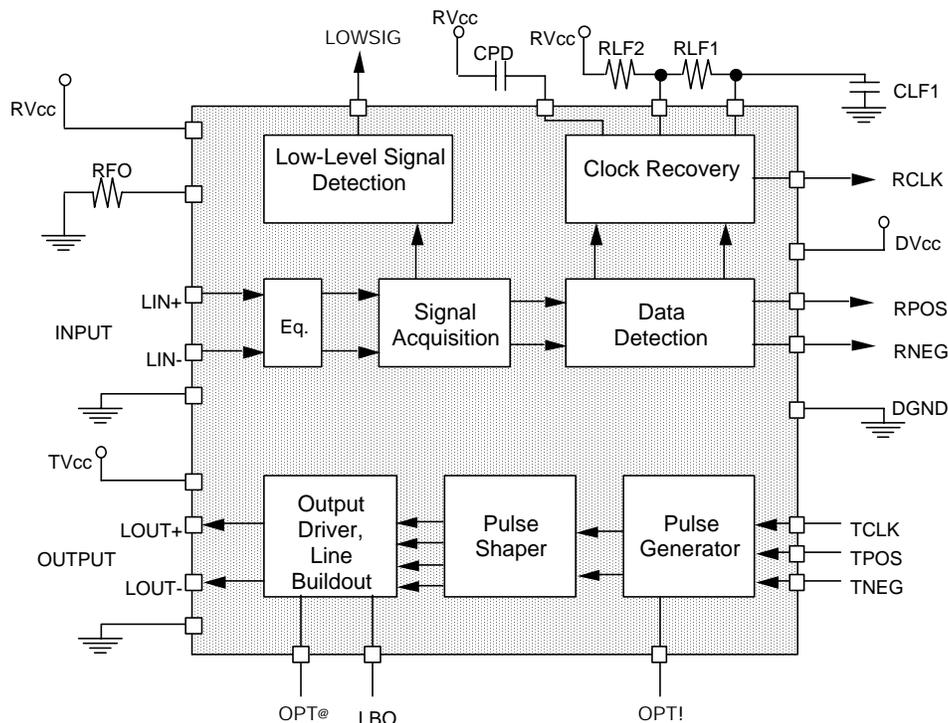
## DESCRIPTION

The 78P7200 is a line interface transceiver IC intended for STS-1 (51.84 Mbit/s), DS3 (44.736 Mbit/s) and E3 (34.368 Mbit/s) applications. The receiver has a very wide dynamic range and is designed to accept either HDB3 or B3ZS-encoded Alternate-Mark Inversion (AMI) inputs; it provides CMOS logic level clock, positive data, negative data and low-level signal detector outputs. An on-chip equalizer improves the intersymbol interference tolerance on the receive path. The transmitter converts CMOS logic level clock, positive data and negative data input signals into AMI pulses of the appropriate shape for transmission. A line buildout (LBO) equalizer may be selected to shape the outgoing pulses for shorter line lengths. The 78P7200 requires a single 5 volt supply and is available in a surface mount package.

## FEATURES

- **Single chip transmit and receive interface for STS-1 (51.84 Mbit/s), E3 (34.368 Mbit/s) or DS3 (44.736 Mbit/s) applications**
- **On-chip Receive Equalizer**
- **Unique clock recovery circuit, requires no crystals, tuned components or external clock**
- **Selectable transmit line buildout (LBO) to accommodate shorter line lengths**
- **Compliant with ANSI T1.102-1993, Bellcore TR-NWT-000499 and GR-253-CORE, ITU-T G.703 and G.823\_1991**
- **Low-level input signal indication**
- **Available in a 28 PLCC surface mount package**
- **-40°C to +85°C operating range**

## BLOCK DIAGRAM



## FUNCTIONAL DESCRIPTION

The 78P7200 is a single chip line interface IC designed to work with either a 51.84 Mbit/s STS-1, 44.736 Mbit/s DS3 or 34.368 Mbit/s E3 signal. The receiver recovers clock, positive data and negative data from an Alternate Mark Inversion (AMI) signal. The input signal should be B3ZS or HDB3 coded.

The transmitter accepts CMOS level logical clock, positive data and negative data and converts them to the AMI signal to drive a 75 $\Omega$  coaxial cable. Programmable internal Line Buildout (LBO) circuitry eliminates the need for external LBO networks. When the option pins are properly selected, the shape of the transmitted signal through any cable length of 0 to 450 feet complies with the published templates of ANSI T1.102, ITU-T G.703, Bellcore TR-NWT-000499 and GR-253-CORE. The 78P7200 is designed to work with a B3ZS or HDB3 coded signal. The B3ZS or HDB3 encoding and decoding functions are normally included in the framer ICs or can easily be implemented in a PAL.

## RECEIVER

The receiver input is normally transformer-coupled to the AMI signal. The inputs to the IC are internally referenced to RVCC. Since the input impedance of the 78P7200 is high, the AMI line must be terminated in 75 $\Omega$ . The input signal to the 78P7200 must be limited to a maximum of three consecutive zeros using a coding scheme such as B3ZS or HDB3.

The AMI signal first enters a fixed equalizer, which is designed to overcome the intersymbol interference caused by long cable lengths and crosstalk. This fixed equalizer is optimized for DS3 application and its effect should be compensated by an external filter circuit similar to Figure 1, for all square shaped signals such as DS3-high or 34 Mbit/s E3. For all new designs, the addition of the filter for DS3 and STS-1 as well as E3 rate allows the circuit to work with sharp pulses such as DS3-high. The signal is then input to a variable gain differential amplifier whose output is maintained at a constant voltage level regardless of the input voltage level. The gain of this amplifier is adjusted by detecting the peak of the signal and comparing it to a fixed reference.

The output of the variable gain amplifier is compared to a threshold value, which is a fixed percentage of the signal peak. In this way, even though the input signal amplitude may fall below the minimum value that can be regulated by the variable gain circuit, the proper detection threshold is maintained.

Outputs of the data comparators are connected to the clock recovery circuits. The clock recovery system employs a unique phase locked loop, which has an auxiliary frequency-sensitive acquisition loop, which becomes active only when cycle-slipping occurs between the received signal rate and the internal oscillator.

This system permits the loop to independently lock to the frequency and phase of the incoming data stream without the need for high precision and/or adjustable oscillator or tuned circuits.

The frequency characteristic for the phase locked loop is established by external filter components, RLF1, RLF2 and CLF1. The values of these components are specified such that the bandwidth of the phase locked loop is greater than 200 kHz.

The jitter tolerance of the 78P7200 exceeds the requirements of TR-NWT-000499 for Category II equipment for DS3 rate and exceeds the requirements of ITU-T G.823 for E3 rate. The jitter transfer function is maximally flat so the IC doesn't add any significant jitter to the system.

Figure 2 shows the recovered clock (RCLK), positive data (RPOS) and negative data (RNEG) signals timing. The data is valid on the rising edge of the clock. The minimum setup and hold times allow easy interface to framer circuits. These signals are CMOS-level outputs.

Should the input signal fall below a minimum value, the LOWSIG pin goes active low. A time delay is provided before this output is active so that transient interruptions do not cause false indications. This signal should be used as one of many indications to the cable disconnect; the framer device should count the number of zeros to declare the loss of signal. The RPOS and RNEG signals generate random data following a silence period. The framer device should ignore RPOS and RNEG data if the LOWSIG pin is active low.

## TRANSMITTER

The transmitter accepts CMOS logic level clock (TCLK), positive data (TPOS) and negative data (TNEG) signals and generates high current drive pulses on the LOUT+ and LOUT- pins. When properly connected to a center tapped transformer, an AMI pulse is generated which can drive a 75Ω coaxial cable.

Figure 3 shows the timing for the transmitter logic signals. The output pulse width is internally set and is not sensitive to input clock (TCLK) pulse width.

When a recommended transformer is used and option pins are properly set, the transmitted pulse shape at the end of a 75Ω terminated cable of 0 to 450 feet will fit the template for DSX3 pulse published in ANSI T1.102-1993, Bellcore TR-NWT-000499 documents.

For 51.84 Mbit/s STS-1 application the transmitted pulse for a short cable meets the requirements of Bellcore GR-253-CORE. For 34 Mbit/s E3 application, the transmitted pulse for a short cable meets the requirements of ITU-T G.703 when both LBO and OPT! pins are set LOW.

The 78P7200 incorporates a selectable Line Buildout (LBO) pulse shaper in the transmitter path. For STS-1 and DS3 applications, the LBO pin should be set HIGH if the cable is shorter than 225 feet and set LOW for longer cable lengths. For E3 application, LBO pin should be set LOW regardless of cable length.

The OPT! pin is set HIGH for DS3 and STS-1 operation. The OPT! pin should be set LOW for E3 applications.

The OPT@ pin should be set HIGH for normal operation. By setting the OPT@ pin to LOW it disables the transmitter drivers and reduces the power consumption of the circuit by approximately 125 mW.

Recommended settings for OPT! and LBO pins

SPEED	CABLE	OPT!	LBO
DS3/STS1	< 225'	HI	HI
DS3/STS1	> 225'	HI	LOW
E3	ALL	LOW	LOW

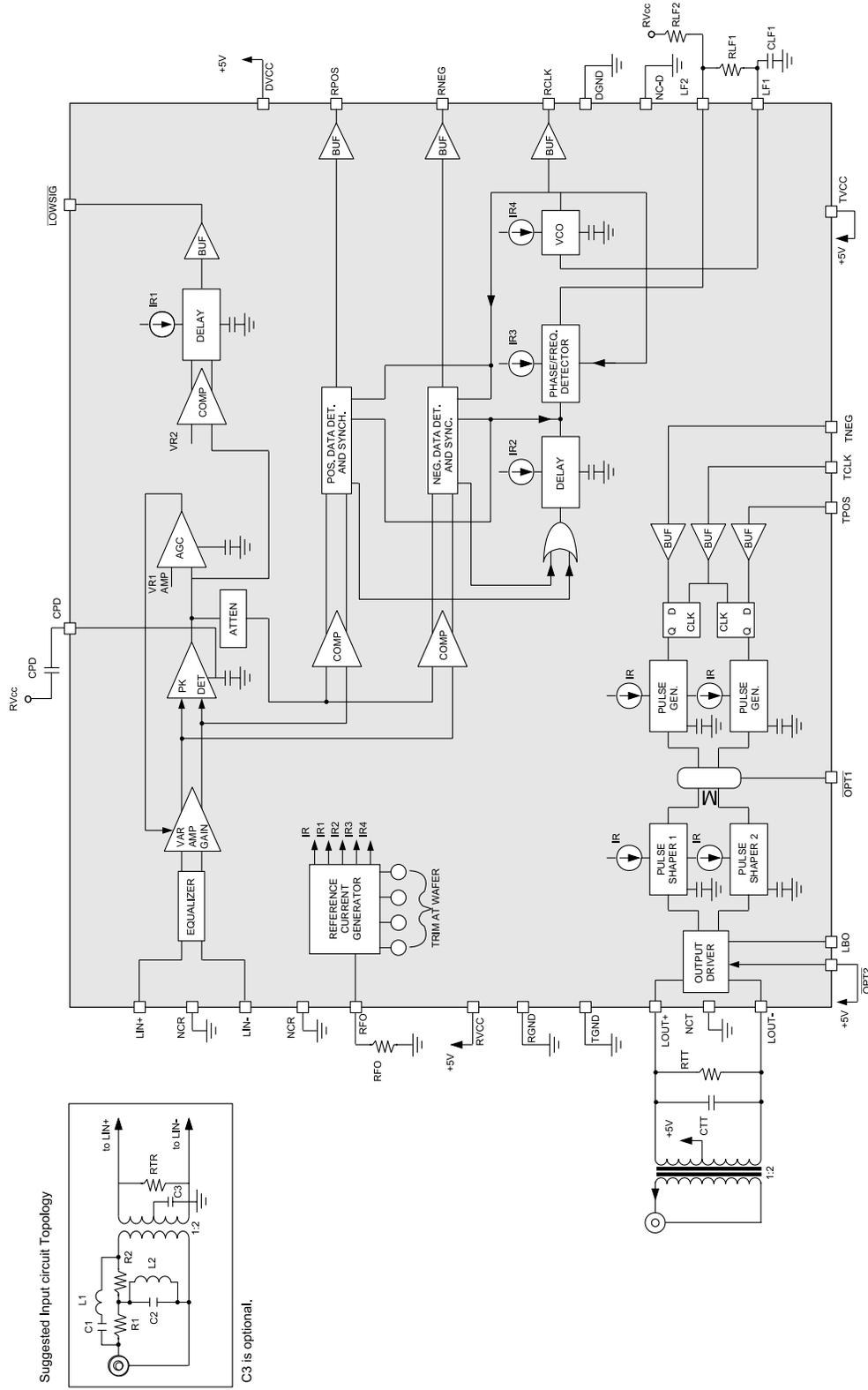


FIGURE 1: Functional Diagram

## PIN DESCRIPTION

### RECEIVER

NAME	TYPE	DESCRIPTION
LIN+, LIN-	I	Differential inputs, transformer-coupled from coax cable.
RPOS	O	Unipolar receiver output, active as result of positive pulse at inputs.
RNEG	O	Unipolar receiver output, active as result of negative pulse at inputs.
RCLK	O	Recovered Clock from line data.
LOWSIG	O	Low signal logic output indicating that input signal is less than threshold value.

### TRANSMITTER

TPOS	I	Unipolar transmitter data input, active high.
TNEG	I	Unipolar transmitter data input, active high.
TCLK	I	Transmitter clock input, active high.
LOUT+	O	Output to transformer for positive data pulses.
LOUT-	O	Output to transformer for negative data pulses.
LBO	I	Transmitter line buildout control. Set low for all E3 or for DS3/STS-1 cable of 225' or longer. Set high for short DS3/ STS-1 cable.
OPT!	I	Transmit option 1. Set high for DS3/STS-1 and set low for E3.
OPT@	I	Transmit option 2. Disables output driver and reduces output bias current when low. Set high for normal transmit operation.

### EXTERNAL COMPONENT CONNECTION

RFO	I	Resistor connected to RGND adjusts the center frequency of receiver phase locked loop oscillator and the transmitter pulse width and amplitude.
LF1, LF2	-	Resistor-capacitor loop filter network to establish bandwidth of phase locked loop.
CPD	-	Capacitor to RVcc that is connected to peak detector node to reduce signal-dependent ripple on that node.

### POWER

TVcc	-	5V power supply for transmit circuits.
RVcc	-	5V power supply for receive circuits.
DVcc	-	5V power supply for receive logic circuits.
TGND	-	Ground return for transmit circuits.
RGND	-	Ground return for receive circuits.
DGND	-	Ground return for receive logic circuits.
NCR	-	No connect, Tie to Receiver Ground (RGND).
NCT	-	No connect, Tie to Transmitter Ground (TGND).
NCD	-	No connect, Tie to Digital Ground.

## ELECTRICAL SPECIFICATIONS

(TA = -40°C to 85°C, Vcc = 5V ±5%, unless otherwise noted.) Currents flowing into the chip are positive. Current maximums are currents with the largest absolute value. Operation above absolute maximum ratings may permanently damage the device.

### ABSOLUTE MAXIMUM RATINGS

PARAMETER	RATING
Positive 5V supply: TVcc, RVcc, DVcc	6V
Storage Temperature	-65 to 150°C
Soldering Temperature (10 sec.)	260 °C
Ambient Operating Temperature, TA	-40 to +85°C
Pin Ratings: LOUT+, LOUT-	Vcc -2 to Vcc +2V
LIN+, LIN-, TPOS, TNEG, TCLK, LBO, RFO, LF2, LF1, OPT!, OPT@ Pins	-0.3 to Vcc +0.3V
RPOS, RNEG, RCLK, LOWSIG Pins	-0.3 to Vcc +0.3V or +12 mA

### SUPPLY CURRENTS AND POWER

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Supply Current	ICC		155	190	mA
	Outputs unloaded, normal operation, transmit and receive all 1's pattern				
Power Dissipation	P			0.93	W
	Outputs unloaded, TA = 85°C				

### EXTERNAL COMPONENTS (Common to STS-1/DS3/E3, nominal value)

Loop filter resistor	RLF1	1% tolerance		6.04		kΩ
Loop filter resistor	RLF2	1%		100		kΩ
Loop filter capacitor	CLF1	5%		0.22		μF
Peak detector capacitor	CPD	10%		0.022		μF
Input Filter	R1, R2	1%		75		Ω
Input Filter	C1	5%		1000		pF
Input Filter	C2	5%		82		pF
Input Filter	C3	20% (See Note)			0.01	μF
Input Filter	L1	5%		0.47		μH
Input Filter	L2	5%		6.8		μH
Transformer Turns Ratio	T1, T2	3%		1:2		
Receiver Termination Resistor	RTR	1%		422		Ω

Note: Optional capacitor to reduce common mode noise.

**EXTERNAL COMPONENTS** (Dependent on speed, nominal Value)

		STS-1	DS3	E3	
Loop center frequency resistor RFO	1% tolerance	4.53	5.23	6.81	kΩ
Transmit termination capacitor CTT	5% (Note 2)	10	10	3	pF
Transmit termination resistor RTT	1%	301	301	604	Ω

Note 1: Optional capacitor to reduce common mode noise.

Note 2: CTT value depends on the PC board design. Nominal values are selected for 78P7200 Demo Board.

**DIGITAL INPUTS AND OUTPUTS**

(CMOS-compatible pins: LOWSIG, RPOS, RNEG, RCLK, TPOS, TNEG, TCLK, LBO, OPT! .) Currents flowing into the chip are positive. Current maximums are currents with the largest absolute value.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Input low voltage VIL		-0.3		1.5	V
Input high voltage VIH		3.5		V <sub>CC</sub> +0.3	V
Input low current IIL	VIL = 1.5V	-5		5	μA
Input high current IIH	VIH = 3.5V	-5		5	μA
Output low voltage VOL	IOL = 0.1 mA			0.4	V
Output high voltage VOH	IOH = -0.1 mA	4			V

**OPT● CHARACTERISTICS**

Input low voltage VIL	IIL = 0.4 mA			0.5	V
Input high voltage VIH		2			V

**RECEIVER**

All of the measurements for the receiver are made with the following conditions unless otherwise stated:

1. The input signal is transformer coupled as shown in Figure 1.
2. RFO = 5.23 kΩ for DS3, 6.81 kΩ for E3 and 4.53 kΩ for STS-1.

Input signal voltage VIN Short cable (3')	Input AC-Coupled	CPD = 0.022 μF	±0.045		±1.2	V
		CPD not used	±0.090		±1.2	V
Input Resistance RIN	Input at device's common mode voltage		15	20	30	kΩ
Receive data detection threshold VDTH	Relative to peak amplitude for 22.37/17.18/25.92 MHz sinusoidal input			50		%
Receive data low signal threshold VLOW			±20		±50	mV
Receive data low signal delay TLOW		CPD = 0.022 μF		500		μs
		CPD not used VIN(max) = ±250 mV	0.5		3	μs

**RECEIVER** (continued)

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Receive clock period TRCF	DS3		22.35		ns
	STS-1		19.29		ns
	E3		29.1		ns
Receive clock pulse width TRC	DS3		12.24		ns
	STS-1		9.65		ns
	E3		14.55		ns
Receive clock positive transition time TRCPT	CL = 15 pF		4.5	6	ns
Receive clock negative transition time TRCNT	CL = 15 pF		4.5	6	ns
Positive or negative receive data pulse width TRDP/ TRDN	DS3		22.35		ns
	STS-1		19.29		ns
	E3		29.1		ns
Receive data set-up time TRDPS/ TRDNS	DS3	5	11.18	13.7	ns
	STS-1		9.65		ns
	E3	5	14.55		ns
Receive data hold time TRDPH/ TRDNH	DS3	5	11.18	13.7	ns
	STS-1		9.65		ns
	E3	5	14.55		ns
Receive input jitter tolerance high frequency (See Note)	60 - 300 kHz DS3	0.3			UIPP
	10 - 800 kHz STS-1				UIPP
	10 - 800 kHz E3 VIN (min) = ±90 mV, short cable	0.20			UIPP
Receive input jitter tolerance low frequency (See Note)	10 Hz to 2.3 kHz STS-1, DS3	10			UIPP
	100 Hz to 10 kHz E3	10			UIPP
Clock Recovery Phase Detector Gain KD	All 1's data pattern, DS3	72	80	88	μA/Rad
	KD = 0.418/RFO STS-1		92		μA/Rad
	E3		62		μA/Rad
Clock Recovery Phase Locked Oscillator Gain KO		12	14.5	17	Mrad/ sec. -Volt

Note: UI (Unit Interval) defined as 22.35 ns for DS3, 29.1 ns for E3 and 19.29 ns for STS-1.

**TRANSMITTER**

All of the measurements for the transmitter are made with the following conditions unless otherwise stated:

1. Transmit pulse characteristics are obtained using a line transformer which has the characteristics, similar to Pulse Engineering PE-65969, Mini circuit T4-1, Valor PT5045.
2. The circuit is connected as in Figure 1.

PARAMETER	CONDITIONS	MIN	NOM	MAX	UNIT
Transmit clock repetition TTCF	DS3		22.35		ns
	STS-1		19.29		ns
	E3		29.1		ns
Transmit clock pulse width TTC	DS3		11.18		ns
	STS-1		9.65		ns
	E3		14.55		ns
Transmit clock negative transition time TTCNT			4.5	6	ns
Transmit clock positive transition time TTCPT			4.5	6	ns
Transmit data set-up time TTPDS	DS3	3.5	11.18		ns
	STS-1	3.5	9.65		ns
	E3	3.5	14.55		ns
Transmit data hold time TTPDH	DS3	3.5	11.18		ns
	STS-1	3.5	9.65		ns
	E3	3.5	14.55		ns
Transmit positive line pulse width TTPL	Measured at transformer, LBO = High DS3	10.62	11.18	12	ns
	LBO = High STS-1		9.65		ns
	LBO = Low E3		14.5		ns
Transmit negative line pulse width TTNL	Measured at transformer, LBO = High DS3	10.62	11.18	12	ns
	LBO = High STS-1		9.65		ns
	LBO = Low E3		14.5		ns
Transmit line pulse waveshape	See Note 1 for DS3 See Note 2 for E3 See Note 3 for STS-1				

Note 1: Characteristics are in accordance with ANSI T1.102 - 1993 Table 4 and Figure 4.

Note 2: Characteristics are in accordance with ITU-T G.703 - 1991 Figure 17.

Note 3: Characteristics are in accordance with ANSI T1.102 - 1993 Figure A.1.

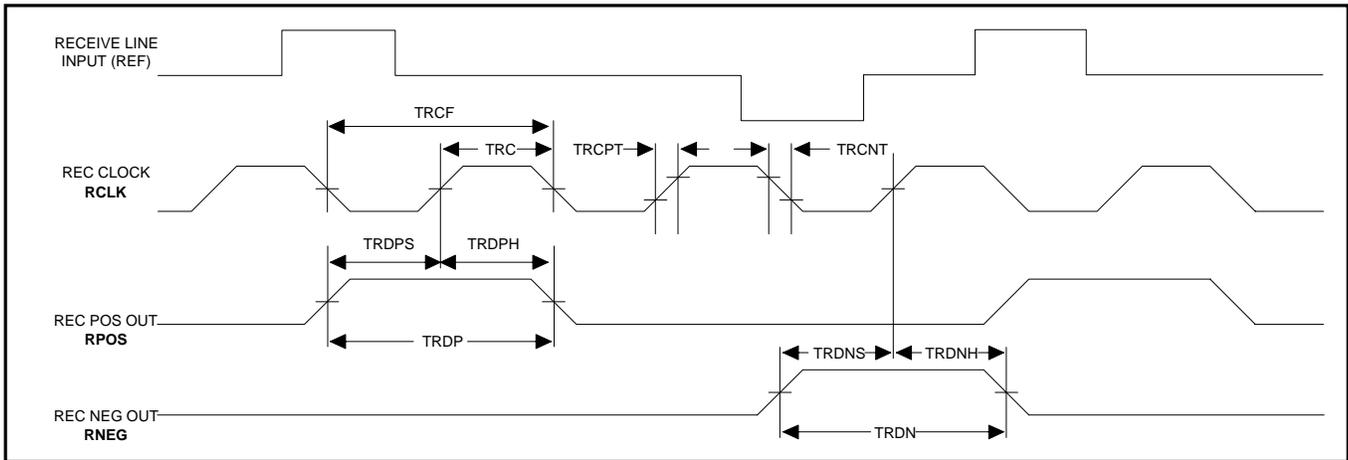


FIGURE 2: Receive Waveforms

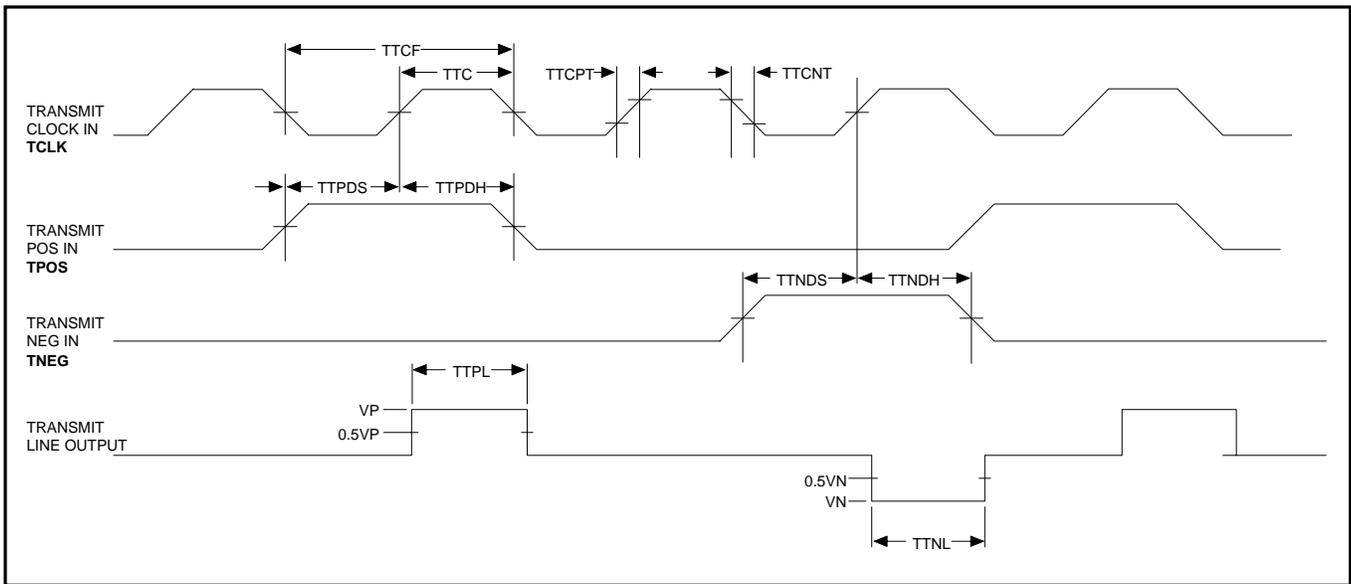
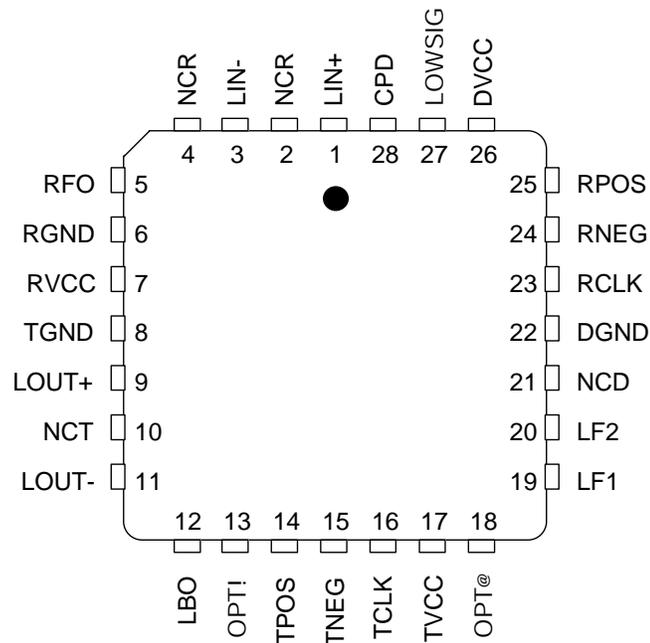


FIGURE 3: Transmit Waveforms

**PACKAGE PIN DESIGNATIONS**

(Top View)

CAUTION: Use handling procedures necessary for a static sensitive component.



**78P7200**  
**28-Pin PLCC**

**ORDERING INFORMATION**

PART DESCRIPTION	ORDER NUMBER	PACKAGE MARK
28-Pin PLCC, Silicon Revision A04	78P7200-IH	78P7200-IH xxxxxxP4
28-Pin PLCC – Lead-Free, Silicon Revision A04	78P7200-IH/F	78P7200-IH xxxxxxP4F

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