



AFE1105

HDSL/MDSL ANALOG FRONT END

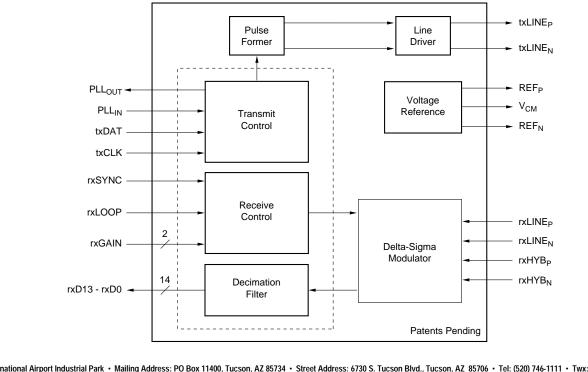
FEATURES

- COMPLETE ANALOG INTERFACE
- T1, E1, AND MDSL OPERATION
- CLOCK SCALEABLE SPEED
- SINGLE CHIP SOLUTION
- +5V ONLY (5V OR 3.3V DIGITAL)
- 250mW POWER DISSIPATION
- 48-PIN SSOP
- -40°C TO +85°C OPERATION

DESCRIPTION

Burr-Brown's Analog Front End greatly reduces the size and cost of an HDSL or MDSL system by providing all of the active analog circuitry needed to connect the Metalink MtH1210B HDSL digital signal processor to an external compromise hybrid and a 1:2.3 HDSL line transformer. All internal filter responses as well as the pulse former output scale with clock frequency—allowing the AFE1105 to operate over a range of bit rates from 196kbps to 1.168Mbps.

Functionally, this unit is separated into a transmit and a receive section. The transmit section generates, filters, and buffers outgoing 2B1Q data. The receive section filters and digitizes the symbol data received on the telephone line and passes it to the MtH1210B. The HDSL Analog Interface is a monolithic device fabricated on 0.6μ CMOS. It operates on a single +5V supply. It is housed in a 48-pin SSOP package.



International Airport Industrial Park • Mailing Address: PO Box 11400, Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd., Tucson, AZ 85706 • Tel: (520) 746-1111 • Twx: 910-952-1111 Internet: http://www.burr-brown.com/ • FAXLine: (800) 548-6133 (US/Canada Only) • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

SPECIFICATIONS

Typical at 25°C, AV_{DD} = +5V, DV_{DD} = +3.3V, f_{tx} = 584kHz (E1 rate), unless otherwise specified.

PARAMETER	COMMENTS	MIN	ТҮР	МАХ	UNITS
RECEIVE CHANNEL					
Number of Inputs	Differential	2			
Input Voltage Range	Balanced Differential ⁽¹⁾		±3.0		V
Common-Mode Voltage	1.5V CMV Recommended		+1.5		v
Input Impedance	All Inputs	See Tv	pical Performar	nce Curves	-
nput Capacitance		000 .)	10		pF
nput Gain Matching	Line Input vs Hybrid Input		±2		%
Resolution		14			Bits
Programmable Gain	Four Gains: 0dB, 3.25dB, 6dB, and 9dB	0		9	dB
Settling Time for Gain Change		0	6	3	Symbol
Setting Time for Gain Change			0		Periods
	Tastad at Each Oais Danas		-		
Gain + Offset Error	Tested at Each Gain Range	-	5	· ·	%FSR ⁽²⁾
Output Data Coding			wo's Compleme		
Dutput Data Rate, rxSYNC ⁽³⁾		98		584 ⁽⁴⁾	kHz
TRANSMIT CHANNEL					
Transmit Symbol Rate, f _{tx}		98		584(4)	kHz
T1 Transmit –3dB Point	Bellcore TA-NWT-3017 Compliant		196		kHz
T1 Rate Power Spectral Density ⁽⁵⁾		See Tv	pical Performar		KI IZ
E1 Transmit –3dB Point	ETSI RTR/TM-03036 Compliant	000 19	292		kHz
E1 Rate Power Spectral Density ⁽⁵⁾		See Tu	pical Performar		KI IZ
Transmit Power ⁽⁵⁾		13			dBm
		-	i		ubm
Pulse Output		See Ty	pical Performar	ice Curves	.,
Common-Mode Voltage, V _{CM}			AV _{DD} /2		V
Output Resistance ⁽⁶⁾	DC to 1MHz		1		Ω
TRANSCEIVER PERFORMANCE					
Uncancelled Echo ⁽⁷⁾	rxGAIN = 0dB, Loopback Enabled			-67	dB
	rxGAIN = 0dB, Loopback Disabled			-67	dB
	rxGAIN = 3.25dB, Loopback Disabled			-69	dB
	rxGAIN = 6dB, Loopback Disabled			-71	dB
	rxGAIN = 9dB, Loopback Disabled			-73	dB
					42
DIGITAL INTERFACE ⁽⁶⁾					
Logic Levels					
V _{IH}	I _{IH} < 10μΑ	DV _{DD} –1		DV _{DD} +0.3	V
V _{IL}	I _{IL} < 10μΑ	-0.3		+0.8	V
V _{OH}	I _{OH} = -20μA	DV _{DD} -0.5			V
V _{OL}	I _{OL} = 20μA			+0.4	V
Transmit/Receive Channel Interface					
t _{tx1}	txCLK Period	1.7		10.2	μs
t _{tx2}	txCLK Pulse Width	t _{tx1} /16		15t _{tx1} /16	ns
POWER				···	
	Creation		_		N/
Analog Power Supply Voltage	Specification	A 75	5	E 05	V
Analog Power Supply Voltage	Operating Range	4.75		5.25	V
Digital Power Supply Voltage	Specification		3.3		V
Digital Power Supply Voltage	Operating Range	3.15		5.25	V
Power Dissipation ^(4, 8)	$DV_{DD} = 3.3V$, 1:2 Line Transformer		250		mW
Power Dissipation ^(4, 8)	DV _{DD} = 5V, 1:2 Line Transformer		300		mW
PSRR		60			dB
TEMPERATURE RANGE					
Operating ⁽⁶⁾		-40		+85	°C
oporating	1	-40	1	,00	0

NOTES: (1) With a balanced differential signal, the positive input is 180° out of phase with the negative input, therefore the actual voltage swing about the common mode voltage on each pin is $\pm 1.5V$ to achieve a differential input range of $\pm 3.0V$ or 6Vp-p. (2) FSR is Full-Scale Range. (3) The output data is available at twice the symbol rate with interpolated values. (4) This specification does not apply to the AFE1105EA. (5) With a pseudo-random equiprobable sequence of HDSL pulses; 13.5dBm applied to the transformer (27dBm output from txLINE_P and txLINE_N). (6) Guaranteed by design and characterization. (7) Uncancelled Echo is a measure of the total analog errors in the transmitter and receiver sections including the effect of non-linearity and noise. See the Discussion of Specifications section of this data sheet for more information. (8) Power dissipation includes only the power dissipated within the component and does not include power dissipated in the external loads. The AFE1105 is tested with a 1:2 line transformer, but will typically be used with a 1:2.3 line transformer, this will slightly increase power dissipation.



PIN DESCRIPTIONS

Image: Second	PIN #	TYPE	NAME	DESCRIPTION
3 Input tbCLK Symbol Clock (MTLE from MtH1210B) (392kHz for T1, 584kHz for E1) 4 Ground DGND Digital Ground 5 Input bDAT XMTDA from MtH1210B 6 Output rxDO ADC Output Bit-3 7 Output rxDO ADC Output Bit-3 (RCVD1 from MtH1210B) 8 Output rxDA ADC Output Bit-3 (RCVD1 from MtH1210B) 10 Output rxDA ADC Output Bit-3 (RCVD1 from MtH1210B) 11 Output rxDA ADC Output Bit-3 (RCVD1 from MtH1210B) 12 Ground DGND Digital Ground 14 Output rxD6 ADC Output Bit-7 (RCVD1 from MtH1210B) 14 Output rxD6 ADC Output Bit-7 (RCVD1 from MtH1210B) 16 Output rxD9 ADC Output Bit-1 (RCVD1 from MtH1210B) 17 Output rxD1 ADC Output Bit-1 (RCVD1 from MtH1210B) 18 Output rxD14 ADC Output Bit-1 (RCVD1 from MtH1210B) 21 Output rxD13 ADC Output Bit-1 (RCVD1 from MtH1210B) <td>1</td> <td>Ground</td> <td>PGND</td> <td>Analog Ground for PLL</td>	1	Ground	PGND	Analog Ground for PLL
3 Input tbcLK Symbol Clock (XMTLE from MtH1210B) (392kHz for T1, 594kHz for E1) 4 Ground DGND Digital Ground XMTDA from MtH1210B 5 Input bDAT XMTDA from MtH1210B XMTDA from MtH1210B 6 Output rxD1 ADC Output Bit-1 RCVD1 from MtH1210B 8 Output rxD2 ADC Output Bit-3 (RCVD1 from MtH1210B) 10 Output rxD4 ADC Output Bit-3 (RCVD1 from MtH1210B) 11 Output rxD4 ADC Output Bit-3 (RCVD1 from MtH1210B) 12 Ground DGND Digital Ground 14 Output rxD6 ADC Output Bit-3 (RCVD4 from MtH1210B) 14 Output rxD6 ADC Output Bit-3 (RCVD6 from MtH1210B) 16 Output rxD6 ADC Output Bit-3 (RCVD6 from MtH1210B) 18 Output rxD1 ADC Output Bit-1 (RCVD6 from MtH1210B) 21 Output rxD13 ADC Output Bit-3 (RCVD1 from MtH1210B) 22 Input rxD14 ADC Cuput Bit-3 (RCVC0 from MtH1210B) 23 <td>2</td> <td>Power</td> <td>PV_{DD}</td> <td>Analog Supply (+5V) for PLL</td>	2	Power	PV _{DD}	Analog Supply (+5V) for PLL
5 Input bDAT XMTDA from MHH1210B 6 Output nxD1 ADC Output Bit-1 7 Output nxD1 ADC Output Bit-1 8 Output nxD2 ADC Output Bit-2 (RCVD0 from MH1210B) 9 Output nxD3 ADC Output Bit-3 (RCVD1 from MH1210B) 10 Output nxD4 ADC Output Bit-3 (RCVD1 from MH1210B) 11 Output nxD4 ADC Output Bit-4 (RCVD3 from MH1210B) 12 Ground DSND Digital Ground 13 Power D'voo Digital Ground 14 Output nxD6 ADC Output Bit-6 (RCVD4 from MH1210B) 16 Output nxD7 ADC Output Bit-6 (RCVD6 from MH1210B) 17 Output nxD1 ADC Output Bit-1 (RCVD6 from MH1210B) 18 Output nxD1 ADC Output Bit-1 (RCVD6 from MH1210B) 21 Output nxD11 ADC Output Bit-1 (RCVD6 from MH1210B) 22 Output nxD12 ADC Output Bit-1 (RCVD6 from MH1210B) 23 Input	3	Input		Symbol Clock (XMTLE from MtH1210B) (392kHz for T1, 584kHz for E1)
6 $Output$ rxD0ADC Output Bit-07OutputrxD1ADC Output Bit-18OutputrxD2ADC Output Bit-2 (RCVD0 from MtH1210B)9OutputrxD4ADC Output Bit-3 (RCVD1 from MtH1210B)10OutputrxD4ADC Output Bit-3 (RCVD2 from MtH1210B)11OutputrxD4ADC Output Bit-3 (RCVD2 from MtH1210B)12GroundDENDDigital Ground13PowerDVrp.Digital Ground14OutputrxD7ADC Output Bit-3 (RCVD4 from MtH1210B)15OutputrxD7ADC Output Bit-3 (RCVD4 from MtH1210B)16OutputrxD8ADC Output Bit-3 (RCVD7 from MtH1210B)17OutputrxD9ADC Output Bit-3 (RCVD7 from MtH1210B)18OutputrxD10ADC Output Bit-10 (RCVD8 from MtH1210B)19OutputrxD11ADC Output Bit-10 (RCVD8 from MtH1210B)20OutputrxD13ADC Output Bit-12 (RCVD1 from MtH1210B)21OutputrxD13ADC Output Bit-13 (RCVD1 from MtH1210B)22PowerDVrp.Digital Supply (+3.3V to +5V)23InputrxGAINOReceive Gain Control Bit-024InputrxGAINOReceive Gain Control Bit-11 (RCVG0 from MtH1210B)25InputrxGAINOReceive Gain Control Bit-11 (RCVG0 from MtH1210B)26InputrxGAINOReceive Gain Control Bit-10 (RCVG0 from MtH1210B)27PowerAVrp.Analog Supply (+50)28Input <td< td=""><td>4</td><td>Ground</td><td>DGND</td><td>Digital Ground</td></td<>	4	Ground	DGND	Digital Ground
7 $OrightrxD1ADC Output Bit-18OutputrxD2ADC Output Bit-2 (RCVD0 from MtH1210B)9OutputrxD3ADC Output Bit-3 (RCVD1 from MtH1210B)10OutputrxD5ADC Output Bit-4 (RCVD2 from MtH1210B)11OutputrxD5ADC Output Bit-4 (RCVD2 from MtH1210B)12GroundDGNDDigital Ground13PowerDVODDigital Ground14OutputrxD6ADC Output Bit-6 (RCVD4 from MtH1210B)15OutputrxD7ADC Output Bit-7 (RCVD5 from MtH1210B)16OutputrxD8ADC Output Bit-7 (RCVD5 from MtH1210B)17OutputrxD10ADC Output Bit-7 (RCVD5 from MtH1210B)19OutputrxD11ADC Output Bit-1 (RCVD2 from MtH1210B)19OutputrxD11ADC Output Bit-1 (RCVD4 from MtH1210B)21OutputrxD12ADC Output Bit-13 (RCVD1 from MtH1210B)22PowerDVDDDigital Supply (+3.3V to +5V)23InputrxGAIN0Receive Gain Control Bit-024InputrxGAIN1Receive Gain Control Bit-025InputrxtGAIN1Receive Gain Control Bit-026InputrxtGAIN1Receive Gain Control Bit-127PowerAVDDAnalog Ground38GroundAGNDAnalog Ground39InputrxtHVBNNegative Inen Input31InputrxtHVBNNegative Reference Output, Nominally 3.5V36Ou$	5	Input	txDAT	XMTDA from MtH1210B
8 $Output$ $rxD2$ ADC Output Bit-2 (RCVD0 from MH1210B)9 $Output$ $rxD4$ ADC Output Bit-4 (RCVD2 from MH1210B)10 $Output$ $rxD4$ ADC Output Bit-4 (RCVD2 from MH1210B)11 $Output$ $rxD4$ ADC Output Bit-5 (RCVD3 from MH1210B)12 $Ground$ DGNDDigital Ground13PowerDVopDigital Supply (43.3V to 45V)14Output $rxD6$ ADC Output Bit-7 (RCVD5 from MH1210B)15Output $rxD6$ ADC Output Bit-7 (RCVD5 from MH1210B)16Output $rxD7$ ADC Output Bit-7 (RCVD5 from MH1210B)17Output $rxD9$ ADC Output Bit-7 (RCVD5 from MH1210B)18Output $rxD14$ ADC Output Bit-10 (RCVD7 from MH1210B)19Output $rxD14$ ADC Output Bit-10 (RCVD6 from MH1210B)20Output $rxD14$ ADC Output Bit-10 (RCVD6 from MH1210B)21Output $rxD13$ ADC Output Bit-10 (RCVD6 from MH1210B)22PowerDVopDigital Supply (43.3V to 45V)23Input $rxGAIN0$ Receive Gain Control Bit-024Input $rxGAIN0$ Receive Gain Control Bit-025Input $rxGAIN0$ Receive Gain Control Bit-026Input $rxGAIN0$ Receive Gain Control Bit-027PowerAVopAnalog Supply (45V)28Input $rxLNE_P$ Positive Input from Hybrid Network29Input $rxLNE_P$ Positive Input31Input r	6	Output	rxD0	ADC Output Bit-0
9 Output rxD3 ADC Output Bit-3 (RCVD1 from MtH1210B) 10 Output rxD4 ADC Output Bit-4 (RCVD2 from MtH1210B) 11 Output rxD5 ADC Output Bit-6 (RCVD2 from MtH1210B) 12 Ground DCND Digital Ground 13 Power DV ₀₀ Digital Ground 14 Output rxD6 ADC Output Bit-6 (RCVD4 from MtH1210B) 16 Output rxD8 ADC Output Bit-7 (RCVD5 from MtH1210B) 16 Output rxD9 ADC Output Bit-7 (RCVD5 from MtH1210B) 17 Output rxD10 ADC Output Bit-10 (RCVD6 from MtH1210B) 18 Output rxD11 ADC Output Bit-13 (RCVD1 from MtH1210B) 20 Output rxD13 ADC Output Bit-3 (RCVD1 from MtH1210B) 21 Output rxD13 ADC Coutput Bit-13 (RCVD1 from MtH1210B) 22 Input rxSTNC ADC Sync Signal (RCVCK from MtH1210B) 23 Input rxSTNC ADC Sync Signal (RCVCK from MtH1210B) 24 Input rxGAIN0 Receive Gain Control	7	Output	rxD1	ADC Output Bit-1
10Output $pD4$ ADC Output Bit-4 (RCVD2 from MtH1210B)11Output $rxD5$ ADC Output Bit-5 (RCVD3 from MtH1210B)12GroundDGNDDigital Ground13Power DV_{p0} Digital Supply (+3.3V to 45V)14Output $rxD6$ ADC Output Bit-7 (RCVD5 from MtH1210B)15Output $rxD7$ ADC Output Bit-7 (RCVD5 from MtH1210B)16Output $rxD7$ ADC Output Bit-7 (RCVD6 from MtH1210B)17Output $rxD9$ ADC Output Bit-7 (RCVD6 from MtH1210B)18Output $rxD1$ ADC Output Bit-10 (RCVD6 from MtH1210B)20Output $rxD1$ ADC Output Bit-11 (RCVD6 from MtH1210B)21Output $rxD1$ ADC Output Bit-12 (RCVD1 from MtH1210B)22Power DV_{p0} Digital Supply (+3.3V to +5V)23Input $rxSYRC$ ADC Sync Signal (RCVCK from MtH1210B)24Input $rxGAIN1$ Receive Gain Control Bit-1 (RCVG0 from MtH1210B)25Input $rxGAIN1$ Receive Gain Control Bit-1 (RCVG0 from MtH1210B)24Input $rxGAIN1$ Receive Gain Control Bit-1 (RCVG0 from MtH1210B)25Input $rxGAIN1$ Receive Gain Control Bit-1 (RCVG0 from MtH1210B)26Input $rxGAIN1$ Receive Gain Control Bit-1 (RCVG0 from MtH1210B)27PowerAV _{p0} Analog Supply (+5V)28Input $rxHYB_N$ Negative Input from Hybrid Network30Input $rxHYB_N$ Negative Input from Hybrid Network <t< td=""><td>8</td><td>Output</td><td>rxD2</td><td>ADC Output Bit-2 (RCVD0 from MtH1210B)</td></t<>	8	Output	rxD2	ADC Output Bit-2 (RCVD0 from MtH1210B)
11 Output rxD5 ADC Output Bit-5 (RCVD3 from MtH1210B) 12 Ground DGND Digital Supply (+3.3V to +5V) 13 Power DV _{DD} Digital Supply (+3.3V to +5V) 14 Output rxD6 ADC Output Bit-6 (RCVD4 from MtH1210B) 15 Output rxD7 ADC Output Bit-6 (RCVD6 from MtH1210B) 16 Output rxD8 ADC Output Bit-10 (RCVD6 from MtH1210B) 17 Output rxD10 ADC Output Bit-10 (RCVD6 from MtH1210B) 18 Output rxD11 ADC Output Bit-12 (RCVD1 from MtH1210B) 20 Output rxD12 ADC Output Bit-12 (RCVD1 from MtH1210B) 21 Output rxD13 ADC Output Bit-13 (RCVD1 from MtH1210B) 22 Power DV _{OD} Digital Supply (+3.3V to +5V) 23 Input rxSAINO Receive Gain Control Bit-0 24 Input rxGAIN1 Receive Gain Control Bit-0 25 Input rxGAIN1 Receive Gain Control Bit-0 26 Input rxGAIN1 Regative Input from Hybrid	9	Output	rxD3	ADC Output Bit-3 (RCVD1 from MtH1210B)
12Gründ GründDGND Digital GründDigital Gründ13Power PowerDV _{DD} Digital Supply (+3.3V to +5V)14Output rxD6 ADC Output Bit-6 (RCVD4 from MtH1210B)15Output rxD7ADC Output Bit-7 (RCVD5 from MtH1210B)16Output rxD9 aDC Output Bit-12 (RCVD6 from MtH1210B)17Output rxD10 aDC Output Bit-11 (RCVD9 from MtH1210B)18Output rxD11 aDC Output Bit-11 (RCVD9 from MtH1210B)20Output rxD12 aDC Output Bit-11 (RCVD9 from MtH1210B)21Output rxD13 aDC Output Bit-11 (RCVD9 from MtH1210B)22Power Power23Input rxSYNC aNGAIN0 c24Input rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN125Input rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN0 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN1 rxGAIN1 rxGAIN1 rxGAIN1 rxGAIN1 rxGAIN1 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN2 rxGAIN1 rxGAIN3 	10	Output	rxD4	ADC Output Bit-4 (RCVD2 from MtH1210B)
13Power DV_{0D} Digital Supply (+3.3V to +5V)14OutputrxD6ADC Output Bit-6 (RCVD4 from MtH1210B)15OutputrxD7ADC Output Bit-6 (RCVD6 from MtH1210B)16OutputrxD8ADC Output Bit-9 (RCVD7 from MtH1210B)17OutputrxD9ADC Output Bit-9 (RCVD7 from MtH1210B)18OutputrxD10ADC Output Bit-10 (RCVD6 from MtH1210B)19OutputrxD11ADC Output Bit-10 (RCVD7 from MtH1210B)20OutputrxD12ADC Output Bit-11 (RCVD9 from MtH1210B)21OutputrxD13ADC Output Bit-13 (RCVD11 from MtH1210B)22PowerDV_{0D}Digital Supply (+3.3V to +5V)23InputrxGNNCADC Sync Signal (RCVCK from MtH1210B)24InputrxGAIN1Receive Gain Control Bit-025InputrxGAIN1Receive Gain Control Bit-026InputrxLOOPLoopback Control Signal (loopback is enabled by positive signal)27PowerAV _{DD} Analog Supply (+5V)28InputrxHVB _P Positive Input from Hybrid Network29InputrxHVB _P Positive Input from Hybrid Network31InputrxLINE _P Positive Reference Output, Nominally 3.5V35OutputV _{CM} Common-Mode Voltage (buffered), Nominally 2.5V36OutputREF _P Positive Reference Output, Nominally 3.5V37PowerAV _{DD} Analog Ground38GroundAGNDAnalog Supply	11	Output	rxD5	ADC Output Bit-5 (RCVD3 from MtH1210B)
14Output $nD0$ ADC Output Bit-6 (RCVD4 from MtH1210B)15 $Output$ $nD7$ ADC Output Bit-7 (RCVD5 from MtH1210B)16 $Output$ $nD7$ ADC Output Bit-6 (RCVD6 from MtH1210B)17 $Output$ $nD9$ ADC Output Bit-6 (RCVD6 from MtH1210B)18 $Output$ $nD10$ ADC Output Bit-10 (RCVD7 from MtH1210B)19 $Output$ $nD11$ ADC Output Bit-12 (RCVD1 from MtH1210B)20 $Output$ $nD11$ ADC Output Bit-12 (RCVD1 from MtH1210B)21 $Output$ $nD20$ $Digital Supply (+3.3V to +5V)$ 23 $Input$ $rxSYNC$ $ADC Sync Signal (RCVCK from MtH1210B) (392kHz for T1, 584kHz for E1)24InputrxGAINI0Receive Gain Control Bit-025InputrxGAINI0Receive Gain Control Bit-026InputrxLOOPLoopback Control Signal (loopback is enabled by positive signal)27PowerAV_{D0}Analog Supply (+5V)28InputrxHYB_PPositive Input from Hybrid Network29InputrxLINE_NNegative Input from Hybrid Network31InputrxLINE_PPositive Line Input33GroundAGNDAnalog Ground34OutputREF_PPositive Reference Output, Nominally 3.5V35OutputREF_PPositive Reference Output, Nominally 2.5V36OutputREF_PPositive Reference Output, Nominally 2.5V37PowerAV_{D0}Analog Ground<$	12	Ground	DGND	Digital Ground
15OutputrxD7ADC Output Bit-7 (RCVD5 from MtH1210B)16OutputrxD8ADC Output Bit-8 (RCVD6 from MtH1210B)17OutputrxD10ADC Output Bit-9 (RCVD7 from MtH1210B)18OutputrxD11ADC Output Bit-10 (RCVD8 from MtH1210B)19OutputrxD12ADC Output Bit-10 (RCVD8 from MtH1210B)20OutputrxD12ADC Output Bit-11 (RCVD9 from MtH1210B)21OutputrxD12ADC Output Bit-13 (RCVD11 from MtH1210B)22PowerDVpoDigital Suppl (+3.3V to +5V)23InputrxSYNCADC Sync Signal (RCVCK from MtH1210B) (392kHz for T1, 584kHz for E1)24InputrxGAIN1Receive Gain Control Bit-025InputrxGAIN1Receive Gain Control Bit-1 (RCVG0 from MtH1210B)26InputrxHVB _N Negative Input from Hybrid Network29InputrxHVB _N Negative Input from Hybrid Network30InputrxHVB _N Negative Input from Hybrid Network31InputrxLINE _P Positive Input from Hybrid Network33GroundAGNDAnalog Ground34OutputREFPPositive Reference Output, Nominally 3.5V35OutputRCMDAnalog Supply (+5V)36OutputREFPPositive Reference Output, Nominally 2.5V36OutputREFPAnalog Supply (+5V)37PowerAVpoAnalog Supply (+5V)38GroundAGNDAnalog Supply (+5V)39 <td>13</td> <td>Power</td> <td>DV_{DD}</td> <td>Digital Supply (+3.3V to +5V)</td>	13	Power	DV _{DD}	Digital Supply (+3.3V to +5V)
16OutputrxD8ADC Output Bil-8 (RCVD6 from MtH1210B)17OutputrxD9ADC Output Bil-19 (RCVD7 from MtH1210B)18OutputrxD10ADC Output Bil-10 (RCVD8 from MtH1210B)19OutputrxD11ADC Output Bil-11 (RCVD8 from MtH1210B)20OutputrxD12ADC Output Bil-12 (RCVD10 from MtH1210B)21OutputrxD13ADC Output Bil-13 (RCVD11 from MtH1210B)22PowerDVppDigital Supply (+3.3V to +5V)23InputrxGAIN0Receive Gain Control Bil-024InputrxGAIN1Receive Gain Control Bil-1 (RCVC0 from MtH1210B)25InputrxGAIN1Receive Gain Control Bil-1 (RCVC0 from MtH1210B)26InputrxGAIN1Receive Gain Control Bil-1 (RCVC0 from MtH1210B)27PowerAVppAnalog Supply (+5V)28InputrxHYB _P Negative Input from Hybrid Network30InputrxLINE _N Negative Line Input31InputrxLINE _P Positive Input from Hybrid Network33GroundAGNDAnalog Ground34OutputREF _P Positive Ine Input35OutputVCMCommon-Mode Voltage (buffered), Nominally 3.5V36OutputREF _P Positive Reference Output, Nominally 1.5V37PowerAVppAnalog Ground38GroundAGNDAnalog Ground39OutputKLINE _P Transmit Line Output Negative40PowerAVpp <t< td=""><td>14</td><td>Output</td><td>rxD6</td><td>ADC Output Bit-6 (RCVD4 from MtH1210B)</td></t<>	14	Output	rxD6	ADC Output Bit-6 (RCVD4 from MtH1210B)
17OutputrxD9ADC Output Bit-9 (RCVD7 from MtH1210B)18OutputrxD10ADC Output Bit-10 (RCVD8 from MtH1210B)19OutputrxD11ADC Output Bit-11 (RCVD9 from MtH1210B)20OutputrxD12ADC Output Bit-13 (RCVD9 from MtH1210B)21OutputrxD13ADC Output Bit-13 (RCVD11 from MtH1210B)22PowerDV _{DD} Digital Supply (+3.3V to +5V)23InputrxSYNCADC Sync Signal (RCVCK from MtH1210B) (392kHz for T1, 584kHz for E1)24InputrxGAIN0Receive Gain Control Bit-1 (RCVG0 from MtH1210B)25InputrxGAIN0Receive Gain Control Bit-1 (RCVG0 from MtH1210B)26InputrxLOOPLoopback Control Signal (loopback is enabled by positive signal)27PowerAV _{DD} Analog Supply (+5V)28InputrxHYBpPositive Input from Hybrid Network29InputrxHYBpPositive Input from Hybrid Network30InputrxLINErNegative Line Input31InputrxLINErPositive Reference Output, Nominally 3.5V35OutputV _{CM} Common-Mode Voltage (buffered), Nominally 2.5V36OutputREF _P Negative Reference Output, Nominally 1.5V38GroundAGNDAnalog Supply (+5V)38GroundAGNDAnalog Supply (+5V)41OutputttLINErTransmit Line Output Negative42GroundAGNDAnalog Supply (+5V)41OutputttLINEr <td>15</td> <td>Output</td> <td>rxD7</td> <td>ADC Output Bit-7 (RCVD5 from MtH1210B)</td>	15	Output	rxD7	ADC Output Bit-7 (RCVD5 from MtH1210B)
18OutputrxD10ADC Output Bit-10 (RCVD8 from MtH1210B)19OutputrxD11ADC Output Bit-12 (RCVD10 from MtH1210B)20OutputrxD13ADC Output Bit-13 (RCVD11 from MtH1210B)21OutputrxD13ADC Output Bit-13 (RCVD11 from MtH1210B)22PowerDVppDigital Supply (+3.3V to +5V)23InputrxGAIN0Receive Gain Control Bit-024InputrxGAIN1Receive Gain Control Bit-1025InputrxGAIN1Receive Gain Control Bit-1 (RCVG0 from MtH1210B)26InputrxGAN0Receive Gain Control Bit-1 (RCVG0 from MtH1210B)27PowerAVppAnalog Supply (+5V)28InputrxHYB _N Negative Input from Hybrid Network29InputrxLINE _P Positive Input from Hybrid Network30InputrxLINE _P Positive Input from Hybrid Network31InputrxLINE _P Positive Input from Hybrid Network33GroundAGNDAnalog Ground34OutputREFPPositive Reference Output, Nominally 3.5V35OutputVCMCommon-Mode Voltage (buffered), Nominally 2.5V36OutputREFPNegative Reference Output, Nominally 1.5V37PowerAVpDAnalog Ground38GroundAGNDAnalog Ground39OutputttLINE _N Transmit Line Output Negative41OutputttLINE _P Transmit Line Output Negative42Ground	16	Output	rxD8	ADC Output Bit-8 (RCVD6 from MtH1210B)
19OutputrxD11ADC Output Bit-11 (RCVD9 from MtH1210B)20OutputrxD12ADC Output Bit-12 (RCVD10 from MtH1210B)21OutputrxD13ADC Output Bit-13 (RCVD11 from MtH1210B)22PowerDV _{DD} Digital Supply (+3.3V to +5V)23InputrxSYNCADC Sync Signal (RCVCK from MtH1210B) (392kHz for T1, 584kHz for E1)24InputrxGAIN0Receive Gain Control Bit-025InputrxLOOPLoopback Control Signal (loopback is enabled by positive signal)26InputrxLNEPAnalog Supply (+5V)28InputrxHYB _P Negative Input from Hybrid Network29InputrxHYB _P Positive Line Input30InputrxLINE _N Negative Line Input31InputrxLINE _N Negative Reference Output, Nominally 3.5V33GroundAGNDAnalog Ground34OutputREF _P Analog Supply (+5V)35OutputREF _N Negative Reference Output, Nominally 2.5V36OutputREF _N Negative Reference Output, Nominally 2.5V37PowerAV _{DD} Analog Ground38GroundAGNDAnalog Supply (+5V)41OutputtkLINE _N Transmit Line Output Negative42GroundAGNDAnalog Supply (+5V)43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Rec	17	Output	rxD9	ADC Output Bit-9 (RCVD7 from MtH1210B)
20OutputrxD12ADC Output Bit-12 (RCVD10 from MtH1210B)21OutputrxD13ADC Output Bit-13 (RCVD11 from MtH1210B)22PowerDVppDigital Supply (+3.3V to +5V)23InputrxSVNCADC Sync Signal (RCVCK from MtH1210B) (392kHz for T1, 584kHz for E1)24InputrxGAIN0Receive Gain Control Bit-025InputrxGAIN1Receive Gain Control Bit-1 (RCVG0 from MtH1210B)26InputrxLOOPLoopback Control Signal (loopback is enabled by positive signal)27PowerAVppAnalog Supply (+5V)28InputrxHYB _N Negative Input from Hybrid Network29InputrxLINE _N Negative Input from Hybrid Network30InputrxLINE _N Negative Line Input31InputrxLINE _P Positive Line Input32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREF _P Positive Reference Output, Nominally 3.5V35OutputREF _P Negative Reference Output, Nominally 1.5V36OutputKLINE _P Transmit Line Output Negative40PowerAVppAnalog Ground39OutputKLINE _P Transmit Line Output Negative40PowerAVppAnalog Supply (+5V)41OutputKLINE _P Transmit Line Output Negative40PowerAVppAnalog Supply (+5V)41OutputKLINE _P Transmit Line	18	Output	rxD10	ADC Output Bit-10 (RCVD8 from MtH1210B)
21OutputrxD13ADC Output Bit-13 (RCVD11 from MtH1210B)22PowerDV _{DD} Digital Supply (+3.3V to +5V)23InputrxSYNCADC Sync Signal (RCVCK from MtH1210B) (392kHz for T1, 584kHz for E1)24InputrxGAINOReceive Gain Control Bit-025InputrxGAIN1Receive Gain Control Bit-1 (RCVG0 from MtH1210B)26InputrxLOOPLoopback Control Signal (loopback is enabled by positive signal)27PowerAV _{DD} Analog Supply (+SV)28InputrxHYB _P Negative Input from Hybrid Network29InputrxLINE _P Positive Input from Hybrid Network30InputrxLINE _P Positive Line Input31InputrxLINE _P Positive Line Input32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREF _P Positive Reference Output, Nominally 3.5V35OutputREF _P Negative Reference Output, Nominally 2.5V36OutputREF _N Negative Reference Output, Nominally 1.5V37PowerAV _{DD} Analog Ground38GroundAGNDAnalog Supply (+5V)41OutputtxLINE _P Transmit Line Output Negative40PowerAV _{DD} Analog Supply (+5V)41OutputtxLINE _P Transmit Line Output Negative42GroundAGNDAnalog Supply (+5V)41OutputtxLINE _P Transmit Line	19	Output	rxD11	ADC Output Bit-11 (RCVD9 from MtH1210B)
22Power DV_{DD} Digital Supply (+3.3V to +5V)23InputrxSYNCADC Sync Signal (RCVCK from MtH1210B) (392kHz for T1, 584kHz for E1)24InputrxGAIN0Receive Gain Control Bit-025InputrxGAIN1Receive Gain Control Bit-1 (RCVG0 from MtH1210B)26InputrxLOOPLoopback Control Signal (loopback is enabled by positive signal)27Power AV_{DD} Analog Supply (+5V)28InputrxHYB _P Positive Input from Hybrid Network29InputrxHINE _N Negative Line Input31InputrxLINE _P Positive Line Input33GroundAGNDAnalog Ground34OutputREF _P Positive Reference Output, Nominally 3.5V36OutputREF _N Negative Reference Output, Nominally 2.5V36OutputREF _N Negative Reference Output, Nominally 1.5V37PowerAV _{DD} Analog Ground38GroundAGNDAnalog Supply (+5V)34OutputttLINE _N Transmit Line Output Negative40PowerAV _{DD} Analog Supply (+5V)41OutputttLINE _N Transmit Line Output Negative43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	20	Output	rxD12	ADC Output Bit-12 (RCVD10 from MtH1210B)
23InputrxSYNCADC Sync Signal (RCVCK from MtH1210B) (392kHz for T1, 584kHz for E1)24InputrxGAIN0Receive Gain Control Bit-025InputrxGAIN1Receive Gain Control Bit-1 (RCVG0 from MtH1210B)26InputrxLOOPLoopback Control Signal (loopback is enabled by positive signal)27PowerAV _{DD} Analog Supply (+5V)28InputrxHVB _P Negative Input from Hybrid Network29InputrxLINE _P Positive Input from Hybrid Network30InputrxLINE _P Positive Input from Hybrid Network31InputrxLINE _P Positive Line Input32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREF _P Positive Reference Output, Nominally 3.5V35OutputV _{CM} Common-Mode Voltage (buffered), Nominally 2.5V36OutputREF _N Analog Supply (+5V)37PowerAV _{DD} Analog Supply (+5V)38GroundAGNDAnalog Supply (+5V)39OutputtxLINE _N Transmit Line Output Negative40PowerAV _{OD} Analog Supply (+5V)41OutputtxLINE _P Transmit Line Output Negative42GroundAGNDAnalog Supply (+5V)41OutputtxLINE _N Transmit Line Output Negative40PowerAV _{OD} Analog Supply (+5V)41OutputtxLINE _P Transmit Line Output Negati	21	Output	rxD13	ADC Output Bit-13 (RCVD11 from MtH1210B)
23InputrxSYNCADC Sync Signal (RCVCK from MtH1210B) (392kHz for T1, 584kHz for E1)24InputrxGAIN0Receive Gain Control Bit-025InputrxGAIN1Receive Gain Control Bit-1 (RCVG0 from MtH1210B)26InputrxLOOPLoopback Control Signal (loopback is enabled by positive signal)27PowerAV _{DD} Analog Supply (+5V)28InputrxHVB _P Negative Input from Hybrid Network29InputrxLINE _P Positive Input from Hybrid Network30InputrxLINE _P Positive Input from Hybrid Network31InputrxLINE _P Positive Line Input32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREF _P Positive Reference Output, Nominally 3.5V35OutputV _{CM} Common-Mode Voltage (buffered), Nominally 2.5V36OutputREF _N Analog Supply (+5V)37PowerAV _{DD} Analog Supply (+5V)38GroundAGNDAnalog Supply (+5V)39OutputtxLINE _N Transmit Line Output Negative40PowerAV _{OD} Analog Supply (+5V)41OutputtxLINE _P Transmit Line Output Negative42GroundAGNDAnalog Supply (+5V)41OutputtxLINE _N Transmit Line Output Negative40PowerAV _{OD} Analog Supply (+5V)41OutputtxLINE _P Transmit Line Output Negati	22	Power	DV _{DD}	Digital Supply (+3.3V to +5V)
25InputrxGAIN1Receive Gain Control Bit-1 (RCVG0 from MtH1210B)26InputrxLOOPLoopback Control Signal (loopback is enabled by positive signal)27PowerAV _{DD} Analog Supply (+5V)28InputrxHYB _N Negative Input from Hybrid Network29InputrxHYB _P Positive Input from Hybrid Network30InputrxLINE _P Positive Input from Hybrid Network31InputrxLINE _P Positive Line Input32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREF _P Positive Reference Output, Nominally 3.5V35OutputREF _N Negative Reference Output, Nominally 2.5V36OutputREF _N Negative Reference Output, Nominally 1.5V38GroundAGNDAnalog Ground39OutputtxLINE _N Transmit Line Output Positive40PowerAV _{DD} Analog Supply (+5V)41OutputtxLINE _N Transmit Line Output Positive42GroundAGNDAnalog Supply (+5V)41OutputtxLINE _P Transmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended	23	Input		ADC Sync Signal (RCVCK from MtH1210B) (392kHz for T1, 584kHz for E1)
26InputrxLOOPLoopback Control Signal (loopback is enabled by positive signal)27PowerAV _{DD} Analog Supply (+SV)28InputrxHYB _N Negative Input from Hybrid Network29InputrxHYB _P Positive Line Input from Hybrid Network30InputrxLINE _N Negative Line Input31InputrxLINE _P Positive Line Input32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREF _P Positive Reference Output, Nominally 3.5V35OutputV _{CM} Common-Mode Voltage (buffered), Nominally 2.5V36OutputREF _N Negative Reference Output, Nominally 1.5V37PowerAV _{DD} Analog Ground39OutputtxLINE _P Transmit Line Output Negative40PowerAV _{DD} Analog Supply (+5V)41OutputtxLINE _P Transmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	24	Input	rxGAIN0	Receive Gain Control Bit-0
27Power AV_{DD} Analog Supply (+5V)28InputrxHYB _N Negative Input from Hybrid Network29InputrxHYB _P Positive Input from Hybrid Network30InputrxLINE _N Negative Line Input31InputrxLINE _P Positive Line Input32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREF _P Positive Reference Output, Nominally 3.5V35OutputREF _N Negative Reference Output, Nominally 1.5V36OutputREF _N Negative Reference Output, Nominally 1.5V37PowerAV _{DD} Analog Ground39OutputtxLINE _N Transmit Line Output Negative40PowerAV _{DD} Analog Supply (+5V)41OutputtxLINE _P Transmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	25	Input	rxGAIN1	Receive Gain Control Bit-1 (RCVG0 from MtH1210B)
28InputrxHYBNNegative Input from Hybrid Network29InputrxHYBpPositive Input from Hybrid Network30InputrxLINENNegative Line Input31InputrxLINEpPositive Line Input32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREFpPositive Reference Output, Nominally 3.5V35OutputVCMCommon-Mode Voltage (buffered), Nominally 2.5V36OutputREFnNegative Reference Output, Nominally 1.5V37PowerAV _{DD} Analog Ground39OutputtxLINEnTransmit Line Output Negative40PowerAV _{DD} Analog Supply (+5V)41OutputtxLINEpTransmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	26	Input	rxLOOP	Loopback Control Signal (loopback is enabled by positive signal)
29InputrxHYBpPositive Input from Hybrid Network30InputrxLINENNegative Line Input31InputrxLINEpPositive Line Input32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREFpPositive Reference Output, Nominally 3.5V35OutputREFNNegative Reference Output, Nominally 2.5V36OutputREFNNegative Reference Output, Nominally 1.5V37PowerAVDDAnalog Supply (+5V)38GroundAGNDAnalog Supply (+5V)39OutputtxLINENTransmit Line Output Negative40PowerAVDDAnalog Supply (+5V)41OutputtxLINEPTransmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	27	Power	AV _{DD}	Analog Supply (+5V)
30InputrxLINENNegative Line Input31InputrxLINEPPositive Line Input32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREFPPositive Reference Output, Nominally 3.5V35OutputV _{CM} Common-Mode Voltage (buffered), Nominally 2.5V36OutputREFNNegative Reference Output, Nominally 1.5V37PowerAV _{DD} Analog Ground38GroundAGNDAnalog Ground39OutputtxLINENTransmit Line Output Negative40PowerAV _{DD} Analog Supply (+5V)41OutputtxLINEPTransmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	28	Input	rxHYB _N	Negative Input from Hybrid Network
31InputrxLINEpPositive Line Input32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREFpPositive Reference Output, Nominally 3.5V35OutputV _{CM} Common-Mode Voltage (buffered), Nominally 2.5V36OutputREFNNegative Reference Output, Nominally 1.5V37PowerAV _{DD} Analog Supply (+5V)38GroundAGNDAnalog Ground39OutputtxLINENTransmit Line Output Negative40PowerAV _{DD} Analog Supply (+5V)41OutputtxLINEpTransmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	29	Input	rxHYB _P	Positive Input from Hybrid Network
32GroundAGNDAnalog Ground33GroundAGNDAnalog Ground34OutputREFpPositive Reference Output, Nominally 3.5V35OutputV _{CM} Common-Mode Voltage (buffered), Nominally 2.5V36OutputREFNNegative Reference Output, Nominally 1.5V37PowerAV _{DD} Analog Ground38GroundAGNDAnalog Supply (+5V)38GroundAGNDAnalog Ground39OutputtxLINENTransmit Line Output Negative40PowerAV _{DD} Analog Supply (+5V)41OutputtxLINEpTransmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	30	Input	rxLINE _N	Negative Line Input
33GroundAGNDAnalog Ground34OutputREFpPositive Reference Output, Nominally 3.5V35OutputV _{CM} Common-Mode Voltage (buffered), Nominally 2.5V36OutputREFNNegative Reference Output, Nominally 1.5V37PowerAV _{DD} Analog Supply (+5V)38GroundAGNDAnalog Ground39OutputtxLINENTransmit Line Output Negative40PowerAV _{DD} Analog Supply (+5V)41OutputtxLINEpTransmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCNCConnection to Ground Recommended	31	Input	rxLINE _P	Positive Line Input
34OutputREFpPositive Reference Output, Nominally 3.5V35OutputV _{CM} Common-Mode Voltage (buffered), Nominally 2.5V36OutputREFNNegative Reference Output, Nominally 1.5V37PowerAV _{DD} Analog Supply (+5V)38GroundAGNDAnalog Ground39OutputtxLINENTransmit Line Output Negative40PowerAV _{DD} Analog Supply (+5V)41OutputtxLINEPTransmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCNCConnection to Ground Recommended	32	Ground	AGND	Analog Ground
35OutputV _{CM} Common-Mode Voltage (buffered), Nominally 2.5V36OutputREF _N Negative Reference Output, Nominally 1.5V37PowerAV _{DD} Analog Supply (+5V)38GroundAGNDAnalog Ground39OutputtxLINE _N Transmit Line Output Negative40PowerAV _{DD} Analog Supply (+5V)41OutputtxLINE _P Transmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	33	Ground	AGND	Analog Ground
36 Output REF _N Negative Reference Output, Nominally 1.5V 37 Power AV _{DD} Analog Supply (+5V) 38 Ground AGND Analog Ground 39 Output txLINE _N Transmit Line Output Negative 40 Power AV _{DD} Analog Supply (+5V) 41 Output txLINE _P Transmit Line Output Positive 42 Ground AGND Analog Ground 43 NC NC Connection to Ground Recommended 44 NC NC Connection to Ground Recommended 45 NC NC Connection to Ground Recommended 46 NC NC Connection to Ground Recommended	34	Output	REFP	Positive Reference Output, Nominally 3.5V
37 Power AV _{DD} Analog Supply (+5V) 38 Ground AGND Analog Ground 39 Output txLINE _N Transmit Line Output Negative 40 Power AV _{DD} Analog Supply (+5V) 41 Output txLINE _P Transmit Line Output Positive 42 Ground AGND Analog Ground 43 NC NC Connection to Ground Recommended 44 NC NC Connection to Ground Recommended 45 NC NC Connection to Ground Recommended 46 NC NC Connection to Ground Recommended	35	Output	V _{CM}	Common-Mode Voltage (buffered), Nominally 2.5V
38 Ground AGND Analog Ground 39 Output txLINE _N Transmit Line Output Negative 40 Power AV _{DD} Analog Supply (+5V) 41 Output txLINE _P Transmit Line Output Positive 42 Ground AGND Analog Ground 43 NC NC Connection to Ground Recommended 44 NC NC Connection to Ground Recommended 45 NC NC Connection to Ground Recommended 46 NC NC Connection to Ground Recommended	36	Output	REFN	Negative Reference Output, Nominally 1.5V
39 Output txLINE _N Transmit Line Output Negative 40 Power AV _{DD} Analog Supply (+5V) 41 Output txLINE _P Transmit Line Output Positive 42 Ground AGND Analog Ground 43 NC NC Connection to Ground Recommended 44 NC NC Connection to Ground Recommended 45 NC NC Connection to Ground Recommended 46 NC NC Connection to Ground Recommended	37	Power	AV _{DD}	Analog Supply (+5V)
40 Power AV _{DD} Analog Supply (+5V) 41 Output txLINE _P Transmit Line Output Positive 42 Ground AGND Analog Ground 43 NC NC Connection to Ground Recommended 44 NC NC Connection to Ground Recommended 45 NC NC Connection to Ground Recommended 46 NC NC Connection to Ground Recommended	38	Ground	AGND	Analog Ground
40 Power AV _{DD} Analog Supply (+5V) 41 Output txLINE _P Transmit Line Output Positive 42 Ground AGND Analog Ground 43 NC NC Connection to Ground Recommended 44 NC NC Connection to Ground Recommended 45 NC NC Connection to Ground Recommended 46 NC NC Connection to Ground Recommended	39	Output	txLINE _N	Transmit Line Output Negative
41OutputtxLINEPTransmit Line Output Positive42GroundAGNDAnalog Ground43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	40	Power	AV _{DD}	Analog Supply (+5V)
43NCNCConnection to Ground Recommended44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	41	Output		Transmit Line Output Positive
44NCNCConnection to Ground Recommended45NCNCConnection to Ground Recommended46NCNCConnection to Ground Recommended	42	Ground	AGND	Analog Ground
45 NC NC Connection to Ground Recommended 46 NC NC Connection to Ground Recommended	43	NC	NC	Connection to Ground Recommended
46 NC NC Connection to Ground Recommended	44	NC	NC	Connection to Ground Recommended
	45	NC	NC	Connection to Ground Recommended
47 Output PLL _{OUT} PLL Filter Output	46	NC		Connection to Ground Recommended
	47	Output	PLL _{OUT}	PLL Filter Output
48 Input PLL _{IN} PLL Filter Input	48	Input		PLL Filter Input

The information provided herein is believed to be reliable; however, BURR-BROWN assumes no responsibility for inaccuracies or omissions. BURR-BROWN assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. Prices and specifications are subject to change without notice. No patent rights or licenses to any of the circuits described herein are implied or granted to any third party. BURR-BROWN does not authorize or warrant any BURR-BROWN product for use in life support devices and/or systems.



PIN CONFIGURATION

Top View				SSOP
			1	
PGND	1		48	PLL _{IN}
PV _{DD}	2		47	PLL _{OUT}
txCLK	3		46	NC
DGND	4		45	NC
txDAT	5		44	NC
rxD0	6		43	NC
rxD1	7		42	AGND
rxD2	8		41	txLINE _P
rxD3	9		40	AV _{DD}
rxD4	10		39	txLINE _N
rxD5	11		38	AGND
DGND	12		37	AV _{DD}
DV _{DD}	13	AFE1105E	36	REF _N
rxD6	14		35	V _{CM}
rxD7	15		34	REF _P
rxD8	16		33	AGND
rxD9	17		32	AGND
rxD10	18		31	rxLINE _P
rxD11	19		30	rxLINE _N
rxD12	20		29	rxHYB _P
rxD13	21		28	rxHYB _N
DV _{DD}	22		27	AV _{DD}
rxSYNC	23		26	rxLOOP
rxGAIN0	24		25	rxGAIN1
	L			

ABSOLUTE MAXIMUM RATINGS

Analog Inputs: Current ±100mA, Momentary
±10mA, Continuous
Voltage AGND –0.3V to AV _{DD} +0.3V
Analog Outputs Short Circuit to Ground (+25°C) Continuous
AV _{DD} to AGND0.3V to 6V
PV _{DD} to PGND0.3V to 6V
DV _{DD} to DGND0.3V to 6V
PLL _{IN} or PLL _{OUT} to PGND0.3V to PV _{DD} +0.3V
Digital Input Voltage to DGND0.3V to DV _{DD} +0.3V
Digital Output Voltage to DGND0.3V to DV _{DD} +0.3V
AGND, DGND, PGND Differential Voltage0.3V
Junction Temperature (T _J) +150°C
Storage Temperature Range40°C to +125°C
Lead Temperature (soldering, 3s) +260°C
Power Dissipation 700mW

ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

PACKAGE/ORDERING INFORMATION

PRODUCT	MAXIMUM BIT RATE	BIT		TEMPERATURE RANGE
AFE1105E	1.168Mbps	48-Pin Plastic SSOP	333	–40°C to +85°C
AFE1105EA	512kbps	48-Pin Plastic SSOP	333	–40°C to +85°C

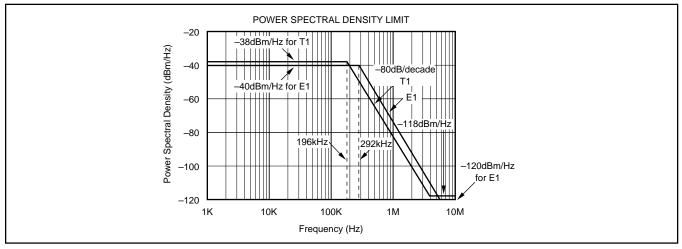
NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.



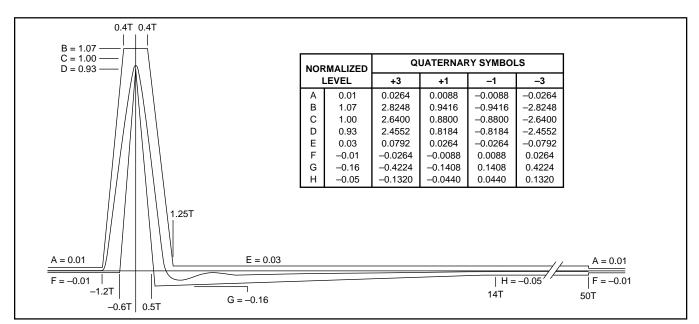
TYPICAL PERFORMANCE CURVES

At Output of Pulse Transformer

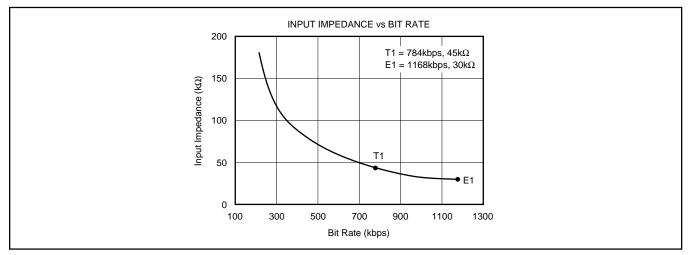
Typical at 25°C, AV_{DD} = +5V, DV_{DD} = +3.3V, unless otherwise specified.



CURVE 1. Upper Bound of Power Spectral Density Measured at the Transformer Output.



CURVE 2. Transmitted Pulse Template and Actual Performance as Measured at the Transformer Output.



CURVE 3. Input Impedance of rxLINE and rxHYB.



THEORY OF OPERATION

The transmit channel consists of a switched-capacitor pulse forming network followed by a differential line driver. The pulse forming network receives symbol data from the XMTDA output of the MtH1210B and generates a 2B1Q output waveform. The output meets the pulse mask and power spectral density requirements defined in European Telecommunications Standards Institute document RTR/ TM-03036 for E1 mode and in sections 6.2.1 and 6.2.2.1 of Bellcore technical advisory TA-NWT-001210 for T1 mode. The differential line driver uses a composite output stage combining class B operation (for high efficiency driving large signals) with class AB operation (to minimize crossover distortion).

The receive channel is designed around a fourth-order delta sigma A/D converter. It includes a difference amplifier designed to be used with an external compromise hybrid for first order analog crosstalk reduction. A programmable gain amplifier with gains of 0dB to +9dB is also included. The delta sigma modulator operating at a 24X oversampling ratio produces 14 bits of resolution at output rates up to 584kHz. The basic functionality of the AFE1105 is illustrated in Figure 1 shown below.

The receive channel operates by summing the two differential inputs, one from the line (rxLINE) and the other from the compromise hybrid (rxHYB). The connection of these two inputs so that the hybrid signal is subtracted from the line signal is described in the paragraph titled "Echo Cancellation in the AFE". The equivalent gain for each input in the difference amp is 1. The resulting signal then passes to a programmable gain amplifier which can be set for gains of 0dB through 9dB. The ADC converts the signal to a 14-bit digital word, rxD13-rxD0.

rxLOOP INPUT

rxLOOP is the loopback control signal. When enabled, the $rxLINE_P$ and $rxLINE_N$ inputs are disconnected from the AFE. The $rxHYB_P$ and $rxHYB_N$ inputs remain connected. Loopback is enabled by applying a positive signal (Logic 1) to rxLOOP.

ECHO CANCELLATION IN THE AFE

The rxHYB input is designed to be subtracted from the rxLINE input for first order echo cancellation. To accomplish this, note that the rxLINE input is connected to the same polarity signal at the transformer (positive to positive and negative to negative) while the rxHYB input is connected to opposite polarity through the compromise hybrid (negative to positive and positive to negative) as shown in Figure 2.

RECEIVE DATA CODING

The data from the receive channel A/D converter is coded in two's complement code.

ANALOG INPUT	OUTPUT CODE (rxD13 - rxD0)
Positive Full Scale	011111111111
Mid Scale	000000000000
Negative Full Scale	100000000000

RECEIVE CHANNEL PROGRAMMABLE GAIN AMPLIFIER

The gain of the amplifier at the input of the Receive Channel is set by two gain control pins, rxGAIN1 and rxGAIN0. The resulting gain between 0dB and +9dB is shown below.

rxGAIN1	rxGAIN0	GAIN
0	0	0dB
0	1	3.25dB
1	0	6dB
1	1	9dB

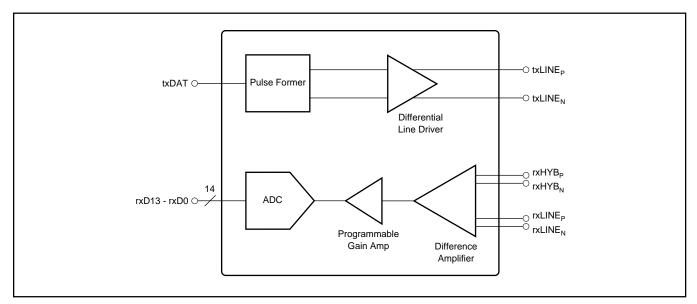


FIGURE 1. Functional Block Diagram of AFE1105.



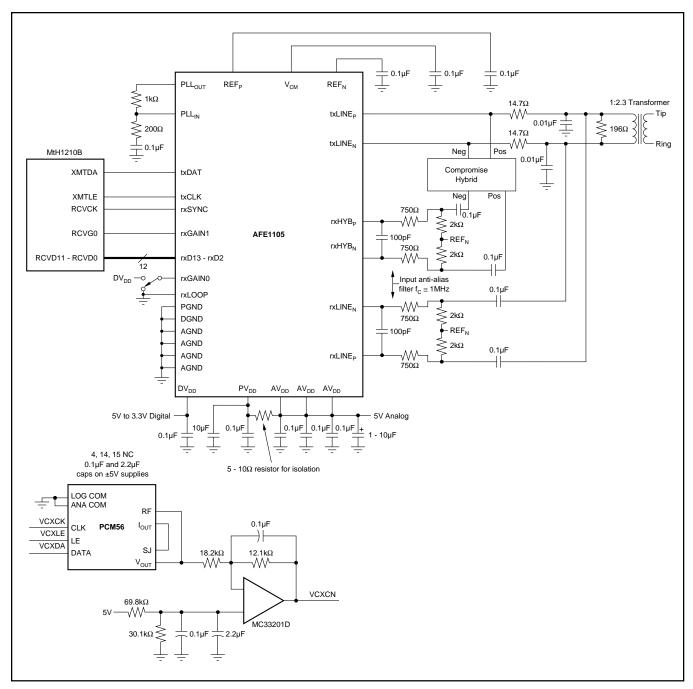


FIGURE 2. Basic Connection Diagram.

rxHYB AND rxLINE INPUT ANTI-ALIASING FILTERS

The -3dB frequency of the input anti-aliasing filter for the rxLINE and rxHYB differential inputs should be about 1MHz. Suggested values for the filter are 750Ω for each of the two input resistors and 100pF for the capacitor. Together the two 750Ω resistors and the 100pF capacitor result in -3dB frequency of just over 1MHz. The 750Ω input resistors will result in a minimal voltage divider loss with the input impedance of the AFE1105.

This circuit applies at both T1 and E1 rates. For slower rates, the antialiasing filters will give best performance with their -3dB frequency approximately equal to the bit rate. For example, a -3dB frequency of 500kHz should be used for a single pair bit rate of 500kbps.

rxHYB AND rxLINE INPUT BIAS VOLTAGE

The transmitter output on the txLINE pins is centered at midscale, 2.5V. But, the rxLINE input signal is centered at 1.5V in the circuit shown in Figure 2 above.

Inside the AFE1105, the rxHYB and rxLINE signals are subtracted as described in the paragraph on echo cancellation above. This means that the rxHYB inputs need to be centered at 1.5V just as the rxLINE signal is centered at 1.5V. REF_{N} (Pin 36) is a 1.5V voltage source. The external compromise hybrid must be designed so that the signal into the rxHYB inputs is centered at 1.5V.



TIMING DIAGRAM

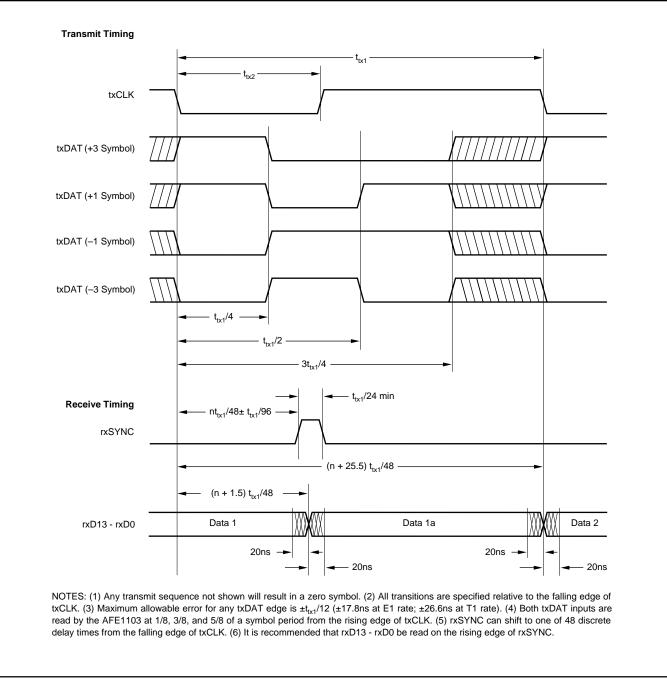


FIGURE 3. Timing Diagram.

RECEIVE TIMING

The rxSYNC signal controls portions of the A/D converter's decimation filter and the data output timing of the A/D converter. It is generated at the symbol rate by the user and must be synchronized with txCLK. The rising edge of rxSYNC can occur at the falling edge of txCLK or it can be shifted by the user in increments of 1/48 of a symbol period to one of 47 discrete delay times after the falling edge of txCLK.

The bandwidth of the A/D converter decimation filter is equal to one half of the symbol rate. The A/D converter data output rate is 2X the symbol rate. The specifications of the AFE1105 assume that one A/D converter output is used per symbol period and the other interpolated output is ignored. The Receive Timing Diagram above suggests using the rxSYNC pulse to read the first data output in a symbol period. Either data output may be used. Both data outputs may be used for more flexible post-processing.



DISCUSSION OF SPECIFICATIONS

UNCANCELLED ECHO

The key measure of transceiver performance is uncancelled echo. This measurement is made as shown in the diagram of Figure 4. The AFE is connected to an output circuit including a typical 1:2 line transformer. The line is simulated by a 135Ω resistor. Symbol sequences are generated by the tester and applied both to the AFE and to the input of an adaptive filter. The output of the adaptive filter is subtracted from the AFE output to form the uncancelled echo signal. Once the filter taps have converged, the RMS value of the uncancelled echo is calculated. Since there is no far-end signal source or additive line noise, the uncancelled echo contains only noise and linearity errors generated in the transmitter and receiver.

The data sheet value for uncancelled echo is the ratio of the RMS uncancelled echo (referred to the receiver input through the receiver gain) to the nominal transmitted signal (13.5dBm into 135Ω , or 1.74Vrms). This echo value is measured under a variety of conditions: with loopback enabled (line input disconnected); with loopback disabled under all receiver gain ranges; and with the line shorted (S₁ closed in Figure 4).

LAYOUT

The analog front end of an HDSL system has a number of conflicting requirements. It must accept and deliver digital outputs at fairly high rates of speed, phase-lock to a high-speed digital clock, and convert the line input to a high-precision (14-bit) digital output. Thus, there are really three sections of the AFE1105: the digital section, the phase-locked loop, and the analog section.

The power supply for the digital section of the AFE1105 can range from 3.3V to 5V. This supply should be decoupled to digital ground with a ceramic 0.1 μ F capacitor placed as close to DGND (pin 12) and DV_{DD} (pin 13) as possible. Ideally, both a digital power supply plane and a digital ground plane should run up to and underneath the digital pins of the AFE1105 (pins 3 through 26). However, DV_{DD} may be supplied by a wide printed circuit board (PCB) trace. A digital ground plane underneath all digital pins is strongly recommended.

The phase-locked loop is powered from PV_{DD} (pin 2) and its ground is referenced to PGND (pin 1). Note that PV_{DD} must be in the 4.75V to 5.25V range. This portion of the AFE1105 should be decoupled with both a 10µF Tantalum capacitor

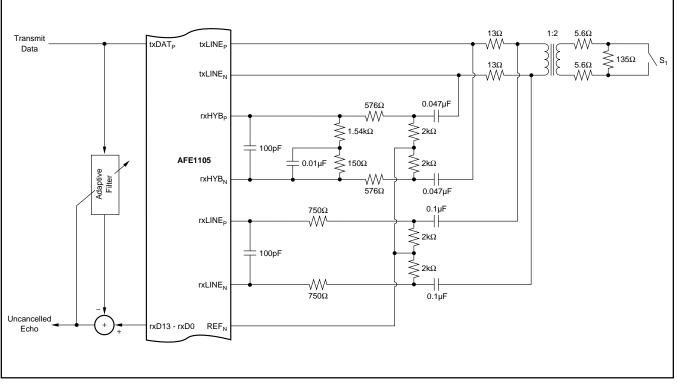


FIGURE 4. Uncancelled Echo Test Diagram.

and a 0.1μ F ceramic capacitor. The ceramic capacitor should be placed as close to the AFE1105 as possible. The placement of the Tantalum capacitor is not as critical, but should be close. In each case, the capacitor should be connected between PV_{DD} and PGND.

In most systems, it will be natural to derive PV_{DD} from the AV_{DD} supply. A 5 Ω to 10 Ω resistor should be used to connect PV_{DD} to the analog supply. This resistor in combination with the 10 μ F capacitor form a lowpass filter—keeping glitches on AV_{DD} from affecting PV_{DD} . Ideally, PV_{DD} would originate from the analog supply (via the resistor) near the power connector for the printed circuit board. Likewise, PGND should connect to a large PCB trace or small ground plane which returns to the power supply connector underneath the PV_{DD} supply path. The PGND "ground plane" should also extend underneath PLL_{IN} and PLL_{OUT} (pins 47 and 48).

The remaining portion of the AFE1105 should be considered analog. All AGND pins should be connected directly to a common analog ground plane and all AV_{DD} pins should be connected to an analog 5V power plane. Both of these planes should have a low impedance path to the power supply.

Ideally, all ground planes and traces and all power planes and traces should return to the power supply connector before being connected together (if necessary). Each ground and power pair should be routed over each other, should not overlap any portion of another pair, and the pairs should be separated by a distance of at least 0.25 inch (6mm). One exception is that the digital and analog ground planes should be connected together underneath the AFE1105 by a small trace.



PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	e Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
AFE1105E	ACTIVE	SSOP	DL	48	30	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
AFE1105E/1K	ACTIVE	SSOP	DL	48	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
AFE1105E/1KG4	ACTIVE	SSOP	DL	48	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
AFE1105EG4	ACTIVE	SSOP	DL	48	30	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

Important Information and Disclaimer:The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DSP	dsp.ti.com	Broadband	www.ti.com/broadband
Interface	interface.ti.com	Digital Control	www.ti.com/digitalcontrol
Logic	logic.ti.com	Military	www.ti.com/military
Power Mgmt	power.ti.com	Optical Networking	www.ti.com/opticalnetwork
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
Low Power Wireless	www.ti.com/lpw	Telephony	www.ti.com/telephony
		Video & Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless

Mailing Address:

Texas Instruments

Post Office Box 655303 Dallas, Texas 75265

Copyright © 2006, Texas Instruments Incorporated