

Subscriber Line Interface Circuit (SLIC)

Key Features

- Battery feed characteristics programmable via external resistors; feed characteristics independent of SLIC battery supply variations
- Battery supply voltage as low as 21 V for power efficient line card designs
- Ring relay driver
- Loop current, ground key and ring trip detection functions
- Programmable loop current detector threshold
- Hybrid function with all types of CODEC/filter devices
- Programmable line terminating impedance, complex or real

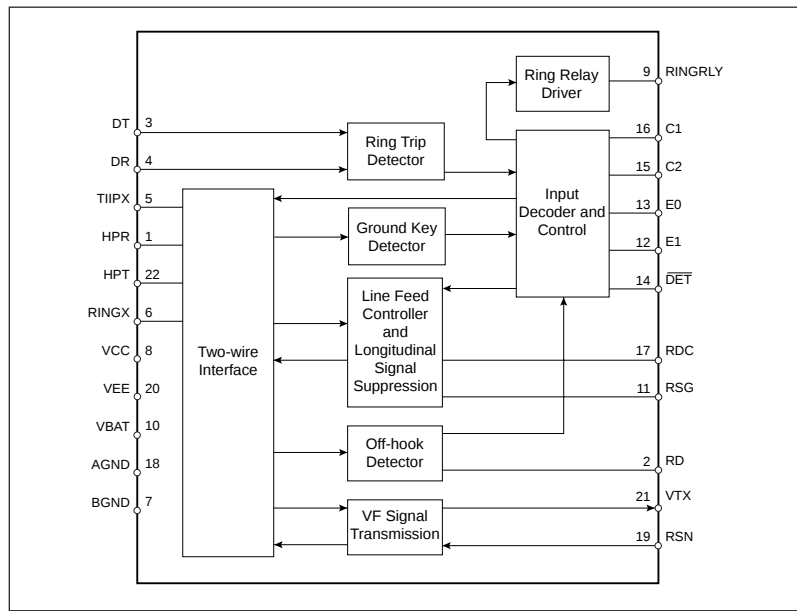


Figure 1. Block diagram.

Description

Note: All data is also valid for PBL 3764A/6, except maximum ratings for battery voltage. (See next page)

The PBL 3764A/4 Subscriber Line Interface Circuit (SLIC) is a bipolar integrated circuit in 90 V technology which replaces the conventional transformer based analog line interface circuit in Digital Loop Carrier, PABX and other telecommunications equipment with a modern, compact solid state design. Not only is required PCB area reduced, but lesser component weight and height result as well. The PBL 3764A/4 has been optimized for low cost and to require only a minimum of external components. The PBL 3764A/4 is an improved version of the PBL 3764 with an internal saturation guard programming resistor. The PBL 3764A/4 programmable, constant-current feed system can operate with battery supply voltages

down to 21 V to reduce line card power dissipation. The SLIC incorporates loop current, ground key and ring trip detection functions as well as a ring relay driver. Two-to four-wire and four- to two-wire voice frequency (vf) signal conversion is accomplished by the SLIC in conjunction with either a conventional CODEC/filter or with a programmable CODEC/filter (e.g. SLAC, SiCoFi, Combo II). The programmable line terminating impedance could be complex or real to fit every market. Longitudinal line voltages are suppressed by a feedback loop in the SLIC. Longitudinal balance specifications exceed Bellcore and EIA requirements. The PBL 3764A/4 packages are 22-pin dual-in-line or 28-pin PLCC. The PBL 3764A/6 package is 28-pin PLCC.

Maximum Ratings

Parameter	Symbol	Min	Max	Unit
Temperature, Humidity				
Storage temperature range	T_{Stg}	-60	+150	°C
Operating junction temperature range	T_J	-25	+140	°C
Power supply, $-40^{\circ}\text{C} \leq T_{Amb} \leq 85^{\circ}\text{C}$				
V_{CC} with respect to AGND	V_{CC}	-0.5	6.5	V
V_{EE} with respect to AGND	V_{EE}	-6.5	0.5	V
V_{Bat} with respect to BGND for PBL 3764A/4	V_{Bat}	-70	$V_{EE} + 0.6$	V
V_{Bat} with respect to BGND for PBL 3764A/6	V_{Bat}	-85	$V_{EE} + 0.6$	V
Power dissipation				
Continuous power dissipation at $T_{Amb} \leq 70^{\circ}\text{C}$	P_D		1.5	W
Peak power dissipation at $T_{Amb} = 70^{\circ}\text{C}$, $t < 100\text{ ms}$, $t_{Rep} > 1\text{ sec.}$	P_{DP}		4	W
Ground				
Voltage between AGND and BGND	V_G	-0.3	0.3	V
Relay driver				
Ring relay supply voltage, Note 4	V_{Ring}	0	12	V
Ring relay current	I_{Ring}		50	mA
Ring trip comparator				
Input voltage	V_{DT}, V_{DR}	V_{Bat}	0	V
Input current	I_{DT}, I_{DR}	-5	5	mA
Digital inputs, outputs (C1, C2, E0, E1, $\overline{DET}$)				
Input voltage	V_{ID}	0	V_{CC}	V
Output voltage ($\overline{DET}$ disabled)	V_{OD}	0	V_{CC}	V
Input current ($\overline{DET}$ enabled)	I_{OD}		5	mA
TIPX and RINGX terminals, $-40^{\circ}\text{C} \leq T_{Amb} \leq 85^{\circ}\text{C}$, $V_{Bat} = -50\text{V}$				
TIPX or RINGX voltage, continuous (referenced to AGND), Note 1	V_{TA}, V_{RA}	V_{Bat}	2	V
TIPX or RINGX, pulse $< 10\text{ ms}$, $t_{Rep} > 10\text{ s}$, Note 1	V_{TA}, V_{RA}	$V_{Bat} - 20$	5	V
TIPX or RINGX, pulse $< 1\text{ }\mu\text{s}$, $t_{Rep} > 10\text{ s}$, Note 1	V_{TA}, V_{RA}	$V_{Bat} - 40$	10	V
TIP or RING, pulse $< 250\text{ ns}$, $t_{Rep} > 10\text{ s}$, Note 2	V_{TA}, V_{RA}	$V_{Bat} - 70$	15	V
TIPX or RINGX current	I_{LT}, I_{LR}		70	mA

Recommended Operating Conditions

Parameter	Symbol	Min	Max	Unit
V_{CC} with respect to AGND	V_{CC}	4.75	5.25	V
V_{EE} with respect to AGND	V_{EE}	-5.25	-4.75	V
V_{Bat} with respect to BGND, Note 3	V_{Bat}	-58	-24	V

Notes

1. A diode in series with the V_{Bat} input increases the permitted continuous voltage and pulse $< 10\text{ ms}$ to -85 V . A pulse $\leq 1\text{ }\mu\text{s}$ is increased to the greater of $|-70\text{ V}|$ and $|V_{Bat} - 40\text{V}|$.
2. $R_{F1}, R_{F2} \geq 20\text{ }\Omega$ is also required. Pulse is supplied to TIP and RING outside R_{F1}, R_{F2} .
3. $-24\text{V} < V_{Bat} < -21\text{V}$ may be used in applications requiring maximum vf signal amplitudes less than $3V_{pk}$ (8.75 dBm, 600 Ω).
4. PBL 3764A/4: the less of: $|V_{Bat} + 75\text{ V}|$ or $+12\text{ V}$.
PBL 3764A/6: the less of: $|V_{Bat} + 90\text{ V}|$ or $+12\text{ V}$

Electrical Characteristics

$-40\text{ }^{\circ}\text{C} \leq T_{\text{Amb}} \leq 85\text{ }^{\circ}\text{C}$, Note 10, $V_{\text{CC}} = +5\text{V} \pm 5\%$, $V_{\text{EE}} = -5\text{V} \pm 5\%$, $V_{\text{Bat}} = -48\text{V}$, $\text{AGND} = \text{BGND}$, $R_{\text{DC1}} = R_{\text{DC2}} = 41.7\text{k}\Omega$, $C_{\text{HP}} = 10\text{nF}$, $C_{\text{DC}} = 1.5\text{ }\mu\text{F}$, $Z_{\text{L}} = 600\Omega$ unless otherwise specified. All pin number references in the text and figures refer to the 22-pin DIP unless otherwise indicated.

Parameter	Ref fig	Conditions	Min	Typ	Max	Unit
Two-wire port						
Overload level, V_{TRO}	2	$Z_{\text{L}} = 600\Omega$, 1% THD Note 1	3.1			V_{Peak}
Input impedance, Z_{TR}		Note 2				
Longitudinal impedance, $Z_{\text{LoT}}, Z_{\text{LoR}}$		$0 < f < 100\text{ Hz}$		10	35	Ω/wire
Longitudinal current limit, $I_{\text{LoT}}, I_{\text{LoR}}$		active state	27			$\text{mA}_{\text{rms}}/\text{wire}$
		stand-by state	8.5			$\text{mA}_{\text{rms}}/\text{wire}$
Longitudinal to metallic balance, B_{LM}		IEEE standard 455-1985				
		$0.2\text{ kHz} \leq f \leq 3.4\text{ kHz}$				
		$0\text{ }^{\circ}\text{C} \leq T_{\text{Amb}} \leq 70\text{ }^{\circ}\text{C}$	63	70		dB
		$-40\text{ }^{\circ}\text{C} \leq T_{\text{Amb}} \leq 85\text{ }^{\circ}\text{C}$	58	70		dB
Longitudinal to metallic balance, B_{LME}	3	$0.2\text{ kHz} \leq f \leq 3.4\text{ kHz}$				
		$B_{\text{LME}} = 20 \cdot \text{Log} \left \frac{E_{\text{Lo}}}{V_{\text{TR}}} \right $				
		$0\text{ }^{\circ}\text{C} \leq T_{\text{Amb}} \leq 70\text{ }^{\circ}\text{C}$	63	70		dB
		$-40\text{ }^{\circ}\text{C} \leq T_{\text{Amb}} \leq 85\text{ }^{\circ}\text{C}$	58	70		dB
Longitudinal to four-wire balance, B_{LFE}	3	$0.2\text{ kHz} \leq f \leq 3.4\text{ kHz}$				
		$B_{\text{LFE}} = 20 \cdot \text{Log} \left \frac{E_{\text{Lo}}}{V_{\text{TX}}} \right $				
		$0\text{ }^{\circ}\text{C} \leq T_{\text{Amb}} \leq 70\text{ }^{\circ}\text{C}$	63	70		dB
		$-40\text{ }^{\circ}\text{C} \leq T_{\text{Amb}} \leq 85\text{ }^{\circ}\text{C}$	58	70		dB
Metallic to longitudinal balance, B_{MLE}	4	$0.2\text{ kHz} < f < 3.4\text{ kHz}$	50	55		dB
		$B_{\text{MLE}} = 20 \cdot \text{Log} \left \frac{E_{\text{TR}}}{V_{\text{Lo}}} \right , E_{\text{RX}} = 0$				

Figure 2. Overload level, V_{TRO} , two-wire port

$$\frac{1}{\omega C} \ll R_{\text{L}}, R_{\text{L}} = 600\Omega$$

$$R_{\text{T}} = 600\text{ k}\Omega, R_{\text{RX}} = 300\text{ k}\Omega$$

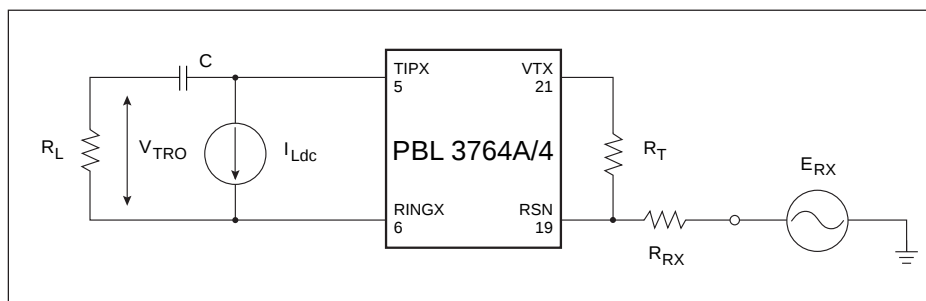
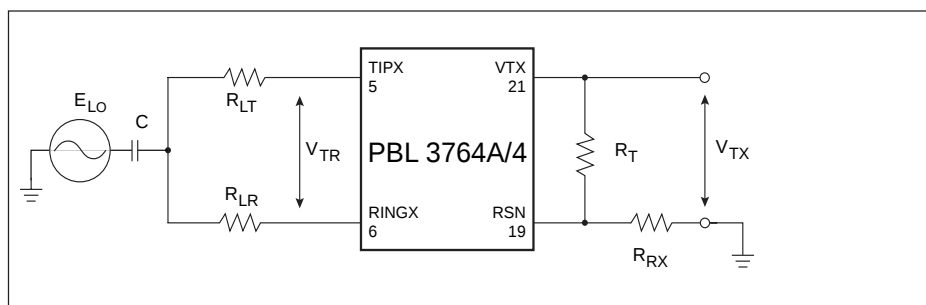


Figure 3. Longitudinal to metallic (B_{LME}) and Longitudinal to four-wire (B_{LFE}) balance

$$\frac{1}{\omega C} \ll 150\Omega, R_{\text{LT}} = R_{\text{LR}} = 300\Omega$$

$$R_{\text{T}} = 600\text{ k}\Omega, R_{\text{RX}} = 300\text{ k}\Omega$$



Parameter	Ref fig	Conditions	Min	Typ	Max	Unit
Four-wire to longitudinal balance, B_{FLE}	4	$0.2 \text{ kHz} < f < 3.4 \text{ kHz}$ $B_{FLE} = 20 \cdot \text{Log} \left \frac{E_{RX}}{V_{Lo}} \right $ E_{TR} source removed	50	55		dB
Two-wire return loss, r		$r = 20 \cdot \text{Log} \frac{ Z_{TR} + Z_L }{ Z_{TR} - Z_L }$ $Z_{TR} \approx Z_L = \text{nom. } 600 \Omega$ $0.2 \text{ kHz} \leq f \leq 0.5 \text{ kHz}$ $0.5 \text{ kHz} \leq f \leq 1.0 \text{ kHz}$ $1.0 \text{ kHz} \leq f \leq 3.4 \text{ kHz, Note 9}$	25 27 23			dB dB dB
TIPX idle voltage, V_{Ti}		active, $I_L = 0$, $R_{SG} = 0\Omega$ stand-by, $I_L = 0$		-1.5 0.6		V V
RINGX idle voltage, V_{Ri}		active, $I_L = 0$, $R_{SG} = 0\Omega$ stand-by, $I_L = 0$		-46.5 -48		V V
TIPX-RINGX open loop metallic voltage, V_{TR}		$I_L = 0$, $R_{SG} = 0\Omega$ $V_{Bat} = -52V$	43.0	45.0	47.0	V
Four-wire transmit port (VTX)						
Overload level, V_{TXO}	5	Load impedance $> 20 \text{ k}\Omega$, 1% THD, Note 3	3.1			V_{Peak}
Output offset voltage, ΔV_{TX}		$0^\circ\text{C} \leq T_{Amb} \leq 70^\circ\text{C}$ $-40^\circ\text{C} \leq T_{Amb} \leq 85^\circ\text{C}$	-30 -40		30 40	mV mV
Output impedance, z_{TX}		$0.2 \text{ kHz} \leq f \leq 3.4 \text{ kHz}$		<5	20	Ω
Four-wire receive port (RSN)						
Receive summing node (RSN) dc voltage		$I_{RSN} = 0 \text{ mA}$		0		V
Receive summing node (RSN) impedance		$0.2 \text{ kHz} \leq f \leq 3.4 \text{ kHz}$		<10	20	Ω
Receive summing node (RSN) current (I_{RSN}) to metallic loop current (I_L) gain, α_{RSN}		$0.3 \text{ kHz} \leq f \leq 3.4 \text{ kHz}$		1000		ratio

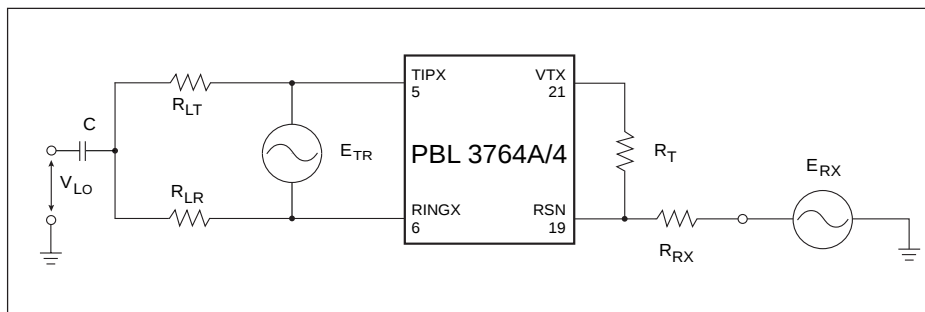


Figure 4. Metallic to longitudinal and four-wire to longitudinal balance

$$\frac{1}{\omega C} \ll 150 \Omega, R_{LT} = R_{LR} = 300 \Omega$$

$$R_T = 600 \text{ k}\Omega, R_{RX} = 300 \text{ k}\Omega$$

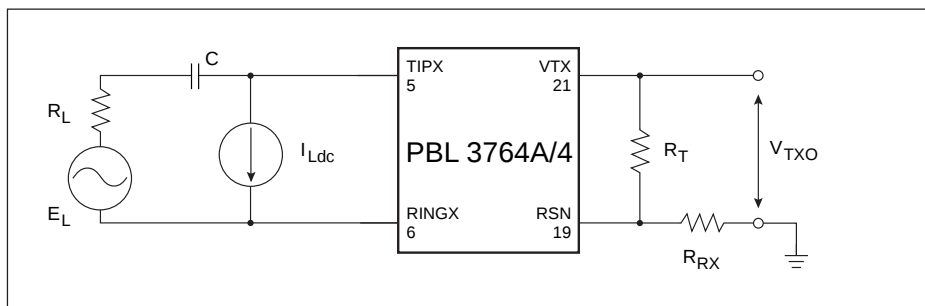


Figure 5. Overload level, V_{TXO} , four-wire transmit port

$$\frac{1}{\omega C} \ll R_L, R_L = 600 \Omega$$

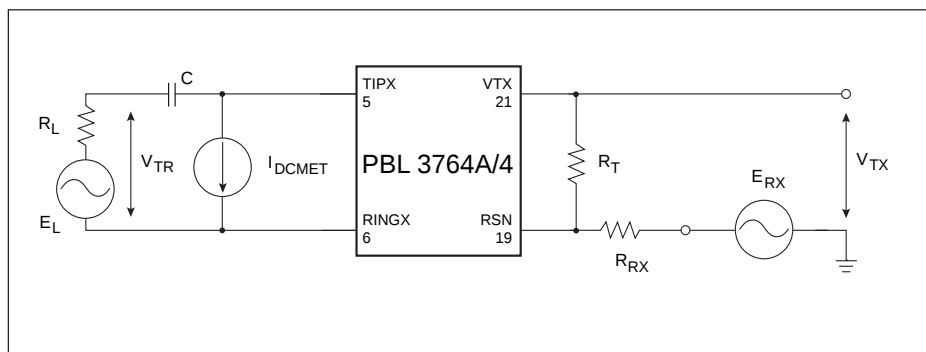
$$R_T = 600 \text{ k}\Omega, R_{RX} = 300 \text{ k}\Omega$$

Parameter	Ref fig	Conditions	Min	Typ	Max	Unit
Frequency response						
Two-wire to four-wire, g_{2-4}	6	0.3 kHz < f < 3.4 kHz relative to 0 dBm, 1.0 kHz. $E_{RX} = 0$ V $0^{\circ}\text{C} \leq T_{Amb} \leq 70^{\circ}\text{C}$ $-40^{\circ}\text{C} \leq T_{Amb} \leq 85^{\circ}\text{C}$	-0.13 -0.20		0.13 0.20	dB dB
Four-wire to two-wire, g_{4-2}	6	0.3 kHz < f < 3.4 kHz relative to 0 dBm, 1.0 kHz. $E_G = 0$ V $0^{\circ}\text{C} \leq T_{Amb} \leq 70^{\circ}\text{C}$ $-40^{\circ}\text{C} \leq T_{Amb} \leq 85^{\circ}\text{C}$	-0.13 -0.20		0.13 0.20	dB dB
Four-wire to four-wire, g_{4-4}	6	0.3 kHz < f < 3.4 kHz relative to 0 dBm, 1.0 kHz. $E_L = 0$ V $0^{\circ}\text{C} \leq T_{Amb} \leq 70^{\circ}\text{C}$ $-40^{\circ}\text{C} \leq T_{Amb} \leq 85^{\circ}\text{C}$	-0.13 -0.20		0.13 0.20	dB dB
Insertion loss						
Two-wire to four-wire, G_{2-4}	6	0 dBm, 1.0 kHz, Note 4 $G_{2-4} = 20 \cdot \text{Log} \left \frac{V_{TX}}{V_{TR}} \right $, $E_{RX} = 0$ $0^{\circ}\text{C} \leq T_{Amb} \leq 70^{\circ}\text{C}$ $-40^{\circ}\text{C} \leq T_{Amb} \leq 85^{\circ}\text{C}$	-0.13 -0.20		0.13 0.20	dB dB
Four-wire to two-wire, G_{4-2}	6	0 dBm, 1.0 kHz, Notes 4, 5 $G_{4-2} = 20 \cdot \text{Log} \left \frac{V_{TR}}{E_{RX}} \right $, $E_L = 0$ $0^{\circ}\text{C} \leq T_{Amb} \leq 70^{\circ}\text{C}$ $-40^{\circ}\text{C} \leq T_{Amb} \leq 85^{\circ}\text{C}$	-0.13 -0.20		0.13 0.20	dB dB
Gain tracking						
Two-wire to four-wire	6	Ref. -10 dBm, 1.0 kHz, Note 7 +3 dBm to +7 dBm -40 dBm to +3 dBm -55 dBm to -40 dBm	-0.15 -0.1 -0.2		0.15 0.1 0.2	dB dB dB
Four-wire to two-wire	6	Ref. -10 dBm, 1.0 kHz, Note 8 -40 dBm to +7 dBm -55 dBm to -40 dBm	-0.1 -0.2		0.1 0.2	dB dB
Noise						
Idle channel noise at two-wire (TIPX-RINGX) or four-wire (V_{TX}) output		C-message weighting Psophometrical weighting Note 6		8.5 -81.5	12 -78	dBrnC dBmp
Harmonic distortion						
Two-wire to four-wire		0 dBm, 1.0 kHz test signal	-65		-54	dB
Four-wire to two-wire		0.3 kHz < f < 3.4 kHz	-65		-54	dB

Figure 6. Frequency response, insertion loss, gain tracking.

$$\frac{1}{\omega C} \ll R_L, R_L = 600 \, \Omega$$

$$R_T = 600 \, \text{k}\Omega, R_{RX} = 300 \, \text{k}\Omega$$



Parameter	Ref fig	Conditions	Min	Typ	Max	Unit
Battery feed characteristics						
Constant loop current, I_L		$I_L = \frac{2500}{R_{DC1} + R_{DC2}}$, R_{DC1}, R_{DC2} in $k\Omega$	$0.92 I_L$	I_L	$1.08 I_L$	mA
Stand-by state loop current, I_L , tolerance range		$I_L = \frac{ V_{Bat} - 3}{R_L + 1800}$ $T_A = 25^\circ C$	$0.8 I_L$	I_L	$1.2 I_L$	mA
Loop current detector						
Loop current detector threshold on-hook to off-hook, I_{LThOff}		$R_D = 33 k\Omega$ $0^\circ C \leq T_{Amb} \leq 70^\circ C$ $-40^\circ C \leq T_{Amb} \leq 85^\circ C$	12.2 11.3	$465/R_D$ $465/R_D$	15.7 16.9	mA mA
Loop current detector threshold off-hook to on-hook, I_{LThOn}		$R_D = 33 k\Omega$ $0^\circ C \leq T_{Amb} \leq 70^\circ C$ $-40^\circ C \leq T_{Amb} \leq 85^\circ C$	10.7 9.8	$405/R_D$ $405/R_D$	13.8 14.7	mA mA
Loop current detector hysteresis, ∂I_{LTh}		$R_D = 33 k\Omega$ $0^\circ C \leq T_{Amb} \leq 70^\circ C$ $-40^\circ C \leq T_{Amb} \leq 85^\circ C$	1.0 0.7	$60/R_D$ $60/R_D$	2.7 2.9	mA mA
Ground key detector						
I_{LTIPX} and I_{RINGX} current difference, ΔI_{LOn} , to trigger the ground key detector		$0^\circ C \leq T_{Amb} \leq 70^\circ C$ $-40^\circ C \leq T_{Amb} \leq 85^\circ C$	9 6.5	12 12	16 17.5	mA mA
I_{LTIPX} and I_{LRINGX} current difference, ΔI_{LOff} , to return the triggered ground key detector to idle state		$0^\circ C \leq T_{Amb} \leq 70^\circ C$ $-40^\circ C \leq T_{Amb} \leq 85^\circ C$	4 2.5	7 7	11 12	mA mA
Hysteresis, ∂I_{LGK}		$ \Delta I_{LOn} - \Delta I_{LOff} $ $0^\circ C \leq T_{Amb} \leq 70^\circ C$ $-40^\circ C \leq T_{Amb} \leq 85^\circ C$	3 0	5 5	8 9	mA mA
Ring trip detector						
Offset voltage, ΔV_{DTR}		Source resistance, $R_S = 0 \Omega$	-20		20	mV
Input bias current, I_B		$I_B = (I_{DT} + I_{DR})/2$	-500	-100		nA
Input resistance unbalanced			1			$M\Omega$
balanced			3			$M\Omega$
Input common mode range, V_{DT}, V_{DR}			$V_{Bat} + 1$		-2	V
Ring relay driver						
Saturation voltage, V_{OL}		$I_{OL} = 25 \text{ mA}$		0.2	0.6	V
Off state leakage current, I_{Lk}		$V_{OH} = 12 \text{ V}$			10	μA
Digital inputs (C1, C2, E0, E1)						
Input low voltage, V_{IL}			0		0.8	V
Input high voltage, V_{IH}			2.0		V_{CC}	V
Input low current, I_{IL}		$V_{IL} = 0.4 \text{ V}$				
C1, C2			-400			μA
E0, E1			-100			μA
Input high current, I_{IH}		$V_{IH} = 2.4 \text{ V}$			40	μA
Detector output ($\overline{DET}$)						
Output low voltage, V_{OL}		$I_{OL} = 2 \text{ mA}$			0.45	V
Output high voltage, V_{OH}		$I_{OH} = 100 \mu A$	2.7			V
Internal pull-up resistor			8	15	25	$k\Omega$
Delay time E0 to $\overline{DET}$						
transition high to low, t_{DHL}	7				1	μs
transition low to high, t_{DLH}	7				2	μs

Parameter	Ref fig	Conditions	Min	Typ	Max	Unit
Power dissipation ($V_{\text{Bat}} = -48\text{V}$)						
P_1		Open circuit state, C1, C2 = 0, 0		40	70	mW
P_2		Stand-by state, C1, C2 = 1, 1; on-hook		60	85	mW
P_3		Active state, C1, C2 = 0, 1 On-hook, $R_L = \infty \Omega$		200	300	mW
P_4		Off-hook, $R_L = 600 \Omega$		1.1	1.4	W
Power supply currents						
V_{CC} current, I_{CC}		Open circuit state		1.7	2.8	mA
V_{EE} current, I_{EE}		C1, C2 = 0, 0		1.0	2.0	mA
V_{Bat} current, I_{Bat}		On-hook		0.5	1.2	mA
V_{CC} current, I_{CC}		Stand-by state		2.1	3.5	mA
V_{EE} current, I_{EE}		C1, C2 = 1, 1		1.0	2.0	mA
V_{Bat} current, I_{Bat}		On-hook		0.9	1.6	mA
V_{CC} current, I_{CC}		Active state		5.1	9.5	mA
V_{EE} current, I_{EE}		C1, C2 = 0,1		2.0	4.0	mA
V_{Bat} current, I_{Bat}		On-hook		3.3	5.2	mA
Power supply rejection ratios						
V_{CC} to 2- or 4-wire port		Active State	43	45		dB
V_{EE} to 2- or 4-wire port		C1, C2 = 0,1	40	45		dB
V_{Bat} to 2- or 4-wire port		50Hz < f < 3400Hz, $V_n = 100\text{mV}_{\text{RMS}}$	40	45		dB
V_{Bat} to 2- or 4-wire port		$V_n = 2 V_{\text{pp}}$, Note 11	40	45		dB
Temperature guard						
Junction threshold temperature, T_{JG}				150		°C
Thermal resistance						
28-pin PLCC, $\theta_{\text{RJP28plcc}}$		Junction to terminals 3, 6, 10, 17, 24 connected together, Note 12		13		°C/W
22-pin PDIP, θ_{RJP22dip}				13,5		°C/W

Notes

- The overload level is specified at the two-wire port with the signal source at the four-wire receive port.
- The two-wire impedance is programmable by selection of external component values according to:
 $Z_{\text{TRX}} = Z_{\text{T}} / |G_{2-4} \cdot \alpha_{\text{RSN}}|$ where:
 Z_{TRX} = impedance between the TIPX and RINGX terminals
 Z_{T} = programming network between the VTX and RSN terminals
 G_{2-4} = transmit gain, nominally = 1
 α_{SRN} = receive current gain, nominally = -1000 (current defined as positive when flowing into the receive summing node (RSN), and when flowing from Tip to Ring).
- The overload level is specified at the four-wire transmit port, V_{TX} , with the signal source at the two-wire port. Note that the gain from the two-wire port to the four-wire transmit port is $G_{2-4} = 1$.
- Fuse resistors R_{F} impact the insertion loss as explained in the text, section Transmission. The specified insertion loss is for $R_{\text{F}} = 0$.
- The specified insertion loss tolerance does not include errors caused by external components.
- The two-wire idle noise is specified with the port terminated in $600 \Omega (R_{\text{L}})$ and with the four-wire receive port grounded ($E_{\text{RX}} = 0$; see figure 5).
The four-wire idle noise at V_{TX} is specified with the two-wire port terminated in $600 \Omega (R_{\text{L}})$. The noise specification is with respect to a 600Ω impedance level at V_{TX} . The four-wire receive port is grounded ($E_{\text{RX}} = 0$).
- The level is specified at the two-wire port.
- The level is specified at the four-wire receive port and referenced to a 600Ω impedance level.
- Higher return loss values can be achieved by adding a reactive component to R_{T} , the two-wire terminating impedance programming resistance, e.g., by dividing R_{T} into two equal halves and connecting a capacitor from the common point to ground. For $R_{\text{T}} = 600 \text{ k}\Omega$ this capacitor would be approximately 30 pF . Increasing C_{HP} to $0.033 \mu\text{F}$ improves low-frequency return loss.
- The $-40^\circ\text{C} - +85^\circ\text{C}$ values are tested, while the $0^\circ\text{C} - +70^\circ\text{C}$ values are given as an indication.
- PSRR for V_{Bat} is reduced to min. 37 dB when the PLCC package is used.
- Junction to ambient thermal resistance will be dependent on external thermal resistance from V_{Bat} terminals to ambient.

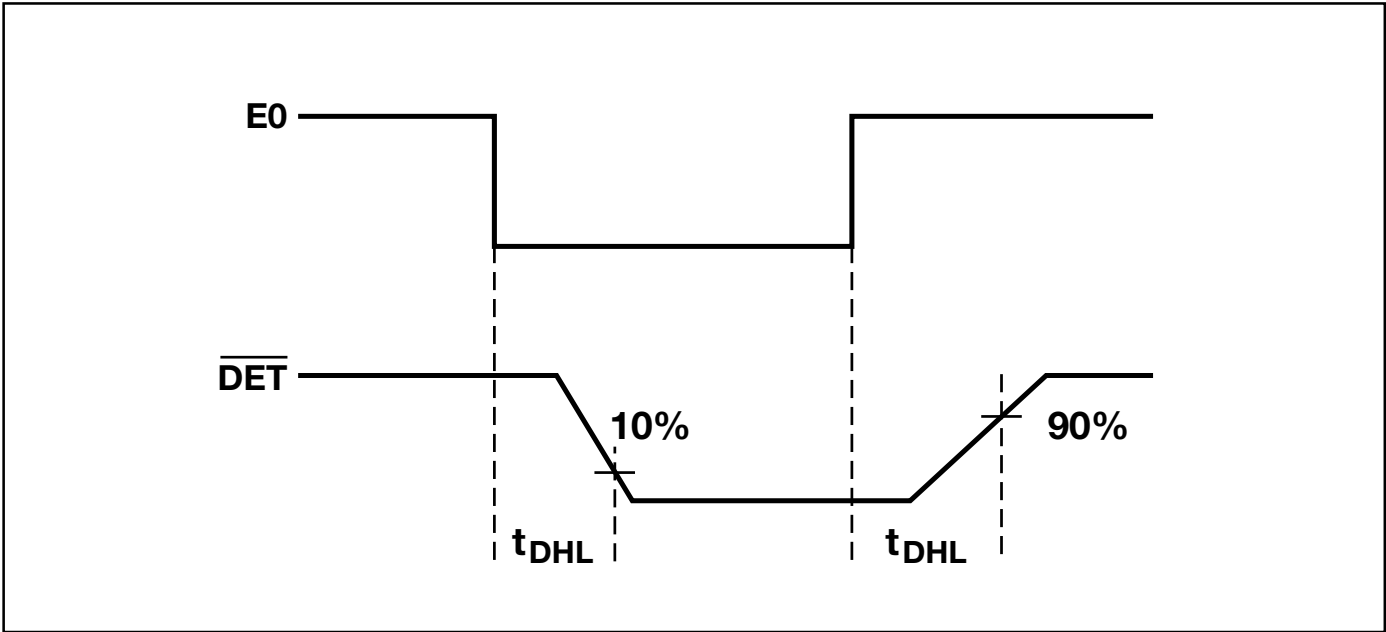


Figure 7. Detector output delay time.

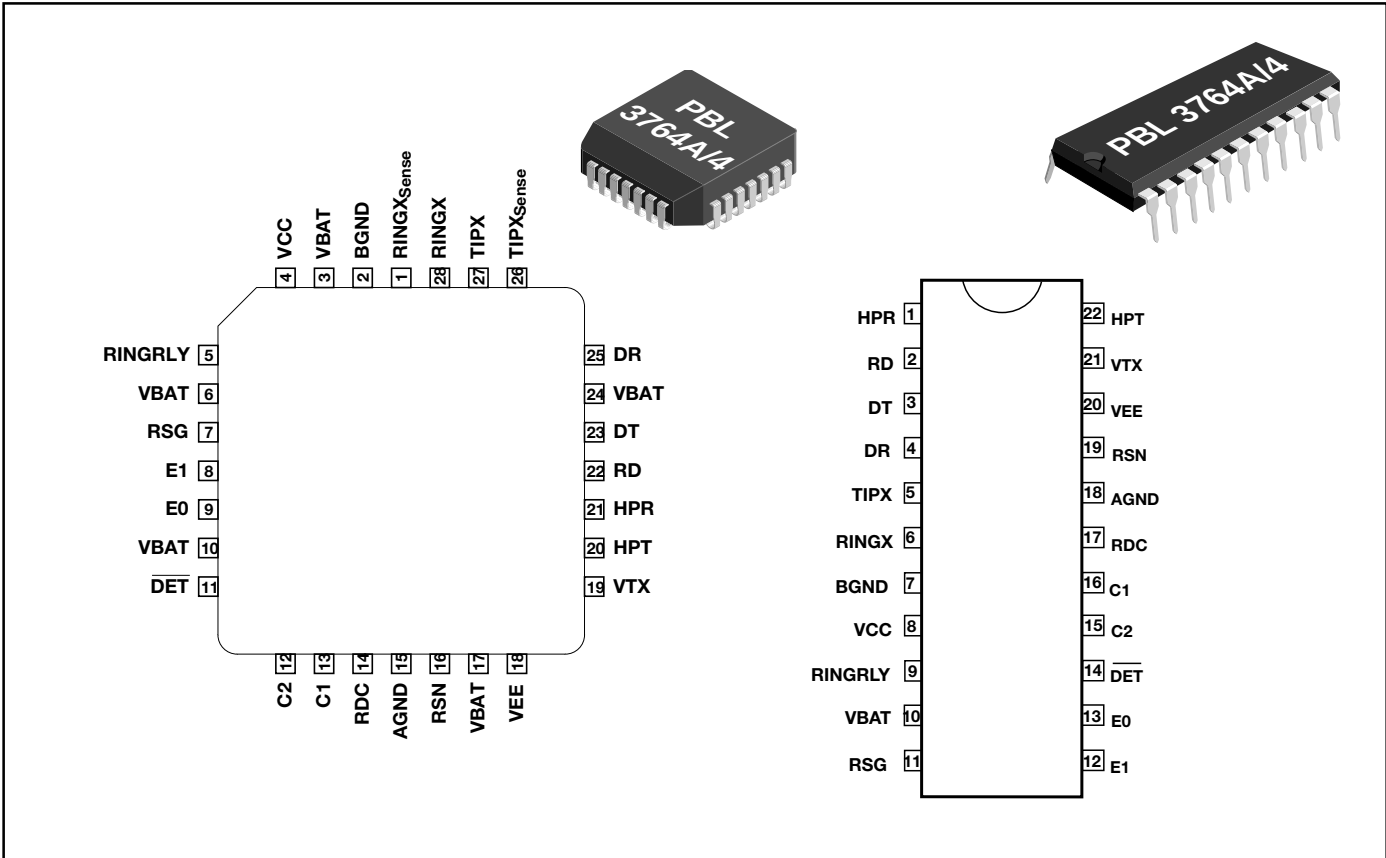


Figure 8. Pin configuration, 28-pin PLCC and 22-pin dual-in-line package, top view.

Pin Description

Refer to figure 8. Note: all pin number references in the text and figures refer to the 22-pin DIP unless otherwise specified.

DIP	PLCC	Symbol	Description
	1	RING _{Sense}	RINGX _{Sense} is internally connected to RINGX. RINGX _{Sense} is used during manufacturing, but require no connections in SLIC applications, i.e. leave open.
7	2	BGND	Ground. Should be tied together with AGND (pin 18).
	3	VBAT	These pins marked VBAT are used for heat sinking and internally connected to VBAT
8	4	VCC	+5V power supply
9	5	RINGRLY	Ring relay driver output. Open collector. Sinks 50 mA to GND.
10	6	VBAT	Battery supply voltage, -24V to -58V. Negative with respect to GND (pins 7, 18).
11	7	RSG	The internal saturation guard programming resistor, R _{SG} , connects from this terminal to V _{EE} (pin 20). Refer to section "Battery feed" for detailed information.
12	8	E1	TTL compatible enable input. Enables desired detector to be gated to the $\overline{\text{DET}}$ (pin 14) output. Refer to section "Enable inputs" for detailed information.
13	9	E0	TTL compatible enable input. Enables the $\overline{\text{DET}}$ (pin 14) output when set to logic level low and disables the $\overline{\text{DET}}$ output when set to logic level high. Refer to section "Enable inputs" for detailed information.
	10	VBAT	These pins marked VBAT are used for heat sinking and internally connected to VBAT.
14	11	$\overline{\text{DET}}$	Detector output. Inputs C1 (pin 16) and C2 (pin 15) together with enable inputs E0 (pin 13) and E1 (pin 12) select one of the three detectors to be connected to the $\overline{\text{DET}}$ output. A logic low at the enabled $\overline{\text{DET}}$ output indicates a triggered detector condition. The $\overline{\text{DET}}$ output is open collector with internal pull-up resistor (approximately 15 k Ω to V _{CC} (pin 8)).
15	12	C2	C1 and C2 are TTL compatible inputs controlling the SLIC operating states.
16	13	C1	Refer to section "Control inputs" for details.
17	14	RDC	Constant current feed is programmed by two resistors connected in series from this pin to the receive summing node (RSN, pin 19). The resistor junction point is decoupled to GND to isolate the ac signal components.
18	15	AGND	Ground. Should be tied together with BGND (pin 7).
19	16	RSN	Receive summing node. 1000 times the current (dc and ac) flowing into this pin equals the metallic (transversal) current flowing from RINGX (pin 6) to TIPX (pin 5). Programming networks for constant current feed, two-wire impedance and receive gain connect to the receive summing node.
	17	VBAT	These pins marked VBAT are used for heat sinking and internally connected to VBAT.
20	18	VEE	-5V power supply.
21	19	VTX	Transmit vf output. The ac voltage difference between TIPX (pin 5) and RINGX (pin 6), the ac metallic voltage, is reproduced as an unbalanced GND referenced signal at V _{TX} with a gain of one. The two-wire impedance programming network connects between V _{TX} and RSN (pin 19).
22	20	HPT	TIP side of ac/dc separation capacitor C _{HP} . Other end of C _{HP} capacitor connects to pin 1, HPR.
1	21	HPR	Ring side of ac/dc separation capacitor CHP. Other end of CHP connects to pin 22, HPT.
2	22	RD	Off-hook detector programming resistor R _D in parallel with filter capacitor C _D connect from R _D to V _{EE} .
3	23	DT	Inputs to the ring trip comparator. With DR more positive than DT the detector output, $\overline{\text{DET}}$ (pin 14), is at logic level low, indicating off-hook condition. The ring trip network connects to these two inputs.
	24	VBAT	These pins marked VBAT are used for heat sinking and internally connected to VBAT.
4	25	DR	Inputs to the ring trip comparator. With DR more positive than DT the detector output, $\overline{\text{DET}}$ (pin 14), is at logic level low, indicating off-hook condition. The ring trip network connects to these two inputs.
	26	TIPX _{Sense}	TIPX _{Sense} is internally connected to TIPX. TIPX _{Sense} is used during manufacturing, but require no connections in SLIC applications, i.e. leave open.
	27	TIPX	The TIPX and RINGX pins connect to the tip and ring leads of the two-wire interface via overvoltage protection components and ring relay (and optional test relays).
	28	RINGX	

Functional Description and Applications Information

Transmission

General

A simplified ac model of the transmission circuits is shown in figure 9. Circuit analysis yields:

$$V_{TR} = V_{TX} + I_L \cdot 2R_F \quad (1)$$

$$\frac{V_{TX}}{Z_T} + \frac{V_{RX}}{Z_B} = \frac{I_L}{1000} \quad (2)$$

$$V_{TR} = E_L - I_L \cdot Z_L \quad (3)$$

where:

V_{TX} is a ground referenced unity gain version of the ac metallic voltage between the TIPX and RINGX terminals.

V_{TR} is the ac metallic voltage between tip and ring.

E_L is the line open circuit ac metallic voltage.

I_L is the ac metallic current.

R_F is a fuse resistor.

Z_L is the line impedance.

Z_T determines the SLIC TIPX to RINGX impedance.

Z_{RX} controls four- to two-wire gain.

V_{RX} is the analog ground referenced receive signal.

Two-Wire Impedance

To calculate Z_{TR} , the impedance presented to the two-wire line by the SLIC including the fuse resistors R_F , let:

$$V_{RX} = 0.$$

$$\text{From (1) and (2): } Z_{TR} = Z_T/1000 + 2R_F$$

Thus with Z_{TR} and R_F known:

$$Z_T = 1000 \cdot (Z_{TR} - 2R_F)$$

Example:

Calculate Z_T to make $Z_{TR} = 900\Omega$ in series with $2.16 \mu F$. $R_F = 40 \Omega$

$$Z_T = 1000 \cdot \left(900 + \frac{1}{j\omega \cdot 2.16 \cdot 10^{-6}} - 2 \cdot 40 \right)$$

which yields:

$$Z_T = 820 \text{ k}\Omega \text{ in series with } 2.16 \text{ nF.}$$

It is always necessary to have a high ohmic resistor in parallel with the capacitor. This gives a DC-feedback loop for low frequency which ensures stability and reduces noise.

Two-Wire to Four-Wire Gain

From (1) and (2) with $V_{RX} = 0$:

$$G_{2-4} = \frac{V_{TX}}{V_{TR}} = \frac{Z_T/1000}{Z_T/1000 + 2R_F}$$

Four-Wire to Two-Wire Gain

From (1), (2) and (3) with $E_L = 0$:

$$G_{4-2} = \frac{V_{TR}}{V_{RX}} = - \frac{Z_T}{Z_{RX}} \cdot \frac{Z_L}{Z_T/1000 + 2R_F + Z_L}$$

For applications where $Z_T/1000 + 2R_F$ is chosen to be equal to Z_L , the expression for G_{4-2} simplifies to:

$$G_{4-2} = - \frac{Z_T}{Z_{RX}} \cdot \frac{1}{2}$$

Four-Wire to Four-Wire Gain

From (1), (2) and (3) with $E_L = 0$:

$$G_{4-4} = \frac{V_{TX}}{V_{RX}} = - \frac{Z_T}{Z_{RX}} \cdot \frac{Z_L + 2R_F}{Z_T/1000 + 2R_F + Z_L}$$

Hybrid Function

The PBL 3764A/4 SLIC forms a particularly flexible and compact line interface when used with programmable CODEC/filters. The programmable CODEC/filter allows for system controller adjustment of hybrid balance to accommodate different line impedances without change of hardware. In addition, the transmit and receive gain may be adjusted. Please, refer to the programmable CODEC/filter data sheets for design information.

The hybrid function can also be implemented utilizing the uncommitted amplifier in conventional CODEC/filter combinations. Please, refer to figure 10. Via impedance Z_B a current proportional to V_{RX} is injected into the summing node of the combination CODEC/filter amplifier. As can be seen from the expression for the four-wire to four-wire gain a voltage

proportional to V_{RX} is returned to V_{TX} . This voltage is converted by R_{TX} to a current flowing into the same summing node. These currents can be made to cancel by letting:

$$\frac{V_{TX}}{R_{TX}} + \frac{V_{RX}}{Z_B} = 0 \quad (E_L = 0) =$$

The four-wire to four-wire gain, G_{4-4} , includes the required phase shift and thus the balance network Z_B can be calculated from:

$$Z_B = - R_{TX} \cdot \frac{V_{RX}}{V_{TX}} =$$

$$= R_{TX} \cdot \frac{Z_{RX}}{Z_T} \cdot \frac{Z_T/1000 + 2R_F + Z_L}{Z_L + 2R_F}$$

Example:

Calculate R_B for the line interface shown in figure 12.

$$R_B = 20 \cdot \frac{261 \cdot 10^3}{523 \cdot 10^3} \cdot \frac{523 \cdot 10^3 / 1000 + 2 \cdot 40}{600 + 2 \cdot 40} =$$

$$= 17.66 \text{ k}\Omega \text{ (i.e. standard value)}$$

$$17.8 \text{ k}\Omega, 1\%$$

If calculation of the Z_B formula above yields a balance network containing an inductor, an alternate method is recommended. Contact Ericsson Microelectronics for assistance.

Longitudinal Impedance

A feed back loop counteracts longitudinal voltages at the two-wire port by injecting longitudinal currents in opposing phase. Thus longitudinal disturbances will appear as longitudinal currents and the TIPX and RINGX terminals will experience very

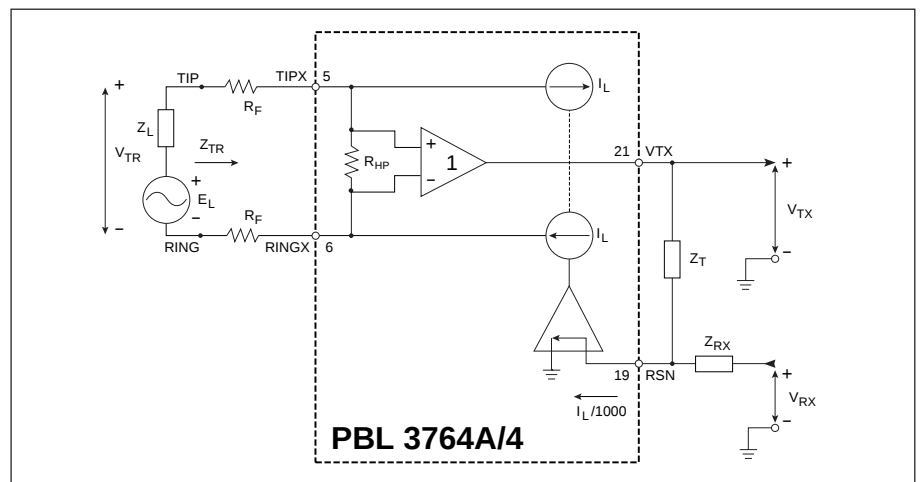


Figure 9. Simplified ac transmission circuit.

small longitudinal voltage excursions, leaving metallic voltages well within the SLIC common mode range. This is accomplished by comparing the instantaneous two-wire longitudinal voltage to an internal longitudinal reference voltage, V_{LoRef} .

$$V_{LoRef} = \frac{V_{Bat}}{2} = \frac{V_T + V_R}{2}$$

where V_T and V_R are tip and ring ground referenced voltages without any longitudinal component. As shown below, the SLIC appears as 20 Ω per wire to longitudinal disturbances. It should be noted that longitudinal currents may exceed the dc loop current without disturbing the vf transmission. Refer to figure 11.

Circuit analysis yields:

$$\frac{V_{Lo}}{R_{Lo}} = \frac{I_{Lo}}{1000}$$

which reduces to

$$R_{LoT} = R_{LoR} = V_{Lo}/I_{Lo} = 20 \text{ k}\Omega/1000 = 20 \text{ }\Omega$$

where:

$$R_{Lo} = 20 \text{ k}\Omega$$

$R_{LoT} = R_{LoR}$ = longitudinal resistance/wire
 V_{Lo} = longitudinal voltage at TIPX, RINGX
 I_{Lo} = longitudinal current.

Capacitors C_{TC} and C_{RC}

The capacitors designated C_{TC} and C_{RC} in figure 12, connected between TIPX and ground as well as between RINGX and ground, are recommended as an addition to the overvoltage protection network. Very fast transients, appearing on tip and ring, may pass by the diode and SCR clamps in the overvoltage protection network, before these devices have had time to activate and could damage the SLIC. C_{TC} and C_{RC} short such very fast transients to ground. The recommended value for C_{TC} and C_{RC} is 2200 pF. Higher capacitance values may be used, but care must be taken to prevent degradation of either longitudinal balance or return loss. C_{TC} and C_{RC} contribute a metallic impedance of $1/(\pi \cdot f \cdot C_{TC}) \approx 1/(\pi \cdot f \cdot C_{RC})$, a TIPX to ground impedance of $1/(2 \cdot \pi \cdot f \cdot C_{TC})$ and a RINGX to ground impedance of $1/(2 \cdot \pi \cdot f \cdot C_{RC})$.

Ac - dc Separation Capacitor, C_{HP}

The high pass filter capacitor connected between terminals 21 and 20 provides the

separation between circuits sensing tip-ring dc conditions and circuits processing ac signals. A C_{HP} value of 10 nF will position the low end frequency response 3dB break point at 48 Hz (f_{3dB}) according to $f_{3dB} = 1/(2 \cdot \pi \cdot R_{HP} \cdot C_{HP})$ where $R_{HP} \approx 330 \text{ k}\Omega$.

Battery Feed

The block diagram in figure 13 shows the PBL 3764A/4 battery feed system.

For a tip to ring dc voltage V_{TR} less than the saturation guard reference voltage V_{SGRef} , the SLIC emulates a constant-current feed characteristic. The constant current is independent of the actual battery voltage, V_{Bat} , connected to the SLIC.

With the tip to ring DC voltage V_{TR} exceeding V_{SGRef} , the feed characteristic changes to a nearly-constant voltage feed. This is to prevent the tip and ring drive amplifiers from distorting the AC signal as might have otherwise occurred due to insufficient voltage margin between V_{TR} and V_{Bat} (pin 6). Thus the SLIC automatically adjusts the tip to ring dc voltage V_{TR} to the maximum safe value.

With the SLIC in the stand-by state ($C1$, $C2 = 1,1$) a resistive feed characteristic is enabled.

The following text explains the three battery feed cases in more detail.

Case 1: SLIC in the Active State;

$$V_{TR} < V_{SGRef}$$

In the active state $C1 = 0$ and $C2 = 1$. In this operating state tip to ring voltages V_{TR} less than V_{SGRef} cause the block titled saturation guard (figure 13) to be disabled, i.e. its output is equal to zero.

For this case circuit analysis yields:

$$R_{DC1} + R_{DC2} = \frac{2.5V}{I_{Ldc}} \cdot 1000$$

where:

I_{Ldc} = constant loop current (independent of the loop resistance R_L)

$R_{DC1} + R_{DC2}$ = the programming resistance which sets the constant loop current

For tip to ring voltages V_{TR} less than V_{SGRef} the PBL 3764A/4 thus emulates a constant current feed with the magnitude of the constant current set by the resistors, R_{DC1} and R_{DC2} .

Capacitor C_{DC} at the $R_{DC1} - R_{DC2}$ common point removes vf signals from the battery feed control loop. C_{DC} is calculated according to:

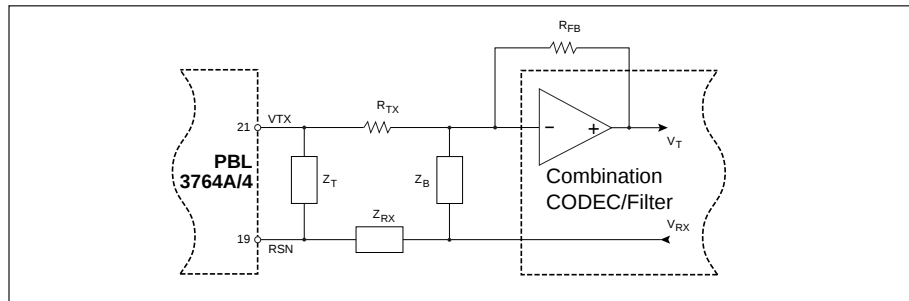


Figure 10. Hybrid function.

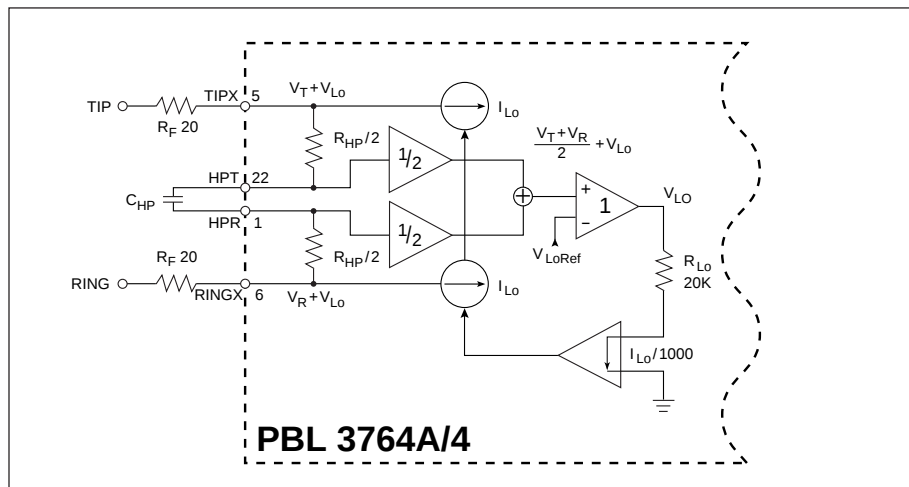


Figure 11. Longitudinal impedance.

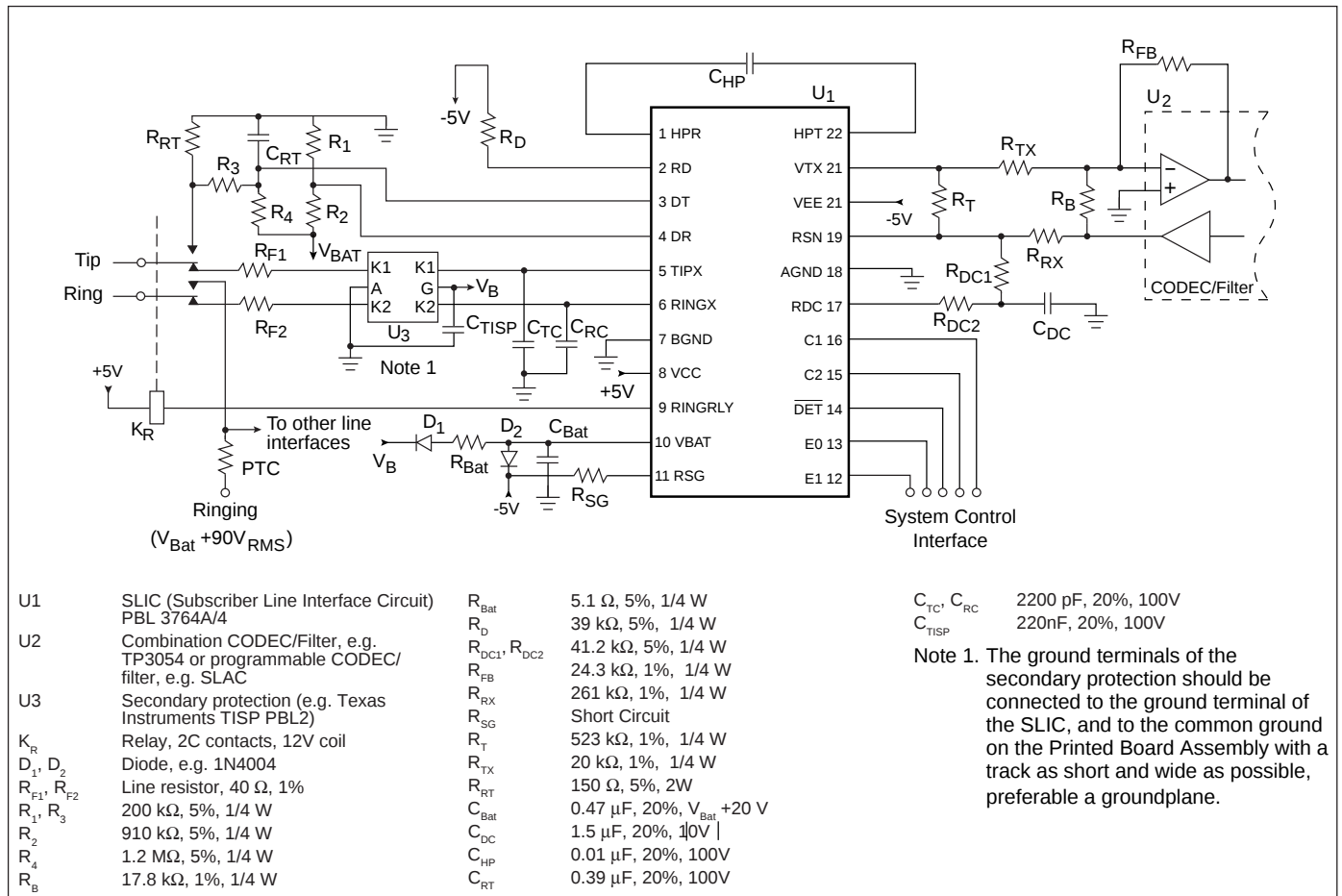
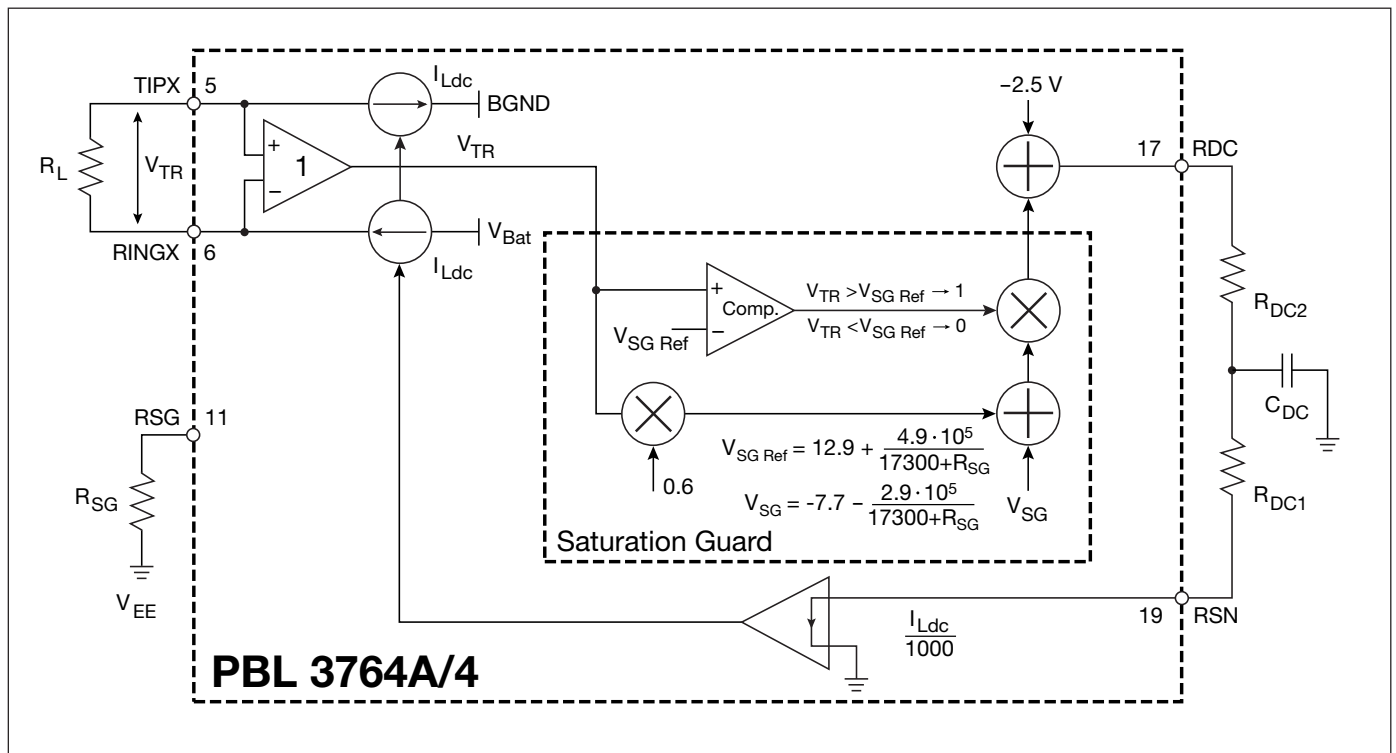


Figure 12. Single-channel subscriber line interface with PBL 3764A/4 and combination CODEC/filter.

Figure 13. Battery feed ($C1, C2 = 0,1$ active state)

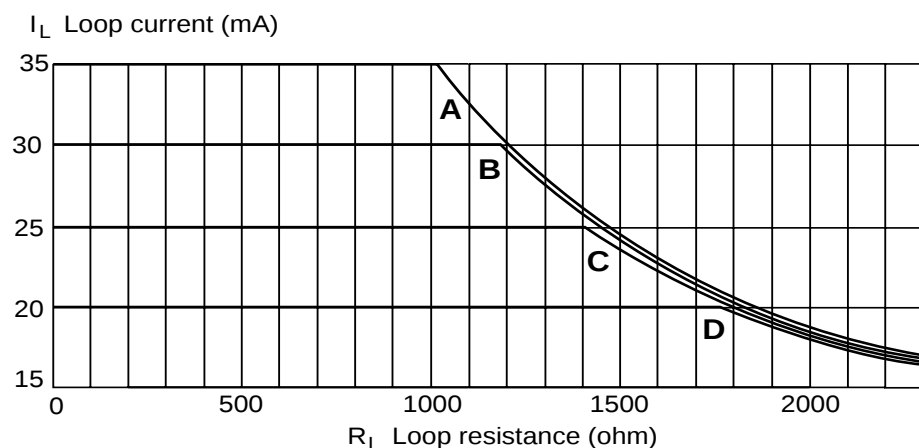


Figure 14. Loop current as a function of loop resistance.

$$V_{Bat} = -48V, R_{SG} = 4k\Omega$$

$$\text{Curve A: } R_{DC1} + R_{DC2} = 71.4k\Omega$$

$$\text{Curve B: } R_{DC1} + R_{DC2} = 83.3k\Omega$$

$$\text{Curve C: } R_{DC1} + R_{DC2} = 100k\Omega$$

$$\text{Curve D: } R_{DC1} + R_{DC2} = 125k\Omega$$

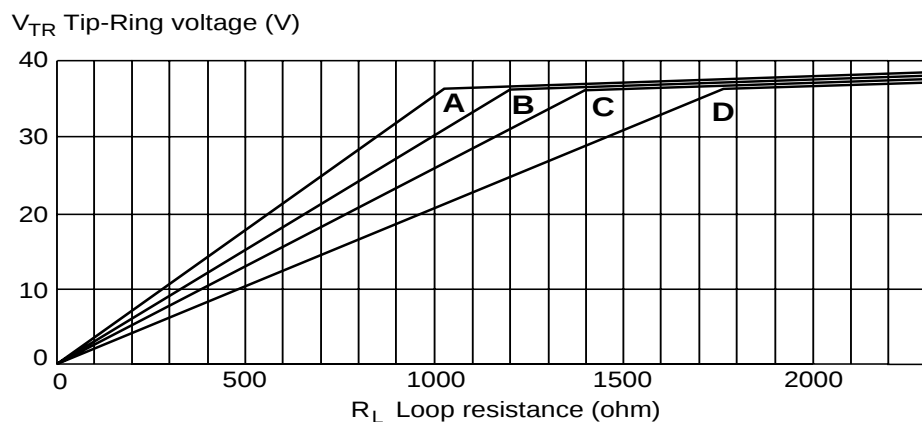


Figure 15. Tip-ring voltage as a function of loop resistance.

$$V_{Bat} = -48V, R_{SG} = 4k\Omega$$

$$\text{Curve A: } I_{Const} = 35mA$$

$$\text{Curve B: } I_{Const} = 30mA$$

$$\text{Curve C: } I_{Const} = 25mA$$

$$\text{Curve D: } I_{Const} = 20mA$$

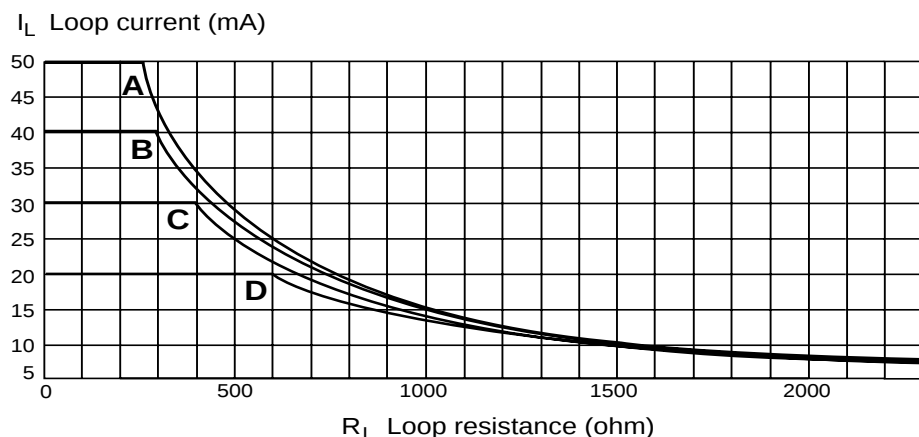


Figure 16. Loop current as a function of loop resistance.

$$V_{Bat} = -24V, R_{SG} = \infty$$

$$\text{Curve A: } R_{DC1} + R_{DC2} = 50.0k\Omega$$

$$\text{Curve B: } R_{DC1} + R_{DC2} = 62.5k\Omega$$

$$\text{Curve C: } R_{DC1} + R_{DC2} = 83.3k\Omega$$

$$\text{Curve D: } R_{DC1} + R_{DC2} = 125.0k\Omega$$

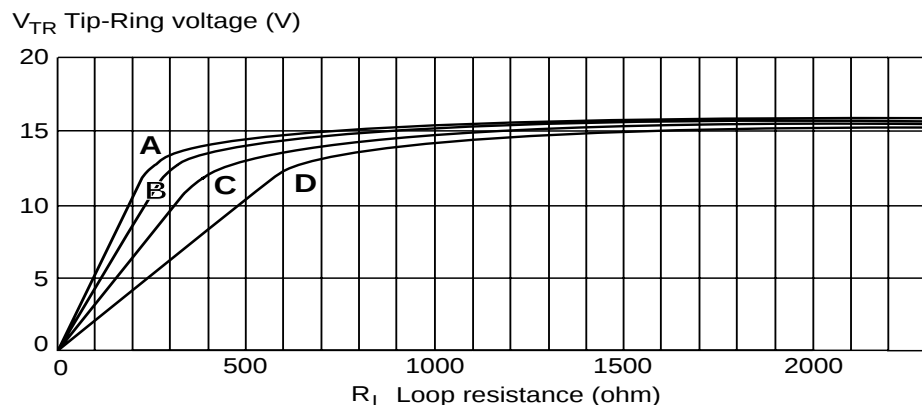


Figure 17. Tip-ring voltage as a function of loop resistance.

$$V_{Bat} = -24V, R_{SG} = \infty$$

$$\text{Curve A: } I_{Const} = 50mA$$

$$\text{Curve B: } I_{Const} = 40mA$$

$$\text{Curve C: } I_{Const} = 30mA$$

$$\text{Curve D: } I_{Const} = 20mA$$

Figure 18. Overload level, V_{TRO} as a function of V_{Margin} *

Max. V_{Margin} = maximum
 $V_{Bat} - V_{TRdc}$ / required for distortion
 free transmission of a given V_{TRO} *

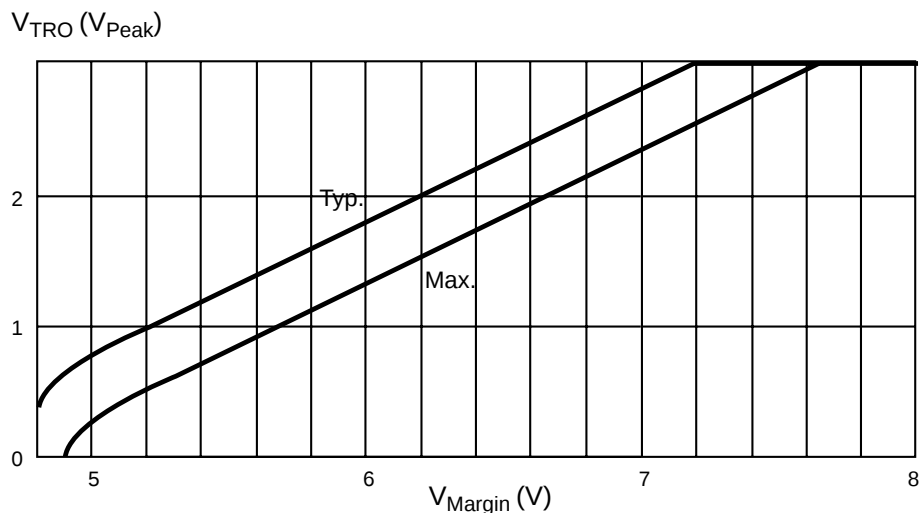


Figure 19. Loop resistance at $I_L = 18\text{mA}$ as a function of V_{Margin} at open loop.

$V_{Bat} = -48\text{V}$

CurveA: $I_{Const} = 20\text{mA}$

CurveB: $I_{Const} = 25\text{mA}$

CurveC: $I_{Const} = 30\text{mA}$

CurveD: $I_{Const} = 35\text{mA}$

R_L (ohm) at $I_L = 18\text{mA}$

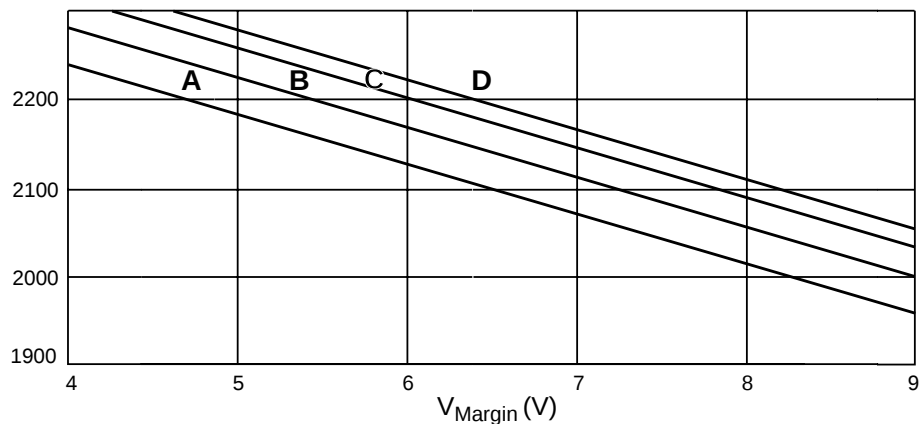


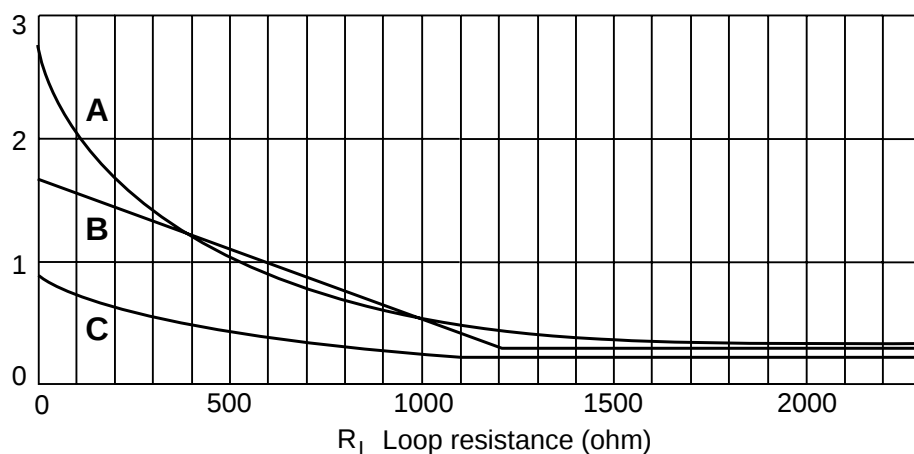
Figure 20. Power Dissipation.

CurveA: Conventional 2X400Ω resistive feed

CurveB: PBL3764A/4, -48V, 30mA

CurveC: PBL3764A/4, -28V, 30mA

P (W)



$$C_{DC} = T \cdot \left(\frac{1}{R_{DC1}} + \frac{1}{R_{DC2}} \right), \text{ where } T = 30\text{ms}$$

Note that $R_{DC1} = R_{DC2}$ yields minimum C_{DC} value.

Case 2: SLIC in the Active State

$$V_{TR} > V_{SGRef}$$

In the active state $C1 = 0$ and $C2 = 1$. The saturation guard reference voltage is user programmable according to:

$$V_{SGRef} = 12.9 + \frac{4.9 \cdot 10^5}{(17300) + R_{SG}}$$

where:

R_{SG} = saturation guard reference programming resistor in Ω .

V_{SGRef} = saturation guard reference voltage in volts.

Once the dc metallic voltage, V_{TR} , exceeds the saturation guard reference voltage, V_{SGRef} the saturation guard becomes active and the following expression describes the battery feed characteristic:

$$V_{TR} = R_L \cdot \frac{16.7 + 4.9 \cdot 10^5 / (R_{SG} + 17300)}{R_L + (R_{DC1} + R_{DC2}) / 653}$$

where R_{SG} , R_L and V_{TR} have the same meaning as described above.

At open loop, i.e. $R_L \rightarrow \infty$, the saturation guard limits the tip-ring voltage to:

$$V_{TR} = 16.7 + (4.9 \cdot 10^5) / (R_{SG} + 17300)$$

Figures 14 through 17 illustrate the PBL 3764A/4 loop feed with $V_{Bat} = -48\text{V}$ and $V_{Bat} = -24\text{V}$.

For applications where the tip-to-ring DC voltage, V_{TR} , approaches the V_{Bat} value. R_{SG} should be adjusted as follows:

As a general guideline, adjust R_{SG} in the V_{TR} expression above to yield $V_{TRMax} \leq |V_{Bat}| - 8\text{V}$ at maximum loop resistance. Maintaining V_{TR} below this limit ensures vf signal transmission through the SLIC without clipping.

R_{SG} can be calculated from:

$$R_{SG} = \frac{4.9 \cdot 10^5}{(|V_{Bat}| - V_{Margin}) \cdot [1 + (R_{DC1} + R_{DC2}) / 653] - 16.7\text{V}} - 17300$$

where:

$V_{Margin} = 8\text{V}$ to allow a maximum overload level, V_{TRO} , of 3.1V.

If transmission is required at open loop, i.e., $R_L \rightarrow \infty$, the above expression simplifies to:

$$R_{SG} = \frac{4.9 \cdot 10^5}{|V_{Bat}| - V_{Margin} - 16.7\text{V}} - 17300$$

In applications where the longest possible two-wire loop length is important,

it is possible to increase the maximum loop resistance at minimum allowable loop current by reducing the voltage margin $V_{Margin} = |V_{Bat}| - V_{TRMax}$ from the 8V suggested above. Doing so will, however, reduce the overload level from 3.1 V_{Peak} as shown in figure 18. Figure 19 shows the typical maximum loop resistance at 18mA as a function of the voltage margin for several values of programmed constant-current feed and $V_{Bat} = -48\text{V}$.

Case 3: SLIC in the Stand-by State.

In the stand-by state $C1 = 1$ and $C2 = 1$. With the SLIC operating in the stand-by, power saving, state the tip and ring drive amplifiers are disconnected and a resistive battery feed is engaged. The loop current can be calculated from:

$$I_{Ldc} \approx \frac{|V_{Bat}| - 3\text{V}}{R_L + 1800\Omega}$$

where:

I_{Ldc} = loop current

R_L = loop resistance

V_{Bat} = battery supply voltage

PBL 3764A/4 Power Dissipation

The short circuit SLIC power dissipation P_{ShTot} is

$$P_{ShTot} = I_{LSh} \cdot (|V_{Bat}| - I_{LSh} \cdot 2R_F) + P_3$$

where:

V_{Bat} is the battery voltage connected to the SLIC at pin 10,

R_F is the line resistance, 40 Ω

$$I_{LSh} = \frac{25\text{V}}{R_{DC1} + R_{DC2}} \cdot 1000 \text{ is the constant loop current.}$$

P_3 is on-hook, active state power dissipation (typ. 200 mW @ $V_{Bat} = -48\text{V}$). Note that a short circuited loop is not a normal operating condition. The terminating equipment will add some dc resistance (200 Ω to 300 Ω) even if the wire resistance is near 0 Ω .

Figure 20 compares line feed power dissipation as a function of loop resistance for three cases: feed resistor dissipation for a conventional 2 • 400 Ω resistive feed, PBL 3764A/4 with 30 mA constant current feed and $V_{Bat} = -48\text{V}$ and PBL 3764A/4 with 30 mA constant current feed and $V_{Bat} = -28\text{V}$. The diagram illustrates the significant PBL 3764A/4 power saving compared to the 2 • 400 Ω feed.

Temperature Guard

A ring to ground short circuit fault condition as well as other improper operating conditions may cause excessive SLIC power dissipation. If junction temperature increases beyond 150°C, the temperature guard will trigger, causing the SLIC to be set to a high-impedance state. In this high-impedance state, power dissipation is reduced and the junction temperature will return to a safe value. Once below 150°C, the SLIC is returned back to its normal operating mode and will remain in that state, assuming the fault condition has been removed. As long as the temperature guard is triggered, the loop current detector will stay in active state.

PBL 3764A/4 Long Loop vf Transmission

To ensure that the maximum vf signal intended to be received/transmitted by the SLIC will not experience limiting in the TIPX (pin 27) /RINGX (pin 28) drive amplifiers at long loops, the saturation guard must be correctly programmed. The section, "Battery Feed, Case 2" describes how to calculate a value for the saturation guard programming resistor R_{SG} .

Loop Monitoring Functions

The loop current, ground key and ring trip detectors report their status through a common output, DET (pin 11). The detector to be connected to DET is selected via the four bit wide control interface C1, C2, E0, E1. Please refer to section Control Inputs for a description of the control interface.

Loop Current Detector

The loop current value at which the loop current detector changes state is programmable by selecting the value of resistor R_D . R_D connects between pins RD (22) and VEE (18). Figure 21 shows a block diagram of the loop current detector. The two-wire interface produces a current flowing out of pin RD (22):

$I_{RD} = |I_{LTIPX} - I_{LRINGX}| / 600 = I_L / 300$
where I_{LTIPX} and I_{LRINGX} are currents flowing into the TIPX and RINGX terminals and I_L is the loop current. The voltage generated by I_{RD} across the programming resistor R_D is compared to an internal reference by a comparator with hysteresis. The hysteresis causes the on-hook to off-hook loop current detect threshold, I_{LThOff} , to be slightly larger than the off-hook to on-hook loop current detect threshold, I_{LThOn} . A logic low

results at the $\overline{\text{DET}}$ (pin 11) output when the loop current exceeds the on-hook to off-hook detect threshold, I_{LThOff} .

The programming resistor R_D value can be calculated for a desired I_{LThOff} from $R_D = 465/I_{\text{LThOff}}$. R_D is in $k\Omega$ for I_{LThOff} in mA. The off-hook to on-hook threshold, I_{LThOn} , for a known R_D is $I_{\text{LThOn}} = 405/R_D$. A logic high results at the $\overline{\text{DET}}$ output when the loop current is less than I_{LThOn} . The C_D filter capacitor is calculated according to $C_D = T/R_D$ with time constant $T = 0.5$ ms. Note that C_D may not be required if $\overline{\text{DET}}$ is software filtered.

Ground Key Detector

The ground key detector circuit examines the difference in TIPX and RINGX currents. Should the current difference exceed the threshold value, ΔI_{LOn} , the detector is triggered. As the current difference decreases the detector is reset at current threshold ΔI_{LOff} . $\Delta I_{\text{LOn}} > \Delta I_{\text{LOff}}$, i.e. the detector has hysteresis. The triggered detector results in a logic low at the $\overline{\text{DET}}$ (pin 11) output, assuming the ground key detector has been selected via the four-bit control input (C1, C2, E0, E1). For ΔI_{LOn} and ΔI_{LOff} numerical values please refer to table "Electrical characteristics".

Ring Trip Detector

Ring trip detection is accomplished by connecting an external network to a comparator in the SLIC with inputs DT (pin 23) and DR (pin 25). The ringing source can be balanced or unbalanced superimposed on V_{Bat} . The unbalanced ringing source may be applied to either the ring lead or the tip lead with return via the other wire. A ring relay driven by the SLIC ring relay driver connects the ringing source to tip and ring.

The ring trip function is based on a polarity change at the comparator input when the line goes off-hook. In the on-hook state no dc current flows through the loop and the voltage at comparator input DT is more positive than the voltage at input DR. When the line goes off-hook, while the ring relay is energized, dc current flows and the comparator input voltage reverses polarity.

Figure 22 is an example of a ring trip detection network. This network is applicable, when the ring voltage superimposed on V_{Bat} is injected on the ring lead of the two-wire port. The dc voltage across sense resistor R_{RT} is

monitored by the ring trip comparator input DT via the network R_3 , R_4 and C_{RT} . Input DR is set to a reference voltage by resistors R_1 and R_2 . With the line on-hook (no dc current) DT is more positive than DR and the $\overline{\text{DET}}$ output will report logic level high, i.e. the detector is not tripped. When the line goes off-hook, while ringing, a dc current will flow through the loop including sense resistor R_{RT} and will cause input DT to become more negative than input DR. This changes output $\overline{\text{DET}}$ to logic level low, i.e. tripped detector condition. The system controller (or line card processor) responds by de-energizing the ring relay, i.e. ring trip

Complete filtering of the 20 Hz ac component at terminal DT is not necessary. A toggling $\overline{\text{DET}}$ output can be

examined by a software routine to determine the duty cycle. When the $\overline{\text{DET}}$ output is at logic level low for more than half the time, off-hook condition is indicated.

Relay Driver

The PBL 3764A/4 SLIC incorporates a ring relay driver designed as open collector (nnp) with a current sinking capability of 50 mA. The drive transistor emitter is connected to BGND. An external inductive kick-back clamp diode must be employed to protect the drive transistor.

Control Inputs

The PBL 3764A/4 SLIC has two TTL compatible control inputs, C1 and C2. A decoder in the SLIC interprets the

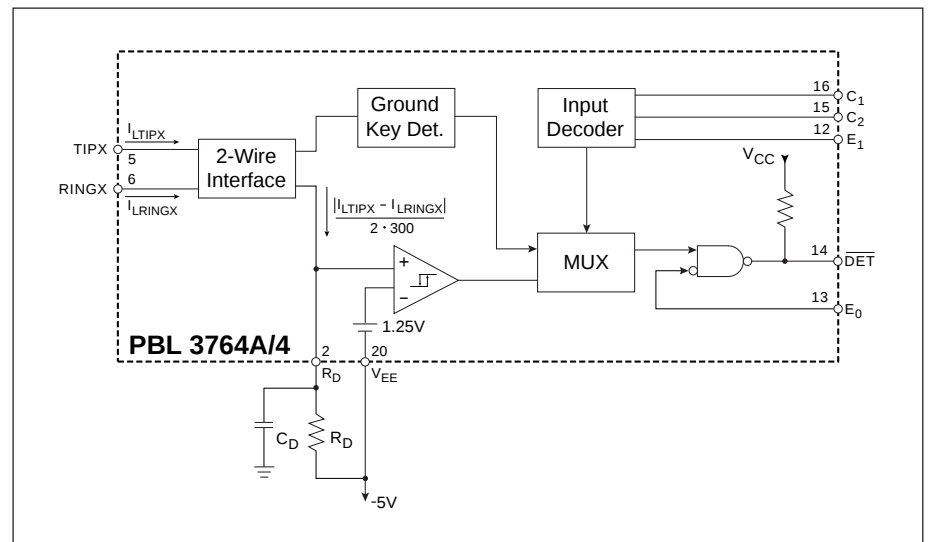


Figure 21. Loop current and ground key detectors.

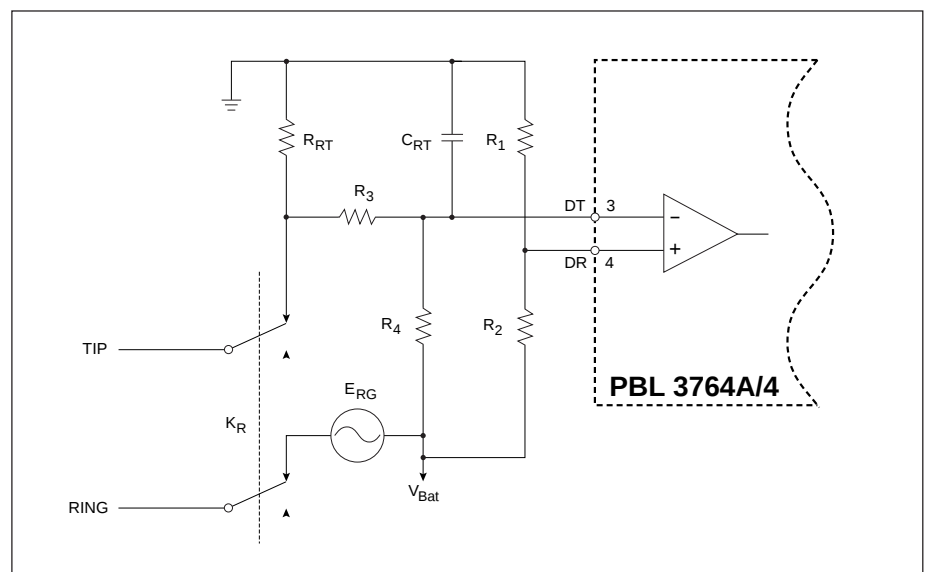


Figure 22. Ring trip network.

control input conditions and sets up the commanded operating state.

Open Circuit State (C1, C2 = 0, 0)

In the Open Circuit State the TIPX and RINGX line drive amplifiers as well as other circuit blocks are powered down. This causes the SLIC to present a high impedance to the line. Power dissipation is at a minimum. No detectors are active.

Ringing State (C1, C2 = 1, 0)

The ring relay driver and the ring trip detector are activated. TIPX and RINGX are in the high impedance state and

Active State (C1, C2 = 0, 1)

TIPX is the terminal closest to ground and sources loop current while RINGX is the more negative terminal and sinks loop current. Vf signal transmission is normal. Both the loop current and the ground key detectors are activated. Inputs E0 and E1 control the selection of one of these detectors to be gated to the $\overline{\text{DET}}$ output. Please, refer to section Enable Inputs.

Stand-By State (C1, C2 = 1, 1)

Signal transmission is inhibited.

In the Stand-by State the line drive amplifiers are disconnected. The loop feed is converted to resistive form according to:

$$I_L \approx \frac{|V_{\text{Bat}}| - 3 \text{ V}}{R_L + 1800 \Omega}$$

where:

I_L = loop current (A)

V_{Bat} = battery supply voltage (V)

R_L = loop resistance (Ω)

The standby short circuit loop current (I_{LSh}) for $V_{\text{Bat}} = -28\text{V}$ is then limited to:

$$I_{\text{LSh}} \approx 13.9 \text{ mA.}$$

Both the loop current and ground key detectors are activated in this operating state. Inputs E0 and E1 control the selection of one of these detectors to be gated to the $\overline{\text{DET}}$ output. Please, refer to section "Enable Inputs".

Table 1 summarizes the above description of the control inputs.

Enable Inputs (E0, E1)

Two TTL compatible enable inputs E0 (pin 13) and E1 (pin 12) control the function of the DET (pin 14) output.

E0, when set to logic level low, enables

the $\overline{\text{DET}}$ output, which is a collector output with internal pull-up resistor (approx. 15 k Ω). A DET output at logic level low indicates triggered detector condition (loop current above threshold current, ground key depressed or telephone off-hook during the ringing cycle). A DET output at logic level high indicates a non triggered detector condition.

E0, when set to logic level high, disables the $\overline{\text{DET}}$ output; i.e. it appears as a resistor connected to V_{CC} .

E1, when set to logic level low, gates the ground key detector to the $\overline{\text{DET}}$ output.

E1, when set to logic level high, gates the loop detector to the $\overline{\text{DET}}$ output.

Table 1 summarizes the above description of the enable inputs.

Overvoltage Protection

The PBL 3764/A4 SLIC must be protected against overvoltages on the telephone line caused by lightning, ac power contact and induction. Refer to Maximum Ratings, TIPX and RINGX terminals, for maximum allowable continuous and transient voltages that may be applied to the SLIC. The circuit shown in figure 12 utilizes series resistors together with a programmable overvoltage protector (e.g. Texas Instrument TISP PBL2), serving as a secondary protection.

The protection network in figure 12 is designed to meet requirements in ITU-T K20, Table 1.

The TISP PBL2 is a dual forward-conducting buffered p-gate overvoltage protector. The protector gate references the protection (clamping) voltage to negative supply voltage (i.e. the battery voltage, V_{Bat}). As the protection voltage will track the negative supply voltage the overvoltage stress on the SLIC is minimized.

Positive overvoltages are clamped to ground by an internal diode. Negative overvoltages are initially clamped close to the SLIC negative supply rail voltage. If sufficient current is available from the overvoltage, then the protector will crowbar into a low voltage on-state condition, clamping the overvoltage close to ground.

A gate decoupling capacitor, C_{TISP} is needed to carry enough charge to supply a high enough current to quickly turn on the thyristor in the protector. Without the capacitor even the low inductance in the

State	E0	E1	C1	C2	SLIC operating state	Active detector	$\overline{\text{DET}}$ Output
1	0	0	0	0	Open circuit	No active detector	Logic level high
2	0	0	0	1	Active	Ground key detector	Ground key status
3	0	0	1	0	Ringing	Ring trip detector	Ring trip status
4	0	0	1	1	Stand-by	Ground key detector	Ground key status
5	0	1	0	0	Open circuit	No active detector	Logic level high
6	0	1	0	1	Active	Loop current detector	Loop current status
7	0	1	1	0	Ringing	Ring trip detector	Ring trip status
8	0	1	1	1	Stand-by	Loop current detector	Loop current status
9	1	0	0	0	Open circuit	Note 1	Logic level high
10	1	0	0	1	Active		Note 1
11	1	0	1	0	Ringing		
12	1	0	1	1	Stand-by		
13	1	1	0	0	Open circuit		
14	1	1	0	1	Active		
15	1	1	1	0	Ringing		
16	1	1	1	1	Stand-by		

Table 1. SLIC operating states

Note 1 For operating states 9-16 active detectors are as for operating states 1-8. The $\overline{\text{DET}}$ output is, however, disabled and remains at logic level high regardless of detector status.

Note 2 For operating states 1- 8 the $\overline{\text{DET}}$ output is enabled and will report the status of the active detector. Logic level low indicates a triggered detector.

track to the V_{Bat} supply will limit the current and delay the activation of the thyristor clamp.

The fuse resistors R_F serve the dual purposes of being non-destructive energy dissipators, when transients are clamped and of being fuses, when the line is exposed to a power cross. Ericsson Microelectronics AB offers a series of thick film resistors networks (e.g. PBR 51-series and PBR 53-series) designed for this application.

Also devices with a built in resetable fuse function is offered (e.g. PBR 52-series) including positive temperature coefficient (PTC) resistors, working as resetable fuses, in series with thick film resistors. Note that it is important to always use PTC's in series with resistors not sensitive to temperature, as the PTC will act as a capacitance for fast transients and therefore the ability to protect the SLIC will be reduced.

If there is a risk for overvoltages on the V_{Bat} terminal on the SLIC, then this terminal should also be protected.

Power-up Sequence

The voltage at pin VBAT sets the substrate voltage, which must at all times be kept more negative than the voltage at any other pin to prevent possible latch-up. The optimal power-up sequence is ground and V_{Bat} , then other supplies and signal leads.

However, V_{CC} may be connected before V_{Bat} and if the V_{Bat} supply voltage should be absent, a diode with a 2A current rating connected with its cathode to VEE and anode to VBAT ensures the presence of the most-negative supply voltage at the VBAT pin. The VBAT pin should not be applied at a faster rate than corresponds to the time constant formed by a 5.1Ω resistor in series with the VBAT pin and a $0.47\mu F$ capacitor from the VBAT pin to ground. This RC network may be shared by several SLICs.

Printed Circuit Board Layout

Care in PCB lay-out is essential for proper PBL 3764A/4 function. The components connecting to the RSN pin (16) should be in close proximity of that pin such that no interference is injected into the RSN terminal. Ground plane surrounding the RSN pin is advisable.

The two ground pins AGND and BGND should be connected together on the PCB at the device location.

Ordering Information

Package	Temp. Range	Part No.
PDIP Tube	-40 to 85°C	PBL3764/4NS
PLCC Tube	-40 to 85°C	PBL3764/4QNS
PLCC Tube	-40 to 85°C	PBL3764/6QNS
PLCC Tape & Reel	-40 to 85°C	PBL3764/4QNT
PLCC Tape & Reel	-40 to 85°C	PBL3764/6QNT

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