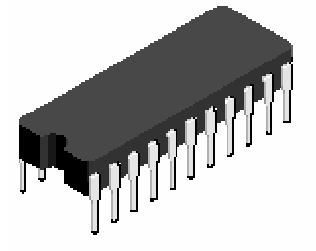
Interface Circuit of Subscriber Line ILF3866N (Interface Circuit)

(Functional Analogue – TFF3866 by Company Megaxess)



Microcircuit ILF3866N is essentially the subsriber's line interface (SLIC).

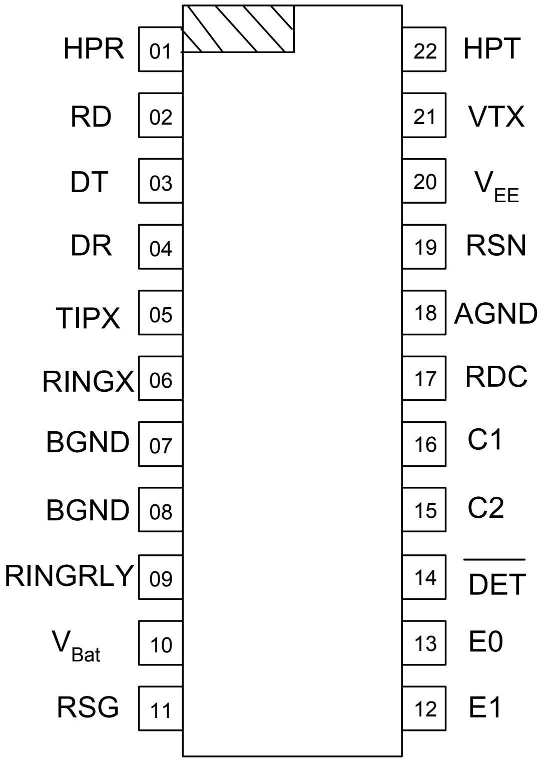
Microcircuit ILF3866N is intended for matching the signals of the subsriber's telephone line and the internal tract of the analogue or analogue-digital automatic telephone station (ATS). Microcircuit is used in the automatic telephone station. In the analogue-digital automatic telephone stations the microcircuit ILF3866N is used in the kit with the codek microcircuit IL145567N (IL145567DW), IL145557DW.

Functional features of the microcircuit:

- provides power supply to the subscriber's line and the phone set (Phone);
- performs receipt and transfer of the signals in two directions, as well as separation of signals between the double-wire and quadruple wire station lines;
- ensures matching of impedances;
- determines the state of stub (receiver is on hook /receiver is off hook);
- controls application of the call signal (via the external relay);
- performs the line testing by the leakage current to the ground;
- performs the line protection from short circuit (heat protection);
- has the digital port for the commands receipt from the microcontroller;
- temperature range is from minus 40 to plus 70 C.

Application of the microcircuit ILF3866N will make it possible to reduce power consumption, dimensions and cost of the telephone station, enhance quality and reliability of the phone communication.

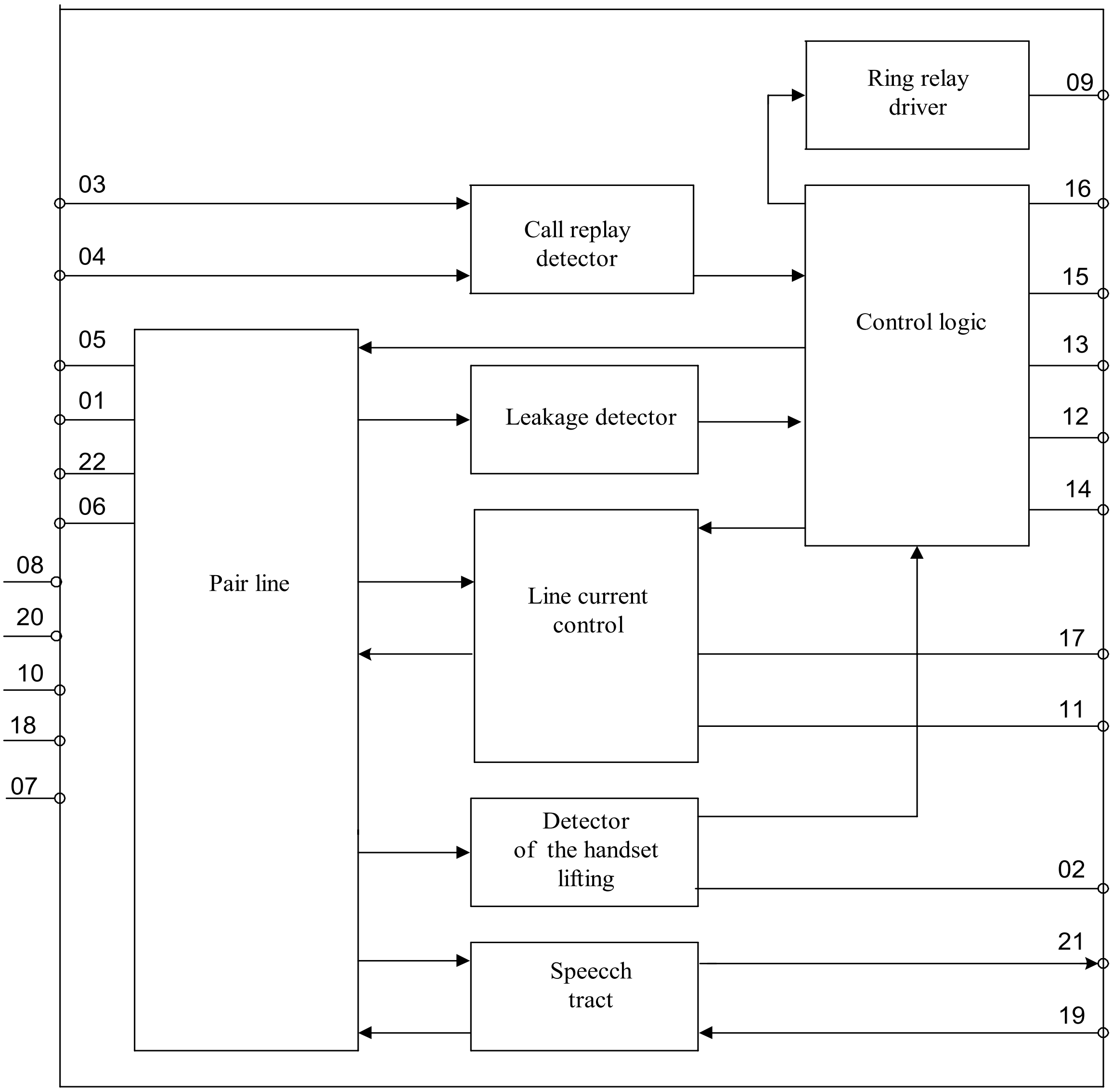
By design the microcircuit is made in the plastic twenty two pin DIP package MS-010AA.



Pins description

Number of Pin	Symbol	Purpose
01	HPR	First connection pin of the AC/DC separation capacitor C_{HP}
02	RD	Pin of programming resistor for determining the receiver off – hook status R_D
03	DT	Comparator first input of subscriber's reply when calling
04	DR	Comparator second input of subscriber's reply when calling
05	TIPX	First input of double wire port
06	RINGX	Second input of double wire port
07	BGND	Common pin
08	Vcc	Supply pin from the voltage source of 5 V
09	RINGRLY	Driver output of bell relay
10	V_{Bat}	Pin of battery supply voltage from minus 24 to minus 75 V
11	RSG	Pin of programming saturation resistor R_{SG}
12	E1	TTL compatible input for control of operating modes
13	E0	TTL compatible input for control of operating modes
14	$\overline{DET}$	Detector output
15	C2	TTL compatible input for control of operating modes
16	C1	TTL compatible input for control of operating modes
17	RDC	Output of reference voltage source (used for control of line current)
18	AGND	Common pin
19	RSN	**Input of quadruple port**
20	V_{EE}	Supply pin from voltage source minus 5 V
21	VTX	Output of quadruple port
22	HPT	Second connection pin of separation AC/DC capacitor C_{HP}

Block-diagram



Maximum and absolute maximum ratings

Mode, Parameter, Unit	Symbol	maximum ratings		absolute maximum ratings	
		Min	Max	Min.	Max
D. C. supply voltage, V Vcc relative to AGND	Vcc	-4.75	5.25	-0.5	7.0
V_{EE} relative to AGND	V_{EE}	-5.25	-4.75	-7.0	0.5
V_{Bat} relative to BGND	V_{Bat}	-75*	-24	-100	V_{EE}
Dissipated power, Wt: – with T 70 C	P_D	-	1.5	-	1.7
– with T 85 C			1.1		1.5
Voltage disbalance of pin AGND relative to pin BGND, V	V_G	-0.2	0.2	-0.3	0.3
Relay driver: - relay voltage, V	V_{RRly}	V_{Bat}	Vcc	V_{Bat}	Vcc
- relay current, mA	I_{RRly}	-25	0	-30	0
Call interruption comparator: - input voltage, V	V_{DT}, V_{DR}	V_{Bat}	0	V_{Bat}	0
- input voltage, mA	I_{DT}, I_{DR}	-4	4	-5	5
Digital inputs, outputs (C1, C2, E0, E1, DET) - low level input voltage, V	V_{IL}	0	0.8	-0.3	Vcc + 0. 3
- high level input voltage, V	V_{IH}	2.0	Vcc	-0.3	Vcc + 0. 3
- output voltage, V	V_O	0	Vcc	-0.3	Vcc + 0. 3
- output current, mA	I_O	-	5	-	6
Subscriber's signal port: current by pin TIPX or RINGX, mA	I_{RT}	-	50	-	70
Storage temperature, C	Tstg	-	-	-60	125
Chip storage temperature, C	Tj	-	140	-	150

* Minus 75 C within not over 30 minutes, minus 72 C — constantly

Electric Parameters

Parameter Description, Measurement Unit	Symbol	Measurement Mode	Norm Min	Norm Max	Ambient Temperature, C
Double Line Port (Fig. 3, 4)					
Overload level [1], %	K_{TRO}	R_L = 600 Ohm, f = 1 kHz, V_{TR}=2.19 V	-	0.8	25 10
Longitudinal balance from double wire to quadruple wire line, dB	B_{LFE}	f = 1 kHz $B_{LFE} = 20 \lg E_{LO}/V_{TX}$	55	-	25 10
			46	-	-40; 70
Harmonics ratio from double wire to quadruple wire port, dB	$K\Gamma_{24}$	-	-	-54	25 10
				-53	-40; 70
Quadruple wire transmitting port (VTX) (Fig. 5, 6)					
Overload level [2], %	K_{TXO}	Load resistance is over 20 kOhm, f = 1 kHz, V_{TX}=2.19 V	-	0.8	25 10
Quadruple wire liongitudinal balance, dB	B_{FLE}	f = 1 kHz $B_{FLE} = 20 \lg V_{RX}/V_{LO}$,	50	-	25 10
			45	-	-40; 70
Internal losses (Fig. 7)					
Transmission ratio from double wire to quadruple wire line [3), 4)], dB	G_{24}	V_{TR} = 0dBm, f =1 kHz, $G_{24} = 20 \lg(V_{TX}/V_{TR})$	-0.15	0.15	25 10
			-0.20	0.20	-40; 70
Transmission ratio from quadruple wire to double wire line [3), 4)], dB	G_{42}	V_{RX} = 0dBm, f =1 kHz, $G_{42} = 20 \lg(V_{TR}/V_{RX})$	-0.15	0.15	25 10
			-0.20	0.20	-40; 70
Transmission ratio from quadruple wire to quadruple wire line [3), 4)], dB	G_{44}	V_{RX} = 0dBm, f =1 kHz, $G_{44} = 20 \lg(V_{TX}/V_{RX})$	-0.15	0.15	25 10
			-0.20	0.20	-40; 70
Battery power supply					
Line current in active mode, mA	I_{LA}	I_{LA}=50/ R_L+(R_{DC1} + + R_{DC2})/50 R_L=600 Ohm, R_{DC1}=R_{DC2}=41 kOhm, V_{Bat} = -60 V, V_{C1} = V_{IL}, V_{C2} = V_{IH}	27.4	33.6	25 10
			26.0	35.0	-40; 70
Line current in the stand-by mode, mA	I_{LS}	I_{LS}=(V_{Bat}–3)/(R_L+1800 Ohm) V_{C1} = V_{IH}, V_{C2} = V_{IL} V_{Bat} = -60 V, R_L = 600 Ohm	19.9	27.6	25 10
			17.6	29.6	-40; 70
Line current sensor					
Switch-on threshold current of line current sensor, mA	I_{LThOn}	R_D = 48.7 kOhm between inputs TIPX and RINGX D.C. oscillator is switched on I_L	8.25	10.7	25 10
			7.5	11.5	-40; 70
Switch-off threshold current of line current sensor, mA	I_{LThOff}	R_D = 48.7 kOhm	7.2	9.4	25 10
			6.5	10.2	-40; 70
Leakage to ground sensor					
Switch-on current of leakage to ground sensor, mA	I_{LOn}	D. C. oscillator is connected between ground and inputs TIPX or RINGX	9.0	16.0	25 10
			8.0	17.0	-40; 70
Switch-off current of leakage to ground sensor, mA,	I_{LOff}	-	4.0	11.0	25 10
			3.0	12.0	-40; 70
Current hysteresis of leakage to ground sensor, mA	I_{LGK}	I_{LOn} - I_{LOff}	3.0	8.0	25 10
			0	9.0	-40; 70

Parameter Description, Measurement Unit	Symbol	Measurement Mode	Norm		Tempera-ture, C
			Min	Max	
Subsciber's reply sensor during call					
Shift voltage, mV	V_{DTR}		-20.0	20.0	25 10
			-30.0	30.0	-40; 70
Driver of calling relay					
Saturation voltage, V	V_{ON}	I_{OL} = -25 mA Vcc = 5.0 V	3.2	5.0	25 10
			3.0	5.0	-40; 70
Leakage current in the state «Switched-off», uA	I_{LK}	V_{LK} = -12 V	-	-20.0	25 10
				-50.0	-40; 70
Sensor's output (DET)					
High level output voltage, V	V_{OH}	I_{OH} = -100 uA	2.7	-	25 10
			2.6		-40; 70
Low level output voltage, V	V_{OL}	I_{OL} = 1.6 mA	-	0.45	25 10
				0.50	-40; 70
Consumption current (Vcc = 5.25V, V_{EE} = -5.25 V, V_{Bat} = -63 V, R_L =)					
Consumption current by pin Vcc, mA	$I_{CC\ OO}$	Mode «Switched-off», $V_{C1} = V_{C2} = V_{IL}$	-	1.5	25 10
				2.0	-40; 70
Consumption current by pin V_{EE}, mA	$I_{EE\ OO}$	-	-	-0.8	25 10
				-1.0	-40; 70
Consumption current by pin V_{Bat}, mA	$I_{Bat\ oo}$	Stand-by mode, $V_{C1} = V_{IH}$, $V_{C2} = V_{IL}$	-	-0.5	25 10
				-0.7	-40; 70
Consumption current by pin Vcc, mA	$I_{CC\ 10}$		-	1.7	25 10
				2.2	-40; 70
Consumption current by pin V_{EE}, mA	$I_{EE\ 10}$		-	-0.8	25 10
				-1.0	-40; 70
Consumption current by pin V_{Bat}, mA	$I_{Bat\ 10}$	Active mode (R_L =), $V_{C1} = V_{IL}$, $V_{C2} = V_{IH}$	-	-0.7	25 10
				-1.0	-40; 70
Consumption current by pin Vcc, mA	$I_{CC\ 01}$		-	5.5	25 10
				7.0	-40; 70
Consumption current by pin V_{EE}, mA	$I_{EE\ 01}$		-	-2.2	25 10
				-3.0	-40; 70
Consumption current by pin V_{Bat}, mA	$I_{Bat\ 01}$		-	-4.2	25 10
				-5.0	-40; 70
Quiet channel noise					
Quiet channel noise by the quadruple wire port [5)], dBmP	N_{24}	Psophometric	-	-78	25 10, -40; 70
Quiet channel noise by double wire port [5)], dBmP	N_{42}			-78	25 10, -40; 70
Low level input current, uA, by pins C1, C2	I_{IL}		-	-300	25 10
				-400	-40; 70
By pin E1			-	-70	25 10
				-100	-40; 70
High level input current, uA	I_{IH}	-		30.0	25 10
				40.0	-40; 70

Notes

1 Measurement mode of electric parameters: Vcc = 5 V 5%, V_{EE} = - 5 V 5%, V_{Bat} = -60 B, AGND = BGND.

2 E_{LO} – input synphase voltage of double wire line;

V_{C1} – voltage at input C1;

V_{C2} – voltage at input C2;

V_{LK} – voltage at pin RINGRLY when measuring the leakage current;

V_{LO} – output synphase voltage of double wire line;

V_{RX} – input voltage of quadruple wire port;

V_{TR} – differential voltage of double wire port (pin TIPX relative to pin RINGX);

V_{TX} –output voltage of quadruple wire port (pin VTX relative to pin AGND);

R_L – active load resistance;

R_D – resitance, connected between the pins V_{EE} and RD (programs the line current sensor);

R_{DC1}, R_{DC2} – current presetting resistors;

I_L – load current;

V(dBm) – voltage value, dBm, determined by the formula

$$V(dBm) = 20 \lg V / 0.775, \tag{1}$$

V – voltage, V;

dBmP – psophometrically suspended voltage in dBm.

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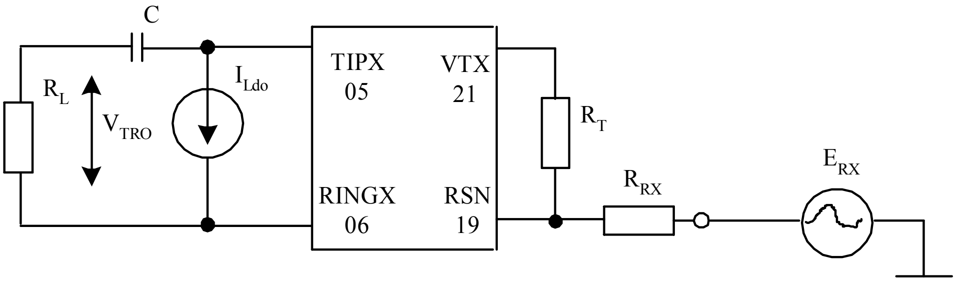
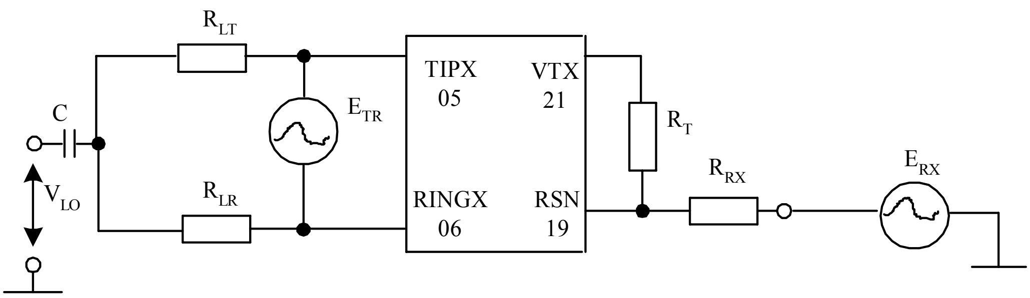
1. Overload level is determined at the double wire port with the signal source at the quadruple wire port.
2. Overload level is determined at the quadruple wire transmitting port with the signal source at the double wire port. Gain ratio from the double wire port to quadruple wire transmitting port is equal to G_{24} = 1, V_{RX} = 0.
3. Protective resistors R_F influence on the introduced losses (the introduced losses are indicated for R_F = 0.)
4. The indicated tolerance at the introduced losses does not includeb the errors, caused by the external components.
5. Double wire noise of the quiet channel is determined at the port overload R_L = 600 Ohm and with the grounded quadruple wire port.

Noise of the quiet quadruple wire channel at VTX is determined with the connected loads of 600 Ohm to the double wire port and to output of the VTX quadruple wire port. Quadruple wire receiving port is grounded (V_{RX} = 0)



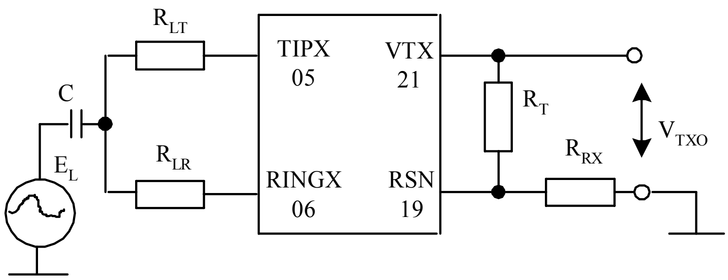
1/ R_L, R_L= 600 Ohm, R_T = 600 kOhm, R_{RX} = 300 kOhm

Fig. 2 – Overload level V_{TRO} at two wire port



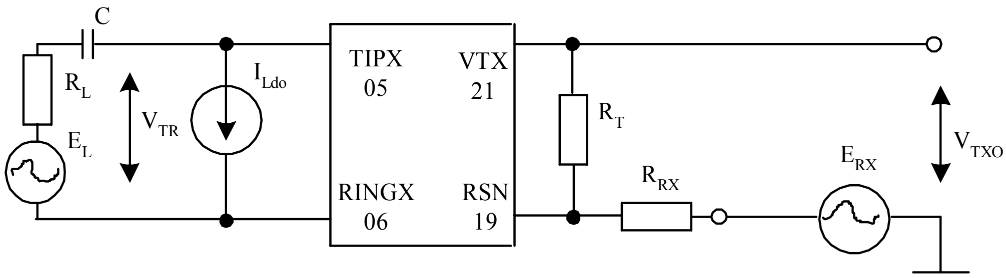
1/ 150 Ohm, R_{LR}=R_{LT}= 300 Ohm, R_T= 600 kOhm, R_{LX}= 300 kOhm

Fig. 3 – Balance B_{FLE}, B_{MLE}



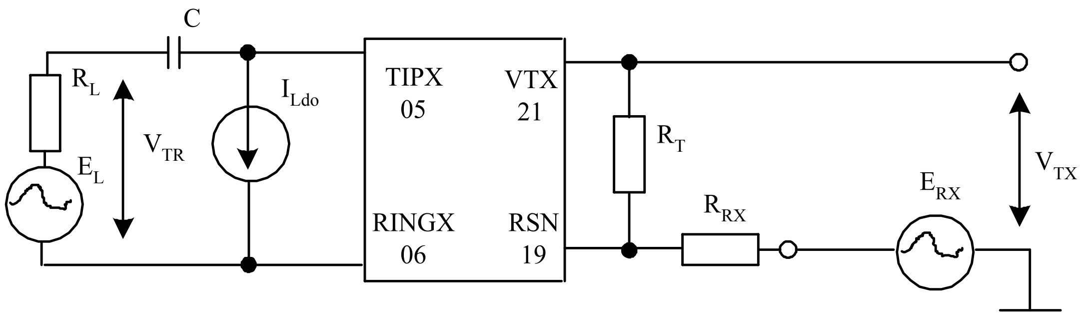
1/ C 150 Ohm, $R_{LT} = R_{LR}$ = 300 Ohm, R_T = 600 kOhm, R_X = 300 kOhm

Fig. 4 – Balance B_{LFE}.,B_{LME}



1/ C R_L, R_L= 600 Ohm, R_T = 600 kOhm, R_X = 300 kOhm, E_{RX} = 0

Fig. 5 – Overload level V_{TXO}



1/ R_L, R_L = 600 Ohm, R_T = 600 kOhm, R_{RX} = 300 kOhm

Fig. 6 – Transfer ratio

Functional description and information on applications

Transfer

Generals

Simplified model of the transfer patterns by the alternating current is indicated in Figure 8. Circuit analysis provides the following expressions:

$$V_{TR} = V_{TX} + I_L \cdot 2R_F, \qquad (2)$$

$$\frac{V_{TR}}{Z_T} + \frac{V_{RX}}{Z_{RX}} = \frac{I_L}{1000}, \qquad (3)$$

$$V_{TR} = E_L - I_L \cdot Z_L, \qquad (4)$$

where V_{TR} – alternating differential voltage between TIPX and RINGX, V;

V_{TX} – voltage at pin V_{TX}, V;

I_L – alternating load current, A;

R_F – safety resistor, Ohm;

Z_T – sets the microcircuit impedance at the double wire port, Ohm;

V_{RX} – input voltage at pin RSN relative to the analogue ground, V;

Z_{RX} – sets amplification from the quadruple wire to double wire port, Ohm;

E_L – differential voltage of idle run ($R_L =$), V;

Z_L – line impedance, Ohm.

Longitudinal voltage (current) – this is the это synphase voltage (current) at pins TIPX and RINGX relative to the common pin.

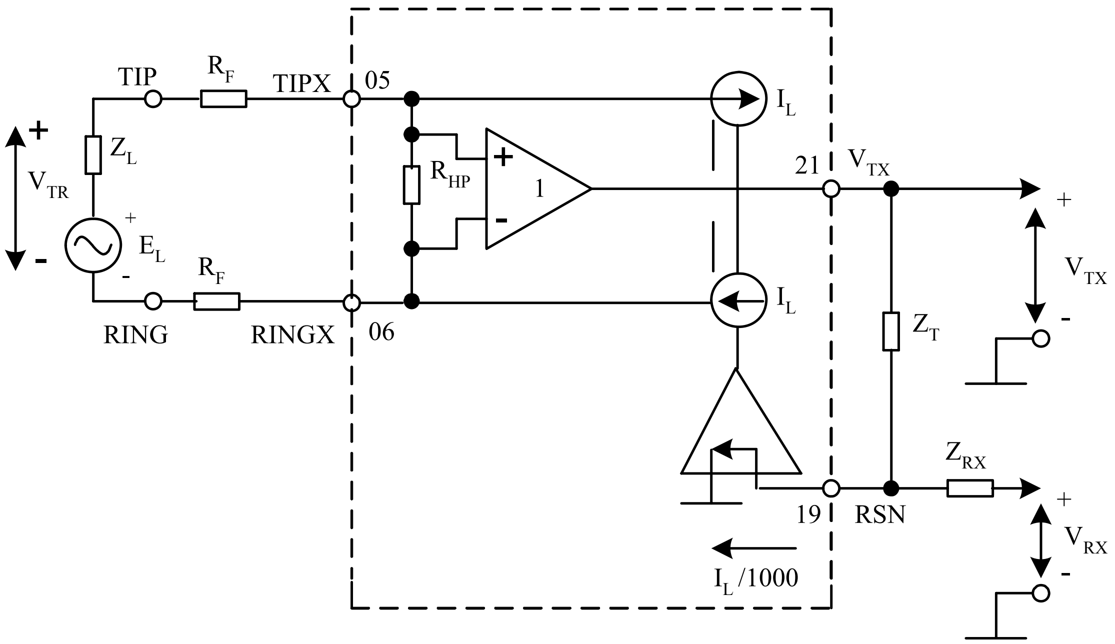


Fig. 8 – Speech tract

Double wire impedance

For computation of impedance Z_{TR} of the microcircuit with the safety resistors R_F on the double wire line, let's consider V_{RX} = 0. Then from the formulae (2) and (3)

$$Z_{TR} = Z_T /1000 + 2R_F. \qquad (5)$$

Then with the known Z_{TR} and R_F

$$Z_T = 1000 \cdot (Z_{TR} – 2R_F). \qquad (6)$$

Example -

Let’s compute Z_T, required for obtaining Z_{TR} = 900 Ohm, connected in series with the capacitor 2.16 uF. R_F = 40 Ohm

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

which ensures Z_T = 820 kOhm in series with capacitor 2.16 uF.

It is necessary to connect the high ohmic resistor parallely to the capacitor. This makes the feedback circuit by the direct current for the low frequency, which ensures stability and reduces noise.

Amplification from double wire to quadruple wire port

From formulae (2) and (3) with V_{RX} = 0 let’s compute the gain ratio from the double wire to quadruple wire port G_{24}

$$G_{24} = \frac{V_{TX}}{V_{TR}} = \frac{Z_L}{Z_T / 1000 + 2R_F}. \qquad (7)$$

Amplification from the quadruple wire to double wire port

From formulae (2), (3) and (4) with E_L = 0 let’s compute the gain ratio from the quadruple wire to double wire port G_{42}

$$G_{42} = \frac{V_{TR}}{V_{TX}} = \frac{Z_T}{Z_{RX}} \cdot \frac{Z_L}{Z_T / 1000 + 2R_F + Z_L}. \qquad (8)$$

For applications, where Z_T /1000 + $2R_F$ is selected to be equal to Z_L, the expression for G_{24} is simplified

$$G_{42} = -\frac{Z_T}{Z_{RX}} \cdot \frac{1}{2}. \qquad (9)$$

Amplification from the quadruple wire to quadruple wire port

From formulae (2), (3) and (4) with E_L = 0 let’s computate the gain ratio from the quadruple wire to the quadruple wire port G_{44}

$$G_{44} = \frac{V_{TX}}{V_{TR}} = \frac{Z_T}{Z_{RX}} \cdot \frac{Z_L + 2R_F}{Z_T / 1000 + 2R_F + Z_L}. \qquad (10)$$

Hybrid function (local effect or suppression of the echo-signal)

Microcircuit ILF3866N forms the especially frexible and compact line interface, when it is used with the programmed codek-filters. Programmed codek-filter makes it possible for the system controller to select the hybrid balance for matching the various line impedances without the circuit revision. In addition to this the gain ratios can be adjusted in transfer and receipt. Hybrid function can also be realized with application of the vacant amplifier in combinations with the regular codek-filter (Figure 9). Via impedance Z_B the current, proportional to V_{RX}, is injected to the summing-up node. From expression (11) for the gain ratio G_{44}, proportionate to V_{RX} voltage is reversed to V_{TX}. This voltage is converted by means of the resistor R_{TX} to the current, flowing to the same summing node. These currents can be surpressed, considering

$$\frac{V_{TX}}{V_{RX}} + \frac{V_{RX}}{Z_B} = 0 \; (EL = 0) \,. \qquad (11)$$

Gain ratio G_{44} includes the required phase shift and thus the balance circuit Z_B can be computed by the formula

$$Z_B = -R_{TX} \cdot \frac{V_{RX}}{V_{TX}} = R_{TX} \cdot \frac{Z_{RX}}{Z_T} \cdot \frac{Z_T / 1000 + 2R_F + Z_L}{2R_F + Z_L} \,. \qquad (12)$$

For instance: computation of the resistor R_B for matching the line by the microcircuit application pattern, indicated in Figure 14

$$R_B = 20 \cdot 10^3 \cdot \frac{261 \cdot 10^3}{523 \cdot 10^3} \cdot \frac{523 \cdot 10^3 / 1000 + 2 \cdot 40 + 600}{600 + 2 \cdot 40} = 17.66 \text{ kOhm}$$

(i. e. standard rated nominal value 17.8 kOhm ± 1%).

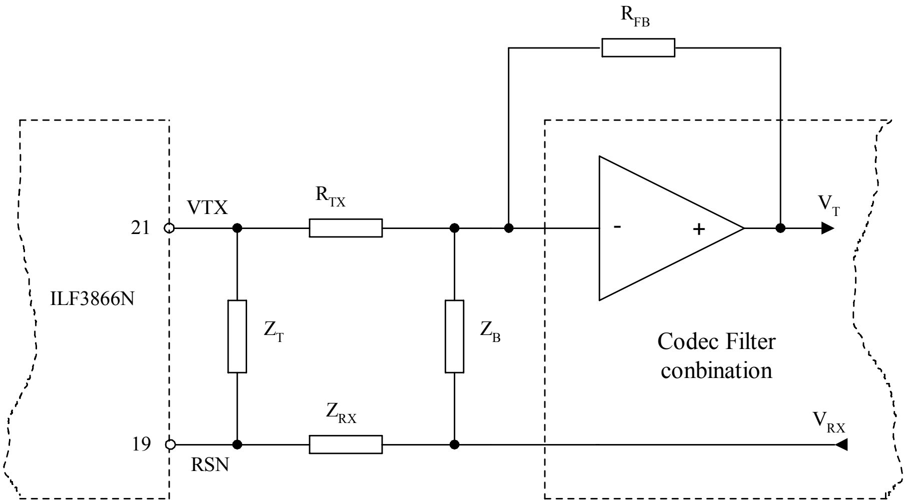


Figure 9 – Hybrid circuit (anti local effect)

Longitudinal impedance

Feedback loop neutralizes the longitudinal voltages on the double wire port by means of injection of the longitudinal currents in the opposite phase. Thus, the terminals TIPX and RINGX will be subject to very small fluctuations of the longitudinal voltages, leaving the differential voltages with the sufficient reserve within the limits of the regular range of the microcircuit operating voltages. This is attained by comparison of the double wire longitudinal voltage with the internal reference voltage V_{LoRef}, computed by the formula

$$V_{LoRef} = \frac{V_{Bat}}{2} = \frac{V_T + V_R}{2}, \qquad (13)$$

where V_T and V_R are the voltages TIPX and RINGX relative to the ground.

As indicated below, the longitudinal resistance constitutes 20 Ohm per wire. It should be noted, that the longitudinal currents may exceed the loop direct current, without influencing transfer of the voice frequency (Figure 10).

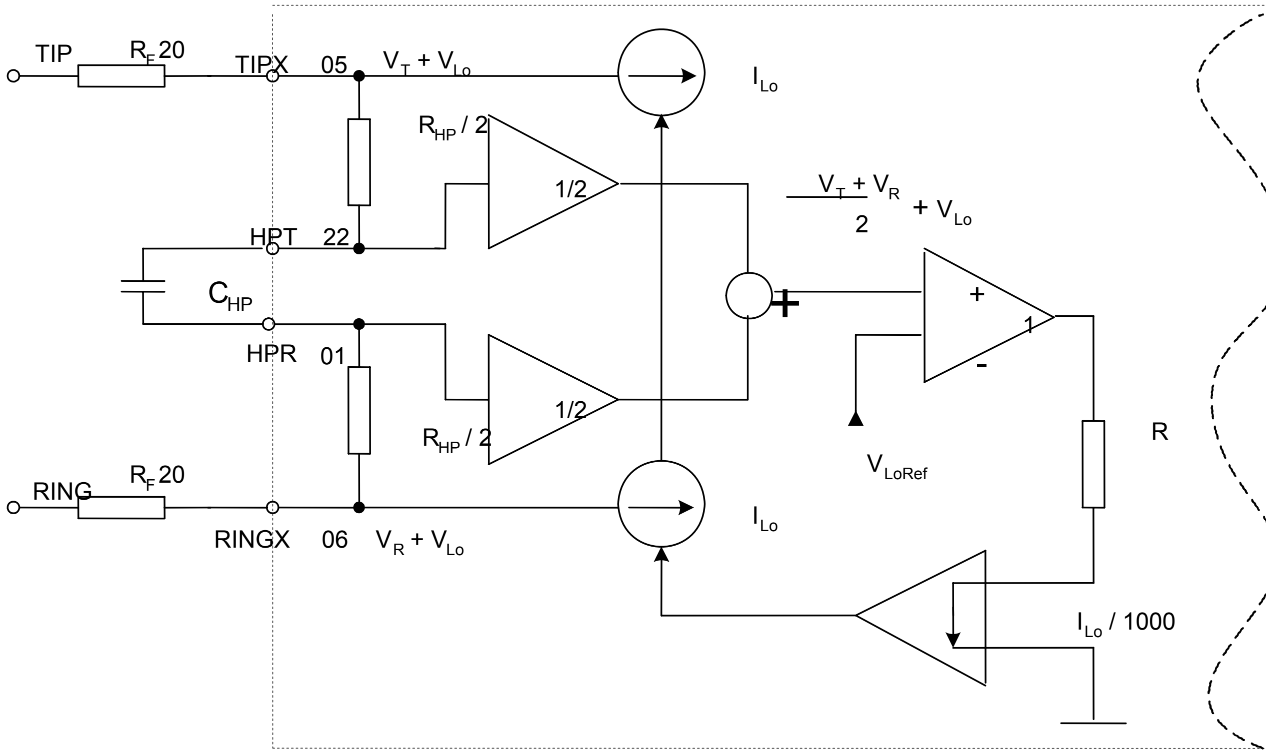


Fig. 10 – Longitudinal impedance

From the circuit analysis ensues the ratio

$$\frac{V_{Lo}}{R_{Lo}} = \frac{I_{Lo}}{1000}\,. \qquad (14)$$

Expression is simplified to

$$R_{LoT} = R_{LoR} = V_{Lo}/I_{Lo} = 20\text{ kOhm}/1000 = 20\text{ Ohm}, \qquad (15)$$

where R_{Lo} = 20 kOhm;
$R_{LoT} = R_{LoR}$ – longitudinal resistance/wire, Ohm;
V_{Lo} – longitudinal voltage on TIPX, RINGX, V;
I_{Lo} - longitudinal current, A.

Capacitors C_{TC} and C_{RC}

Capacitors, indicated as C_{TC} and C_{RC} on the microcircuit application diagram, indicated below, connected between TIPX and ground, and also between RINGX and ground, are recommended as addition to the protection circuit from the excessive voltage. The fast switch-overs of the input voltages at TIPX and RINGX can pass through the protection circuit from the excessive voltage prior to its actuation and may damage the microcircuit. C_{TC} and C_{RC} short circuit such fast switch-overs to the ground. The recommended values for C_{TC} and C_{RC} constitute 2200 pF. There may be used the higher values, but one should observe caution in order not to deteriorate the longitudinal balance or the return losses. C_{TC} and C_{RC} introduce the differential impedance $Z_{дифф}$

$$Z_{дифф} = 1/(\ \ \cdot f \cdot C_{RC}) \quad 1/(\ \ \cdot f \cdot C_{TC}), \qquad (16)$$

impedance TIPX to the ground Z_{TIPX}

$$Z_{TIPX} = 1/(2 \cdot \quad \cdot f \cdot C_{TC}), \qquad (17)$$

as well as impedance RINGX to the ground Z_{RINGS}

$$Z_{RINGS} = 1/(2 \cdot \quad \cdot f \cdot C_{RC}). \qquad (18)$$

Separation capacitor of the alternating / direct current C_{HP}

The filter capacitor of the upper frequencies is connected between the pins 01 and 22, ensuring separation between the circuits, responding to the signals TIPX, RINGX by the direct current, and the circuits, processing the signals by the alternating current. The value C_{HP} = 10 nF determines the marginal frequency at the level 50 Hz (f_{3dB}) in compliance with the expression

$$f_{3dB} = 1/(2 \cdot \quad \cdot R_{HP} \cdot C_{HP}), \qquad (19)$$

where R_{HP} 330 kOhm.

Battery power supply in the active mode (C1=0, C2 = 1)

The microcircuit ensures the line direct current, if the voltage on the load (between the pins TIPX and RINGX) less than 43 V, i. e. for the short lines, and reduces the line current with the high voltages between the pins TIPX and RINGX (for the long lines) – for protection from saturation of the output drivers. As soon as the direct voltage V_{TR} between the pins TIPX and RINGX becomes less than the protection voltage from saturation $V_{SG\ Ref}$, set by the resistor R_{SC}, the line direct current I_{Ldc} is determined as follows

$$I_{Ldc} = 1000 \cdot 2.5/(R_{DC1} + R_{DC2}). \qquad (20)$$

Meanwhile, the line current (of loop) does not depend on the bload resistance. With the help of the resistors R_{DC1} and R_{DC2} it is possible to ensure the required current (Figure 11). as soon as the voltage V_{TRX} becomes more, than $V_{SG\ Ref}$, the circuit switches over to the direct voltage mode.

Voltage V_{RDC} at the pin RDC becomes to reduce with he voltage V_{TR} 40 V, reducing the current I_{Ldc}. In order to eliminate the sound frequency signal influence on the supply circuit, it is recommended to switch on the capacitor C_{DC} from the common point R_{DC1} and R_{DC2} to the ground. The value C_{DC} is determined by the formula

$$C_{DC} = T_{DC}\,(1/R_{DC1} + 1/R_{DC2}), \qquad (21)$$

where T_{DC} – the time constant with the value of the order 30 msec.

For the ruptured loop the saturation limitation circuit limits the voltage V_{TR} 43 V.

For the normal operation it is required, that

$$V_{TR\ max} \quad V_{Bat} - Vmargin, \qquad (22)$$

where Vmargin = 8 V – the required reserve by voltage for the signal transfer without distortions.

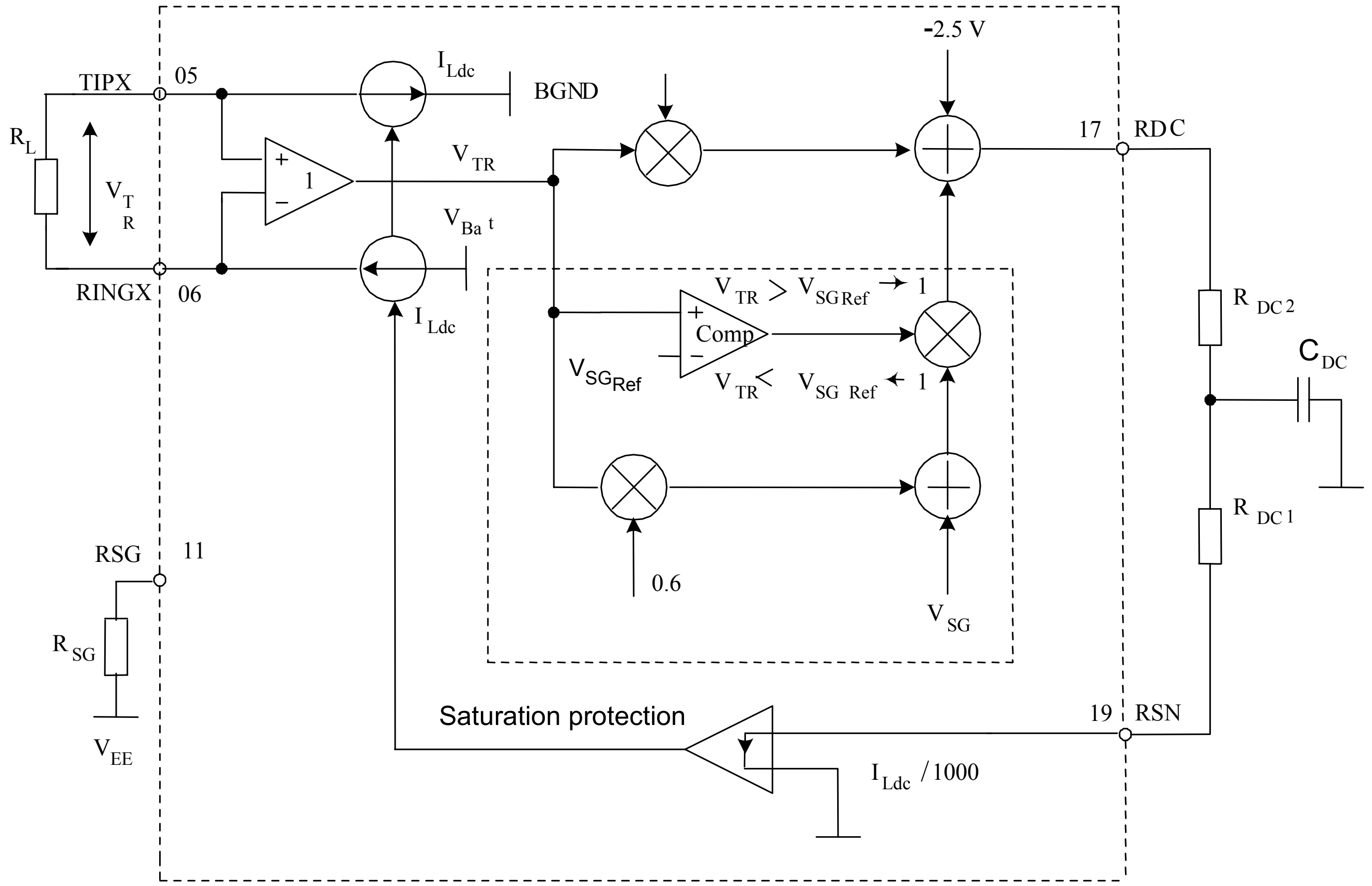


Fig. 11 – Battery supply

Resistor R_{SG} is computed for the maximum loop resistance $R_{L\,max}$

$$R_{SG} = 5 \quad 10^5 / ((V_{Bat\,min} - Vmargin)(1 + (R_{DC1} + R_{DC2}) / 600 \bullet R_{L\,max}) - 43), \quad (23)$$

where $V_{Bat\,min}$ – minimum battery voltage.

For the case of the ruptured loop ($R_L =$)

$$R_{SG} = 5 \quad 10^5 / (V_{Bat\,min} - Vmargin - 43). \quad (24)$$

For the certain applications, if the maximum value of the speech signal V_{TRO} is less, than 3.1 V (peak), the value Vmargin can be reduced.

Thus, with the voltage between the pins TIPX and RINGX lower, than 43 V it is permitted to leave the pin R_{SG} in rupture. With the voltage between the pins TIPX and RINGX over 43 V it is recommended to use the external resistor R_{SG}, computated by (23).

Battery supply in the state «Off» (C1=0, C2=0) and in the stand-by state (C1=1, C2=0)

In the states "Off" and "Stand-by" the output drivers are switched off. TIPX is connected to the ground, RINGX is connected to V_{Bat} via the internal resistances of 900

Ohm each. The loop current is computed by the formula

$$I_L = V_{Bat} - 3 / (R_L + 1800\ \text{Ohm}). \quad (25)$$

Microcircuit in the state "Off"

In the state «Off» C1=1 and C2=0. With operation of the microcircuit in the state «Off» for the sake of power saving the drivers-amplifiers TIPX and RINGX will switch off, and battery supply will beb activated. The current loop can be computed

$$I_{Ldc} \approx \frac{|V_{Bat}| - 3\ \text{В}}{R_L + 1800\ \text{Ом}}, \quad (26)$$

where I_{Ldc} – line direct current, A;
R_L – loop resistance, Ohm;
V_{Bat} – battery supply voltage, V.

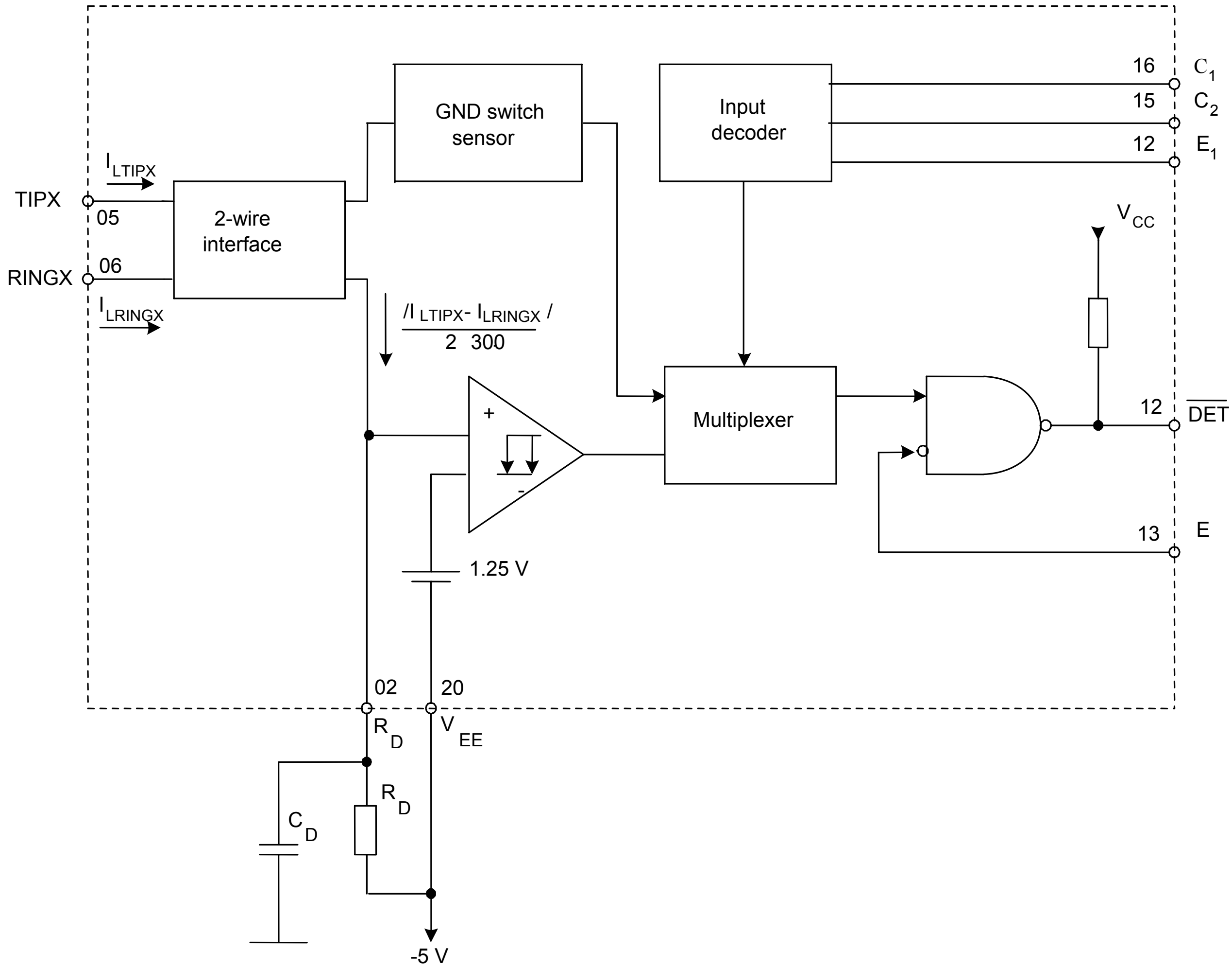


Fig. 12 – Sensors of loop current and leakage to ground

Loop state detection function

Loop current, short circuit current to ground and ring arrival sensors will transfer their status via the digital output DET (pin 14). Connected with the output DET, sensor is selected through the control interface C1, C2, E1. Description of the control interface is indicated in the provision "Control inputs".

Loop current sensor

Loop current value, with which the loop current sensor changes the status, is programmed by means of selecting the resistor value R_D. R_D is connected between the pins RD (02) and V_{EE} (20). Fig. 12 shows the block-circuit of the loop current sensor.

Current at pin RD I_{RD} is proportionate to line current I_L

$$I_{RD} = |I_{LTIPX} - I_{LRINGX}|/600 = I_L/300, \qquad (27)$$

where I_{LTIPX}, I_{LRINGX} – curents, inflowing into the terminals TIPX and RINGX, A.

Voltage at resistor R_D is compared with the internal reference voltage V = 1.25 V.

Programming resistor R_D, kOhm, can be computed

$$R_D = 375/I_{LTh}, \qquad (28)$$

where I_{LTh} – known desired threshold line current, mA.

Filter capacitor can be computed in compliance

$$C_{RD} = T_D/R_D, \qquad (29)$$

where T_D = 0.5 msec – time constant.

We'll note, that the capacitor C_{RD} is not required, if the output DET is filtered by the software means.

Leakage to ground sensor

Line leakage to ground sensor checks difference in the currents TIPX and RINGX. When difefrence of the currents exceed the threshold value I_{LOn}, sensor will be actuated. As the difference of currents reduces, the sensor will switch off at the threshold current sensor will switch off with the threshold current I_{LOff}. The value I_{LOn} is greater, than I_{LOff}, i. e. the sensor has hystheresis. The actuated sensor sets the low logical level at the output DET (pin 14), if the leakage to ground sensor is selected via the three digit control input (C1, C2, E1). The values I_{LOn} and I_{LOff} are listed in the table 3.

Reply sensor when being called – (receiver lift-off at the time of calling)

Reply detection when being called is performed by connection of the external circuit to the comparator in the microcircuit with the inputs DT (pin 03) and DR (pin 04).

Reply function when being called is based on polarity switch-over at the input of the comparator, when the line proceeds to the state of the lifted-off receiver. In the state of the on-hook receiver the direct current does not pass across the line and the voltage at input DT is higher, than on DR. When the line switches over to the to the off-hook receiver state during connection of the bell relay, the direct current appearsand the comparator input voltage alters polarity.

Fig.13 is an example of the bell signal arrival detection circuit.

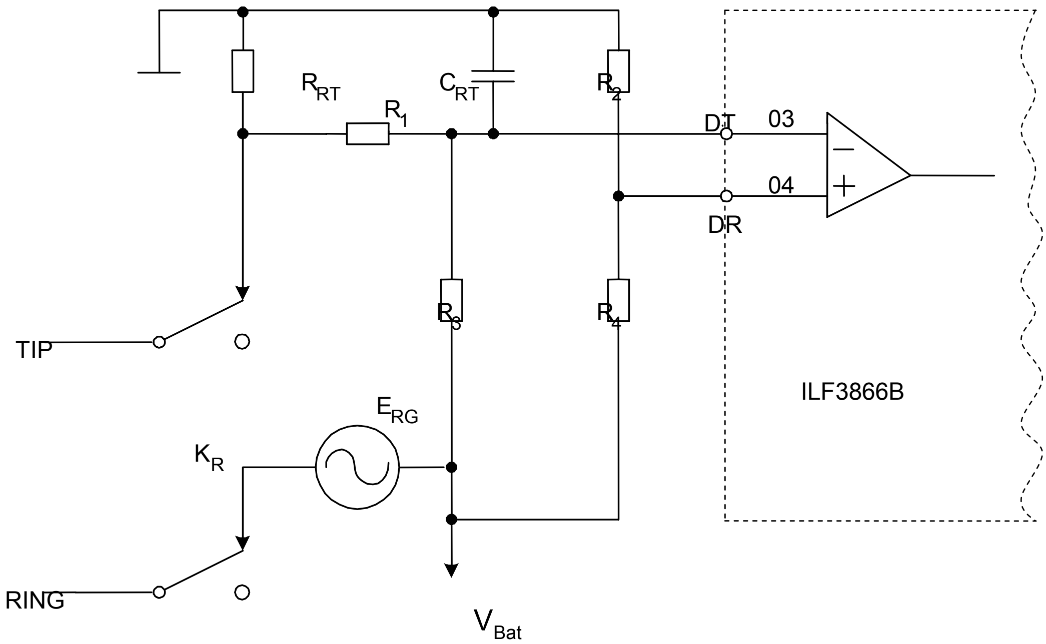


Fig. 13 – Reply sensor actuation when being called.

Direct voltage on the read-out resistor R_{RT} is monitored by the input DT of the comparator for bell signal arrival through the circuit R_3, R_4 and C_{RT}.

Reference voltage at the input DR is set by the resistors R_1 and R_2. With the receiver on hook (nodirect current) the positive voltage at the input DT exceeds the positive voltage at the input DR, and the output DET produces the high logic level, i.e. the sensor is not actuated. With the receiver off-hook at the time of the arrived bell signal through the loop, including the resistor R_{RT}, the direct current passes and sets the negative voltage at the input DT, greater by module, than the negative voltage at the input DR. This alters the state at the output DET for the low logic level, which is the condition for detection of arrival. The system controller (or the processor of the line circuit board) responds with cessation of the ring.

Complete filtration of the variable, constituting 20 Hz at the terminal DT is not mandatory. Switch-over of the output DET can be checked by the programme for determination of the cycle fulfillment. When the output DET is at the low logic level for more, than half the time, then the state of the off-hook receiver is depicted.

Relay driver

Microcircuit incorporates the bell relay driver, designed as per the circuit with the open emitter (n-p-n) with the maximum outflowing current 25 mA. Colelctor of the ransistor driver is connected to V_{CC}. For protection of the transistor driver one has to use the external diodes for limitation of the reverse surges. The bell relay is connected between the driver output and the voltage source, sufficient for its actuation. The source voltage can be from 0 V to V_{bat}.

Control inputs

Microcircuit has three TTL-compatible control inputs E1, C1 and C2. Decoder in the mnicrocircuit identifies the state of the control input and sets the appropriate operating status.

Operating status of microcircuit

Status	E1	C1	C2	Operating Status of Microcircuit	Active Sensor	Output DET
1	0	0	0	Off	No	High logic level
2	1	0	1	Active	Leakage to ground sensor	Leakage to ground sensor status
3	1	0	0	Off	No	High logic level
4	0	0	1	Active	Line current	Line status
5	0	1	1	Call	Bell arrival	Line status
6	0	1	0	Stand-by	Line current	Line status

Status «Off» (C1=C2 =0, E1 - any)

In the status «Off» the line amplifiers-drivers TIPX and RINGX, as well as other circuit blocks reduce the consumed power. This causes the microcircuit switch-over to the status with the high impedance relative to the line. The dissipated power is minimum. All sensors are not active.

Call status (C1=1, C2=1, E1=0)

Bell relay driver and bell arrival sensor are activated. TIPX and RINGX are in the high impedance status, and transfer of the speech signal is interlocked.

Active status (C1=0, C2=1, E1=1 or E1=0)

TIPX is the terminal, most close to the ground and supplies the loop current, RINGX is the more negative terminal and draws the loop current. Both sensors : of the loop current, and leakage to ground are activated. Input E1 controls selection of one of these sensors, which is commutated to the output DET.

Stand-by status (C1=1, C2 =0, E1 - any)

In the stand-by status the amplifiers / line drivers are disconnected. Line is supplied via the internal resistors. Line current

$$I_{Ldc} \approx \frac{|V_{Bat}| - 3\ \text{В}}{R_L + 1800\ \text{Ом}}, \qquad (30)$$

where I_{Ldc} – line current, A;

V_{Bat} – battery supply voltage, V;

R_L – line resistance, Ohm.

The line current sensor is activated in this operating status.

Protection from excessive voltage

Microcircuit ILF3866N should be protected from the excessive voltages on the phone line, caused by the lighting fixtures, contact witht he mains alternating voltage and induction. In order to determine the maximum permissible continuous voltages and voltages of the transient processes, which can be applied to the microcircuit, consult the table of the limit parameters (Table 2) for the terminals TIPX and RINGX. The type application circuit, indicated in Figure 14, uses the serial resistors jointly with protection, programmed from overvoltage, serving as the secondary protection (this can be the special purpose microcircuit or four power pulse diodes).

Safety resistors R_F limit current with the short overvoltage pulses and serve the circuit breakers, when the line is subjected to powerful influence.

If there's risk of overvoltages at the V_{Bat} terminal of the microcircuit, when this terminal should also be protected.

Sequence of power supply switch-on

Voltage at pin V_{Bat} sets the substrate voltage, which should always be more negative, than voltage at some other pin for prevention from the possible latching. The optimum sequence of supply connection – first ground and V_{Bat}, then other pins of supply and signals.

V_{Bat} should not be applied with a higher rate, than the appropriate time constant, formed by the serial connection of the resistor of 5.1 Ohm with the pin V_{Bat} and the capacitor 0.47 uF from the pin V_{Bat} to the ground. This RC circuit may be common for several microcircuits.

Layout of printed circuit board

Design thoroughness of the printed circuit board layout is substantial for the correct functioning of the microcircuit ILF3866N. Components, connected to the input RSN (pin 19), should be in the immediate proximaty to this pin. It is advisable, that the pin RSN should be surrounded by the ground bus.

Two ground pins AGND and BGND should be connected on the printed circuit board at the place of the device location.

In order to improve heat sink it is advisable to have the metallized pad on the circuit board under the microcircuit base. It is impermissible to locate the microcircuits on the circuit board in such a way, so as in the process of operation they should heat each other (one over another).

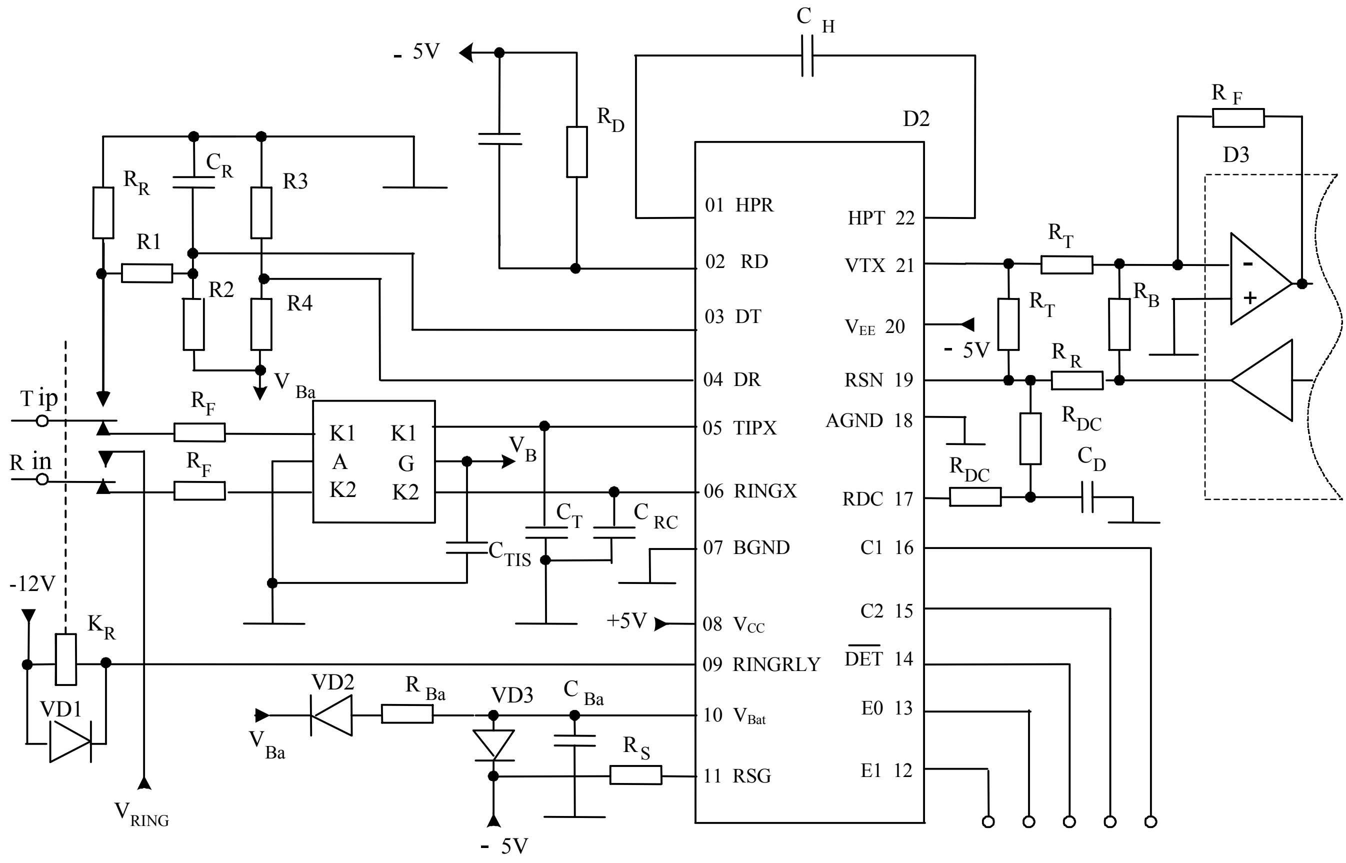


Fig. 14 – Type application diagram

To Fig. 14

D1 – microcircuit IWO140A4
D2 – microcircuit ILF3866N
D3 – microcircuit IL145567N (IL145567DW)
K_R – connection relay of call signal V_{RINGX}
C_{RT} - capacitor with capacitance of 0.39 uF 20 %, 100 V
C_{TISP} – capacitor with capacitance of 220 nF 20 %, 100 V
C_{TC}, C_{RC} – capacitors with capacitance of 2200 pF 20 %, 100 V
C_{Bat} – capacitor with caoacitance of 0.47 uF 20 %, 100 V
C_{HP} - capacitor with capacitance of 0.01 uF 20 %, 100 V
C_{DC} - capacitor with capacitance of 3.3 uF 20 %, 10 V
C_{RD} - capacitor with capacitance of 22 nF 20 %, 10 V
VD1, VD2, VD3 – diodes BAV21
R_{RT} – resistor with resistance of 150 Ohm 5%, power 2 Wt
R1, R3 – resistors with resistance of 200 kOhm 5%, power 0.25 Wt
R2 – resistor with resistance of 1.2 MOhm 5%, power 0.25 Wt
R4 – resistor with resistance of 920 kOhm 5%, power 0.25 Wt
R_{F1}, R_{F2} – protection resistors with resistance of 40 Ohm 1%
R_D – resistor with resitance of 51 kOhm 5%, power 0.25 Wt
R_{Bat} – resistor with resistance of 5.1 Ohm 5%, power 0.25 Wt
R_{SG} - limiting resistance of 10 kOhm 5%, for short line – in rupture
R_T – resistor with resitance of 560 kOhm 1%, power 0.25 Wt
R_{TX} – resistor with resistance of 20 kOhm 1%, power 0.25 Wt
R_{RX} – resistor with resistance of 280 kOhm 1%, power 0.25 Wt
R_B – resistor with resistance of 17.8 kOhm 1%, power 0.25 Wt
R_{DC1}, R_{DC2} - resistors with resistance of 42 kOhm 5%, power 0.25 Wt
R_{FB} – resistor with resistance of 24.3 kOhm 1%, power 0.25 Wt

Package Dimensional Sizes

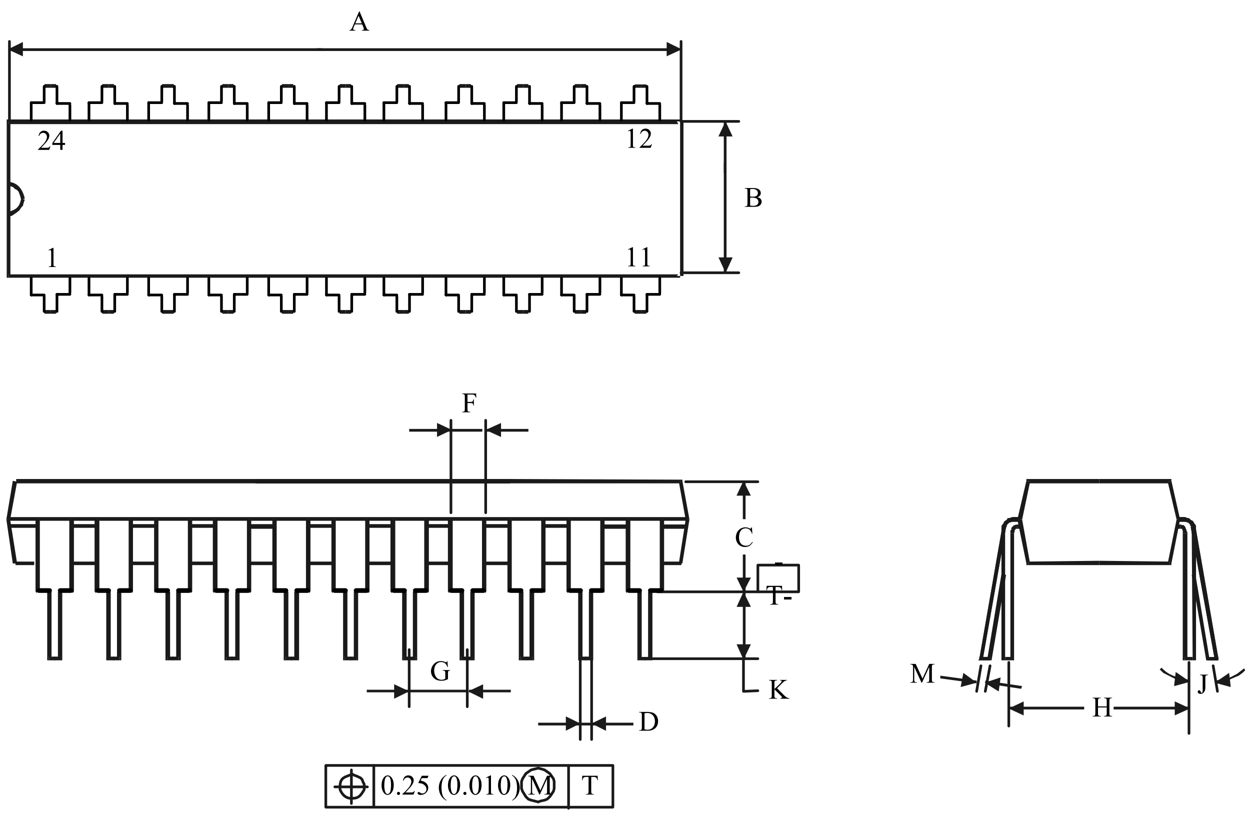


Figure 15 – Dimensional sizes of DIP package MS-010AA

Identification	MIN	MAX
A	29.205	29.595
B	8.7	8.8
C		4.5
D	0.35	0.55
F		1.45
G	2.54	
H	10.16	
J	0	15
K	3.35	3.65
M	0.20	0.3