APPLICATION NOTE

UBA1707 Cordless Telephone and Answering Machine Line Interface IC

AN98036.1

Philips
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Abstract

The UBA1707 is a BICMOS line interface IC for application in mains powered telecom terminals as Cordless telephones and Answering machines. It offers a DC mask for voltage or current regulation, electronic hook-switch control, transmit amplifier, receive amplifier, auxiliary amplifier, a loudspeaker channel and general purpose switches.

The characteristics of the IC are programmable via a 3-wire serial bus interface.

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Summary

This report presents the UBA1707 line interface IC for use in cordless telephones and answering machines. It contains a description of the IC-blocks with its pin functions, a description of the address registers, characterisation results of the IC and two application proposals.

CONTENTS

1. INTRODUCTION

The UBA1707 offers transmit, receive and line interface functions for application in cordless base stations and answering machines. It realises the interface between the telephone line and the RF interface of a cordless telephone or between the telephone line and the codec of a digital answering machine.

The circuit requires external supply from the mains or battery and have to be programmed via a simple 3-line unidirectional serial bus to select or control circuit characteristics.

The line interface block of the IC controls the external hook-switch and line regulation which can operate in applications with line voltage or line current regulation. It contains furthermore a receive amplifier, a transmit amplifier with symmetrical inputs which can handle large input signals, a low voltage function and AGC control. An auxiliary amplifier is available for general use. The loudspeaker channel has two selectable inputs, volume setting in 3 dB steps, a dynamic limiter which can be inhibited and a output stage for single ended use.

The transmit, receive and auxiliary amplifiers have a fixed gain. MUTE control is available for the auxiliary and receive amplifier. Two power down functions are integrated; one local PD for the loudspeaker channel and a PD for the whole device. The AGC function controls the gain of the transmit and receive amplifier. The AGC-slope and the ratio between stop and start currents can be selected; the AGC function can be switched-off.

The IC offers three selectable open collector switches for general use.

1.1 Abbreviations and definitions

Pin names and functions of UBA1707: consult chapter 2.

Register names and functions of UBA1707: consult chapter 3.2.

AGC	Automatic Gain Control (line loss compensation)
AN	Application Note
AUX	AUXiliary amplifier
BICMOS	IC process
CRM	Current Regulation Mode
C_{REG}	Capacitor connected between REG and GND
CT0	Cordless Telephone; up to 50 MHz frequency band
CT1	Cordless Telephone; 900 MHz frequency band
DAM	Digital Answering Machine
DC	Direct Current
DC slope	$\Delta V_{LINE} / \Delta I_{LINE}$
DECT	Digital European Cordless Telephone
HIGH	High voltage value (with respect to LOW) of logic input or output
IC	Integrated Circuit
I_{knee}	Value of the transitional line current between small and high DC slope at CRM
I_{line}	Line current
LN+	Positive terminal of the telephone set or application (without diode bridge)
LN–	Negative terminal of the telephone set or application (without diode bridge)
LOW	Low voltage value of logic input or output
LSA	Loudspeaker amplifier
PCB	Printed Circuit Board
PD	Power Down (low current consumption mode)
PHS	Personal Handy Phone System
R_{AGC}	External resistor to adapt selected AGC curve

R_P	Internal resistance of 35 kΩ between LN and REG
R_{LVI}	Resistor of external DC mask / hook-switch control circuit
R_{VA}	Voltage adjustment resistor to adjust V_{REF}
R_{SET}	External resistor to define Z_{SET}
R_{SLPE}	Resistor connected between SLPE and GND
RF	Radio Frequency
RX	Receive amplifier
TN_{SWITCH}	NPN transistor of external DC mask / hook-switch control circuit
TN_{ONHOOK}	NPN transistor of external DC mask / hook-switch control circuit
TP_{DARL}	PNP transistor of external DC mask / hook-switch control circuit
TX	Transmit amplifier
VRM	Voltage Regulation Mode
V_{LINE}	Voltage between the line terminals
V_{REF}	Reference voltage between LN and SLPE
Z_{LINE}	Line Impedance
Z_{SET}	Impedance of the telephone set between the LN+/LN– terminals (defined by R_{SET})
$2V_D$	Bias level of about 1.4 V

1.2 References

[1] Philips Semiconductors DATA SHEET: ‘UBA1707 Cordless telephone, answering machine line interface’

2. PININING

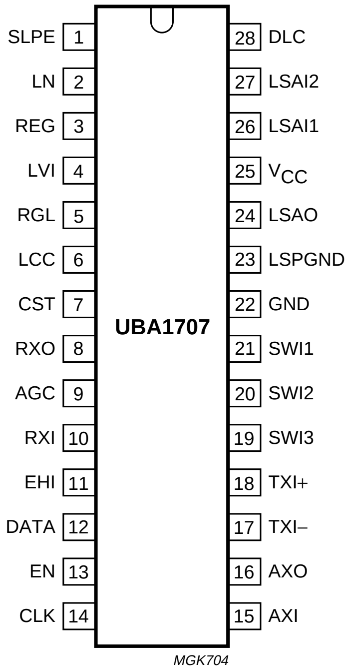

Fig.1 Pin configuration

TABLE 1 Pin functions

Symbol	Pin	Description
SLPE	1	Connection for slope resistor
LN	2	Positive line terminal
REG	3	Line voltage regulator decoupling
LVI	4	Negative line voltage sense input
RGL	5	Reference for current regulator mode
LCC	6	Line current control output
CST	7	Input for stability capacitor
RXO	8	Receive amplifier output
AGC	9	Automatic gain control
RXI	10	Receive amplifier input
EHI	11	Electronic hook-switch control input
DATA	12	Serial bus data input
EN	13	Serial bus enable input
CLK	14	Serial bus clock input
AXI	15	Auxiliary amplifier input
AXO	16	Auxiliary amplifier output
TXIM	17	Inverted transmit amplifier input
TXIP	18	Non-inverted transmit amplifier input
SWI3	19	NPN open collector output 3
SWI2	20	NPN open collector output 2
SWI1	21	NPN open collector output 1
GND	22	Ground reference
LSPGND	23	Ground reference of loudspeaker amplifier
LSAO	24	Loudspeaker amplifier output
V_{CC}	25	Supply voltage input
LSA1	26	Loudspeaker amplifier input 1
LSA2	27	Loudspeaker amplifier input 2
DLC	28	Dynamic limiter timing adjustment

3. BLOCK DIAGRAM

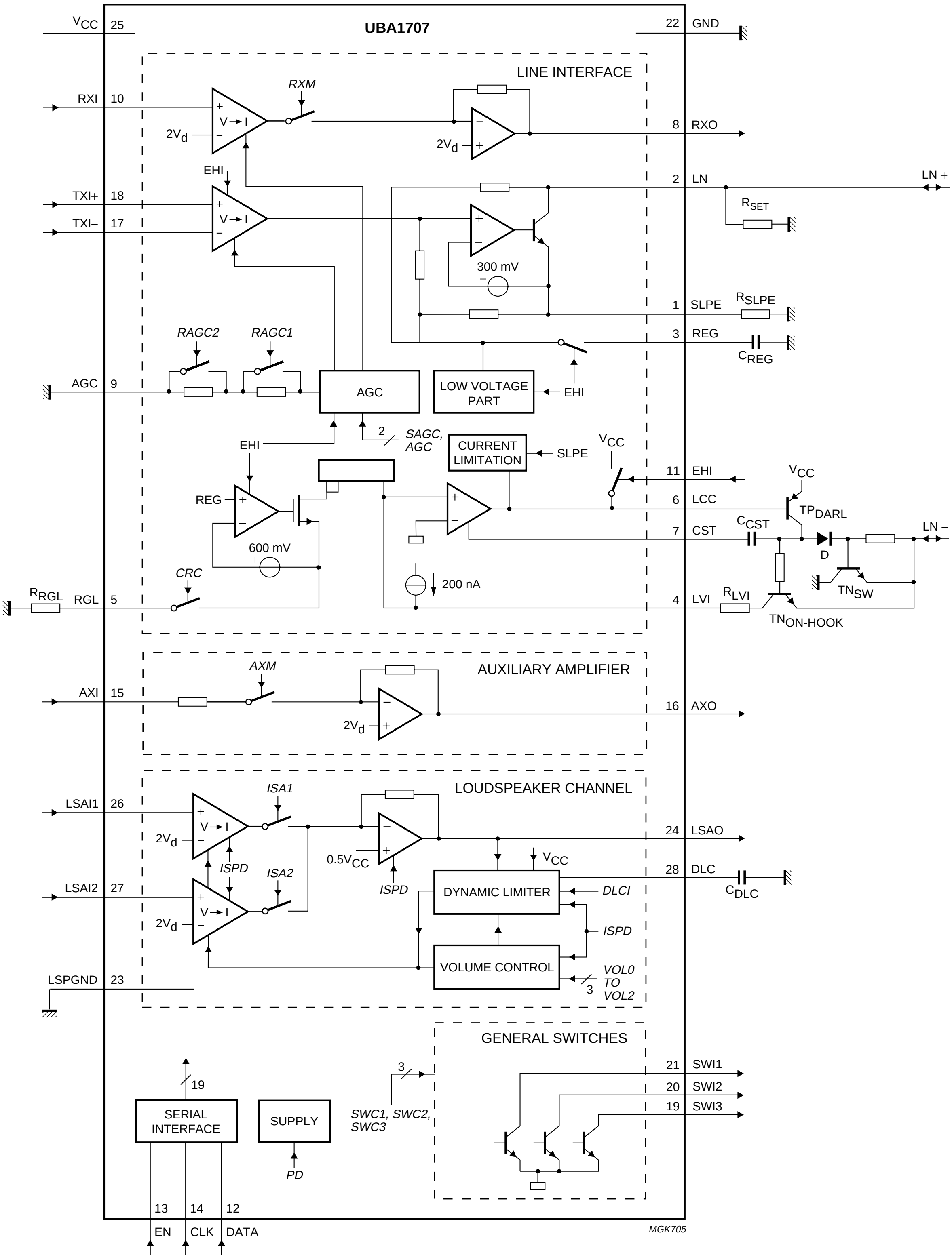

Fig.2 Block diagram

General

The block diagram of Fig.2 contains 6 main functions which are briefly described. The values of gain and impedance are typical values. The voltage gain of the RX, TX and AUX amplifiers are internally fixed. The IC is provided with two ground references GND and LSPGND which have to be interconnected on the board as recommended in chapter 6. TABLE 2, at the end of this chapter, indicates which circuit blocks are managed by the basic control functions as MUTE, AGC and the PD's.
Consult the UBA1707 data sheet [1] for circuit details and characteristics.

Line interface

The line interface contains the RX amplifier, TX amplifier combined with the LN-SLPE voltage stabilizer, DC mask regulation circuit, hook-switch control, AGC circuit and low voltage part.

RX amplifier: With input RXI and output RXO. Input and output are biased at $2V_D$. RXI has an input impedance to GND of 20 kΩ.

The RX amplifier is operational at control bit RXM = "0" with a gain of 38 dB. The gain is controlled by the AGC block when AGC is operational. The RX amplifier is disabled at RXM = "1"

TX amplifier: Inputs are TXIP and TXIM with an input impedance to GND of 20 kΩ each. The outputs of the TX amplifier are LN and SLPE to modulate the line current flowing from LN to SLPE.

The gain from the inputs to LN is 12 dB at R_{SLPE} = 10 Ω and Z_{SET} = Z_{LINE} = 600 Ω. The gain is controlled by the AGC block when AGC is operational.

LN-SLPE voltage stabilizer: Stabilizes $V_{REF} = V_{LN\text{-}SLPE}$ at 3.0 V. V_{REF} can be increased by means of a resistor R_{VA} connected between REG and SLPE. The stabilizer is decoupled by C_{REG}. An electronic coil function is realised between LN and GND which has an equivalent inductance value of $L_{EQ} = C_{REG} . R_{SLPE} . R_P$. The value of the internal resistance R_P is 35 kΩ.

The preferred value of R_{SLPE} = 10 Ω. Changing R_{SLPE} will affect DC settings, transmit and receive characteristics and set impedance at lower audio frequencies as published in the data sheet [1].

The impedance of the IC between LN and GND is much more than 600 Ω. The set impedance Z_{SET}, defined as the impedance between the line terminals LN+ and LN–, has to be made by means of an external network (resistor R_{SET} or complex network) connected between LN and GND or between SWI(x) and GND. Connection of the network between SWI(x) and GND means that SWI(x) has to be selected to realise the desirable Z_{SET}.

DC mask regulation and hook-switch control: These functions are realized by the external circuit with the transistors TP_{DARL}, TN_{SWITCH} and TN_{ONHOOK}.

Depending on the state of control bit CRC, two regulation modes are offered. VRM is selected at CRC = "0" at which the line voltage is stabilized as function of the line current while CRM is selected at CRC = "1" offering a DC mask regulation according to French requirements. In this mode the slope ($\Delta V_{line} / \Delta I_{line}$) of the DC curve will be adapted when $I_{line} > I_{knee}$. This slope is determined by R_{RGL} (7.15 kΩ) together with R_{SLPE} and R_{LVI} at $I_{line} > I_{knee}$. Consult the data sheet [1].

The hook-switch function is controlled by the logic input EHI. Input EHI has to be "LOW" for ON-hook conditions and "HIGH" for OFF-hook. During pulse dialling EHI determines the timing of the 'make and break' periods. Capacitor C_{REG} will be isolated from the internal circuitry during the 'break' periods (EHI = "LOW") to avoid start-up effects.

AGC: The AGC function controls the gain of the RX and TX amplifier as a function of line current when control bit AGC is set to "1" and the AGC pin is connected to GND (directly or via an external R_{AGC} resistor) to compensate the line losses.

By means of the bits SAGC, RAGC2 and RAGC1 several AGC curves can be selected as shown in the data sheet and Fig.25 and Fig.26. Adaption of the selected AGC curves is possible by means of an external R_{AGC} resistor connected between AGC and GND. The AGC function affects also the max. input level of the RX and TX amplifiers.

Low voltage part: This function reduces the voltage between LN+ and LN– at I_{line} < 8 mA to keep the UBA1707 operational when a telephone set with a carbon microphone is connected into parallel. Transmission is possible down to I_{line} = 3 mA while the receive amplifier is operational down to I_{line} = 1 mA due to external V_{CC} supply.

Auxiliary amplifier

Auxiliary amplifier: Input AXI and output AXO are biased at $2V_D$. AXI has an input impedance to GND of 3.65 kΩ. The AUX amplifier is operational at control bit AXM = “0” with a gain of 32 dB. The AUX amplifier is disabled at AXM = “1”.
The AUX amplifier is not affected by the AGC function.

Loudspeaker channel

The loudspeaker channel consists of the output amplifier with pre-amplifiers, dynamic limiter and volume control.

Loudspeaker amplifier: The signal from input LSAI1 or LSAI2 is amplified to output LSAO when input LSAI1 or LSAI2 is selected (control bit LSA1 or LSA2 = “1”) and when the power down of the loudspeaker amplifier LSPD = “0”. The input impedance from LSA1 as well as LSA2 to GND is 20 kΩ.

The gain from one of the inputs to the output is 28 dB with the volume control bits at maximum state. The output stage can drive loudspeaker loads down to 8 Ω. Consult data sheet [1] for V_{CC}-max versus loudspeaker impedance.

Dynamic limiter: This block reduces the harmonic distortion of the loudspeaker signal at overdrive conditions as long as the signal offered to LSAI1 or LSAI2 is not saturated. The maximum input level of LSAI1 or LSAI2 is about 500 mVrms.

Volume control: This function has 3 control bits (VOL0, VOL1, VOL2) to control the gain of the loudspeaker amplifier from 28 dB maximum level down to 7 dB minimum level by means of – 3 dB steps.

General switches

Three open-collector NPN switches SWI1, SWI2 and SWI3 are available to connect external components to GND. They can be switched-on or switched-off by the control bits SWC1, SWC2 and SWC3 respectively. Each of them can conduct up to 20 mA (Fig.38) while the maximum operating voltage is limited to 12 V.

Serial interface

The serial bus interface has 3 inputs: EN, CLK and DATA. Data is entered by using 8 bits. The leading 6 bits contain the data field (bits D5 to D0) while the 2 trailing bits contain the addressing (bits AD1 and AD0). TABLE 3 gives an overview of the register functions.

Data is loaded in bursts framed by EN. Clock edges and data are ignored until EN goes active HIGH. Data is loaded into the addressed register when EN returns inactive LOW or left open-circuit. EN should be kept LOW during normal operation.
The timing of the bus control bits is shown in the data sheet.

Device supply and device power down

Device supply: The internal circuitry is supplied by an external stabilized source V_{CC}; V_{CC} can be set between 3.0 V and 5.5 V depending on the impedance of the applied loudspeaker. The current consumption I_{CC} = 2.2 mA at operating mode at V_{CC} = 3.3 V, without loudspeaker signal. I_{CC} increases with about 600 µA for each selected SWI(x) switch.

Use of the loudspeaker amplifier results in an additional increase of I_{CC}. Take into account a total maximum current consumption of about 70 mA at maximum signal across a loudspeaker of 8 Ω or 15 Ω at maximum allowed V_{CC} level.

Device power down: Control bit PD has to be “0” to get the UBA1707 operational. At PD = “1” the device is in low current consumption mode. The current consumption is reduced to 120 µA at V_{CC} = 3.3 V.

Note 1:
The device is in PD mode at start-up. Bit PD has to be set to “0” to alter operation mode. The serial bus is always operational, even at PD = “1”.

Note 2:
The characteristics of the device are defined at a DC load (R_{SET}) of 619 Ω between LN and GND to create a Z_{SET} of 600 Ω. A change of this load results in a deviation of the specified characteristics given in [1].

3.1 Basic control functions

TABLE 2 Basic control functions (X: function is available)

Amplifier	MUTE	AGC	LSPD	PD
Transmit		X		X
Receive	X [1]	X		
Auxiliary	X [2]			
Loudspeaker			X	

1.Control bit RXM
2.Control bit AXM

3.2 Register description

TABLE 3 Register description

NAME	FUNCTION	POLARITY	DATA	ADDRESS	RESET [1]
Register 0: general purpose switches and DC mask regulation					
SWC1	SWI1 output connection	0: SWI1 switched-off 1: SWI1 switched-on	D0	AD1,AD0 = 00	0
SWC2	SWI2 output connection	0: SWI2 switched-off 1: SWI2 switched-on	D1		0
SWC3	SWI3 output connection	0: SWI3 switched-off 1: SWI3 switched-on	D2		0
–	unused	must be set to logic 0	D3		0
CRC	current regulation mode	0: voltage regulation VRM 1: current regulation CRM	D4		0
Register 1: automatic gain control					
RAGC1	AGC start current selection 1	RAGC1,RAGC2 = 00 to 11 4 selection possibilities	D0	AD1,AD0 = 01	0
RAGC2	AGC start current selection 2		D1		0
SAGC	AGC slope selection	0: high slope 1: low slope	D2		0
AGC	line loss compensation	0: AGC disabled 1: AGC operational	D3		0
Register 2: loudspeaker channel					
LSA1	LSAI1 input selection	0: LSAI1 unselected 1: LSAI1 selected	D0	AD1,AD0 = 10	0
LSA2	LSAI2 input selection	0: LSAI2 unselected 1: LSAI2 selected	D1		0
LSPD	loudspeaker channel power down	0: channel operational	D2		0
		1: channel in power down			
VOL0	volume control (least significant bit)		D3		0
VOL1	volume control		D4		0
VOL2	volume control (most significant bit)		D5		0
Register 3: mute functions and (device) power down					
AXM	auxiliary amplifier mute	0: amplifier operational 1: amplifier muted	D0	AD1,AD0 = 11	0
RXM	receive amplifier mute	0: amplifier operational 1: amplifier muted	D1		0
PD	(device) power down (reduced current consumption)	0: device operational **1: device in power down**	D2		**1**
DLCI	dynamic limiter inhibit	0: limiter operational 1: limiter inhibited	D3		0

1. State after power-up reset

4. TYPICAL CHARACTERISTICS

This chapter shows characterisation results from a ‘typical’ sample of the UBA1707 to indicate the behaviour of the blocks of this line interface device. Refer to block diagram Fig.2 and the concise description of the IC in chapter 3. The table of ‘CONTENTS’ gives an overview of the showed graphs; Fig.4 up to Fig.41.

The general test conditions are, **unless otherwise written**: Set-up for characterisation Fig.3, Temp = 25 ^{o}C, V_{CC} = 3.3 V, I_{line} = 15 mA, EHI = ‘1’, PD = ‘0’, CRC = ‘0’, ground reference is GND.
AC tests of the TX, RX, AUX and LSA amplifiers: freq = 1 kHz, input levels are low without saturation of output signals, VOL control max. = ‘111’.

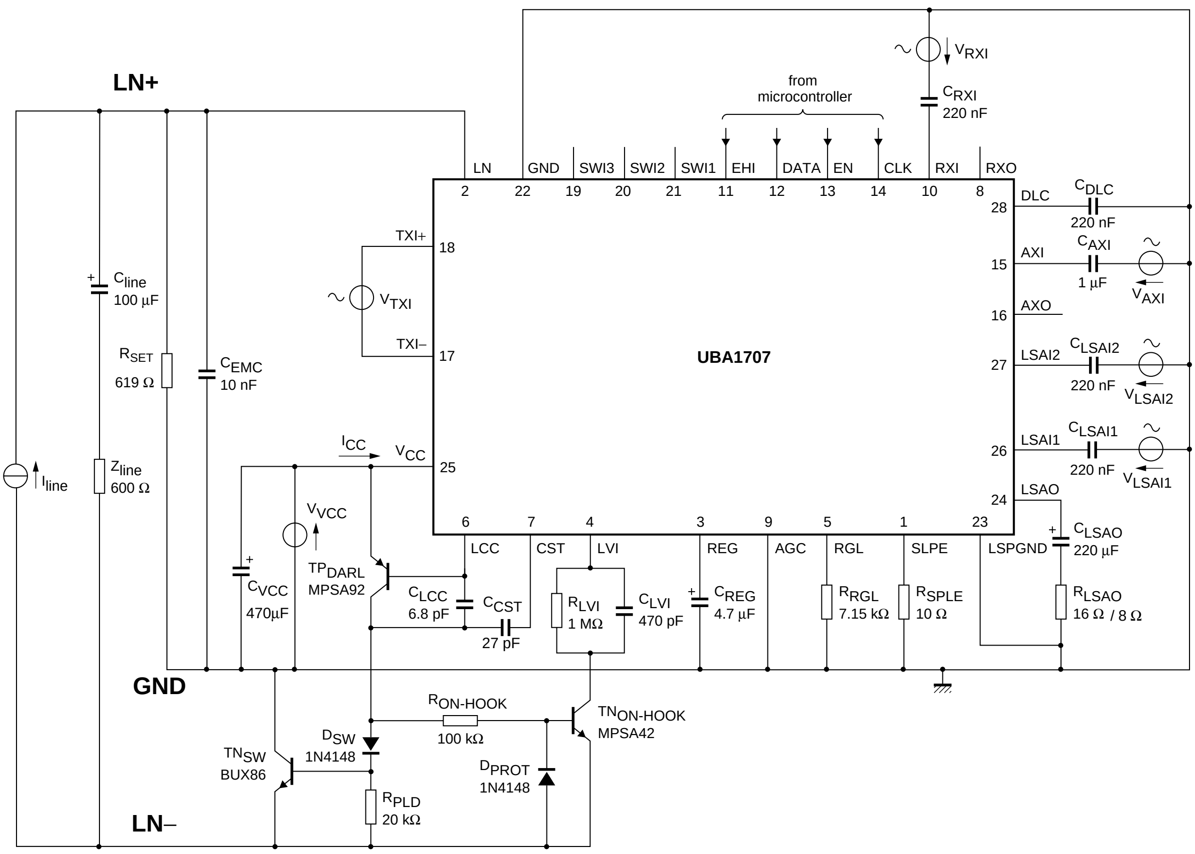

Fig.3 Test set-up

4.1 LN-SLPE voltage stabilizer

The reference voltage, defined between the IC-pins LN and SLPE, is stabilized at 3.0 V typical. The dependency with the line current is shown in Fig.4.

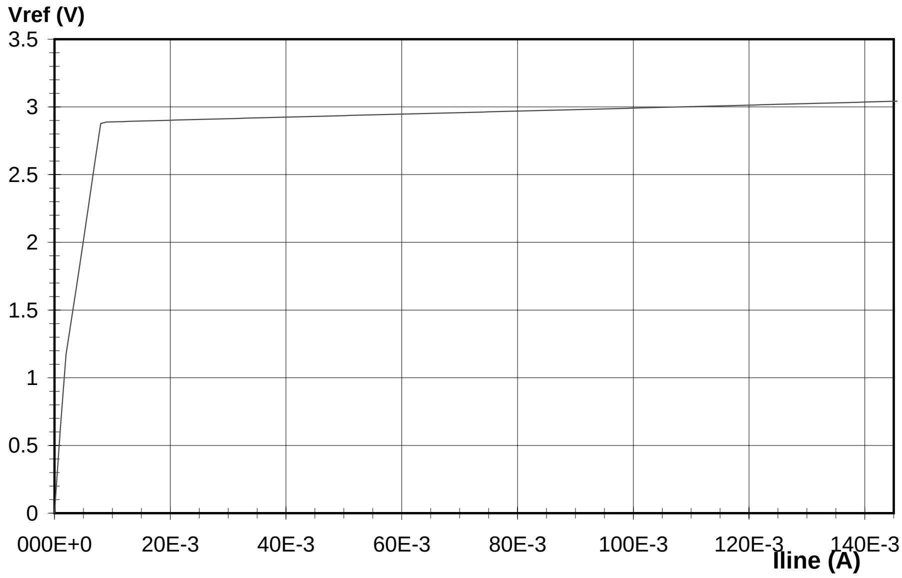

Fig.4 Reference voltage between LN and SLPE versus I_{line}

The reference voltage V_{REF} can be adjusted by means of a resistor between SLPE and REG as shown in Fig.5. The effect of the supply voltage V_{CC} on V_{REF} is shown in Fig.6.

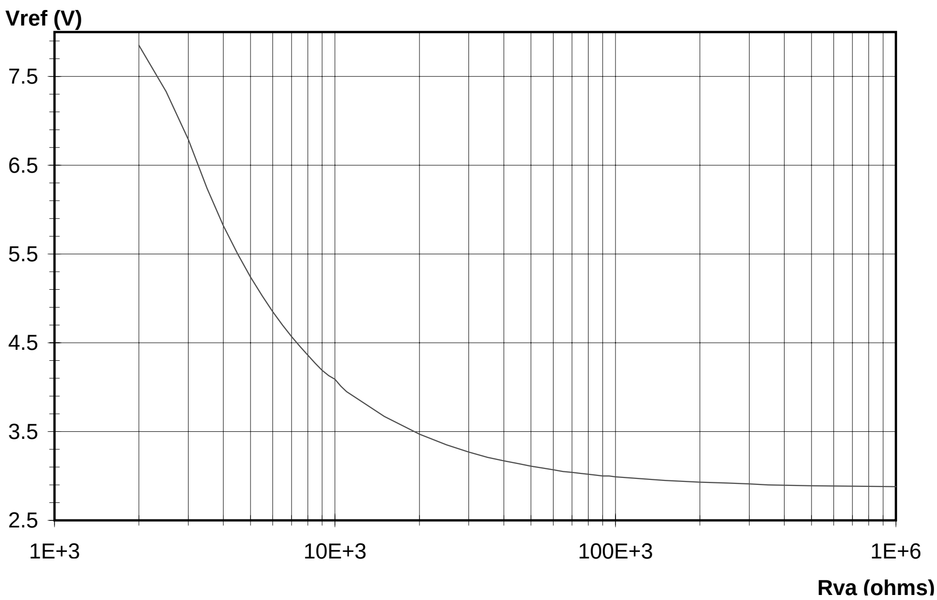

Fig.5 Adjustment of V_{REF} with resistor R_{VA}, connected between SLPE and REG

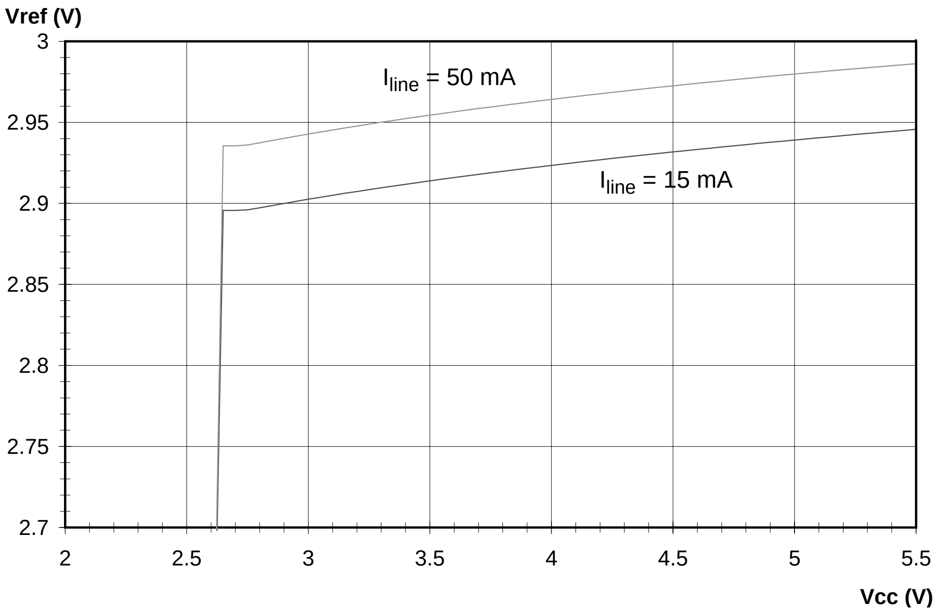

Fig.6 Dependency of V_{REF} with the supply voltage V_{CC}

4.2 Mask regulation and hook-switch

The voltage at LN+ and LN–, both with respect to GND at VRM, as function of the line current are shown in Fig.7 for the whole line current range and in Fig.8 at lower line current. The voltage between LN+ and LN– is built up by the reference voltage of Fig.4, the voltage drop across R_{SLPE} = 10 Ω and the voltage from GND to LN– (collector - emitter voltage of TN_{SW}) which is controlled at about 200 mV according Fig.8.

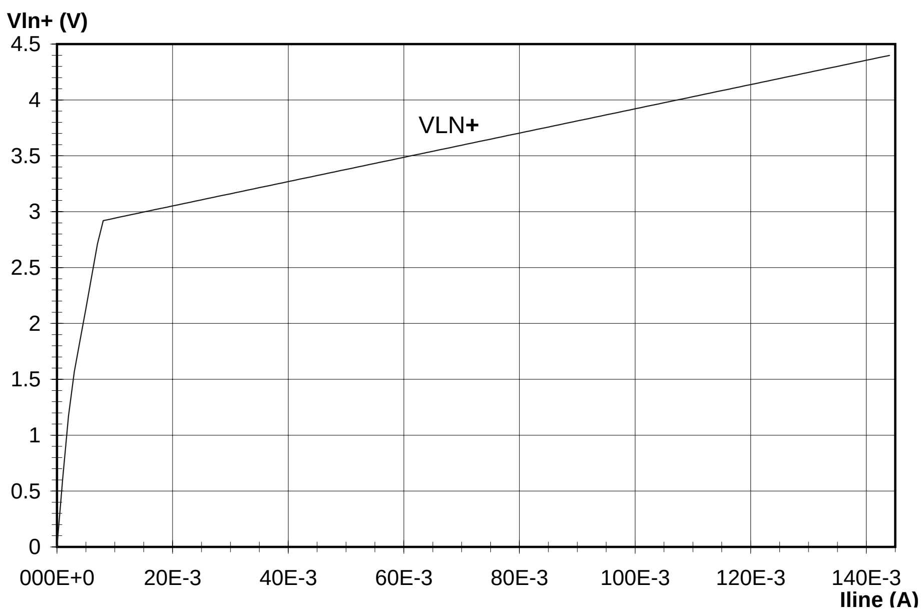

Fig.7 The voltage between VLN+ and GND versus I_{line} at VRM

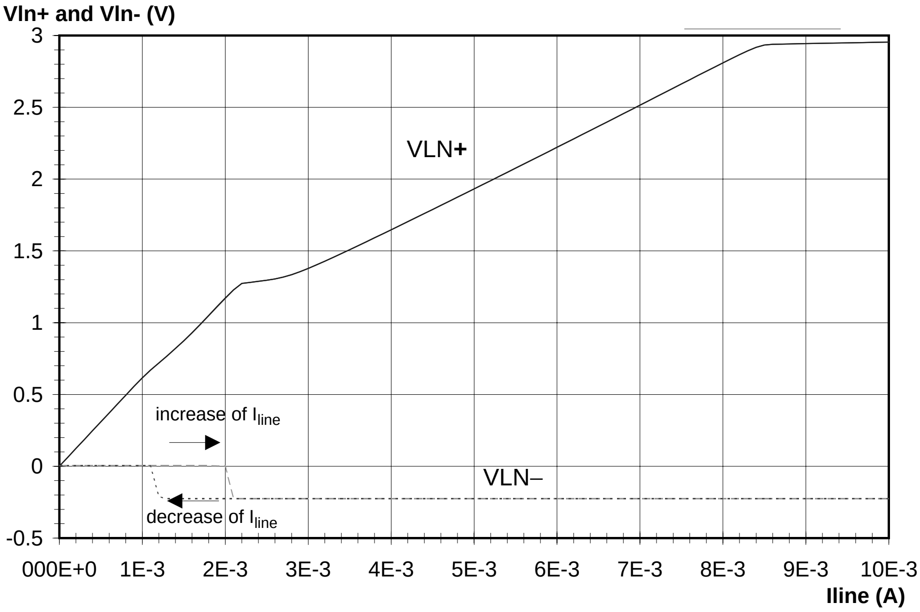

Fig.8 The voltage on VLN+ and VLN– both wrt GND versus I_{line} at VRM at low I_{line}

The voltage at LN+ and LN–, both with respect to GND, as function of the line current at CRM in this case, are shown in Fig.9. To meet the French DC-mask requirements, the voltage between LN– and GND increases at $I_{line} > I_{knee}$ with $I_{knee} \cong 35$ mA.

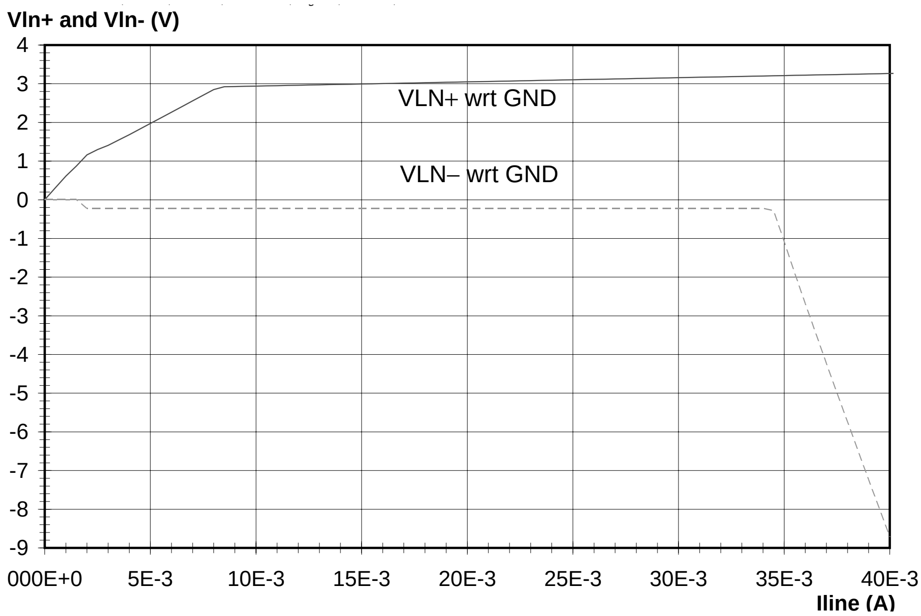

Fig.9 The voltage on VLN+ and VLN– wrt GND versus I_{line} at CRM

Fig.10 shows the current protection function. At I_{line} > 144 mA (typical value is 140 mA) the voltage from LN– to GND is enlarged to limit the line current in practice conditions.

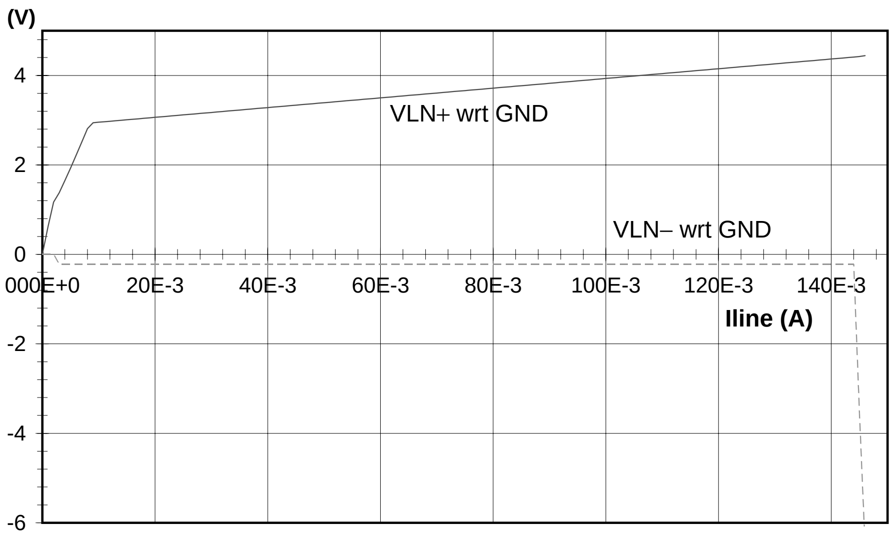

Fig.10 Activated current protection at I_{line} > 144 mA

During on-hook at EHI = 'LOW', the hook-switch transistor TN_{SW} is not conducting. The leakage current from the exchange into the UBA1707-application is shown in Fig.11.

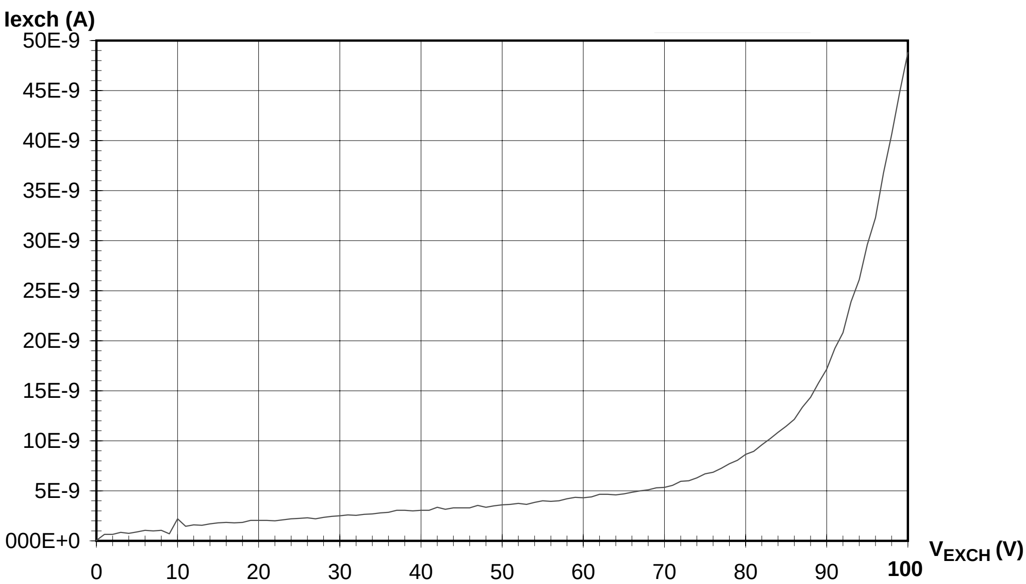

Fig.11 Leakage (line) current at on-hook conditions

The line voltage between LN+ and LN– at pulse dialling at VRM and CRM is shown in Fig.12 respectively in Fig.13.
V_{EXCH} = 40 V while R_{EXCH} = 600 Ω resulting in a line current of 60 mA at VRM and 42 mA at CRM at EHI = 'HIGH' in both cases.

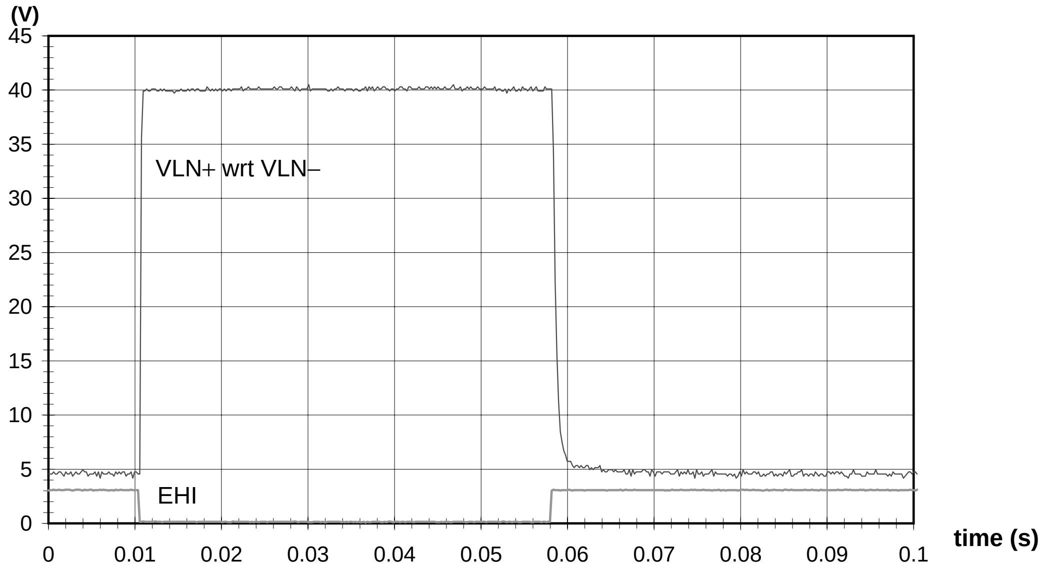

Fig.12 Hook-switch control; line voltage and EHI pulse at VRM

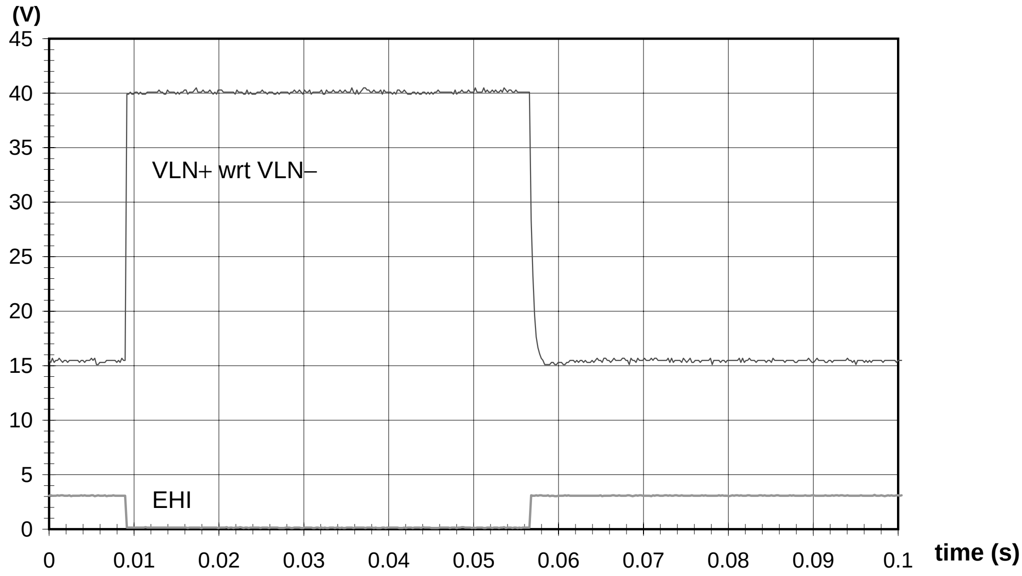

Fig.13 Hook-switch control; line voltage and EHI pulse at CRM

4.3 Set impedance / BRL

The following figures Fig.14 up to Fig.18, showing line impedances and BRL, are measured between the LN+ and LN– terminals at line currents of 15 mA and 40 mA with a resistor R_{SET} = 619 Ω.

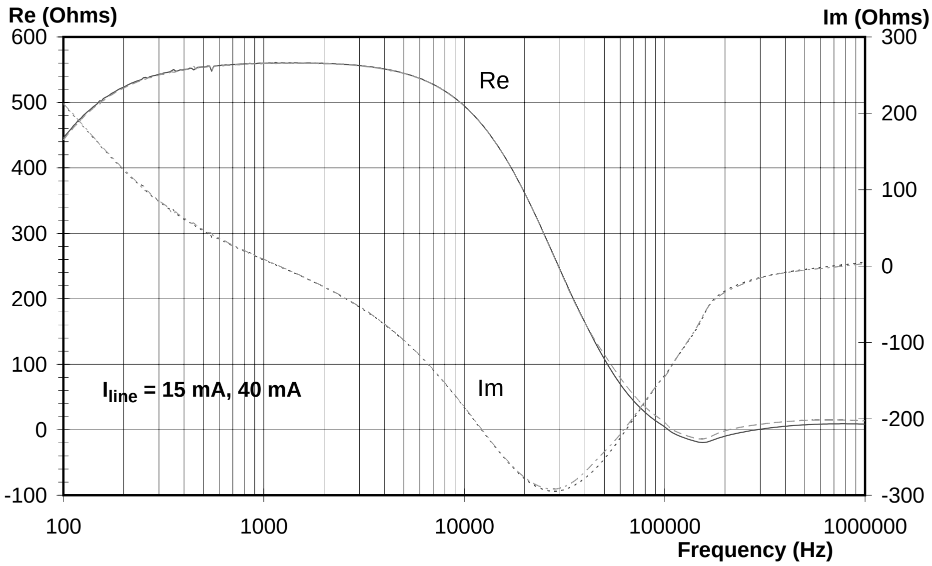

Fig.14 Impedance between LN+ and LN– at VRM; Zi = Re + j.Im

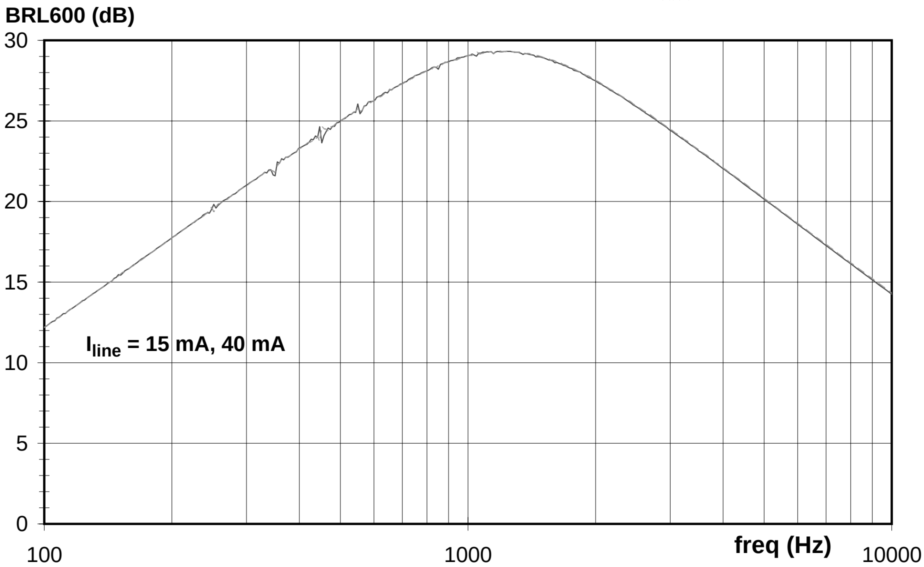

Fig.15 BRL at VRM wrt 600 Ω

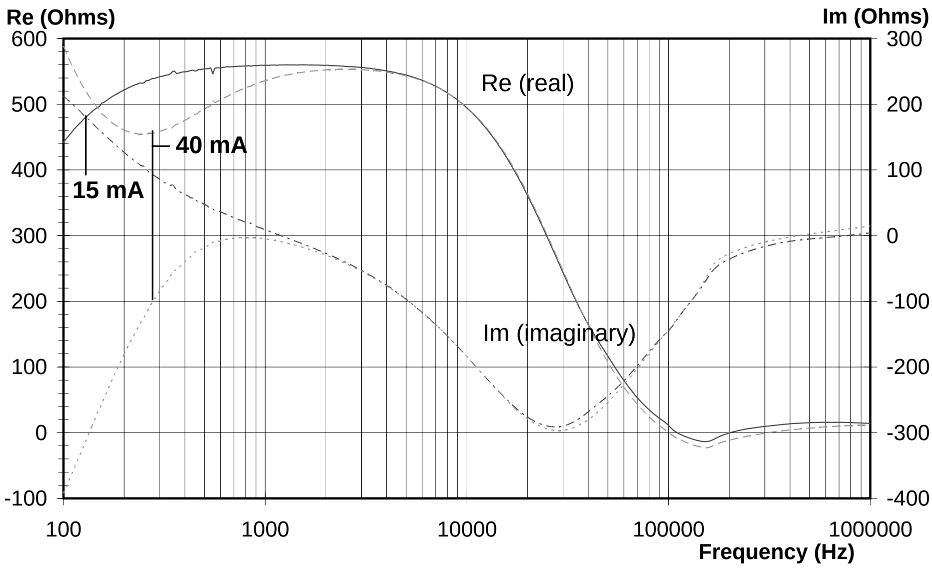

Fig.16 Impedance between LN+ and LN– at CRM; Zi = Re + j.Im

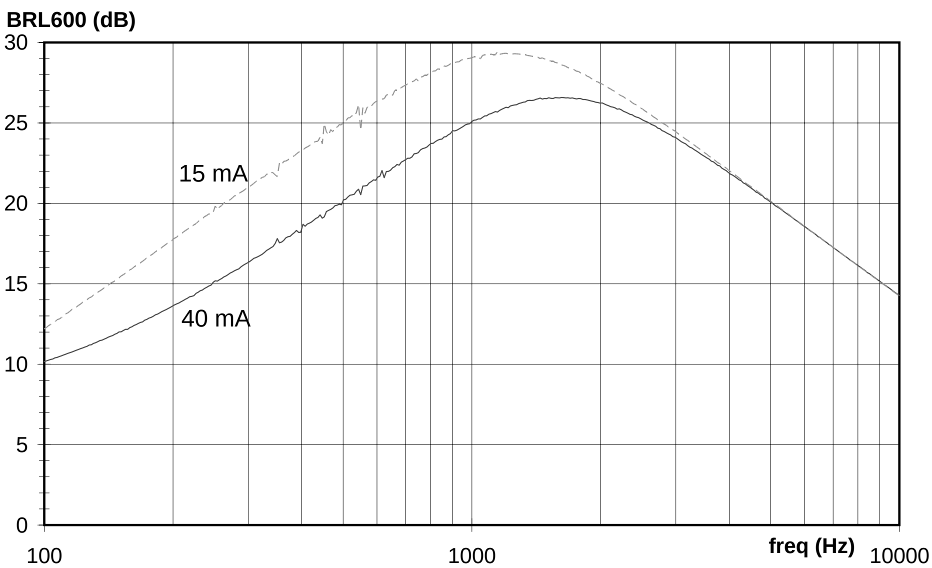

Fig.17 BRL at CRM wrt 600 Ω

Fig.18 gives the BRL, measured between LN+ and LN–, at two conditions. The lower curve shows the BRL with R_{SET} connected between LN+ and LN– while the upper curve is measured with R_{SET} connected between LN+ and SWI1. Naturally, SWI1 is selected by SWC1 = '1'.
The BRL of Z_{SET} is measured with respect to a reference impedance of 600 Ω. Z_{SET} on his turn, is composed of the 'open' impedance of the circuitry between LN+ and LN– into parallel with the connected R_{SET}. The upper curve of Fig.18 gives a higher BRL than the lower curve. The total resistance, R_{SET} + R-SWI1$_{switch}$, approximates the reference impedance of 600 Ω in a better way than R_{SET} alone.
Actually, at R_{SET} > 619 Ω the BRL results at the two given conditions can be interchanged.

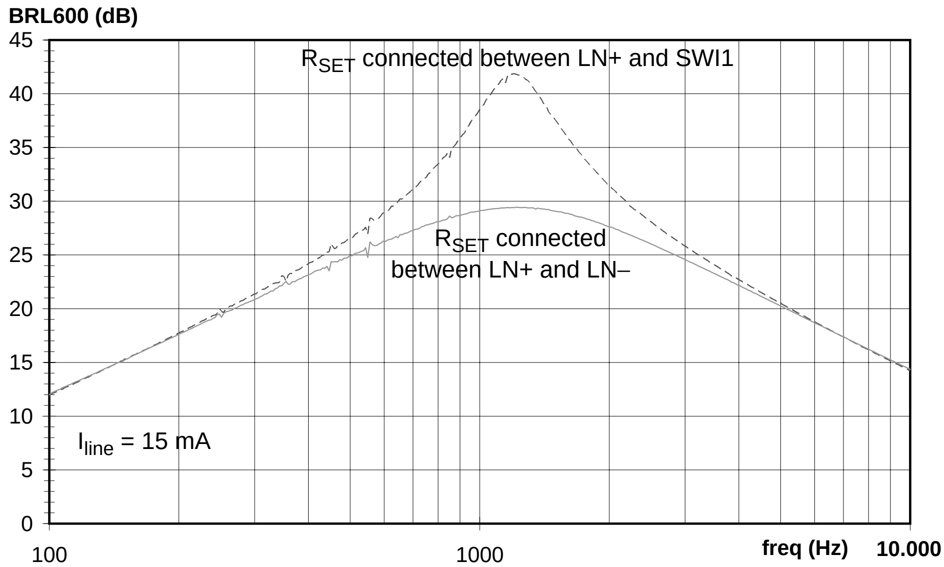

Fig.18 BRL at VRM; Z_{SET} realised at two ways

4.4 Transmit amplifier

The gain of the transmit (TX) amplifier is shown in Fig.19 at VRM as well as at CRM. Note that the gain at CRM increases at the lower frequencies due to the increase of the set impedance at the lower frequencies according Fig.16; $I_{line} > I_{knee}$

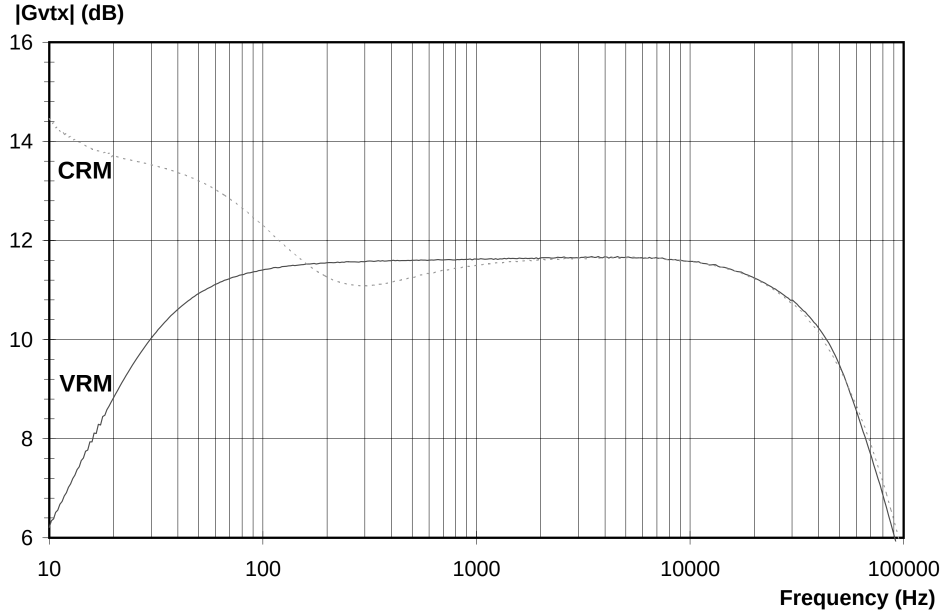

Fig.19 Gain of the transmit amplifier at VRM and CRM

The distortion of the signal on the line (between LN+ and LN–) as a function of the line level at $\mathbf{I_{line} = 15\ mA}$ is shown in Fig.20.

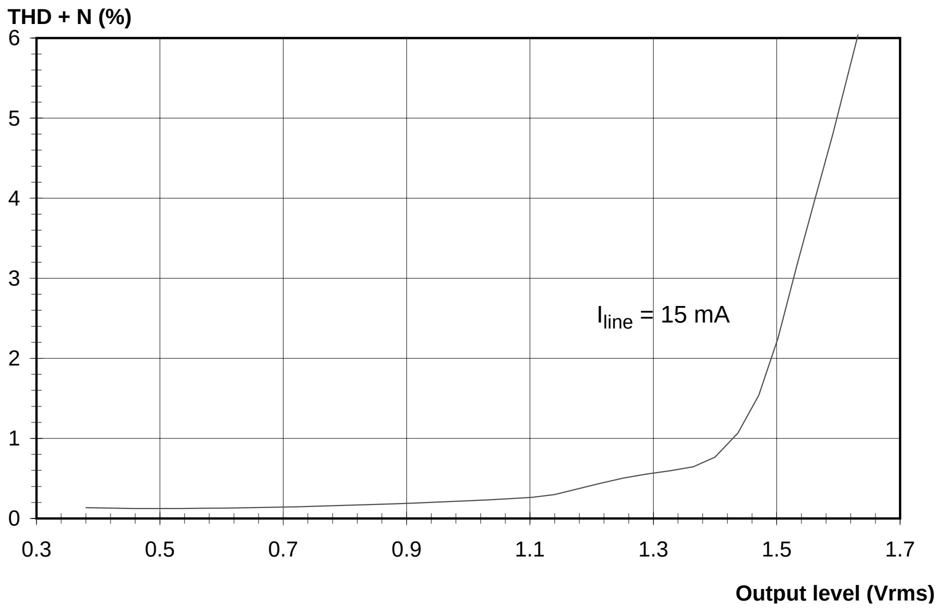

Fig.20 Distortion of the line signal versus line level

The distortion of the signal on the line (between LN+ and LN–) as a function of the line level at $\mathbf{I_{line} = 4\ mA}$ is shown in Fig.21.

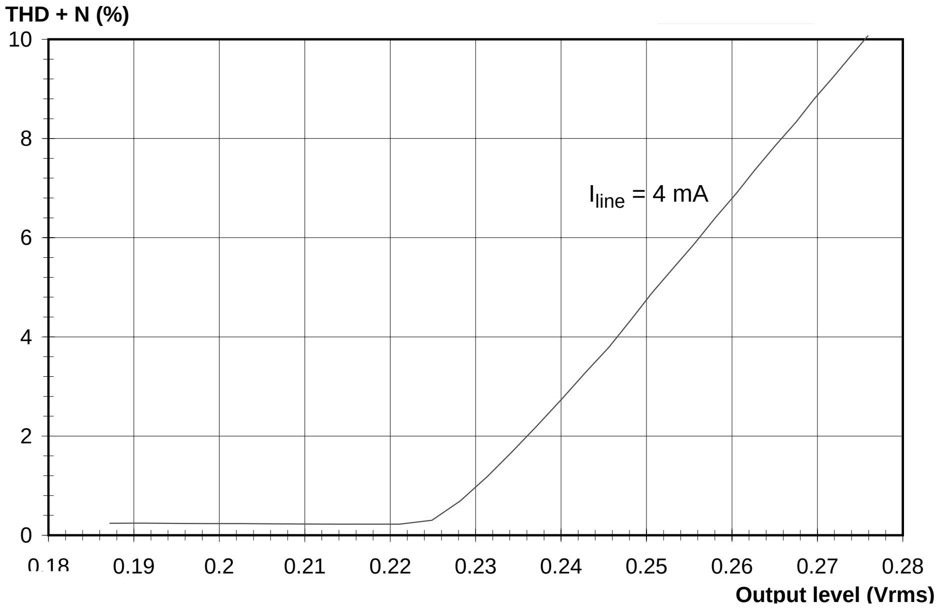

Fig.21 Distortion of the line signal versus line level at low line current

Fig.22 shows the distortion of the line signal versus input level at TXIM/TXIP. The AGC function is operational; at I_{line} = 15 mA the gain of the TX amplifier is 12 dB while at I_{line} = 90 mA the gain is decreased with about 6.5 dB. The input level at 90 mA is about the double with respect to 15 mA for the same THD figures.

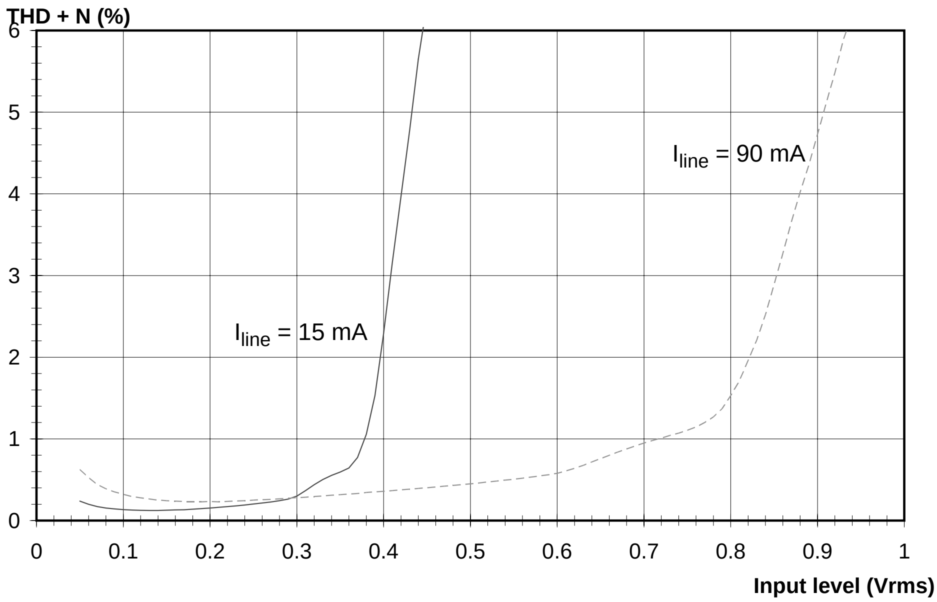

Fig.22 Distortion of the line signal versus input level of TX amplifier

4.5 Receive amplifier

The gain of the receive (RX) amplifier is shown in Fig.23 with open output and at loaded output by a resistor of 4.7 kΩ connected to GND via 10 µF.

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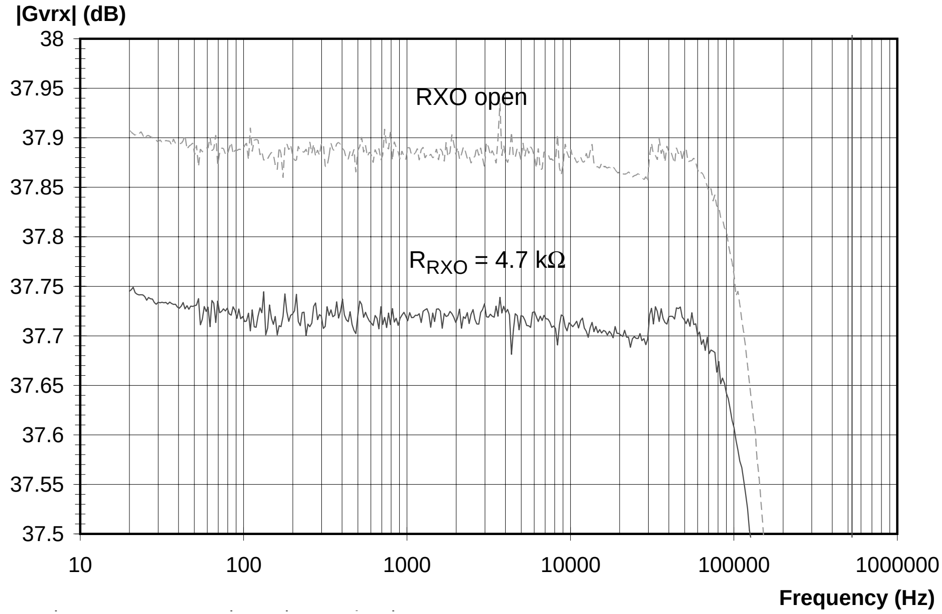

Fig.23 Gain of the receive amplifier

Fig.24 shows the distortion of the output signal on RXO versus input level at RXI. The AGC function is operational; the RX-gain decreases with about 6.5 dB at I_{line} = 90 mA resulting in a larger input level capability at the same distortion of the output signal.

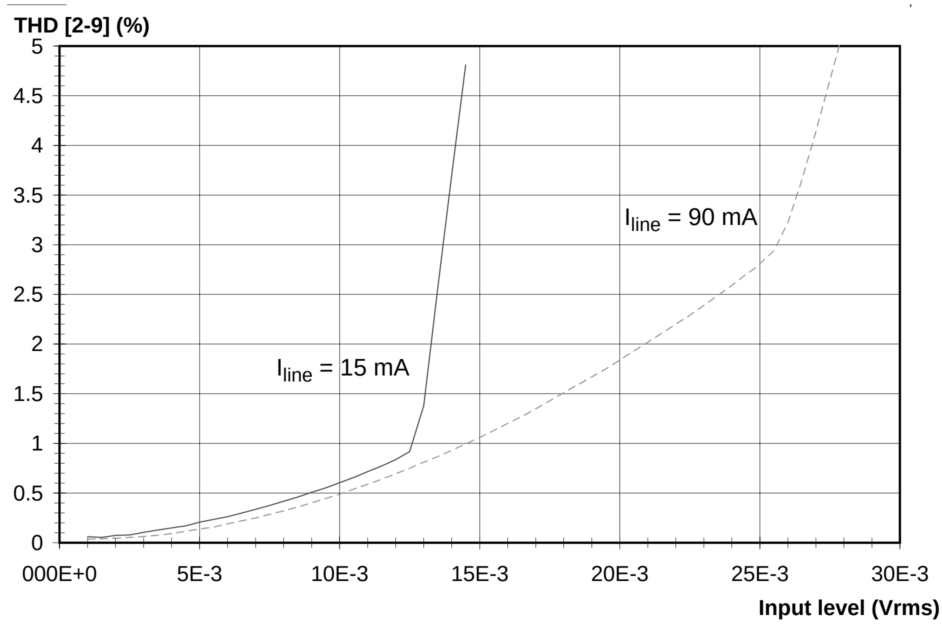

Fig.24 Distortion of RXO-signal versus input level of RX amplifier

4.6 AGC function (TX and RX amplifier)

The effect of AGC control on the gain of TX and RX amplifier, versus line current, are shown in Fig.25 respectively Fig.26. The setting of the 4 AGC-bits for each of the curves is shown in both pictures with the sequence: 'AGC', 'SAGC, 'RAGC1' and 'RAGC2'. Note that the gain of the TX amplifier increases slowly with the line current at setting '0000' as well as at maximum AGC control for the other settings.

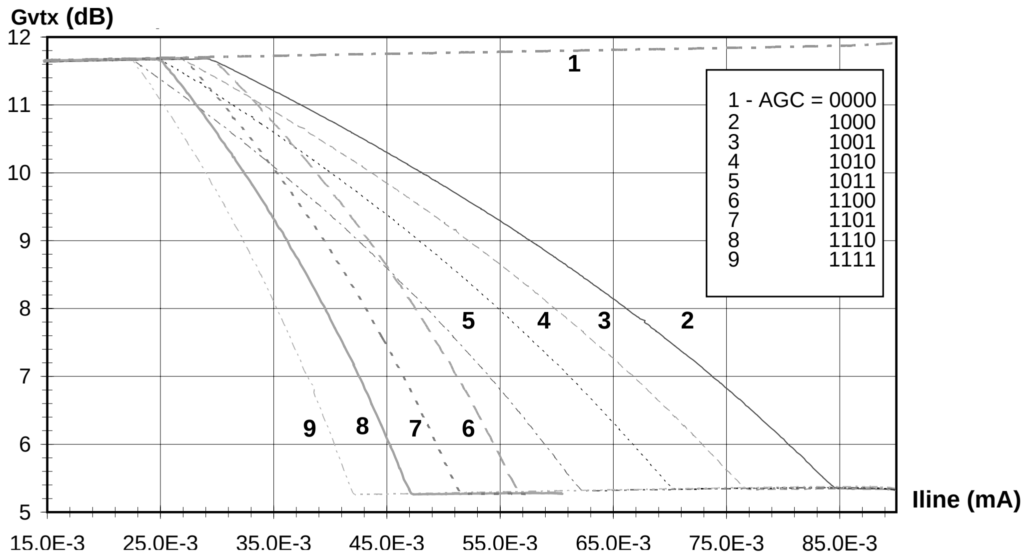

Fig.25 AGC control of the TX amplifier

'AGC = AGC - SAGC - RAGC1 - RAGC2'

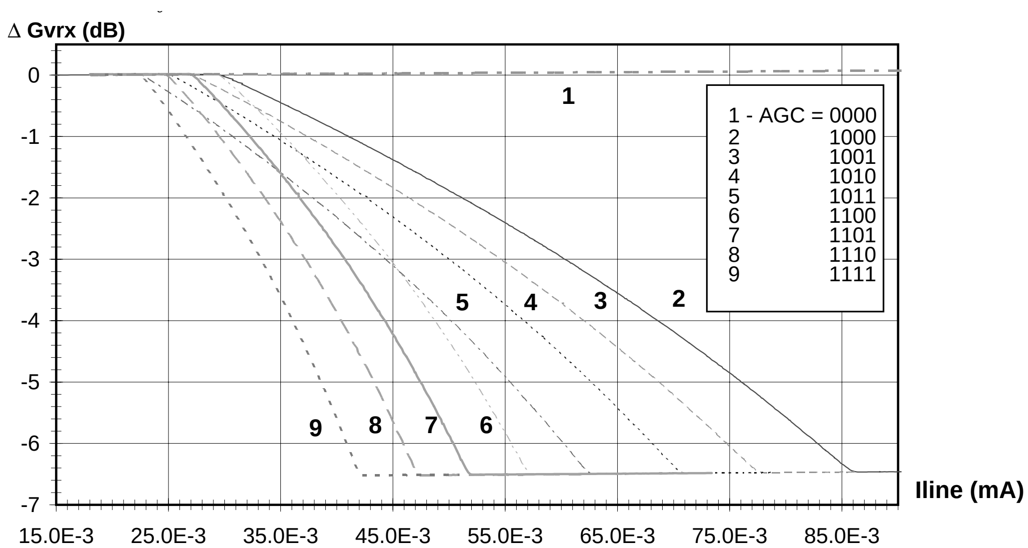

Fig.26 AGC control of the RX amplifier

4.7 Auxiliary amplifier

The gain of the auxiliary (AUX) amplifier is shown in Fig.27 with open output and at loaded output by a resistor of 4.7 kΩ connected to GND via 10 µF.

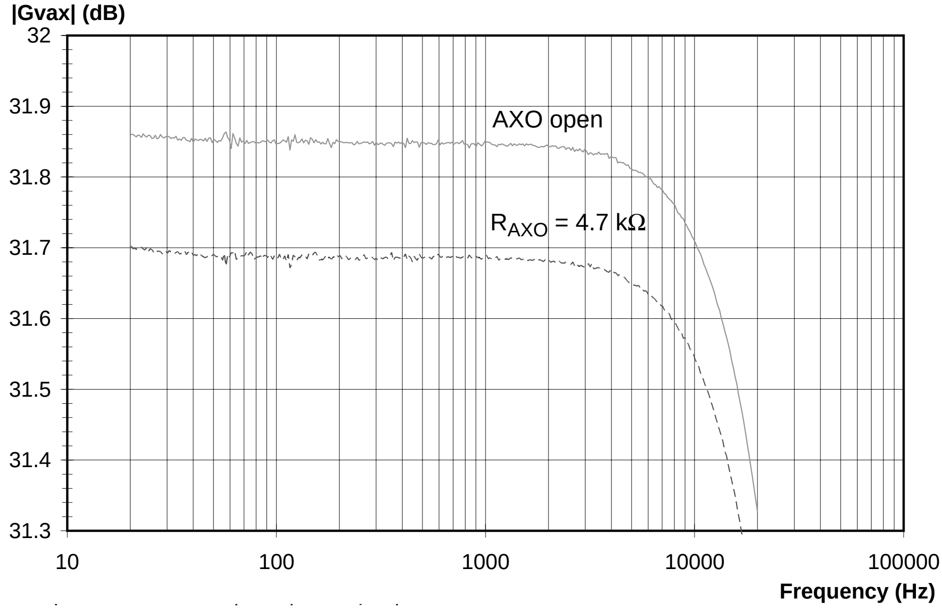

Fig.27 Gain of the auxiliary amplifier

Fig.28 shows the distortion of the output signal on AXO versus input level at AXI at both conditions also; output open and loaded. AGC has no effect on the gain of this amplifier.

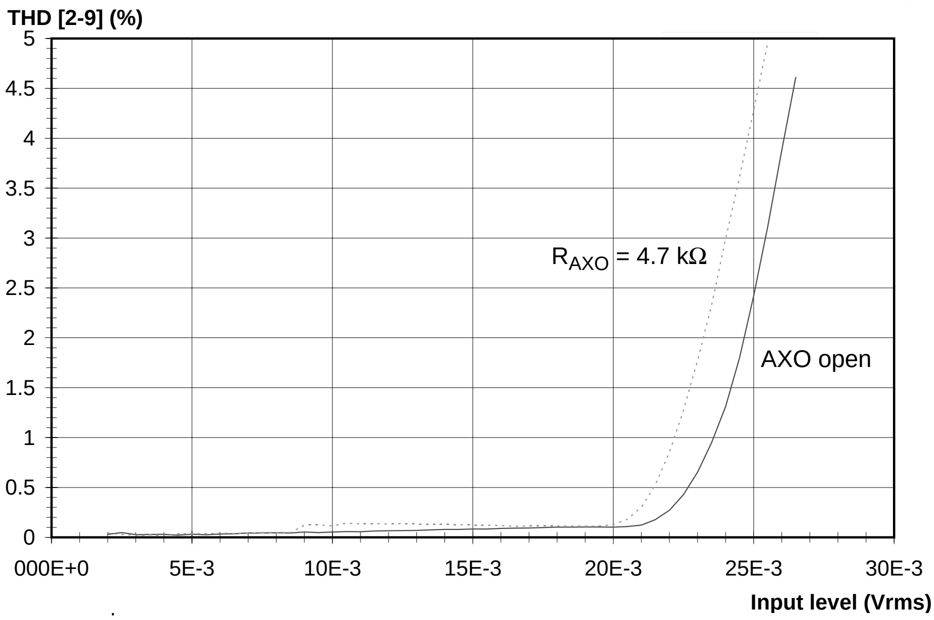

Fig.28 Distortion of AXO-signal versus input level of AUX amplifier

4.8 Loudspeaker amplifier

The gain of the loudspeaker (LSA) amplifier is shown in Fig.29; the dynamic limiter is disabled in this case.

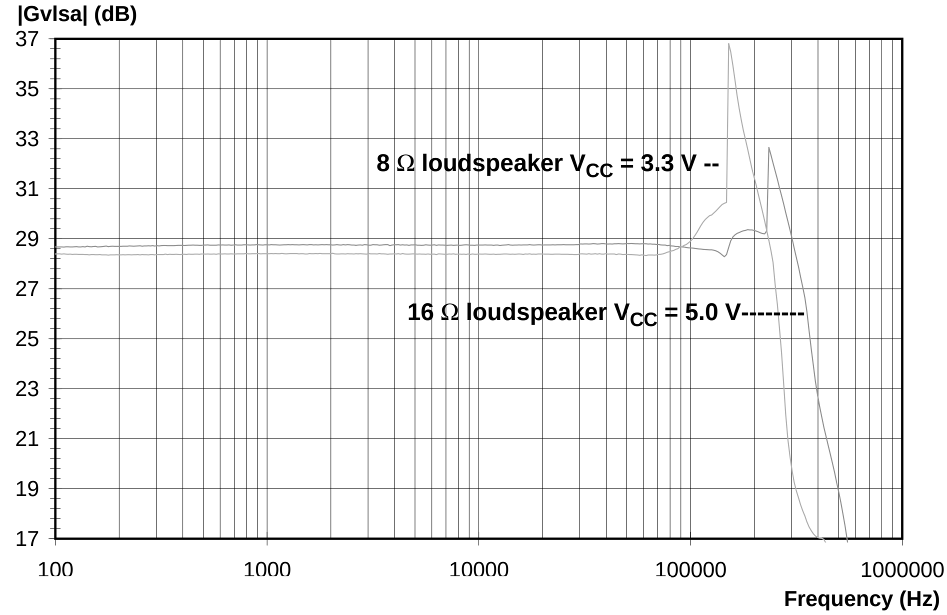

Fig.29 Gain of the loudspeaker amplifier at two output loads

Fig.30 shows the distortion of the loudspeaker signal caused by the level of the input signal on LSAI1 and LSAI2. The gain is set to minimum (7 dB) at VOL = ‘000’, V_{CC} = 5.0 V, loudspeaker impedance 16 Ω and the dynamic limiter is not activated.

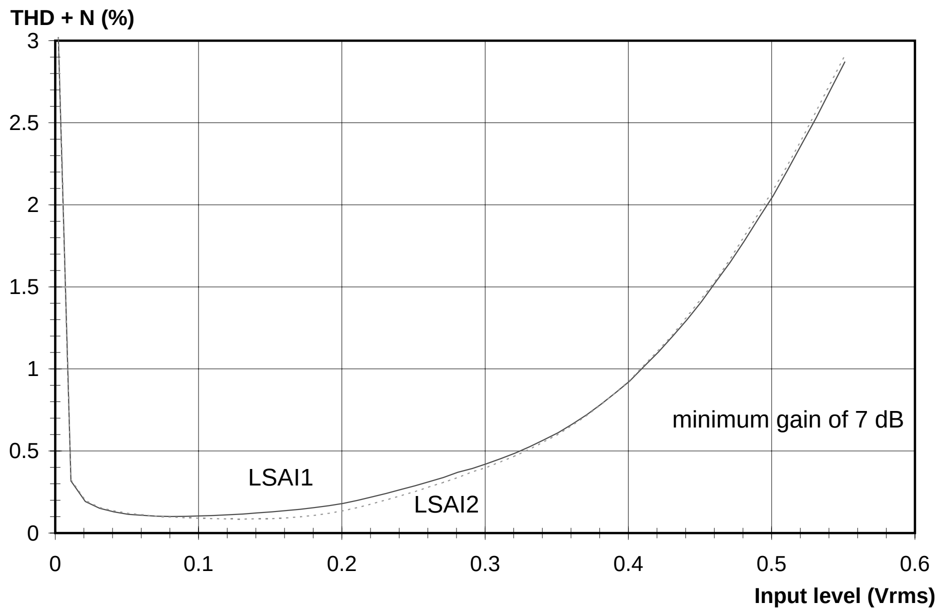

Fig.30 Distortion of the loudspeaker signal caused by the input level at min. LSA gain

Fig.31 gives the distortion of the loudspeaker signal caused by clipping of this signal without activated dynamic limiter; the gain of the LSA amplifier is set to maximum of 28 dB.

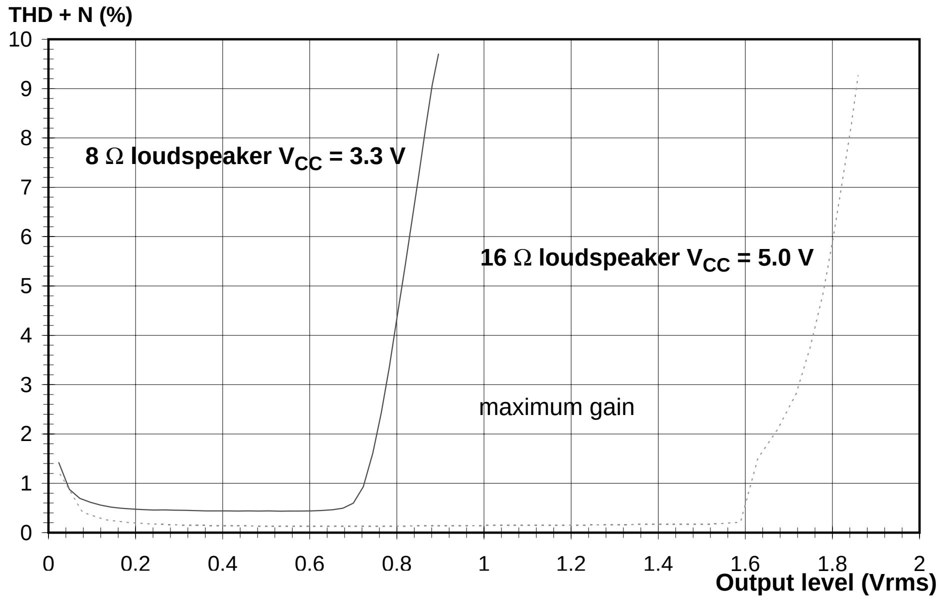

Fig.31 Distortion of the loudspeaker signal caused by the output level at max. gain

The maximum output level (peak-peak) of the loudspeaker amplifier is shown in Fig.32 for two output loads with dynamic limiter enabled. See [1] for V_{CC}-max. versus loudspeaker impedance.

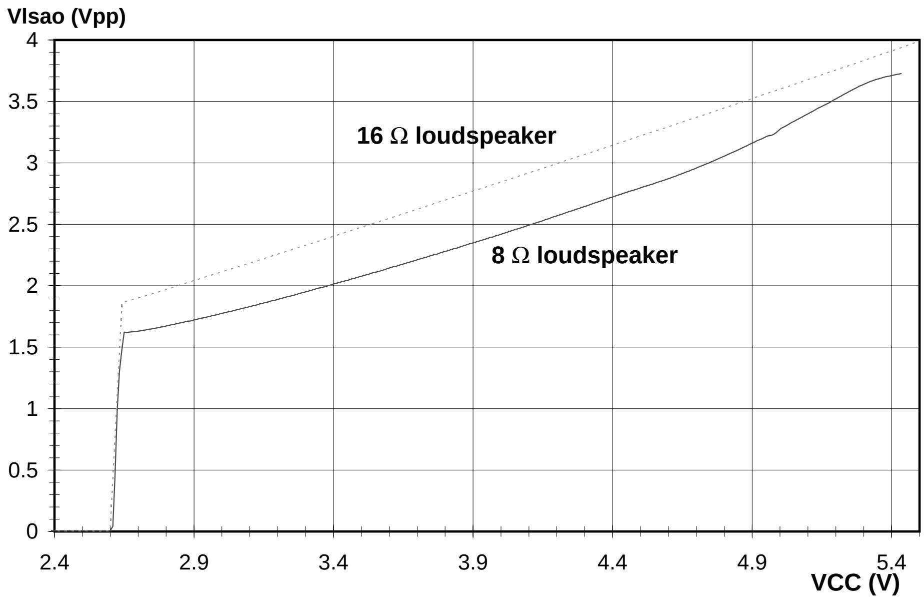

Fig.32 Output voltage capability of the loudspeaker amplifier

Fig.33 gives the maximum output current of the LSA amplifier versus DC output level at V_{CC} = 3.3 V. Due to the structure of the amplifier is the sink current capability more than the current deliverable as source current.

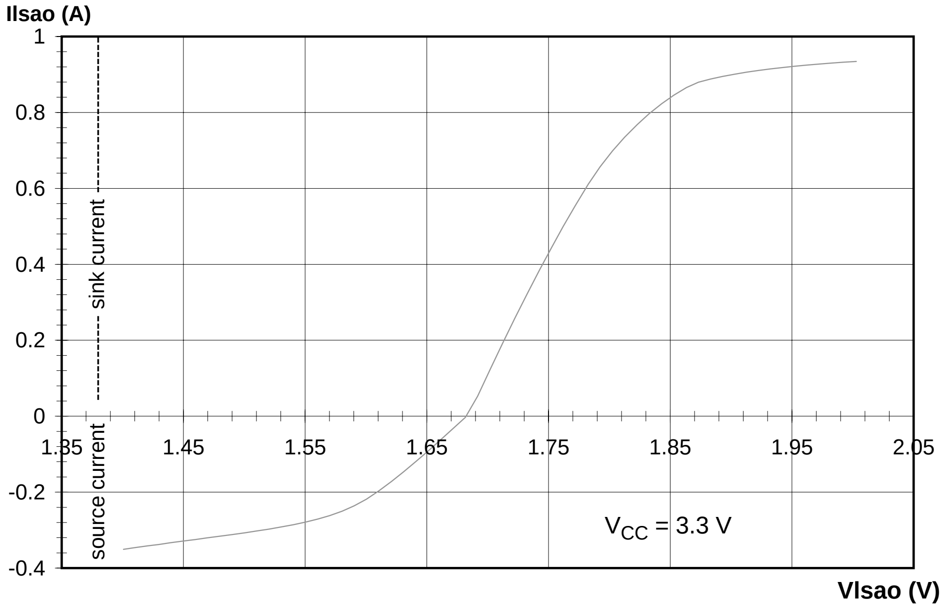

Fig.33 Output current capability at V_{CC} = 3.3 V

The effect of the dynamic limiter on the loudspeaker signal, when the level of the input signal (V_{LSAI}) is enlarged from 20 mVrms to 63 mVrms, is shown in Fig.34. The attack time to reduce the signal clipping is less than 2 ms. The output load is 16 Ω.

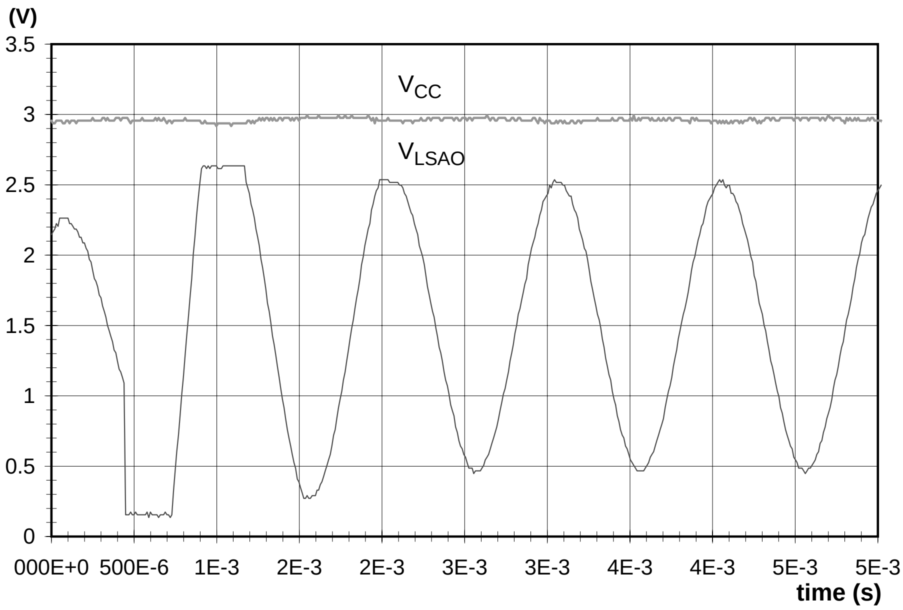

Fig.34 Attack control of the loudspeaker signal at overdrive of the input level

Release of the loudspeaker signal when V_{LSAI} is reduced from 63 mVrms to 20 mVrms is shown in Fig.35.

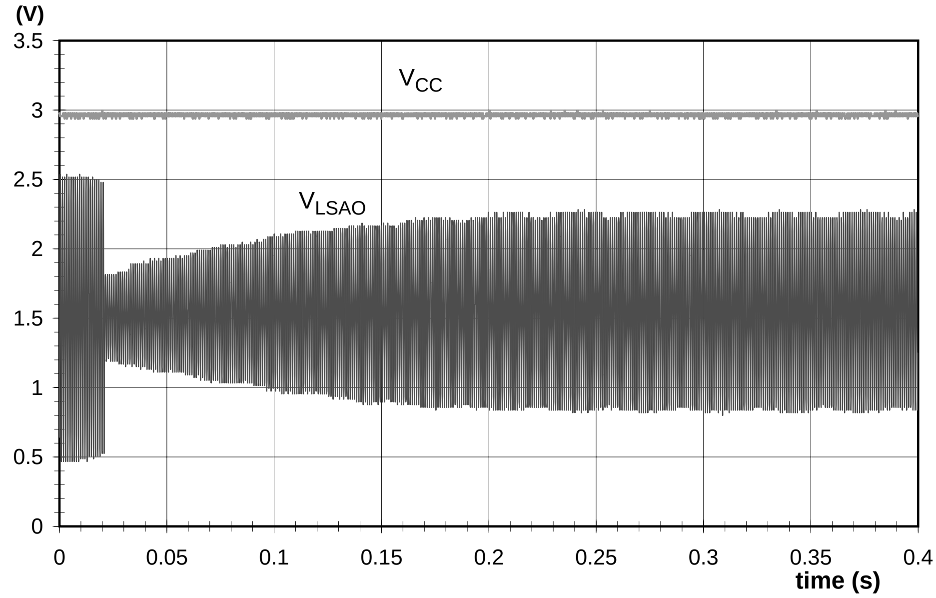

Fig.35 Release control of the loudspeaker signal at reduction of the input level

Fig.36 shows the gain control of the LSA amplifier caused by the dynamic limiter. The gain is maximum at about 28 dB when V_{DLC} > 2.0 V while maximum gain reduction is obtained at V_{DLC} < 1.54 V.

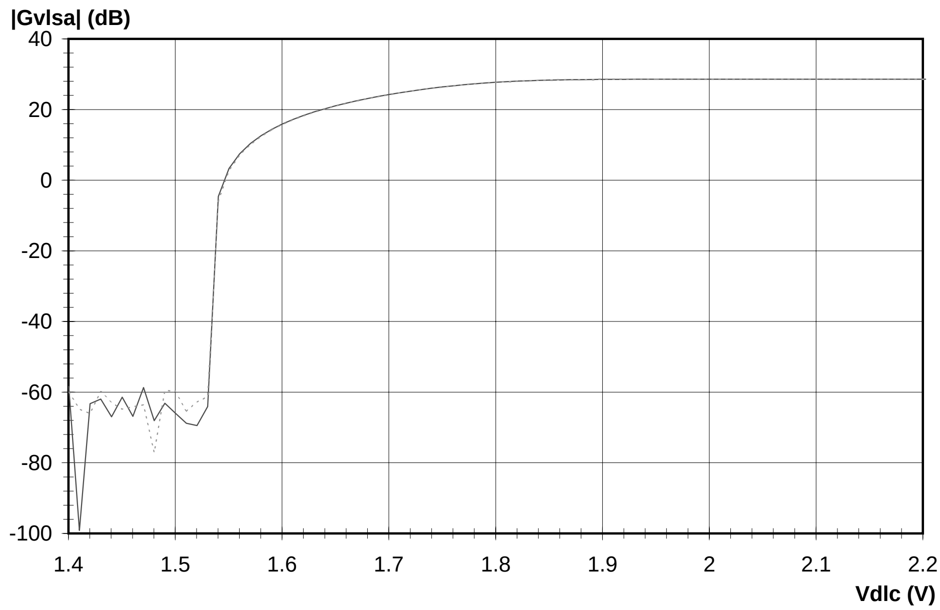

Fig.36 Gain control of the LSA amplifier versus DC control level on DLC

The LSA gain at the different volume control settings is shown in Fig.37.

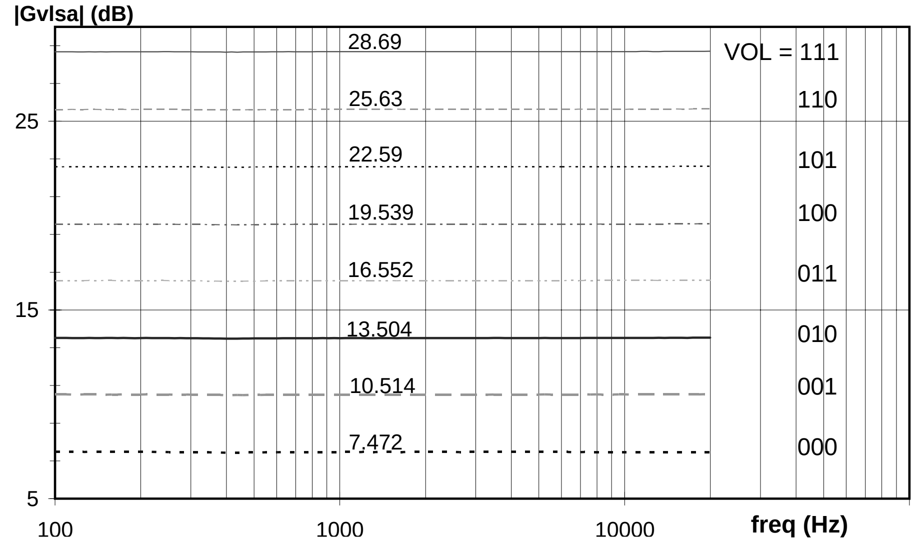

Fig.37 LSA gain versus VOL control setting

4.9 General switches

The dynamic resistance of the SWI1, SWI2 and SWI3 switches, measured between the SWI(x)-output and GND, as a function of the current through these switches, are given in Fig.38. The switches are selected by there respectively control bits SWC1 up to SWC3.

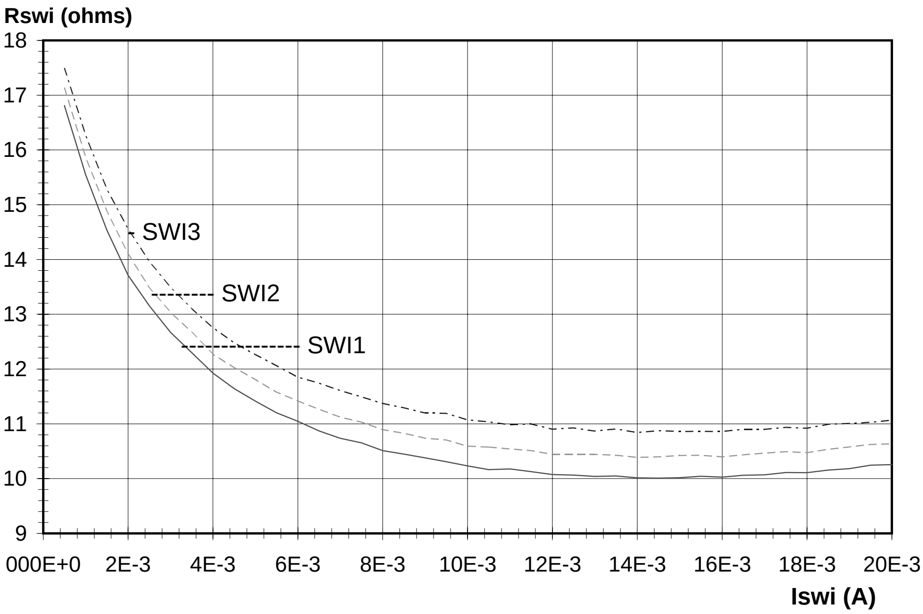

Fig.38 Dynamic resistance of the SWI-switches versus current

4.10 Device supply and device power down

The UBA1707 is externally supplied by means of the pins V_{CC} and GND. The IC is operational at PD = ‘0’; Fig.39 shows the current consumption I_{CC} in this stand-by condition. In case switch SWI1 is selected the stand-by current increases with about 600 µA at V_{CC} = 3.3 V as shown in Fig.40.
The current consumption at power down PD = ‘1’ is shown in Fig.41.

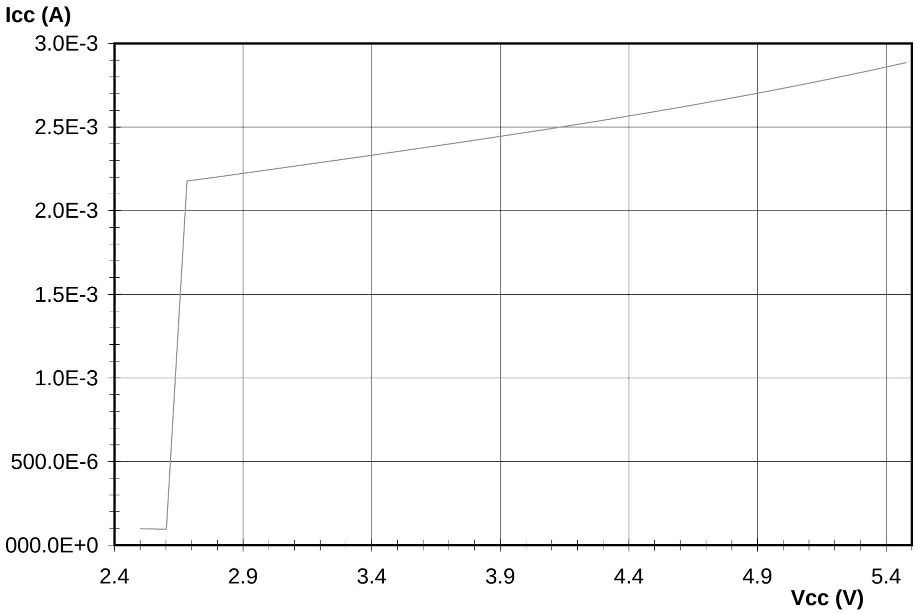

Fig.39 Current consumption I_{CC} versus V_{CC} in standby condition; PD = 0, SWC(x) = 0

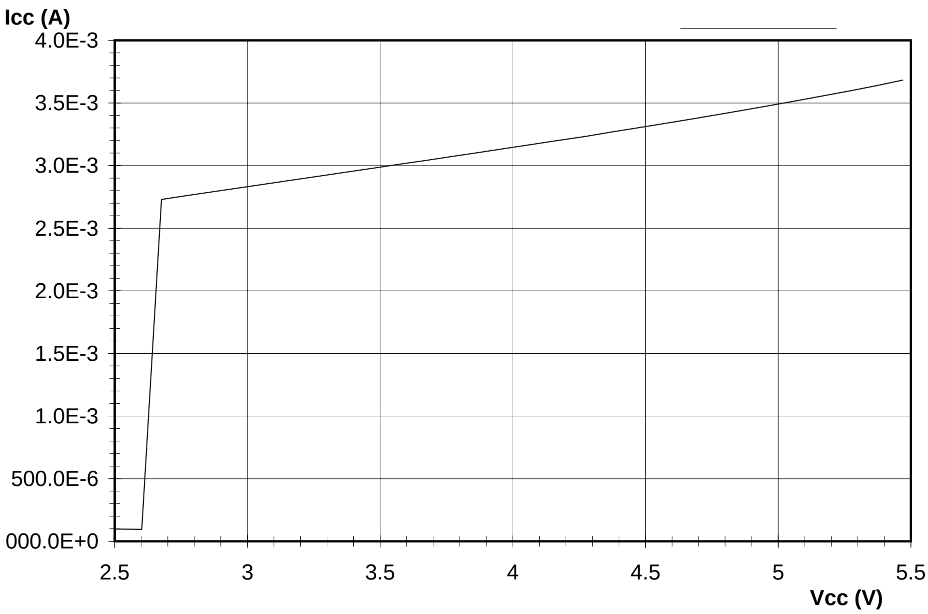

Fig.40 Current consumption I_{CC} versus V_{CC} with one selected switch; PD = 0, SWC1 = 1

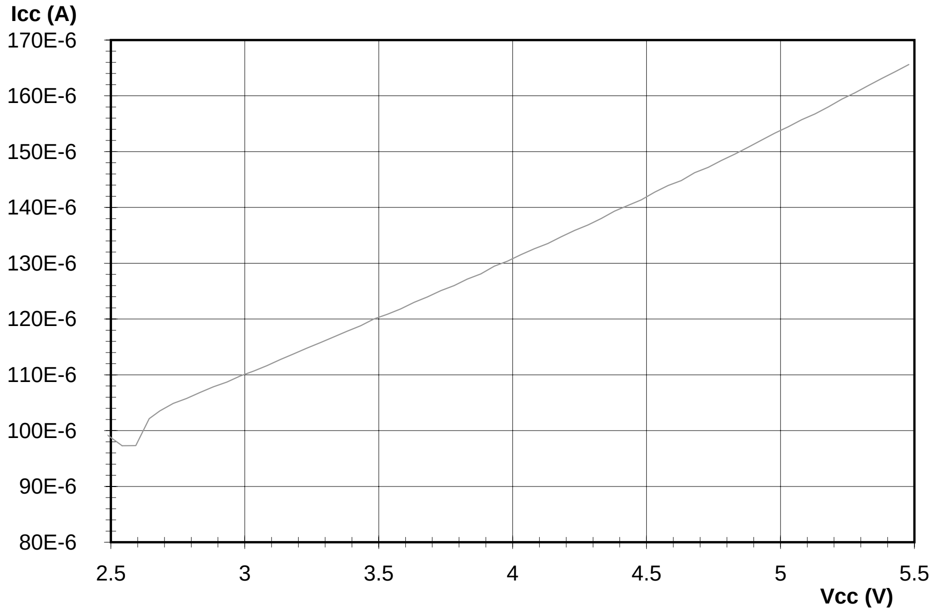

Fig.41 Current consumption I_{CC} versus V_{CC} at power down; PD = 1

5. APPLICATION PROPOSALS

Two application ideas on system level, using the UBA1707, are shown in Fig.42 and Fig.43. The first one shows an application in a cordless base station (CT0, CT1, PHS, DECT, ...) while the second one shows a digital answering machine application. Both applications are published as proposals only.

5.1 Cordless application

The cordless application of block diagram Fig.42 (base only) includes the following features:

- basic conversation between the line and the mobile set
- intercom function between the base and the mobile set
- listening-in on the base set
- on-hook/off-hook control
- DC mask control
- dialling, flash

Communication between base-station and mobile set is possible at two ways depending of the required mode.

N**ormal mode**: the receive signal from the line is transferred to the RF interface from RXI to RXO via the enabled receive amplifier. The auxiliary amplifier of the UBA1707, used for the base microphone, is muted in this state. The transmit signal from the mobile set is sent to the line via the RF interface and the TXIP/TXIM inputs of the transmit amplifier.

Intercom mode: Transmit from base to mobile is possible via the enabled microphone amplifier while the receive amplifier is muted. Signal transfer from mobile set to the base is realised via the RF interface output and the loudspeaker amplifier input LSAI1. Loudspeaker amplifier as well as auxiliary amplifier have to be enabled during intercom mode.

Listening-in: In normal mode, listening-in can be offered by means of the loudspeaker amplifier via the LSAI2 input which has to be driven by the receive amplifier output RXO.

All these modes as well as volume control of the loudspeaker amplifier and DC mask control are managed by the microcontroller via the serial interface of the UBA1707. Loop control, pulse dialling and flash are controlled by the microcontroller via the pin EHI. Transistor TNS, driven by TNP, opens or closes the loop. The UBA107 can be programmed by means of the keypad depending on the applied software of the controller.

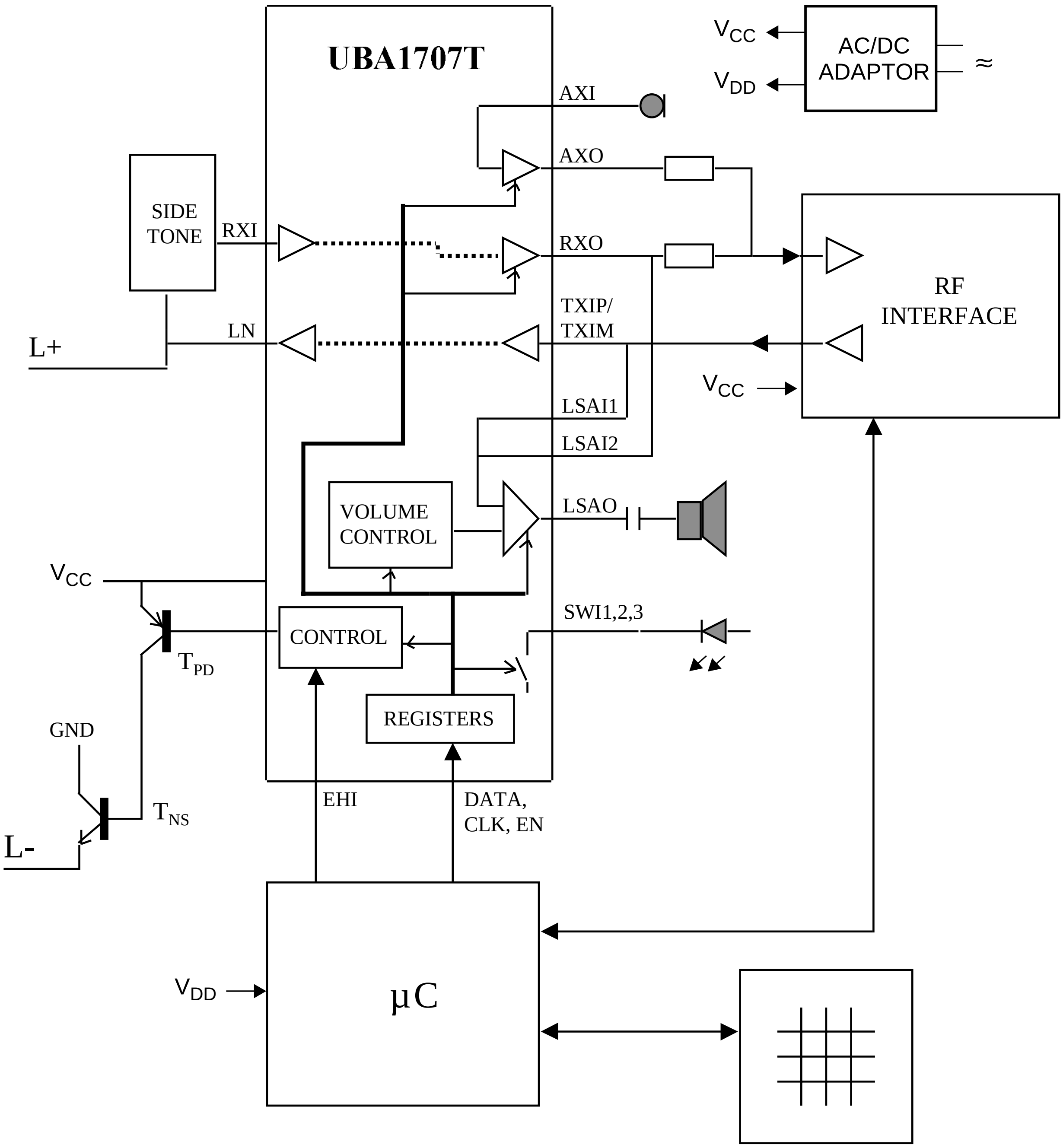

Fig.42 Application of the UBA1707 in the base-station of a Cordless set

5.2 Digital answering machine application

The digital answering machine application depicted in block diagram of Fig.43 includes the following features:

- recording of outgoing messages
- recording of incoming messages (with or without monitoring by means of the loudspeaker)
- play of outgoing messages (with or without monitoring by means of the loudspeaker)
- play of messages by the loudspeaker
- detection of remote control signals
- On-hook/off-hook control
- DC mask control

On this block diagram, the microcontroller functions are separated from the DSP which may be different in the application.

Recording of outgoing messages uses the auxiliary microphone amplifier of the UBA1707 while the receive amplifier is muted. During recording of incoming messages and detection of remote control signals, the auxiliary microphone is muted while the receive amplifier is enabled. The signal from the line is transferred to the codec input via RXI and RXO. In this mode monitoring by the loudspeaker is possible when output RXO is connected to an enabled loudspeaker amplifier input (LSAI2).

Outgoing messages to the line from the codec output are to be offered to the transmit inputs TXIP/TXIM.

Any recorded message can be monitored by means of the loudspeaker. The signal transfer is from codec output to enabled loudspeaker amplifier input LSAI1.

All these modes as well as volume control of the loudspeaker amplifier and DC mask control are managed by the microcontroller via the serial interface of the UBA1707. Loop control, pulse dialling and flash are controlled by the microcontroller via the pin EHI. Transistor TNS, driven by TNP, opens or closes the loop. The UBA1707 can be programmed by means of the keypad depending on the applied software of the controller.

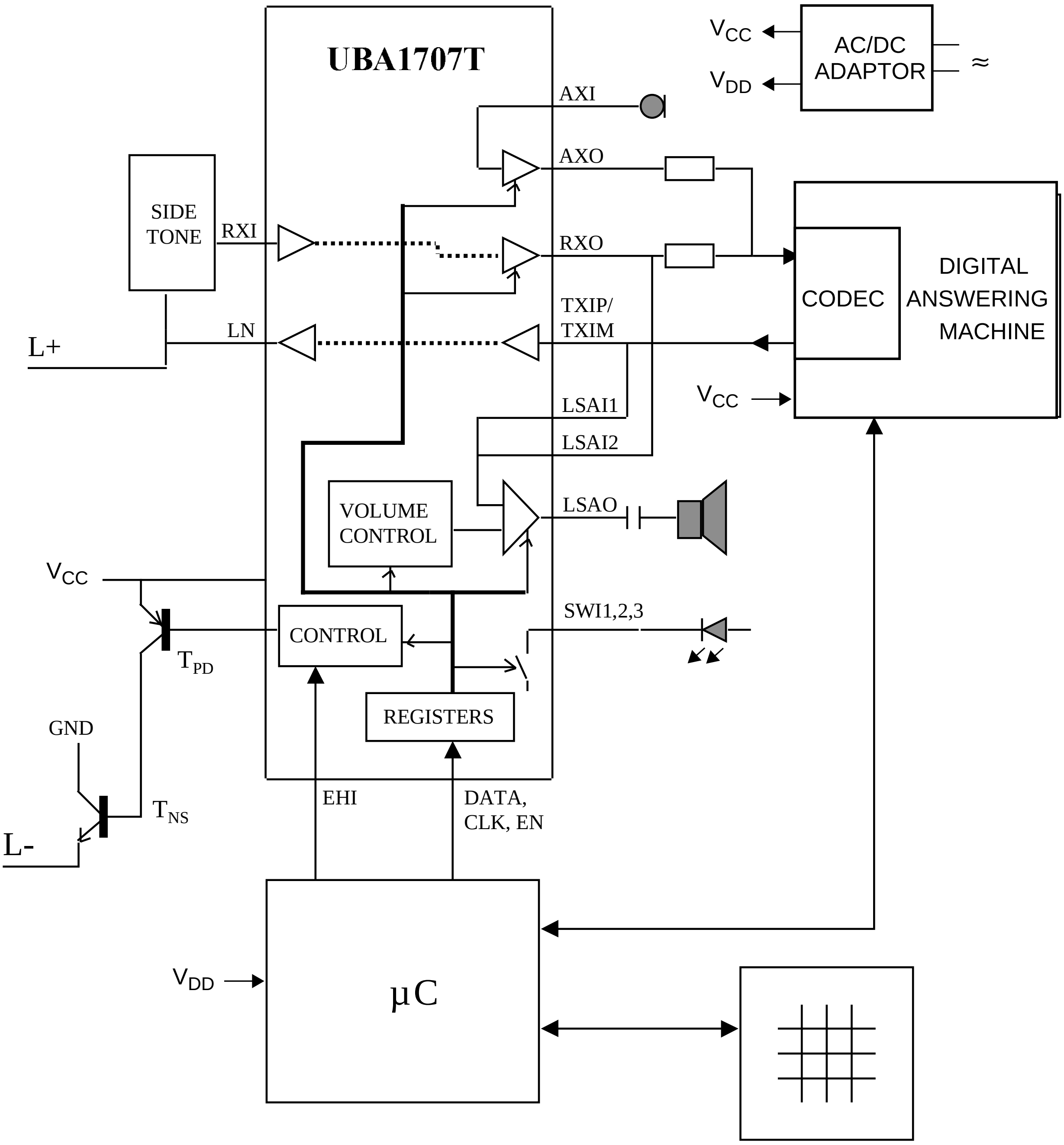

Fig.43 Application of the UBA1707 in an Answering Machine

6. APPLICATION HINTS

- **Speech quality:** A low pass RC-filter has to be placed in the receive channel to prevent audible disturbances of the loudspeaker signal. This RC-filter, consisting of a resistor of at least 1 kΩ and a capacitor of 10 nF, has to be mounted between RXO and LSAI1 or LSAI2 according Fig.44. The filter reduces the loop gain of the receive channel at the higher frequencies of more than 15 kHz. It can also be applied to create a low pass filter for audio frequencies with resistor values of more than 1 kΩ.

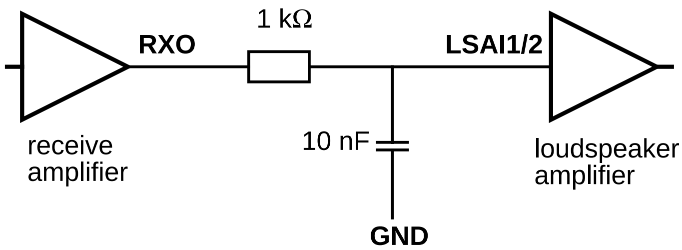

Fig.44 RC filter to improve speech quality

- **Maximum output power:** A loudspeaker with a impedance of about 15 Ω is adviced to be applied to obtain maximum output power from the loudspeaker amplifier in combination with the maximum supply voltage for this type of loudspeaker.
- **External components:** Extra components in the application are required to prevent instabilities, which are: a 10 nF capacitor between LN and GND a 6.8 pF capacitor between the base and collector of TR1 and a 27 pF capacitor between pin CST and the collector of TR. Consult the ‘typical application’ of the data sheet [1].
- **PCB design:** The PCB has to be designed carefully with respect to the ground connections GND and LSPGND. The RXI, LSAI1/2, AXI and TXI inputs have to be referred to GND while the ‘return wire’ of the loudspeaker have to be connected to LSPGND or V_{CC}– (the ‘–’ connection of the V_{CC} supply). Moreover, take into account that the device pins GND and LSPGND have to be ‘star-connected’ to V_{CC}– and **not interconnected under the IC on the device-pins**.
  Warning: Interconnection of GND and LSPGND on the UBA1707-pins can result in oscillations of the loudspeaker signal in case of applications where both loudspeaker amplifier inputs LSAI1 as well as LSAI2 have to be selected at the same time.
- **V_{CC} supply:** Use a supply source with a low ripple on V_{CC} of < 1 mVpp. The signal attenuation between V_{CC} and loudspeaker amplifier output is 6 dB only. A signal of a few ‘mV’ across the loudspeaker is well audible in a quiet environment.
  Furthermore, take care of the ground reference connections of the supply sources of V_{CC} and line supply in the test set-up. The line can be ‘open’ while V_{CC} is still present which can give ‘rumble’ from the loudspeaker.
  Disable the receive amplifier (RXM = ‘1’) during ON-hook (EHI = ‘LOW’) to prevent transfer of disturbing signals from the line to the loudspeaker amplifier input.

7. ACKNOWLEDGEMENTS

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