APPLICATION NOTE

Application of the UBA1702/A Line Interrupter Driver and Ringer Circuit

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Abstract

The UBA1702/A performs the high voltage interface and ringer functions for corded telephone sets. The IC itself, its typical behaviour and the combination of this circuit with a transmission IC (a member of the TEA106X family) and a microcontroller are described in detail. Information on adjustments to fulfil country requirements and several application proposals are given.

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Summary

This report is intended to provide application support for designing telephone sets with the UBA1702/A integrated circuit. It contains worked-out examples of application circuits. The necessary operation principles and adjustments have been included to enable the designer to adapt the basic circuit to his specific application.

The first chapter gives an introduction and elucidates some of the backgrounds of the circuit. Chapter two gives the blockdiagram and the pinning of the circuit. Chapter three contains a detailed description of the specific blocks, together with possible adjustments and performance of the separate blocks. Notes on the overall system performance can be found in chapter four. The consecutive steps to meet specific country requirements are described in chapter five. Worked out application examples for the UBA1702 as well as the UBA1702A in combination with various transmission circuits are given in chapter six. EMC aspects are discussed in chapter seven. Chapter eight contains a list with references. The appendices contain: quick reference data for the TEA106X family (A), a list of abbreviations (B) and the application diagrams printed on two pages A4 size paper each (C).

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1. INTRODUCTION

The considerations which played an important role during development of the UBA1702/A Line Interrupter Driver and Ringer Circuit were the following:

- the circuit must be complementary to the existing range transmission circuits (TEA106X/TEA111X family) and microcontrollers (PCD33XX) in such a way that these ICs in combination with the UBA1702/A offer a complete system solution. Therefore the software controlled ringer concept is supported. In this concept the ringer-melody is generated under control of (microcontroller-)software. This flexible approach makes adaptation of the melody to the individual preference of the user possible.
- a certain degree of versatility must be built in to meet requirements for various countries.
- the number of required external (discrete) components must be minimized.

The proposed system concept will be illustrated with the help of figure 1.

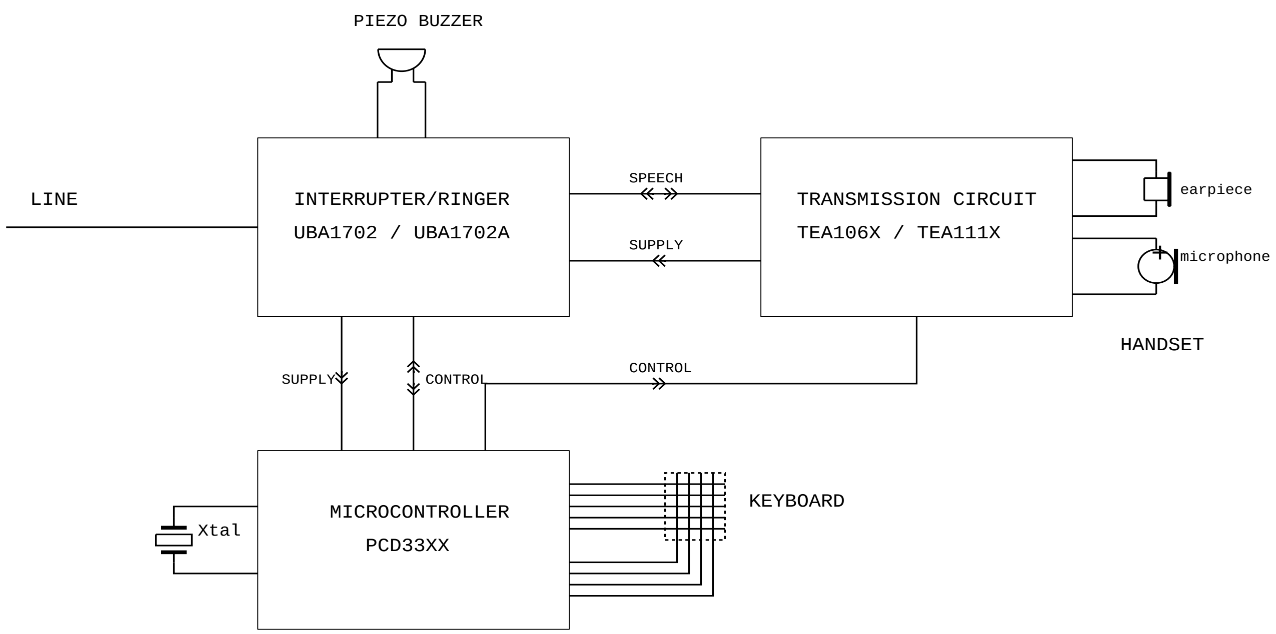


Fig.1 System concept corded telephone.

Two different operation modes can be determined:

the ringer mode. This mode occurs during 'on hook', the set is in quiescent condition. After applying an AC ringer signal to the set a square wave with twice the ringer signal frequency is generated by the UBA1702/A. This square wave signal is checked by the microcontroller for the correct frequency (frequency discrimination). In case of a correct ringer frequency a melody is generated by the microcontroller which is fed back to the UBA1702/A in combination with a specific output volume setting. After a check for the correct amplitude of the ringer signal the generated melody is amplified by the UBA1702/A as well to the desired level. A piezo transducer makes the melody audible. The microcontroller is supplied from the telephone line via the UBA1702/A.

the conversation / dialling mode. This mode is related with 'off hook', the set is in dialling or loop condition. In this mode the UBA1702/A serves as an overvoltage- and overcurrent protection circuit for the transmission circuit. The IC also contains a line current detection circuit to inform the microcontroller about the status of the line and the hookswitch. In pulse dialling mode the UBA1702/A takes care of interrupting the loop current during the breakperiod and for proper set resistance during the make period. The microcontroller is supplied via the UBA1702/A directly from the line or indirectly by the supply point of the transmission circuit.

To meet specific market demands two different versions are developed:

- the UBA1702, intended to drive an external PMOST interrupter and
- the UBA1702A which is adapted to drive an external bipolar PNP interrupter.

The UBA1702/A is fabricated in Philips' proprietary High Voltage Bipolar Complementary and Double-diffused Metal Oxyde Semiconductor (HV-BCDMOS) process. The circuit is capable of withstanding up to 400 V on pins connected directly or indirectly to the telephone line.

The detailed description in this report is given by means of the blockdiagram of the UBA1702/A (ch. 2) and by discussing the details of each block (ch. 3). Notes on the overall system performance can be found in ch. 4. The application is treated by giving guidelines for application also in relation with specific requirements (ch. 5) and by giving a number of worked-out examples including electronic hookswitch application (ch. 6). EMC aspects are discussed (ch. 7) and a list with references is given (ch.8). The appendices contain quick reference data for the TEA106X family (A), a list of abbreviations (B) and application diagrams of the UBA1702/A printed on A3 size paper (C).

Note: by the addition /A in UBA1702/A two different circuits are meant at the same time: UBA1702 as well as UBA1702A.

2. BLOCKDIAGRAM

The blockdiagram of the UBA1702/A is depicted in figure 2 while the pin configuration is given in figure 3 with the belonging table.

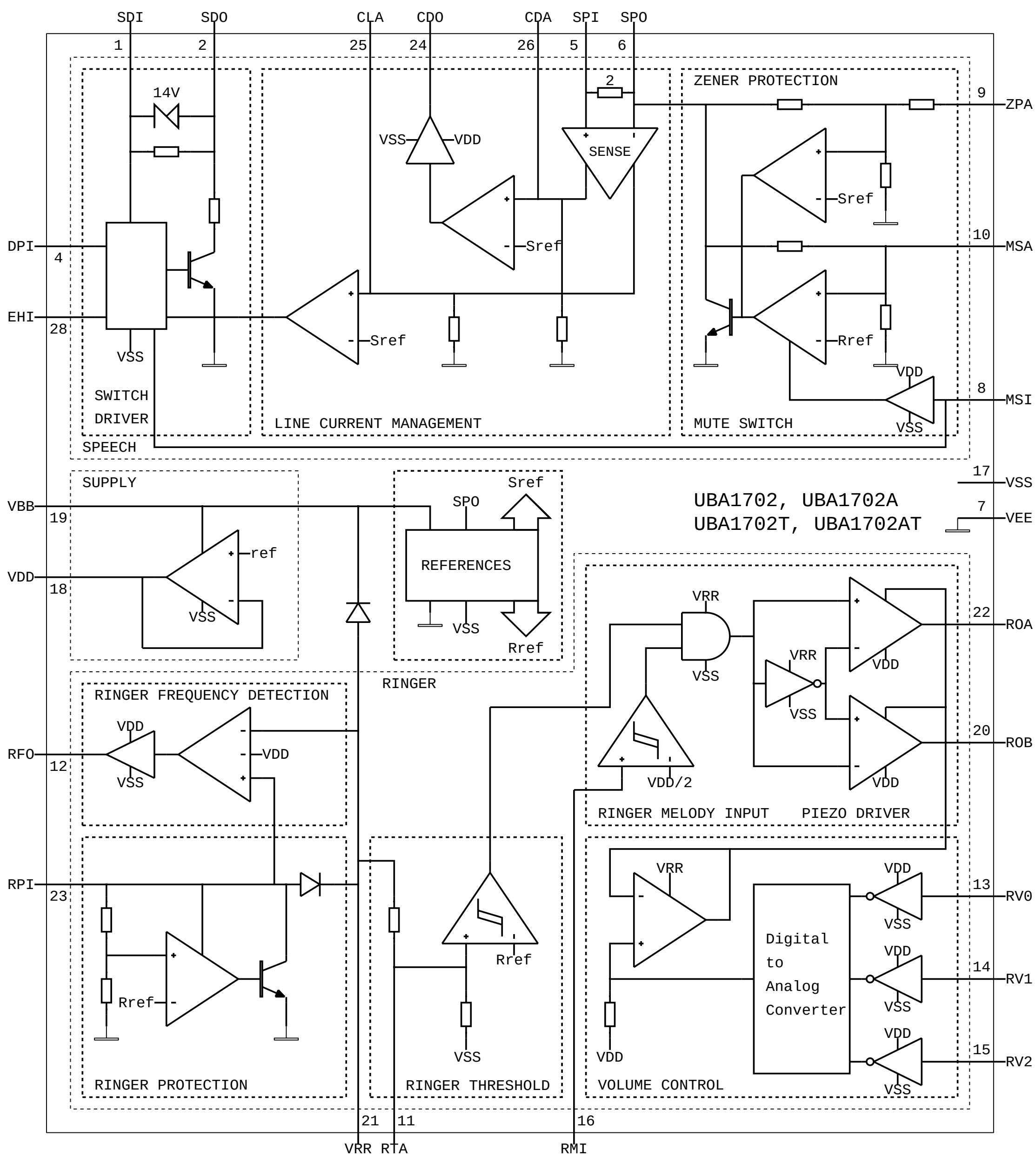


Fig.2 Blockdiagram

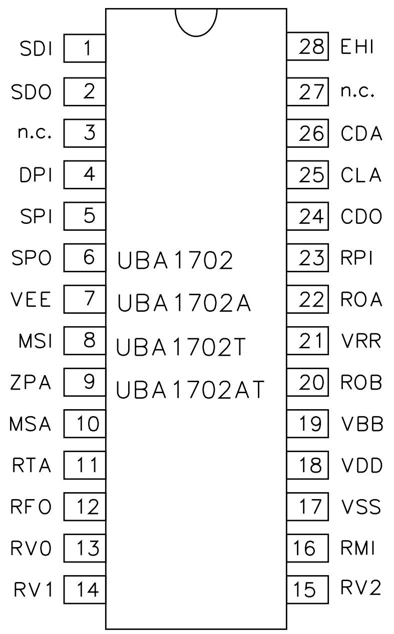


Fig.3 Pinconfiguration

SYMBOL	PIN	DESCRIPTION	SYMBOL	PIN	DESCRIPTION
SDI	1	Switch Driver Input.	RV2	15	Ringer Volume; bit 2 (MSB).
SDO	2	Switch Driver Output.	RMI	16	Ringer Melody Input.
nc	3	not connected.	VSS	17	Ground ref. micro and ringer.
DPI	4	Dialling Pulse Input.	VDD	18	Microcontroller supply.
SPI	5	Speech Part Input.	VBB	19	Supply from transm. circuit.
SPO	6	Speech Part Output.	ROB	20	Ringer Output B.
VEE	7	Ground ref. transm. circuit.	VRR	21	Ringer supply.
MSI	8	Mute Switch Input.	ROA	22	Ringer Output A.
ZPA	9	Zener Protection Adjustment.	RPI	23	Ringer Part Input.
MSA	10	Mute Switch Adjustment.	CDO	24	Current Detection Output.
RTA	11	Ringer Threshold Adjustment.	CLA	25	Current Limitation Adjustment.
RFO	12	Ringer Frequency Output.	CDA	26	Current Detection Adjustment.
RV0	13	Ringer Volume; bit 0 (LSB).	nc	27	not connected.
RV1	14	Ringer Volume; bit 1.	EHI	28	Electronic Hookswitch Input.

In the blockdiagram of figure 2 three main parts can be distinguished:

- speech interface part
- ringer part
- supply

The subparts / blocks which correspond with these parts and the related pins are shortly described below.

Speech interface part

This part can be subdivided into:

switchdriver. This block controls via pins SDI and SDO the external PMOST (in case of UBA1702) or external PNP (in case of UBA1702A) interrupter switch. By making DPI high the interrupter is switched off, which corresponds with a line break. For basic applications pin SDI and EHI are shorted, but by applying a control signal to EHI the interrupter switch can be used as hookswitch.

line current management. This block measures the line current flowing through pins SPI and SPO. This line current information is used for two purposes:

- protection: the line current has to be limited in case of over current. The limiting value is adjustable via pin CLA.
- detection: a minimum value has to be detected to determine line- and hookswitch status. This minimum value is adjustable via pin CDA, the status information (logic signal) is available at pin CDO.

mute switch / zener protection. This block influences the voltage present on pin SPO in the following cases:

- overvoltage: for protection of the transmission circuit the voltage is clamped to a value adjustable by pin ZPA.
- DMO operation: to assure a specific set resistance during the make period of pulse dialling the voltage is clamped at a low value (adjustable via pin MSA) under control of pin MSI. This function is also designated as NSA or Mute2.

Ringer part

This part includes:

ringer protection. This block shows similarities with a zener diode. It limits the ringer voltage present on pin RPI.

ringer frequency detection. The AC ringer signal is converted by this block to a logic (square wave) signal with twice the frequency. This signal is available at pin RFO.

ringer threshold. The ringer signal is checked for the required minimum level by this block. The level is adjustable by means of pin RTA.

volume control. To control the ringer output volume three control inputs: RV0, RV1 and RV2 are available.

melody input / piezo driver. The ringer melody is applied to pin RMI. The output stage is enabled by the ringer threshold block if the voltage on pin VRR crosses a certain threshold. The piezo transducer can be connected between pins ROA and ROB.

Supply

A stabilized voltage is available to supply the microcontroller via pin VDD. Input of this supply is VRR in ringer mode and VBB in conversation / dialling mode.

VEE is the ground reference for speech and VSS for the ringer and the microcontroller.

3. BLOCKDESCRIPTION OF THE UBA1702/A

This chapter describes in detail the three main parts of the IC: the speechpart (ch. 3.1), the ringer part (ch. 3.2) and the supply (ch. 3.3). For each part the operation principle is described and its adjustments and performance are discussed.

All values and graphs given in this chapter are typical and at room temperature unless otherwise stated.

3.1 Speech interface part

The speech interface part consists of the switchdriver (ch. 3.1.1), the line current management (ch. 3.1.2) and the zener protection / mute switch (ch. 3.1.3).

3.1.1 Switchdriver of the UBA1702

Principle of operation

The blockdiagram of the switchdriver with external components is given in figure 4.

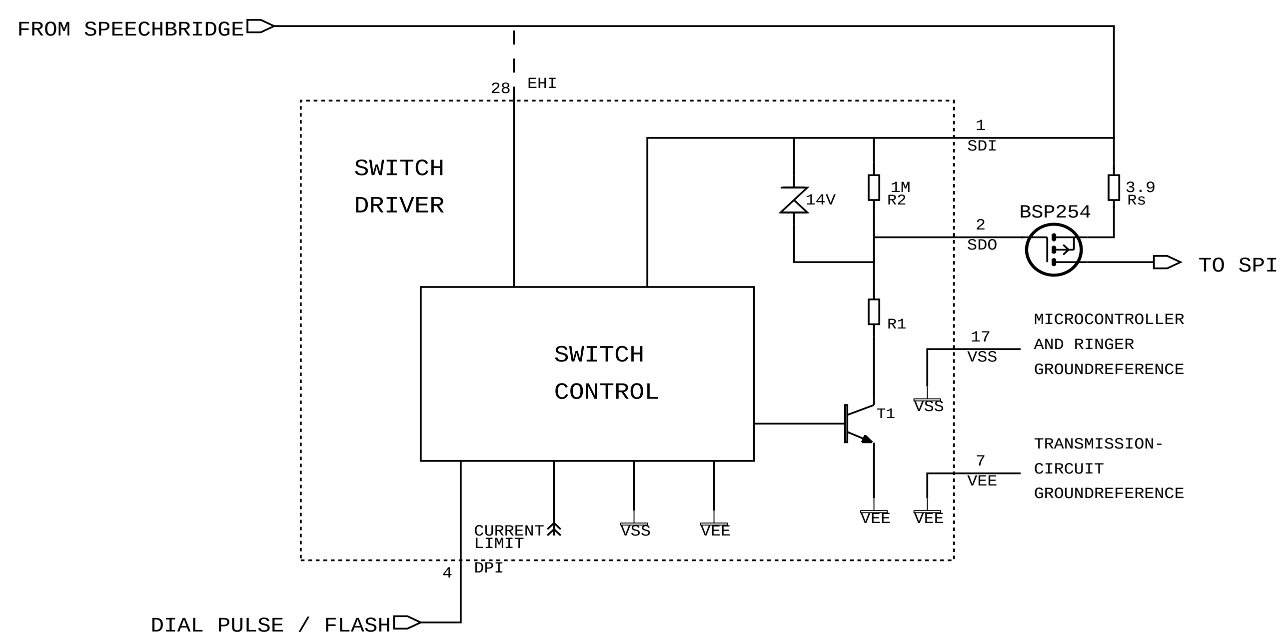


Fig.4 Switchdriver of the UBA1702

Start-up of the circuit is accomplished by applying a voltage greater than one junction voltage (about 0.6 V) to pin EHI. In the basic application with mechanical hookswitch this voltage is derived from the telephone line: EHI has to be connected to SDI. In case the interrupter switch is also used as an Electronic Hook Switch (EHS) the output of a microcontroller may be connected to pin EHI. This pin has a high voltage capability (400 V_{peak}). The same holds for SDI and SDO.

The input voltage on EHI is converted to a drive current which finally controls the external PMOST by creating a voltage drop across R2. By making DPI high the drive current is interrupted and the PMOST is switched off. The reference of DPI is VSS, which may be different from the one of the transmission circuit (shifted reference), which is VEE. This solution makes it possible to use all members of the TEA106X family:

- in case of TEA1064 peripherals (e.g. microcontroller) are supplied between VCC and SLPE. The VSS pin of the peripheral has to be connected to SLPE and the VEE pin of the UBA1702/A with the VEE pin of the TEA1064.
- in all other cases peripherals are supplied between VCC and VEE. The VSS and VEE pins of the UBA1702/A have to be interconnected.

The PMOST is switched on by the voltage across R2, which is caused by the drive current. The voltage is limited by an internal zenerdiode to 14 V. A current source, controlled by the DMO signal (see ch. 3.1.3), has been added to supply drive current during low voltage DMO operation. To put it in another way: if MSI is high (= VDD) it is not possible to create a linebreak by making EHI low, this is only accomplished by making DPI high (= VDD).

The active state of the DPI input has been chosen in such a way that it has the same parity as the power down input of the transmission circuit, viz low is make and high (> VSS + 1.5 V) is break (corresponds with power down). In case very fast transients may occur (e.g. lightning) a series resistor Rs (value 3.9 Ω) in the source connection of the PMOST is recommended.

Performance

The performance of the switchdriver / PMOST combination depends mainly on the characteristics of the PMOST: the outputvoltage on pin SDO (reference VEE, DPI low, voltage on SDI < 12 V) is lower than 0.2 V. Consequently almost the entire voltage across the transmission circuit is available to minimize the ON-resistance of the PMOST and maximize the output swing of the transmission circuit. Delay and switching times are determined by the value of the drive current, R2 and capacitances and voltages across the PMOST. The drive current is about

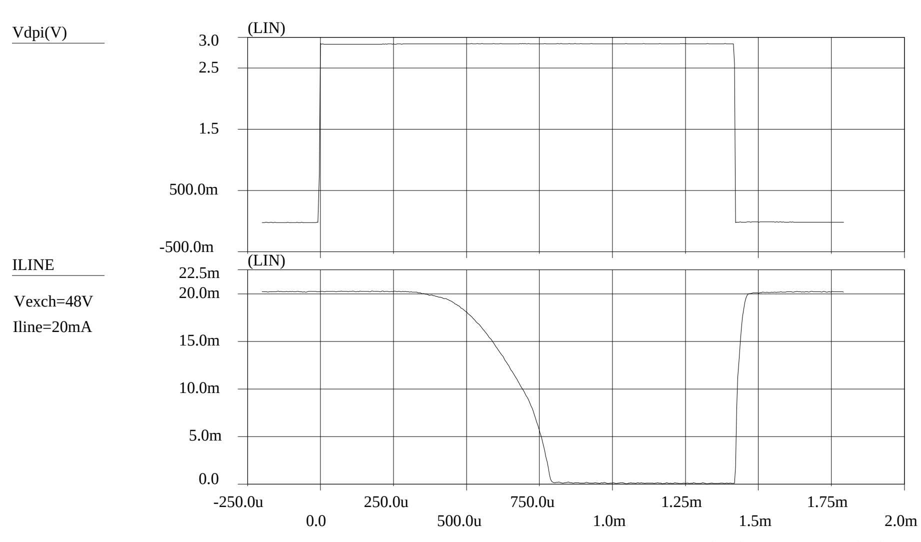


Fig.5 Typical switching times of UBA1702 combined with BSP254

20-30 µA (if voltage on EHI > 1.5 V). If a BSP254 PMOST is used the typical turn-off delay time is 700 µs, the switching-off time 250 µs, the turn-on delay time 50 µs and the switching-on time 25 µs, see figure 5. For testcircuit the basic application (see figure C1 in the appendix) has been used.
It may be clear that if EHI is low, no drive current is generated by T1 and no current is drawn from SDI. This is important for EHS application while SDI is permanently connected to the line. Therefore during 'on hook', while the set is in quiescent condition, an insulation resistance of greater than 5 MΩ can be guaranteed. Insulation resistance is not always equal to break resistance. Break resistance is the loop resistance during the break period of pulse dialling:

- in basic application (interconnection between EHI and SDI) this resistance is solely determined by the input resistance of pin EHI and greater than 100 kΩ. If the voltage at EHI exceeds a certain value (typical 35 V) the current through this pin remains constant and therefore the resistance increases.
- in EHS application (EHI driven from external source) the break resistance is equal to the insulation resistance (> 5 MΩ).

The difference between break and insulation resistance is elucidated by means of figure 6. The given resistance values are for indication only.

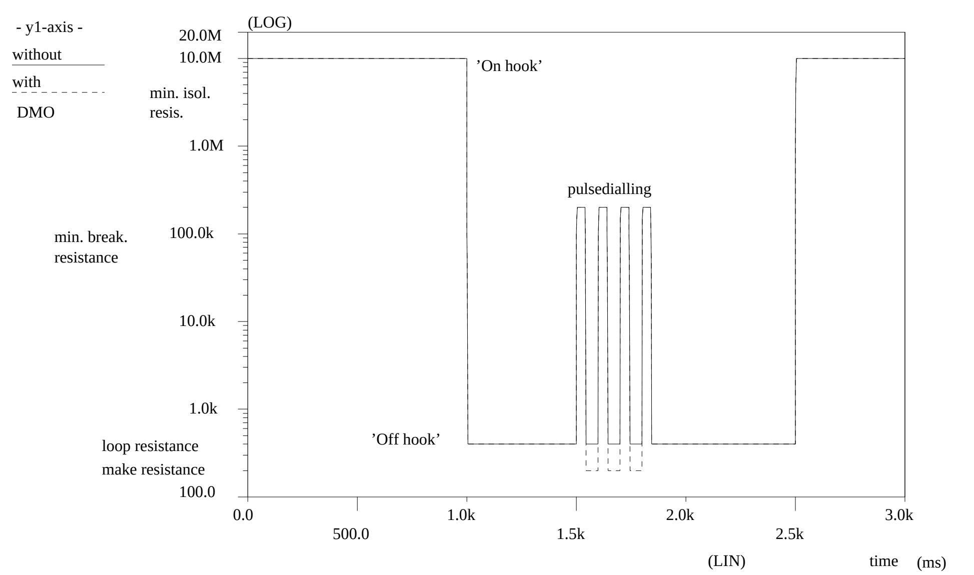


Fig.6 Loopresistance as function of operation mode (basic set)

3.1.2 Switchdriver of the UBA1702A

Principle of operation

A bipolar interrupter switch requires a considerable base drive current, consequently T1 in figure 4 is replaced by a darlington resistor combination with T1 and T2. Remaining circuitry has not been altered, see figure 7.

Due to the small voltage difference between SDI and SDO (one junction voltage) a series resistance (R1) is necessary to limit the basecurrent. Its value (2 kΩ) is a compromise:

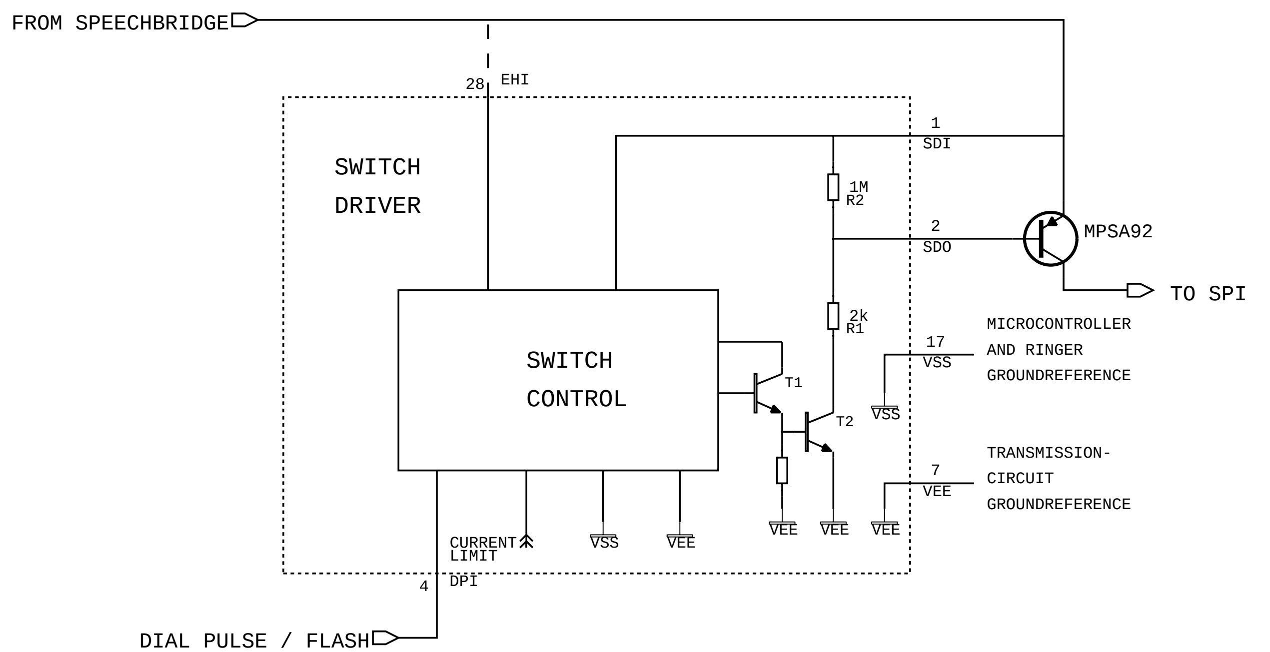


Fig.7 Switchdriver of the UBA1702A

- a low value is necessary for sufficient base current to keep the bipolar transistor saturated at high line currents. In case of non-saturation the impedance and set voltage would increase considerably.
- this resistance is connected in parallel with the set and to not deteriorate the set characteristics too much a high value is necessary.

It may be clear that the H_{FE} in saturation in the required line current range is an important parameter of the external PNP interrupter, it may be necessary to select for this parameter.

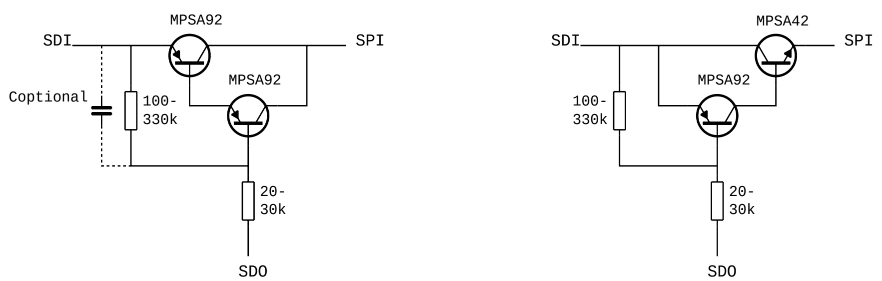


Fig.8 Various two transistor combinations to replace single PNP

An alternative is to add a transistor to make a PNP / PNP or PNP / NPN combination, see figure 8. Disadvantages of a two transistor solution are:

- increased number of required components (four instead of one)
- increased voltage drop across the interrupter switch (one junction voltage extra).

Advantages are:

- the possibility to increase the series resistance and hence the parallel set resistance by adding a resistor of a few times 10 kΩ
- the interrupter transistor remains saturated even at high line currents.

In case very fast voltage transients may occur (e.g. lightning) it is recommended to connect a capacitor Coptional in parallel with the be-resistor in the first configuration. This is not required for the second configuration.

Performance

Performance of driver / PNP combination is to a large extent dependent on the characteristics of the PNP. Because of the fact that this bipolar transistor is current driven instead of voltage driven like a PMOST, delay times (turn-on: 5 µs, turn-off: 80 µs) are shorter and switching (on: 5 µs, off: 70 µs) is faster, see figure 9. For testcircuit the basic application given in figure C2 has been used.

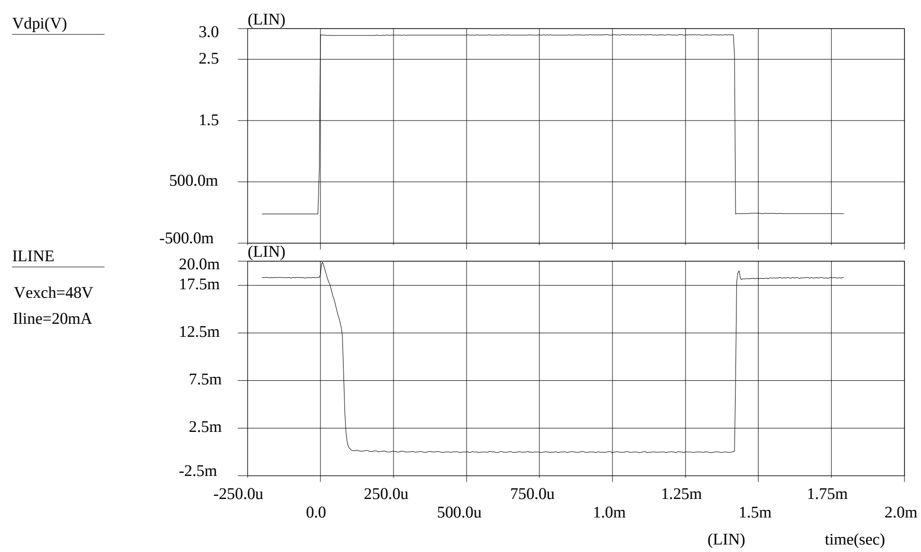


Fig.9 Typical switching times of UBA1702A in combination with MPSA92

Insulation and break resistance are equal to UBA1702.

3.1.3 Line current management circuit

Principle of operation

The blockdiagram is depicted in figure 10.

The line current is flowing through SPI, the sense resistor R1 (typical value 2 Ω) and SPO. The voltage drop across the resistor is converted to a small sense current which is used for two purposes:

- current detection (minimum level). For this purpose the sense current is reconverted to a voltage by R2 and compared to a reference voltage. A voltage across R2 greater than the reference results in the logic output CDO high (= VDD).
- current limitation (maximum level). Operation is comparable to the way line current is detected. The output of the comparator however is not used for driving a pin, but it directly controls the switch driver.

Reference voltages are generated by an internal bandgap voltage source.

Current detection is intended for use by microcontrollers to give information about hookswitch- and line status.

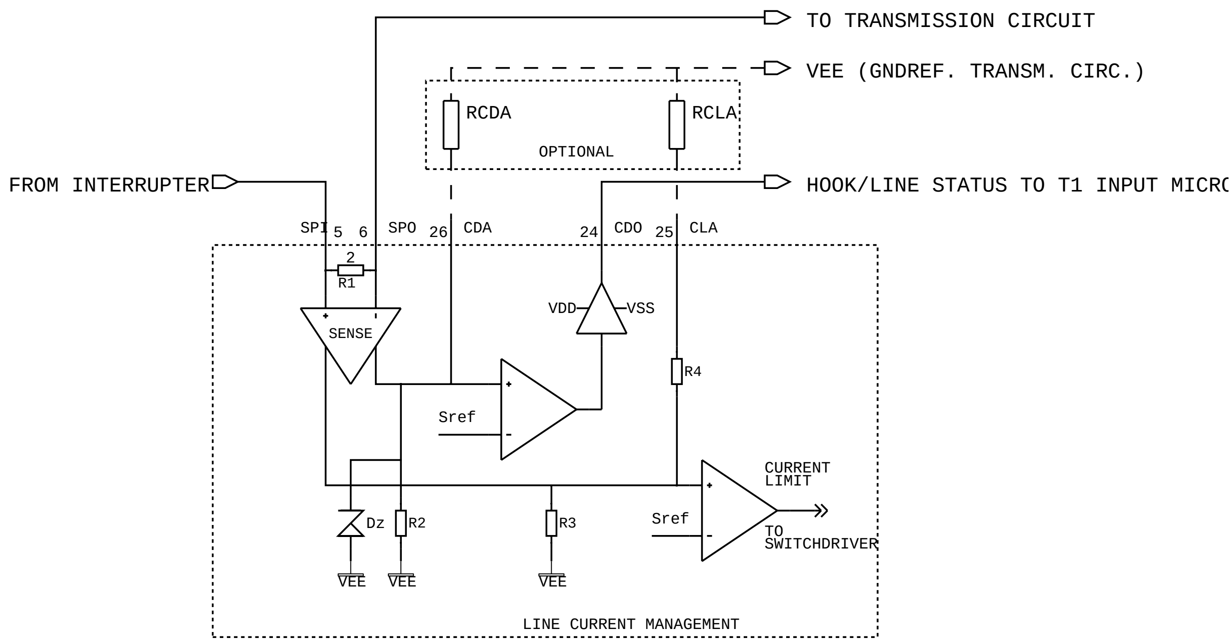


Fig.10 Linecurrent management circuit

Therefore CDO has to be connected with the ’test 1’ (T1, CSI, hook) input of the microcontroller. In case of a line current interruption the microcontroller can force the transmission circuit into a powerdown condition during which the charge on the supply capacitors is maintained. A large AC line voltage swing can also cause the detection threshold to be passed. To avoid an unwanted powerdown two measures can be taken:

- apply a sufficiently large time window in software. This is usually the case.
- introduce delay by connecting a capacitor to pin CDA

Both measures have influence on the current detection response time.

Adjustments and performance

The current detection threshold and the current limit level can be adjusted by connecting resistors to respective pins CDA and CLA. The voltages at CDA and CLA are proportional to the line current. However, the voltage at CDA is limited by Dz, which represents an internal zener diode. The influence of R_{CDA} (the resistance between pin CDA and VEE) is given in figure 11.

The graph for the current limiting action is given in figure 12. R_{CLA} is the resistance between pin CLA and VEE.

Note that the maximum current is fixed at approx. 120 mA. This is achieved by resistor R4 in series with pin CLA.

Stability of the currentlimiter for low line currents (approx. 45 mA) can be improved by connecting a capacitor of 10 nF between pin SPO and VEE. However in most cases this capacitor is already present for EMC purposes.

If necessary it is possible to decrease the minimum level for current detection (3 mA) and current limiting (45 mA) even further by connecting the respective pins instead of VEE to a constant voltage by means of an appropriate resistor.

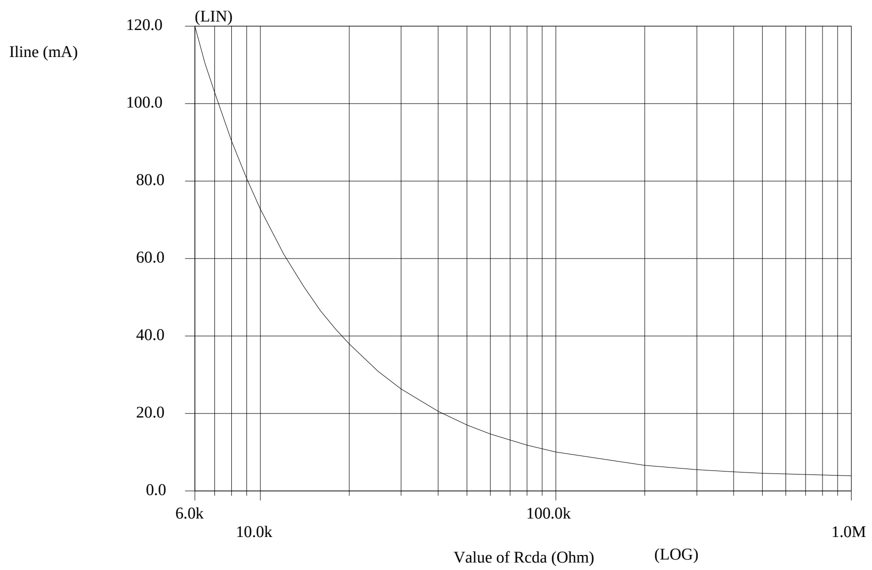


Fig.11 Current detection threshold as function of R_{CDA}

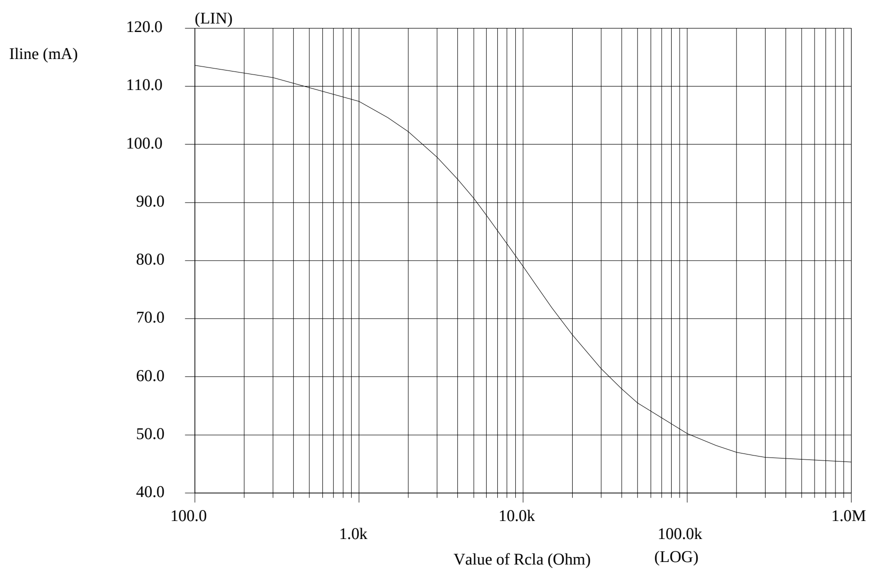


Fig.12 Current limiting level as function of R_{CLA}

3.1.4 The mute switch / zener protection circuit

Principle of operation

The blockdiagram is given in figure 13.

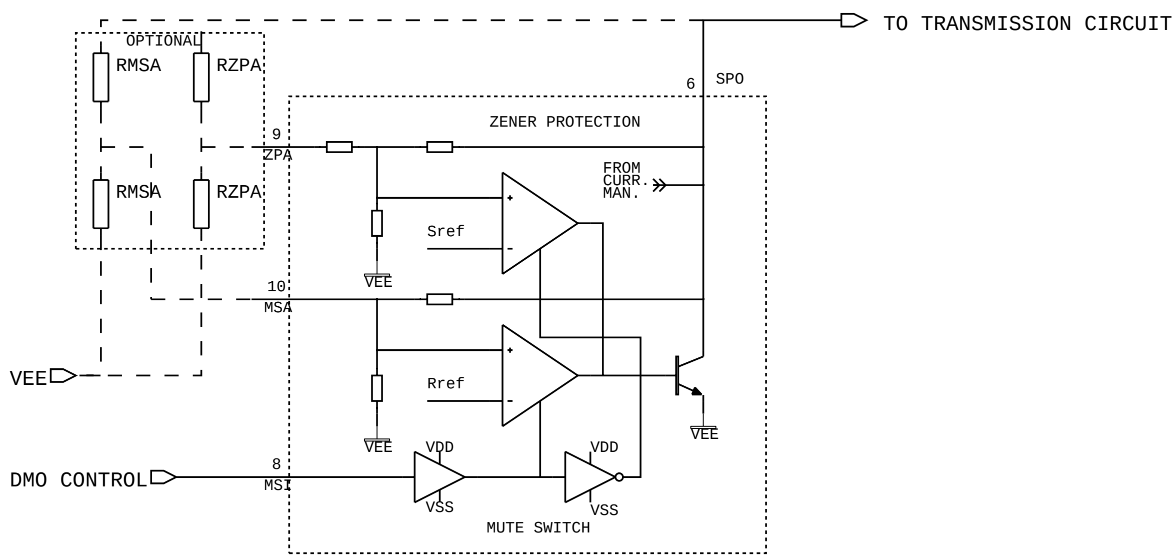


Fig.13 Mute switch and zener protection

This part of the UBA1702/A controls the maximum voltage on pin SPO. Dependent on the level on pin MSI two different modes exist, these two modes are mutual exclusive:

- DMO-mode (MSI = high). This mode guarantees a decreased loop resistance of the set during the make period of pulse dialling. Therefore a logic control signal is generated by the microcontroller, which is applied to pin MSI. A buffer has been added to convert the logic levels to appropriate values. In case of a high MSI input level the voltage on SPO is compared with a reference and dependent on the difference more or less current flows through the shunt transistor. The DMO voltage can be adjusted by connecting a resistor between pins MSA and SPO. A provision has been made for proper operation of the switch driver even if the voltage at SDI drops to a low value due to low voltage DMO operation.

Remarks:

* to achieve low DMO voltages (< 2.5 V, R_{MSA} between MSA and SPO) it is required that VDD and therefore VBB does not drop below a certain minimum value (about 2 - 2.5 V).
* the differential resistance of the shunt at low DMO voltage (1.6 V) has increased from < 0.5 Ω to 5 - 6 Ω.
* the control voltage on pin MSI may not exceed VDD.
* it is recommended not to increase the DMO voltage to values greater than 4 V.

- protection mode (MSI = low). This is the default operation mode which is intended to protect the transmission-circuit against overvoltage. Its operation principle is similar to the DMO mode, with this exception that a different voltagedivider and comparator has been used. For the zener voltage can be chosen between three values: by connecting pin ZPA to pin SPO, pin ZPA to pin VEE or by leaving pin ZPA open. Intermediate values can be realized by replacing the shorts by a resistor.

Adjustments and performance

The influence of a resistor R_{MSA} between pins MSA and SPO / VEE is depicted in figure 14 and 15 and of R_{ZPA} between pins ZPA and SPO / VEE in figure 16 and 17.

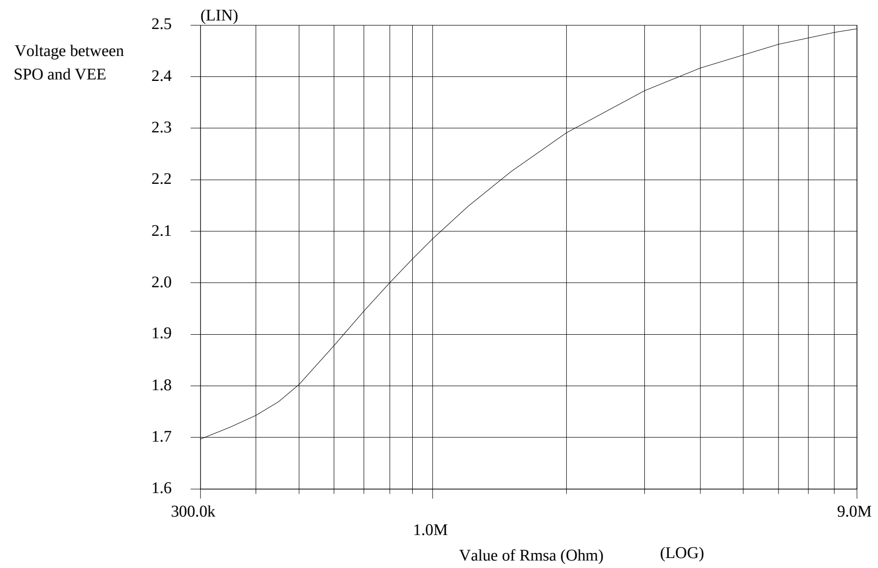


Fig.14 DMO voltage as function of R_{MSA} (connection to SPO)

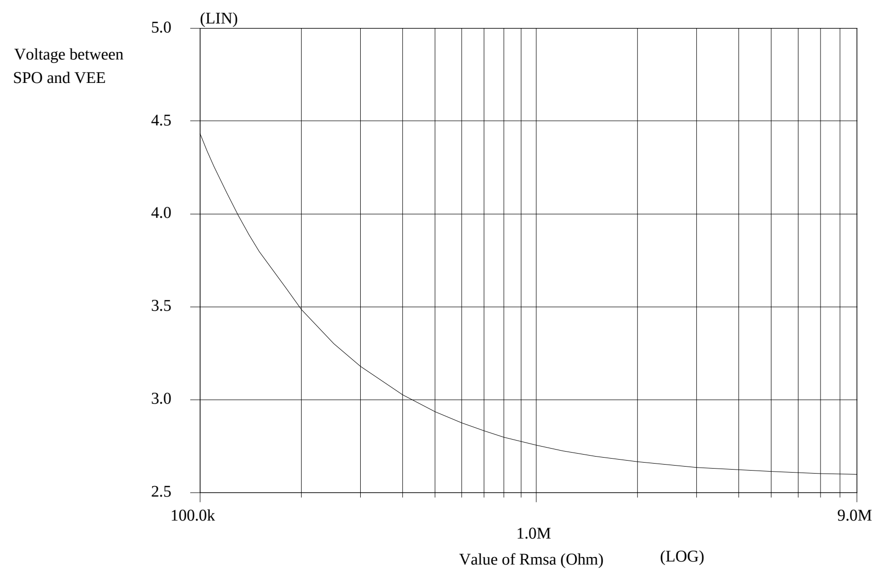


Fig.15 DMO voltage as function of R_{MSA} (connection to VEE)

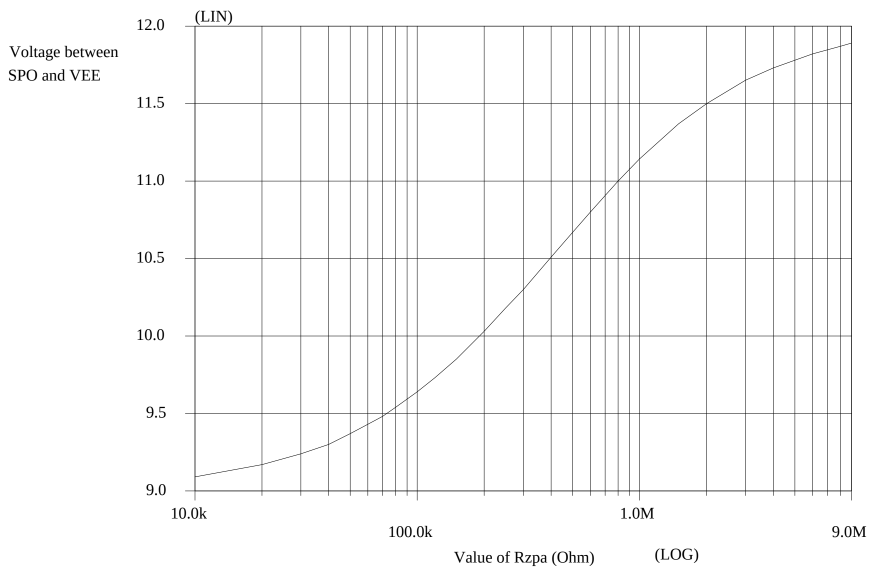


Fig.16 Zenerprotection voltage as function of R_{ZPA} (connection to SPO)

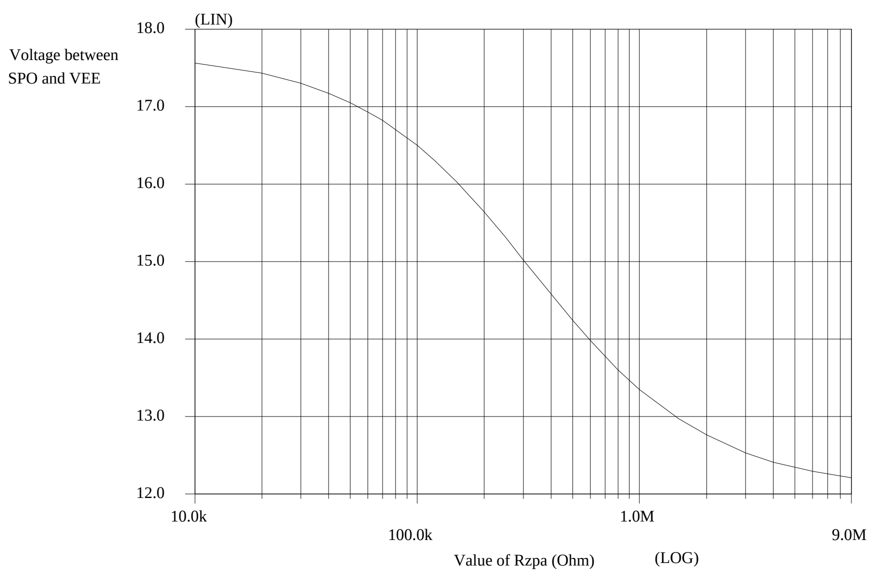


Fig.17 Zenerprotection voltage as function of R_{ZPA} (connection to VEE)

Note that the minimum and maximum zener protection voltages (respectively 9 and 18 V) have finite values. This is accomplished by the resistor in series with pin ZPA. In this way the minimum and maximum voltage settings do not require external components and have a reasonable accuracy. This accuracy can not be achieved with external resistors because they do not match with on chip resistors .

3.2 Ringer part

The ringer part consists of the protection circuit (ch. 3.2.1), the frequency detection (ch. 3.2.2), the threshold comparator (ch. 3.2.3), the volume control (ch. 3.2.4) and the melody input / piezo driver (ch. 3.2.5).

3.2.1 Protection circuit

Principle of operation

The voltage between pins RPI and VEE is limited to a fixed level (typ. 20.4 V) by a comparator / shunttransistor combination which represents an electronic zener diode, see figure 18.

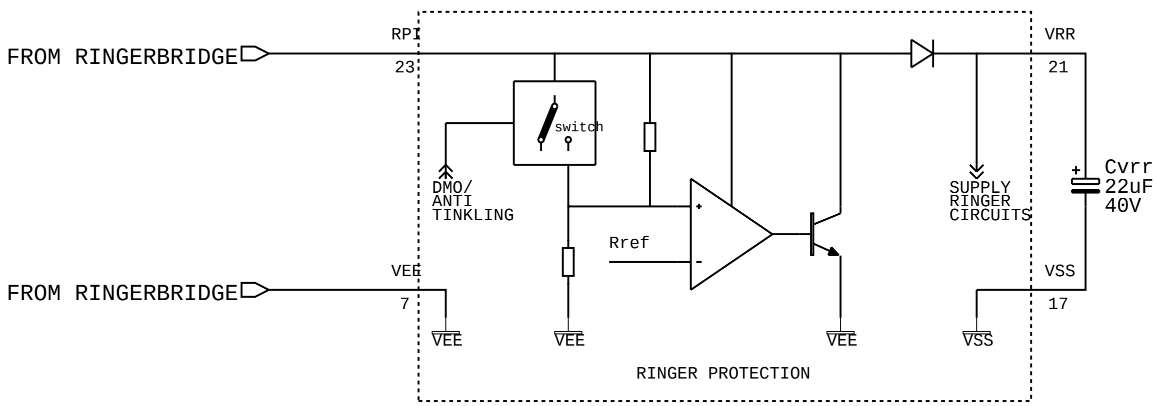


Fig.18 Ringer protection and limiting circuit

This input circuit has to be preceded by a ringer bridge, consisting of a series RC-combination and four diodes to rectify the AC-ringer signal. The capacitor blocks the DC current and determines in combination with the series resistor the input impedance for voltages higher than the limiting voltage. The RC network has also a current limiting function.

A provision has been built in to avoid ringers connected in parallel with the ringer bridge and which share the same RC-network from making noise during pulse dialling, the so called anti-tinkling function. Condition is that during dialling a high level (= VDD) is applied to pin MSI. This signal causes a switch across the voltage divider to close and in this way the input voltage across RPI and VEE is limited to a value insufficient for ringers to make any noise (typ. 2 V + voltage drop ringer bridge). In case the anti-tinkling function is wanted but the DMO function not, the latter can be made inoperative by connecting an appropriate resistor between pin MSA and VEE with such a value that the voltage in zenerprotection mode and DMO mode are equal, see figure 15. This is necessary because the speech zenerprotection is inoperative during MSI = high.
The internal diode between pins RPI and VRR has two functions:

- the voltage at RPI must return to zero to make frequency detection possible
- this diode only conducts if the input voltage is above a certain level. In this way a high series input impedance for speech signals is created, which is required for EHS application.

Performance

The voltage divider which determines the limiting voltage is not external accessible and this voltage is therefore not adjustable.
The ringer supply voltage is smoothed by buffercapacitor C_{VRR}. The recommended value for this capacitor is 22 µF. A larger value will result in a longer ringer start-up time, while a smaller value will cause increased ripple amplitude, especially at low ringersignal frequencies.

3.2.2 Frequency detector

Principle of operation

This block consists of a comparator with hysteresis and an output buffer for level shifting, see figure 19.

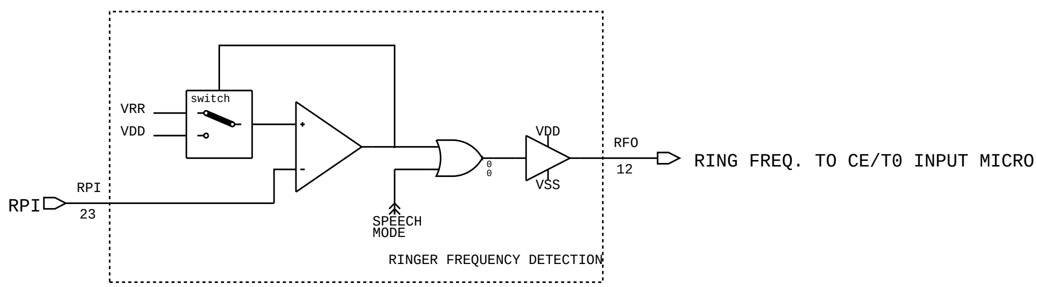


Fig.19 Frequency detector.

The non-inverting input of the comparator is connected to VDD or VRR, dependent on the most recently passed threshold, see figure 20.

The full wave rectified AC ringer signal is applied to pin RPI. This signal must cross a high threshold level before RFO is high and the output on RFO only returns to a low output level if a low threshold level is crossed. The selection of these threshold levels is rather arbitrary under restriction of the following conditions:

- the levels must lay within the amplitude range of V_{RPI}
- the voltage difference between the levels have to be as large as possible.

For the high level VRR and for the low level VDD have been chosen. These voltages satisfy the conditions and are already available.
Advantage of the applied hysteresis is the insensitivity to superimposed signals, this insensitivity is required for some countries.
RFO is a logical output (levels VSS and VDD) intended for processing by a microcontroller. Therefore this pin must be connected to the ’chip enable / not test zero’ (CE/notT0, FDI, RF) input of the microcontroller. Note: because the AC ringer signal is full wave rectified the frequency of the RFO signal is twice the frequency of the original ringer signal!
In speech mode the CE/notT0 input has to be high. Hence the speechmode infosignal is combined with the ringer signal by an OR-gate.

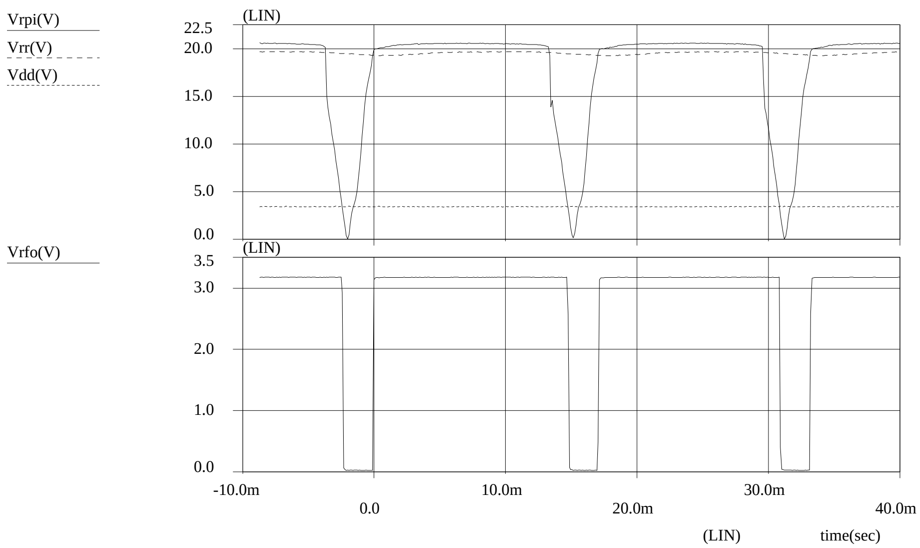


Fig.20 Switching thresholds frequency detector

Performance

In the previous paragraph it is pointed out that the threshold levels (VRR and VDD) for the ring frequency detector are fixed.

The insensitivity to superimposed signals of the circuit is made visible in figure 21. A 6 V_{RMS}, 1 kHz sinewave is

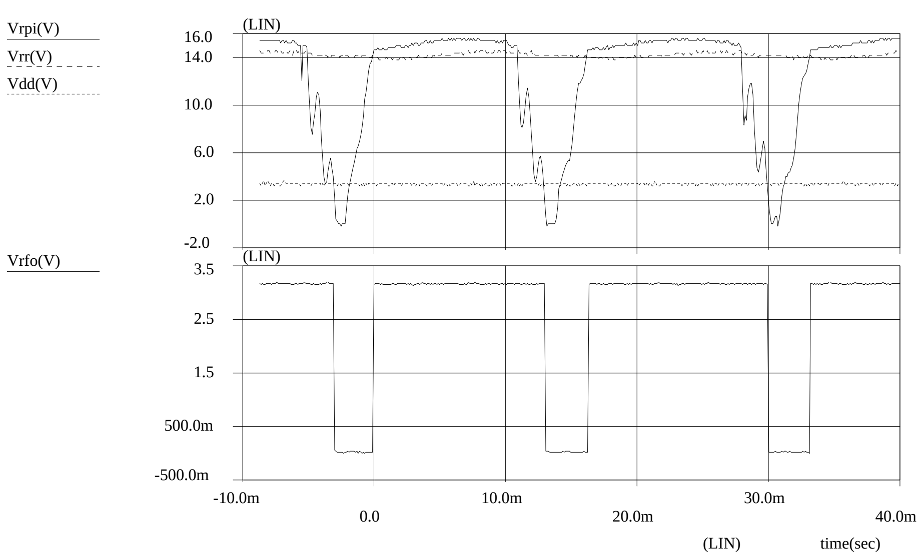


Fig.21 Response of frequency detection circuit to superimposed signals

superimposed to a 45 V_{RMS}, 20 Hz ringer signal. Despite various single threshold crossings within one period of the inputsignal the interference of the superimposed signal can not found back in the outputsignal available at pin RFO.

Care must be taken in case EMC capacitors are connected between the lineterminals and ground (VEE). During the zero crossings of the AC ringer signal these capacitors are not discharged completely which can result in not crossing the lower threshold and hence not generating a 2F ringer frequency signal. This can be solved by connecting a high ohmic resistor (in the order of hundred kilo Ohm) between RPI and VEE.

3.2.3 Threshold comparator

Principle of operation

This block checks the amplitude of the ringer signal. If this signal has the required level this block enables the input of the piezo output stage, see figure 22.

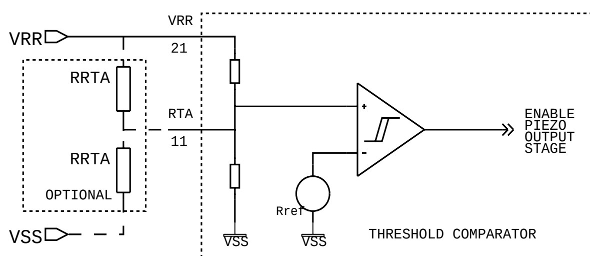


Fig.22 Threshold comparator

After applying a ringer signal to the protection circuit (ch. 3.2.1) capacitor C_{VRR} is charged. The voltage across the capacitor is divided by a resistor network and compared with a reference voltage. If VRR crosses an adjustable threshold the output of the comparator is switched to a high level.
A hysteresis has been built in to avoid faltering. In case the output stage is enabled and a melody is applied the current consumption of the circuit will increase. Consequently VRR will drop and without hysteresis the output stage would be disabled. The current consumption would decrease, VRR would rise and the cycle would repeat itself.

Adjustment and performance

The threshold level can be adjusted by connecting a resistor R_{RTA} between pins RTA and VSS (to increase the level) and between RTA and VRR (to decrease the level). In figure 23 and 24 the upper threshold level and hysteresis as function of R_{RTA} is given.
The hysteresis is not independently adjustable but correlated with the threshold level: it is about 60 % of the upper threshold level.

If pin RTA is not connected (default threshold values) the UBA1702/A is suitable for the German FTZ specification as described in 1TR2 2.4.3.1/2 (June 1990).

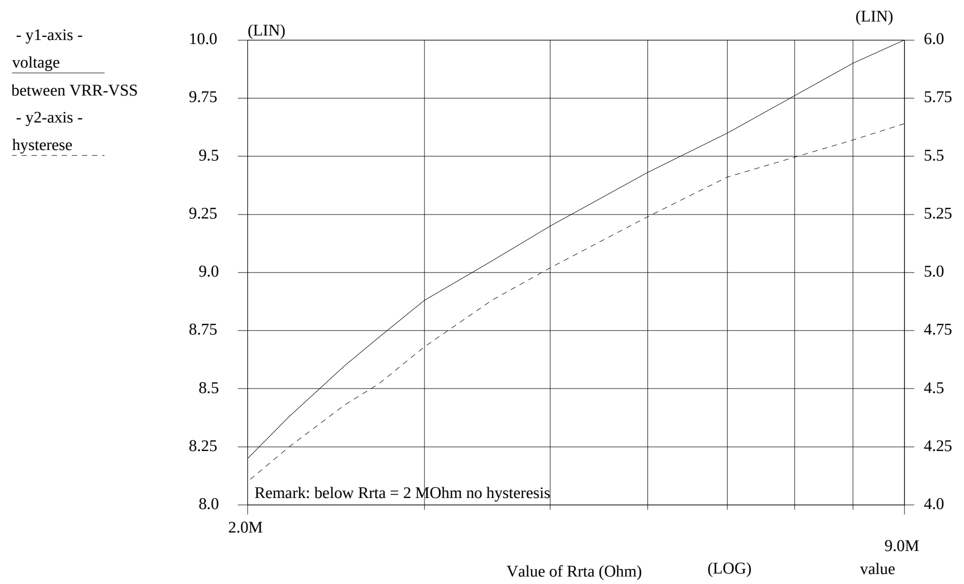


Fig.23 Upper threshold level and hysteresis as function of R_{RTA} (connection to VRR)

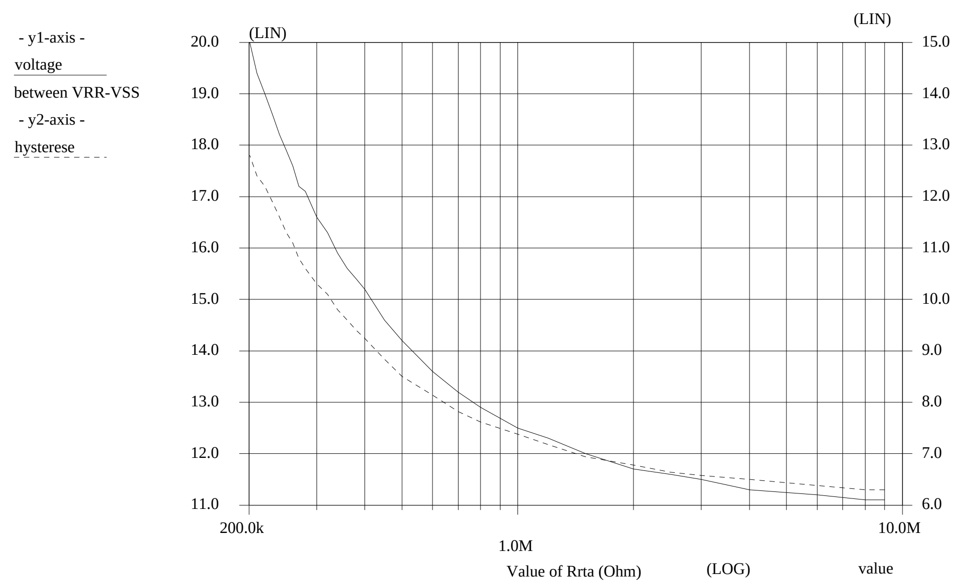


Fig.24 Upper threshold level and hysteresis as function of R_{RTA} (connection to VSS)

3.2.4 Volume control

Principle of operation

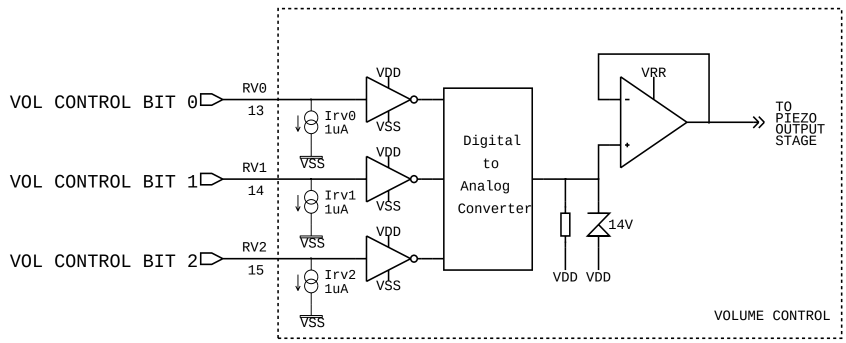


Fig.25 Volume control

Volume control is implemented rather straightforward with a D/A-converter, three inputbuffers and an output-buffer, see figure 25.
The three logic inputs RV0 (least significant bit), RV1 and RV2 (most significant bit) are provided with pull-down current sources, which sink about 1 µA. In case of floating (high Z) microcontrolleroutputs connected to RV0-2 (for instance during start-up) these sources assure a minimum volume setting. The output of the three bits D/A-converter is a controlcurrent which is converted to a voltage with reference VDD by resistor R and limited by a zenerdiode Dz. This voltage is buffered and determines the positive peaklevel of the piezo output signal. The negative peaklevel is fixed and close to VDD. Note: the voltage on pins RV0, RV1 and RV2 may not exceed VDD.

Performance

Output voltage across ROA and ROB for minimum volume setting (bits RV2-0 all low) is 150 mV_{pp}. This level is independent of ringersupply conditions. For the following six steps (RV2-0 (0,0,1) to (1,1,0)) each step doubles the output voltage (6 dB steps). The last but one **level** (RV2-0 (1,1,0)) is 2^6 = 64 times the first level and therefore 64 * 0.15 = 9.6 V_{pp}, on condition that the ringersupply voltage suffices. The last step is the largest and consequently the positive peaklevel of the piezo output signal is almost equal to the supply voltage VRR. However to protect the piezo element the output amplitude is internally limited by an internal zenerdiode to about 2 * 14 = 28 V_{pp} (unloaded).
The level of the outputsignal (available between pins ROA and ROB) as function of the volume setting is given in figure 26.

3.2.5 Melody input and piezo driver

Principle of operation

This (sub)block amplifies the ringermelody generated by the microcontroller to the desired level for the piezo. It contains an input comparator, an AND-gate, an inverter and two outputbuffers for BTL operation, see figure 27.

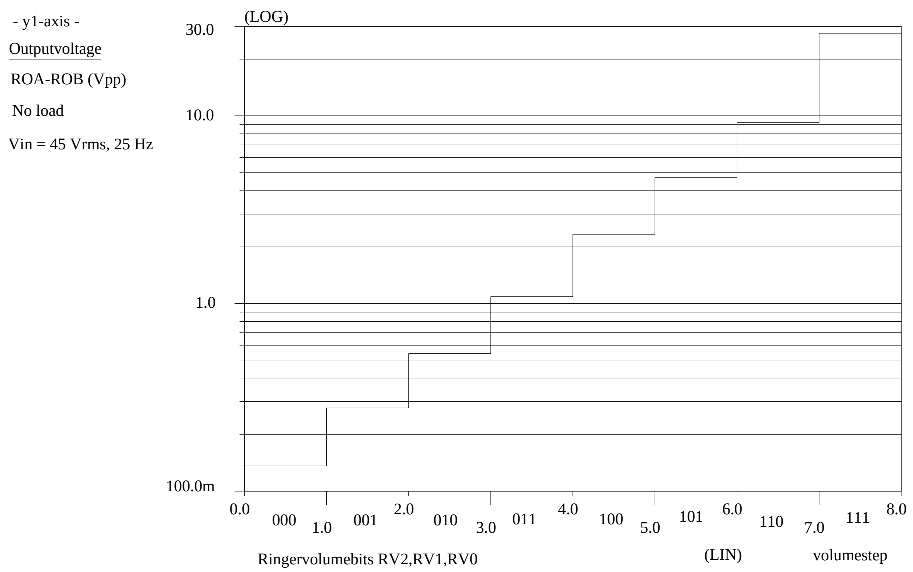


Fig.26 Output level as function of volumesetting

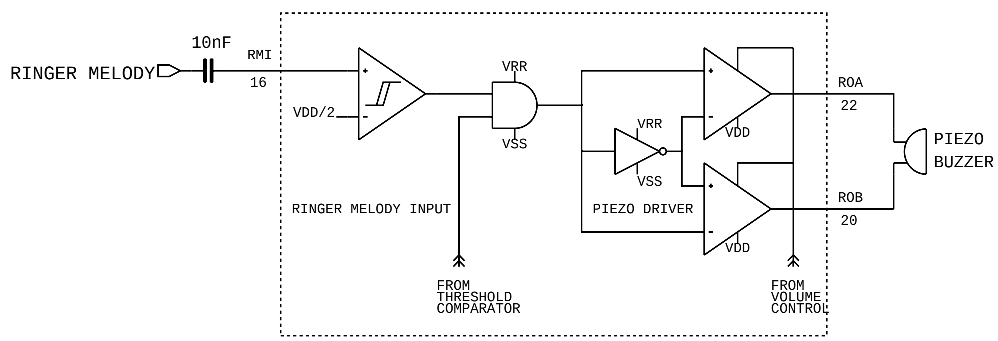


Fig.27 Melody input and piezo driver

The input comparator has a threshold at ½ VDD. It is possible to apply square wave signals (min. / max. level VSS and VDD) as well as sinewave signals superimposed on a DC level of ½ VDD. However if the DTMF output is used (sinewave signals) it is advised to use a series capacitor of 10 nF to avoid problems caused by DC shift as a result of e.g. resistor mismatch. A small hysteresis of about 20 mV has been built in for schmitt-trigger action to assure jitterfree operation. This hysteresis has no influence on the duty cycle of 50 %. Because of the high inputimpedance of the RMI input (in the order of hundred kilo Ohm) the attenuation for DTMF signals is low: less than 0.05 dB.
The square wave output of the comparator is combined in an AND-gate with the output of ring threshold comparator (ch. 3.2.3). If VRR has reached the required level the ring melody is routed to the output buffers. These buffers switch their outputs (ROA / ROB) between a DC level coming from the volume control and VDD. The resulting signal is a squarewave which is applied to the piezo. The slew rate of the outputs is rather high and

the outputsignal contains therefore a lot of higher harmonics which contribute considerably to the produced sound-pressure. Because the piezo shows equivalence with a capacitor there flows no DC current through it and therefore the output stage may operate in Single Ended Load (SEL) configuration with the piezo connected between ROA or ROB and VDD.

Performance

It is already mentioned that the piezo shows a capacitive behaviour, the outputcurrent reaches its peak value during switching.
Current capability is an important specification parameter for sound pressure: if limiting at a low current level occurs there will be less harmonics and the produced sound will be dull. The UBA1702/A can deliver more than 100 mA and piezo transducers with a capacitance up to at least 80 nF can be used.
In stead of a piezo transducer a high ohmic (> 25 Ω) loudspeaker can be used to make the ringer melody audible. A capacitor in the range 100 - 470 nF must be connected in series.

3.3 Supply part

Principle of operation

The reference block generates all the bias currents and reference voltages for the IC. All reference voltages are derived from bandgaps and converted to biascurrents by internal resistors. The supply can be split up in a series and a shunt regulator, see figure 28.

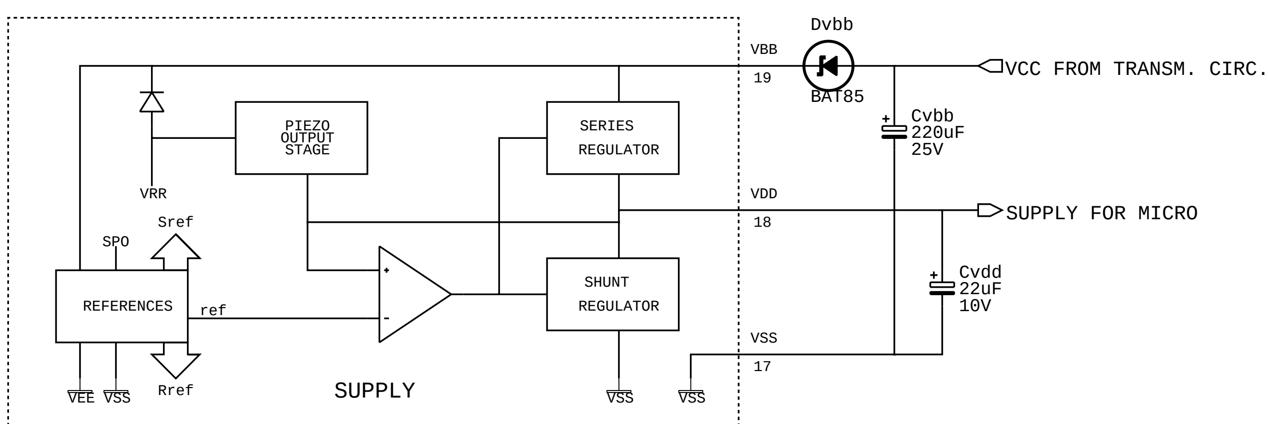


Fig.28 Supply

Operation is different for speech and ringer mode:

- speech mode. The supply is powered via pin VBB by VCC of the transmission circuit. The internal diode between VRR and VBB avoids current flowing to ringcapacitor C_{VRR} and other ringer parts. There is no current flowing through the ringer output stage, consequently all current for VDD flows through the series regulator. VDD is stabilized by comparing it with a reference voltage and by feeding the errorsignal back to the regulator.
- ringer mode. In ringer mode the supply point is VRR. To avoid current flowing through VBB to the transmission circuit an external seriesdiode has to be added. To minimize the voltage drop (important in case of low line currents) it is recommended to use a schottky type (e.g. BAT85).

Current to VDD can be delivered by the series regulator as well as the piezo outputstage which is connected in parallel. It is likely that at high output volume the output stage consumes (sources) more current than the micro-controller sinks from VDD. As a consequence VDD would increase.
To keep VDD constant a shunt regulator has been added to sink the superfluous current. This series concept (outputstage and microcontroller supply in series) has been chosen because it has advantages in case of low ringer power conditions: the ring current is used more efficiently. VDD is also used to supply some internal blocks.

Performance

The output of the supply is a fixed 3.3 V stabilized voltage. Advantage of a rather low supply voltage is a decrease of current consumption of the microcontroller. This can be attractive during line current interruptions. The output voltage VDD is smoothed by C_{VDD}. Besides a smoothing function this capacitor is also essential for stability of the supply. The recommended value is 22 µF. A larger value will result in increased start-up times in speech and ringer mode. For supplying the microcontroller during long line interruptions it is advised to choose a larger value for C_{VBB}.

In quiescent condition (supply point voltages VBB and VRR low) the internal current consumption from VDD is minimized. With this provision memory retention of the microcontroller is possible with a resistor (> 5 MΩ) connected in front of the hook switch to the line (trickle current), see figure C2.
Because of the rather low current consumption of microcontrollers the source capability of the supply is accordingly low: max. 2 mA. The currentsink capability (necessary in ringer mode at high volume settings) is much higher. The voltage drop between VBB and VDD at low values for VBB is minimized (100 mV @ IDD = 1 mA) to make operation with low line currents possible. The output voltage VDD as function of IDD for two values of VBB is given in figure 29. IDD is positive in case pin VDD sources current and negative if current is sinked.

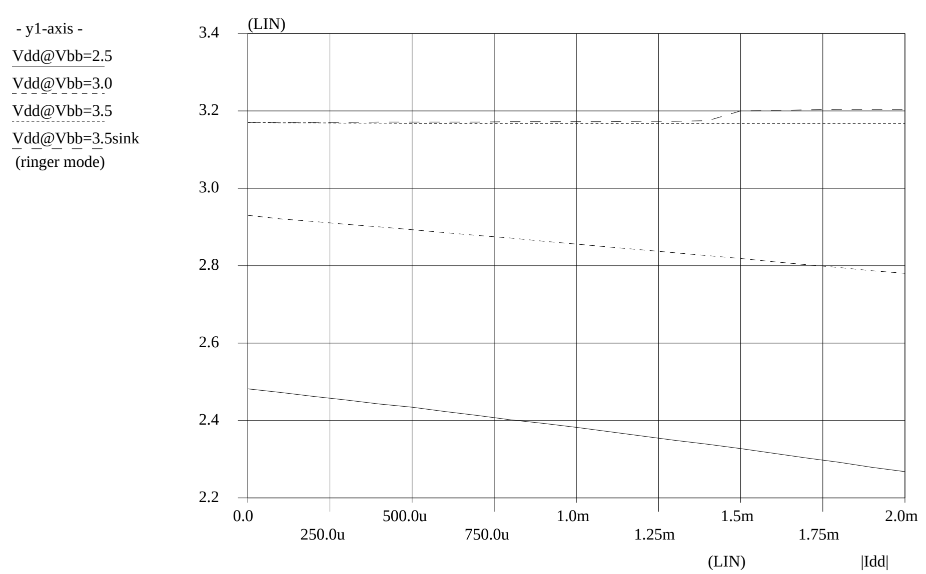


Fig.29 VDD as function of +/- IDD

4. DESCRIPTION OF THE COMPLETE SYSTEM FEATURING THE UBA1702/A

Apart from the UBA1702/A a transmission circuit and a microcontroller (dialler / ringer) are required to form a (basic) telephone set. Typical set parameters are not solely dependent on the individual circuit characteristics but also on their interaction. This interaction will be described in this chapter with the help of a typical application diagram which is given in the appendix, see figure C1.
Two different modes can be distinguished: the 'off hook' situation (ch. 4.1) and the 'on hook' situation (ch. 4.2).

4.1 'Off hook' situation

In this mode a conversation mode (ch. 4.1.1) and pulse dial / flash operation (ch. 4.1.2) can be distinguished.

4.1.1 Conversation mode

Principle of operation (See also appendix figure C1)

Start-up is accomplished by putting the hookswitch S1 in an upwards position. The ringer series RC-network is shortcircuited. The current through the switch and C_{rng} is limited by R_{rng}. A DC line current starts flowing and after the voltage on EHI has crossed the threshold value interrupter T1 starts conducting under condition that DPI is low. As soon as the line current is larger than 3 mA (default) the microcontroller receives a chip enable (CE). Because of the electronic coil function of the transmission circuit it takes some time before the line current has reached its endvalue. In the meantime the voltage across the transmission circuit (and the set) is limited by the electronic zener of the UBA1702/A through which most of the line current is flowing. C1 is charged by R1, the transmission circuit is supplied via VCC, starts operating and takes over the current from the zener.
Dependent on the used transmission circuit there are two ways to feed the supply point VBB of the UBA1702/A:

- ground reference is VEE. This is the case for all transmissioncircuits except the TEA1064A. VSS and VEE of the UBA1702/A are interconnected and VBB to the supplypoint of the transmission circuit VCC. A series diode is necessary to separate the ringersupply from the speech part. Because of the rather large series resistance the supply current capability is small, but sufficient for the UBA1702/A in combination with a microcontroller.
- ground reference is SLPE. This structure is possible if the transmissioncircuit has a powerdown / mute input which is referenced to SLPE: TEA1064A or TEA1064B. VSS of the UBA1702/A is connected to SLPE and VEE with VEE. In this case the supply point is not VCC but directly the line with a (small) series resistor. Due to the reference of this supply point (SLPE), this resistor has no influence on the set impedance, see [Ref. 5]. This results in a better supply capability. To bridge large supply interruptions the value of C_{VBB} can be increased. This has almost no influence on the start-up time of the transmission circuit.

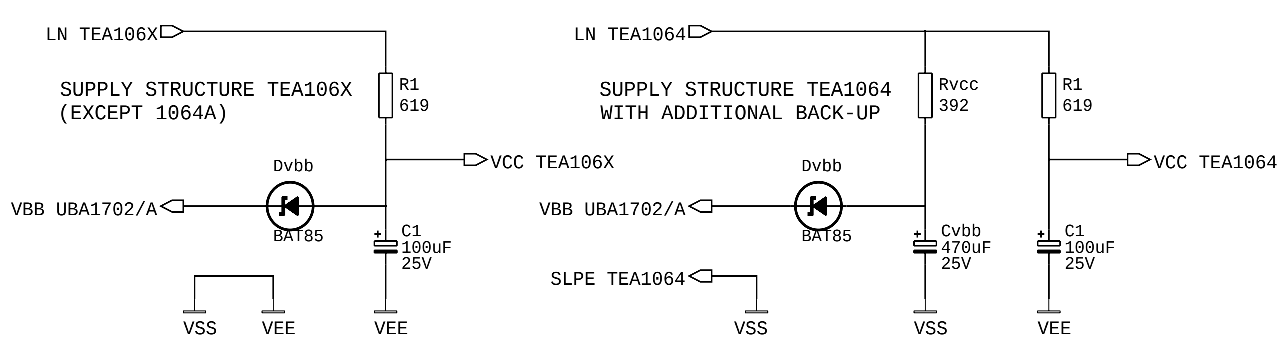


Fig.30 Supply structures for combination with TEA106X

After supplying the UBA1702/A via VBB, C_{VDD} is charged, VDD rises and when the reset reference voltage of the microcontroller has been reached start-up is accomplished under condition the CE/notT0 input is high.

This CE/notT0 (FDI,RF) input of the microcontroller has two functions:

- as chip enable input it is used to initialize the system and in combination with the test1 input of the micro-controller it determines the operation mode (speech, ringer or stand by).
- as ringer frequency discriminator input the time between two low-to-high transients (reciprocal to the ringer-frequency) of RFO is measured, see table.

TABLE 1 Operation modes of microcontroller

	CE/notT0 = 0	CE/notT0 = sq. wave	CE/notT0 = 1
T1 = 0	standby	ringer	standby *)
T1 = 1	X	X	speech

*) if T1 = 0 longer than reset delay time

Performance

In conversation mode the UBA1702/A and its peripheral components has a slight influence on the set characteristics. This influence is caused by the (small) current consumption and (large) parallel impedance of the UBA1702/A. However, in case the UBA1702A with a single bipolar interrupter is applied the parallel resistance is considerably low, see also ch. 3.1.2. The influenced set characteristics are:

Balance Return Loss. The BRL is a figure that gives the accuracy a set impedance approximates the nominal impedance required by the local PTT. Because of the high parallel impedance (> 20 kΩ) of the UBA1702 the deterioration of the BRL is almost negligible with respect to the situation without UBA1702. For the UBA1702A the effect is considerable because of the low baseresistor value. To a certain extent the effect can be compensated by increasing the value of R1, although the supply capability (voltage drop) is deteriorated. The same holds for the transmit / receive gain.

Sidetone Suppression. A certain amount of attenuation (suppression) of transmitted signal to the earpiece is required. The parallel impedance of the UBA1702 has only a minor effect on the anti sidetone network. In case of the UBA1702A the sidetone suppression will be worse.

Maximum Sending Level. Sending level can be limited by voltage or by current. Maximum voltage swing is determined by the voltage difference between LN and SLPE of the transmission circuit. The UBA1702A has no influence on this parameter, in case of the UBA1702 the minimum peak may be limited by the threshold voltage V_{th} of the applied PMOST (for BSP254 V_{th} can vary between 0.8 and 2.8 V). A capacitor between source and gate can give improvement (bootstrapping), though switching times are getting worse.
Limitation by current occurs if there is not enough current available to be modulated by the outputstage of the transmissioncircuit. Because of the low current consumption the influence is negligible.

Automatic Gain Control. A provision can be present to compensate transmit / receive gain for long line lengths. This gain control is determined by the line current flowing through the transmission circuit. Current consumption of the UBA1702/A (UBA1702: typ. 350 µA, UBA1702A: typ. 500 µA PNP interrupter base current excluded) reduces this current, which results in a very small gain increase in the relevant range. If really necessary this gain increase can be compensated by decreasing the value of R6.

Low Voltage / Parallel Set Operation. In case of bad supply conditions e.g. operation with long lines or with a classical set (impedance about 200 Ω) connected in parallel the available supplyvoltage may be insufficient for proper operation of transmission circuit and microcontroller. The influence of the UBA1702/A is small, see figure 31.

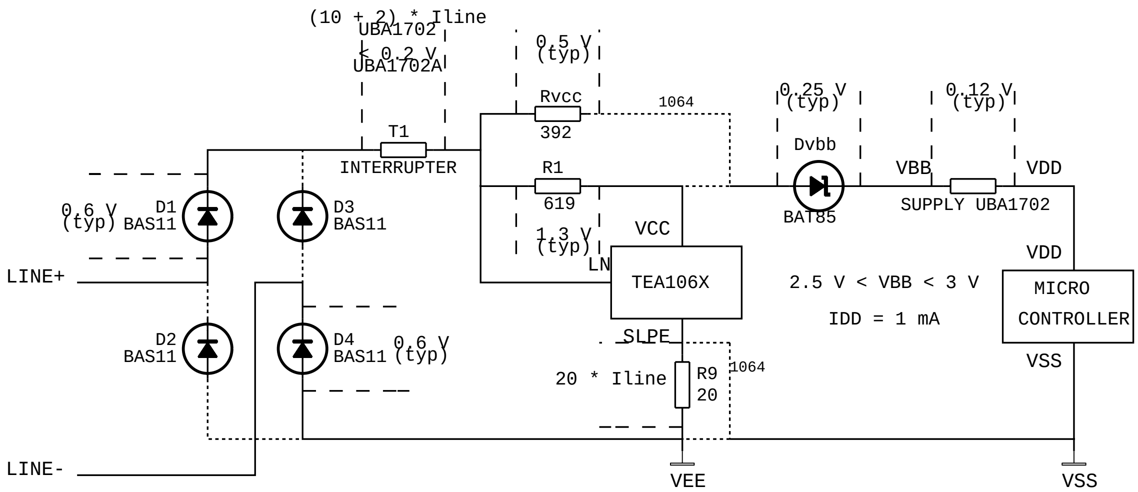


Fig.31 Supply voltage drop

4.1.2 Pulse dial / flash operation

Principle of operation

The dial- and flash pulses are generated by the microcontroller under control of the keyboard. Interrupting the line current has consequences for the supply and several measures may be taken to guarantee a non-interrupted supply of the microcontroller. The kind of measure depends on the type of transmission circuit used.

Circuits without power down function (e.g. TEA1062/A). During the breakperiod of pulse dialling and eventually flash operation there is still flowing current because of the electronic coil function. C3 (C_{reg}) and C1 are discharged and VCC drops to unacceptable level to supply VBB and consequently the microcontroller. Increasing the value of C1 is not recommendable because the discharge current requires unrealistic capacitance values. Workable alternatives are the following two solutions:
Solution 1 requires an additional series low drop diode (Schottky e.g. BAT85) and capacitor connected between the diodes and VEE. Disadvantage is the additional voltage drop caused by the diode.
Solution 2 comprises only an increase of the value of C_{VDD}. Disadvantage is an increase in microcontroller start-up time.

Circuits with power down and VEE as logic reference (most of the circuits of the TEA106X family). Because of the power down function the current consumption is reduced almost a factor 20 and increasing the value of C1 could be an alternative to increase of C_{VDD}.
Note that the power down function can be used for external generated interrupts (e.g. due to switching of a connected PABX) as well. The CDO output of the UBA1702/A controls the power down mode of transmission circuit and microcontroller. Restriction is that the power down control and the pulse dial / flash output can not be combined.

Circuits with power down and SLPE as logic reference (e.g. TEA1064A and TEA1064B). C_{VBB} (see fig. 30) can be chosen in accordance with the required interruption time.

Performance

The pulse dialling waveform is mainly determined by the transmission circuit if DMO is not used. In case C3 (C_{reg}) is discharged during the break period of pulse dialling due to a missing power down mode or because of a resistor R17 between REG and SLPE, it takes some time before C3 is charged again and the line current / voltage across the set has reached its steady state. Considerable pulse distortion occurs. In stead of using R17 to increase the voltage between LN and SLPE silicon diodes in series with pin LN may be used, however in practice the exchange feeding bridge may be highly inductive and in this case the inductors determine the current waveform.
If DMO is used the set voltage during the pulsing period is determined by the UBA1702/A and not by the transmission circuit. Pulse distortion occurs not until the transmission circuit has taken over the line current after the DMO input (MSI) has become low, hence in the post-pulsing period. Dialling waveforms are depicted in figure 32.

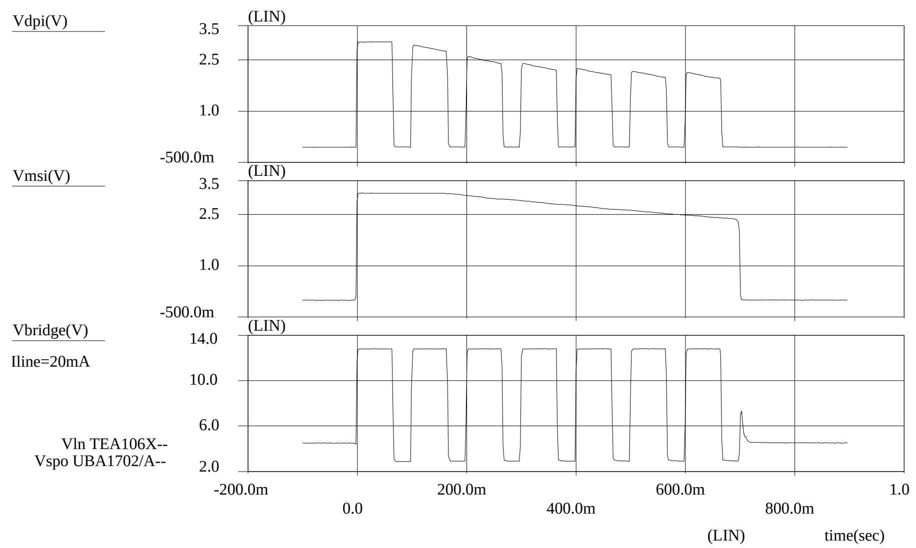


Fig.32 Pulse dialling waveforms with DMO.

4.2 'On hook' situation

In this mode the DC set resistance must be very high. After applying an AC voltage the set can enter the ringer mode (ch. 4.2.2), otherwise the memory retention / stand-by mode (ch. 4.2.1) can be maintained.

4.2.1 Memory retention / stand-by mode

Principle of operation

The PTT in some countries allows the subscriber to draw a very small DC current (in the order of 10 μA) from the line for e.g. memory retention. For this purpose the microcontroller has a stand-by mode which is entered by making the CE/notT0 input zero for a longer time interval. In this mode the VDD supply voltage is allowed to drop to a low value (1 V) and the current is likewise decreased to a very low value (about 1 μA for the PCD3349).

The UBA1702/A has a stand-by mode too, entered under condition that the voltages on supply points VBB and VRR are low. In this mode the current sink from the VDD supply point is minimized by disconnecting some internal circuit parts.

In the 'on hook' situation DC line current is blocked by the ringer capacitor C_{rng} and the interrupter. These have to be bridged by high ohmic resistors (for most countries a total minimum resistance of 5 MΩ is required) for direct supply of VDD from the line.

In case of an electronic hookswitch (the interrupter may incorporate the hookswitch function as well) it also possible to achieve set start up from this mode. For this purpose a key out of the keyboard matrix can be used. By depressing this key and at the same time making the CE/notT0 input high the microcontroller can enter the conversation / dialling mode and force the interrupter via EHI in the conducting state. An application proposal is given in which this function has been worked out further.

Performance

In stand-by mode the UBA1702/A has a resistance between VDD and VSS of more than 300 kΩ at 1 V. If the trickle current is 9 µA, more than 5 µA remains for the microcontroller.
It may be clear that after connecting a set with a discharged VDD capacitor it will take some time before this stand-by mode is operational. This is caused by the large RC time constant.

4.2.2 Ringer mode

The functions required for ringer operation have been partitioned between UBA1702/A and microcontroller:

TABLE 2 Function partitioning between UBA1702/A en microcontroller in ringer mode

UBA1702/A	microcontroller
Line termination ringer signal	ringer signal frequency check
Overvoltage protection	ringer melody generation
Supply	volume control
Superimposed signal discrimination	
Ringer signal amplitude check	
Volume controlled piezo output stage	

Note: ringer signal: low frequency AC signal generated by the exchange
ringer melody: audio frequency melody (warble) generated by microcontroller to be made audible by piezotransducer.

Principle of operation

A concise description of the operation principle of the software controlled ringer concept has already been given in the introduction: the AC ringer signal is rectified and if necessary limited and used for supply. A square wave with twice the frequency of the ringer signal is generated and available at pin RFO. Frequency check is done by the microcontroller which measures the time interval between low to high transients. In most cases the required frequency interval can be set by internal bits for versions with EEPROM or by diode option with versions without EEEPROM. If the measured time interval is according the setting a melody is generated. After the voltage at VRR (below the limiting voltage proportional to the ringer voltage) has crossed a minimum threshold the melody is routed to the piezo output stage. This is the amplitude check. Advantage of applying the result of the amplitude check at this point instead of gating the ringer frequency output is gain in start up time: charging of the VRR capacitor is done in parallel with the frequency check. This is particularly advantageous when the ringer signal has a low amplitude and frequency. The ringer melody is amplified to a level according the volume setting. If only two volume control bits are available it is recommended to interconnect the two least significant bits (RV0 and RV1) of the UBA1702/A. The steps are larger (12 dB instead of 6), but with exception of the last one the levels are still equidistant.

Performance

Ring input impedance. The input impedance is dependent on the ringer signal amplitude and the value of the series RC-network (R_{rng} and C_{rng}). Because of the limiting function it is also not linear. Above a certain amplitude the impedance is only influenced by the RC network. Decreasing the resistance and / or increasing the capacitance to increase output power has then little use because most of the additional available power is dissipated in the limiting / protection circuit. Minimum ringimpedance is in most cases fixed by local PTT requirements.
The V / I curve for a typical application (figure C1) is given in figure 33.

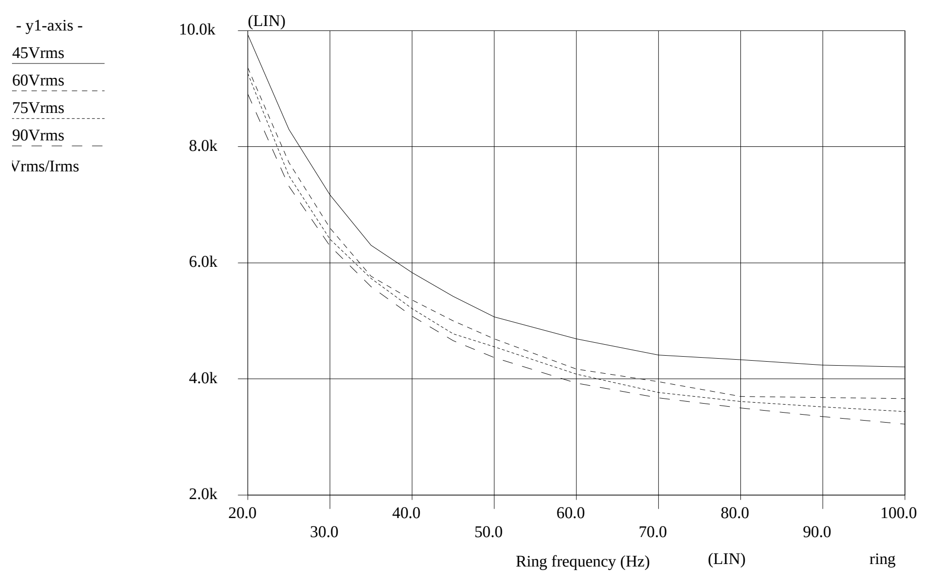


Fig.33 Ring input impedance as function of ringervoltage

Impedance is defined as the RMS value of the ringer voltage across the line terminals divided by the RMS value of the ringer current. The impedance for speech signals (up to 1 V_{rms}) is larger than 200 kΩ.

Start up time. Ringer start up time can be defined as time between applying a ringer signal the moment the melody is audible. This time has been minimized by paralleling supply capacitor charge and frequency check and is determined by various parameters like capacitance values for C_{VRR} and C_{VDD}, frequency and amplitude of ringer signal, reset level of microcontroller and number of required low to high transients for the frequency check. In a typical application with a ringer signal of 45 V_{rms} and 25 Hz this time is about 80 ms. See figure 34.
The frequency check can only be carried out after the microcontroller has been reset. In case this reset is generated externally by means of an RC-network the time constant of this network adds up to the total start time. Between ringer bursts VDD can drop below the reset level because of the VDD current consumption of the UBA1702/A. So every burst a start-up delay will occur. However, an external reset is not necessary under condition that the XTAL minimum operating voltagelevel (for f_{XTAL} = 3.579545 MHz this voltagelevel is 1.8 V) is available on VDD before the clock generated by this XTAL is applied. This condition is generally fulfilled with quartz resonators since oscillator start-up takes several milliseconds.

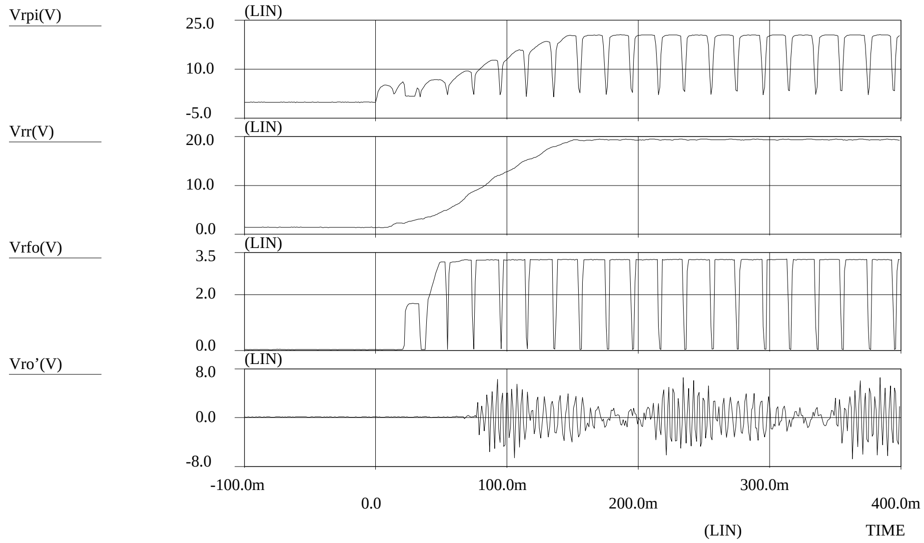


Fig.34 Ringer start up

Output sound pressure. The output sound pressure is dependent on the available output voltage, the applied piezo transducer and the acoustical properties of the cabinet. The output voltage of the UBA1702/A is limited to 28 V_{pp}, a value most piezo's can handle without degradation. The frequency characteristic of the piezo is very irregular: output levels within the specified frequency range can vary 20 dB.

5. APPLICATION GUIDELINE

In this chapter the procedure for making a basic application with a transmission circuit of the TEA106X-family and the UBA1702/A will be given. By means of figure C1 (basic application, see appendix) the design flow is given as a number of consecutive steps which should be taken. As far as possible for every step also the components involved and their influence on every step are given, the preferred value is given between brackets: [...]. For the UBA1702/A also a reference to the relevant graph in chapter 3 or 4 is made. Two adjustment resistors, R_{ZPA} and R_{RTA}, can be connected in different ways, only one is given in the application diagram.
For more information on the settings of the TEA106X see datahandbook (IC03), appendix A and [Ref. 4-6].

The basic application given in figure C1 comprises a TEA106X transmission circuit, a PCD3349A microcontroller and the UBA1702/A. As can be seen only few components have a fixed value. These components are R5, setting the reference current for the transmission circuit and various EMC components, which are indicated by a '⋆' in the diagram.

STEP	ADJUSTMENT
1 OFF HOOK CONDITION	
1.1 Conversation mode	
1.1.1 DC settings. First adjust the DC settings of the UBA1702/A and TEA106X to the local PTT requirements and maximum ratings of the transmission circuit.	
a) Voltage limit between LN and VEE	R_{ZPA} [open], see fig. 16/17
b) Line current limit	R_{CLA} [short to VEE], see fig. 12
c) Line current detection sensitivity	R_{CDA} [open], see fig. 11
d) Voltage between LN and SLPE	R17 or silicon diodes in series with pin LN
e) DC slope	R9 [20Ω], combination with R_{onT1}+$R_{SPI-SPO}$ (= 12 + 2 Ω)
f) Supply point VCC	C1 [100 µF]
g) Artificial inductor	C3 [4.7 µF]
h) Reset time microcontroller	C_{rst} [open], R_{rst} [short]
i) Supply point VDD	C_{VDD} [22 µF]
1.1.2 Impedance and sidetone. After setting the setimpedance, the sidetone has to be optimized for mean linelength and linetype. Also AGC can be chosen.	
a) Set impedance	Z1 (R_{onT1} and $R_{SPI-SPO}$ are in series)
b) Sidetone	R2, R3, R8, R11, R12 and C12
c) AGC	R6
1.1.3 TEA106X microphone and earpiece amplifiers, see also appendix A. After adjusting the microphone sensitivity, the gain and frequency curve can be set for the desired value. The same holds for the ear piece.	
a) Sensitivity microphone	R20, R21
b) Microphone gain	R7 (TEA106X dependent), R_{mic}, R_{mic-}, R_{mic+}
c) Low pass	C6 (combination with R7 + 3.5 kΩ)

d) Stability	C20 (= 10 * C6) (TEA1062 only)
e) High pass	R_{mic}, C8, C9 (combination with inputimpedance)
f) Earpiece gain	R4 (TEA106X dependent)
g) Low pass	C4 (combination with R4)
h) Stability	C7 (= 10 * C4)
i) High pass	C11 (combination with IR inputimpedance), C2 (combination with earpiece impedance)
1.2 Dialling mode	
1.2.1 DTMF dialling	
a) DTMF attenuation	R_{dtmf1}, R_{dtmf2}
b) High pass	C_{dtmf1}, C_{dtmf2} (combination with R_{dtmf1}, R_{dtmf2} and impedance DTMF input)
1.2.2 Pulse dialling	
a) Make resistance	DMO not used: R9 DMO used: R_{MSA} [open], see fig. 14/15

STEP	ADJUSTMENT
2 ON HOOK CONDITION	
2.1 Ringer mode. First select the value of C_{rng} (often a certain value is prescribed by local PTT requirements). R_{rng} will follow as a result of minimum allowed impedance.	
a) AC input impedance	R_{rng} [2.2 kΩ], C_{rng} [1 µF], see fig. 33
b) Ring threshold sensitivity	R_{RTA} [open], see fig. 23/24
c) Start-up time	C_{VRR} [22 µF], C_{rst} [open], R_{rst} [short]
d) Input coupling (DC block)	C_{RMI} [10 nF]
2.2 Standby mode. This mode is optional and not required if microcontroller has EEPROM or memory retention is not necessary.	
a) Standby current	R_{sb1} in series with R_{sb2} [2 * 2.7 MΩ]

6. APPLICATION EXAMPLES

As a follow up of the preceding guideline some practical examples of applications with the UBA1702/A are given in this chapter. The proposed examples include all functions required for a complete functional set like ringer, interrupter, 4 to 2 wire conversion, protection etc. Therefore the PCD3349A/53A single chip 8-bit telecom micro-controllers are used which can be programmed as multistandard repertory dialler/ringer: PCD3332-2 and PCD3330-1, see [Ref. 7] and [Ref. 8].

Figure C1 gives the basic application which has already been discussed in chapter 5.
Pulse or DTMF dialling can be selected by means of switch S2 (diode option). Because the power down function is not present, flash operation can be critical: the supply of the microcontroller (VDD) can drop below the reset level during flash and the microcontroller will reset itself. The same holds for DMO operation: the setvoltage during the make period can be too low to 'survive' the break period.

Figure C2 is more or less an extension of figure C1 for which the guideline is followed. Instead of a PMOST interrupter a bipolar transistor (MPSA92) is used.

DC settings:

- Voltage limit LN - VEE: 12 V.
- Line current limit: 120 mA.
- Line current detection sensitivity: 3 V.
- Voltage LN - SLPE: 4.5 V.
- DC slope: 25 Ω (at low line currents).
- On-hook loopresistance: > 5 MΩ.

AC settings:

- Voltage gain mic.: 52 dB.
- Voltage gain DTMF: 25.5 dB.
- Transmit cut-off frequency: 23.4 kHz.
- Voltage gain IR - QR: 31 dB.
- Receive cut-off frequency: 15.9 kHz.
- AGC startvalue: 25 mA.
- AGC stopvalue (gain -6 dB): 60 mA.

Ringer:

- Ring threshold sensitivity: 10.5 V.
- Ringer melody high pass cut-off: 65 Hz.

Figure C3 depicts an application with the TEA1064B and the PCD3353A microcontroller. The latter contains EEPROM. This kind of memory makes number storage without the need for trickle current (flowing through resistors R_{sb1} and R_{sb2} in fig. C2) possible.
The TEA1064B features a power down function, selectable reference for logical inputs and a dynamic limiter. This dynamic limiter is combined with a mic.mute (switch Smmute). The reference input (VEE2) is in this application connected to SLPE. This results in combination with R_{VBB} and C_{VBB} in improved supply capabilities.
EMC measures are extended by the addition of C31 and C32. R_{RPI} is then required for correct 2F ringer detection. Compared to the previous example the following settings have been changed:

DC settings:

- Voltage between LN and SLPE: 4.2 V

- DC slope: 35 Ω.
- On hook loop resistance: > 5 MΩ.

AC settings:

- AGC start value: 40 mA.
- AGC stop value (gain -6 dB): 80 mA.

The last proposal is given in figure C4 and features on-hook dialling and call progress monitoring (TEA1083A). The on-hook dialling facility requires a separate ringerbridge (D7-10) capacitively coupled by C_{rng1} and C_{rng2}. Two capacitors are needed because of the common reference of ringer and speech part: VEE. The voltage across both capacitors has always the same polarity and therefore the capacitors can be unipolar. Going off-hook can be done in two ways:

- by closing the cradle switch (corresponds with picking up the handset). The EHI pin of the UBA1702 is connected to the line via R_{ehs} and T1 starts conducting. The microcontroller is informed whether the cradle has been operated by its hookinput. Going on-hook is achieved by opening the cradle switch. Consequently the hookinput of the micro is pulled down by R_{hook1}.
- by operation of the pushbutton 'HOOK'. Start up is comparable to the previous case, however a takeover signal is necessary to keep pin EHI high. This signal is generated by the microcontroller and available on pin LSE (LoudSpeaker Enable). At the same time T_{hook} conducts to simulate a switch in the matrix.

In case the handset is lifted (cradle switch closed) the hook push button can be used to switch the LS amplifier on and off. A diode (D14) has been added to protect the microcontroller input for overvoltage. The TEA1083A is supplied from the line, therefore the line current is split up in a constant part flowing through R22 (about 3 mA) and a line current dependent part flowing through the TEA1083A to SLPE. The output volume can be adjusted by means of R22. To save a microcontroller pin two ringer volumebits are combined. The stepsize is doubled and as a consequence there are 4 levels instead of 8.

7. ELECTROMAGNETIC COMPATIBILITY

With respect to electromagnetic compatibility (EMC) no common European or international specification yet exists. Also the measurement methods differ and are not always reproducible. At the application laboratory in Eindhoven (PCALE) the German current injection method is used (VDE 0878 part 200). It is a reliable method of measuring and is highly reproducible. The method is described in [Ref. 3]. The hints for EMC of the TEA106X transmission circuit given in the second paragraph of this chapter are based on this method. The same counts for the hints of the printed circuit board design given in the first paragraph.

7.1 Printed circuit board

In the current injection method, radio frequency (RF) signal currents enter the telephone set at the a/b wires and leave the set via any capacitive coupling to ground. Normally, in a telephone set the handset has the largest capacitance to ground and thus the main part of the RF signal current flows to ground via the handset. However, a proper PCB layout is essential for good EMC.

The first measure to be taken is to create a groundplane on the PCB. The RF signals entering the PCB should be decoupled immediately to this groundplane. Preferably this groundplane is homogeneous and is not cut into parts by interconnection wires. To reach this a double layered PCB, with interconnection wires on one side of the board and a groundplane on the other side, is a minimum. When interconnection wires within the groundplane are inevitable, the continuity of the groundplane should be restored. This is done by cross coupling these interconnection wires by jumpers and wires at the interconnect side of the PCB. In this way RF signal currents can flow freely over the groundplane.

Another measure is to keep the length of the wires between the different components as short as possible. Of course this measure is especially important for those wires which interconnect one or more RF signal sensitive parts, in particular the wire connected to SLPE which can also be a reference for the UBA1702/A. As any current, RF signal currents prefer to flow to ground via the lowest ohmic path. Therefore, it should be noted that a wire of 10 mm corresponds to an inductor of 10 nH.

7.2 TEA106X

In this paragraph the standard measures for the TEA106X are given. When, after the proposed measures are taken, the EMC behaviour has to be optimized, it is advised to start with the transmit direction of the telephoneset and to optimize the receive part thereafter. This because, due to sidetone, signals demodulated by the transmit channel will be seen in the receiver channel.

In the text below it is supposed that the printed circuit board on which the TEA106X-UBA1702/A is built, is provided with a groundplane which is connected to VEE. It is preferred to place the components meant for EMC as close as possible to the pins, except when otherwise stated.

For more details on the EMC performance of the TEA106X, see [Ref. 3].

RF signals entering the printed circuit board at the a/b wires should be decoupled to the groundplane via capacitors, preferably placed as close as possible to the a/b connection. Since these capacitors will be in parallel with the set impedance, their value is limited. In practice, a total capacitance of 10nF between the a/b wires may be applied without degrading the balance return loss.

Between the a/b wires and the groundplane two capacitors of can be placed, as well as a series inductance of 22 µH in series with the diode bridge.

RF signals entering the inputs of the transmit channel (MIC+, MIC-) will be demodulated and amplified to the line. Because of the high gain (in the order of 50 dB) the transmit channel is very sensitive to RF signals. Therefore, decoupling at the inputs is essential.

The inputs MIC+ and MIC- can preferably be decoupled by 2 capacitors of 2.2 nF connected to the groundplane. Also series resistors can be applied which in combination with the capacitors form low pass filters towards the inputs. Resistors of 1 kΩ are advised (in case of an electret microphone) which reduce the gain setting with less than half a dB, depending on the input impedance of pins MIC+ and MIC-. This can be compensated by adapting the transmit gain adjustment resistor R7 of the TEA106X.

In case a handset microphone is connected to the TEA106X microphone inputs via a long cord, extra decoupling is needed. This can be done by adding two capacitors of 2.2 nF each, placed between the cord connection and the groundplane, preferably as close as possible to the cord connection.

RF signals entering the inputs of the receive channel (IR) will be demodulated and amplified to the earpiece and therefore decoupling at the input is essential.

At the input IR of the TEA106X a capacitor of 1 nF connected to the groundplane is advised.

In case an earpiece is connected to the TEA106X via a long cord, extra decoupling is needed. This can be done by adding two capacitors of 10nF each, placed between the cord connection and the groundplane, preferably as close as possible to the cord connection. To prevent the remaining RF signals from entering the earpiece output-stage of the TEA106X via the QR pin, a series resistor should be applied to create a high ohmic path. The value of this resistor is dependent on the type of earpiece capsule used. When a dynamic capsule of 150 Ω is used, a resistors of 22 Ω is advised. This will reduce the gain setting with 1.19 dB. This can be compensated by adapting the receive gain adjustment resistor R4 of the TEA106X.

Besides these essential measures some additional measures can be taken. A capacitor between GAS2 and the groundplane of 100 pF can improve EMC in the transmit direction. A series combination of a resistor of 365 Ω and a capacitor of 4.7 nF connected between STAB and the groundplane can improve EMC for both transmit and receive direction.

8. REFERENCES

[Ref. 1] Philips Semiconductors Data Handbook
Semiconductors for telecom systems - IC03
Philips Semiconductors, 1995

[Ref. 2] UBA1702/A Line Interrupter Driver and Ringer IC
Preliminary specification
October 1995

[Ref. 3] Measures to meet EMC requirements for TEA1060-family speech transmission circuits
by M. Coenen and K. Wortel
PCALE reportnumber: ETT89016

Extended application information on the speech transmission circuits can be found in:

[Ref. 4] TEA1060 family versatile speech/transmission ICs for electronic telephone sets
Designers' guide by P.J.M. Sijbers
July 1987, 12NC 939834110011

[Ref. 5] Application of the versatile speech/transmission circuit TEA1064 in full electronic telephone sets
by F. van Dongen and P.J.M. Sijbers
PCALE reportnumber: ETT89009

[Ref. 6] Application of the speech-transmission circuit TEA1062
by P.T.J. Biermans
PCALE reportnumber: ETT89008

More information on dialler / ringers can be found in:

[Ref. 7] PCD3330-1: A multi-standard repertory dialler/ringer with EEPROM (programmed PCD3353A)
Objective specification; July 1993

[Ref. 8] PCD3332-2: A multi-standard pulse/tone repertory dialler/ringer (programmed PCD3349A)
Objective specification; March 1994

APPENDIX A. TEA106X QUICK REFERENCE DATA

	DC-CHARACTERISTICS (with slope resistance R9 = 20 Ω)		
Member	V(LN-VEE) (in V)at Iline = 15 mA	V(LN-VEE) (in V) at R(REG-LN) = 68 kΩ	V(LN-VEE) (in V) at R(REG-SLPE) (in Ω)
TEA1060	4.45 ± 0.20	3.80 + 0.25 / -0.30	5.0 ± 0.30 at 39 k
TEA1062	4.00 + 0.25 / -0.45	3.50 ±	4.5 ± .... at 39 k
TEA1064B	3.50 ± 0.25	---	4.4 ± 0.35 at 20 k
TEA1067	3.90 ± 0.25	3.40 ± 0.30	4.5 ± 0.30 at 39 k
TEA1068	4.45 ± 0.25	3.80 ± 0.30	5.0 ± 0.35 at 39 k

	SENDING GAIN		RECEIVE GAIN (from IR to QR+)	
Member	Setting range (in dB)	Gain (in dB) with R7 = 68 kΩ	Setting range (in dB)	Gain (in dB) with R4=100 kΩ
TEA1060	44 - 60	52 ± 1	17 - 33	25 ± 1
TEA1062	44 - 52	52 ± 1.5	20 - 31	31 ± 1.5
TEA1064B	44 - 52	52 ± 1	20 - 39	31 ± 1
TEA1067	44 - 52	52 ± 1	20 - 39	31 ± 1
TEA1068	44 - 60	52 ± 1	17 - 33	25 ± 1

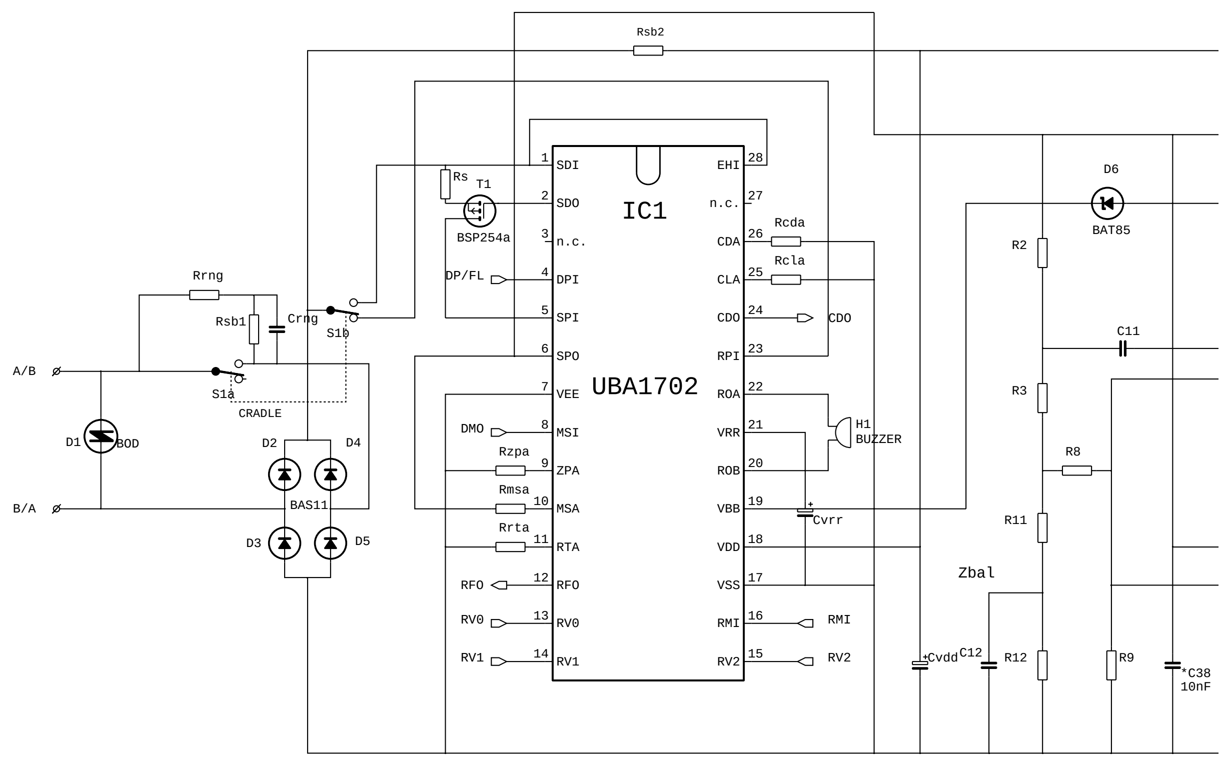
	SENDING NOISE	
Member	Noise (in dBmp) with R7 = 68 kΩ	Noise (in dBmp) with sending gain of 44 dB
TEA1060	-70	-78
TEA1062	-69	-77
TEA1064B	-72	-80
TEA1067	-72	-80
TEA1068	-72	-80

For more data see datahandbook [Ref. 1].

APPENDIX B. LIST OF ABBREVIATIONS AND DEFINITIONS

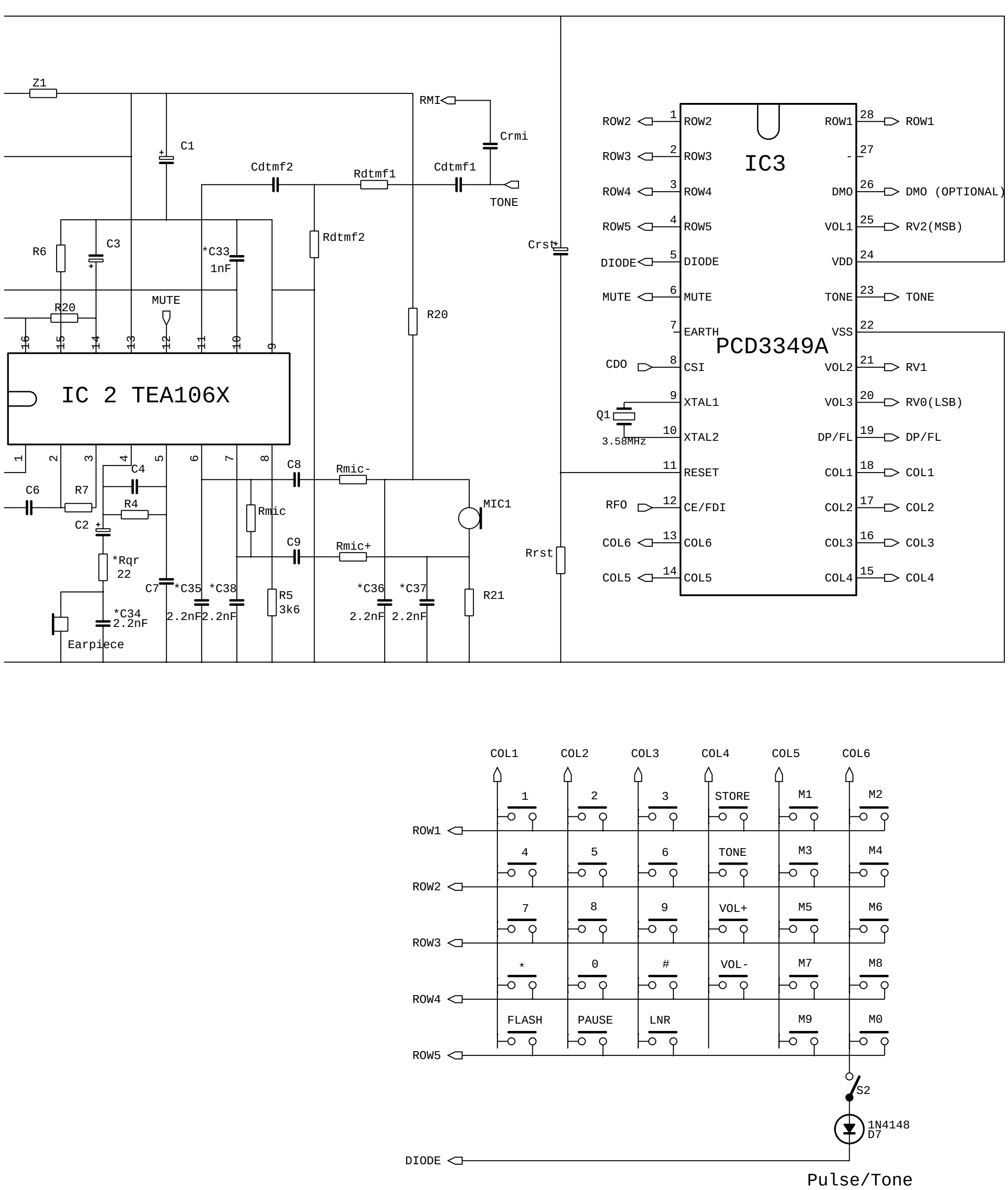
AGC	Automatic Gain Control: line loss compensation of the TEA106X
BRL	Balance Return Loss
CE/notT0	Chip enable / not test0 input of microcontroller, used for putting the device in active mode and for ringer frequency discriminator input
Crng	Ringer input capacitor
Crst	Capacitor for generating external reset for microcontroller
CSI	Cradle Switch Input, see T1
DMO	Dial Mode Operation, provision to guarantee a low set resistance during the make period of pulse dialling, also designated as Mute2 or NSA
DTMF	Dual Tone Multi Frequency (dialling system)
EHS	Electronic Hook Switch (required for on-hook dialling)
EMC	Electro Magnetic Compatibility: the collective noun for the susceptibility and the radiation of a circuit / apparatus
FDI	Frequency Discriminator Input, see CE/notT0
Flash	Timed break of (DC) line current for call transfer by the exchange
HOOK	Hook switch control input, see T1
IR	Receive input pin of the TEA106X
LN	Positive line terminal pin of the TEA106X
MIC	Microphone input pin
MIC+, MIC-	Microphone inputs pins on the TEA106X
MOSFET	Metal Oxide Field Effect Transistor
Mute	Mode which is operational during dialling
PCALE	Product Concept & Application Laboratory Eindhoven
PCB	Printed Circuit Board
Powerdown	Reduced current consumption mode during pulse dialling or flash operation
PTT	Telephone administration
QR-, QR+	Telephone earpiece output on TEA106X
Rcda	Resistor setting line current detection sensitivity
Rcla	Resistor setting line current limit value
RF	Radio Frequencies / Ringer Frequency input, see CE/notT0
Rmic	Resistor setting the microphone sensitivity
Rmsa	Resistor setting mute (DMO) voltage
Rrng	Ringer input resistor
Rrst	Resistor for generating external reset for microcontroller
Rrta	Resistor setting ringer threshold
Rsb1, Rsb2	Resistors for stand-by (trickle) current for memory retention
Rzpa	Resistor setting zener protection voltage
SLPE	DC slope pin on TEA106X
T1	Test1 input of microcontroller, used for on / off hook detection
TEA106X	IC of the TEA106X speech transmission family: TEA1060/61, TEA1062, TEA1063, TEA1064A, TEA104B, TEA1065, TEA1066, TEA1067, TEA1068
VCC	Supply pin of the TEA106X
VEE	Ground reference pin of TEA106X and UBA1702/A
VSS	Ground reference for microcontroller and logic reference for the UBA1702/A

APPENDIX C APPLICATION DIAGRAMS



EMC components marked with *

Figure C1 Basic application with TEA106X


IC 2 TEA106X
IC3
PCD3349A
Z1
C1
Cdtmf2
Rdtmf1
Cdtmf1
RMI
Crmi
TONE
R6
C3
*C33 1nF
Rdtmf2
MUTE
R20
Crst
C4
C6
R7
R4
C2
*Rqr 22
*C34 2.2nF
Earpiece
C7
*C35 *C38
2.2nF 2.2nF
Rmic
C8
Rmic-
C9
Rmic+
R5 3k6
*C36 *C37
2.2nF 2.2nF
MIC1
R21
Rrst
Q1
3.58MHz
ROW2 ROW3 ROW4 ROW5 DIODE MUTE EARTH CSI XTAL1 XTAL2 RESET CE/FDI COL6 COL5
ROW1 DMO VOL1 VDD TONE VSS VOL2 VOL3 DP/FL COL1 COL2 COL3 COL4
CDO
RFO
DMO (OPTIONAL)
RV2(MSB)
RV1
RV0(LSB)
COL1 COL2 COL3 COL4 COL5 COL6
ROW1 ROW2 ROW3 ROW4 ROW5
1 2 3 STORE M1 M2
4 5 6 TONE M3 M4
7 8 9 VOL+ M5 M6
* 0 # VOL- M7 M8
FLASH PAUSE LNR M9 M0
S2
1N4148 D7
DIODE
Pulse/Tone

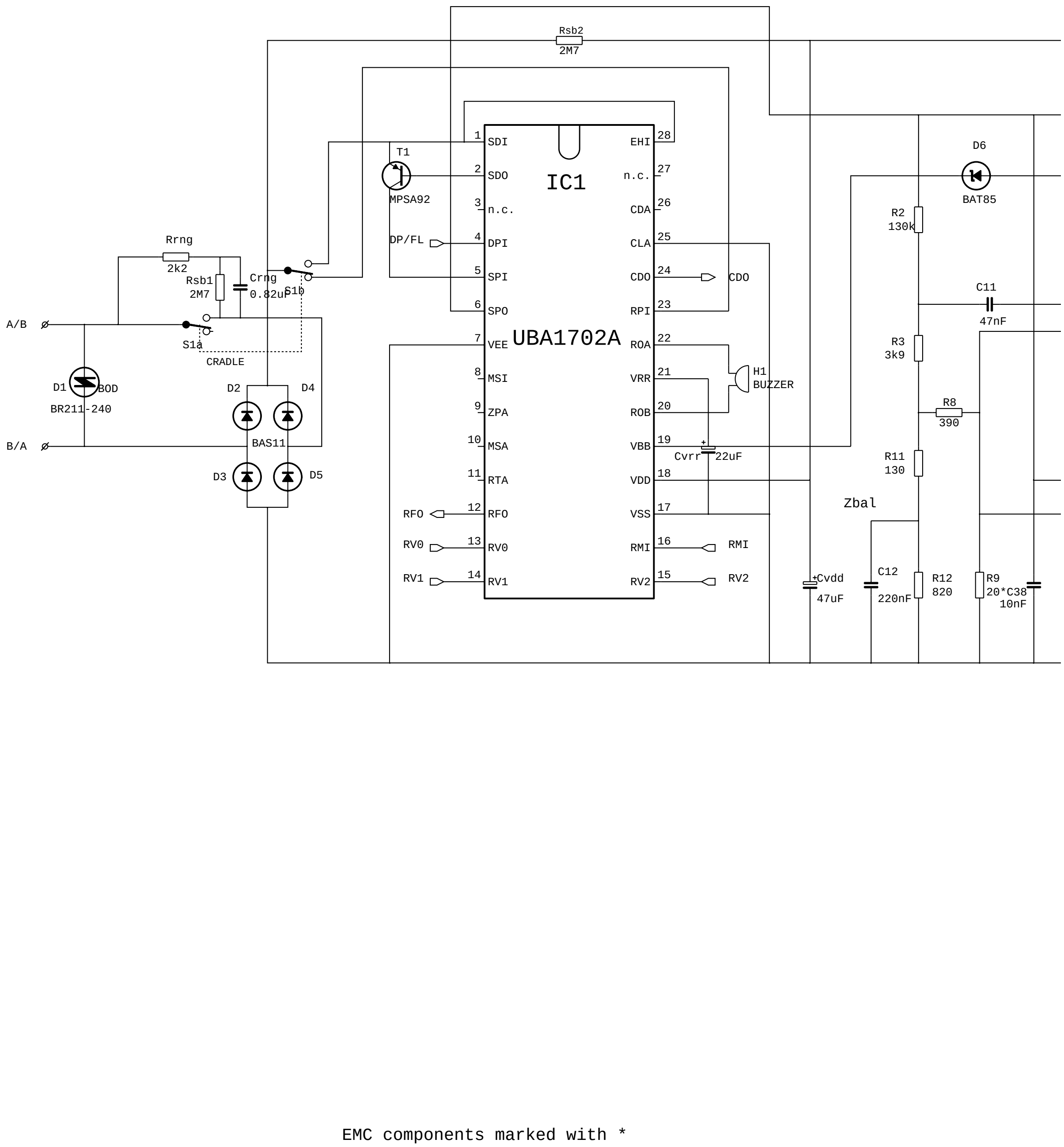
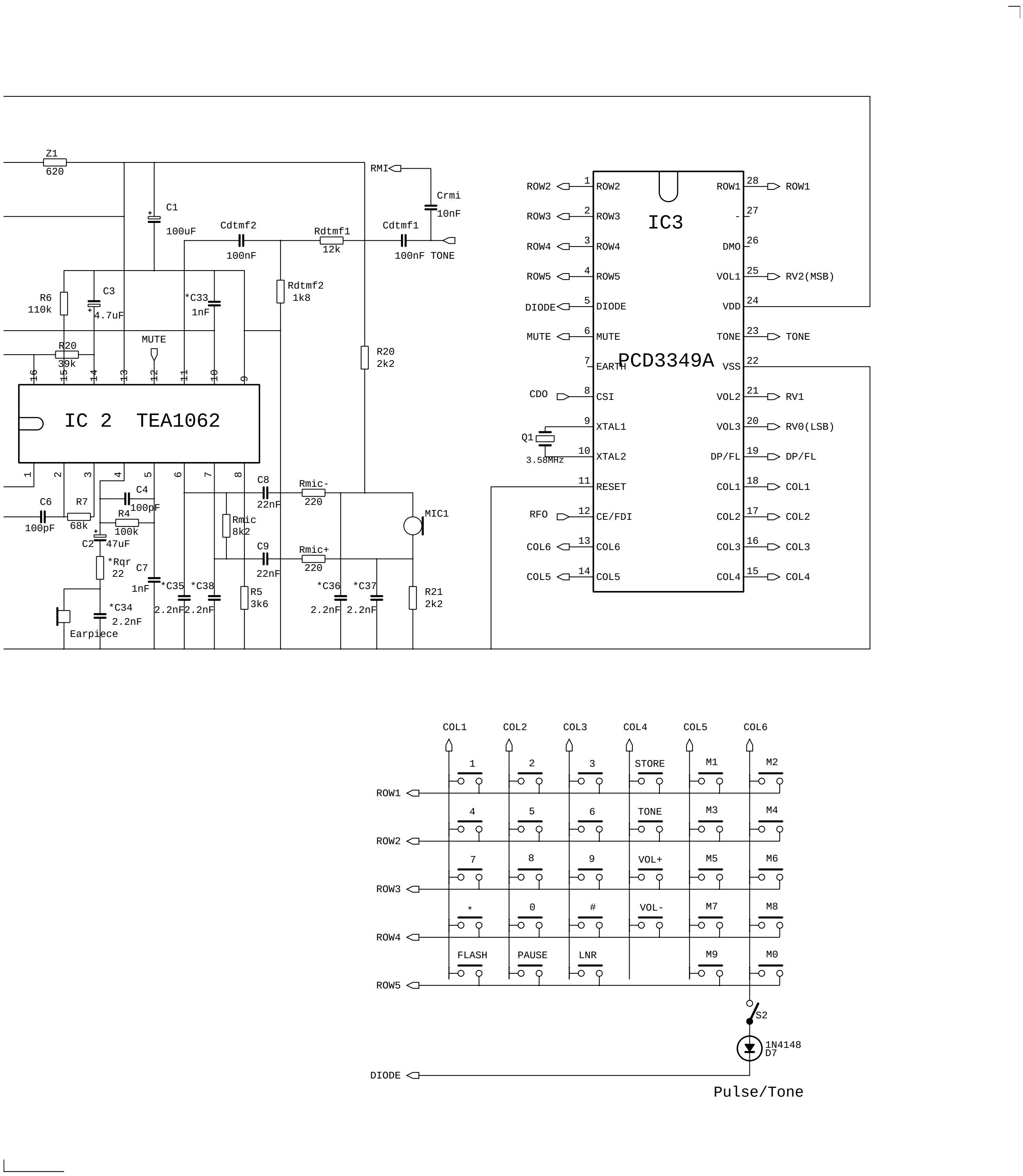


Figure C2 Application UBA1702A with TEA1062


IC 2 TEA1062
IC3
PCD3349A
Z1 620
C1 100uF
Cdtmf2 100nF
Rdtmf1 12k
Cdtmf1 100nF
Crmi 10nF
RMI
TONE
Rdtmf2 1k8
R6 110k
C3 4.7uF
*C33 1nF
MUTE
R20 39k
R20 2k2
C6 100pF
R7 68k
C4 100pF
R4 100k
C2 47uF
*Rqr 22
C7 1nF
*C34 2.2nF
*C35 2.2nF
*C38 2.2nF
Earpiece
C8 22nF
Rmic- 220
Rmic 8k2
C9 22nF
Rmic+ 220
R5 3k6
*C36 2.2nF
*C37 2.2nF
MIC1
R21 2k2
Q1 3.58MHz
ROW1 ROW2 ROW3 ROW4 ROW5
DIODE
EARTH
CDO
CSI
XTAL1
XTAL2
RESET
RFO
CE/FDI
COL1 COL2 COL3 COL4 COL5 COL6
DMO
VOL1 VOL2 VOL3
VDD
VSS
RV2(MSB)
RV1
RV0(LSB)
DP/FL
STORE
M1 M2 M3 M4 M5 M6 M7 M8 M9 M0
VOL+
VOL-
FLASH
PAUSE
LNR
S2
1N4148 D7
Pulse/Tone

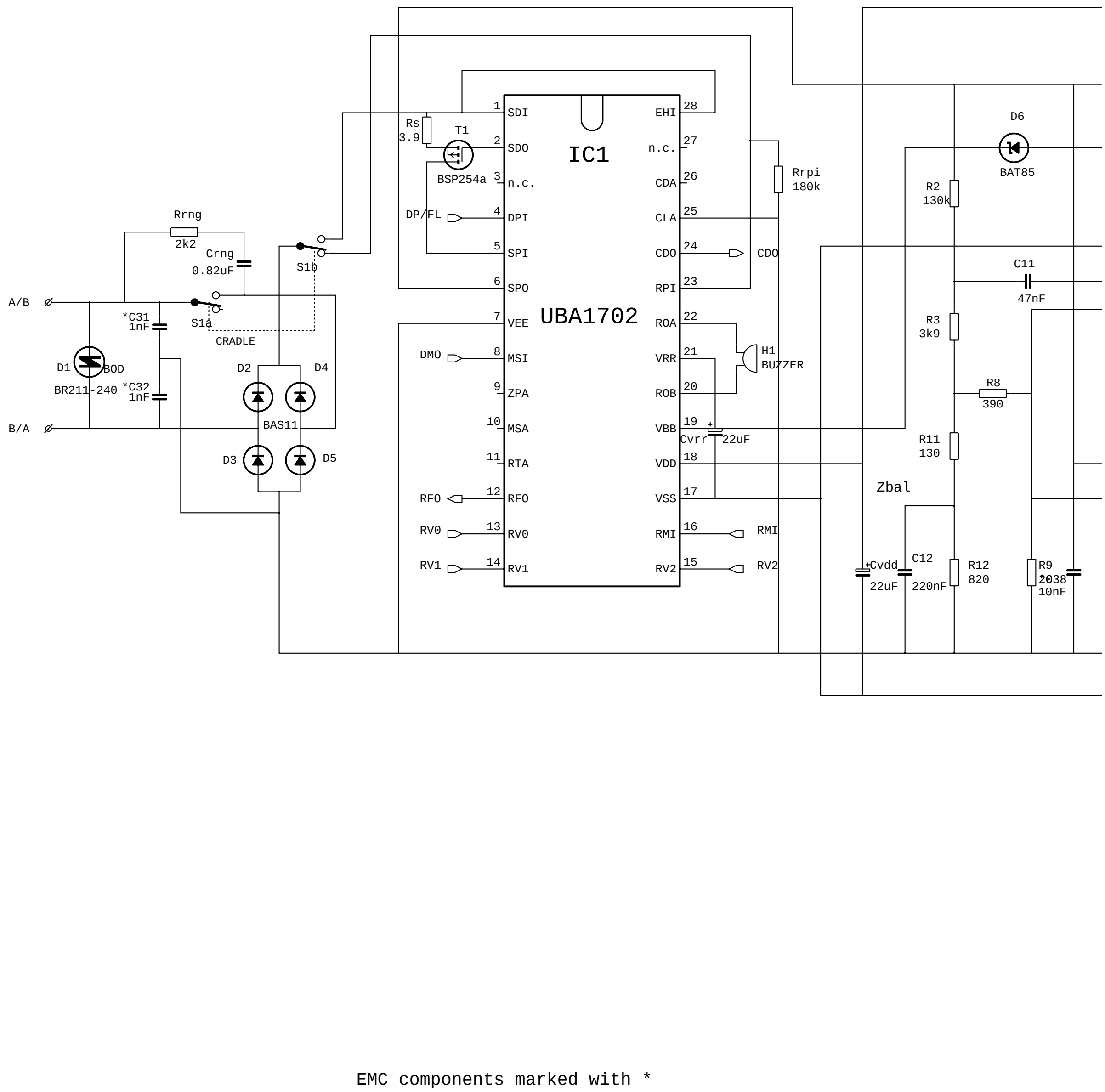
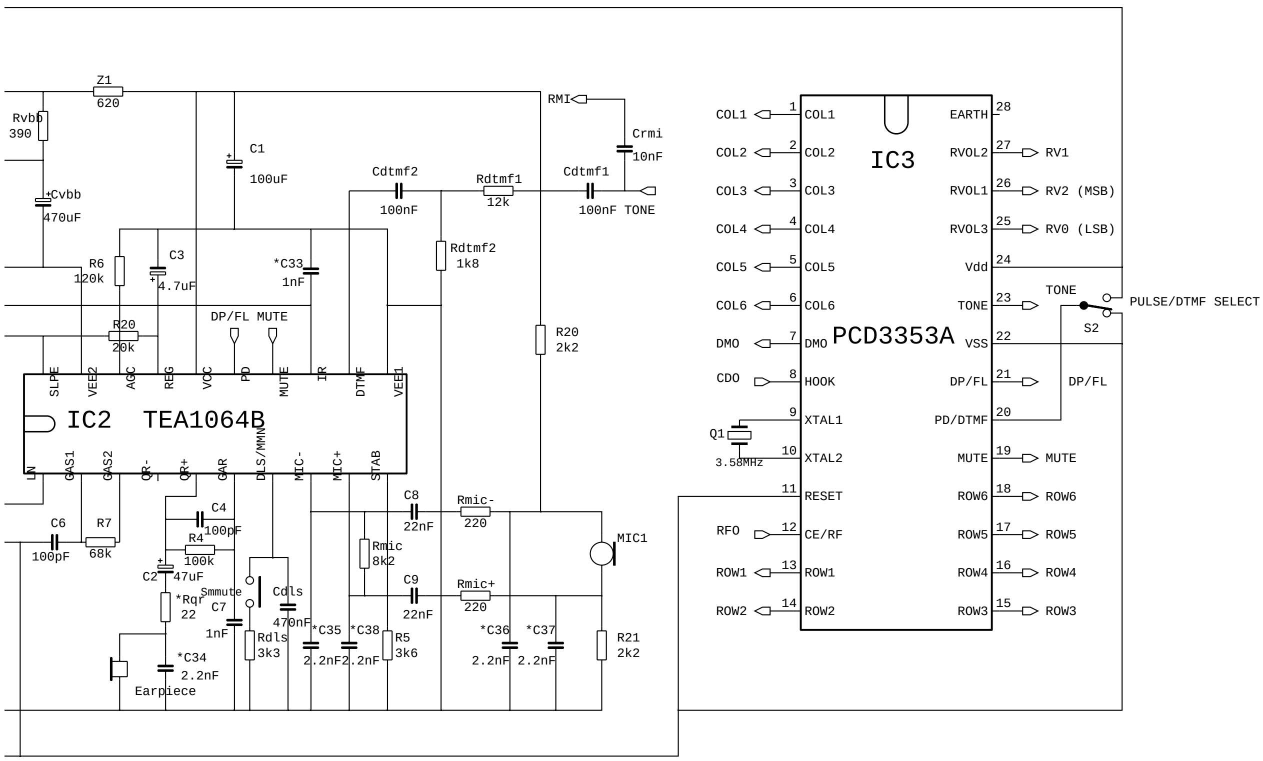
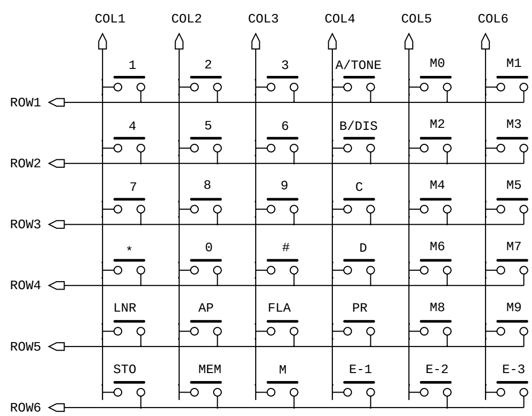


Figure C3 Application UBA1702 with TEA1064B


Z1
620
Rvbb
390
C1
100uF
Cvbb
470uF
RMI
Crmi
10nF
Cdtmf2
100nF
Rdtmf1
12k
Cdtmf1
100nF TONE
R6
120k
C3
4.7uF
*C33
1nF
Rdtmf2
1k8
DP/FL MUTE
R20
20k
R20
2k2
SLPE
VEE2
AGC
REG
VCC
PD
MUTE
IR
DTMF
VEE1
IC2 TEA1064B
LN
GAS1
GAS2
QR-
QR+
GAR
DLS/MMN
MIC-
MIC+
STAB
C8
22nF
Rmic-
220
C6
100pF
R7
68k
C4
100pF
R4
100k
MIC1
Rmic
8k2
C2
47uF
Smmute
Cdls
470nF
C9
22nF
Rmic+
220
*Rqr
22
C7
1nF
Rdls
3k3
*C35
2.2nF
*C38
2.2nF
R5
3k6
*C36
2.2nF
*C37
2.2nF
R21
2k2
*C34
2.2nF
Earpiece
COL1
COL2
COL3
COL4
COL5
COL6
DMO
CDO
Q1
3.58MHz
RFO
ROW1
ROW2
IC3
PCD3353A
1 COL1
2 COL2
3 COL3
4 COL4
5 COL5
6 COL6
7 DMO
8 HOOK
9 XTAL1
10 XTAL2
11 RESET
12 CE/RF
13 ROW1
14 ROW2
28 EARTH
27 RVOL2
26 RVOL1
25 RVOL3
24 Vdd
23 TONE
22 VSS
21 DP/FL
20 PD/DTMF
19 MUTE
18 ROW6
17 ROW5
16 ROW4
15 ROW3
RV1
RV2 (MSB)
RV0 (LSB)
TONE
PULSE/DTMF SELECT
S2
DP/FL
MUTE
ROW6
ROW5
ROW4
ROW3


COL1
COL2
COL3
COL4
COL5
COL6
ROW1
ROW2
ROW3
ROW4
ROW5
ROW6
1
2
3
A/TONE
M0
M1
4
5
6
B/DIS
M2
M3
7
8
9
C
M4
M5
*
0
#
D
M6
M7
LNR
AP
FLA
PR
M8
M9
STO
MEM
M
E-1
E-2
E-3

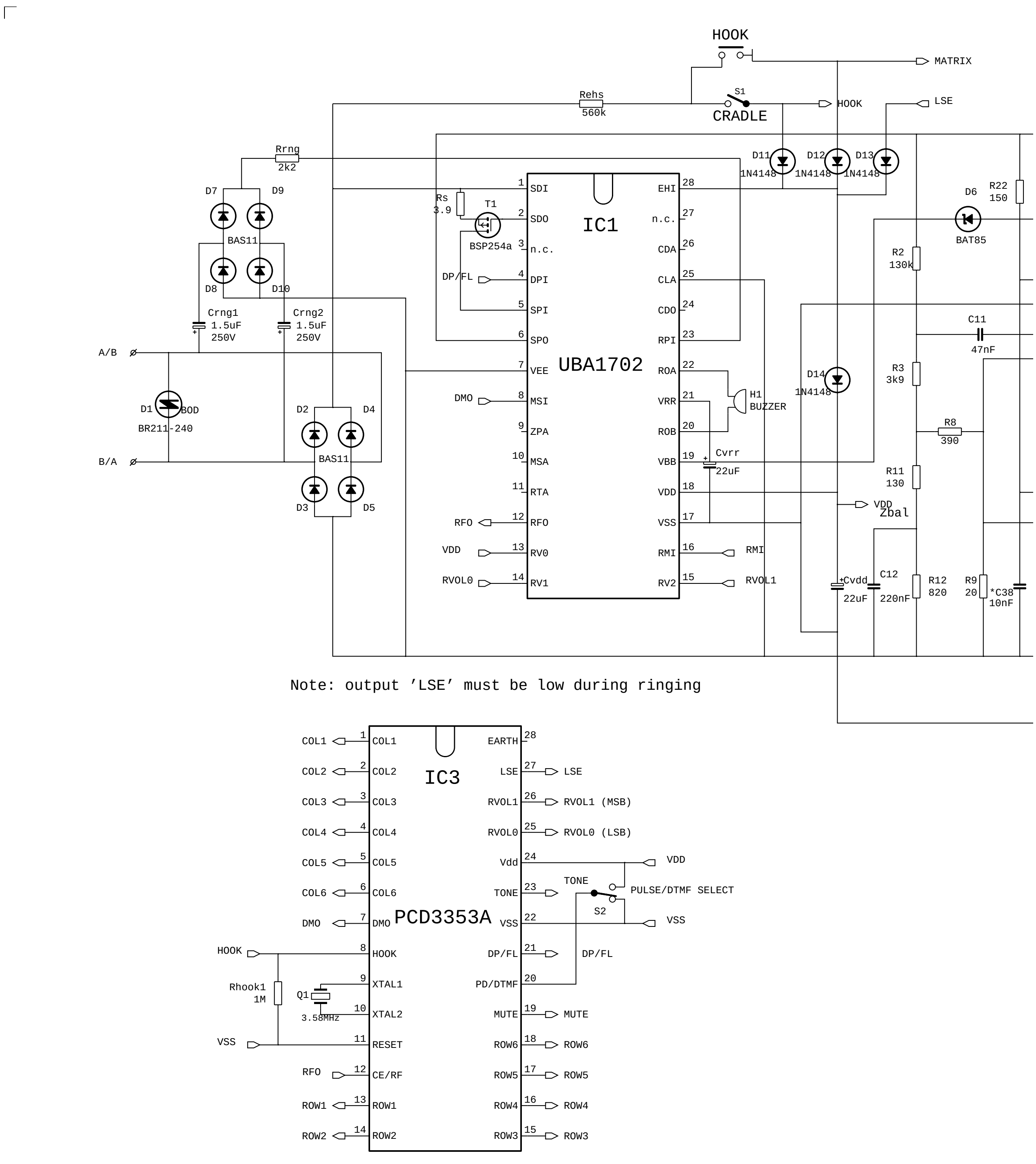
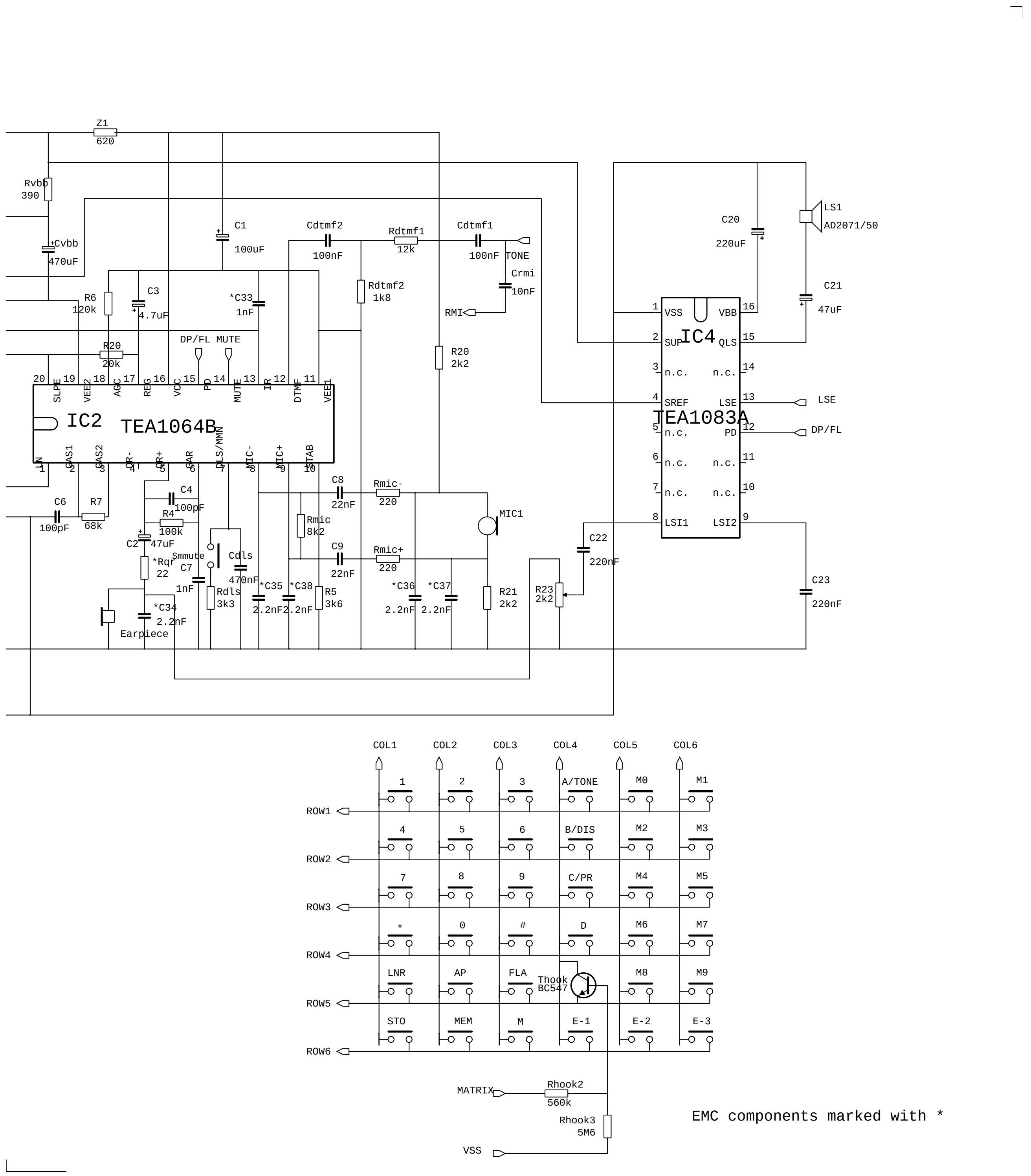


Figure C4 Application UBA1702 with TEA1064B/1083(A)


Z1
620
Rvbb
390
Cvbb
470uF
C1
100uF
Cdtmf2
100nF
Rdtmf1
12k
Cdtmf1
100nF
TONE
Crmi
10nF
RMI
Rdtmf2
1k8
R6
120k
C3
4.7uF
*C33
1nF
R20
20k
DP/FL MUTE
R20
2k2
IC2
TEA1064B
SLPE
VEE2
AGC
REG
VCC
PD
MUTE
IR
DTMF
VEE1
LN
GAS1
GAS2
QR-
QR+
GAR
DLS/MMN
MIC-
MIC+
STAB
C6
100pF
R7
68k
C4
100pF
R4
100k
C2
47uF
*Rqr
22
Smmute
C7
1nF
Cdls
470nF
Rdls
3k3
*C34
2.2nF
Earpiece
*C35
2.2nF
*C38
2.2nF
R5
3k6
C8
22nF
Rmic-
220
Rmic
8k2
C9
22nF
Rmic+
220
*C36
2.2nF
*C37
2.2nF
MIC1
R21
2k2
R23
2k2
C22
220nF
C20
220uF
LS1
AD2071/50
C21
47uF
IC4
TEA1083A
VSS
VBB
SUP
QLS
n.c.
SREF
LSE
PD
LSI1
LSI2
LSE
DP/FL
C23
220nF
COL1
COL2
COL3
COL4
COL5
COL6
ROW1
ROW2
ROW3
ROW4
ROW5
ROW6
1
2
3
A/TONE
M0
M1
4
5
6
B/DIS
M2
M3
7
8
9
C/PR
M4
M5
*
0
#
D
M6
M7
LNR
AP
FLA
Thook
BC547
M8
M9
STO
MEM
M
E-1
E-2
E-3
MATRIX
Rhook2
560k
Rhook3
5M6
VSS
EMC components marked with *