Cellular Engine TC35

The extra compact module for voice and data transmission

Application Note: **AUDIO Interface**

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Table of contents

Figures

Tables

1 Introduction

The purpose of this document is to provide technical recommendations for designing the audio interface intended for a TC35 based cellular application.

Specifications subject to change without notice. This product is an original Siemens product protected by US, European and other patents.

1.1 References

Related documents
/1/ AT Command Set for TC35 and TC35 Terminal
/2/ TC35 TC37 Hardware Interface Description

1.2 Terms and Abbreviations

DSB35	Development Support Box 35
EMC	Electro Magnetic Compatibility
EMI	Electromagnetic Interference
EPP	Ear Peace Positive
EPN	Ear Peace Negative
ESD	Electrostatic discharge
FFC	Flat Flexible Cable
GSM	Global System for Mobile Communication
RF	Radio Frequency
MICP	Microphone Positive
MICN	Microphone Negative
PCB	Printed Circuit Board
SIM	Subscriber Identifier Module
VANA	Voltage Analogue
VREF	Voltage Reference
opamp	Operational amplifier

2 General

The purpose of this document is to provide recommendations for integrating audio accessories into your TC35 application. To give an example, the technical specifications proceed from the certified Siemens reference GSM application that consists of the following components:

- TC35 module
- DSB35 Support box
- Siemens M20 Terminal Handset.

The DSB35 Support Box can be purchased for testing and evaluating GSM applications that incorporate the TC35 module. Click here for more details and ordering information: http://www.siemens.com/wm

2.1 Approval Considerations

For Europe (R&TTE) it is not mandatory to provide an extra approval for the audio equipment that integrates with the TC35 GSM engine. However, should your application be enhanced beyond the certified Siemens reference configuration, it is recommended that you apply for an additional approval.

3 Reference configuration

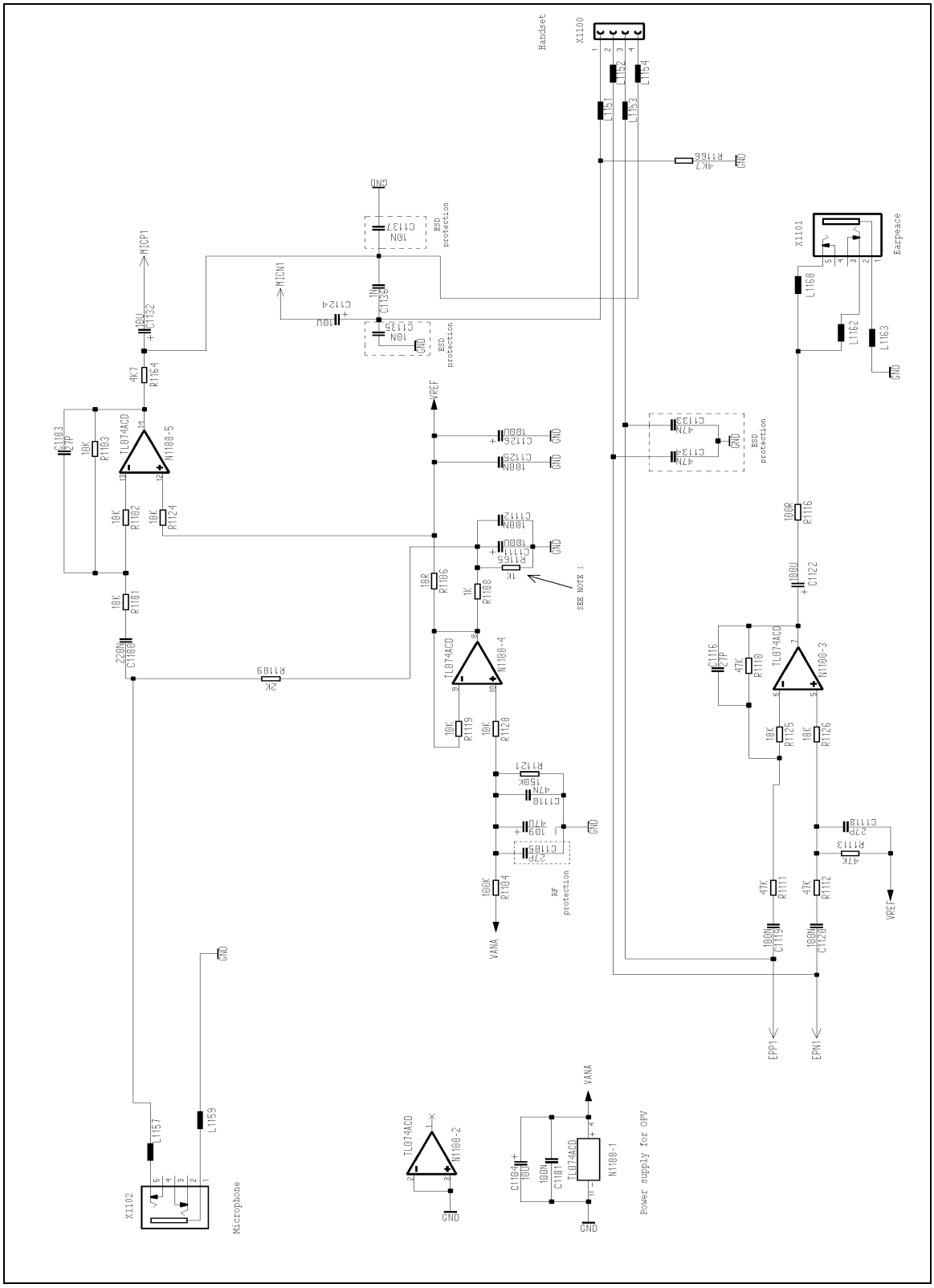

Figure 1: Audio Interface Schematic on the DSB35 Support Box

*) Note (to Figure 1)
The two R1108 (1K) and R1165 (1K) resistors are used as voltage divider for the separate microphone. This results in 3V at R1165 (1K) for feeding of the external microphone (X1102). 6V feeding voltage are used for the handset microphone.

3.1 Description of the receive path

The differential output signal EPP1/EPN1 of the TC35 connects directly to X1100 pin 3 and 2 via the EMI chokes L1153 and L1152. The handset speaker is powered directly from GSM module.

Two capacitors C1133 and C1134 (47nF) and two clamp diodes (not in circuit) protect EPP1/EPN1 against ESD.

The differential amplifier N1100-3 picks up the balanced EPP1/EPN1 signal from GSM module and converts it into an asymmetric output signal for earpiece jack X1101. This amplifier can drive a common stereo headphone plugged into X1101.

3.2 Description of the transmit path

The amplifier N1100-5 provides a dc output voltage of 6V for feeding the handset's microphone. R1164 (4k7) and R1166 (4k7) form a feeding bridge for the microphone at X1100.

The differential microphone signal has to be decoupled from TC35 by capacitors C1132 and C1124.

ESD protection is provided by C1135 to C1137 and two clamp diodes (not in circuit).

An external electret microphone can be connected to jack X1102, which provides a 3V feeding source with a load resistance of 2kΩ. This signal is superimposed to the feeding voltage of the handset's microphone by the unity gain amplifier N1100-5.

In applications with the M20T handset only, N1100-5 can be replaced by a clean 6V dc source.

3.2.1 Earpiece stereo jack (X1101)

The earpiece signal is generated by the audio interface (earpiece signal output, pin 2 and pin 5). The audio interface can be designed as a 3.5 mm stereo connector like the X1101 jack located on the DSB35 Support Box board.
On the DSB35 Support Box board, the X1100 Western jack for the handset are connected in parallel with the opamp driving the X1101 earpiece jack.

The stereo jack connections are shown in Figure 2 below.

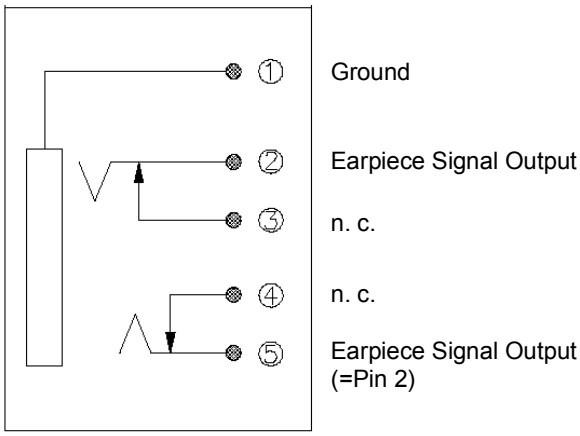

Figure 2: Pin assignment - X1101 jack for earpiece signal

3.2.2 Microphone Signal (X1102)

For the microphone signal, the DSB35 Support Box board uses a 3.5 stereo jack (external mic. input, pin 5). In Figure 1 it is designated X1102.
On the DSB35 Support Box board, the signals of the X1102 microphone jack and the X1100 Western jack for the handset are added with N1100-5.
The stereo jack connections are shown in Figure 3 below.

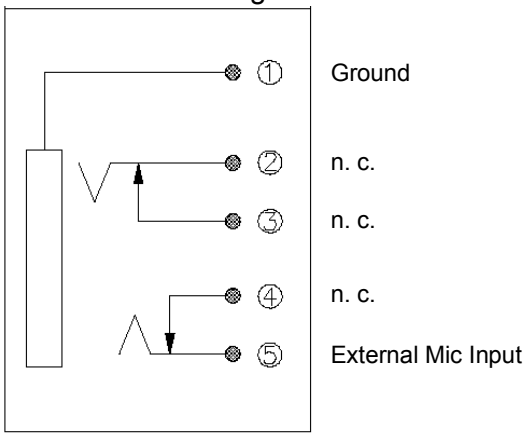

Figure 3: Pin assignment – X1102 jack for microphone signal

3.3 Handset connector (X1100)

The DSB35 Support Box uses a 4-pin Western jack for the handset. The pin assignment of the Western jack is shown in Table 3.1 below:

Signal name	Pin	I/O	Description
HS_MIC-	1	I	Microphone minus
HS_LS-	2	O	Loudspeaker minus
HS_LS+	3	O	Loudspeaker signal
HS_MIC+	4	I	Microphone signal

Table 3.1: Pin assignment of the Western jack used for the Handset

3.4 Type Approved Handset for TC35

This passive handset requires an extra power supply for the microphone as implemented on DSB35 Support Box. The power supply of the microphone has a voltage of 6V, the load resistance is 2 x 4.7kΩ.

Other handset types you may want to integrate into your TC35 application are not covered by the approval issued for the Siemens reference configuration. You may be required to achieve an extra approval for specific handsets or audio equipment (see also Chapter 2).

Odering information:
M20 Terminal Handset Votronic no. HH-SI-30.3/V2.0/0

3.5 Power supply for audio interface

The power supply for the analog part (VANA) is 10V.

3.6 RF Protection

C1105, C1116, C1103, prevent your TC35 application from causing RF interference across the audio path. These capacitors are located close to the pins to be protected.

3.7 EMC

To ensure that your TC35 application meets EMC requirements, it is recommended to add ferrite beads L1151,L1152, L1153, L1154, L1157, L1159, L1159, L1160, L1162, L1163 to protect external lines from radiating. These inductors are located close to the appropriate connectors if necessary.

3.8 Component lists

3.8.1 Bill of material (audio interface)

Pos	Label	Component	-Tol	+Tol	Form	Voltage	Others
1	C1100	220N	10%	10%	0603	10	
2	C1101	100N	80%	20%	0402	16	
3	C1103	27P	5%	5%	0402	25	
4	C1104	10U	20%	20%	Tantal A	10	
5	*C1105*	*27P*	*2%*	*2%*	0402	*25*	*RF protection*
7	C1109	47U	20%	20%	Tantal D	16	
8	C1110	47N	10%	10%	0805	25	
9	C1111	100U	20%	20%	Tantal D	16	
10	C1112	100N	80%	20%	0402	16	
11	C1116	27P	5%	5%	0402	25	
12	C1118	27P	5%	5%	0402	25	
13	C1119	100N	80%	20%	0402	16	
14	C1120	100N	80%	20%	0402	16	
15	C1122	100U	20%	20%	Elko E	25	
16	C1124	10U	20%	20%	Tantal A	10	
17	C1125	100N	20%	20%	0402	16	
18	C1126	100U	20%	20%	Tantal E	16	
21	C1132	10U	20%	20%	Tantal A	10	
22	C1133	47N	10%	10%	0805	25	
23	C1134	47N	10%	10%	0805	25	
24	C1135	10N	10%	10%	0603	50	
25	C1136	1N	5%	5%	0603	25	
26	C1137	10N	10%	10%	0603	50	
27	L1151	600R/100MHZ	0%	0%	0805		Murata
28	L1152	600R/100MHZ	0%	0%	0805		Murata
29	L1153	600R/100MHZ	0%	0%	0805		Murata
30	L1154	600R/100MHZ	0%	0%	0805		Murata
31	L1157	600R/100MHZ	0%	0%	0805		Murata
32	L1159	600R/100MHZ	0%	0%	0805		Murata
33	L1160	600R/100MHZ	0%	0%	0805		Murata
34	L1162	600R/100MHZ	0%	0%	0805		Murata
35	L1163	600R/100MHZ	0%	0%	0805		Murata
36	N1100-1	TL074ACD	-	-	SO14		Texas Instrument
37	N1100-2	TL074ACD	-	-	SO14		Texas Instrument
38	N1100-3	TL074ACD	-	-	SO14		Texas Instrument
39	N1100-4	TL074ACD	-	-	SO14		Texas Instrument
40	N1100-5	TL074ACD	-	-	SO14		Texas Instrument
41	R1101	10K	1%	1%	0402		
42	R1102	10K	5%	5%	0402		
43	R1103	10K	5%	5%	0402		
44	R1104	100K	1%	1%	0402		
45	R1106	10R	2%	2%	0805		
47	R1108	1K	5%	5%	0402		

Pos	Label	Component	-Tol	+Tol	Form	Voltage	Others
48	R1109	2K	2%	2%	0603		
49	R1110	47K	5%	5%	0402		
50	R1111	47K	5%	5%	0402		
51	R1112	47K	5%	5%	0402		
52	R1113	47K	5%	5%	0402		
54	R1116	100R	2%	2%	0805		
57	R1119	10K	5%	5%	0402		
58	R1120	10K	5%	5%	0402		
59	R1121	150K	1%	1%	0402		
60	R1123	10K	5%	5%	0402		
61	R1124	10K	5%	5%	0402		
62	R1125	10K	5%	5%	0402		
63	R1126	10K	5%	5%	0402		
64	R1164	4K7	1%	1%	0603		
65	*R1165*	*1K*	*1%*	*1%*	0402		
66	R1166	4K7	5%	5%	0402		
67	X1100	4-POL	-	-	4P4C Western		
68	X1101	5-POL	-	-	5pol stereo jack		
69	X1102	5-POL	-	-	5pol stereo jack		

Table 3.2: Bill of Material (audio interface)

4 Solutions

4.1 Solutions with internal microphone feeding

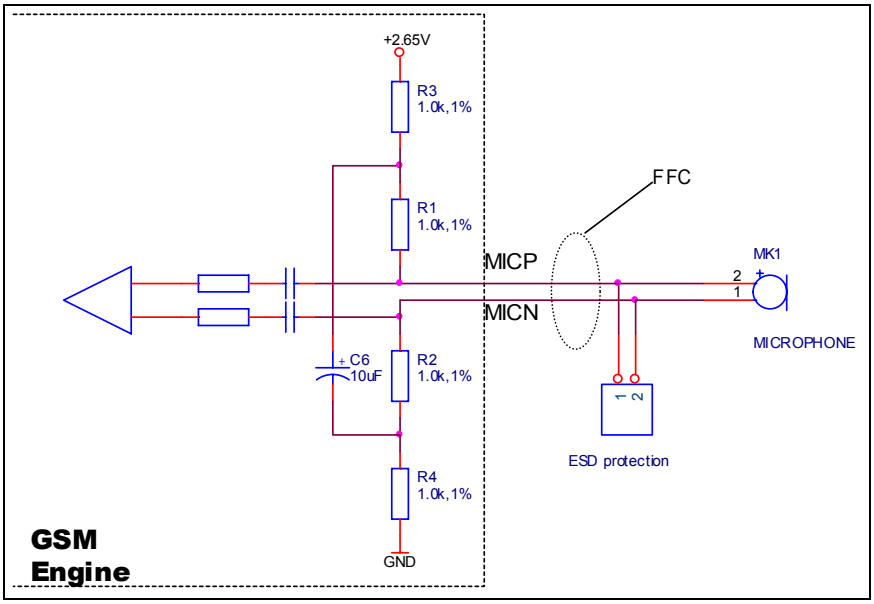

Figure 4: Idealised diagram of the audio input terminal

TC35/37 comes with an internal microphone feeding according to Figure 4 (same for MIC1and MIC2). The microphone signal is very sensitive for any disturbers via power supply, ground bouncing or direct RF intrusion and demodulation. It is recommended to use a strictly balanced microphone line. The microphone should have a sensitivity of at least –44 ±3 dB/Pa at 2V and 2kΩ (0dB=1V/Pa, 1kHz). It should be equipped with internal EMI capacitors for GSM900/1800.

If there is a need for an independend microphone feeding, there are recommended two solutions in chapter 4.2

4.2 Solutions for external microphone feeding

1. Figure 5 with opamp shows a simple feeding of the electret microphone (R1, R2, C6). If the output resistance of the opamp is below 3 Ohms, the balance requirements should be meet sufficiently. The sensitivity of GSM-module can be reduced easily by AT^SNFI command. Compare chapter 6.2.

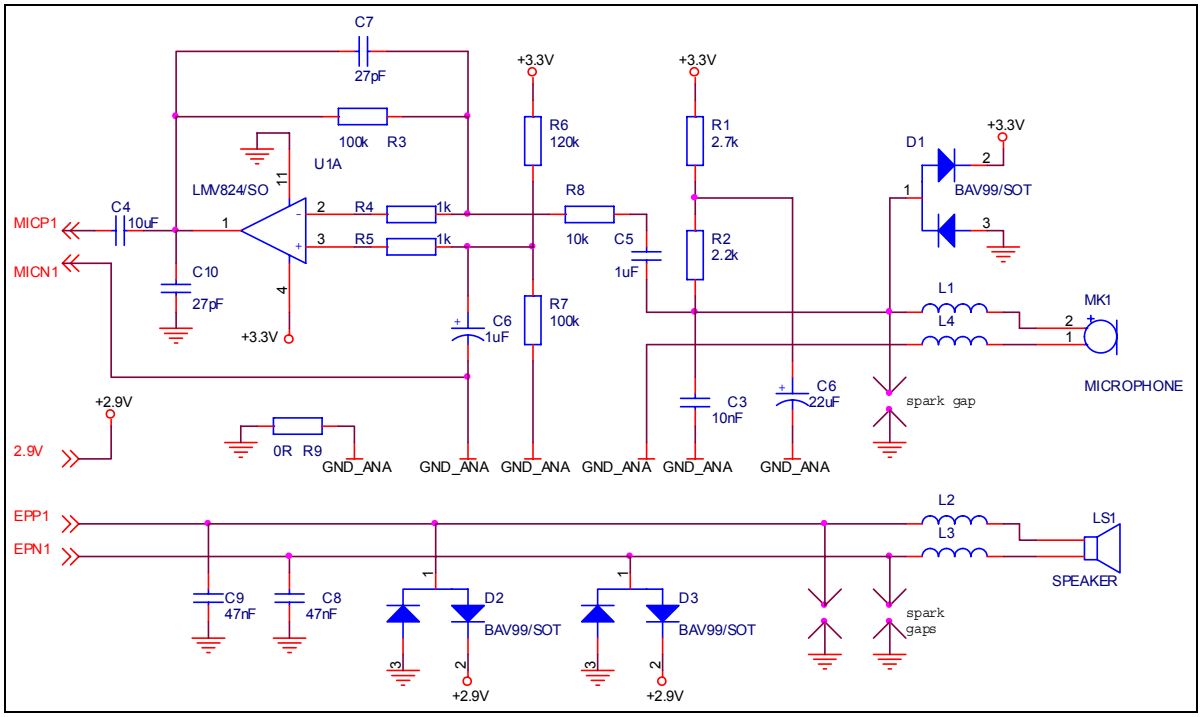

Figure 5: Circuit of microphone feeding with use of an opamp close to the microphone

C10, R4 and R5 in Figure 5 shall suppress demodulation close to the opamp. There should be no gnd next to these parts – if possible. The GND_ANA net should be a separate small net which is connected to GND at a single point (symbolic R9).

2. Figure 6 shows a solution with balanced feeding of microphone. The distance to the GSM-module should be short because of the small level of the microphone signal and ground bouncing between GSM-module and application.

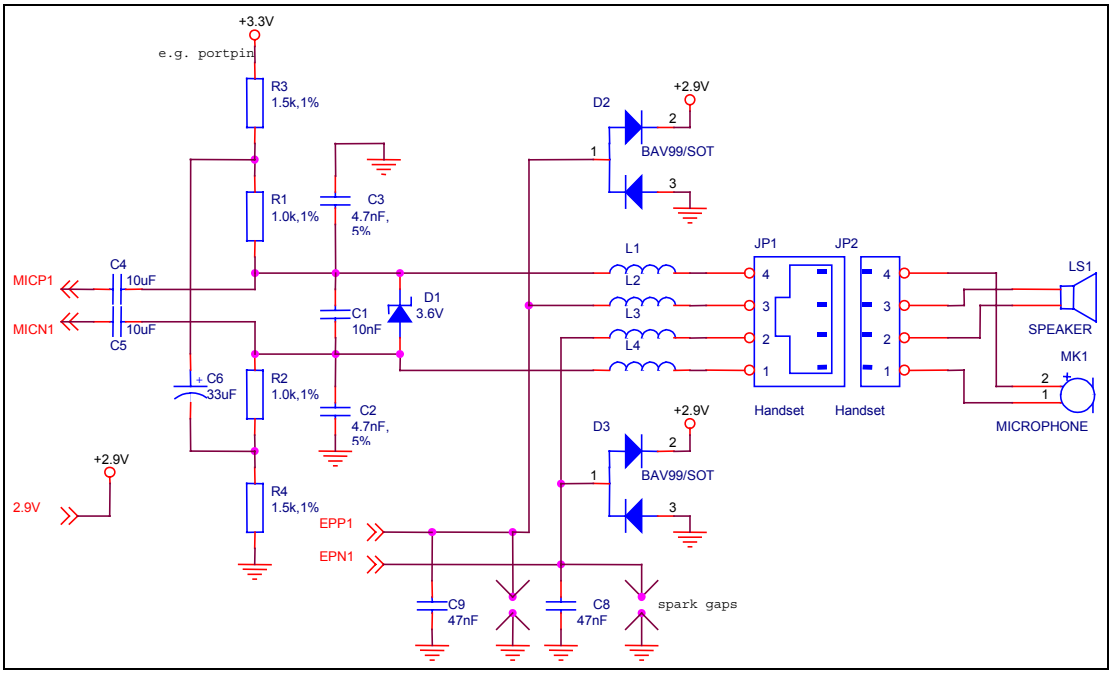

Figure 6: Circuit of a balanced microphone feeding

R3, R4, C6 have to provide sufficient smoothing of feeding voltage. In the second case the microphone should have a sensitivity of at least –38 ±3 dB/Pa at 3.3V and 2kΩ (0dB=1V/Pa, 1kHz).

There are proposed ESD and EMC devices in both figures which are explained in chapter 5.

4.3 Direct use of speaker signal

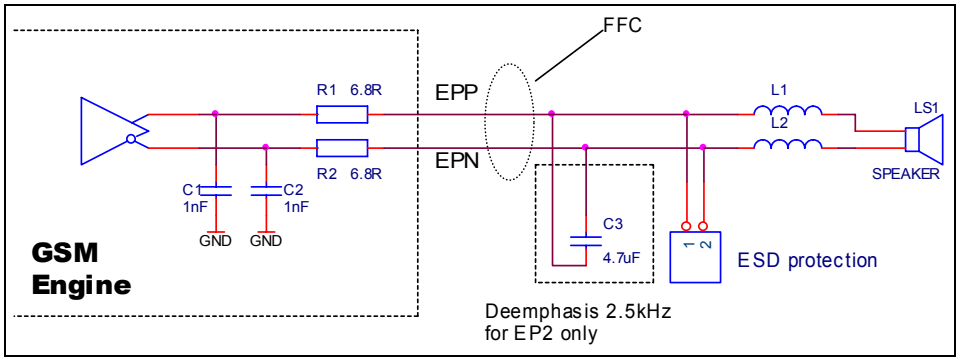

Figure 7: Idealised diagram of the audio output terminal

The GSM Engine is able to drive speakers which are close to the ear (Figure 7). C3 compensates the 2.5kHz, 1st order preemphasis beeng implemented in mode AT^SNFS=2 and 3 as default. This reduces noise floor of power amplifier.
Figure 5 and Figure 6 show samples of direct speaker connections to the GSM module. The frequency response and loudness heavy depends on measurement method, housing, fitting and impedance. An impedance of 16Ω (louder) to 32Ω is recommended.

4.4 Solutions for decoupling the speaker signal

The speaker signal is balanced. Ground bouncing inhibits direct use of this signal. Therefore it is recommended to use an opamp to transform the reference point. C10 avoids demodulation at output of U1.

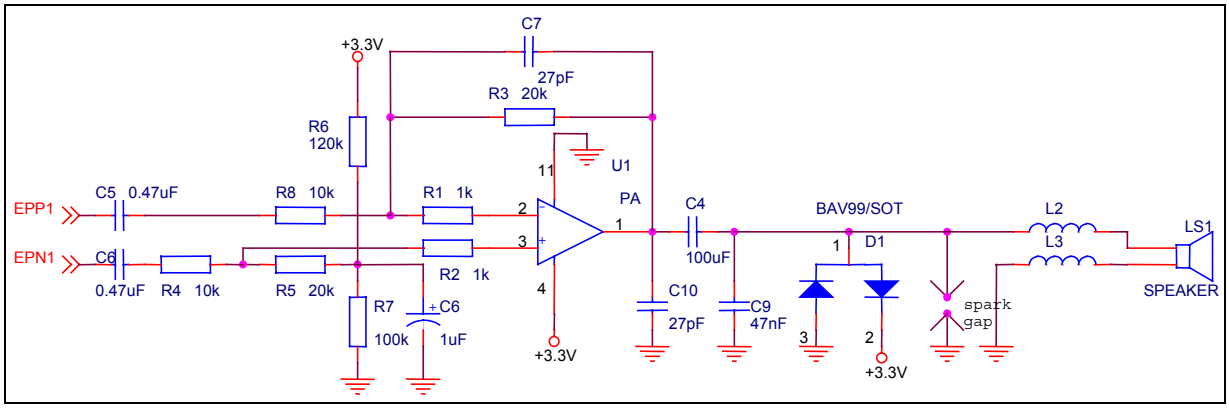

Figure 8: speaker decoupling

5 Methods of Overvoltage-Protection

In the following there are some possibilities of Overvoltage Protection described which are especially recommended against ESD (Electic Static Discharge). You can use one of the described methods or several methods in parallel.

5.1 Spark Gap

The main protection against ESD is the Spark Gap (e.g. realized at the SIM-interface of the Module TC37). The Spark Gap should be realized within the layout, close to the possible place of flashover. One tip must be connected to the ground plane the other to the point to be protected.
Advantages: Low cost, if realized by the layout
Disadvantage: value of the ignition voltage is fuzzy.

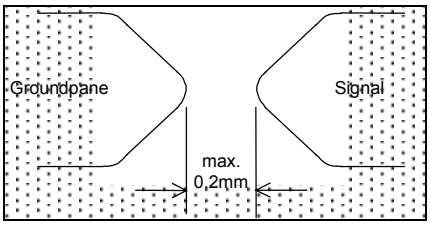

Figure 9: Spark gap

5.2 Clamp Diodes

A pair of diodes (e.g. BAV99) is required; the anode must be connected to GND and the cathode to the positive supply voltage (see the schematic Figure 5, Figure 6 and Figure 8).
Advantages: Low cost, little space consumption.
Disadvantages: The overvoltage is fuzzy as it depends mainly on the internal resistor of the diode. You can improve it by using Schottky-diodes or highcurrent diodes.

5.3 Clamp Diodes with external serial resistor

By using a resistor in series to the clamp diodes you can reduce the current flowing through the diodes. In this way the voltagedrop over the diodes decreases. The higher the value of the resistor the lower the voltagedrop of the diodes, but the higher the voltagedrop of the resistor.

5.4 Z-Diodes

Especially feeded electret microphones should be protected by a Z-diode in parallel (see Figure 6).

5.5 Capacitors

Additional to the described methods above some capacitors to GND are recommended – especially in the audio-lines (see Figure 5, Figure 6 and Figure 8).

6 Use of AT^SNFS, AT^SNFO and AT^SNFI

Here are shown samples of usage of the above mentioned audio commands being described in the ATC handbook.

No.	Name	Selection with AT command	Purpose	Mic.-fee-ding	Description
1	Default Handset	AT^SNFS=1	Approval configuration	*2.65V*	MIC1, EP1, adapted to M20T-Handset with DSB35
2	Basic Handsfree	AT^SNFS=2		*2.65V*	MIC2, EP2, adapted to Siemens CarKit Portable 5 volume steps selectable
3	Headset	AT^SNFS=3		*2.65V*	MIC2, EP2, adapted to Mono-Headset K45 5 volume steps selectable
4	UserHandset	AT^SNFS=4		*2.65V*	MIC1, EP1, adapted to M20T-Handset with DSB35 5 volume steps selectable
5	Plain Codec	AT^SNFS=5		*0V*	MIC1, EP1, no filtering 5 volume steps selectable
6	Plain Codec	AT^SNFS=6		*0V*	MIC2, EP2, no filtering 5 volume steps selectable

Table 6.1: Selectable audio modes

A further description of these audio modes you can find in the TC35_HW_Interface_description.

There are many ways to adjust the volume at different places permanently or volatile. The easiest volatile way is the AT^SNFL or AT+CLVL command with 5 predefined volume steps for each audio mode. Table 6.2 shows the default settings for output parameters. You get this as a result of AT^SNFO?

Mode	default settings	
^SNFS=1	^SNFO=1,16384,16384,16384,16384,16384,4,4096	(no steps)
^SNFS=2	^SNFO=3,4658,6301,8500,11205,15115,4,0	(2.5dB steps)
^SNFS=3	^SNFO=3,1254,2452,4891,9759,16383,4,1365	(6dB steps)
^SNFS=4	^SNFO=1,10337,11598,13014,14602,16384,4,4096	(1dB steps)
^SNFS=5	^SNFO=0,16384,16384,16384,16384,16384,4,0	(no steps)
^SNFS=6	^SNFO=0,16384,16384,16384,16384,16384,4,0	(no steps)

Table 6.2: Default values of audio modes (subject to be changed)

6.1 Change of loudness step settings

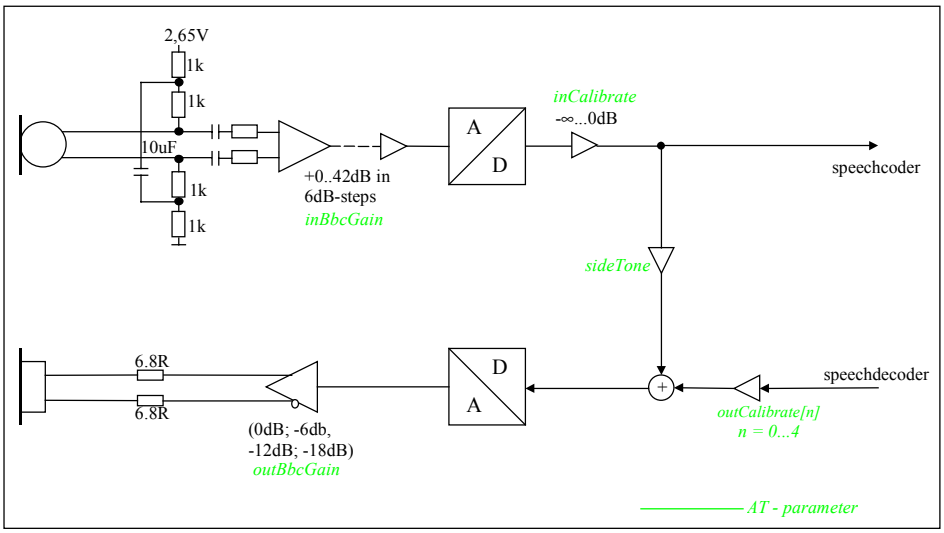

Figure 10: By AT commands influenced values

At modes AT^SNFS=<2...6> these volume steps can be changed to customer values permanently. This is demonstrated in the following lines:

AT^SNFS=4	(select UserHandset)
AT^SNFO?	
^SNFO=1,10337,11598,13014,14602,16384,4,4096	(default 1dB steps)
steps	
AT^SNFS=4	(select UserHandset)
AT^SNFO=1,6528,8192,10368,13056,16384,4,4096	(2dB steps)
AT^SNFW	(write to nonvolatile memory)
or	
AT^SNFS=4	(select UserHandset)
AT^SNFO=1,4096,5824,8192,11616,16384,4,4096	(3dB steps)
AT^SNFW	(write to nonvolatile memory)

Now AT+CLVL=<0...4> chooses the new loudness step. These permanent settings can be reversed by

AT^SNFD	(recall manufacturer default)

The value for sideTone is adapted automatically depending on the volume. So there is no need to change it if is been adjusted one time.

An alternative possibility with use of the 6dB step analogue attenuators you can find here. This causes better noise characteristic at smaller loudness rates. Command AT+CLVL does not work in this kind of loudness control because it is kept at a fix value. So you have to type the full command line if a new volume step is needed.

AT^SNFS=4	(select UserHandset)
AT+CLVL=4	(default)
AT^SNFO=1,0,0,0,0,16384,4,4096	(default)
AT^SNFO=0,0,0,0,0,16384,4,4096	(default + 6 dB)
AT^SNFO=2,0,0,0,0,16384,4,4096	(default – 6 dB)
AT^SNFO=2,0,0,0,0,12288,4,4096	(default – 9 dB)
AT^SNFO=3,0,0,0,0,16384,4,4096	(default – 12 dB)
AT^SNFD	(recall manufacturer default)

6.2 Change of microphone sensitivity

The microphone sensitivity contains 6dB step analogue amplifiers and a digital multiply value. As in the previous chapter it can be made permanent.

AT^SNFS=4	(select UserHandset)
AT^SNFI?	
^SNFI=5,14602	(default)
AT^SNFI=2,14602	(default – 18 dB)
AT^SNFW	(write to nonvolatile memory)

These permanent settings can be reversed by

AT^SNFD	(recall manufacturer default)

7 Handsfree concept

The Handsfree mode (AT^SNFS=2) has been optimized for Car Kit Portable and for a special arrangement of microphone, speaker and user (see Figure 11). Physically audio interface 2 is used.
EP2 output is followed by a power amplifier with gain 20..40dB. The external microphone amplifier with gain 30..50dB needs to have good noise characteristic. Final adjustments can be done easily with AT^SNFO, AT^SNFI and AT^SNFW.
High sensitivity of microphone and small speaker distortion increase the efficiency of DSP echo cancellation and noise reduction routine.

Odering information:
Car Kit Portable (Siemens product no. L36880-N3015-A117)

Reference application:

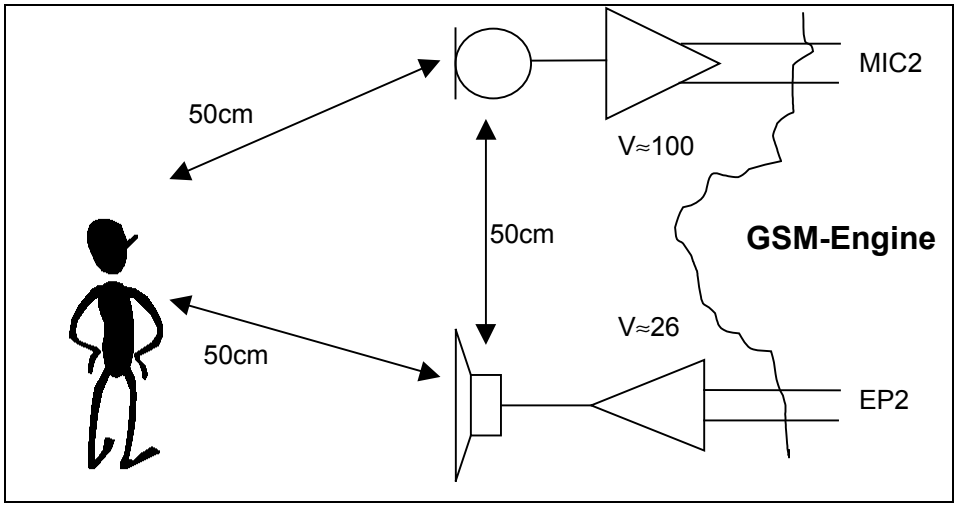

Figure 11: hands free arrangement with Car Kit Portable

There is no filter implemented at Handsfree mode so the frequency response of added devices should be flat.
There is nearly no automatic gain control at microphone path due to the better voice quality. Only loudness of speaker is influenced by user. An environmental noise depending dynamic compression of approx. 10dB is activated in the receive path, which is pleasant, particularly in noisy environment (car).

8 Suppliers of acoustic devices

The following list does not represent any kind of quality evidence of company. Its just a starting point for further investigations:

Company	Country	Product types
Panasonic	USA	mic, rcv, spk
Hosiden	Japan	mic, rcv, spk
Bujeon	Korea	mic, rcv, spk
Keyrin	Korea	rcv, spk
YiLi	China	mic,

Table 8.1: Suppliers of acoustic devices

legend:
mic: microphones
rcv: receiver
spk: speaker