

GE864 Hardware User Guide

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1 Overview

The aim of this document is the description of some hardware solutions useful for developing a product with the [Telit GE864-QUAD / PY module](#).

In this document all the basic functions of a mobile phone will be taken into account; for each one of them a proper hardware solution will be suggested and eventually the wrong solutions and common errors to be avoided will be evidenced. Obviously this document cannot embrace the whole hardware solutions and products that may be designed. The wrong solutions to be avoided shall be considered as mandatory, while the suggested hardware configurations shall not be considered mandatory, instead the information given shall be used as a guide and a starting point for properly developing your product with the [Telit GE864-QUAD / PY module](#). For further hardware details that may not be explained in this document refer to the Telit GE864-QUAD / PY Product Description document where all the hardware information is reported.

NOTICE

(EN) The integration of the GSM/GPRS GE864-QUAD cellular module within user application shall be done according to the design rules described in this manual.

(IT) L'integrazione del modulo cellulare GSM/GPRS GE864-QUAD all'interno dell'applicazione dell'utente dovrà rispettare le indicazioni progettuali descritte in questo manuale.

(DE) Die Integration des GE864-QUAD GSM/GPRS Mobilfunk-Moduls in ein Gerät muß gemäß der in diesem Dokument beschriebenen Konstruktionsregeln erfolgen

(SL) Integracija GSM/GPRS GE864-QUAD modula v uporabniški aplikaciji bo morala upoštevati projektna navodila, opisana v tem priročniku.

(SP) La utilización del modulo GSM/GPRS GE864-QUAD debe ser conforme a los usos para los cuales ha sido diseñado descritos en este manual del usuario

(FR) L'intégration du module cellulaire GE864-QUAD GSM/GPRS dans l'application de l'utilisateur sera faite selon les règles de conception décrites dans ce manuel

(HE) האינטגרטור מתבקש ליישם את ההנחיות המפורטות במסמך זה בתהליך האינטגרציה של המודם הסלולרי GE864-QUAD עם המוצר.

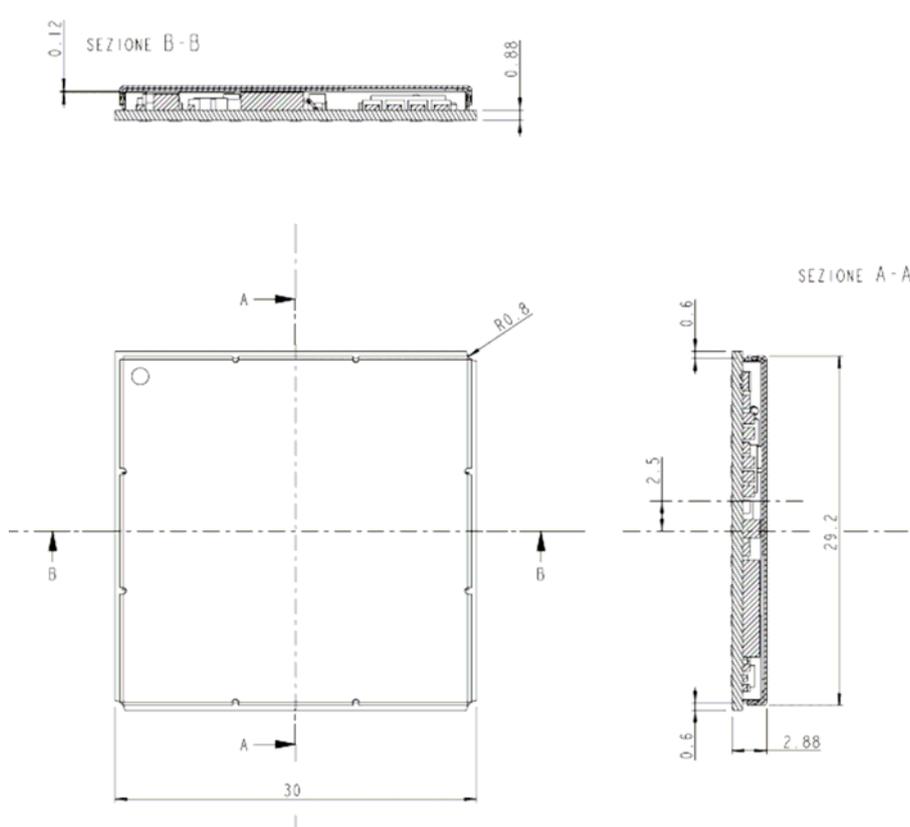
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2 GE864 Mechanical Dimensions

The [Telit GE864 module](#) overall dimension are:

- **Length:** 30 mm
- **Width:** 30 mm
- **Thickness:** 2.8 mm



3 GE864 module connections

3.1 PIN-OUT

Ball	Signal	I/O	Function	Internal PULL UP	Type
Audio					
H9	EAR_MT-	AO	Handset earphone signal output, phase -		Audio
G10	EAR_MT+	AO	Handset earphone signal output, phase +		Audio
H10	EAR_HF+	AO	Handsfree ear output, phase +		Audio
J10	EAR_HF-	AO	Handsfree ear output, phase -		Audio
J8	MIC_MT+	AI	Handset mic.signal input; phase+, nom. level 50mVrms		Audio
G9	MIC_MT-	AI	Handset mic.signal input; phase-, nom. level 50mVrms		Audio
G8	MIC_HF+	AI	Handsfree mic. input; phase +, nom. level 3mVrms		Audio
J9	MIC_HF-	AI	Handsfree mic.input; phase -, nom. level 3mVrms		Audio
F9	AXE	I	Handsfree switching	100K	CMOS 2.8V
G5	VMICP	O	Microphone supply (*)		
G3	VMICN	O	Microphone supply (*)		
SIM card interface					
C10	SIMCLK	O	External SIM signal – Clock		1,8 / 3V
E9	SIMRST	O	External SIM signal – Reset		1,8 / 3V
D10	SIMIO	I/O	External SIM signal - Data I/O		1,8 / 3V
C11	SIMIN	I	External SIM signal - Presence (active low)	47K	1,8 / 3V
D4 ¹	SIMVCC	-	External SIM signal – Power supply for the SIM		1,8 / 3V
Trace					
D11	TX_TRACE	O	TX Data for debug monitor		CMOS 2.8V
F10	RX_TRACE	I	RX Data for debug monitor		CMOS 2.8V
Prog. / Data + HW Flow Control					
E7	C103/TXD	I	Serial data input (TXD) from DTE		CMOS 2.8V
H8	C104/RXD	O	Serial data output to DTE		CMOS 2.8V
B7	C108/DTR	I	Input for Data terminal ready signal (DTR) from DTE		CMOS 2.8V
F7	C105/RTS	I	Input for Request to send signal (RTS) from DTE		CMOS 2.8V
F6	C106/CTS	O	Output for Clear to send signal (CTS) to DTE		CMOS 2.8V
D9	C109/DCD	O	Output for Data carrier detect signal (DCD) to DTE		CMOS 2.8V
E11	C107/DSR	O	Output for Data set ready signal (DSR) to DTE		CMOS 2.8V

¹ On this line a maximum of 10nF bypass capacitor is allowed



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Ball	Signal	I/O	Function	Internal PULL UP	Type
B6	C125/RING	O	Output for Ring indicator signal (RI) to DTE		CMOS 2.8V
IIC bus					
D7	CAM_SDA / IIC_SDA	I/O	Camera IIC interface / Configurable GPIO		CMOS 2.8V
C6	CAM_SCL / IIC_SCL	I/O	Camera IIC interface / Configurable GPIO		CMOS 2.8V
DAC and ADC					
C7	DAC_OUT	AO	Digital/Analog converter output		D/A
J11	ADC_IN1	AI	Analog/Digital converter input		A/D
H11	ADC_IN2	AI	Analog/Digital converter input		A/D
G11	ADC_IN3	AI	Analog/Digital converter input		A/D
Miscellaneous Functions					
A2	RESET*	I	Reset input		
E2	VRTC	AO	VRTC Backup capacitor		Power
D8	STAT_LED	O	Status indicator led		CMOS 1.8V
G1	CHARGE	AI	Charger input (*)		Power
G2	CHARGE	AI	Charger input (*)		Power
F8	MON1 / CAM_CLK	I/O	MON1 / Camera interface		CMOS 2.8V
J5	ON_OFF*	I	Input command for switching power ON or OFF (toggle command). The pulse to be sent to the GE864 must be equal or greater than 1 second.	47K	Pull up to VBATT
D5	VAUX1	-	Power output for external accessories		-
C5	VIBRO_EP	O	Vibrator motor driver output (*)		
L8	PWRMON	O	Power ON Monitor		CMOS 2.8V
L4	Antenna	O	Antenna output - 50 ohm		RF
GPIO					
G4	TGPIO_12	I/O	Telit GPIO12 Configurable GPIO		CMOS 2.8V
E5	TGPIO_23	I/O	Reserved to detect ON/OFF. It is physically connected to L8 (PWRMON)		CMOS 2.8V
C2	TGPIO_03	I/O	Telit GPIO03 Configurable GPIO		CMOS 2.8V
B3	TGPIO_04	I/O	Telit GPIO04 Configurable GPIO		CMOS 2.8V
C3	TGPIO_20	I/O	Telit GPIO20 Configurable GPIO		CMOS 2.8V
B4	TGPIO_14	I/O	Telit GPIO14 Configurable GPIO		CMOS 2.8V
D1	TGPIO_11	I/O	Telit GPIO11 Configurable GPIO		CMOS 2.8V
B1	TGPIO_19	I/O	Telit GPIO19 Configurable GPIO		CMOS 2.8V
C1	TGPIO_01	I/O	Telit GPIO01 Configurable GPIO		CMOS 2.8V
K7	TGPIO_18	I/O	Telit GPIO18 I/O pin		CMOS 2.8V
H5	TGPIO_17	I/O	Telit GPIO17 GPIO pin		CMOS 2.8V
F5	TGPIO_15	I/O	Telit GPIO15 GPIO pin		CMOS 2.8V
K11	TGPIO_08 / CAM_ON	I/O	Telit GPIO08 Configurable GPIO / Camera Interface		CMOS 2.8V
B5	TGPIO_06 / ALARM	I/O	Telit GPIO06 Configurable GPIO / ALARM		CMOS 2.8V
C9	TGPIO_09 / CAM_RST	I/O	Telit GPIO09 GPIO I/O pin / Camera Interface		CMOS 2.8V
E6	TGPIO_02 / JDR	I/O	Telit GPIO02 I/O pin / Jammer detect report		CMOS 2.8V
L9	TGPIO_07 / BUZZER	I/O	Telit GPIO07 Configurable GPIO / Buzzer		CMOS 2.8V
H6	TGPIO_16	I/O	Telit GPIO16 Configurable GPIO		CMOS 2.8V
K10	TGPIO_13	I/O	Telit GPIO13 Configurable GPIO		CMOS 2.8V



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Ball	Signal	I/O	Function	Internal PULL UP	Type
K8	TGPIO_05 / RFTXMON	I/O	Telit GPIO05 Configurable GPIO / Transmitter ON monitor		CMOS 2.8V
L10	TGPIO_21	I/O	Telit GPIO21 Configurable GPIO		CMOS 2.8V
E8	TGPIO_22	I/O	Telit GPIO22 Configurable GPIO		CMOS 1.8V (not 2.8V !!)
H3	TGPIO_10	I/O	Telit GPIO10 I/O pin		CMOS 2.8V
Power Supply					
J1	VBATT	-	Main power supply		Power
K1	VBATT	-	Main power supply		Power
J2	VBATT	-	Main power supply		Power
K2	VBATT	-	Main power supply		Power
A1	GND	-	Ground		Power
F1	GND	-	Ground		Power
H1	GND	-	Ground		Power
L1	GND	-	Ground		Power
H2	GND	-	Ground		Power
L2	GND	-	Ground		Power
J3	GND	-	Ground		Power
K3	GND	-	Ground		Power
L3	GND	-	Ground		Power
K4	GND	-	Ground		Power
K5	GND	-	Ground		Power
D6	GND	-	Ground		Power
K6	GND	-	Ground		Power
L6	GND	-	Ground		Power
A11	GND	-	Ground		Power
F11	GND	-	Ground		Power
L11	GND	-	Ground		Power
RESERVED					
A10		-			
A3		-			
A4		-			
A5		-			
A6		-			
A7		-			
A8		-			
A9		-			
B10		-			
B11		-			
B2		-			
B8		-			
B9		-			
C4		-			
C8		-			



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Ball	Signal	I/O	Function	Internal PULL UP	Type
D2		-			
D3		-			
E1		-			
E10		-			
E3		-			
E4		-			
F2		-			
F3		-			
F4		-			
G6		-			
G7		-			
H4		-			
H7		-			
J4		-			
J6		-			
J7		-			
K9		-			
L5		-			
L7		-			

NOTE: RESERVED pins must not be connected

NOTE: If not used, almost all pins should be left disconnected. The only exceptions are the following pins:

pin	signal
J1,K1,J2,K2	VBATT
A1,F1,H1,L1,H2,L2,J3,K3,L3, K4,K5,D6,K6,L6,A11,F11,L11	GND
J5	ON/OFF*
E7	TXD
A2	RESET*
H8	RXD
F7	RTS ²

² RTS should be connected to the GND (on the module side) if flow control is not used



3.1.1 BGA Balls Layout

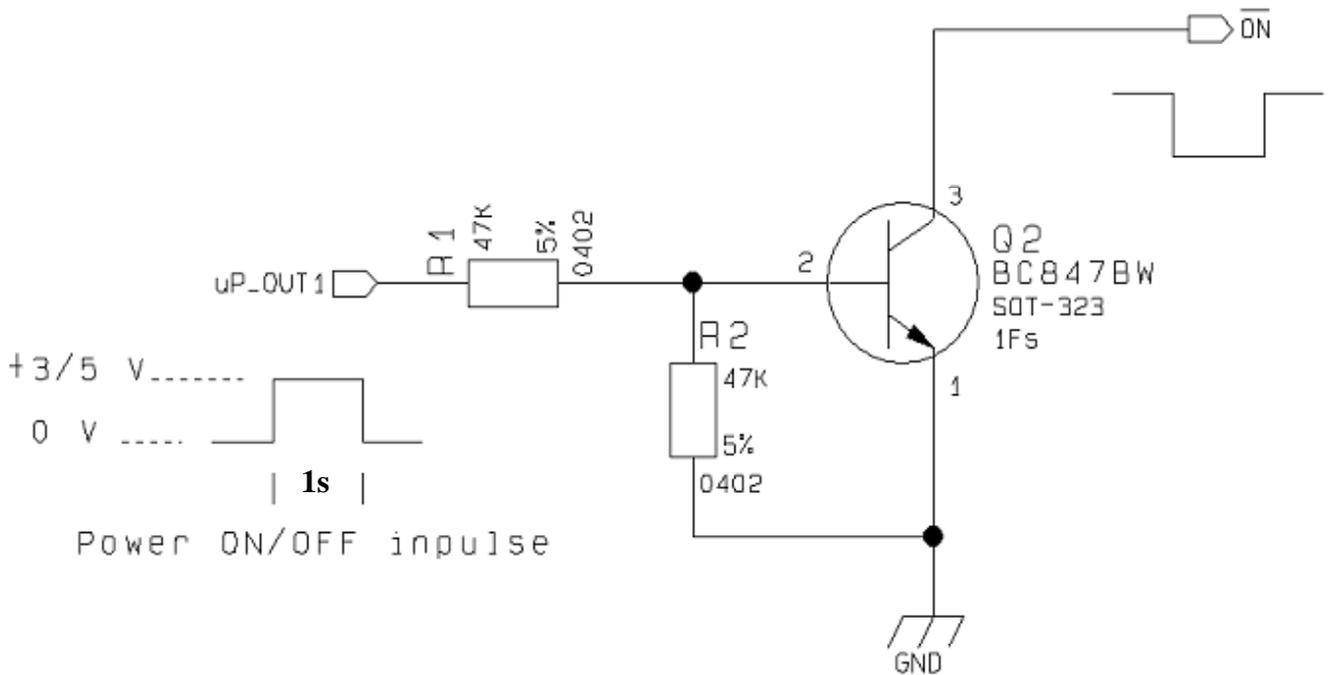
TOP VIEW

	A	B	C	D	E	F	G	H	J	K	L
1	GND	TGPIO_19	TGPIO_01	TGPIO_11	-	GND	CHARGE	GND	VBATT	VBATT	GND
2	RESET*	-	TGPIO_03	-	VRTC	-	CHARGE	GND	VBATT	VBATT	GND
3	-	TGPIO_04	TGPIO_20	-	-	-	VMICN	TGPIO_10	GND	GND	GND
4	-	TGPIO_14	-	SIMVCC	-	-	TGPIO_12	-	-	GND	Antenna
5	-	TGPIO_06 / ALARM	VIBRO_EP	VAUX1	TGPIO_23	TGPIO_15	VMICP	TGPIO_17	ON_OFF*	GND	-
6	-	C125/RING	CAM_SCL / IIC_SCL	GND	TGPIO_02 / JDR	C106 / CTS	-	TGPIO_16	-	GND	GND
7	-	C108 / DTR	DAC_OUT	CAM_SDA / IIC_SDA	C103 / TXD	C105 / RTS	-	-	-	TGPIO_18	-
8	-	-	-	STAD_LED	TGPIO_22	MON1 / CAM_CLK	MIC_HF+	C104 / RXD	MIC_MT+	TGPIO_05 / RFTXMON	PWRMON / TESTMODE*
9	-	-	TGPIO_09 / CAM_RST	C109 / DCD	SIMRST	AXE	MIC_MT-	EAR_MT-	MIC_HF-	-	TGPIO_07 / BUZZER
10	-	-	SIMCLK	SIMIO	-	RX_TRACE	EAR_MT+	EAR_HF+	EAR_HF-	TGPIO_13	TGPIO_21
11	GND	-	SIMIN	TX_TRACE	C107 / DSR	GND	ADC_IN3	ADC_IN2	ADC_IN1	TGPIO_08 / CAM_ON	GND

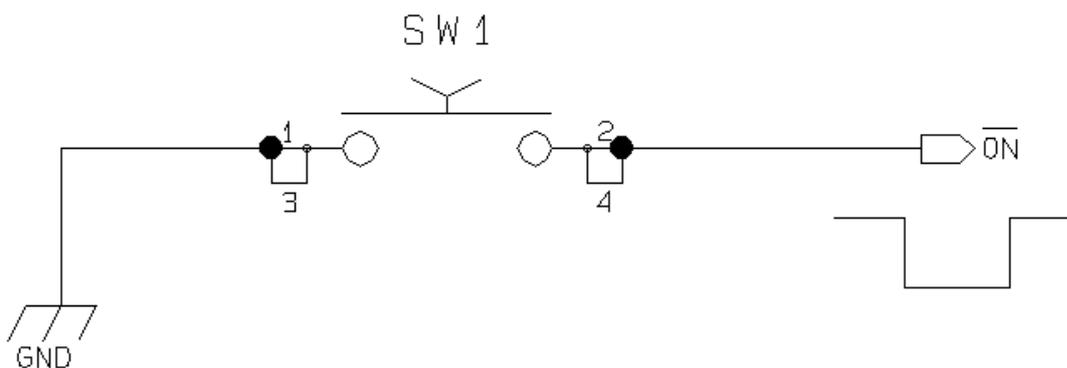


For example:

1- Let's assume you need to drive the ON# pad with a totem pole output of a +3/5 V microcontroller (uP_OUT1):



2- Let's assume you need to drive the ON# pad directly with an ON/OFF button:



4.2 Turning OFF the GE864-QUAD / PY

The turning off of the device can be done in three ways:

- by software command (see GE864-QUAD / PY Software User Guide)
- by hardware shutdown
- by Hardware Unconditional Restart

When the device is shut down by software command or by hardware shutdown, it issues to the network a detach request that informs the network that the device will not be reachable any more.

4.2.1 Hardware shutdown

To turn OFF the GE864-QUAD / PY the pad ON# must be tied low for at least 2 seconds and then released.

The same circuitry and timing for the power on shall be used.
The device shuts down after the release of the ON# pad.

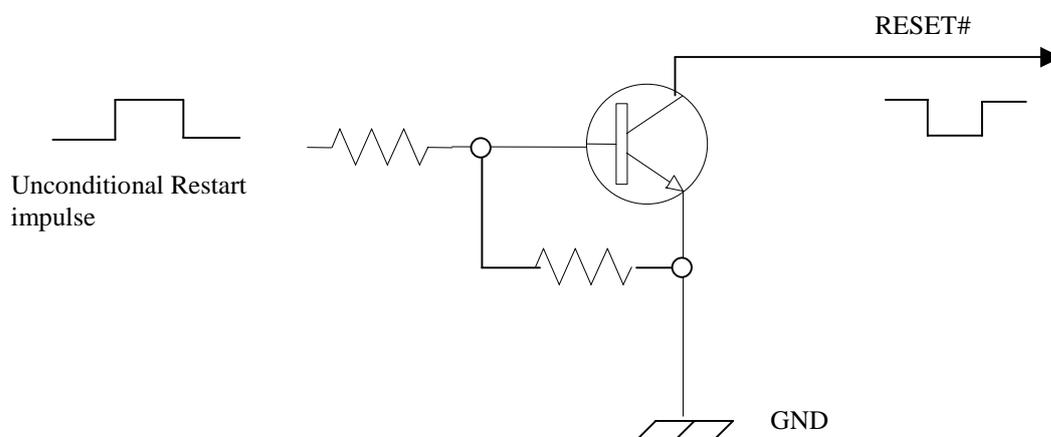


TIP: To check if the device has powered off, the hardware line PWRCTL should be monitored. When PWRCTL goes low, the device has powered off.

4.2.2 Hardware Unconditional Restart

To unconditionally Restart the GE864-QUAD / PY, the pad RESET# must be tied low for at least 200 milliseconds and then released.

The maximum current that can be drained from the ON# pad is 0,15 mA.
A simple circuit to do it is:





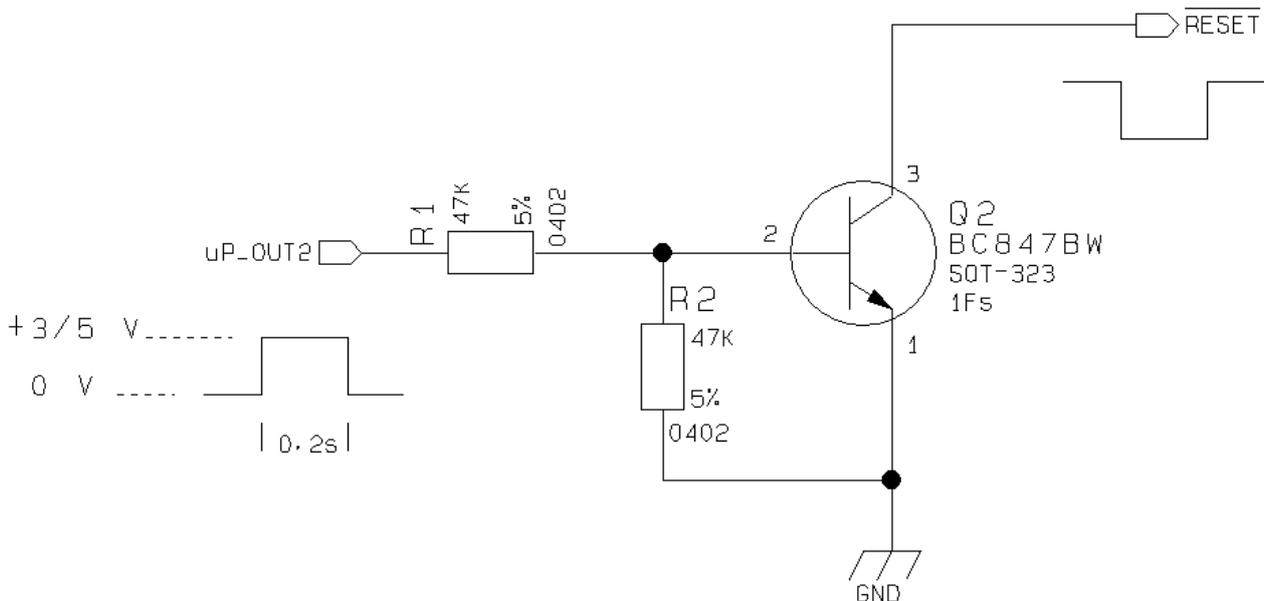
NOTE: don't use any pull up resistor on the RESET# line nor any totem pole digital output. Using pull up resistor may bring to latch up problems on the GE864-QUAD / PY power regulator and improper functioning of the module. The line RESET# must be connected only in open collector configuration.



TIP: The unconditional hardware Restart should be always implemented on the boards and software should use it as an emergency exit procedure.

For example:

1- Let's assume you need to drive the RESET# pad with a totem pole output of a +3/5 V microcontroller (uP_OUT2):



Reset Signal Operating levels:

Signal	Min	Max
RESET Input high	2.2V*	3.3V
RESET Input low	0V	0.2V

* this signal is internally pulled up so the pin can be left floating if not used.



5 Power Supply

The power supply circuitry and board layout are a very important part in the full product design and they strongly reflect on the product overall performances, hence read carefully the requirements and the guidelines that will follow for a proper design.

5.1 Power Supply Requirements

The GE864-QUAD / PY power requirements are:

- *Nominal Supply Voltage:* 3.8 V
- *Max Supply Voltage:* 4.2 V
- *Supply voltage range:* 3.4 V - 4.2 V
- *Max Peak current consumption (impulsive):* 1.9 A
- *Max Average current consumption during GPRS transmission (rms):* 500 mA
- *Max Average current consumption during VOICE/CSD transmission (rms):* 270 mA
- *Average current during Power Saving:* ≈ 4 mA
- *Average current during idle (Power Saving disabled)* ≈ 19 mA

The GSM system is made in a way that the RF transmission is not continuous, else it is packed into bursts at a base frequency of about 216 Hz, the relative current peaks can be as high as about 2A. Therefore the power supply has to be designed in order to withstand with these current peaks without big voltage drops; this means that both the electrical design and the board layout must be designed for this current flow.

If the layout of the PCB is not well designed a strong noise floor is generated on the ground and the supply; this will reflect on all the audio paths producing an audible annoying noise at 216 Hz; if the voltage drop during the peak current absorption is too much, then the device may even shutdown as a consequence of the supply voltage drop.



***TIP:** The electrical design for the Power supply should be made ensuring it will be capable of a peak current output of at least 2 A.*



5.2 General Design Rules

The principal guidelines for the Power Supply Design embrace three different design steps:

- the electrical design
- the thermal design.
- the PCB layout.

5.2.1 Electrical Design Guidelines

The electrical design of the power supply depends strongly from the power source where this power is drained. We will distinguish them into three categories:

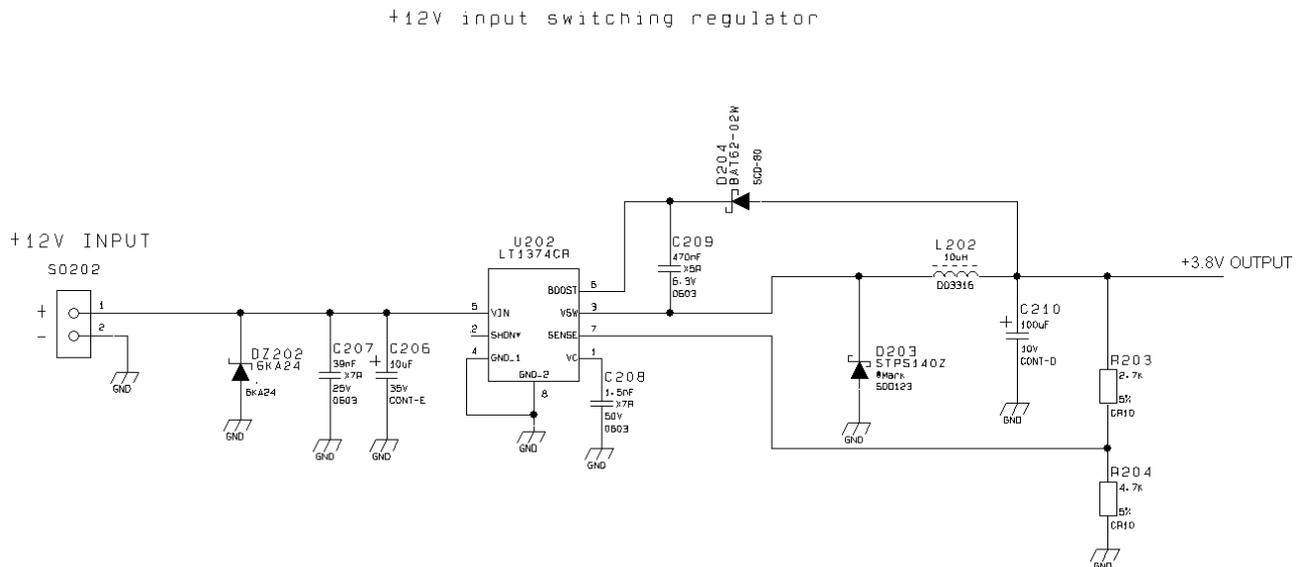
- +5V input (typically PC internal regulator output)
- +12V input (typically automotive)
- Battery

5.2.1.1 + 5V input Source Power Supply Design Guidelines

- The desired output for the power supply is 3.8V, hence there's not a big difference between the input source and the desired output and a linear regulator can be used. A switching power supply will not be suited because of the low drop out requirements.
- When using a linear regulator, a proper heat sink shall be provided in order to dissipate the power generated.
- A Bypass low ESR capacitor of adequate capacity must be provided in order to cut the current absorption peaks close to the GE864-QUAD / PY, a 100 μ F tantalum capacitor is usually suited.
- Make sure the low ESR capacitor on the power supply output (usually a tantalum one) is rated at least 10V.
- A protection diode should be inserted close to the power input, in order to save the GE864-QUAD / PY from power polarity inversion.



An example of switching regulator with 12V input is:



5.2.1.3 Battery Source Power Supply Design Guidelines

- The desired nominal output for the power supply is 3.8V and the maximum voltage allowed is 4.2V, hence a single 3.7V Li-Ion cell battery type is suited for supplying the power to the Telit GE864-QUAD / PY module.
The three cells Ni/Cd or Ni/MH 3,6 V Nom. battery types or 4V PB types **MUST NOT BE USED DIRECTLY** since their maximum voltage can rise over the absolute maximum voltage for the GE864-QUAD / PY and damage it.



NOTE: DON'T USE any Ni-Cd, Ni-MH, and Pb battery types directly connected with GE864-QUAD / PY. Their use can lead to overvoltage on the GE864-QUAD / PY and damage it. USE ONLY Li-Ion battery types.

- A Bypass low ESR capacitor of adequate capacity must be provided in order to cut the current absorption peaks, a 100µF tantalum capacitor is usually suited.
- Make sure the low ESR capacitor (usually a tantalum one) is rated at least 10V.
- A protection diode should be inserted close to the power input, in order to save the GE864-QUAD / PY from power polarity inversion. Otherwise the battery connector should be done in a way to avoid polarity inversions when connecting the battery.
- The battery capacity must be at least 500mAh in order to withstand the current peaks of 2A; the suggested capacity is from 500mAh to 1000mAh.



7 Serial Port

The serial port on the Telit GE864 is the core of the interface between the module and OEM hardware. Several configurations can be designed for the serial port on the OEM hardware, but the most common are:

- RS232 PC com port
- microcontroller UART @ 2.8V - 3V (Universal Asynchronous Receive Transmit)
- microcontroller UART@ 5V or other voltages different from 2.8V

Depending from the type of serial port on the OEM hardware a level translator circuit may be needed to make the system work. The only configuration that doesn't need a level translation is the 2.8V UART.

The serial port on the GE864 is a +2.8V UART with all the 7 RS232 signals. It differs from the PC-RS232 in the signal polarity (RS232 is reversed) and levels. The levels for the GE864 UART are the CMOS levels:

Absolute Maximum Ratings -Not Functional

Parameter	Min	Max
Input level on any digital pad when on	-0.3V	+3.75V
Input voltage on analog pads when on	-0.3V	+3.0 V

Operating Range - Interface levels (2.8V CMOS)

Level	Min	Max
Input high level V_{IH}	2.1V	3.3V
Input low level V_{IL}	0V	0.5V
Output high level V_{OH}	2.2V	3.0V
Output low level V_{OL}	0V	0.35V



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The signals of the GE864 serial port are:

RS232 Pin Nr	Signal	GE864 Ball Number	Name	Usage
1	DCD - dcd_uart	D9	Data Carrier Detect	Output from the GE864 that indicates the carrier presence
2	RXD - tx_uart	H8	Transmit line *see Note	Output transmit line of GE864 UART
3	TXD - rx_uart	E7	Receive line *see Note	Input receive of the GE864 UART
4	DTR - dtr_uart	B7	Data Terminal Ready	Input to the GE864 that controls the DTE READY condition
5	GND	A1,F1,H1,L1, H2, L2, J3, K3....	Ground	ground
6	DSR - dsr_uart	E11	Data Set Ready	Output from the GE864 that indicates the module is ready
7	RTS - rts_uart	F7	Request to Send	Input to the GE864 that controls the Hardware flow control
8	CTS - cts_uart	F6	Clear to Send	Output from the GE864 that controls the Hardware flow control
9	RI - ri_uart	B6	Ring Indicator	Output from the GE864 that indicates the incoming call condition

 **NOTE:** According to V.24, RX/TX signal names are referred to the application side, therefore on the GE864 side these signal are on the opposite direction: TXD on the application side will be connected to the receive line (here named TXD/ rx_uart) of the GE864 serial port and viceversa for RX.

 **TIP:** For a minimum implementation, only the TXD and RXD lines can be connected, the other lines can be left open provided a software flow control is implemented.

The signals in the UART connector on the EVK2 are:

DCD	RXD
TXD	DTR
GND	DSR
RTS	CTS
RI	GND



7.1 RS232 level translation

In order to interface the Telit GE864 with a PC com port or a RS232 (EIA/TIA-232) application a level translator is required. This level translator must

- invert the electrical signal in both directions
- change the level from 0/3V to +15/-15V

Actually, the RS232 UART 16450, 16550, 16650 & 16750 chipsets accept signals with lower levels on the RS232 side (EIA/TIA-562) , allowing for a lower voltage-multiplying ratio on the level translator. Note that the negative signal voltage must be less than 0V and hence some sort of level translation is always required.

The simplest way to translate the levels and invert the signal is by using a single chip level translator. There are a multitude of them, differing in the number of driver and receiver and in the levels (be sure to get a true RS232 level translator not a RS485 or other standards).

By convention the driver is the level translator from the 0-3V UART level to the RS232 level, while the receiver is the translator from RS232 level to 0-3V UART.

In order to translate the whole set of control lines of the UART you will need:

- 5 driver
- 3 receiver



NOTE: The digital input lines working at 2.8VCMOS have an absolute maximum input voltage of 3,75V; therefore the level translator IC shall not be powered by the +3.8V supply of the module. Instead it shall be powered from a +2.8V / +3.0V (dedicated) power supply.

This is because in this way the level translator IC outputs on the module side (i.e. GE864 inputs) will work at +3.8V interface levels, stressing the module inputs at its maximum input voltage.

This can be acceptable for evaluation purposes, but not on production devices.



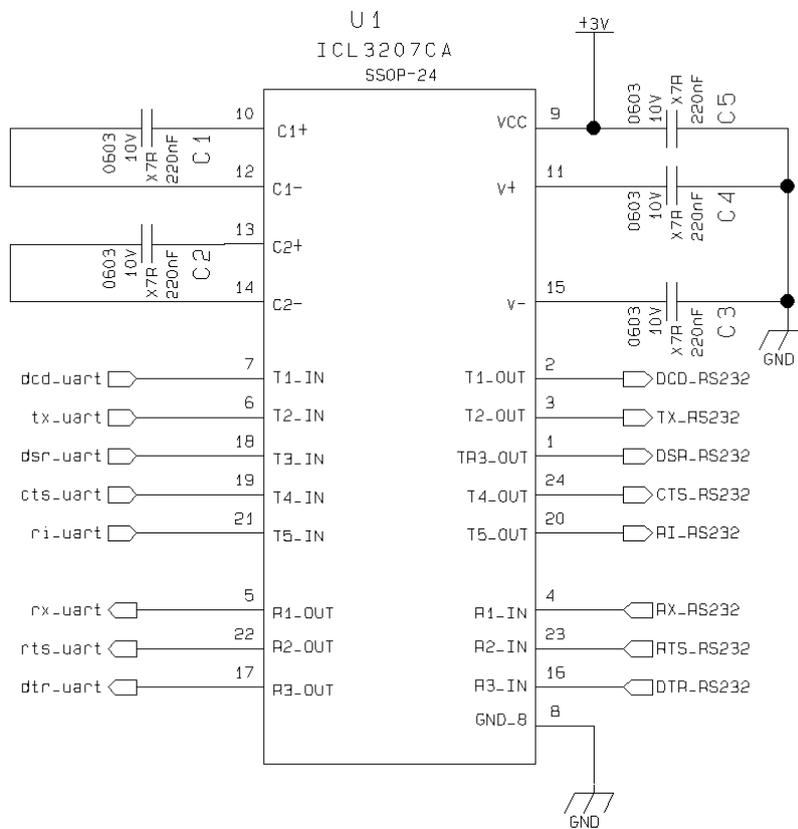
NOTE: In order to be able to do in circuit reprogramming of the GE864 firmware, the serial port on the Telit GE864 shall be available for translation into RS232 and either it's controlling device shall be placed into tristate, disconnected or as a gateway for the serial data when module reprogramming occurs.

Only RXD, TXD, GND and the On/off module turn on pad are required to the reprogramming of the module, the other lines are unused.

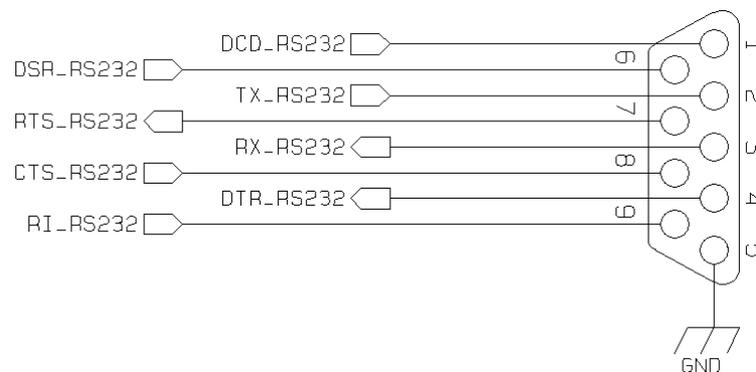
All applicator shall include in their design such a way of reprogramming the GE864.



An example of level translation circuitry of this kind is:

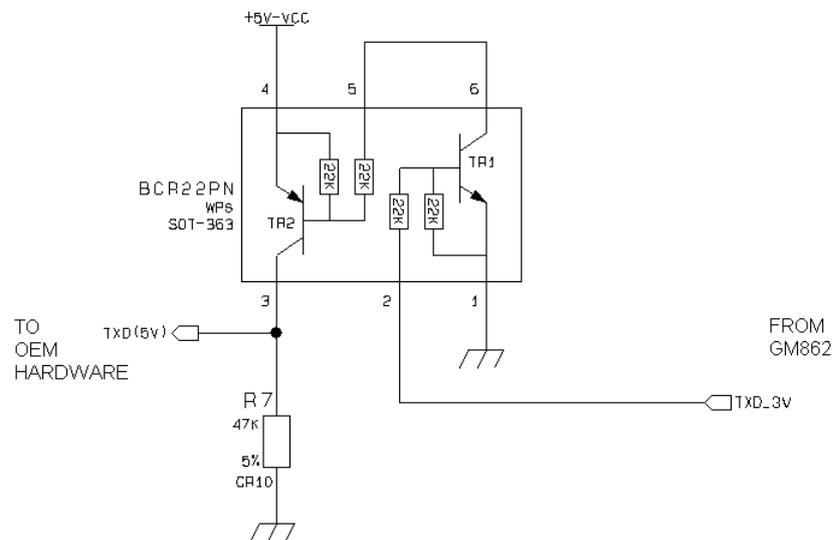


the RS232 serial port lines are usually connected to a DB9 connector with the following layout:

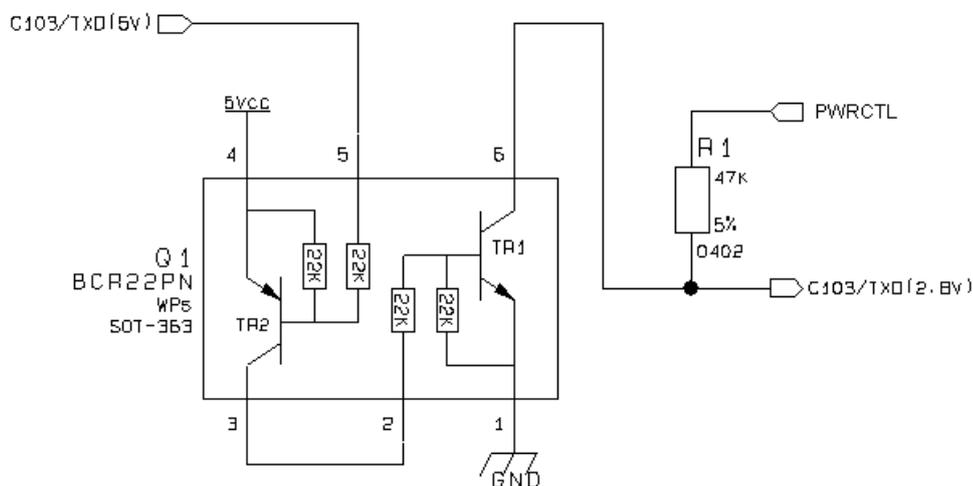


7.2 5V UART level translation

If the OEM application uses a microcontroller with a serial port (UART) that works at a voltage different from 2.8 - 3V, then a circuitry has to be provided to adapt the different levels of the two sets of signals. As for the RS232 translation there are a multitude of single chip translators, but since the translation requires very few components, then also a discrete design can be suited. For example a possible inexpensive translator circuit for a 5V driver can be:



and for a 5V receiver:





NOTE: The UART input line TXD (*rx_uart*) of the GE864 is NOT internally pulled up with a resistor, so there may be the need to place an external 47KΩ pull-up resistor, either the DTR (*dtr_uart*) and RTS (*rts_uart*) input lines are not pulled up internally, so an external pull-up resistor of 47KΩ may be required.

7.3 VAUX power output

A regulated power supply output is provided in order to supply small devices from module. This output is active when the module is ON and goes off when module is shut down. The operating range characteristics of the supply are:

Operating Range - Vout power supply

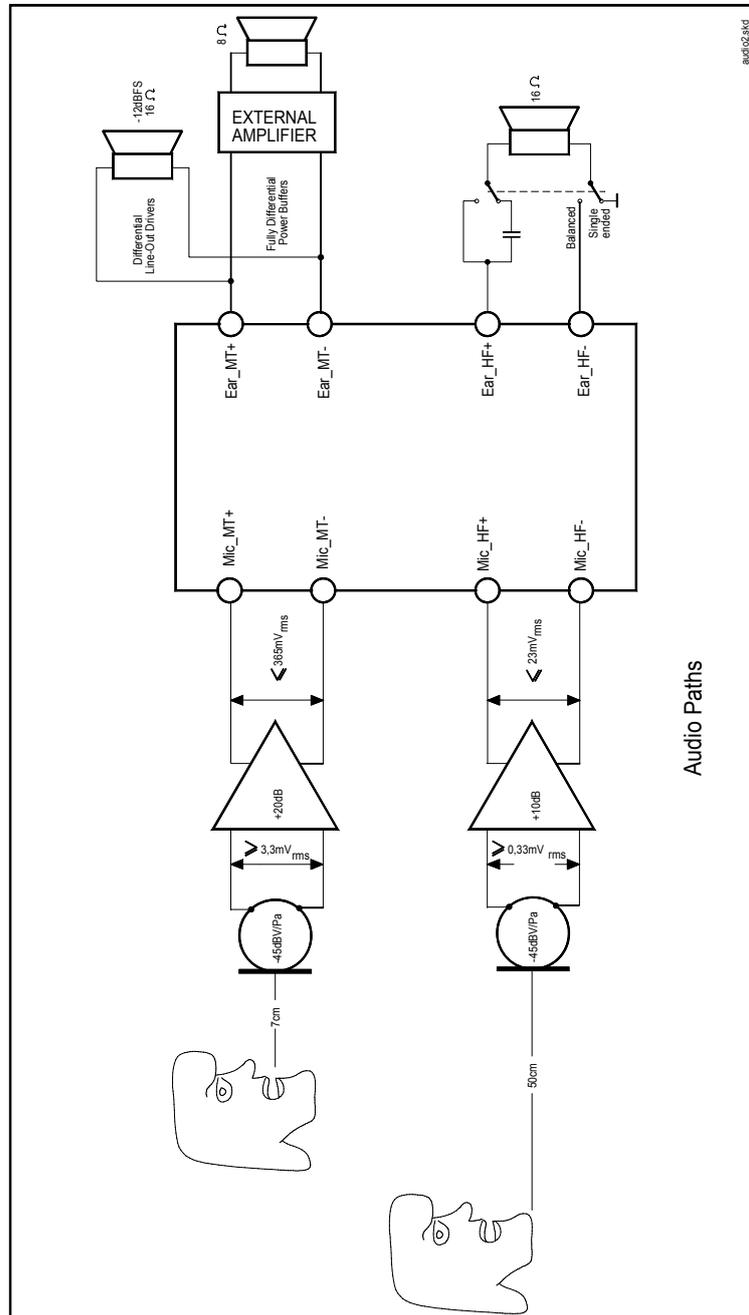
	Min	Typ	Max
Output voltage	2.75V	2.85V	2.95V
Output current			100mA
Output bypass capacitor			2.2μF

Pull-up resistors can be connected to the VAUX pad provided that the pulled-up lines are GE864 input lines connected to open collector outputs in order to avoid latch-up problems on the GE864. Care must be taken to avoid latch-up on the GE864 and the use of this output line to power electronic devices shall be considered with care, especially for devices that generate spikes and noise such as level translators, digital ICs or microcontroller, failure in any of these condition can severely compromise the GE864 functionality.



NOTE: The input lines working at 2.8VCMOS can be pulled-up with 47KΩ resistors that can be connected directly to the VAUX line. NO disturbing devices should be powered with the VAUX line, otherwise the module functionality may be compromised.





8.1 Microphone Paths Characteristic and Requirements



TIP: being the microphone circuitry the more noise sensitive, its design and layout must be done with particular care. Both microphone paths are balanced and the OEM circuitry should be balanced designed to reduce the common mode noise typically generated on the ground plane. However also an unbalanced circuitry can be used for particular OEM application needs.



TIP: due to the difference in the echo canceller type, the “Mic_MT” audio path is suited for Handset applications, while the “Mic_HF” audio path is suited for hands-free function (car kit). The Earphone applications should be made using the “Mic_HF” audio path but **DISABLING** the echo canceller by software AT command. If the echo canceller is left active with the Earphone, then some echo might be introduced by the echo cancel algorithm.

“Mic_MT” 1st differential microphone path

<ul style="list-style-type: none"> • line coupling • line type • coupling capacitor • differential input resistance • differential input voltage • microphone nominal sensitivity • analog gain suggested • echo canceller type 	<p>AC balanced ≥ 100nF 50kΩ ≤ 1,03V_{pp} (365mV_{rms}) -45 dBV_{rms}/Pa + 20dB handset</p>
---	--

“Mic_HF” 2nd differential microphone path

<ul style="list-style-type: none"> • line coupling • line type • coupling capacitor • differential input resistance • differential input voltage • microphone nominal sensitivity 	<p>AC balanced ≥ 100nF 50kΩ ≤ 65mV_{pp} (23mV_{rms}) -45 dBV_{rms}/Pa</p>
<ul style="list-style-type: none"> • analog gain suggested • echo canceller type 	<p>+10dB car kit hands-free</p>





TIP: definition of the nominal sensitivity of the microphone lines .

The nominal sensitivity of the microphone lines indicates the voltage level on the GE864-QUAD / PY pins present during "normal spoken" conditions.
For a handset , the "normal spoken" conditions take place when the talker mouth is 7cm far from the microphone ; under these conditions the voice will produce an acoustic pressure of $-4,7\text{dBPa} @ 1\text{kHz}$ on the microphone membrane .



TIP: electrical equivalent signal and operating voice levels .

At "normal spoken" conditions, a microphone having the suggested nominal sensitivity of $-45\text{dBV}_{\text{rms}}/\text{Pa}$, will produce

the electrical equivalent signal : $\text{MicLevel} = (-45) + (-4.7) = -49.7 \text{ dBV}_{\text{rms}}$

that means :

$$\text{MicVoltage} = 10^{(-49.7/20)} = 3.3 * 10^{-3} \text{ V}_{\text{rms}}$$

During a call, this level varies according to the volume of the talker voice; usually the following rough thumb rule for the dynamic range may be used :

- 1) the talker is screaming . This is the *strongest voice level* condition: the signal increases by +20dB;
- 2) the talker is whispering. This is the *lowest voice level* condition: the voice level decreases by – 50dB.

These changes must be considered for designing the external microphone amplifier.



TIP: example of external microphone amplifier calculation .

Let's suppose to use the *1st differential* microphone path .In this case the maximum differential input voltage to "Mic_MT" lines is $365\text{mV}_{\text{rms}}(1,03\text{V}_{\text{pp}})$ corresponding to $-8,76\text{dBV}$.
Now we can calculate the maximum voltage gain of an external microphone amplifier G_A :

$$[(\text{MicLevel} + 20\text{dB}) + G_A] = -8,76\text{dBV}$$

$$[-49,7 + 20 + G_A] = -8,76$$

$$-40,9 + 20 = -G_A$$

$G_A = 20,94\text{dB}$ → you can set $G_A = +20\text{dB}$ to use standard resistor values .





TIP: environment consideration .

For *hands-free/car kit* microphone, you must take into account the voice attenuation, due to the distance between the microphone itself and the talker , when designing the external microphone amplifier.

Not only, you must consider that the microphone will pick up also ambient noise; to overcome this problem it is preferable to set the gain of the microphone *10dB* lower with respect to the calculated value for a nominal sensitivity. The corresponding reduction in signal level will be compensated by an increased voice volume of the talker which will speak louder because of the ambient noise.

For a car cabin usually the distance between the microphone itself and the talker is *40/50cm* ; in these conditions the attenuation can be considered as a thumb rule around *20dB* .

For the earphone we shall distinguish two different types: the earphones having the microphone sustained close to the mouth and the ones having the microphone on the earpiece cable.

The same considerations for the additional voice attenuation due to the distance from the microphone and the noise pick up can be made for the earphone having the microphone on the earpiece cable, while the other kind of earphone shall be threaten as an handset.



TIP: how to compensate the losses in car cabin hands-free condition .

The voice signal , that in the "normal spoken" conditions produces on the microphone membrane an acoustic pressure of -4,7dBPa at 1kHz , will have a further attenuation of 20dB due the 50cm distance .

Therefore a microphone having the suggested nominal sensitivity of -45dBV_{rms}/Pa, will produce a lower electrical

equivalent signal :

$$\text{MicLevel} = (-45) + (-4.7) - 20 = -69.7$$

that means :

$$\text{MicVoltage} = 10^{(-49.7 / 20)} = 0,33 * 10^{-3}$$

Setting the "microphone gain" at +10dB (3 times), the signal in the nominal conditions on the "Mic_HF" inputs of GE864-QUAD / PY Telit Module will be :

$$\text{"Mic_HF" Level} = 0,33 * 10^{-3} * 3 = 1 * 10^{-3}$$

Hence in these conditions the signal level on the "**Mic_HF**" input pads of the GE864-QUAD / PY is 10 dB (3 times) lower than the nominal, as suggested.



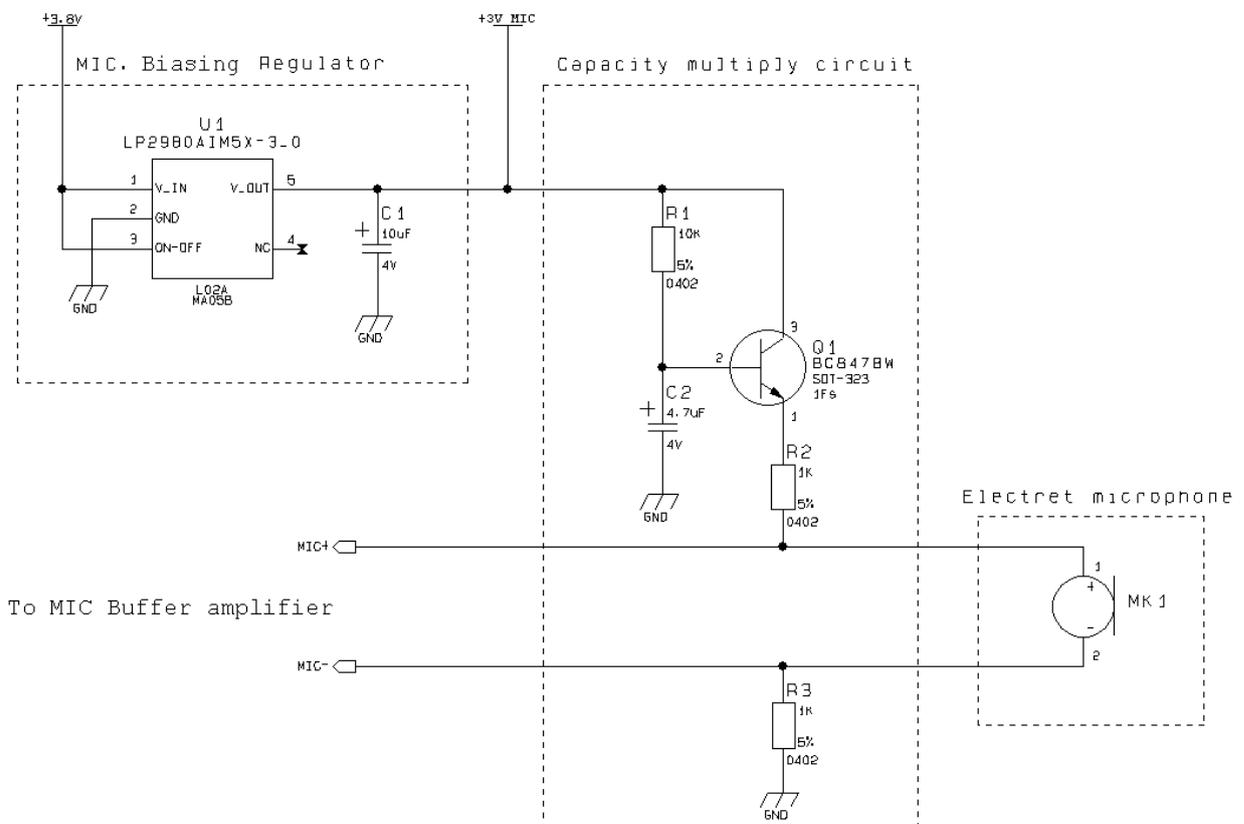
8.4 Microphone Biasing

The electret microphones usually need a biasing voltage to work properly. Refer to your microphone provider for the characteristics required.

NOTE: *The microphones have a hot wire were the positive biasing must be connected. Usually it is indicated by a + symbol or a red point. If the polarity of the bias is reversed, then the microphone will not work properly. For this reason be sure to respect the mic. biasing polarity.*

8.4.1 Balanced Microphone Biasing

The balanced microphone bias voltage should be obtained from a dedicated voltage regulator, in order to eliminate the noise present on the power lines. This regulator can be the same for all the audio paths. The microphone should be supplied from a capacitor multiply circuit. For example a circuit for the balanced microphone biasing can be:



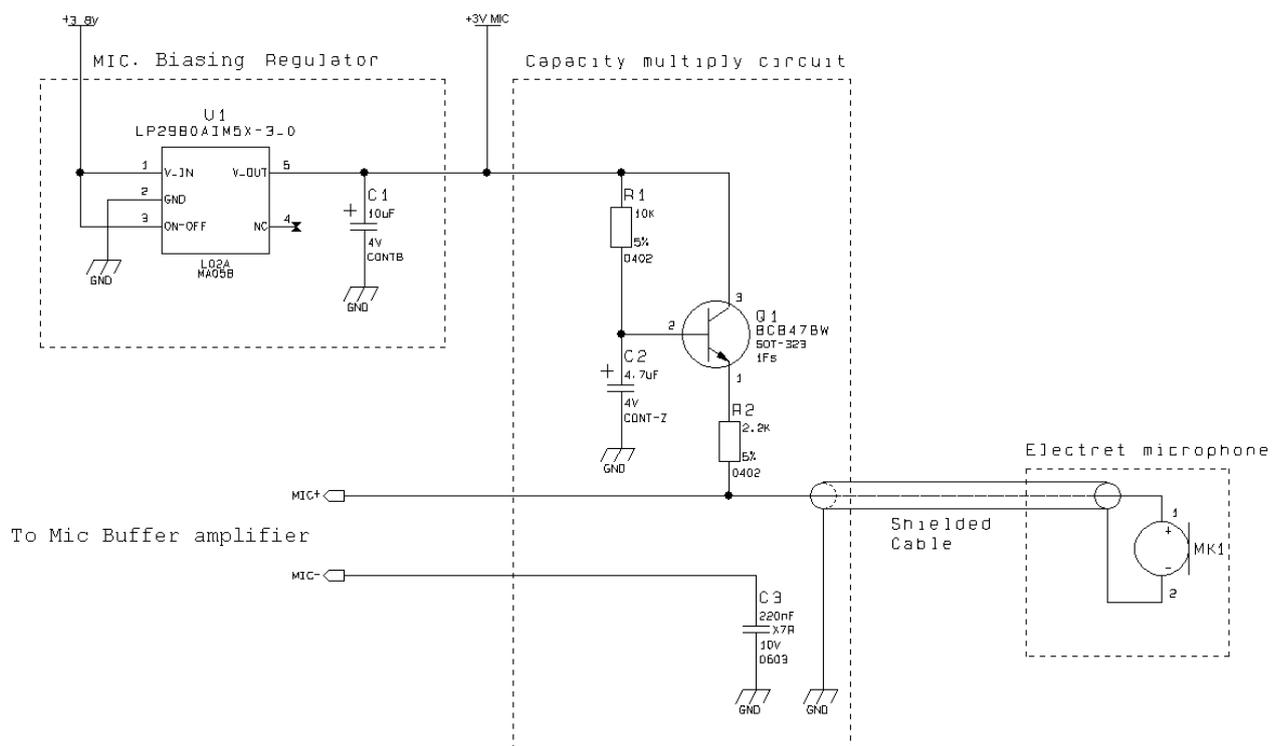
- NOTE:** In the balanced application the resistors R2 and R3 must have the same value to keep the circuit balanced.

- NOTE:** The cable to the microphone should not be shielded, instead a twisted pair cable shall be used.

- NOTE:** The microphone sensitivity changes with the value of R2 and R3. Usually the microphones are characterized with 2kΩ biasing resistance, so try to keep the sum of R2 and R3 around 2kΩ. Refer to your microphone manufacturer for the mic. characteristics.

8.4.2 Unbalanced Microphone Biasing

The unbalanced microphone biasing voltage should be obtained from a dedicated voltage regulator, in order to eliminate the noise present on the power lines. This regulator can be the same for all the audio paths. The microphone should be supplied from a capacity multiply circuit. For example a circuit for the unbalanced microphone biasing can be:



 **NOTE:** In the unbalanced application the capacitor C3 shall be $> 200\text{nF}$ otherwise the frequency response will be cut at low band frequencies (down to 300Hz). This capacitor can be placed close to the MIC- pad (MIC_HF- or MIC_MT- depending on the audio path chosen) or if possible it should be placed close to the shielded cable connector. If the ground return path is well designed, then it is possible to eliminate the C3 capacitor, provided the buffer is close to the mic. input.

 **NOTE:** The cable to the microphone should be shielded.

 **NOTE:** The microphone changes with the value of R2. Usually the microphone sensitivity is characterized with $2\text{k}\Omega$ biasing resistance, so try to keep the value of R2 around $2\text{k}\Omega$. For mic. characteristics refer to the manufacturer.

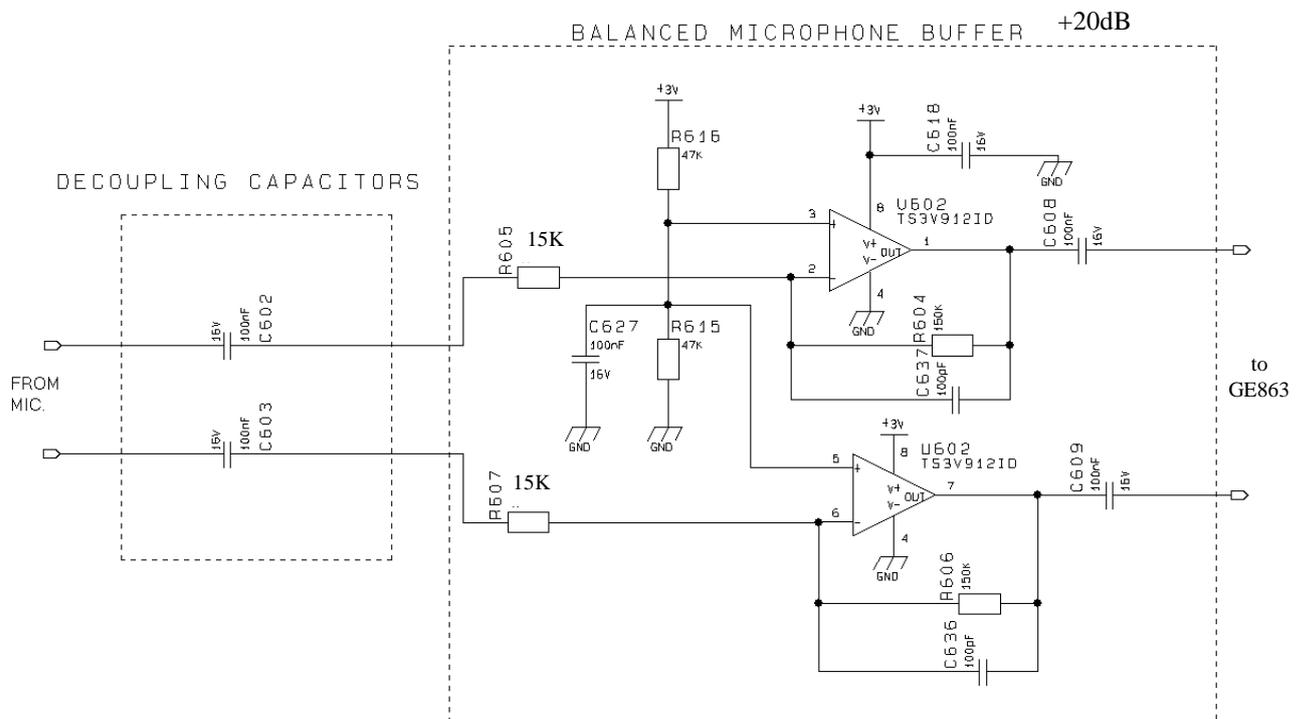


8.5 Microphone Buffering

As seen previously, a microphone shall be connected to the input pins of the GE864-QUAD / PY through a buffer amplifier that boosts the signal level to the required value. Again the buffered microphone circuitry can be balanced or unbalanced: where possible it is always preferable a balanced solution. The buffering circuit shall be placed close to the microphone or close to the microphone wire connector.

8.5.1 Buffered Balanced Mic

A sample circuit can be:



This circuit has a gain of 10 times (+20 dB), and is therefore suited for the "**Mic_{MT}**" input if you have a microphone with a sensitivity close to the suggested one ($-45 \text{ dBV}_{\text{rms}}/\text{Pa}$). If your microphone has a different sensitivity or if the buffer is connected to the "**Mic_{HF}**" inputs, then a gain adjustment shall be done by changing resistors R604 and R606 (if the required value is not a standard one, you can change R605 and R607) and as a consequence the capacitors C636 and C637 to maintain the bandwidth 150-4000Hz (at -3dB).



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As a consequence of the assigned values of the resistors, the nominal values of C726 and C727 are :

$$C726 = 1 / (2\pi * 4000 * R719) = 7.10 * 10^{-9} F$$

$$C727 = 1 / (2\pi * 4000 * R711) = 2.65 * 10^{-9} F$$

*modified in **6,8nF** ($f_{c1}=4181\text{Hz}$) and **2,7nF** ($f_{c2}=3931\text{Hz}$) because of commercial values .*



9.4 Handset Earphone Design

As seen previously, a 16Ω earpiece can be directly connected to the output pads EAR_MT+ and EAR_MT- of the GE864-QUAD / PY.

This solution is often the more cost effective, reducing the components count to a minimum. There are several limitations to the use of this solution: speaker direct connect imposes the speaker characteristics to be almost exactly the suggested ones, otherwise the power output may be reduced (if speaker impedance is bigger than 16Ω) or the GE864-QUAD / PY ear port may be damaged (if speaker impedance is less than 15Ω).

The other limitation of the speaker direct connection is the power output capability of the GE864-QUAD / PY which is limited and for some particular applications may not be enough.

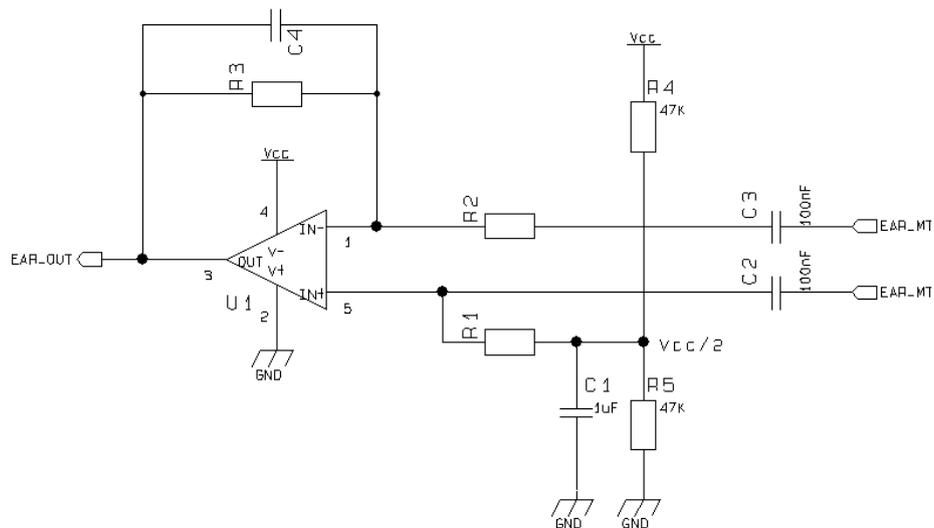
For these reasons, when the power output of the GE864-QUAD / PY is not enough or if the speaker characteristics are different from the suggested, then it is preferable to use an amplifier to increase the power and current output capabilities.

Again the output from the GE864-QUAD / PY is bridged and both lines should be used, where possible, as inputs to the power amplifier. This ensures a higher common mode rejection ratio, reducing the GSM current busts noise on the speaker output.

In this case the "EAR_MT" lines from the GE864-QUAD / PY should be AC coupled with a ceramic capacitor of 100nF (or bigger).

It is always desirable to have a mute control on the amplifier, in order to turn it off while the device is not sending signal to the output, in this manner the amplifier background noise which may be audible during idle conditions is cut off.

A principle schematic may be:

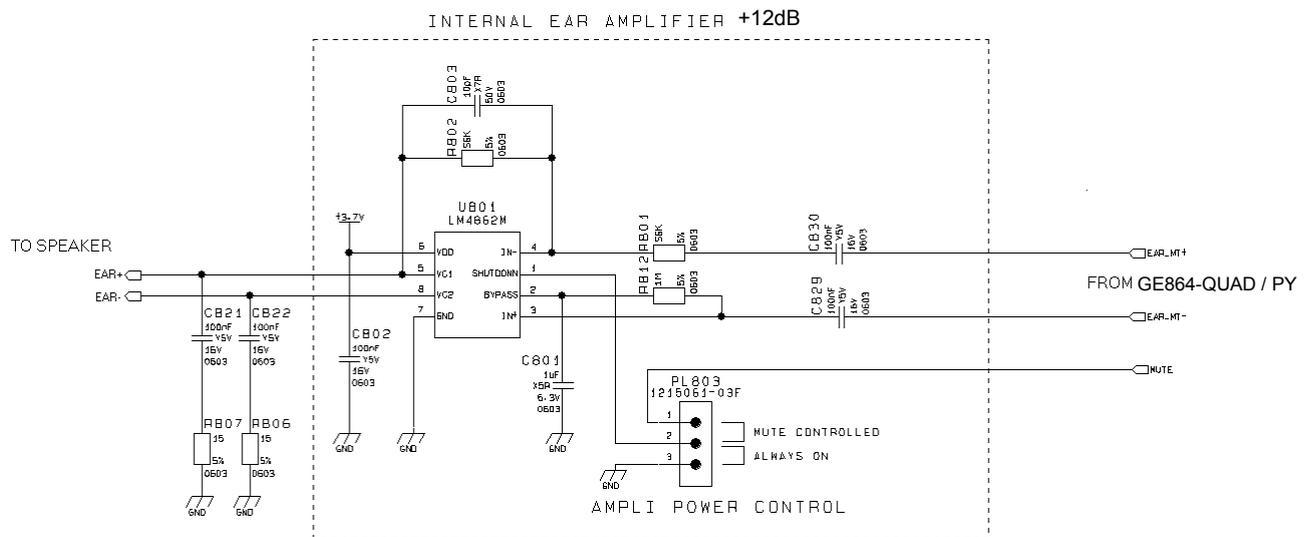


The resulting gain and high pass cut can be obtained with the formula:

$$Gain = \frac{R3}{R2}$$

$$freq. = \frac{1}{2\pi * R3 * C4} \text{ [Hz]}$$

And an example of internal Ear amplifier could be :



Some amplifier require a low impedance load at high frequency in order to avoid auto oscillation, this can be made with a capacitor (100nF) in series with a resistor (15Ω).

When designing your application, remember to provide an adequate bypass capacitor to the amplifier and place it close to the power input pin of the IC, keeping the traces as short as possible.

9.5 Hands-Free Earphone (Low Power) Design

The same design considerations made for the handset are valid for the hands-free earphone.



9.6 Car Kit Speakerphone Design

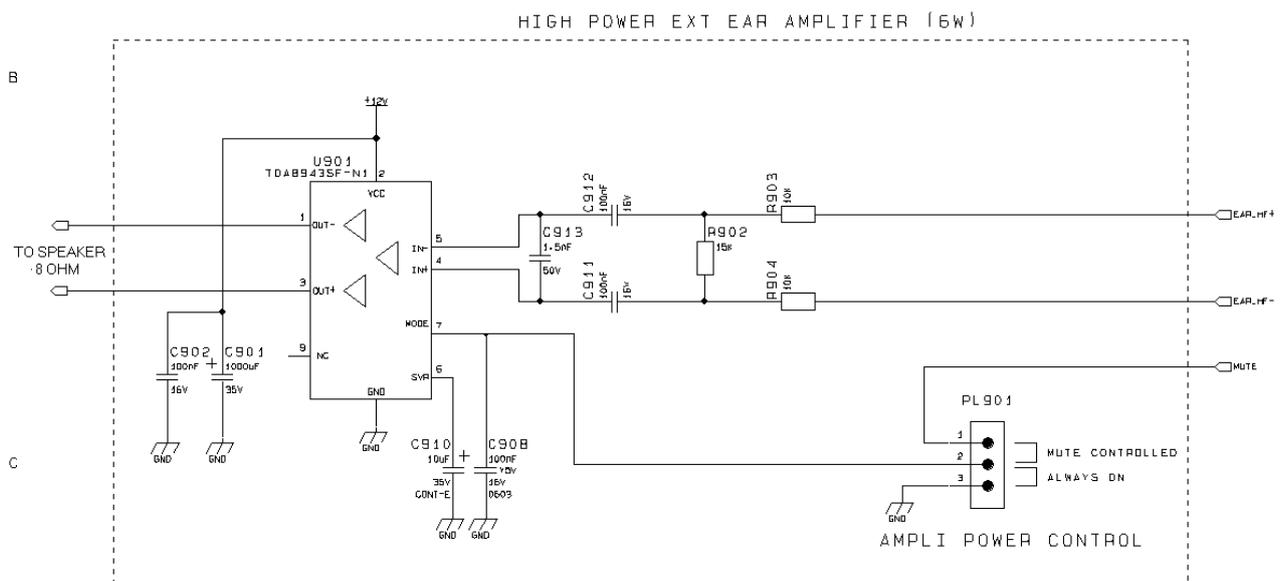
For the car kit speaker phone function the power output requirement is usually at least 4W, therefore an amplifier is needed to boost the *GE864-QUAD / PY* output.

The design of the amplifier shall comply with the following guidelines:

- The input to the amplifier **MUST** be taken from the “*Ear_HF*” audio path of the *GE864-QUAD / PY*, because of its echo canceller parameters suited to a car cabin use.
- The amplifier shall have a gain of 30-40 times (29-32 dB) to provide the desired output power of 5-10W with the signal from the *GE864-QUAD / PY* “*Ear_HF*” audio output lines.
- If the amplifier has a fixed gain then it can be adjusted to the desired value by reducing the input signal with a resistor divider network.
- The amplifier shall have a mute control to be used while not in conversation. This results in two benefits: eliminating the background noise when not in conversation and saving power.
- The power to the amplifier should be decoupled as much as possible from the *GE864-QUAD / PY* power supply, by either keeping separate wires and placing bypass capacitors of adequate value close to the amplifier power input pads.
- The biasing voltage of the amplifier shall be stabilized with a low ESR (e.g. a tantalum) capacitor of adequate value.

NOTE: The *GE864-QUAD / PY* audio path connected to the car kit hands-free amplifier **MUST** be “*Ear_HF*” one, otherwise the echo cancellation will not be done due to the difference in the echo canceller characteristics of the *GE864-QUAD / PY* internal audio path from the external audio path.

Example of car kit amplifier schematic.



The ASC1 port is used for:

- Continuous of debug messages of the PYTHON Script Interpreter (requires PYTHON version modules;

For further detailed description refer to Technical Specification 30276st10285a_r3.

9.7.2 EVK2 Audio Lines Characteristics

Low Power Audio1 Outputs (*Ear_MT+” line*)

- | | |
|------------------------------------|---|
| • line coupling: | AC |
| • line type: | single ended referred to GND |
| • load impedance: | $\geq 16 \Omega$ |
| • signal bandwidth: | 150 - 4000 Hz @ -3 dB |
| • max.output | 655mV _{rms} (open circuit) |
| • max. differential output voltage | 164mV _{rms} (typ) /16 Ω @ -12dBFS |

Low Power Audio2 Outputs (*Ear_HF+” line*)

- | | |
|------------------------------------|-------------------------------------|
| • line coupling: | AC |
| • line type: | single ended referred to GND |
| • load impedance: | $\geq 16 \Omega$ |
| • signal bandwidth: | 150 - 4000 Hz @ -3 dB |
| • max. single ended output voltage | 655mV _{rms} (open circuit) |

High Power Audio1 / Audio2 Outputs

- | | |
|-------------------------|-----------------------|
| • line coupling: | DC |
| • line type: | balanced |
| • load impedance: | $\geq 8 \Omega$ |
| • signal bandwidth: | 150 - 4000 Hz @ -3 dB |
| • maximum power output: | 500 mW @ 8 Ω |
| • THD+N | 1% @ 350mW |



10.3ESD

Take standard ESD caution if application based on TELIT module has SIM holder with contacts reachable from human body.

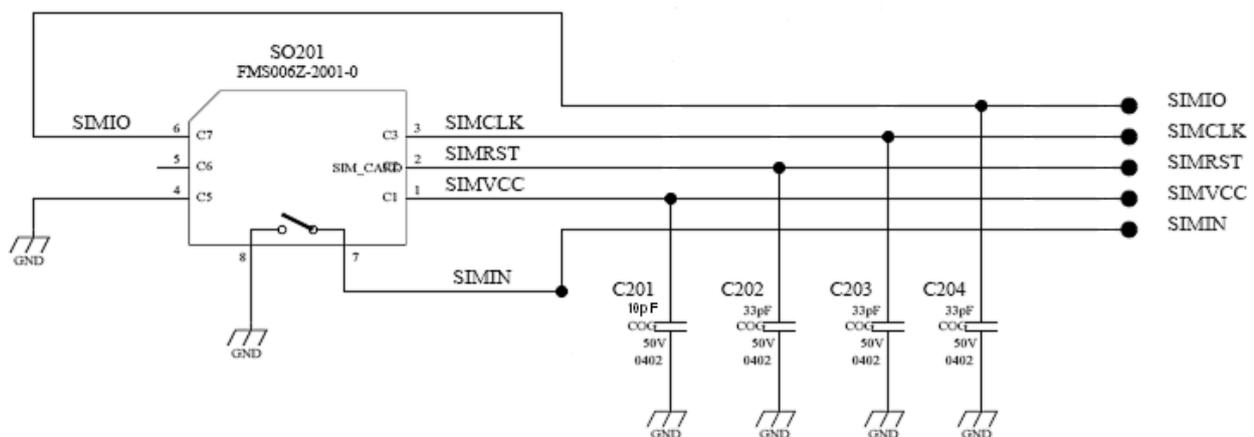
10.4SIM Supply

Do not connect capacitance greater than 10nF to SIMVCC line.

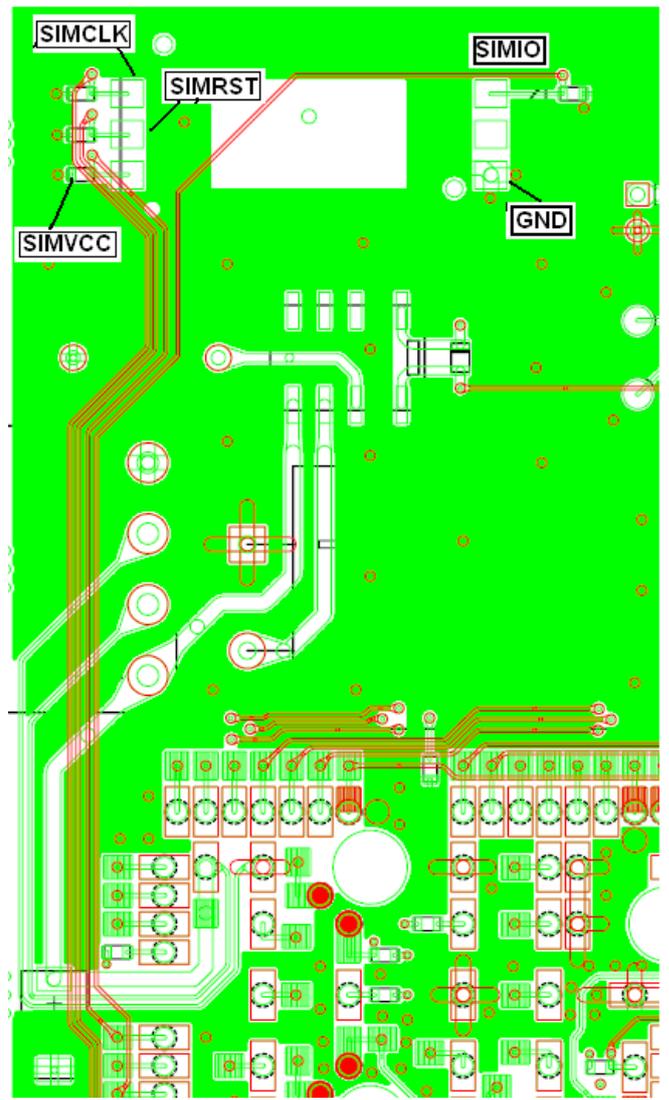
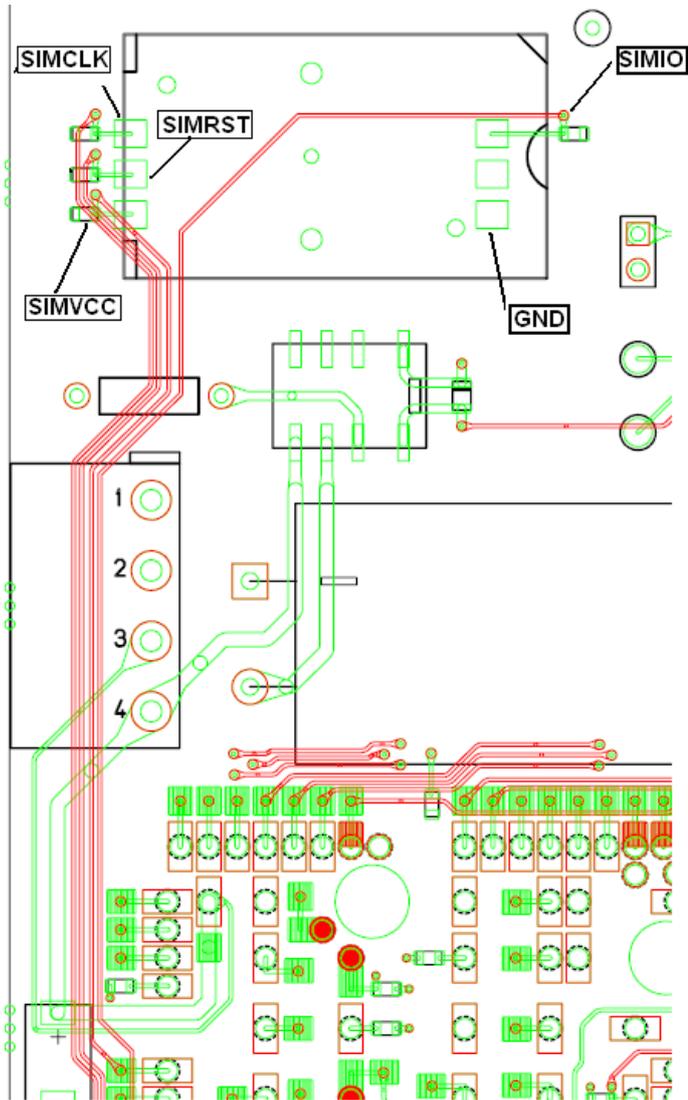
Other notes:

- SIMIN doesn't require any pull-up resistor. It is built in.
- SIM card is detected inserted when this line is short to ground.
- If in the application the SIM holder doesn't foresee the switch for the presence/absence of the SIM card, the **SIMIN** line must be connected to ground.

10.5SCHEMATIC



10.6 LAYOUT



12 DAC and ADC section

12.1 DAC Converter

12.1.1 Description

The GE864-QUAD / PY module provides a Digital to Analog Converter. The signal (named DAC_OUT) is available on BGA Ball C7 of the GE864-QUAD / PY module and on pin 17 of PL104 on EVK2 Board (CS1152).

The on board DAC is a 10 bit converter, able to generate a analogue value based a specific input in the range from 0 up to 1023. However, an external low-pass filter is necessary

	Min	Max	Units
Voltage range (filtered)	0	2,6	Volt
Range	0	1023	Steps

The precision is 10 bits so, if we consider that the maximum voltage is 2V, the integrated voltage could be calculated with the following formula:

$$\text{Integrated output voltage} = 2 * \text{value} / 1023$$

DAC_OUT line must be integrated (for example with a low band pass filter) in order to obtain an analog voltage.

12.1.2 Enabling DAC

An AT command is available to use the DAC function.

The command is **AT#DAC[=<enable>[,<value>]]**

<value> - scale factor of the integrated output voltage (0..1023 - 10 bit precision)
it must be present if **<enable>=1**

Refer to SW user guide or to GE864-QUAD / PY AT commands specification for the full description of this function.

 **NOTE: The DAC frequency is selected internally. D/A converter must not be used during POWERSAVING.**



13.1.1 Camera Interface Connectors

The pinout of the module and a 24 pins ZIF connector for the CMOS camera provide the interface connection between GE864-QUAD / PY and Transchip camera.

GE864-QUAD / PY signal			Notes	TC5747MF24L		
Pin	Signal	I/O		Pin	Signal	I/O
C6	CAM_SCL	O	I2C bus serial clock	1	SCLK	I
A1, F1, H1 ...	GND		Ground	2	AGND	I
D5	VAUX1	O	Power Supply	3	AVDD28	I
C9	CAM_RST	O	Camera Reset	4	RESET_N	I
F8	MON1_CAM	O	Clock	5	CLK_IN**	I
A1, F1, H1 ...	GND		Ground	6	DGND	I
	n.c.		n.c.	7	DOUT_0	I/O
	n.c.		n.c.	8	DOUT_1	I/O
	n.c.		n.c.	9	DOUT_2	I/O
	n.c.		n.c.	10	DOUT_3	I/O
	n.c.		n.c.	11	DOUT_4	I/O
	n.c.		n.c.	12	DOUT_5	I/O
	n.c.		n.c.	13	DOUT_6	I/O
	n.c.		n.c.	14	DOUT_7	I/O
	n.c.		n.c.	15	DOUT_8	I/O
	n.c.		n.c.	16	VCLKOUT	O
	n.c.		n.c.	17	VALIDH	O
	n.c.		n.c.	18	VALIDV	O
D5	VAUX1	O	Power Supply	19	DVDD28	I
D7	CAM_SDA	I/O	I2C bus serial data	20	SDIN	I/O
A1, F1, H1 ...	GND		Ground	21	PS1	I
K11	CAM_ON	O	Camera power type selector	22	PS2	I
A1, F1, H1 ...	GND		Ground	23	SHIELD	-
			Flash Enable	24	LED_CTRL	O

* Filter the AVDD28.

** Use a Buffer between module clk out, MON1_CAM and camera clk in, CLK_IN.

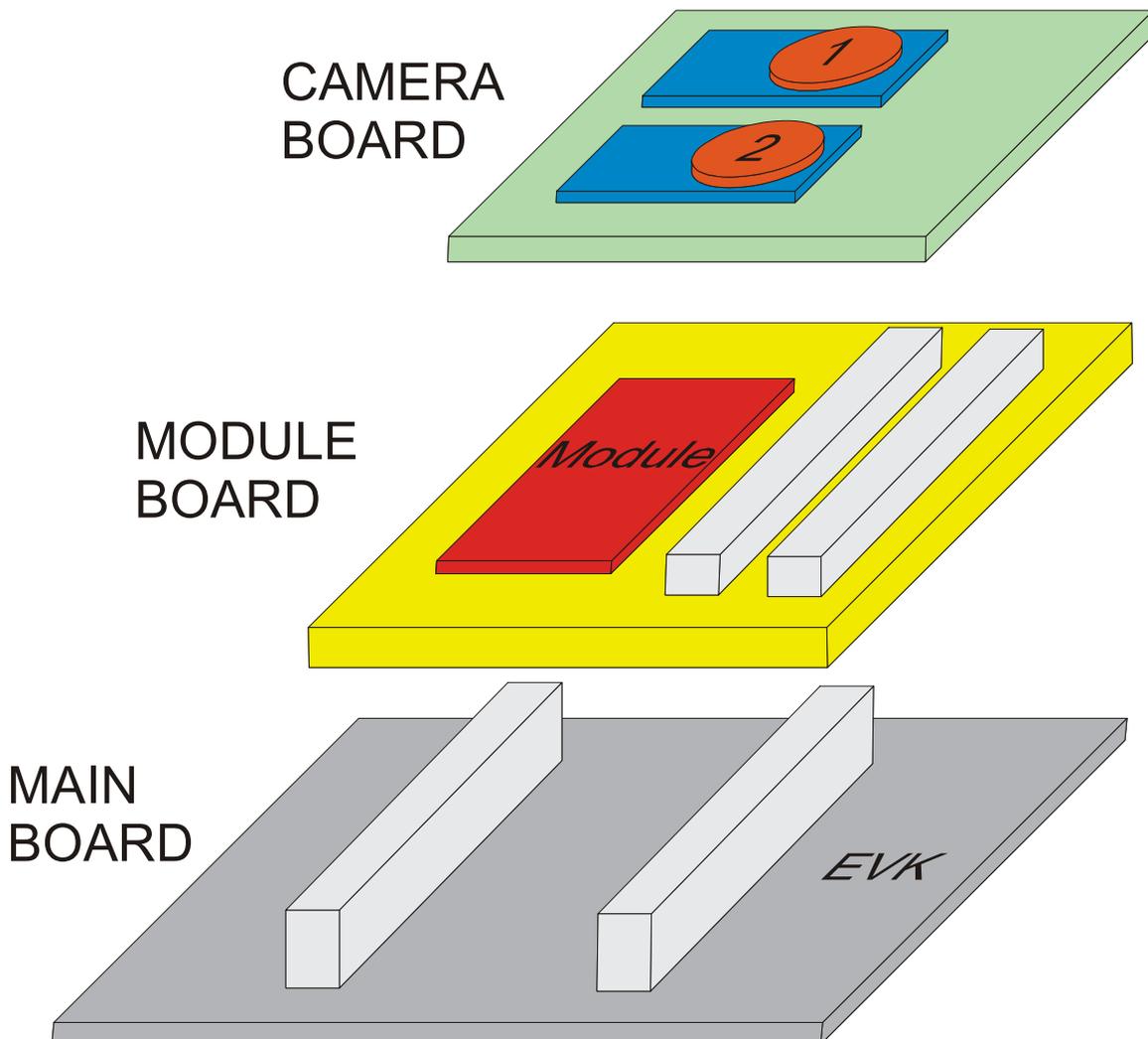
*** Non-connected.



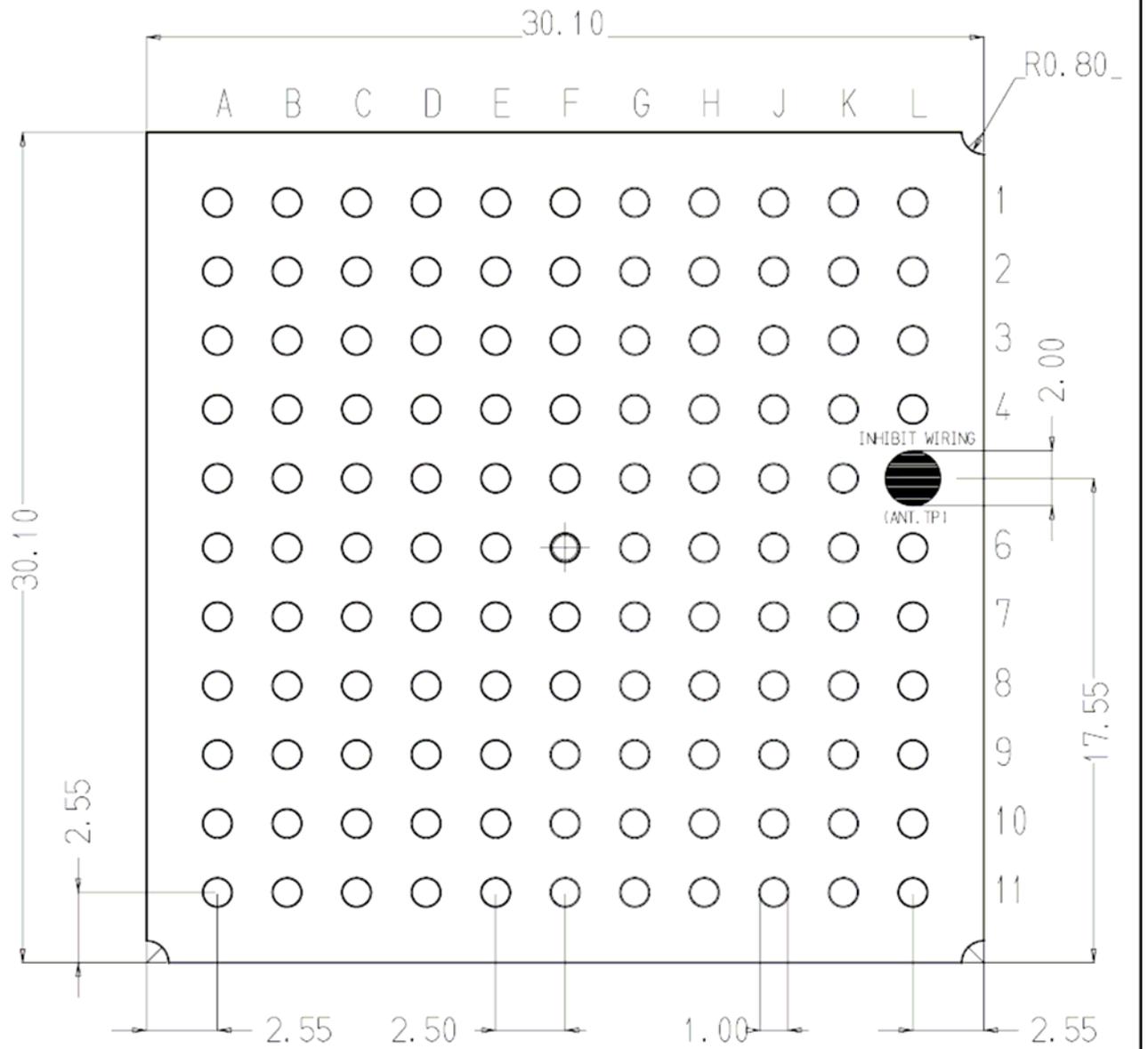
13.1.2 EVB for Transchip camera support

In order to interface the Telit GE864-QUAD / PY with a CMOS camera, Telit has developed an evaluation board. The EVK allows the connector of all Telit modules through 2 connectors of 40 pins each.

The I2CBUS DUAL CAMERA board is plugged in the 2 connectors of 30 pins each on the module board.

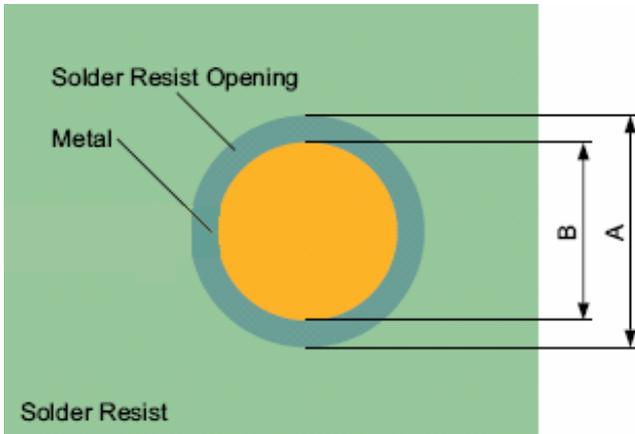


13.2.3 Recommended foot print for the application (GE864)



Top View

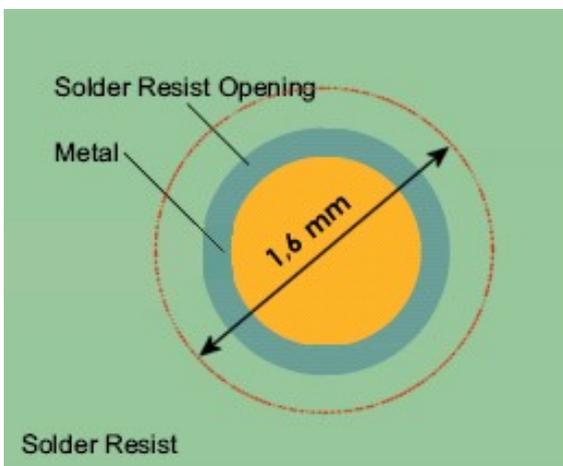




Recommendations for PCB pad dimensions

Ball pitch [mm]	2,5
Solder resist opening diameter A [mm]	1,150
Metal pad diameter B [mm]	1 ± 0.05

Placement of microvias not covered by solder resist is not recommended inside the “Solder resist opening”, unless the microvia carry the same signal of the pad itself.



Holes in pad are allowed only for blind holes and not for through holes.

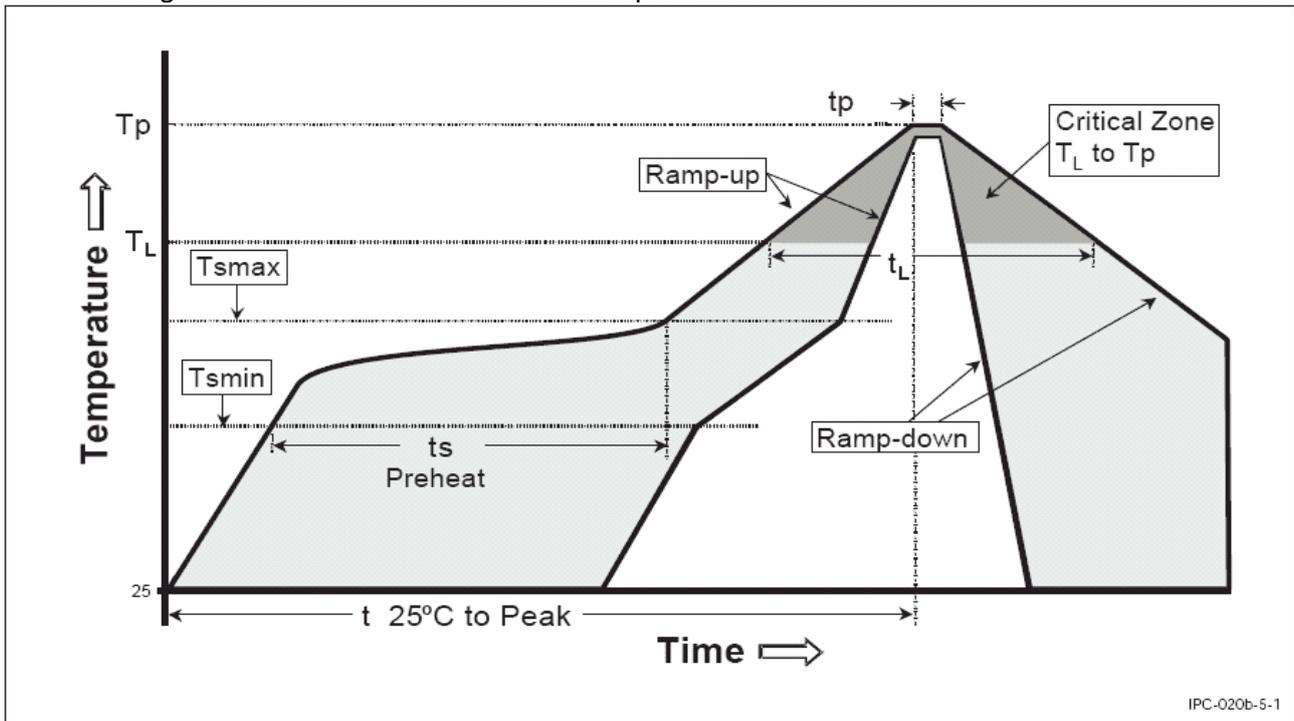
Recommendations for PCB pad surfaces:

Finish	Layer thickness [µm]	Properties
Electro-less Ni / Immersion Au	3 – 7 / 0.05 – 0.15	good solder ability protection, high shear force values



13.2.8 GE864 Solder reflow

The following is the recommended solder reflow profile



IPC-020b-5-1

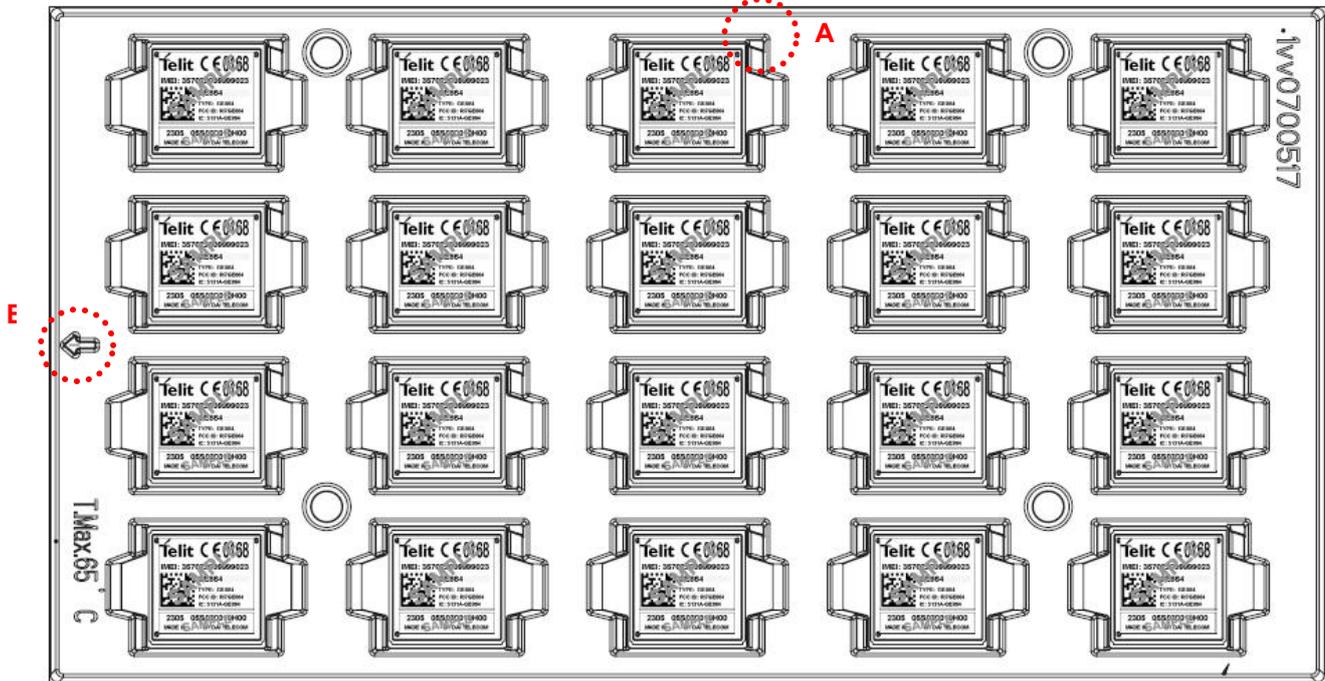
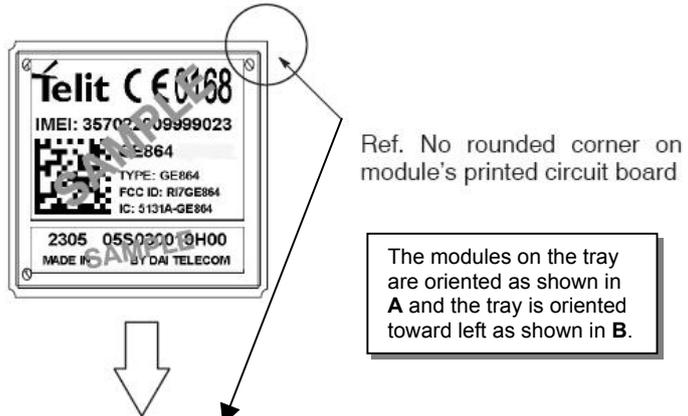
Profile Feature	Pb-Free Assembly
Average ramp-up rate (T_L to T_p)	3°C/second max
Preheat	
– Temperature Min (T_{smin})	150°C
– Temperature Max (T_{smax})	200°C
– Time (min to max) (t_s)	60-180 seconds
T_{smax} to T_L	
– Ramp-up Rate	3°C/second max
Time maintained above:	
– Temperature (T_L)	217°C
– Time (t_L)	60-150 seconds
Peak Temperature (T_p)	245 +0/-5°C
Time within 5°C of actual Peak Temperature (t_p)	10-30 seconds
Ramp-down Rate	6°C/second max.
Time 25°C to Peak Temperature	8 minutes max.

NOTE: All temperatures refer to topside of the package, measured on the package body surface.

NOTE: GE864 module can accept only one reflow process



13.3.1 GE864 orientation on the tray



15 SAFETY RECOMMANDATIONS

READ CAREFULLY

Be sure the use of this product is allowed in the country and in the environment required. The use of this product may be dangerous and has to be avoided in the following areas:

- Where it can interfere with other electronic devices in environments such as hospitals, airports, aircrafts, etc
- Where there is risk of explosion such as gasoline stations, oil refineries, etc

It is responsibility of the user to enforce the country regulation and the specific environment regulation.

Do not disassemble the product; any mark of tampering will compromise the warranty validity.

We recommend following the instructions of the hardware user guides for a correct wiring of the product. The product has to be supplied with a stabilized voltage source and the wiring has to be conforming to the security and fire prevention regulations.

The product has to be handled with care, avoiding any contact with the pins because electrostatic discharges may damage the product itself. Same cautions have to be taken for the SIM, checking carefully the instruction for its use. Do not insert or remove the SIM when the product is in power saving mode.

The system integrator is responsible of the functioning of the final product; therefore, care has to be taken to the external components of the module, as well as of any project or installation issue, because the risk of disturbing the GSM network or external devices or having impact on the security. Should there be any doubt, please refer to the technical documentation and the regulations in force.

Every module has to be equipped with a proper antenna with specific characteristics. The antenna has to be installed with care in order to avoid any interference with other electronic devices and has to guarantee a minimum distance from the body (20 cm). In case of this requirement cannot be satisfied, the system integrator has to assess the final product against the SAR regulation.

The European Community provides some Directives for the electronic equipments introduced on the market. All the relevant information's are available on the European Community website:

<http://europa.eu.int/comm/enterprise/rtte/dir99-5.htm>

The text of the Directive 99/05 regarding telecommunication equipments is available, while the applicable Directives (Low Voltage and EMC) are available at:

http://europa.eu.int/comm/enterprise/electr_equipment/index_en.htm



