

# GM862-GPS Hardware User Guide

GM862-GPS HW User Guide  
1v0300728 Rev. 6 - 04/01/07





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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 GM862-GPS 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 GM862-GPS module](#). For further hardware details that may not be explained in this document refer to the Telit GM862-GPS Product Description document where all the hardware information is reported.

## NOTICE

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***(EN) The integration of the GSM/GPRS GM862-GPS cellular module within user application shall be done according to the design rules described in this manual.***

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***(IT) L'integrazione del modulo cellulare GSM/GPRS GM862-GPS all'interno dell'applicazione dell'utente dovrà rispettare le indicazioni progettuali descritte in questo manuale.***

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***(DE) Die integration des GM862-GPS GSM/GPRS Mobilfunk-Moduls in ein Gerät muß gemäß der in diesem Dokument beschriebenen Konstruktionsregeln erfolgen***

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***(SL) Integracija GSM/GPRS GM862-GPS modula v uporabniški aplikaciji bo morala upoštevati projektna navodila, opisana v tem piročniku.***

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***(SP) La utilización del modulo GSM/GPRS GM862-GPS debe ser conforme a los usos para los cuales ha sido diseñado descritos en este manual del usuario.***

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***(FR) L'intégration du module cellulaire GSM/GPRS GM862-GPS dans l'application de l'utilisateur sera faite selon les règles de conception décrites dans ce manuel.***

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***(HE) האינטגרציה של המודול הסלולרי GM862-GPS עם המוצר. את ההנחיות המפורטות במסמך זה בתהליך האינטגרציה של המודם הסלולרי.***

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# 3 Interface connectors on GM862-GPS

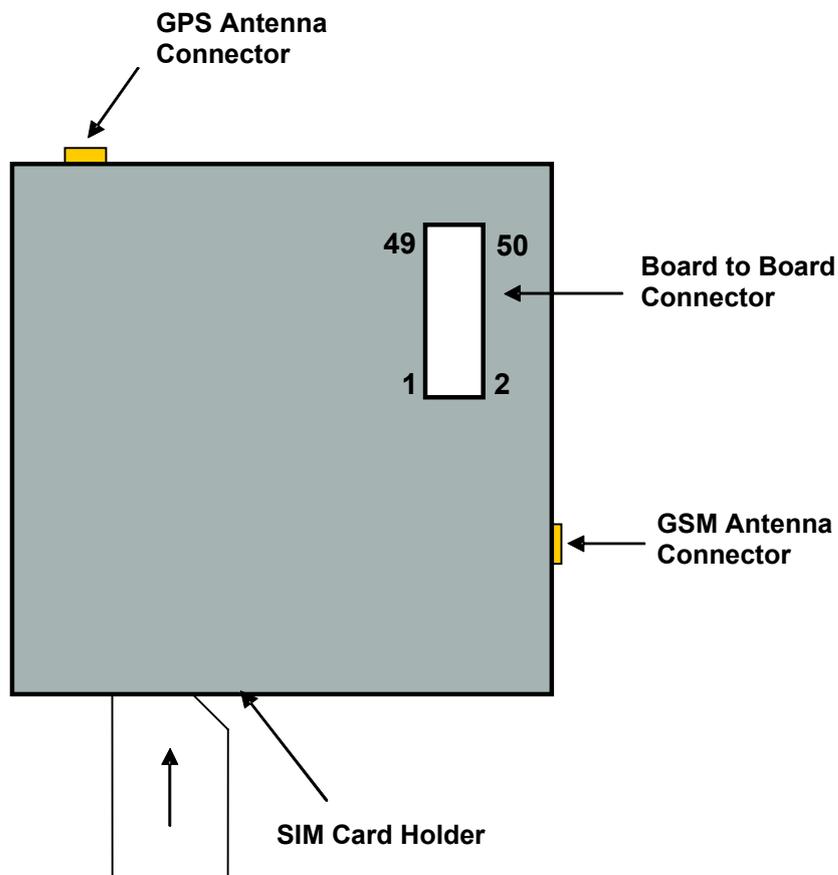
## 3.1 Description

The [Telit GM862-GPS](#) is provided of the following interfaces:

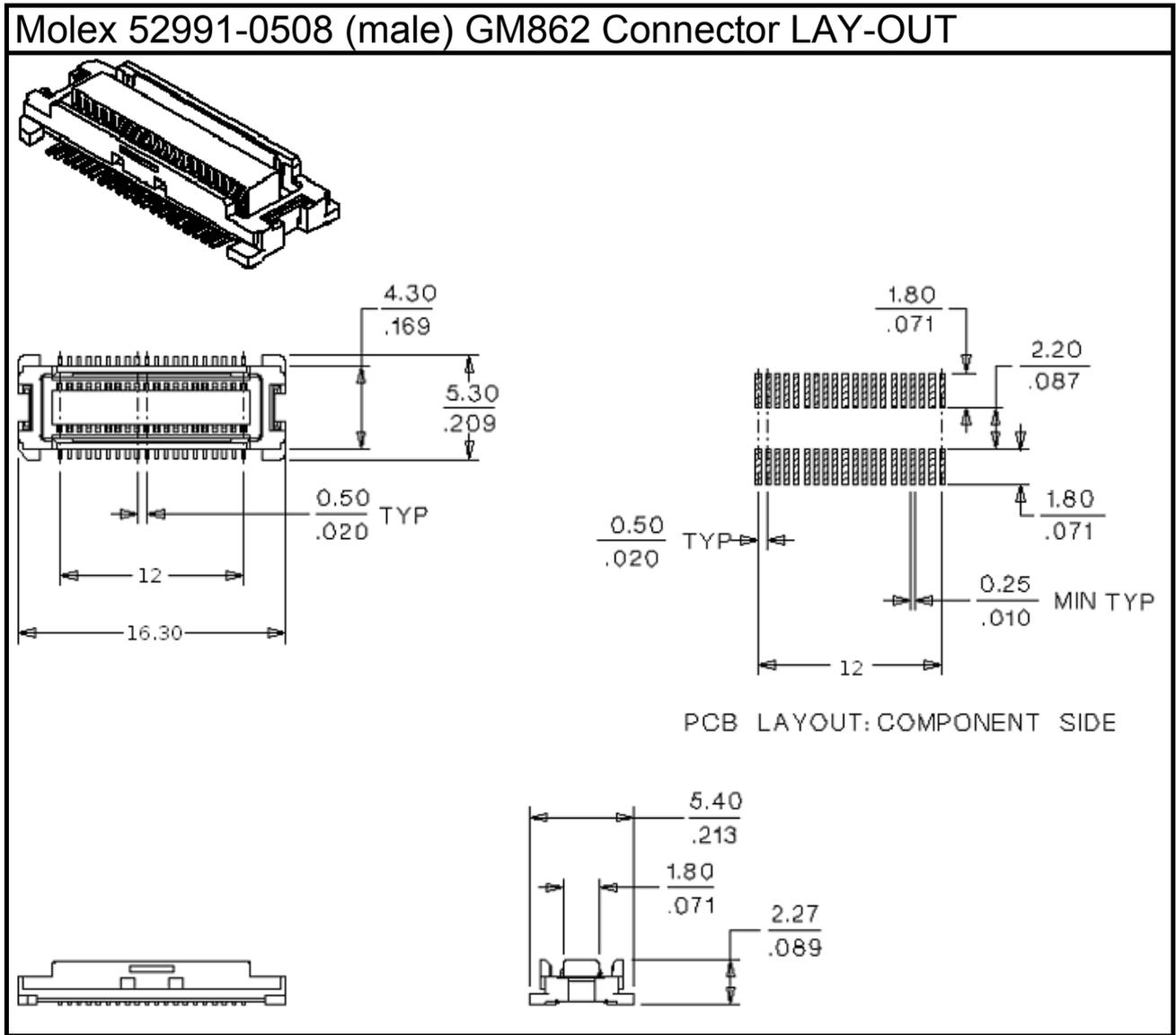
- **GSM antenna connector**
- **Board To Board Interface connector**
- **SIM Card Reader**
- **GPS antenna connector**

The [Telit GM862-GPS](#) board to board connector is a CSTP 50 pin vertical SMD Molex 52991-0508 (male).

## 3.2 Connectors Position



### 3.3 Board to Board Connector



### 3.3.1 Molex 52991-0508 (male) GM862 Connector PIN-OUT

| Pin | Signal     | I/O | Function   | Internal Pull up | Type             |
|-----|------------|-----|--|------------------|------------------|
| 1   | VBATT      | -   | Main power supply  |                  | Power            |
| 2   | GND        | -   | Ground   |                  | Power            |
| 3   | VBATT      | -   | Main power supply  |                  | Power            |
| 4   | GND        | -   | Ground   |                  | Power            |
| 5   | VBATT      | -   | Main power supply  |                  | Power            |
| 6   | A/D        | -   | A/D converter @ 11 bit (Input Impedance >100Kohm)  |                  | Max 2V input     |
| 7   | VBATT      | -   | Main power supply  |                  | Power            |
| 8   | CHARGE     | AI  | Battery Charger Input  |                  | Power            |
| 9   | EAR_HF+    | AO  | Handsfree ear output, phase +  |                  | Audio            |
| 10  | EAR_MT-    | AO  | Handset earphone signal output, phase -  |                  | Audio            |
| 11  | EAR_HF-    | AO  | Handsfree ear output, phase -  |                  | Audio            |
| 12  | EAR_MT+    | AO  | Handset earphone signal output, phase +  |                  | Audio            |
| 13  | MIC_HF-    | AI  | Handsfree microphone input; phase -  |                  | Audio            |
| 14  | MIC_MT+    | AI  | Handset microphone signal input; phase+  |                  | Audio            |
| 15  | MIC_HF+    | AI  | Handsfree microphone input; phase +  |                  | Audio            |
| 16  | MIC_MT-    | AI  | Handset microphone signal input; phase-  |                  | Audio            |
| 17  | ON_OFF     | I   | Input command for switching power ON or OFF (toggle command).                            | 47K $\Omega$     | Pull Up to VBATT |
| 18  | AXE        | I   | Handsfree switching  | 100K $\Omega$    | CMOS 2.8V        |
| 19  | SIMIO      | I/O | External SIM signal - Data I/O   |                  | 1.8 / 3V         |
| 20  | C103/TXD   | I   | Serial data input (TXD) from DTE   |                  | CMOS 2.8V        |
| 21  | PWRMON     | O   | Module Status ON indication (Signal output for power on/off control of external devices) | 1K $\Omega$      | CMOS 2.8V        |
| 22  | SIMVCC     | -   | External SIM signal – Power (3)  |                  | 1.8 / 3V         |
| 23  | RESET      | I   | Reset input  |                  |                  |
| 24  | SIMRST     | O   | External SIM signal – Reset  |                  | 1.8 / 3V         |
| 25  | RESERVED   | -   | RESERVED   |                  | -                |
| 26  | SIMCLK     | O   | External SIM signal – Clock  |                  | 1.8 / 3V         |
| 27  | SIMIN      | I/O | External SIM signal – Presence (active low)  | 47K $\Omega$     | CMOS 2.8V        |
| 28  | GPO2 / JDR | O   | General purpose output (Open Collector) / Jammer Detect Report                           |                  | Open Collector   |
| 29  | C106/CTS   | O   | Output for Clear to send signal (CTS) to DTE   |                  | CMOS 2.8V        |
| 30  | C125/RING  | O   | Output for Ring indicator signal (RI) to DTE   |                  | CMOS 2.8V        |
| 31  | GPI1       | I   | General purpose input  |                  | transistor base  |
| 32  | GPIO8      | I/O | Configurable general purpose I/O pin   |                  | CMOS 2.8V        |



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| Pin | Signal         | I/O | Function  | Internal Pull up | Type           |
|-----|----------------|-----|---|------------------|----------------|
| 33  | C107/DSR       | O   | Output for Data set ready signal (DSR) to DTE           |                  | CMOS 2.8V      |
| 34  | GPIO9          | I/O | Configurable general purpose I/O pin                    |                  | CMOS 2.8V      |
| 35  | TX_GPS         | O   | TX Data NMEA GPS protocol                               |                  | CMOS 2.8V      |
| 36  | C109/DCD       | O   | Output for Data carrier detect signal (DCD) to DTE      |                  | CMOS 2.8V      |
| 37  | C104/RXD       | O   | Serial data output to DTE                               |                  | CMOS 2.8V      |
| 38  | GPIO10/ CLK    | I/O | Configurable general purpose I/O pin / Python DEBUG 4)  |                  | CMOS 2.8V      |
| 39  | STAT_LED       | O   | Status indicator led                                    |                  | Open Collector |
| 40  | GPIO11         | I/O | Configurable general purpose I/O pin                    | 4.7 Kohm         | CMOS 2.8V      |
| 41  | RX_GPS         | I   | RX Data NMEA GPS protocol                               |                  | CMOS 2.8V      |
| 42  | GPIO12         | I/O | Configurable general purpose I/O pin                    | 47 Kohm          | CMOS 2.8V      |
| 43  | C108/DTR       | I   | Input for Data terminal ready signal (DTR) from DTE     |                  | CMOS 2.8V      |
| 44  | GPIO13 / MRST  | I/O | Configurable general purpose I/O pin / Python DEBUG (4) |                  | CMOS 2.8V      |
| 45  | C105/RTS       | I   | Input for Request to send signal (RTS) from DTE         |                  | CMOS 2.8V      |
| 46  | GPIO3          | I/O | Configurable general purpose I/O pin                    | 47 Kohm          | CMOS 2.8V      |
| 47  | GPIO4          | I/O | Configurable general purpose I/O pin                    | 4.7 Kohm         | CMOS 2.8V      |
| 48  | GPIO5 / MTSR   | I/O | Configurable general purpose I/O pin / Python DEBUG (4) |                  | CMOS 2.8V      |
| 49  | GPIO6 / ALARM  | I/O | Configurable general purpose I/O pin / ALARM            |                  | CMOS 2.8V      |
| 50  | GPIO7 / BUZZER | I/O | Configurable general purpose I/O pin / BUZZER           |                  | CMOS 2.8V      |

- (1) For the exclusive use of the Technical Support Service
- (2) An earphone with a 150 ohm impedance can be directly connected to EAR+ and EAR-
- (3) On this pin a maximum of 10nF bypass capacitor is allowed.
- (4) This output requires an external circuit to connect it to a serial port.

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

| pin     | signal           |
|---------|------------------|
| 1,3,5,7 | VBATT            |
| 2,4,8   | GND              |
| 17      | ON/OFF*          |
| 20      | TXD              |
| 23      | RESET*           |
| 37      | RXD              |
| 45      | RTS <sup>1</sup> |

<sup>1</sup> RTS should be connected to the GND (on the module side) if flow control is not used





# 4 Antenna

## 4.1 GSM Antenna Requirements

The antenna for a Telit GM862-GPS device shall fulfill the following requirements:

| ANTENNA REQUIREMENTS     |  |
|--------------------------|--|
| <b>Frequency range</b>   | Depending by frequency band(s) provided by the network operator, the customer shall use the most suitable antenna for that/those band(s) |
| <b>Bandwidth</b>         | 80 MHz in EGSM 900, 70 MHz if GSM 850, 170 MHz in DCS, 140 MHz PCS band  |
| <b>Gain</b>              | Gain < 3dBi  |
| <b>Impedance</b>         | 50 ohm   |
| <b>Input power</b>       | > 2 W peak power   |
| <b>VSWR absolute max</b> | <= 10:1  |
| <b>VSWR recommended</b>  | <= 2:1   |

Furthermore if the device is developed for the US market and/or Canada market, it shall comply to the FCC and/or IC approval requirements:

*This device is to be used only for mobile and fixed application. The antenna(s) used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter. End-Users must be provided with transmitter operation conditions for satisfying RF exposure compliance. OEM integrators must ensure that the end user has no manual instructions to remove or install the GM862-GPS module. Antennas used for this OEM module must not exceed 3dBi gain for mobile and fixed operating configurations.*



## 4.2 GSM Antenna - Installation Guidelines

- Install the antenna in a place covered by the GSM signal.
- The Antenna must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter;
- Antenna shall not be installed inside metal cases
- Antenna shall be installed also according Antenna manufacturer instructions.

## 4.3 GPS Antenna Requirements

The GM862-GPS module is not provided with an internal LNA amplifier. The use of an active antenna is important to achieve a good performance.

The module is provided of an Antenna supply circuit with the following characteristics:

- Supply voltage referred to VBATT (3.4 to 4.2 V DC)
- Supply enable controlled internally by the BB
- Current measurement circuit (readable also with AT commands)
- Voltage measurement circuit (readable also with AT commands)
- HW Protection for Antenna Short Circuit (if consumption exceeds 40mA)

The external active antenna for a Telit GM862-GPS device shall fulfill the following requirements:

| ANTENNA REQUIREMENTS       |                              |
|----------------------------|------------------------------|
| <b>Frequency range</b>     | 1575.42 MHz (GPS L1)         |
| <b>Bandwidth</b>           | +/- 1.023 MHz                |
| <b>Gain</b>                | 1.5 dBi < Gain < 4.5 dBi     |
| <b>Impedance</b>           | 50 ohm                       |
| <b>Amplification</b>       | Typical 25dB (max 27dB)      |
| <b>Supply voltage</b>      | Must accept from 3 to 5 V DC |
| <b>Current consumption</b> | Typical 20 mA (40 mA max)    |

Furthermore if the device is developed for the US market and/or Canada market, it shall comply to the FCC and/or IC approval requirements:

*This device is to be used only for mobile and fixed application.*



## 4.4 GPS Antenna - Installation Guidelines

- The GM862-GPS due to its characteristics of sensitivity is capable to perform a Fix inside the buildings. (In any case the sensitivity could be affected by the building characteristics i.e. shielding)
- The Antenna must not be co-located or operating in conjunction with any other antenna or transmitter;
- Antenna shall not be installed inside metal cases
- Antenna shall be installed also according Antenna manufacturer instructions.



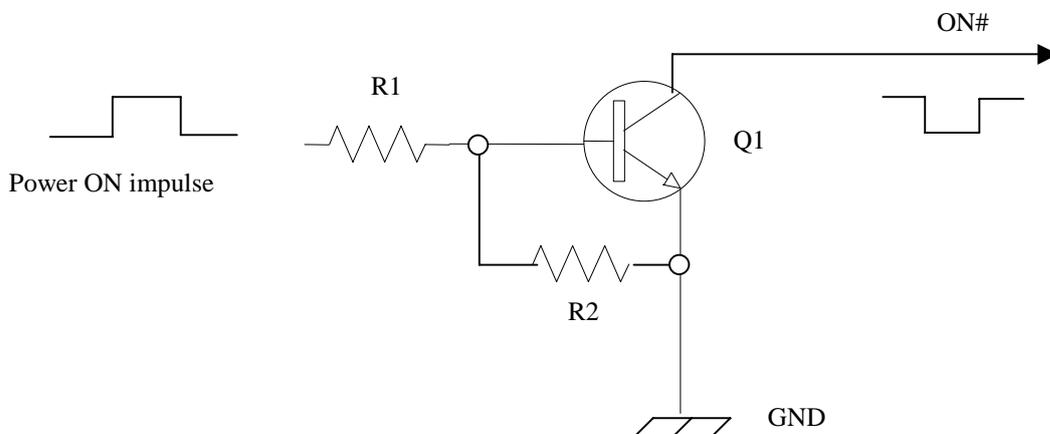




# 5 Hardware Commands

## 5.1 Turning ON the GM862-GPS

To turn on the GM862-GPS the pin ON# must be tied low for at least 1 second and then released. The maximum current that can be drained from the ON# pin is 0,1 mA. A simple circuit to do it is:



**NOTE:** don't use any pull up resistor on the ON# line, it is internally pulled up. Using pull up resistor may bring to latch up problems on the GM862-GPS power regulator and improper power on/off of the module. The line ON# must be connected only in open collector configuration.

**NOTE:** In this document all the lines that are inverted, hence have active low signals are labelled with a name that ends with a "#" or with a bar over the name.

**TIP:** To check if power has raised it is possible to monitor the START line, when this line goes high the module is powered on, but before it remains on the device needs other 900 ms for software startup. Hence check the PWRMON line and 900 ms after its transition to high it is possible to release the ON# pin.





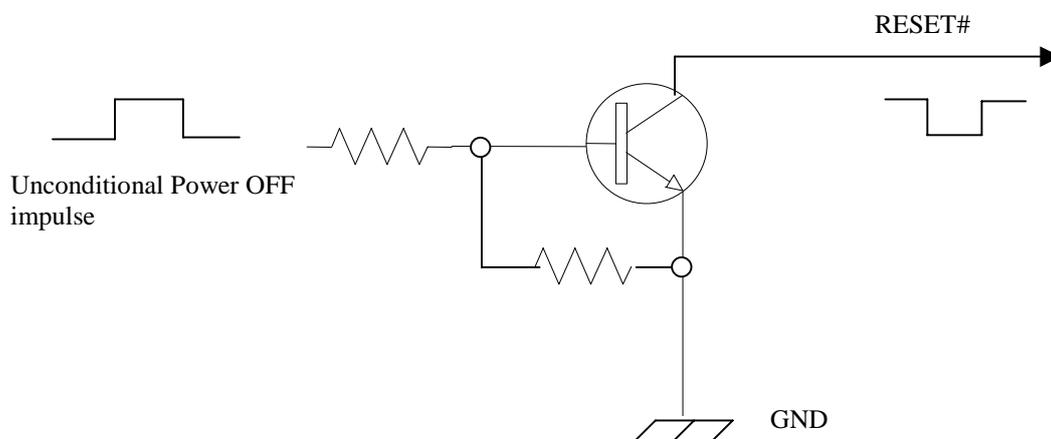


## 5.2.2 Hardware Unconditional Shutdown

To unconditionally Shutdown the GM862-GPS the pin RESET# must be tied low for at least 200 milliseconds and then released.

The maximum current that can be drained from the ON# pin 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 GM862-GPS power regulator and improper functioning of the module. The line RESET# must be connected only in open collector configuration.

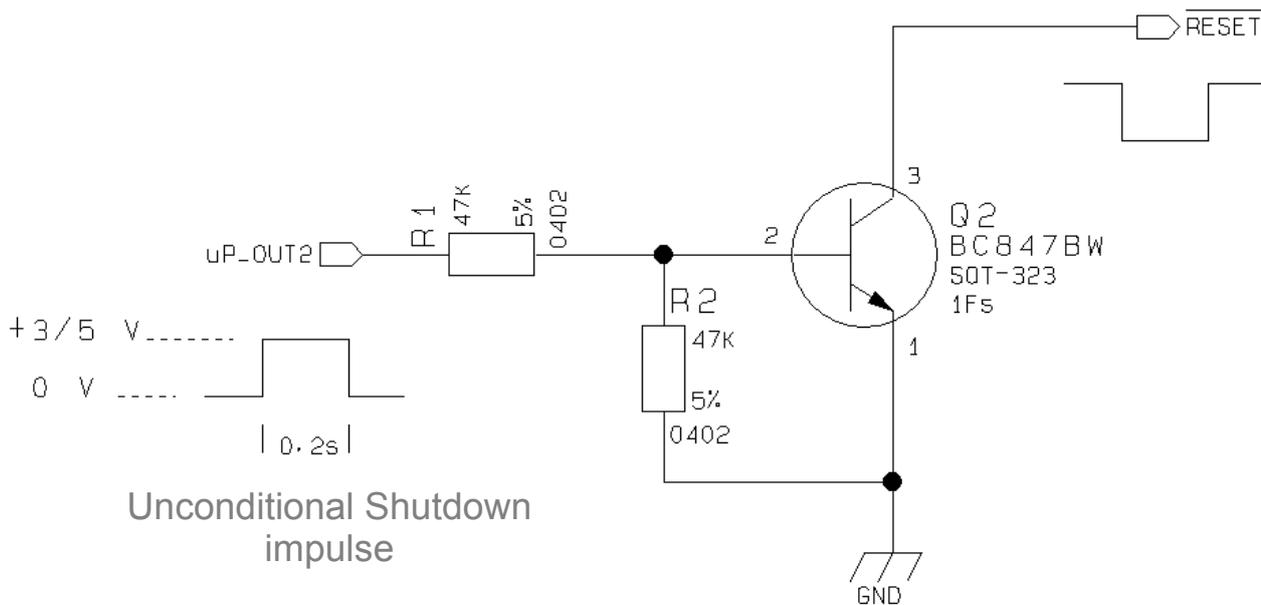


**TIP:** The unconditional hardware reset should be always implemented on the boards and software should use it as an emergency exit procedure.



For example:

1- Let's assume you need to drive the RESET# pin with a totem pole output of a +3/5 V microcontroller (uP\_OUT2):



The hardware unconditional shutdown must not be used during normal operation of the device since it does not detach the device from the network. It shall be kept as an emergency exit procedure to be done in the rare case that the device gets stacked waiting for some network or SIM responses. If device does not respond to a command in the timeout window, retry issuing the command and if still no response is received a hardware reset shall be issued.



# 6 Power Supply

The power supply circuitry and board layout are the most 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.

## 6.1 Power Supply Requirements

The GM862-GPS power requirements are:

- |   |               |
|---|---------------|
| • <i>Nominal Supply Voltage:</i>  | 3.8 V         |
| • <i>Max Supply Voltage:</i>  | 4.2 V         |
| • <i>Supply voltage range:</i>  | 3.4 V - 4.2 V |
| • <i>Max Peak current consumption (impulsive):</i>                      | 1.9 A         |
| • <i>Max Average current consumption during GPRS transmission:</i>      | 400 mA        |
| • <i>Max Average current consumption during VOICE/CSD transmission:</i> | 270 mA        |
| • <i>Average current during Power Saving (CFUN=5):</i>                  | ≈ 4 mA        |
| • <i>Average current during idle (Power Saving disabled)</i>            | ≈ 17 mA       |
| • <i>GPS Max Peak current consumption:</i>                              | 80 mA         |
| • <i>GPS Max Average current consumption during Tracking:</i>           | 60 mA         |
| • <i>GPS Average current during Power Saving:</i>                       | ≈ 1 mA        |
| • <i>GPS antenna consumption (external active antenna)</i>              | ≈ 20 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.



## 6.2 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.

### 6.2.1 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

#### 6.2.1.1 + 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 GM862-GPS, a 100 $\mu$ 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 GM862-GPS from power polarity inversion.



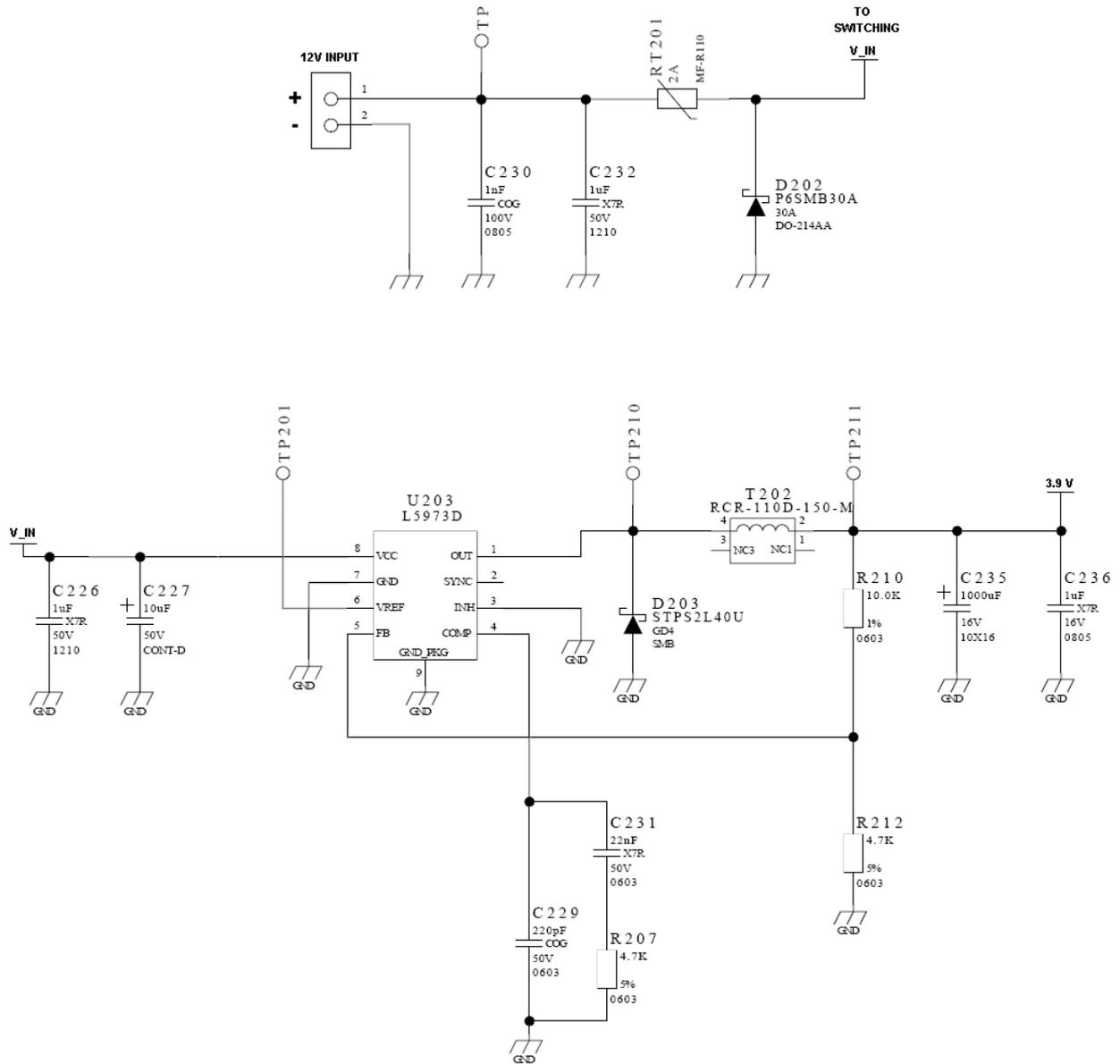




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An example of switching regulator with 12V input is in the below schematic (it is split in 2 parts):



SWITCHING REGULATOR



### 6.2.1.3 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 GM862-GPS 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 GM862-GPS and damage it.



***NOTE: DON'T USE any Ni-Cd, Ni-MH, and Pb battery types directly connected with GM862-GPS. Their use can lead to overvoltage on the GM862-GPS 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 GM862-GPS 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.



#### 6.2.1.4 Battery Charge control Circuitry Design Guidelines

The charging process for Li-Ion Batteries can be divided into 4 phases:

- Qualification and trickle charging
- Fast charge 1 - constant current
- Final charge - constant voltage or pulsed charging
- Maintenance charge

The qualification process consists in a battery voltage measure, indicating roughly its charge status. If the battery is deeply discharged, that means its voltage is lower than the trickle charging threshold, then the charge must start slowly possibly with a current limited pre-charging process where the current is kept very low with respect to the fast charge value: the trickle charging.

During the trickle charging the voltage across the battery terminals rises; when it reaches the fast charge threshold level the charging process goes into fast charge phase.

During the fast charge phase the process proceeds with a current limited charging; this current limit depends on the required time for the complete charge and from the battery pack capacity. During this phase the voltage across the battery terminals still raises but at a lower rate.

Once the battery voltage reaches its maximum voltage then the process goes into its third state: Final charging. The voltage measure to change the process status into final charge is very important. It must be ensured that the maximum battery voltage is never exceeded, otherwise the battery may be damaged and even explode. Moreover for the constant voltage final chargers, the constant voltage phase (final charge) must not start before the battery voltage has reached its maximum value, otherwise the battery capacity will be highly reduced.

The final charge can be of two different types: constant voltage or pulsed. GM862-GPS uses constant voltage.

The constant voltage charge proceeds with a fixed voltage regulator (very accurately set to the maximum battery voltage) and hence the current will decrease while the battery is becoming charged. When the charging current falls below a certain fraction of the fast charge current value, then the battery is considered fully charged, the final charge stops and eventually starts the maintenance.

The pulsed charge process has no voltage regulation, instead the charge continues with pulses. Usually the pulse charge works in the following manner: the charge is stopped for some time, let's say few hundreds of ms, then the battery voltage will be measured and when it drops below its maximum value a fixed time length charging pulse is issued. As the battery approaches its full charge the off time will become longer, hence the duty-cycle of the pulses will decrease. The battery is considered fully charged when the pulse duty-cycle is less than a threshold value, typically 10%, the pulse charge stops and eventually the maintenance starts.

The last phase is not properly a charging phase, since the battery at this point is fully charged and the process may stop after the final charge. The maintenance charge provides an additional charging process to compensate for the charge leak typical of a Li-Ion battery. It is done by issuing pulses with a fixed time length, again few hundreds of ms, and a duty-cycle around 5% or less.

This last phase is not implemented in the GM862-GPS internal charging algorithm, so that the battery once charged is left discharging down to a certain threshold so that it is cycled from full charge to slight discharge even if the battery charger is always inserted. This guarantees that anyway the remaining charge in the battery is a good percentage and that the battery is not damaged by keeping it always fully charged (Li-Ion rechargeable battery usually deteriorate when kept fully charged).





## 6.2.2 Thermal Design Guidelines

The thermal design for the power supply heat sink should be done with the following specifications:

- Average current consumption during transmission @PWR level max (rms): 500mA
- Average current consumption during transmission @ PWR level min (rms): 100mA
- Average current during Power Saving (CFUN=5): 4mA
- Average current during idle (Power Saving disabled): 17mA
- Average GPS current during Power Saving: 1mA
- Average GPS current during Tracking (Power Saving disabled): 60mA



**NOTE:** The average consumption during transmissions depends on the power level at which the device is requested to transmit by the network. The average current consumption hence varies significantly.



**TIP:** The thermal design for the Power supply should be made keeping an average consumption at the max transmitting level during calls of 500mA rms.

Considering the very low current during idle, especially if Power Saving function is enabled, it is possible to consider from the thermal point of view that the device absorbs current significantly only during calls.

If we assume that the device stays into transmission for short periods of time (let's say few minutes) and then remains for a quite long time in idle (let's say one hour), then the power supply has always the time to cool down between the calls and the heat sink could be smaller than the calculated one for 500mA maximum RMS current, or even could be the simple chip package (no heat sink).

Moreover in the average network conditions the device is requested to transmit at a lower power level than the maximum and hence the current consumption will be less than the 500mA, being usually around 200mA.

For these reasons the thermal design is rarely a concern and the simple ground plane where the power supply chip is placed can be enough to ensure a good thermal condition and avoid overheating.





# 7 Serial Ports

The serial port on the Telit GM862-GPS is the core of the interface between the module and OEM hardware.

2 serial ports are available on the module:

- MODEM SERIAL PORT
- GPS SERIAL PORT (NMEA)

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 GPS Serial Port is a 3 wire (RX, TX GND) +2.8V UART.

The MODEM serial port on the GM862-GPS 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 GM862-GPS UART are the CMOS levels:

### Absolute Maximum Ratings -Not Functional

| Parameter                              | Min   | Max    |
|--|-------|--------|
| Input level on any digital pin when on | -0.3V | +3.75V |
| Input voltage on analog pins when on   | -0.3V | +3.0 V |

### Operating Range - Interface levels (2.8V CMOS)

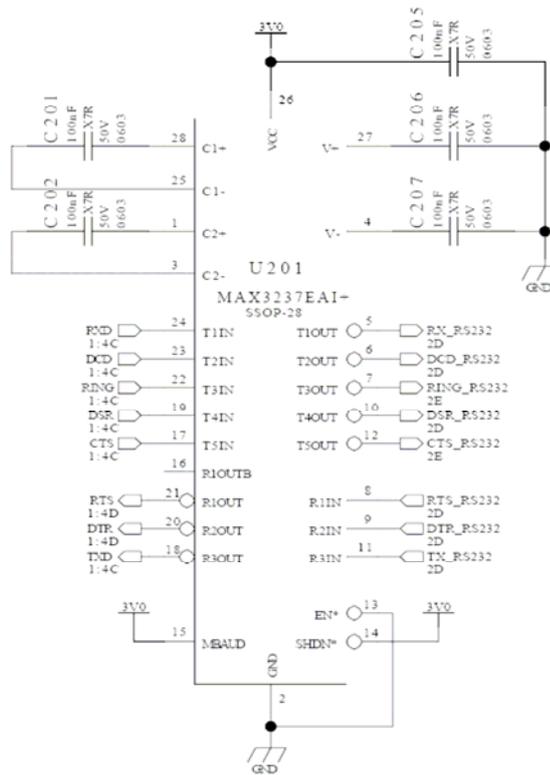
| Level                      | Min  | Max   |
|----------------------------|------|-------|
| Input high level $V_{IH}$  | 2.1V | 3.3V  |
| Input low level $V_{IL}$   | 0V   | 0.5V  |
| Output high level $V_{OH}$ | 2.2V | 3.0V  |
| Output low level $V_{OL}$  | 0V   | 0.35V |





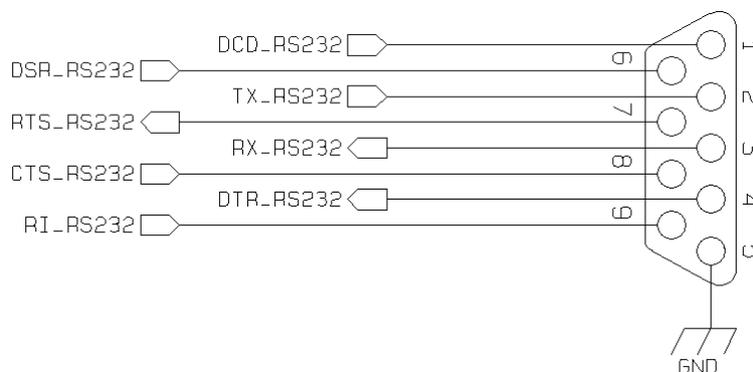


An example of level translation circuitry of this kind is:



RS232 LEVEL TRSANSULATOR

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







**NOTE:** The UART input line TXD (*rx\_uart*) of the GM862-GPS is NOT internally pulled up with a resistor, so there may be the need to place an external 47K $\Omega$  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 47K $\Omega$  may be required.

A power source of the internal interface voltage corresponding to the 2.8VCMOS high level is available at the PWRMON pin on the connector, whose absolute maximum output current is 1mA. A maximum of 9 resistors of 47 K $\Omega$  pull-up can be connected to the PWRMON pin, provided no other devices are connected to it and the pulled-up lines are GM862-GPS input lines connected to open collector outputs in order to avoid latch-up problems on the GM862-GPS. Care must be taken to avoid latch-up on the GM862-GPS and the use of this output line to power electronic devices shall be avoided, especially for devices that generate spikes and noise such as switching level translators, micro controllers, failure in any of these condition can severely compromise the GM862-GPS functionality.

**NOTE:** The input lines working at 2.8VCMOS can be pulled-up with 47K $\Omega$  resistors that can be connected directly to the PWRMON line provided they are connected as in this example. NO OTHER devices than those suggested should be powered with the PWRMON line; otherwise the module functionality may be compromised.



**It is important to consider that the added circuit must have consumption lower than 1mA. In case of reprogramming of the module has to be considered the use of the RESET line to start correctly the activity.**

**The preferable configuration is having an external supply for the buffer.**



## 8 Audio Section Overview

The Base Band Chip of the GM862-GPS Telit Module provides two different audio blocks; both in transmit (*Uplink*) and in receive (*Downlink*) direction:

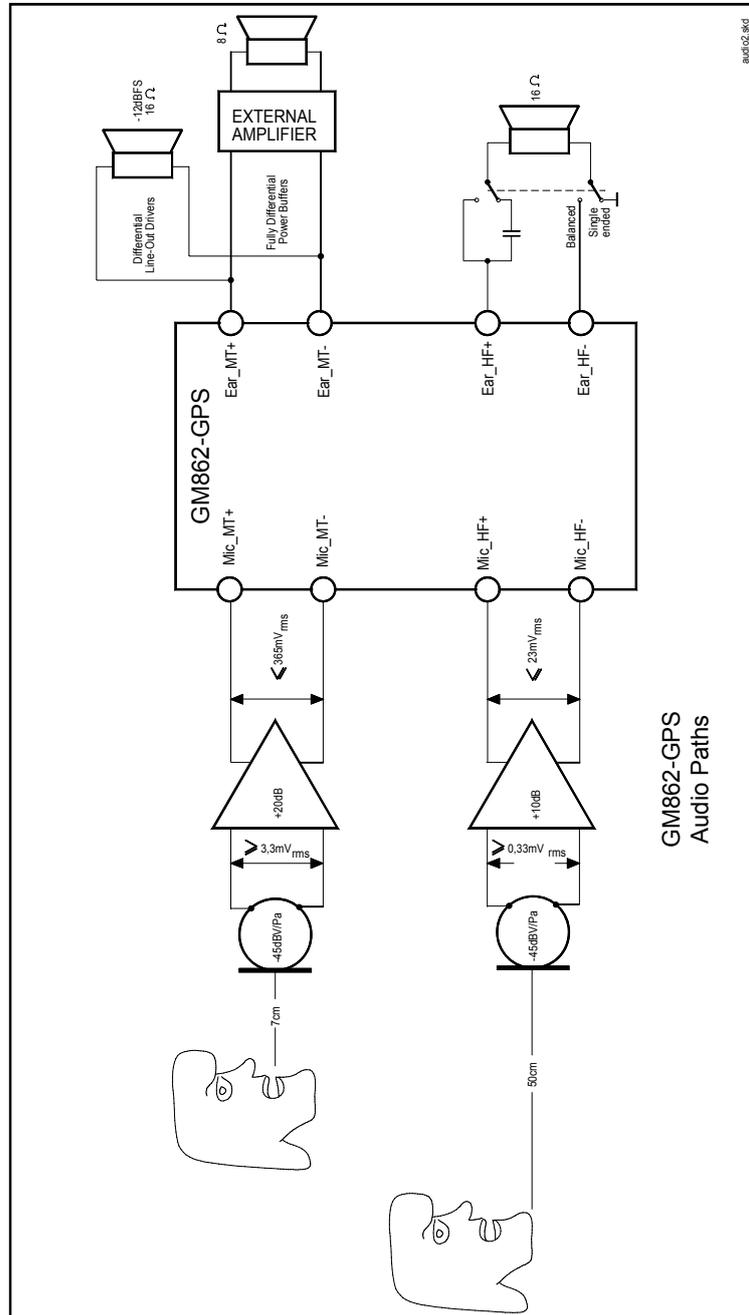
“*MT lines*” should be used for handset function,  
“*HF lines*” is suited for hands -free function (car kit).

These two blocks can be active only one at a time, selectable by *AXE* hardware line or by *AT* command.

The audio characteristics are equivalent in transmit blocks, but are different in the receive ones and this should be kept in mind when designing.



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## 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” 1<sup>st</sup> differential microphone path

|   |  |
|---|--|
| <ul style="list-style-type: none"> <li>• line coupling</li> <li>• line type</li> <li>• coupling capacitor</li> <li>• differential input resistance</li> <li>• differential input voltage</li> <li>• microphone nominal sensitivity</li> <li>• analog gain suggested</li> <li>• echo canceller type</li> </ul> | <p><b>AC</b><br/> <b>balanced</b><br/> <math>\geq 100\text{nF}</math><br/> <math>50\text{k}\Omega</math><br/> <math>\leq 1,03\text{V}_{\text{pp}}</math> (<math>365\text{mV}_{\text{rms}}</math>)<br/> <math>-45 \text{ dBV}_{\text{rms}}/\text{Pa}</math><br/> <math>+ 20\text{dB}</math><br/> <b>handset</b></p> |
|---|--|

### “Mic\_HF” 2<sup>nd</sup> differential microphone path

|   |  |
|---|--|
| <ul style="list-style-type: none"> <li>• line coupling</li> <li>• line type</li> <li>• coupling capacitor</li> <li>• differential input resistance</li> <li>• differential input voltage</li> <li>• microphone nominal sensitivity</li> </ul> | <p><b>AC</b><br/> <b>balanced</b><br/> <math>\geq 100\text{nF}</math><br/> <math>50\text{k}\Omega</math><br/> <math>\leq 65\text{mV}_{\text{pp}}</math> (<math>23\text{mV}_{\text{rms}}</math>)<br/> <math>-45 \text{ dBV}_{\text{rms}}/\text{Pa}</math></p> |
| <ul style="list-style-type: none"> <li>• analog gain suggested</li> <li>• echo canceller type</li> </ul>  | <p><b>+10dB</b><br/> <b>car kit hands-free</b></p>   |







**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<sub>rms</sub>/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 s of GM862-GPS 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 GM862-GPS is 10 dB (3 times) lower than the nominal, as suggested.



## 8.2 General Design Rules

There are several configurations for the audio paths, but the most effective difference is between balanced and unbalanced microphone configuration.

It is highly recommended to keep the whole microphone path balanced even if this means having 2 wires connecting the microphone instead of one needed (plus ground) in the unbalanced case. The balanced circuitry is more suited because of its good common mode noise rejection, reducing the 216 Hz burst noise produced during the GSM transmissions.

- Where possible use balanced microphone circuitry
- Keep the microphone traces on the PCB and wires as short as possible.
- If your application requires an unbalanced microphone, then keep the lines on the PCB balanced and "unbalance" the path close to the microphone wire connector if possible.
- For the microphone biasing voltage use a dedicated voltage regulator and a capacitor multiply circuit.
- Make sure that the microphone traces in the PCB don't cross or run parallel to noisy traces (especially the power line)
- If possible put all around to the microphone lines a ground trace connected to the ground plane by several vias. This is done in order to simulate a shielded trace on the PCB.
- The biasing circuit and eventually the buffer can be designed in the same manner for the internal and external microphones.

## 8.3 Other Considerations

If your application is a hands-free/car kit scenario, but you need to put microphone and speaker inside the same box:

- Try to have the maximum possible distance between them, at least 7cm;
- because the microphone type is very important, if you use an omni-directional one ( and this is the typical application ) please seal it on the rear side (no back cavity) in order not to collect unwanted signals ;
- try to make divergent the main axes of the two devices .



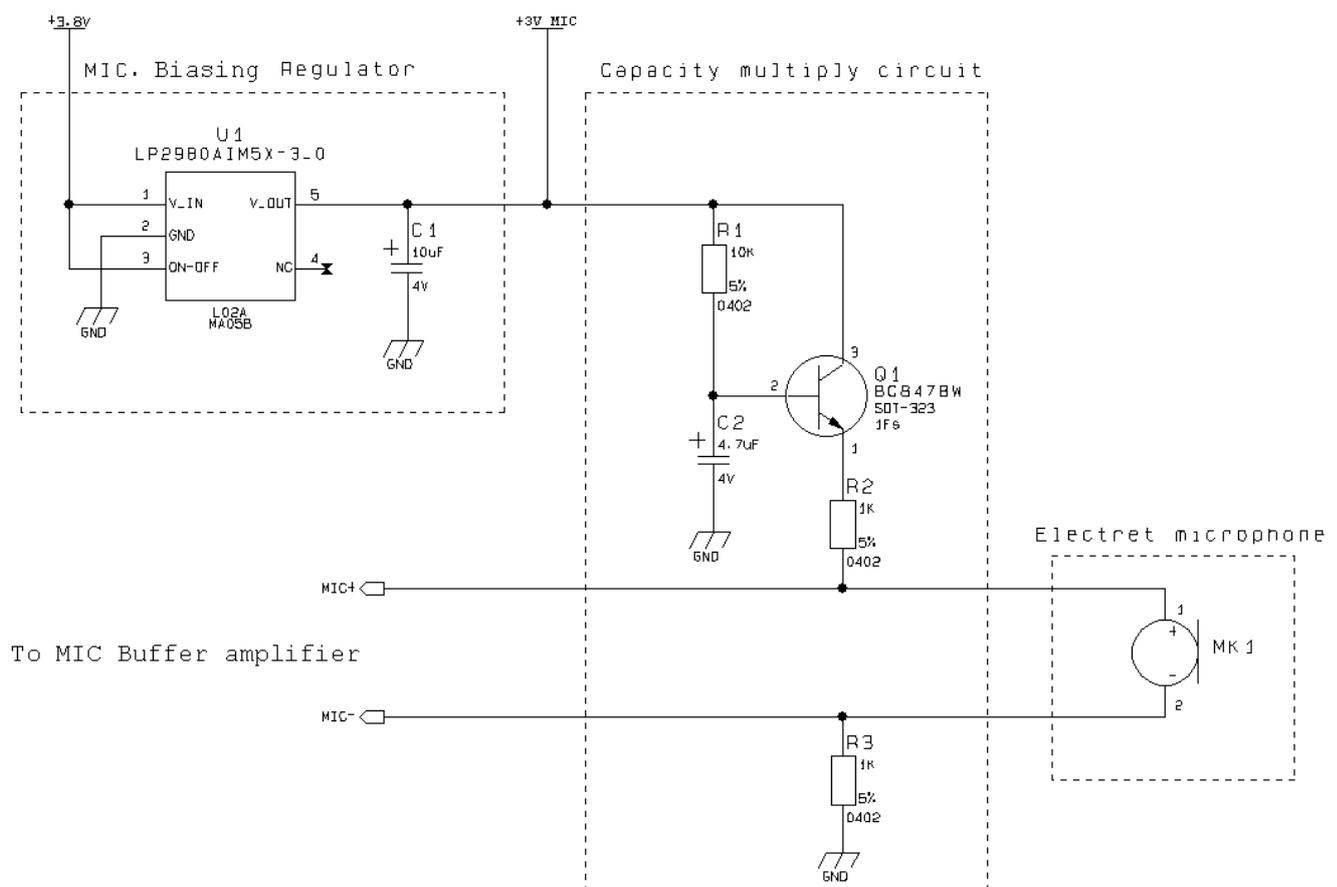
## 8.4 Microphone Biasing

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

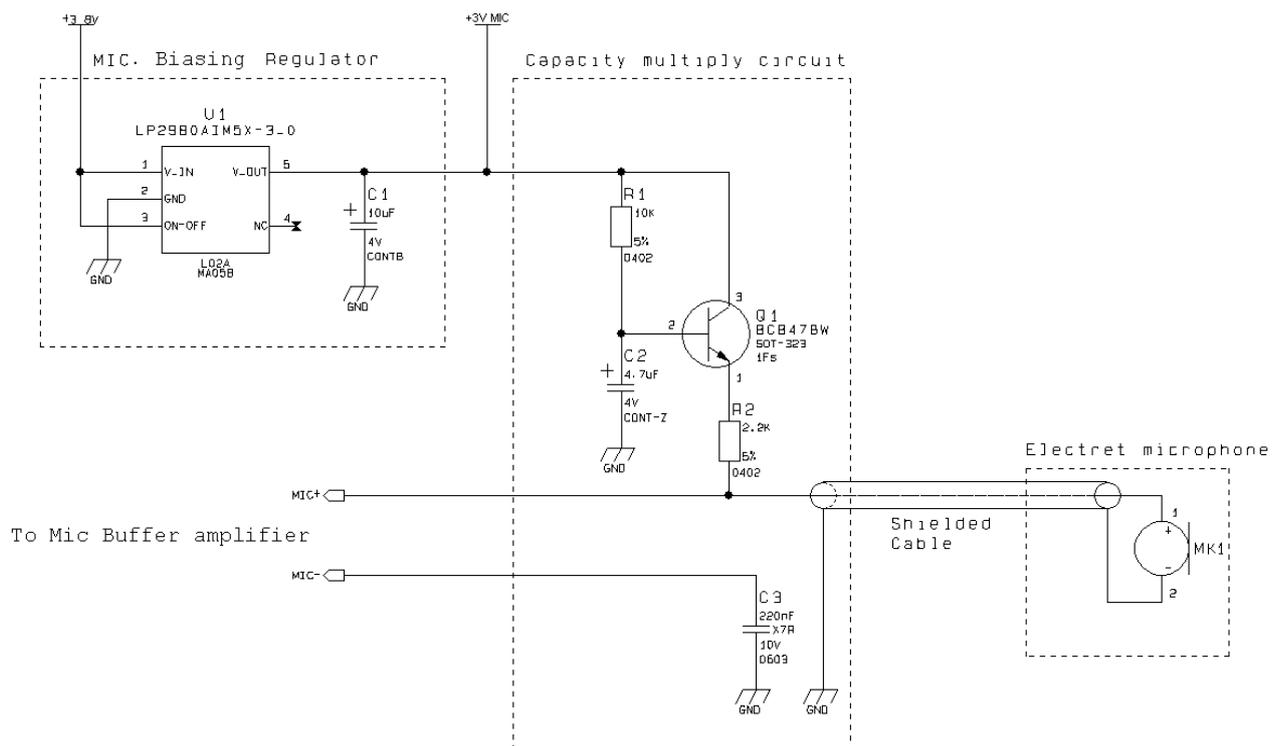
The balanced microphone bias voltage should be obtained from a dedicated voltage regulator, in order to eliminate the noise present on the power lines. This regulator can be the same for all the audio paths. The microphone should be supplied from a capacitor multiply circuit. For example a circuit for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





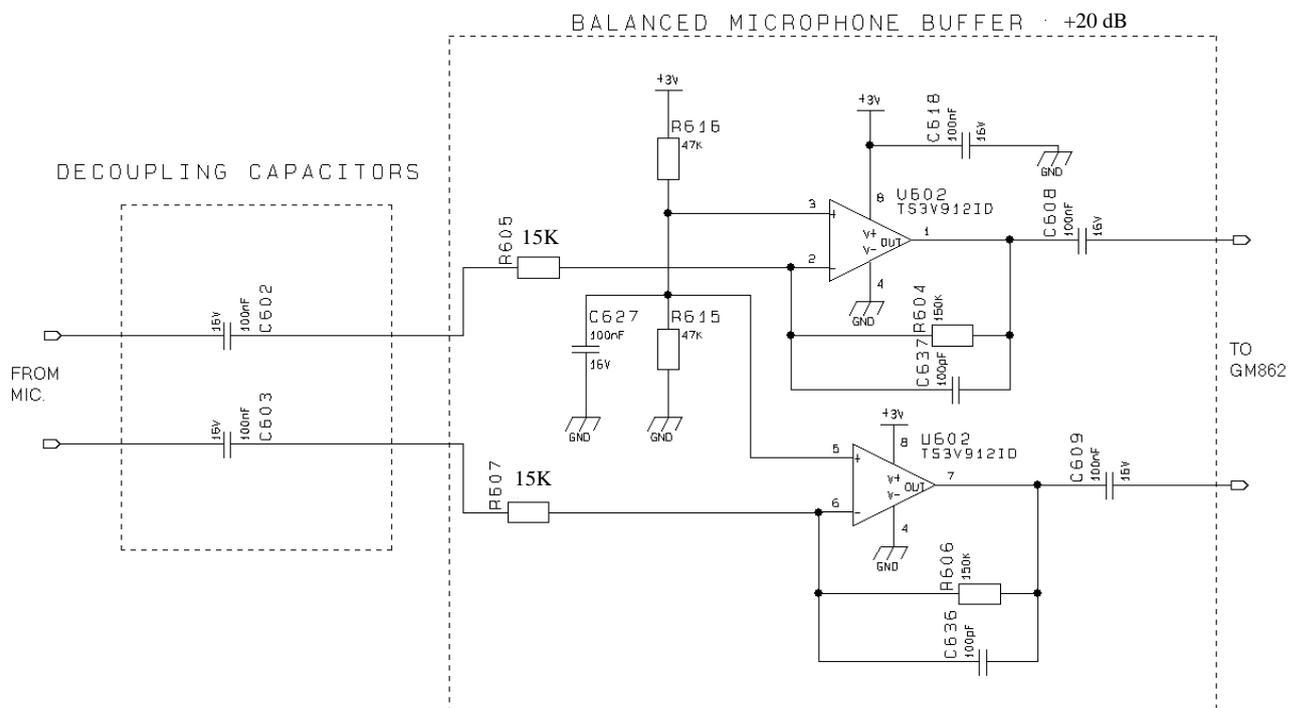
## 8.5 Microphone Buffering

As seen previously, a microphone shall be connected to the input pins of the GM862-GPS 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 e R607) and as a consequence the capacitors C636 and C637 to maintain the bandwidth 150-4000Hz (at -3dB).



The buffer gain is given by the formula:

$$Gain = \frac{R604}{R605} = \frac{R606}{R607}$$

The C636 and C637 capacitors are placed in order to cut off the gain at higher frequencies than the transmitted GSM band, the cutoff frequency (-3dB) should be 3500Hz in order to have -1dB at 3kHz. The cutoff frequency is given by the formula:

$$freq. = \frac{1}{2\pi * R604 * C637} = \frac{1}{2\pi * R606 * C636} \text{ [Hz]}$$



**TIP: example of calculation.**

Let's assume you have a microphone with a sensitivity of -45 dBV<sub>rms</sub>/Pa and you want to use it in 1st differential microphone path ("Mic\_MT" inputs) in "normal spoken" conditions at acoustic pressure of -4.7dBPa.

As reported at page 33 , the electrical level output from the microphone will be :

$$MicLevel = (-45) + (-4.7) = -49.7 \text{ dB}_{V_{rms}}$$

corresponding to:

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

When the talker is screaming , we will have a signal of 330 mV<sub>rms</sub> on the "Mic\_MT" inputs due to a 20dB higher Mic Level (see TIP 1) with a buffer gain G<sub>A</sub> :

$$G_A = 20 \log (AmplifierOutput / MicVoltage) = 20 \log (330 * 10^{-3}) / (3.3 * 10^{-3}) = 20 \log 10 = 20 \text{ dB}$$

The corresponding values for the resistors on the buffer could be ( if we keep the input resistance 10kΩ )

$$R604 = R606 = gain * R607 = gain * R605 = 10 * 15 = 150 \text{ k}\Omega$$

The commercial values of 150kΩ & 15kΩ are then chosen.

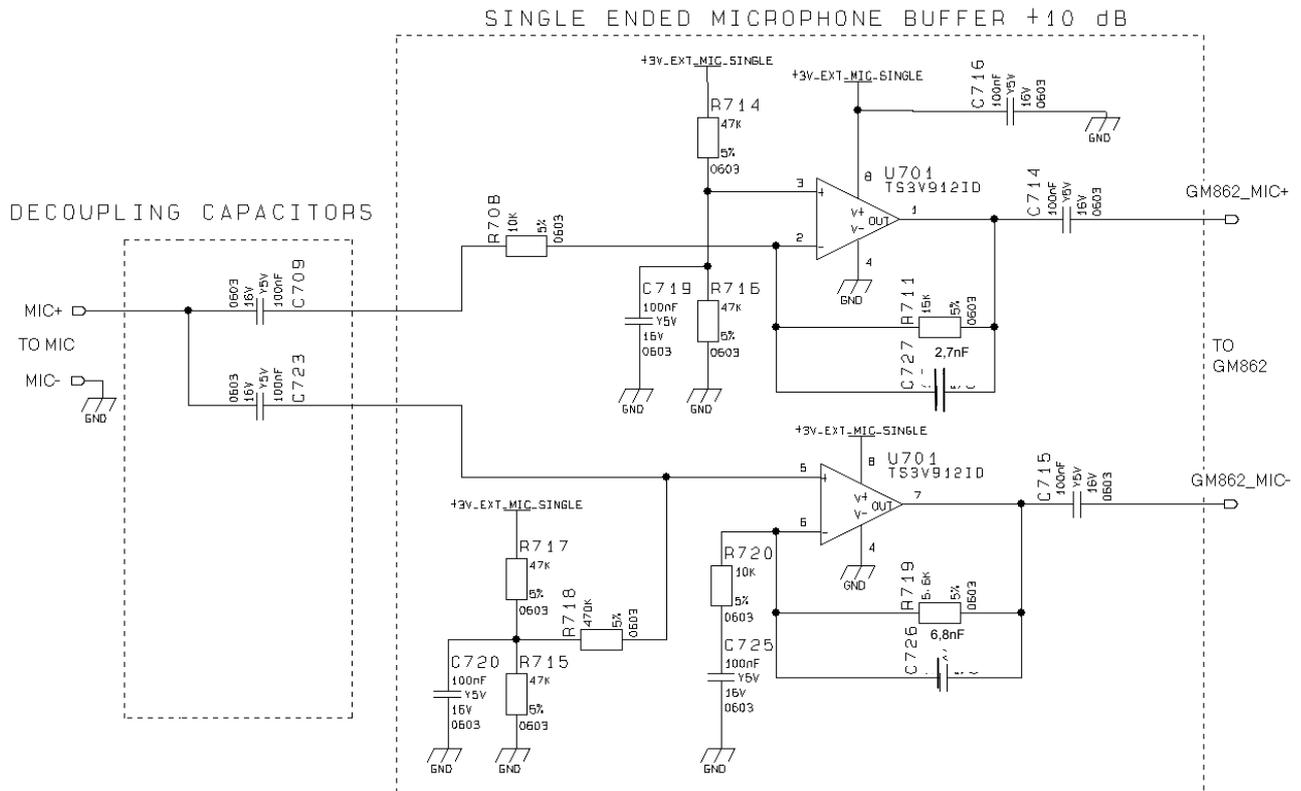
As a consequence the values of the capacitors C636 and C637 shall be:

$$C636 = C637 = 1 / (2\pi * 4000 * R606) = 265 * 10^{-12} \text{ F}$$

A commercial value of 270pF gives a cutoff frequency of 3931Hz with an error less than 1,8% .



### 8.5.2 Buffered Unbalanced (Single Ended) Microphone



The above schematic can be used for a single ended (*buffered unbalanced*) microphone; the required biasing circuitry is not included. Note also that the capacitor C3 is not needed. The gains of the two amplifiers are given by the formulas:

$$Gain(\text{not inverting buffer}) = 1 + \frac{R719}{R720} \qquad Gain(\text{inverting buffer}) = \frac{R711}{R708}$$

Assigning half of overall gain to each amplifier, you will obtain the requested gain because of doubling the microphone signal path; in fact by the use of two amplifiers (the upper as “inverting” and the lower as “not inverting” configuration) we obtain an additional +6dB gain (2 times).

Remember: the “not inverting” amplifier section gain shall not be less than 1 . Like for the balanced buffered microphone, the amplifier overall gain can be modify changing the value of resistor R719/R720 and R711 and as a consequence the capacitors C726 and C727. It is advisable to change R708 only if you have difficulty to find a commercial value for R711; in this case change R708 as little as possible.

The -3dB bandwidth is given by the approximated formula (considering C725 >> C726):

$$freq. = \frac{1}{2\pi * R719 * C726} = \frac{1}{2\pi * R711 * C727} \text{ [Hz]}$$





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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 OUTPUT LINES (Speaker)

### 9.1 Short Description

The Telit GM862-GPS provides two audio paths in receive section. Only one of the two paths can be active at a time, selectable by AXE hardware line or by AT command.

You must keep in mind the different audio characteristics of the receive blocks when designing:

- the “**Ear\_MT**” lines *EPN1* and *EPP1* are the *Differential Line-Out Drivers* ; they can drive an external amplifier or directly a **16 Ω earpiece** at  $-12\text{dBFS}$  (\*) ;
- the “**Ear\_HF**” lines *EPPA1\_2* and *EPPA2* are the *Fully Differential Power Buffers* ; they can directly drive a **16Ω speaker** in differential (*balanced*) or single ended (*unbalanced*) operation mode .

(\*) *FS* : acronym of *Full Scale*. It is equal to 0dB, the maximum Hardware Analog Receive Gain of BaseBand Chip.

The “**Ear\_MT**” audio path should be used for handset function, while the “**Ear\_HF**” audio path is suited for hands-free function (car kit).

Both receiver outputs are B.T.L. type (Bridged Tie Load) and the OEM circuitry shall be designed bridged to reduce the common mode noise typically generated on the ground plane and to get the maximum power output from the device; however also a single ended circuitry can be designed for particular OEM application needs.



## 9.2 Output Lines Characteristics

### **“Ear\_MT” Differential Line-out Drivers Path**

- |                                    |   |
|------------------------------------|---|
| • line coupling:                   | DC  |
| • line type:                       | bridged                                     |
| • output load resistance :         | $\geq 14 \Omega$                            |
| • internal output resistance:      | 4 $\Omega$ (typical)                        |
| • signal bandwidth:                | 150 - 4000 Hz @ -3 dB                       |
| • max. differential output voltage | 1310 mV <sub>rms</sub> (typ, open circuit)  |
| • differential output voltage      | 328mV <sub>rms</sub> /16 $\Omega$ @ -12dBFS |
| • SW volume level step             | - 2 dB                                      |
| • number of SW volume steps        | 10  |

### **“Ear\_HF” Power Buffers path**

- |                                    |  |
|------------------------------------|--|
| • line coupling:                   | DC   |
| • line type:                       | bridged                                    |
| • output load resistance :         | $\geq 14 \Omega$                           |
| • internal output resistance:      | 4 $\Omega$ ( >1,7 $\Omega$ )               |
| • signal bandwidth:                | 150 - 4000 Hz @ -3 dB                      |
| • max. differential output voltage | 1310 mV <sub>rms</sub> (typ, open circuit) |
| • max. single ended output voltage | 656 mV <sub>rms</sub> (typ, open circuit)  |
| • SW volume level step             | - 2 dB                                     |
| • number of SW volume steps        | 10   |





## 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 GM862-GPS.

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 GM862-GPS 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 GM862-GPS which is limited and for some particular applications may not be enough.

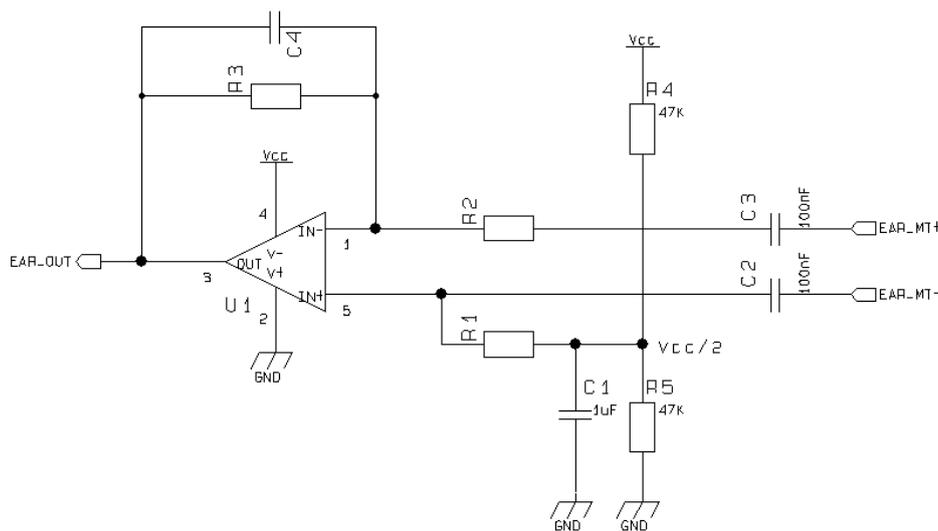
For these reasons, when the power output of the GM862-GPS is not enough or if the speaker characteristics are different from the suggested, then it is preferable to use an amplifier to increase the power and current output capabilities.

Again the output from the GM862-GPS 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 GM862-GPS 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:

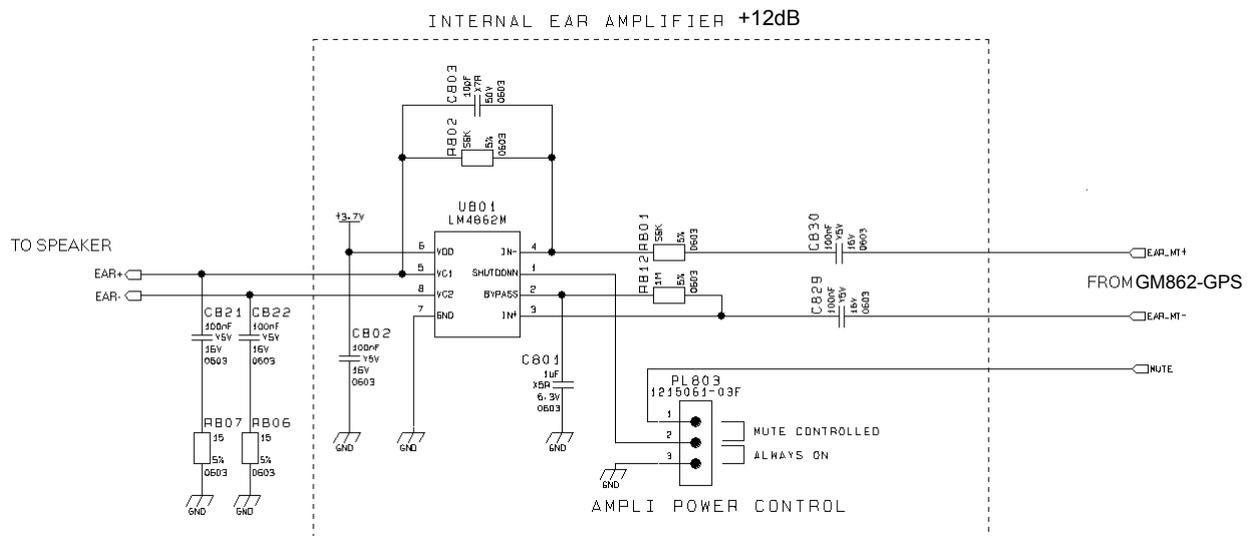


The resulting gain and high pass cut can be obtained with the formula:

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

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

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

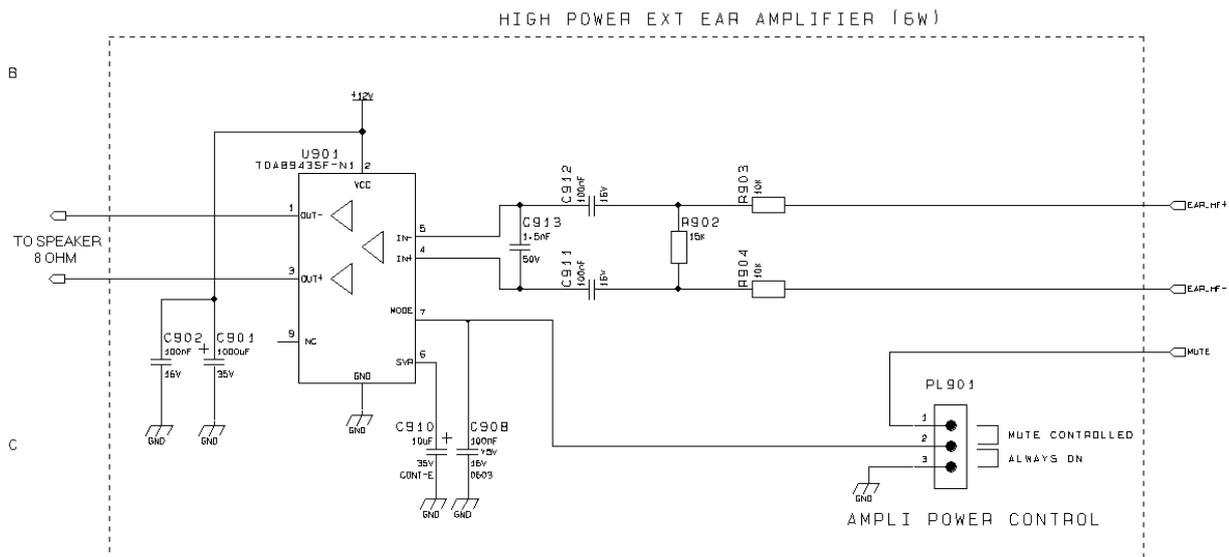
For the car kit speaker phone function the power output requirement is usually at least 4W, therefore an amplifier is needed to boost the *GM862-GPS* output.

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 *GM862-GPS*, 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 *GM862-GPS* “*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 *GM862-GPS* 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 *GM862-GPS* 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 *GM862-GPS* internal audio path from the external audio path.

Example of car kit amplifier schematic.



# 10 General Purpose I/O

The general-purpose I/O pins can be configured to act in three different ways:

- input
- output
- alternate function (internally controlled)

Input pins can only be read and report the digital value (high or low) present on the pin at the read time; output pins can only be written or queried and set the value of the pin output; an alternate function pin is internally controlled by the GM862-GPS firmware and acts depending on the function implemented.

Not all GPIO pins support all these three modes:

- GPIO1 is an INPUT ONLY
- GPIO2 is an OUTPUT ONLY (open collector)
- GPIO3, GPIO4, GPIO8 to GPIO13 support both input or output mode but not Alternate function.
- GPIO5 supports all three modes and can be input, output, RFTXMON output (Alternate function)
- GPIO6 supports all three modes and can be input, output, ALARM output (Alternate function)
- GPIO7 supports all three modes and can be input, output, BUZZER output (Alternate function)

All GPIO pins except from GPIO1 and GPIO2 that are buffered with a transistor, are 2.8V CMOS signals and their interface levels are the same specified in the paragraph 7 Serial Port.

## 10.1 Using a GPIO pin as INPUT

The GPIO pins, when used as inputs, can be connected to a digital output of another device and report its status, provided this device has interface levels compatible with the 2.8V CMOS levels of the GPIO.

If the digital output of the device to be connected with the GPIO input pin has interface levels different from the 2.8V CMOS, then it can be connected to GPIO1 or can be buffered with an open collector transistor, provided a 47KΩ pull-up resistor is connected as seen in the paragraph 7.2 5V UART level translation.

## 10.2 Using a GPIO pin as OUTPUT

The GPIO pins, when used as outputs, can drive 2.8V CMOS digital devices or compatible hardware. When set as outputs, the pins (except from GPIO2 which is Open Collector) have a push-pull output and therefore the pull-up resistor may be omitted.

The GPIO2 pin, since it is an Open Collector output needs an external pull-up resistor.







# 11 ADC section

## 11.1 ADC converter

### 11.1.1 Description

The GM862-GPS module provides a Analog to Digital Converter. The input line (named ADC\_IN1) is available on Pin #6 of the Module's connector of the module and on pin 19 of PL103 on EVK2 Board.

The on board A/D is 11-bit converter. It is able to read a voltage level in the range of 0÷2 volts applied on the ADC pin input, store and convert it into 11 bit word.

|                     | Min | Max | Units |
|---------------------|-----|-----|-------|
| Input Voltage range | 0   | 2   | Volt  |
| AD conversion       | -   | 11  | bits  |
| Resolution          | -   | < 1 | mV    |

### 11.1.2 Using ADC Converter

An AT command is available to use the ADC function.

The command is **AT#ADC=1,2**

The read value is expressed in mV

Refer to SW user guide or to GM862-GPS AT commands specification for the full description of this function.



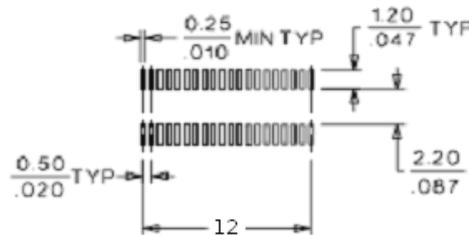
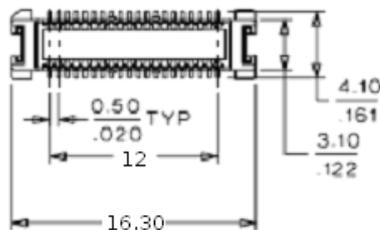
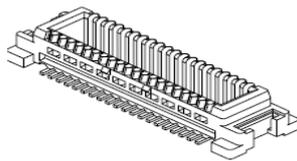


# 13 Mounting the GM862 module on your Board

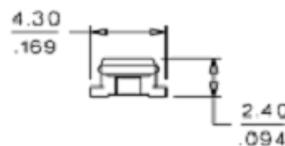
In order to electrically connect your board to the [Telit GM862-GPS modules](#), use a **CSTP 2x25 pin vertical SMD SCH-SCH Molex 53748 - 0504 (female, low profile)** as a counterpart to the **CSTP 50 pin vertical SMD Molex 52991-0508 (male)** of your [Telit GM86-GPS](#).

When mounting the [Telit GM862-GPS](#) on your board, take care of soldering the GM862 shielding reeds on a ground plane or signal.

## Molex 53748-0504 (female, low profile) Connector LAY-OUT



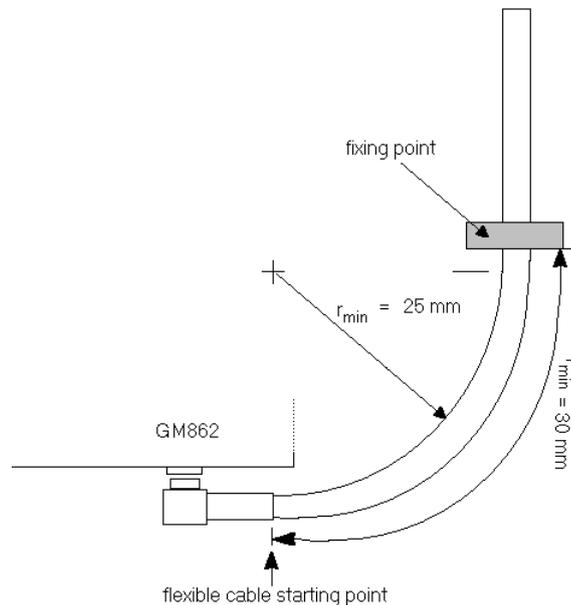
PCB LAYOUT: COMPONENT SIDE



**NOTE:** be very careful when connecting the [Telit GM862 module](#) RF connector. The [Telit GM862 module](#) RF connector can be damaged if not connected with the proper antenna RF connector. The minimum number of insertion cycles is recommended.







- Angle connector fixing example 2 -

**NOTE:** in the examples the cable is always bent, this is not a constrain. If the installation does not require it, then the cable can be kept straight, ensuring that the fixing is without sliding.

## 13.2 Precautions

- The plug should be inserted in the connector only after the installation of the [Telit GM862-GPS modules](#) in the board. This is to prevent accidental breaking of the antenna connection during the transport.
- The coaxial cable must be fixed at least in one point, without sliding possibilities.
- The plug insertion/removal must be done axially with the female connector of the GM862, keeping lateral strains to a minimum.
- The insertion/crimping pull out force must be less than 15N.
- The Hole's diameter for GM862 shielding reed soldering is: (1,5 +/- 0,05) mm





