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RESUME / SUMMARY
This document is HiLo module application note.
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FICHE RECAPITULATIVE / SUMMARY SHEET

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SOMMAIRE / CONTENTS

Direction des Recherches et des Développements	Etablissement de VELIZY	1
NOTE D'ETUDE / TECHNICAL DOCUMENT		1
Direction des Recherches et des Développements	Etablissement de VELIZY	2
NOTE D'ETUDE / TECHNICAL DOCUMENT		2
FICHE RECAPITULATIVE / SUMMARY SHEET		2
SOMMAIRE / CONTENTS		3
1. OVERVIEW		5
1.1 OBJECT OF THE DOCUMENT		5
1.1 REFERENCE DOCUMENTS		5
1.2 MODIFICATION OF THIS DOCUMENT		5
2. BLOCK DIAGRAM		6
3. FUNCTIONAL INTEGRATION		6
3.1 HOW TO CONNECT TO A SIM CARD		7
3.2 HOW TO CONNECT THE AUDIOS?		7
3.2.1 Connecting microphone and speaker		7
3.2.2 Characteristics of the microphone and speaker recommended by Sagem communications		9
3.3 PWM		10
3.3.1 PWM for LED		10
3.3.2 PWM for Buzzer connection		10
3.4 POWER SUPPLY		10
3.5 EXAMPLE OF POWER SUPPLY		12
3.5.1 Example 1		12
3.5.2 Example 2		12
3.6 V24		13
3.6.1 Complete V24 – connection HiLo - host		13
3.6.2 Complete V24 interface with PC		13
3.6.3 Partial V24 (RX-TX-RTS-CTS) – connection HiLo - host		14
3.6.4 Partial V24 (RX-TX) – connection HiLo - host		14
3.7 SPI		15
3.8 GPIO		15
3.9 BACKUP BATTERY		15
3.9.1 Backup battery function feature		15
3.9.2 Current consumption on the backup battery		16
3.9.3 Charge by internal HiLo charging function		16
3.9.4 Backup Battery technology recommended		16
3.10 HARDWARE POWER MANAGEMENT AND MULTIPLEXING INTERFACES		17
3.11 STARTING THE MODULE		17
3.12 MODULE SWITCH OFF		17
3.13 SLEEP MODE MANAGEMENT		18
4. MANDATORY POINTS FOR THE FINAL TESTS AND TUNING		19
5. ESD & EMC RECOMMENDATIONS		19
5.1 STANDARD REQUIREMENTS		19
5.1.1 Analysis		19
5.1.2 Recommendations to avoid ESD issues		19
5.2 ESD FEATURES		20
6. RADIO INTEGRATION		20
6.1 ANTENNA		20
6.2 GROUND LINK AREA		21
6.3 LAYOUT		21
6.4 MECHANICAL SURROUNDING		21
6.5 OTHER RECOMMENDATIONS – TESTS FOR PRODUCTION/DESIGN		21
7. AUDIO INTEGRATION		22
7.1 MECHANICAL INTEGRATION AND ACOUSTICS		22
7.2 ELECTRONICS AND LAYOUT		22



- 8. RECOMMENDATIONS ON LAYOUT OF MMI BOARD22
 - 8.1 GENERAL RECOMMENDATIONS ON LAYOUT.....22
 - 8.2 EXAMPLE OF LAYOUT FOR MMI BOARD23
- 9. LABEL23

1. OVERVIEW

1.1 OBJECT OF THE DOCUMENT

The aim of this document is to describe some examples of hardware solutions for developing some products around the SAGEM HiLo GPRS Module. Most part of these solutions is not mandatory. Use them as suggestions of what should be done to have a working product and what should be avoided thanks to our experiences.

This document suggests how to integrate the HiLo GPRS module in machine devices such as automotive, AMM (Automatic Metering Management), tracking system: connection with external devices, layout advises, external components (decoupling capacitors...).

1.1 REFERENCE DOCUMENTS

URD1 OTL 5635.1 005 70086 - HiLo technical specification

URD1 OTL 5635.1 008 70248 - AT Command Set for SAGEM HiLo Modules

1.2 MODIFICATION OF THIS DOCUMENT

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2. BLOCK DIAGRAM

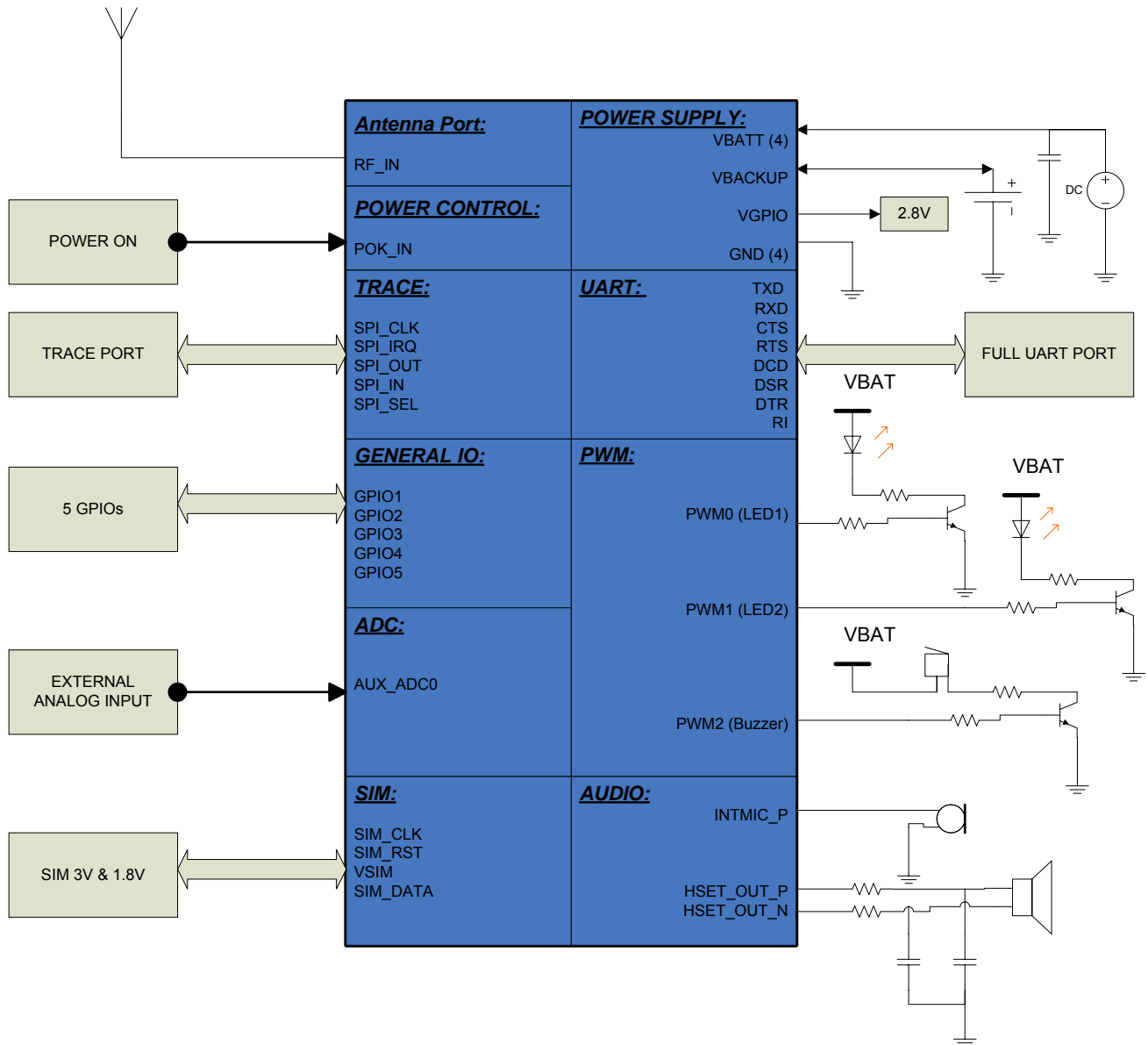


Figure 1: Block diagram of HiLo module

3. FUNCTIONAL INTEGRATION

The improvement of Silicon technologies heads toward functionality improvement, less power consumption. The HiLo Module meets all these requirements and uses the latest high-end technology. All digital I/Os at the 40 pins connector are in 2.8V domain, which is suitable for most systems except VSIM (the SIM I/Os at 1.8V or 2.9V) and VBAT which ranges from 3.2V to 4.5V.

3.1 HOW TO CONNECT TO A SIM CARD

Preliminary notes:

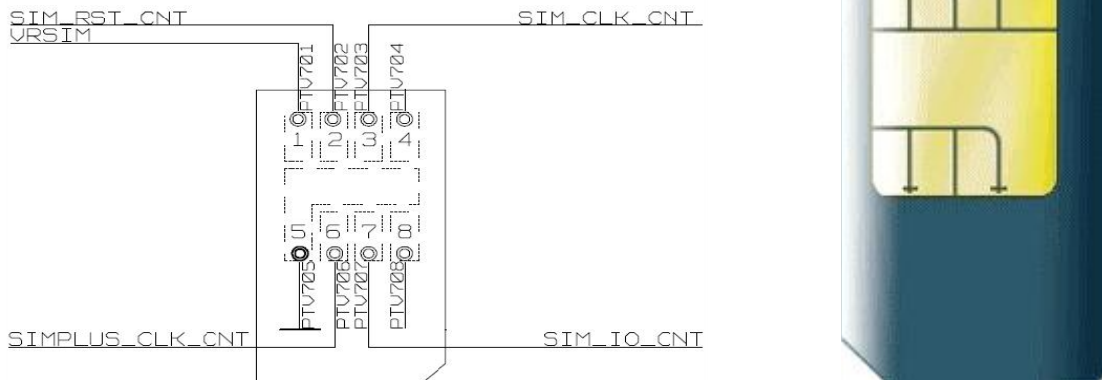


Figure 2: SIM Card signals

HiLo module provides the SIM signals on the board to board connector. A SIM card holder with 6 pins needs to be adopted to use the SIM function. In this case, decoupling capacitors have to be added on SIM_CLK, SIM_RST, VSIM and SIM_DATA signals **as close as possible** to the SIM card connector to avoid EMC issues. Moreover, use ESD protection components to protect SIM card and module I/Os against Electro Static Discharges. The following schematic show how to protect the SIM access for 6 pins connector.

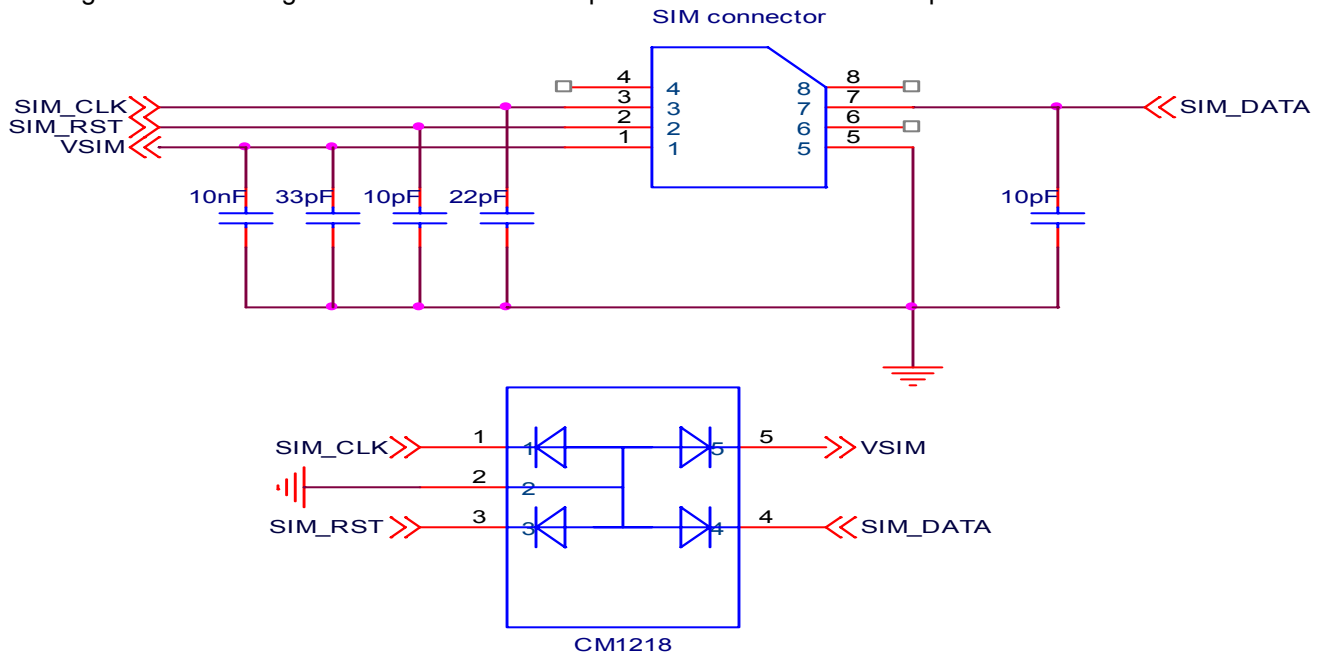


Figure 3: Protections: EMC and ESD components closed to the SIM

3.2 HOW TO CONNECT THE AUDIOS?

The HiLo module features one input audio path and one output audio path. The input path is single-end while the output path is differential. In this following chapter examples of design will be given including protections against EMC and ESD and some notes about the routing rules to follow to avoid the TDMA noise usually present in this sensitive area of design.

3.2.1 Connecting microphone and speaker

The HiLo module can manage an external microphone (INTMIC_P) in single-end mode and an external speaker (HSET_OUT_P / HSET_OUT_N) in differential mode. Thus, one speaker and one microphone can be

connected to the module. The bias supply to microphone is implemented in the module. The speaker connected to the module should be 32 ohms.

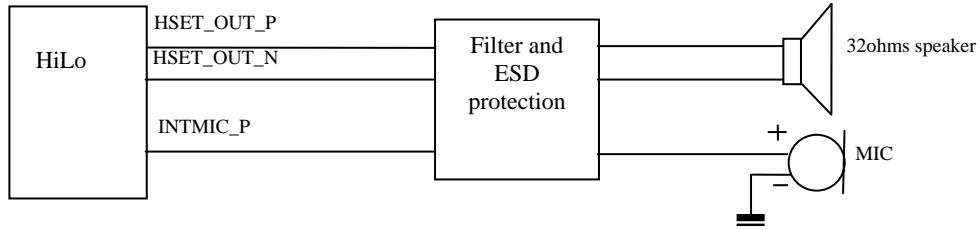


Figure 4: Audio connection

If the design is ESD or EMC sensitive we strongly recommend to read the notes below.

The weakness can either come from the PCB routing and placement or from the chosen components (or both).

3.2.1.1 Notes for microphone:

- Pay attention to the microphone device, It must not be sensitive to RF disturbances.
- Some microphone includes two spatial microphones inside the same shell and allow to make an electrical difference between the environment noise (received by one of the two mic.) and the active signal (received by the other mic. + noise) resulting in a very high SNR.
- If you need to have deported microphone out of the board with long wires, you should pay attention to the EMC and ESD effect. It also the case when your design is ESD sensitive. In those cases, add the following protections to improve your design.
- To ensure proper operation of such sensitive signals, they have to be isolated from the others by analogue ground on mother board layout. (Refer to Layout design chapter)

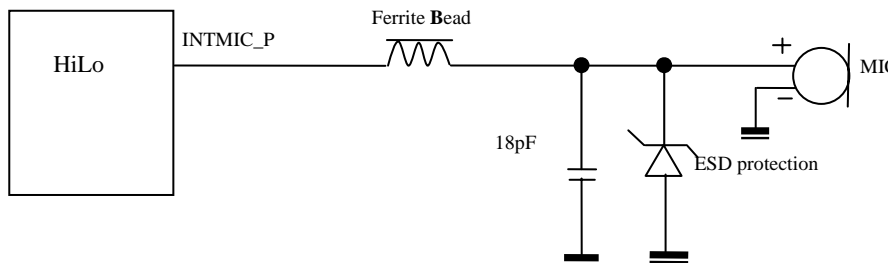


Figure 5 : Filter and ESD protection of microphone

3.2.1.2 Notes for speaker:

- As explained for the microphone, if the speaker is deported out of the board or is sensitive to ESD, use the schematic here after to improve the audio.
- HSET_OUT_P, HSET_OUT_N, and tracks must be larger than other tracks: 0.1 mm.
- As described in the layout chapter, differential signals have to be routed in parallel: it is the case for HSET_OUT_P and HSET_OUT_N.

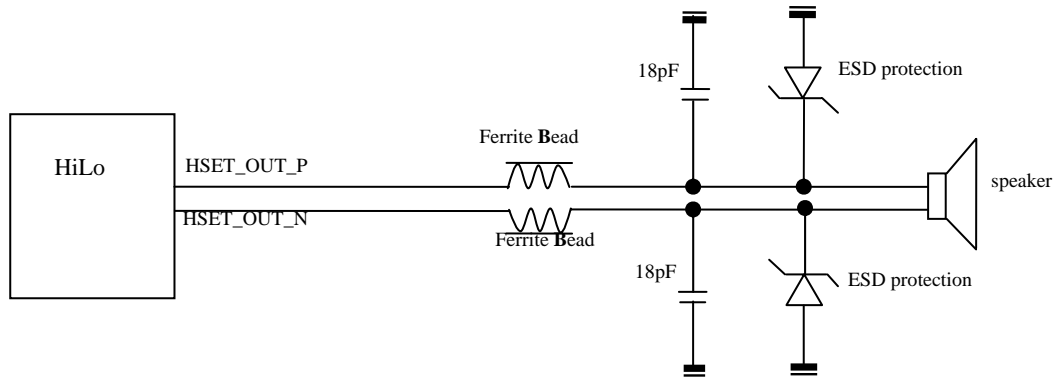


Figure 6: Filter and ESD protection of 32 ohms speaker

The impedance of audio chain (filter + speaker) must be lower than 32 Ohm.

3.2.2 Characteristics of the microphone and speaker recommended by Sagem communications

3.2.2.1 Characteristics of the microphone recommended by Sagem communications

Item to be inspected	Acceptance criterion																											
Sensitivity	- 40 dB SPL +/-3 dB (0 dB = 1 V/Pa @ 1kHz)																											
Frequency response	Limits (relative values) <table border="1"> <thead> <tr> <th>Freq. (Hz)</th> <th>Lower limit</th> <th>Upper limit</th> </tr> </thead> <tbody> <tr> <td>100</td> <td>-1</td> <td>1</td> </tr> <tr> <td>200</td> <td>-1</td> <td>1</td> </tr> <tr> <td>300</td> <td>-1</td> <td>1</td> </tr> <tr> <td>1000</td> <td>0</td> <td>0</td> </tr> <tr> <td>2000</td> <td>-1</td> <td>1</td> </tr> <tr> <td>3000</td> <td>-1.5</td> <td>1.5</td> </tr> <tr> <td>3400</td> <td>-2</td> <td>2</td> </tr> <tr> <td>4000</td> <td>-2</td> <td>2</td> </tr> </tbody> </table>	Freq. (Hz)	Lower limit	Upper limit	100	-1	1	200	-1	1	300	-1	1	1000	0	0	2000	-1	1	3000	-1.5	1.5	3400	-2	2	4000	-2	2
Freq. (Hz)	Lower limit	Upper limit																										
100	-1	1																										
200	-1	1																										
300	-1	1																										
1000	0	0																										
2000	-1	1																										
3000	-1.5	1.5																										
3400	-2	2																										
4000	-2	2																										
Current consumption	1 mA (maximum)																											
Operating voltage	DC 1 to 3 V (minimum)																											
S / N ratio	55 dB minimum (A-Curve at 1 kHz, 1 Pa)																											
Directivity	Omni-directional																											
Maximum input sound pressure level	100 dB SPL (1 kHz) Maximum distortion 1%																											
Radio frequency protection	Over 800 -1200 MHz and 1700 -2000 MHz, S/N ratio 50 dB minimum (signal 1 kHz, 1 Pa)																											

3.2.2.2 Characteristics of the speaker recommended by Sagem communications

Item to be inspected	Acceptance criterion
Input power: rated / max	0.1W (Rate)
Audio chain impedance	32 ohm +/- 10% at 1V 1KHz
Frequency Range	300 Hz ~ 4.0 KHz
Sensitivity (S.P.L)	>105 dB at 1KHz with IEC318 coupler,

3.3 PWM

3.3.1 PWM for LED

The HiLo module can manage two PWM outputs to drive for example two LEDs. These LEDs can be used to interact with the network activity.

If more than Two LEDs are required, any GPIO can be used to drive a LED. A maximum of 5 GPIOs are available on the HiLo Module.

As LEDs are driven through PWM outputs of the HiLo, they can be configured with appropriate AT command (for more details refer to AT command set for Sagem HiLo module specification).

User application can set for each output:

- Frequency between : 25.6KHz and 1083.3KHz
- Duty range from: 0 to 100%

3.3.2 PWM for Buzzer connection

The HiLo module can manage a dedicate PWM output to drive a buzzer. The buzzer can be used to alarm for abnormal state.

Resistors should be added to protect the buzzer. The value of these resistors depends on the buzzer and the transistor. Normally, they can be set as 1K ohm.

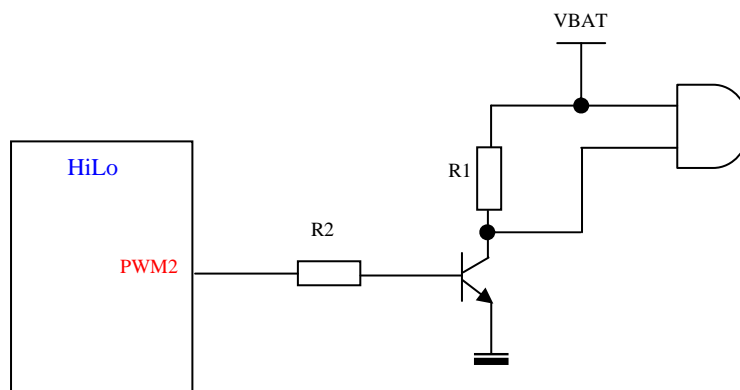


Figure 7: Buzzer connection

3.4 POWER SUPPLY

The HiLo module can be supplied by a battery or any DC/DC converter compliant with the module supply range 3.2V to 4.5V 2.2 A.

The PCB tracks must be well dimensioned to support 2.2 A maximum current. The voltage ripple caused by resistance of power supply path (Battery internal resistance, tracks and contact resistance) could result in the low voltage to the module.

The HiLo module does not manage the battery charging

3.4.1.1 Burst conditions

- Communication mode (worst case: 2 continuous GSM time-slot pulse):

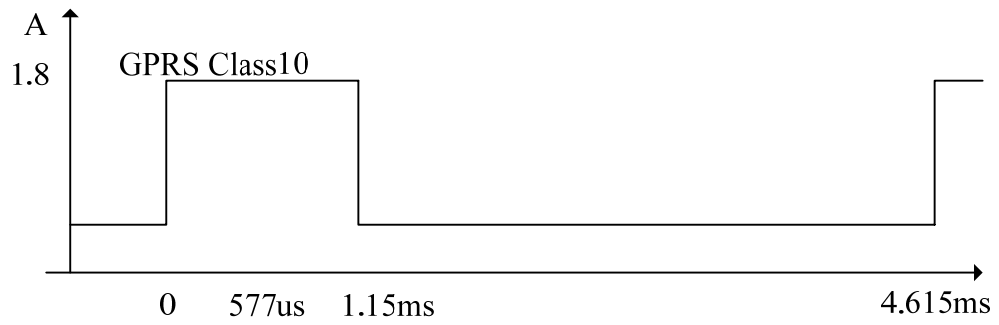


Figure 8: GSM/GPRS Burst

A 47uF capacitor is highly recommended for VBAT and close to the module.

3.5 EXAMPLE OF POWER SUPPLY

3.5.1 Example 1

It the following application note from Linear Technology LTC3440, this schematic is an example of a DC/DC power supply able to power 3.6V under 2.1A. This can be use with a AC/DC 5V unit or an USB or PCMCIA bus as input power source.

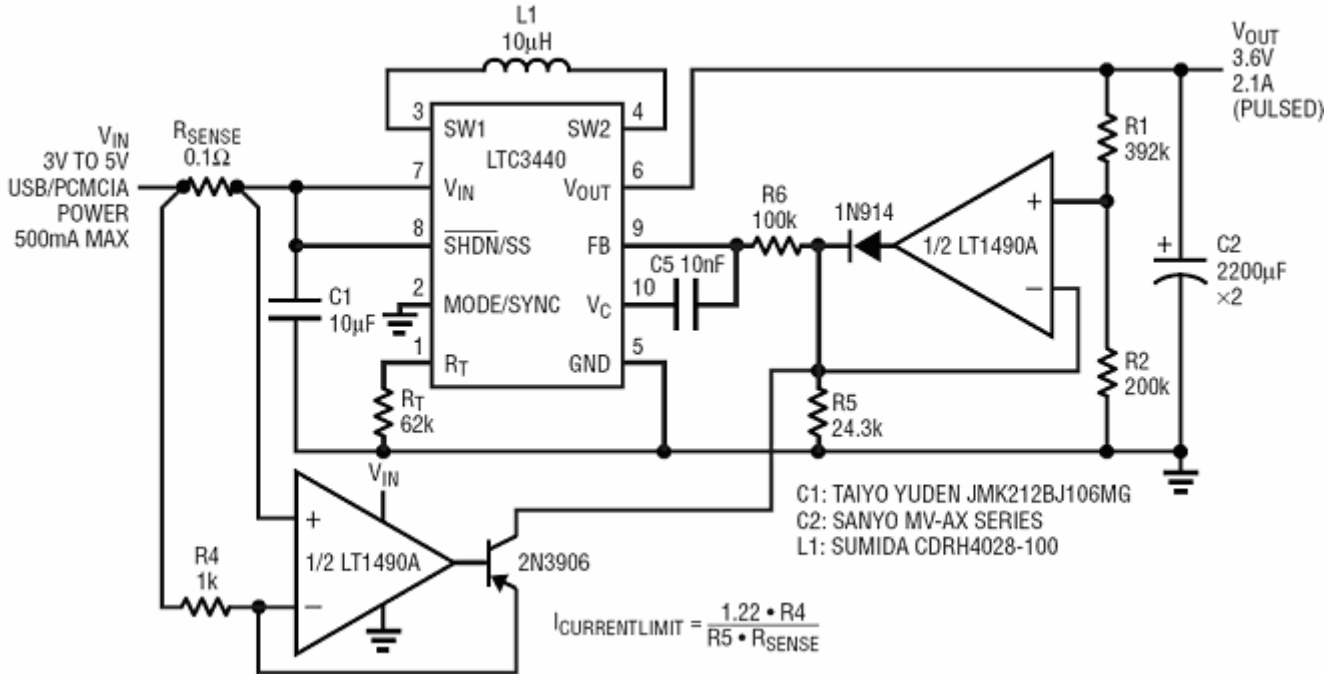


Figure 9: Example of power supply based on a DC/DC step down converter

3.5.2 Example 2

If the whole power consumption is not an issue, this example of a voltage regulator used with an AC/DC 5V converter, can be used as a DC power supply.

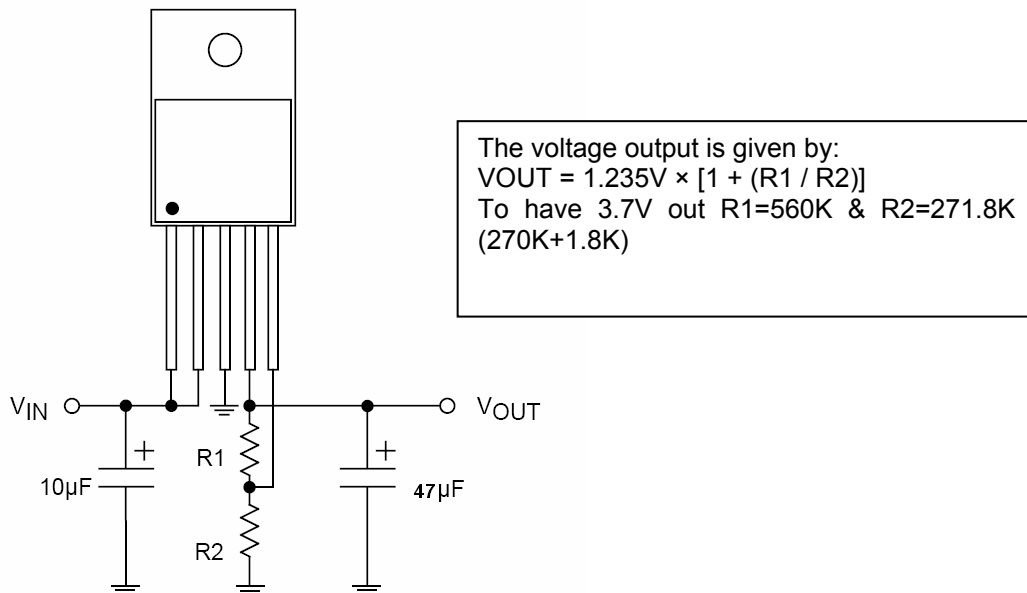


Figure 10: Example of power supply based on regulator

3.6 V24

The HiLo module features a V24 interface to communicate with the Host through AT commands or for easy firmware upgrading purpose.

Pull-up resistors () must be connected to DCD, DTR, DSR and RI signals.

3.6.1 Complete V24 – connection HiLo - host

A V24 interface is provided on the main connector of the HiLo module with the following signals: RTS/CTS, RXD/TXD, DSR, DTR, DCD, RI.

It is recommended to manage an external access to the V24 interface, in order to allow easy software upgrade.

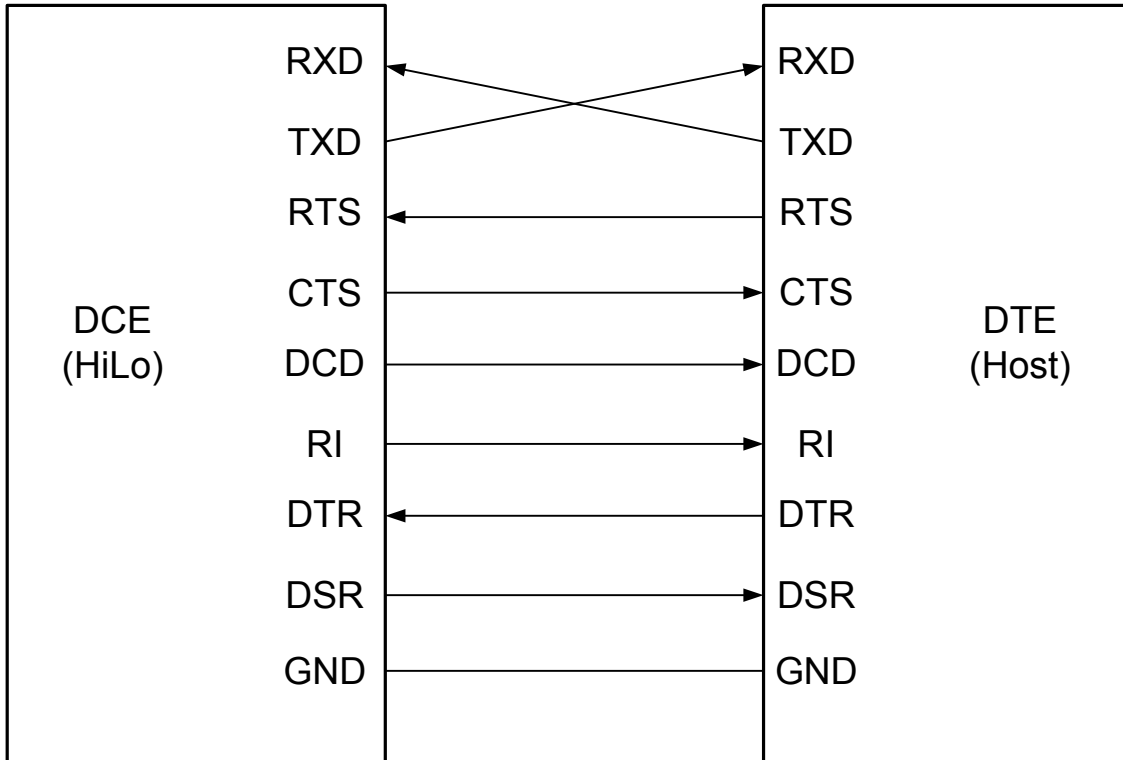


Figure 11: Complete V24 connection between HiLo and host

3.6.2 Complete V24 interface with PC

It supports speeds up to 115.2 Kbps and may be used in auto bauding mode.

To use the V24 interface, some adaptation components are necessary to convert the +2.8V signals from the HiLo to +/- 5V signals compatible with a PC.

Note: Sagem communications recommends using this full interface.

To create your own data cable (for software download purpose...etc...) please refer to the following schematic as an example:

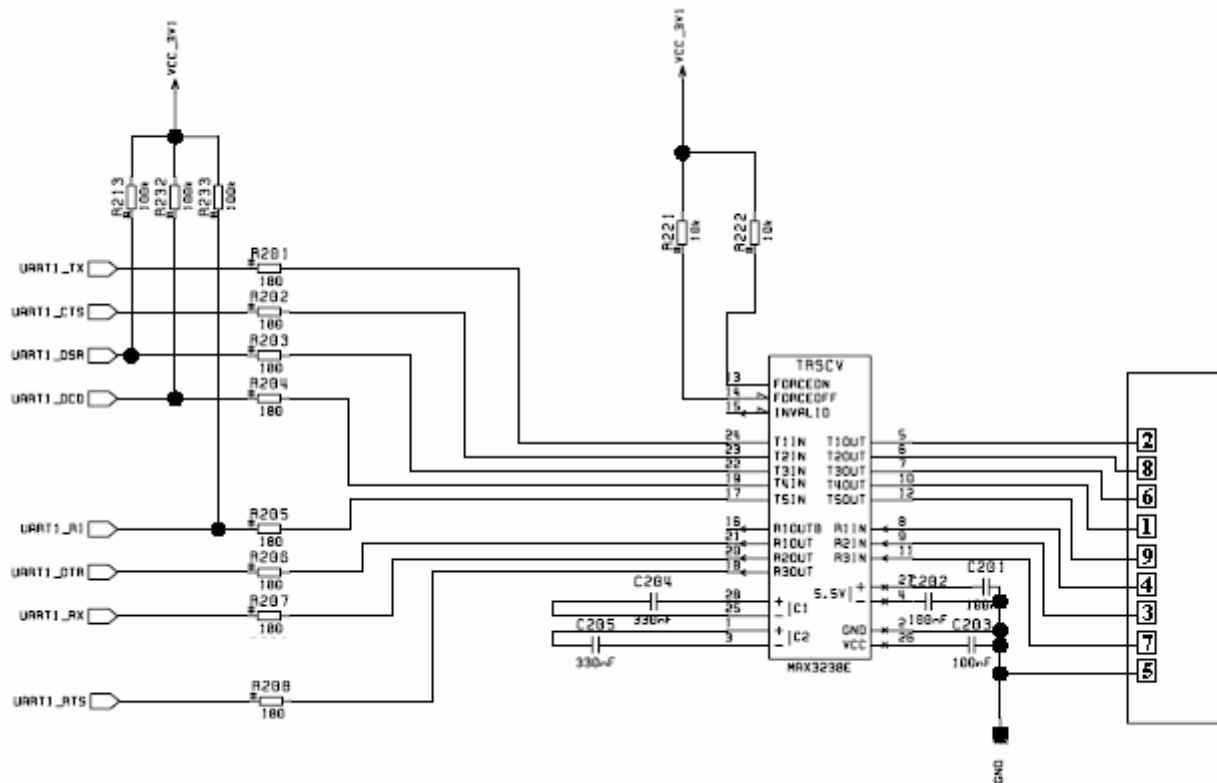


Figure 12: connection to a data cable

3.6.3 Partial V24 (RX-TX-RTS-CTS) – connection HiLo - host

When using only RX/TX/RTS/CTS instead of the complete V24 link, we recommend following schematic: As we need DTR active (low electrical level), a loop DSR on DTR is sufficient because DSR is active (low electrical level) once the HiLo is switched on.

DCD and RI can stay not connected and floating.

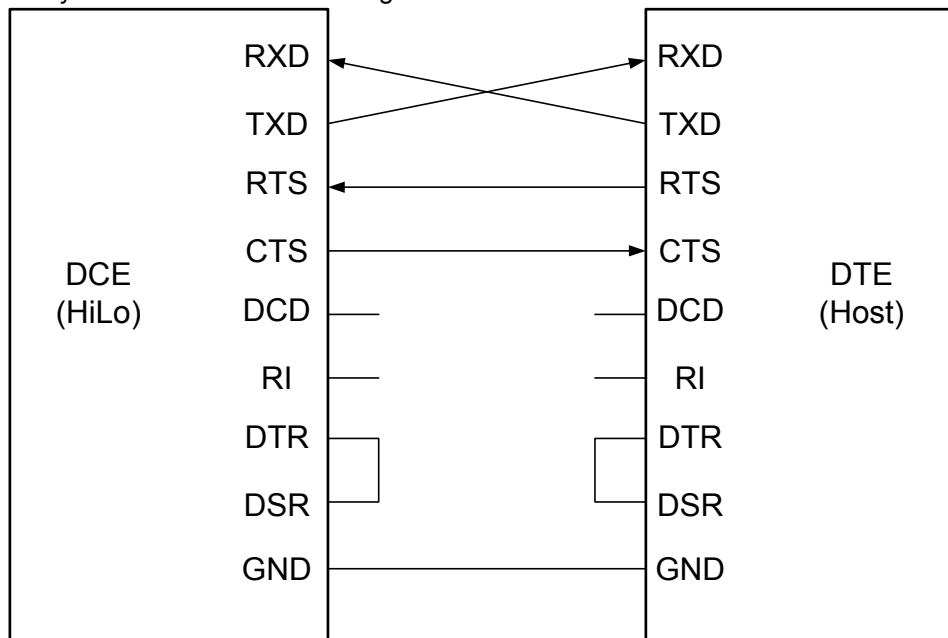


Figure 13: Partial V24 connection (4 wires) between HiLo and host

3.6.4 Partial V24 (RX-TX) – connection HiLo - host

When using only RX/TX instead of the complete V24 link, we recommend following schematic:

We need DTR active (low electrical level), a loop DSR on DTR is sufficient because DSR is active (low electrical level) once the HiLo is switched on.

We also need RTS active (low electrical level), a loop RTS on CTS is sufficient because CTS is active (low electrical level) once the HiLo is switched on.

DCD and RI can stay not connected and floating.

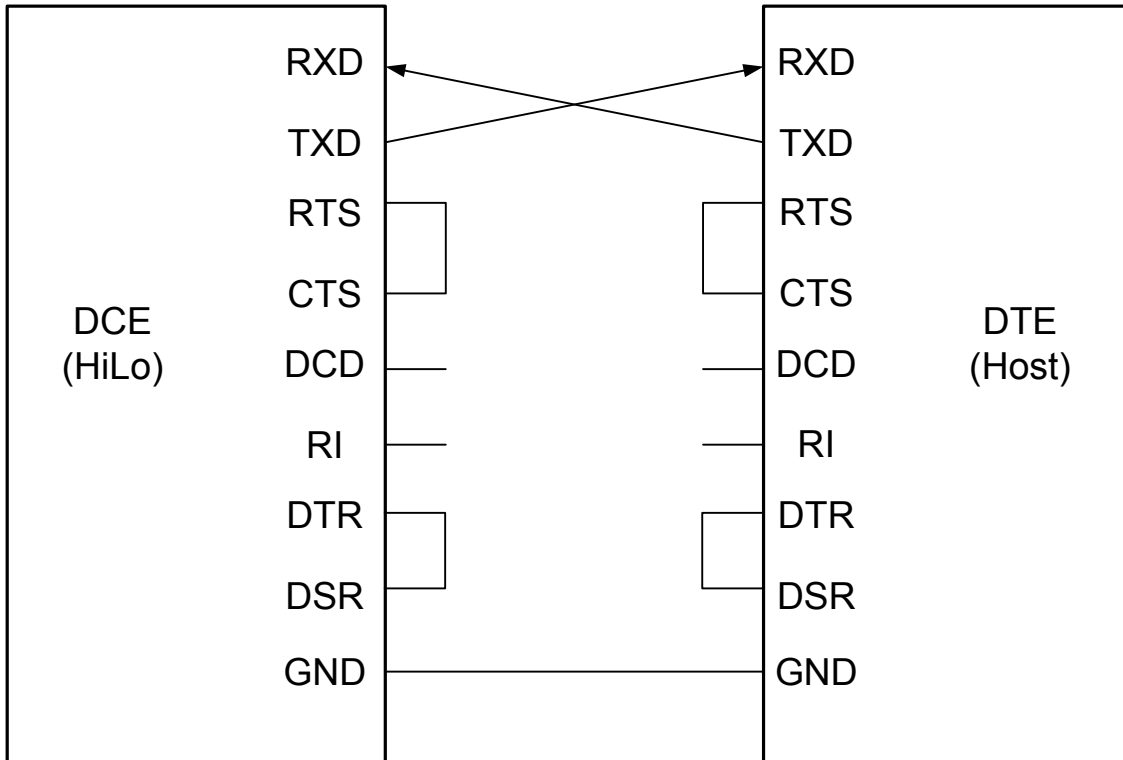


Figure 14: Partial V24 connection (2 wires) between HiLo and host

3.7 SPI

HiLo module manages a host SPI interface. This SPI interface is dedicated for trace. Sagem communications strongly recommends leaving this interface externally accessible for trace (e.g. access by test point pads).

3.8 GPIO

There are five GPIOs available on HiLo. The GPIO1, 2 and 3 have internal pull-up resistors while GPIO4 and 5 are open collector. So when using GPIO4 and 5 as output, they must be pulled up to VGPI0. The typical value of the pull-up resistors is 100K ohms.

3.9 BACKUP BATTERY

3.9.1 Backup battery function feature

A backup battery can be connected to the module in order to supply internal RTC (Real Time Clock) when the main power supply is removed. Thus, when the main power supply is removed, the RTC is still supplied and the module keep the time running.

With external BACKUP:

- If VBAT < 3V, internal RTC is supplied by VBACKUP.
- If VBAT > =3V, internal RTC is supplied by VBAT.

If there is no backup battery, VBACKUP input of the module has to be connected to VBAT signal.

Without external VBACKUP (VBACKUP input connected to VBAT)

- If VBAT > 1.5V, internal RTC is supplied by VBAT.
- If VBAT < 1.5V, internal RTC is not supplied.

Pin Name	Min	Max	Remarks
VBACKUP	+1.5V	+3.18V	Protection

3.9.2 Current consumption on the backup battery

When the power supply is removed, the internal RTC will be supplied by backup battery.

3.9.3 Charge by internal HiLo charging function

The charging function is available on the HiLo without any additional external power supply (the charging power supply is provided by the HiLo).

The recommended schematic is given hereafter:

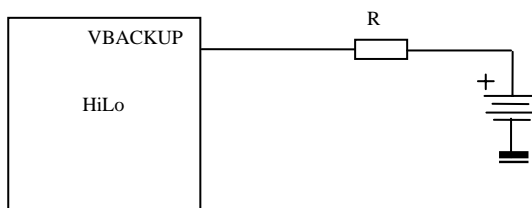


Figure 15: Backup battery internally charged

The resistor R depends on the charging current value provided by the battery manufacturer. The charging curve which is done by the HiLo is given hereafter:

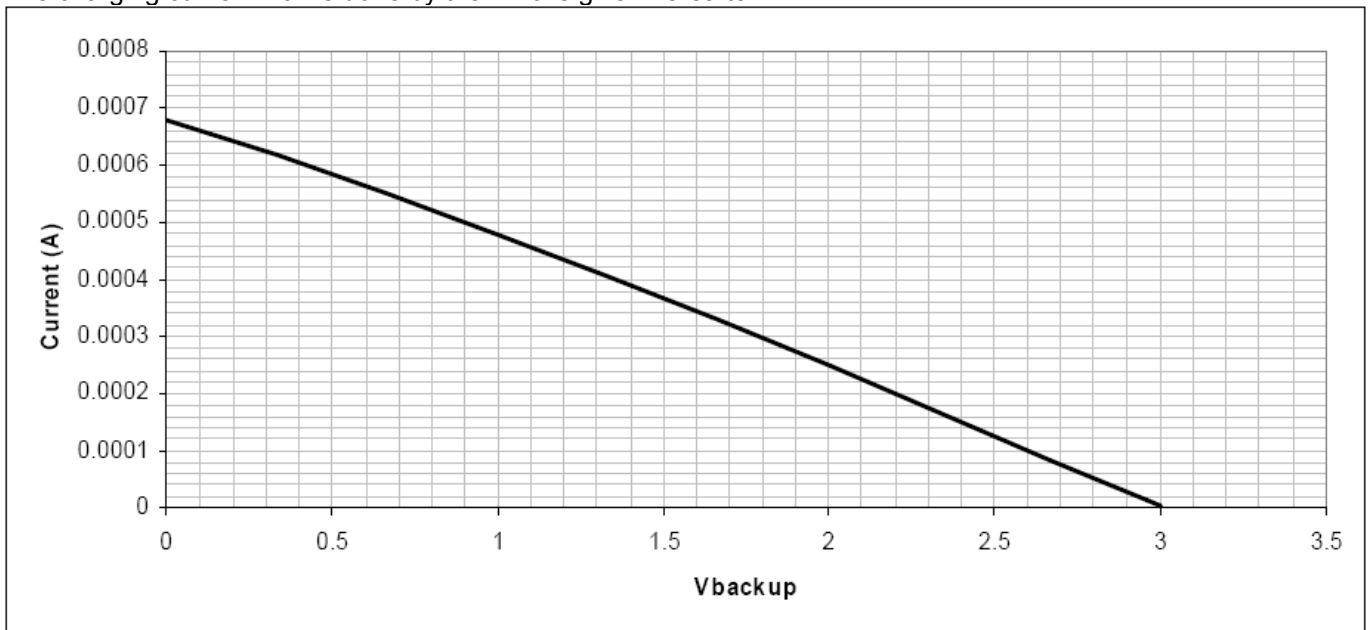


Figure 16: Charging curve of backup battery

3.9.4 Backup Battery technology recommended

3.9.4.1 Manganese Silicon Lithium-Ion rechargeable Battery

Sagem communications does not recommend using this kind of technology because of the following drawbacks:

- The maximum discharge current is limited (Shall be compliant with the module characteristics)

- The over-discharge problem: most of the Lithium Ion rechargeable batteries are not able to recover their charge when their voltage reaches a low-level voltage. To avoid this, it is necessary to add a safety component to disconnect the backup battery in case of over-discharge condition. In such a case, this implementation is too complicated (too much components for that function).
 - The charging current has to be regulated
- Sagem communications does not recommend using this kind of backup battery technology.**

3.9.4.2 Capacitor battery

These kinds of backup battery have not the drawbacks of the Lithium Ion rechargeable battery. As there are only capacitors:

- The maximum discharge current is generally bigger,
- There is no problem of over-discharge: the capacitor is able to recover its full charge even if its voltage has previously fallen to 0V.
- There is no need to regulate the charging current.

Moreover, this kind of battery is available in the same kind of package than the Lithium Ion cell and fully compatible on a mechanical point of view. The only disadvantage is that the capacity of this kind of battery is significantly smaller than Manganese Silicon Lithium Ion battery. But for this kind of use (supply internal RTC when the main battery is removed), the capacity is generally enough.

Sagem communications strongly recommends using this kind of backup battery technology.

3.10 HARDWARE POWER MANAGEMENT AND MULTIPLEXING INTERFACES

In case hardware power management and multiplexing are used, it is necessary to isolate host and HiLo module in order not to generate current re-injection when HiLo is switched-off.

Typical schematic (only useful signals are represented):

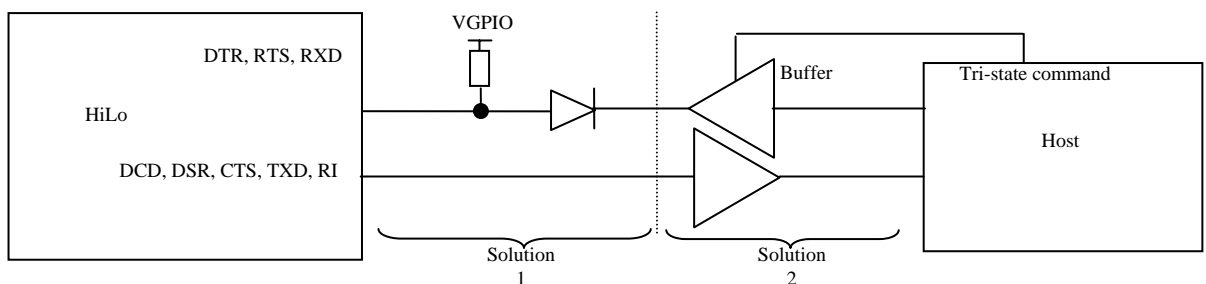


Figure 17: Hardware interface between HiLo and host

In general, solution1 is enough to protect HiLo module.

3.11 STARTING THE MODULE

First power up VBAT, which must be in the range 3.2V – 4.5V, and able to provide 2.2A during the TX bursts (Refer to the module specification for more details).

To start the module, a low level pulse must be sent on POK_IN during 1 s minimum (at 25°C).

After a few seconds, the module put in active state CTS when it is ready to receive AT commands.

3.12 MODULE SWITCH OFF

AT command “AT*PSCPOF” allows to switch off the module.

3.13 SLEEP MODE MANAGEMENT

AT command "AT+KSLEEP" allows the module to enter sleep mode.

4. MANDATORY POINTS FOR THE FINAL TESTS AND TUNING

The design of the main board (which the module is connected to) must provide an access to following signals when the final product will be completely integrated.

To upgrade the module software, Sagem communications recommends providing a direct access to the module serial link through an external connector or any mechanism allowing the upgrade of the module without opening the whole product.

Serial link:

TXD	Output	UART transmit
RXD	Input	UART receive

5. ESD & EMC RECOMMENDATIONS

5.1 STANDARD REQUIREMENTS

Test levels:

Contact discharge		Air discharge	
Level	Test voltage (kV)	Level	Test voltage (kV)
1	2	1	2
2	tbd	2	tbd
3	tbd	3	tbd
4	tbd	4	tbd
X*	Special	X*	Special

* "X" is a level which has to be defined. This level is specified in the particular specification of the device. If higher voltages as specified are needed, special testers have to be used.

Standard indicates that tests have to be done when module is in call with its charger. These tests consist to put some ESD impulses of 8 kV maximum everywhere on the module. It mustn't lose the call or other functions and if one of them is lost, the module has to come back in its normal configuration without external action.

Classification of test results:

N°1: normal behaviour in specification limits

N°2: temporary degradation or function loss or auto-recoverable behaviour

N°3: temporary degradation or function loss or behaviour lost needing help of operator or a system reset

N°4: irreparable degradation or function loss due to failure of material (components), software or data loss

5.1.1 Analysis

ESD current can penetrate inside the device via the typical following components:

- SIM connector
- Microphone
- Speaker
- Battery / data connector
- All pieces with conductive paint (plastron, special keys, etc...)

Therefore, in order to avoid ESD issues, efforts shall be done to decrease the level of ESD current on electronic components located inside the device (MMI board, input of the HiLo module, etc...)

5.1.2 Recommendations to avoid ESD issues

They can be summarized as below:

- Insure good ground connections of the HiLo module to the MMI board
- Flex (if any) shall be shielded and FPC connectors shall be correctly grounded at each extremity

- Put capacitor 100nF on battery (not on charger), or better put varistor or ESD diode in parallel on battery and charger wires and on all wires on bottom connector
- Uncouple microphone and speaker by putting capacitor or varistor in parallel of each wire of these devices

5.2 ESD FEATURES

The HiLo module can hold 2KV on each pin and on RF connector.

6. RADIO INTEGRATION

6.1 ANTENNA

- Antenna contact
- 50Ω line matching (between module and MMI board, and with RF test point)
- Sagem communications strongly recommends soldering the spring contact on the whole surface instead of only 2 points

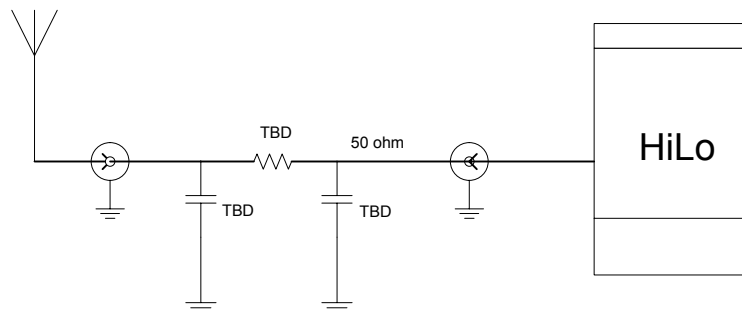


Figure 18: Antenna connection

- Keep matching circuit on MMI board but with direct connection in the first step – it could be necessary to make some adjustment later, during RF qualification stage
- The selected antenna must comply with FCC RF exposure limits in GSM850 and PCS1900 band:
 - GSM850: MPE < 0.55mW/cm² (Distance is 20 cm)
 - PCS1900: ERP < 3W

6.2 GROUND LINK AREA

Warning: Sagem communications emphasizes the fact that a good ground contact is needed between the module shielding and the MMI board to have the best radio performances (spurious, sensitivity...)

Solder the three pads of the shielding on the ground pads of MMI board, then the HiLo module will have a good ground contact with the MMI board.

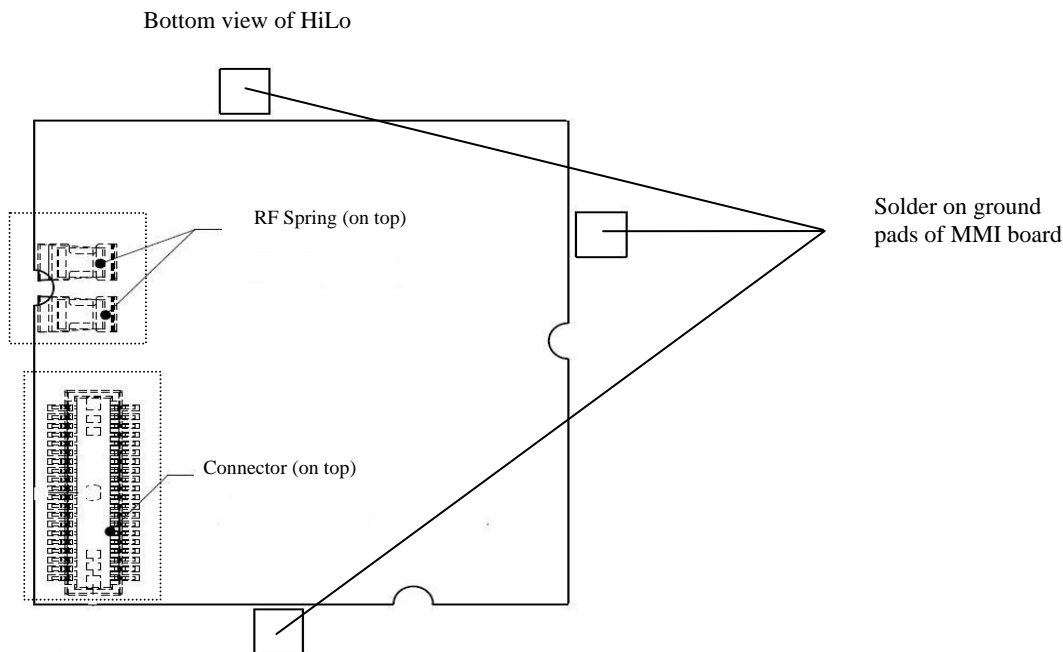


Figure 19: How to ground HiLo to MMI board

6.3 LAYOUT

Warning: Isolate RF line and antenna from others bus or signals

- No signals on 50 ohms area and if that is not possible, add ground shielding using different layers.
- Do not add any ground layer under the antenna contact area.
- Be careful on the position of the network LED (sometimes situated in front of the antenna pad ...)

6.4 MECHANICAL SURROUNDING

- Avoid any metallic part around the antenna area
- Keep jacks, FPCs and battery contact far from antenna area (FLEX)
- FPC has to be a shielded one

6.5 OTHER RECOMMENDATIONS – TESTS FOR PRODUCTION/DESIGN

Sagem communications guarantees the RF performances in conductive mode but strongly recommends making RF measurements in an anechoic chamber in radiated mode (tests conditions for FTA): the radiated performances strongly depend on radio integration (layout, antenna, matching circuit, ground area.....)

7. AUDIO INTEGRATION

Audio mandatory tests for FTA are in handset mode only so a particular care must be brought to the design of audio (mechanical integration, gasket, electronic) in this mode.

The audio norms which describe the audio tests are 3GPP TS 26.131 & 3GPP TS 26.132.

7.1 MECHANICAL INTEGRATION AND ACOUSTICS

Particular care to Handset Mode: FTA

- Design of the microphone and speaker gasket (elastomer)
- All receivers and speaker must be completely sealed on front side
- For the speaker mode, the back volume must be completely sealed
- The sealed volume must be as big as possible
- Microphone sensitivity depends on the shape of the device eg. about -40 ± 3 dBV/Pa for clamshell
- Pre-amplified microphone
- Foresee a stable and large enough area for the gasket of the artificial ear
- Place the microphone and the speaker as far as possible from one another

7.2 ELECTRONICS AND LAYOUT

Avoid Distortion & Burst noise

- Audio signals must be symmetric (same components on each path)
- Differential signals must be routed parallel
- Audio layer must be surrounded by 2 ground layers
- The link from one component to the ground must be as short as possible
- If possible separate the PCB of the microphone and the one of the speaker
- Reduce as much as possible the number of electronics components (loss of quality, more dispersion)
- Audio tracks must be larger than 0.5 mm

8. RECOMMENDATIONS ON LAYOUT OF MMI BOARD

8.1 GENERAL RECOMMENDATIONS ON LAYOUT

There are many different types of signals in the module which are disturbing each other. Particularly, Audio signals are very sensitive to external signals as VBAT*.... Therefore it is very important to respect some rules to avoid disruptions or abnormal behaviour.

Main rules:

Ground:

- A ground plane as complete as possible
- Ground of components has to be connected to the ground layer through many vias not regularly distributed.
- Top and bottom layer shall have as much as possible of ground planes.

Power supplies

- Plan for power supply signals (VBAT, VGPIO), no loop.
- Suitable power supply (VBAT, VGPIO) track width, thickness.

Clocks

- Clock signals must be shielded between two grounds planes and bordered with ground vias.

Data bus and other signals

- Data bus and commands have to be routed on the same plane, none of the lines of the bus shall be parallel to other lines

- Lines crossing shall be perpendicular
- Suitable other signals track width, thickness.
- Data bus must be protected by upper and lower ground plans

Radio

- Provide a 50 Ohm microstrip line for antenna connection

Audio (see also § 10.2)

- Differential signals have to be routed together, parallel (for example HSET_OUT_P/HSET_OUT_N).
- Audio signals have to be isolated, by pair, from all the other signals (ground all around each pair).
- Cancel any loops between VBAT and GND next to the speaker to avoid the TDMA burst noise in the speaker during a communication.
- The single-end audio signal should be adopted the same rules as differential signals.

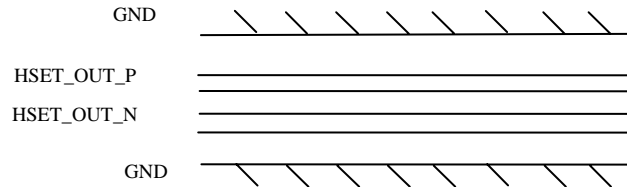


Figure 20: Layout of audio differential signals on a layer n

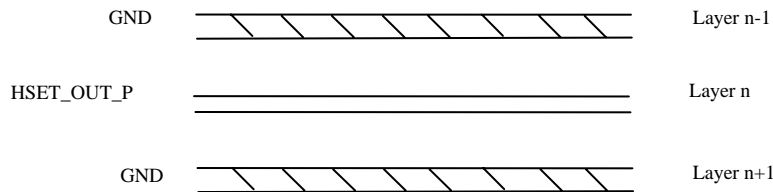


Figure 21: Adjacent layers of audio differential signals

***Warning:** Magnetic field generated by VBAT tracks may disturb the speaker, causing audio burst noise. In this case, one shall modify routing of the VBAT tracks to reduce the phenomena.

8.2 EXAMPLE OF LAYOUT FOR MMI BOARD

The figure Figure 22 shows an example of layer allocation for a 6 layers circuit (for reference only):

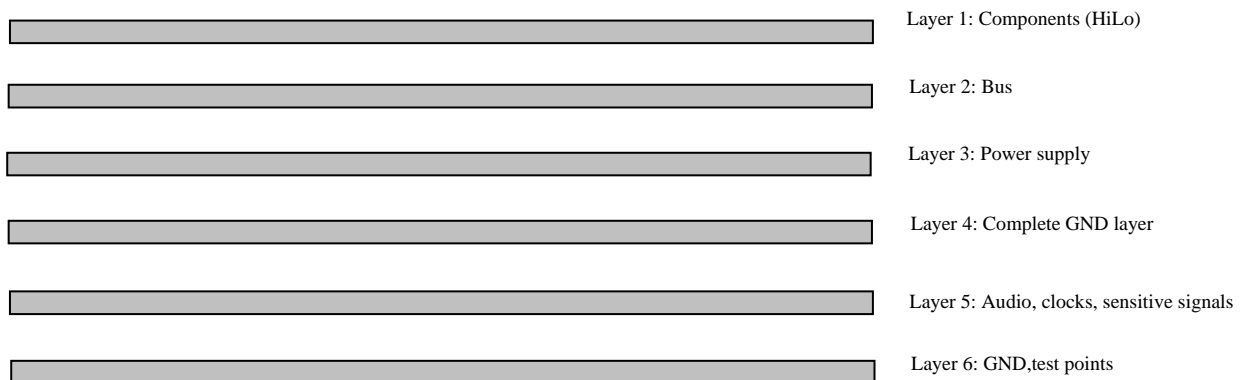


Figure 22: layer allocation for a 6 layers circuit

9. LABEL

The HiLo module is labelled with its own FCC ID(VW3HILOC) on its bottom side. When the module is installed in customer’s product, the FCC ID label on the module will not be visible. To avoid this case, an exterior label must be stuck on the surface of customer’s product signally to indicate the FCC ID of the enclosed module. This



label can use wording such as the following: "Contains Transmitter module FCC ID: VW3HILOC" or "Contains FCC ID: VW3HILOC".

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