LE920
Hardware User Guide

1vv0301026 Rev.0 - draft4 – 2013-05-21 (Preliminary)

Making machines talk.

APPLICABILITY TABLE

PRODUCT
LE920-EU
LE920-NA

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

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Contents

1. Introduction

1.1. Scope

The aim of this document is the description of some hardware solutions useful for developing a product with the Telit LE920-EU/NA module. All the features and solutions detailed are applicable to all LE920, whereas "LE920" is intended the modules listed in the applicability table.

When a specific feature is applicable to a specific product, it will be clearly highlighted.

1.2. Audience

This document is intended for Telit customers, who are integrators, about to implement their applications using our LE920 module.

1.3. Contact Information, Support

For general contact, technical support, to report documentation errors and to order manuals, contact Telit's Technical Support Center (TTSC) at:

TS-EMEA@telit.com
TS-NORTHAMERICA@telit.com
TS-LATINAMERICA@telit.com
TS-APAC@telit.com

Alternatively, use:

http://www.telit.com/en/products/technical-support-center/contact.php

For detailed information about where you can buy the Telit modules or for recommendations on accessories and components visit:

http://www.telit.com

To register for product news and announcements or for product questions contact Telit's Technical Support Center (TTSC).

Our aim is to make this guide as helpful as possible. Keep us informed of your comments and suggestions for improvements.

Telit appreciates feedback from the users of our information.

1.4. Document Organization

This document contains the following chapters:

Chapter 1: "Introduction" provides a scope for this document, target audience, contact and support information, and text conventions.

Chapter 2: "General Product Description" gives an overview of the features of the product.

Chapter 3: "LE920 Module Connections" deals with the pin out configuration and layout.

Chapter 4: "Hardware Commands" How to control the module via hardware

Chapter 5: "Power Supply" deals on supply and consumption.

Chapter 6: "Antenna" The antenna connection and board layout design are the most important parts in the full product design

Chapter 7: "Logic Level specifications" Specific values adopted in the implementation of logic levels for this module.

Chapter 8: "USB Port"

Chapter 9: "Serial Ports"

Chapter 10: "Audio Section Overview"

Chapter 11: "General Purpose I/O" How the general purpose I/O pads can be configured.

Chapter 12 "DAC and ADC Section" Deals with these two kind of converters.

Chapter 13: "Mounting the module on your board"

Chapter 14: "Application Guides"

Chapter 15: "Packing System"

Chapter 16: "Conformity Assessments"

Chapter 17: "Safety Recommendations"

Chapter 18: "Document History"

1.5. Text Conventions

Danger – This information MUST be followed or catastrophic equipment failure or bodily injury may occur.

Caution or Warning – Alerts the user to important points about integrating the module, if these points are not followed, the module and end user equipment may fail or malfunction.

Tip or Information – Provides advice and suggestions that may be useful when integrating the module.

All dates are in ISO 8601 format, i.e. YYYY-MM-DD.

1.6. Related Documents

- LE920-EU/NA Product Description, 80407ST10118A
- LE920-EU/NA AT command reference guide, 80407ST10116A
- Telit EVK2 User Guide, 1vv0300704

2. General Product Description

2.1. Overview

The aim of this document is the description of some hardware solutions useful for developing a product with the Telit LE920 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 must be considered as mandatory, while the suggested hardware configurations must not be considered mandatory, instead the information given must be used as a guide and a starting point for properly developing your product with the Telit LE920 module.

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NOTICE:

The integration of the GSM/GPRS/EGPRS/WCDMA/HSPA+/LTE LE920 cellular module within user application must be done according to the design rules described in this manual.

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2.2. LE920 Mechanical Dimensions

The Telit LE920 module overall dimensions are:

- Length: 34 mm
- Width: 40 mm
- Thickness: 2.9 mm

2.3. Weight

The module weight of LE920-EU/NA is about 9.0 gram.

2.4. Environmental requirements

2.4.1. Temperature range

		Note
Operating Temperature Range	–20°C ~ +55°C	The module is fully functional (*) in all the temperature range, and it fully meets the ETSI specifications.
	–40°C ~ +85°C	The module is fully functional (*) in all the temperature range. Temperatures outside of the range –20°C ÷ +55°C might slightly deviate from ETSI specifications.
Storage and non-operating Temperature Range	–40°C ~ +85°C	

(*)Functional: the module is able to make and receive voice calls, data calls and SMS.

2.4.2. RoHS compliance

As a part of Telit corporate policy of environmental protection, the LE920 complies with the RoHS (Restriction of Hazardous Substances) directive of the European Union (EU directive 2002/95/EG).

2.5. Operating Frequency

The operating frequencies in GSM850, EGSM900, DCS1800, PCS1900, WCDMA & LTE modes are conformed to the 3GPP specifications.

Mode	Freq. TX (MHz)	Freq. RX (MHz)	Channels	TX - RX offset
GSM850	824 ~ 849	869 ~ 894	128 ~ 251	45 MHz
EGSM900	890 ~ 915	935 ~ 960	0 ~ 124	45 MHz
	880 ~ 890	925 ~ 935	975 ~ 1023	45 MHz
DCS1800	1710 ~ 1785	1805 ~ 1880	512 ~ 885	95MHz
PCS1900	1850 ~ 1910	1930 ~ 1990	512 ~ 810	80MHz
WCDMA2100 – B1 (LE920 both models)	1920 ~ 1980	2110 ~ 2170	Tx: 9612 ~ 9888 Rx: 10562 ~ 10838	190MHz
WCDMA1900 – B2 (LE920-NA only)	1850 ~ 1910	1930 ~ 1990	Tx: 9262 ~ 9538 Rx: 9662 ~ 9938	80MHz
WCDMA1800 – B3 (LE920-EU only)	1710 ~ 1785	1805 ~ 1880	Tx: 937 ~ 1288 Rx: 1162 ~ 1513	95MHz
WCDMA1700 – B4 (LE920-NA only)	1710 ~ 1755	2110 ~ 2155	Tx: 1312 ~ 1513 Rx: 9662 ~ 9938	400 MHz
WCDMA850 – B5 (LE920-NA only)	824 ~ 849	869 ~ 894	Tx: 4132 ~ 4233 Rx: 4357 ~ 4458	45MHz
WCDMA800 – B6 (LE920-NA only)	830 ~ 840	875 ~ 885	Tx: 4162 ~ 4188 Rx: 4387 ~ 4413	45MHz
WCDMA900 – B8 (LE920-EU only)	880 ~ 915	925 ~ 960	Tx: 2712 ~ 2863 Rx: 2937 ~ 3088	45MHz
LTE2100 – B1 (LE920 both models)	1920 ~ 1980	2110 ~ 2170	Tx: 18000 ~ 18599 Rx: 0 ~ 599	190MHz

LTE1900 – B2 (LE920-NA only)	1850 ~ 1910	1930 ~ 1990	Tx: 18600 ~ 19199 Rx: 600 ~ 1199	80MHz
LTE1800 – B3 (LE920-EU only)	1710 ~ 1785	1805 ~ 1880	Tx: 19200 ~ 19949 Rx: 1200 ~ 1949	95MHz
LTE1700 – B4 (LE920-NA only)	1710~ 1755	2110 ~ 2155	Tx: 19950 ~ 20399 Rx: 1950 ~ 2399	400MHz
LTE850 – B5 (LE920-NA only)	824 ~ 849	869 ~ 894	Tx: 20400 ~ 20649 Rx: 2400 ~ 2649	45MHz
LTE2600 – B7 (LE920-EU only)	2500 ~ 2570	2620 ~ 2690	Tx: 20750 ~ 21449 Rx: 2750 ~ 3449	120MHz
LTE900 – B8 (LE920-EU only)	880 ~ 915	925 ~ 960	Tx: 21450 ~ 21799 Rx: 3450 ~ 3799	45MHz
LTE700 – B17 (LE920-NA only)	704 ~ 716	734 ~ 746	Tx: 23730 ~ 23849 Rx: 5730 ~ 5849	30MHz
LTE800 – B20 (LE920-EU only)	832 ~ 862	791 ~ 821	Tx: 24150 ~ 24449 Rx: 6150 ~ 6449	-41MHz

3. LE920 Module Connections

3.1. PIN-OUT

PAD	Signal	I/O	Function	Type	COMMENT
USB HS 2.0 Communication Port					
D19	USB_D+	I/O	USB differential Data(+)		
F19	USB_D-	I/O	USB differential Data(+)		
A18	USB_VBUS	AI	Power sense for the internal USB transceiver	Power	
Asynchronous UART – Prog. / data +HW Flow Control					
AH19	C103/TXD	I	Serial data input (TXD) from DTE	1.8V	
AF19	C104/RXD	O	Serial data output to DTE	1.8V	
AC18	C108/DTR	I	Input for Data terminal ready signal (DTR) from DTE	1.8V	
AA18	C105/RTS	I	Input for Request to send signal (RTS) from DTE	1.8V	
AK19	C106/CTS	O	Output for Clear to send signal (CTS) to DTE	1.8V	
AE18	C109/DCD	O	Output for Data carrier detect signal (DCD) to DTE	1.8V	
AG18	C107/DSR	O	Output for Data set ready signal (DSR) to DTE	1.8V	
AJ18	C125/RING	O	Output for Ring indicator signal (RI) to DTE	1.8V	
Asynchronous Auxiliary UART					
AB19	TXD_AUX	O	Auxillary UART (TX Data to DTE)	1.8V	
AD19	RXD_AUX	I	Auxillary UART (RX Data from DTE)	1.8V	
SIM Card Interface 1					
A10	SIMCLK1	O	External SIM signal – Clock	1.8/2.85V	
B11	SIMRST1	O	External SIM signal – Reset	1.8/2.85V	
B9	SIMIO1	I/O	External SIM signal - Data I/O	1.8/2.85V	
B7	SIMIN1	I	External SIM signal - Presence (active low)	1.8V	
A8	SIMVCC1	-	External SIM signal – Power supply for the SIM	1.8/2.85V	
Audio					
B5	EAR1_MT+	AO	Earphone signal output1, phase +	Audio	
A4	EAR1_MT-	AO	Earphone signal output1, phase -	Audio	
B3	MIC1_MT+	AI	Mic signal input1, phase +	Audio	
A2	MIC1_MT-	AI	Mic signal input1, phase -	Audio	
E2	EAR2_MT+	AO	Earphone signal output2, phase +	Audio	
D1	EAR2_MT-	AO	Earphone signal output2, phase -	Audio	
C2	MIC2_MT+	AI	Mic signal input2, phase +	Audio	
B1	MIC2_MT-	AI	Mic signal input2, phase -	Audio	
Digital Voice interface (DVI)					
D11	DVI_WA0	O	Digital Voice interface (WA0 master output)	1.8V	
C8	DVI_RX	I	Digital Voice interface (RX)	1.8V	
D9	DVI_TX	O	Digital Voice interface (TX)	1.8V	

PAD	Signal	I/O	Function	Type	COMMENT
C10	DVI_CLK	O	Digital Voice interface (CLK master output)	1.8V	
Digital I/O					
F9	GPIO_01	I/O	GPIO_01	1.8V	
E10	GPIO_02	I/O	GPIO_02	1.8V	
F11	GPIO_03	I/O	GPIO_03	1.8V	
E12	GPIO_04	I/O	GPIO_04	1.8V	
F13	GPIO_05	I/O	GPIO_05	1.8V	
E14	GPIO_06	I/O	GPIO_06	1.8V	
R18	GPIO_07	I/O	GPIO_07	1.8V	
S19	GPIO_08	I/O	GPIO_08	1.8V	
U19	GPIO_09	I/O	GPIO_09	1.8V	
W19	GPIO_10	I/O	GPIO_10	1.8V	
RF Section					
AD1	Antenna	I/O	GSM/EDGE/UMTS/LTE Antenna (50 Ohm)	RF	
AU9	ANT_DIV	I	UMTS/LTE Antenna Diversity Input (50 Ohm)	RF	
GPS Section					
S1	ANT_GPS	I	GPS Antenna (50 Ohm)	RF	
Miscellaneous Function					
AP1	RESET#	I	Reset Input		Active Low
AS1	ON_OFF#	I	Input Command for Power ON		Active Low
AN12	SHDN_N	I	Unconditional Shut down Input		Active Low
F17	VRTC	AI	VRTC Backup Capacitor	Power	To be used to back up the RTC section
P17	VAUX/PWRMON	O	Supply Output for External Accessories / Power ON Monitor	1.8V	
D5	ADC_IN1	AI	Analog/Digital Converter Input 1	Analog	
E6	ADC_IN2	AI	Analog/Digital Converter Input 2	Analog	
F7	ADC_IN3	AI	Analog/Digital Converter Input 3	Analog	
AU3	STAT_LED	O	Status Indicator LED	1.8V	
AN10	SW_RDY	O	Indicates that the boot sequence completed successfully	1.8V	
Power Supply					
AP17	VBATT	-	Main Power Supply (Digital Section)	Power	
AP19	VBATT	-	Main Power Supply (Digital Section)	Power	
AR18	VBATT	-	Main Power Supply (Digital Section)	Power	
AS17	VBATT_PA	-	Main Power Supply (RF Transmit Power Section)	Power	
AS19	VBATT_PA	-	Main Power Supply (RF Transmit Power Section)	Power	
AT18	VBATT_PA	-	Main Power Supply (RF Transmit Power Section)	Power	
AU17	VBATT_PA	-	Main Power Supply (RF Transmit Power Section)	Power	
AU19	VBATT_PA	-	Main Power Supply (RF Transmit Power Section)	Power	
A6	GND	-	Ground		

PAD	Signal	I/O	Function	Type	COMMENT
A12	GND	-	Ground		
B13	GND	-	Ground		
B15	GND	-	Ground		
B17	GND	-	Ground		
C4	GND	-	Ground		
C6	GND	-	Ground		
D3	GND	-	Ground		
D7	GND	-	Ground		
E18	GND	-	Ground		
F1	GND	-	Ground		
G18	GND	-	Ground		
H19	GND	-	Ground		
M1	GND	-	Ground		
N2	GND	-	Ground		
P1	GND	-	Ground		
P3	GND	-	Ground		
R2	GND		Ground		
T2	GND		Ground		
T18	GND	-	Ground		
U1	GND	-	Ground		
V18	GND	-	Ground		
W1	GND	-	Ground		
X2	GND	-	Ground		
X18	GND	-	Ground		
Y1	GND	-	Ground		
Y19	GND		Ground		
AA2	GND	-	Ground		
AB1	GND	-	Ground		
AC2	GND	-	Ground		
AE2	GND	-	Ground		
AF1	GND	-	Ground		
AG2	GND	-	Ground		
AH1	GND	-	Ground		
AJ2	GND	-	Ground		
AK1	GND	-	Ground		
AK17	GND	-	Ground		
AL18	GND	-	Ground		
AM17	GND	-	Ground		
AM19	GND	-	Ground		
AN16	GND	-	Ground		
AN18	GND	-	Ground		

PAD	Signal	I/O	Function	Type	COMMENT
AP3	GND	-	Ground		
AP5	GND	-	Ground		
AP7	GND	-	Ground		
AP9	GND	-	Ground		
AP11	GND	-	Ground		
AP13	GND	-	Ground		
AP15	GND	-	Ground		
AR2	GND	-	Ground		
AR4	GND	-	Ground		
AR6	GND	-	Ground		
AR8	GND	-	Ground		
AR10	GND	-	Ground		
AR12	GND	-	Ground		
AR14	GND	-	Ground		
AR16	GND	-	Ground		
AS5	GND	-	Ground		
AS7	GND	-	Ground		
AS9	GND	-	Ground		
AS11	GND	-	Ground		
AS13	GND	-	Ground		
AS15	GND	-	Ground		
AT4	GND	-	Ground		
AT6	GND	-	Ground		
AT8	GND	-	Ground		
AT10	GND	-	Ground		
AT12	GND	-	Ground		
AT14	GND	-	Ground		
AT16	GND	-	Ground		
AU1	GND	-	Ground		
AU5	GND	-	Ground		
AU7	GND	-	Ground		
AU11	GND	-	Ground		
AU15	GND	-	Ground		
Reserved					
C12	Reserved	-	Reserved		
A14	Reserved	-	Reserved		
A16	Reserved	-	Reserved		
M17	Reserved	-	Reserved		
AN6	Reserved	-	Reserved		
V2	Reserved	-	Reserved		
C14	Reserved	-	Reserved		

PAD	Signal	I/O	Function	Type	COMMENT
D13	Reserved	-	Reserved		
C16	Reserved	-	Reserved		
D17	Reserved	-	Reserved		
E16	Reserved	-	Reserved		
C18	Reserved	-	Reserved		
D15	Reserved	-	Reserved		
F15	Reserved	-	Reserved		
E4	Reserved	-	Reserved		
E8	Reserved	-	Reserved		
F3	Reserved	-	Reserved		
F5	Reserved	-	Reserved		
G2	Reserved	-	Reserved		
H1	Reserved	-	Reserved		
H3	Reserved	-	Reserved		
H17	Reserved	-	Reserved		
J2	Reserved	-	Reserved		
J18	Reserved	-	Reserved		
K1	Reserved	-	Reserved		
K3	Reserved	-	Reserved		
K17	Reserved	-	Reserved		
K19	Reserved	-	Reserved		
L2	Reserved	-	Reserved		
L18	Reserved	-	Reserved		
M3	Reserved	-	Reserved		
M19	Reserved	-	Reserved		
N18	Reserved	-	Reserved		
P19	Reserved	-	Reserved		
S3	Reserved	-	Reserved		
S17	Reserved	-	Reserved		
U3	Reserved	-	Reserved		
U17	Reserved	-	Reserved		
W3	Reserved	-	Reserved		
W17	Reserved	-	Reserved		
Y3	Reserved	-	Reserved		
Y17	Reserved	-	Reserved		
AB3	Reserved	-	Reserved		
AB17	Reserved	-	Reserved		
AD3	Reserved	-	Reserved		
AD17	Reserved	-	Reserved		
AF3	Reserved	-	Reserved		
AF17	Reseved	-	Reserved		

PAD	Signal	I/O	Function	Type	COMMENT
AH3	Reserved	-	Reserved		
AH17	Reserved	-	Reserved		
AK3	Reserved	-	Reserved		
AL2	Reserved	-	Reserved		
AM1	Reserved	-	Reserved		
AM3	Reserved	-	Reserved		
AN2	Reserved	-	Reserved		
AN4	Reserved	-	Reserved		
AN8	Reserved	-	Reserved		
AN14	Reserved	-	Reserved		
AS3	Reserved	-	Reserved		
AT2	Reserved	-	Reserved		
B19	Reserved	-	Reserved		
AU13	Reserved	-	Reserved		

NOTE:

When the UART signals are used as the communication port between the Host to the Modem:

- DTR pin must be connected in order to enter LE920's power saving mode.
- RI pin must be connected in order to wake up the host when a call is coming in sleep mode of host.
- RTS must be connected to the GND (on the module side) if flow control is not used

In case UART port isn't used, all UART signals may be left disconnected

NOTE:

RESERVED pins must not be connected

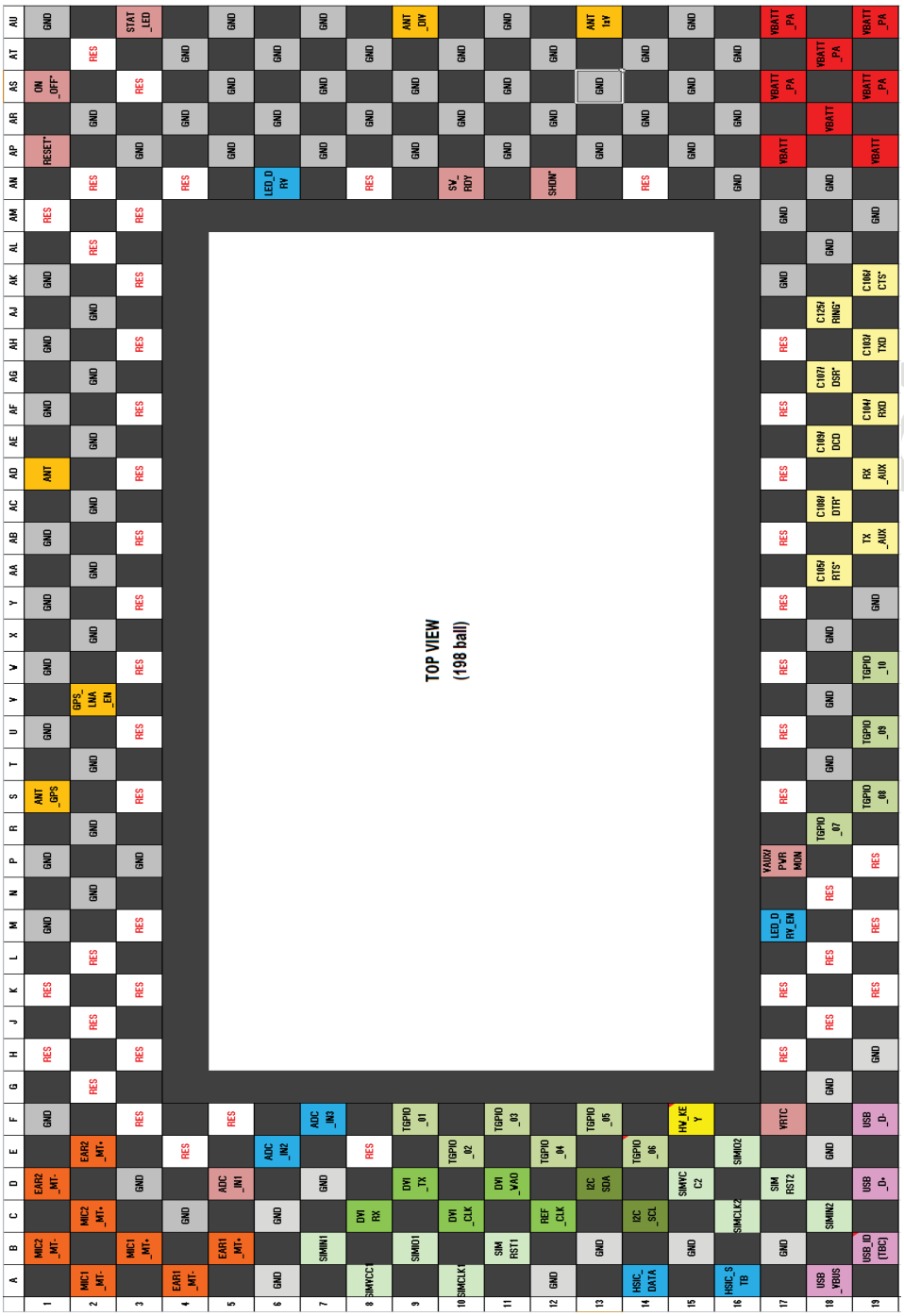
NOTE:

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

PAD	Signal
AP17,AP19,AR18,AS17,AS19,AT18,AU17,AU19	VBATT & VBATT_PA
A6,A12,B13,B15,B17,C4,C6,D3,D7,E18,F1,G18,H19, M1,N2,P1,P3,R2,T2,T18,U1,V18,W1,X2,X18,Y1,Y19, AA2,AB1,AC2,AE2,AF1,AG2,AH1,AJ2,AK1,AK17, AL18,AM17,AM19,AN16,AN18,AP3,AP5,AP7,AP9, AP11,AP13,AP15,AR2,AR4AR6,AR8,AR10,AR12, AR14,AR16,AS5,AS7,AS9,AS11,AS13,AS15,AT4, AT6,AT8,AT10,AT12,AT14,AT16,AU1,AU5,AU7,	GND

AU11,AU15	
AS1	ON/OFF*

3.1.1. LGA Pads Layout



NOTE:

The pin defined as RES has to be considered RESERVED and not connected on any pin in the application. The related area on the application has to be kept empty.

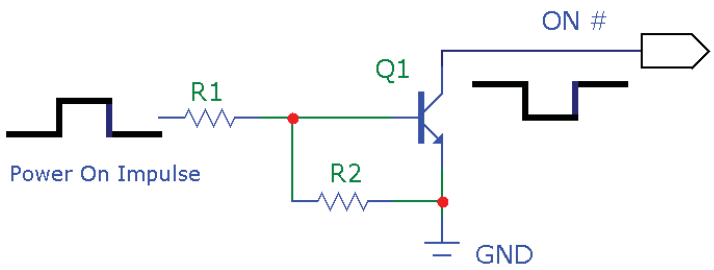
4. Hardware Commands

4.1. Turning ON the LE920

To turn on LE920, the pad ON# must be tied low for at least 1 second and then released.

The maximum current that can be drained from the ON# pad is 0.1 mA.

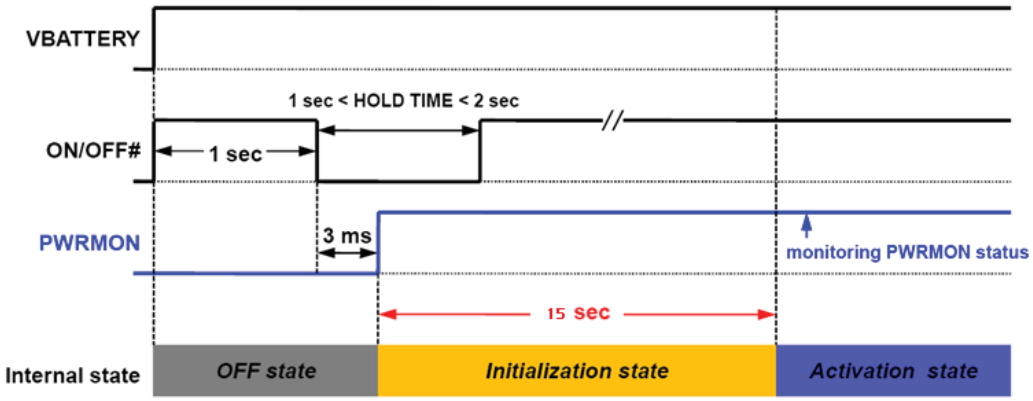
A simple circuit to power on the module is illustrated below:



4.2. Initialization and Activation state

Upon turning on LE920 module, The LE920 is not activated yet because the boot sequence of LE920 is still going on internally. It takes about 10 seconds to complete the initializing the module internally.

For this reason, it would be useless to try to access LE920 during the Initialization state as below. To get the desirable stability, The LE920 needs at least 15 seconds after the PWRMON goes High to become operational by reaching the activation state.



During the *Initialization state*, any kind of AT-command is not available. DTE must be waiting for the *Activation state* to communicate with LE920.

NOTE:

To check if the LE920 has powered on, the hardware line PWRMON must be monitored. When PWRMON goes high, the module has powered on.

NOTE:

Do not 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 LE920 power regulator and improper power on/off of the module. The line ON# must be connected only in open collector configuration.

NOTE:

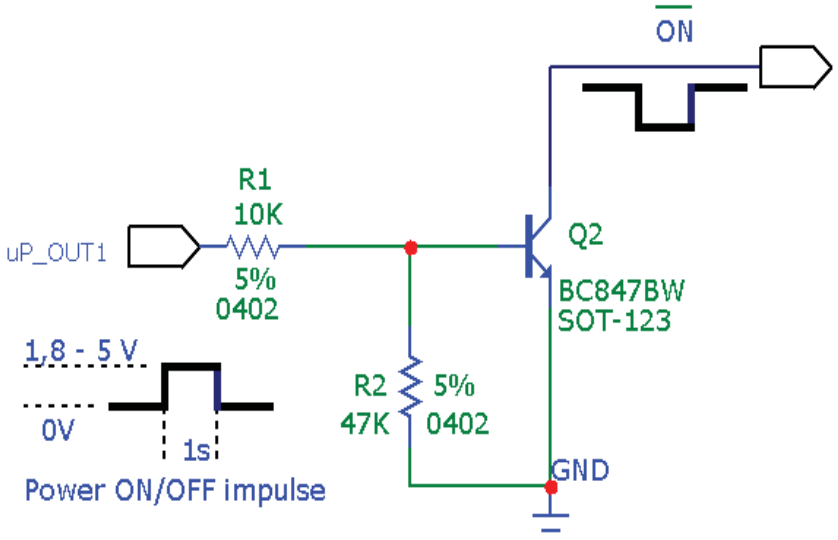
In this document all the lines are inverted. Active low signals are labeled with a name that ends with "#" or with a bar over the name.

NOTE:

In order to avoid a back powering effect it is recommended to avoid having any HIGH logic level signal applied to the digital pins of the module when is powered OFF or during an ON/OFF transition.

For example:

1- Let us assume you need to drive the ON# pad with a totem pole output of a +1.8/5 V microcontroller (uP_OUT1):



4.3. Turning OFF the LE920

Turning off the device can be done in three ways:

- by Software command
- by Hardware shutdown
- by Hardware Unconditional Restart
- by Hardware Unconditional shutdown

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.

TIP:

To check if the device has powered off, hardware line PWRMON must be monitored. When PWRMON goes low it can be considered the device has powered off.

NOTE:

In order to avoid a back powering effect it is recommended to avoid having any HIGH logic level signal applied to the digital pins of the module when is powered OFF or during an ON/OFF transition.

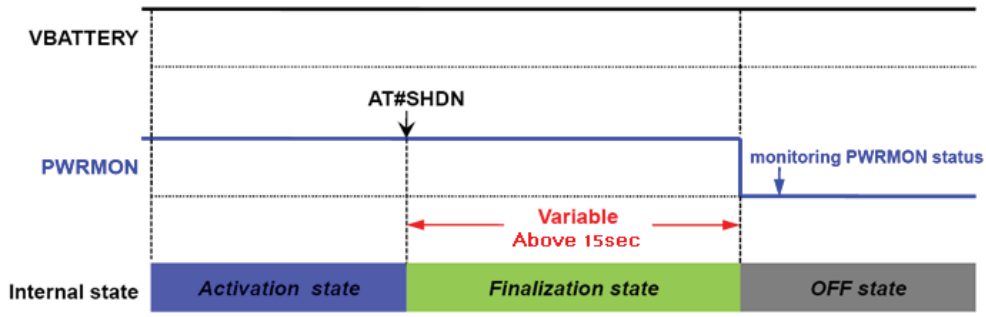
4.3.1. Shutdown by Software Command

LE920 can be shut down by a software command.

When a shut down command is sent, LE920 goes into the finalization state and finally will shut down PWRMON at the end of this state.

The period of the finalization state can differ according to the situation in which the LE920 is so it cannot be fixed definitely.

Normally it will be above 10 seconds later from sending a shut down command and DTE should monitor the status of PWRMON to see the actual power off.



TIP:

To check if the device has powered off, hardware line PWRMON must be monitored. When PWRMON goes low, the device has powered off.

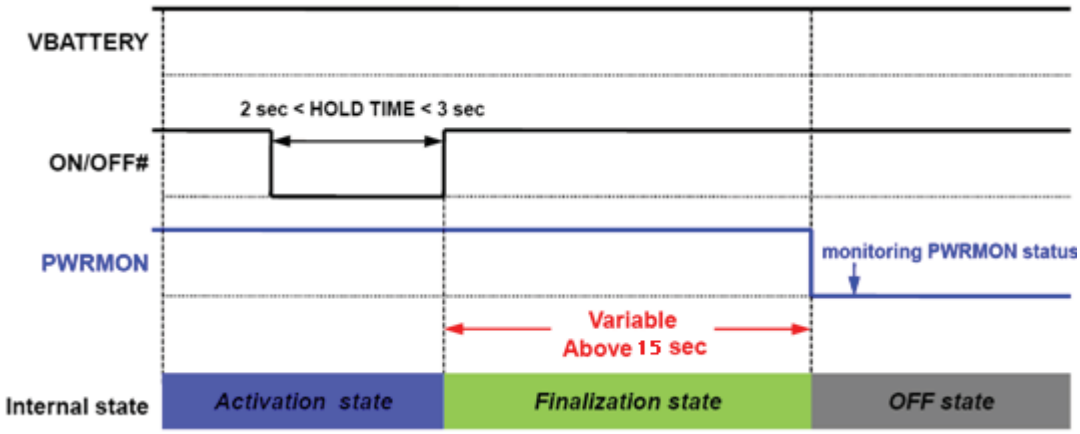
4.3.2. Hardware Shutdown

To turn OFF LE920 the pad ON/OFF# must be tied low for at least 2 seconds and then released. Same circuitry and timing for the power on must be used.

When the hold time of ON/OFF# is above 2 seconds, LE920 goes into the finalization state and finally will shut down PWRMON at the end of this state.

The period of the finalization state can differ according to the situation in which the LE920 is so it cannot be fixed definitely.

Normally it will be above 10 seconds later from releasing ON/OFF# and DTE should monitor the status of PWRMON to see the actual power off.



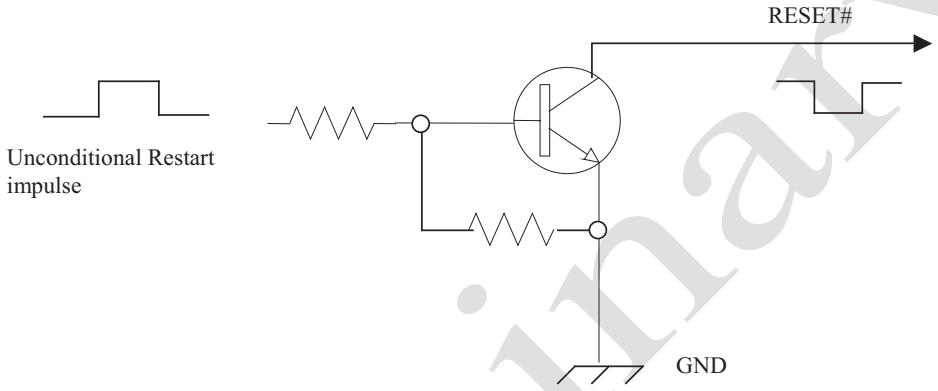
TIP:

To check if the device has powered off, hardware line PWRMON must be monitored. When PWRMON goes low, the device has powered off.

4.3.3. Hardware Unconditional Restart

To unconditionally restart LE920, the pad RESET# must be tied low for at least 200 milliseconds and then released.

A simple circuit to do it is:



NOTE:

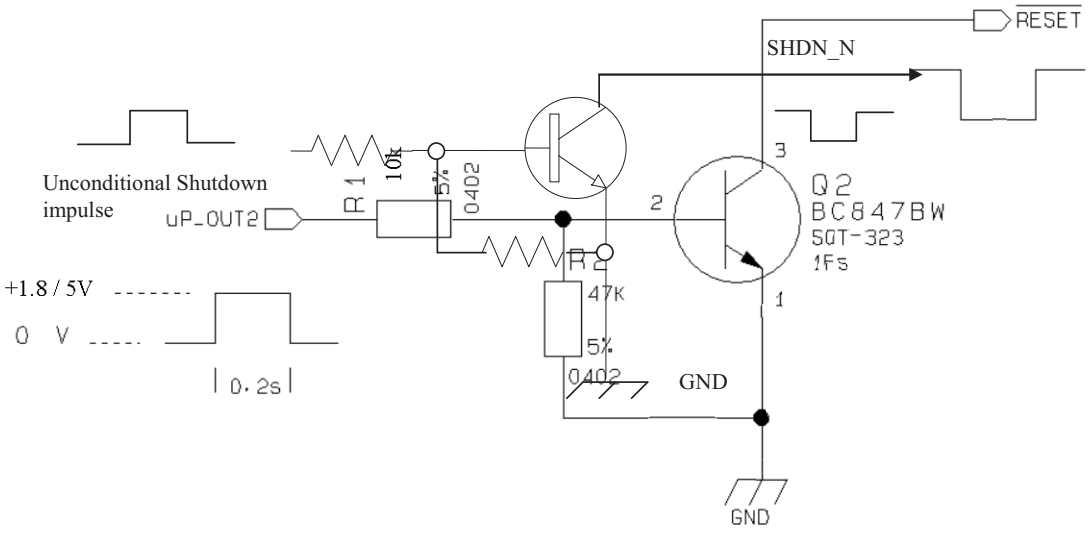
Do not use any pull up resistor on the RESET# line or any totem pole digital output. Using pull up resistor may bring to latch up problems on the LE920 power regulator and improper functioning of the module. The line RESET# must be connected only in open collector configuration.

TIP:

The unconditional hardware Restart must always be implemented on the boards and the software must use it as an emergency exit procedure, and **not** as a normal power-off operation

For example:

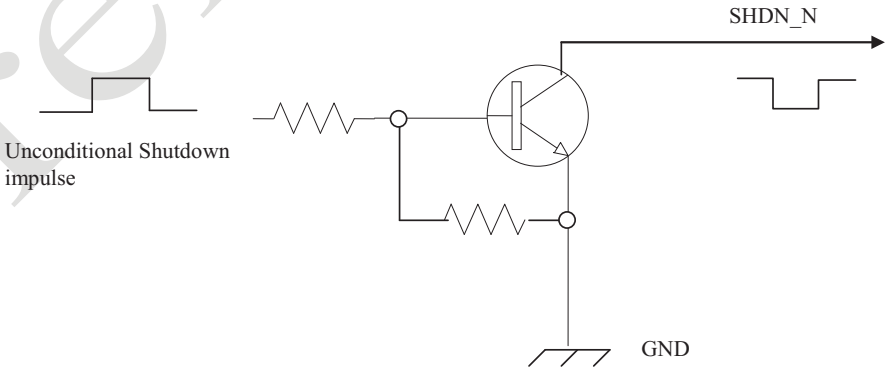
1- Let us assume you need to drive the RESET# pad with a totem pole output of a +1.8/5 V microcontroller (uP_OUT2):



4.3.4. Hardware Unconditional Shutdown

To unconditionally Shutdown LE920, the pad SHDN_N must be tied low for at least 200 milliseconds and then released.

A simple circuit to do it is:



NOTE:

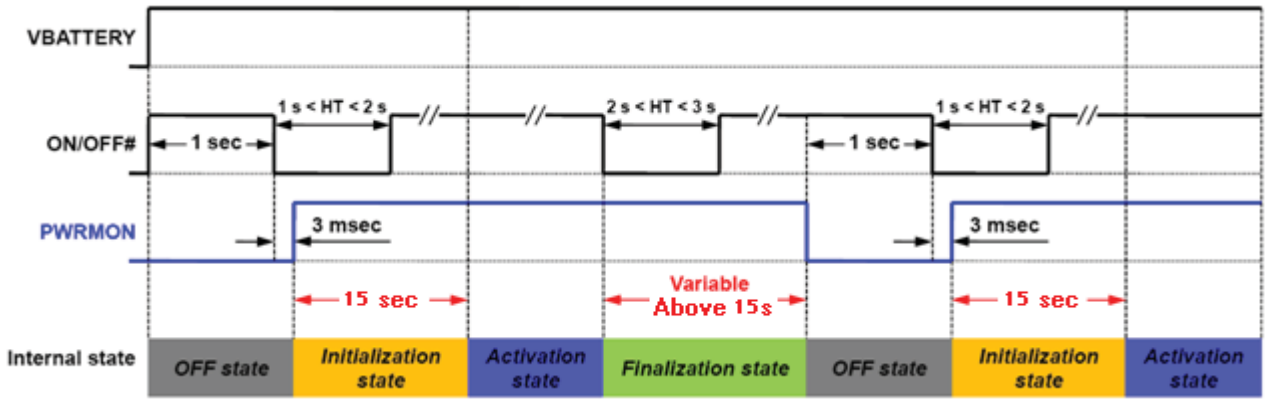
Do not use any pull up resistor on the SHDN_N line or any totem pole digital output. Using pull up resistor may bring to latch up problems on the LE920 power regulator and improper functioning of the module. The line SHDN_N must be connected only in open collector configuration.

Note:

The unconditional hardware SHDN_N must always be implemented on the boards and the software must use it as an emergency exit procedure, and **not** as a normal power-off operation

4.4. Summary of Turning ON and OFF the module

Below chart describes the overall sequences for Turning ON and OFF.



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. Read carefully the requirements and the guidelines that will follow for a proper design.

5.1. Power Supply Requirements

The LE920 power requirements are:

Power Supply	
Nominal Supply Voltage	3.8V
Max Supply Voltage	4.2V
Supply Voltage Range	3.3V– 4.2V

LE920 current consumption			
Mode		**Average(mA)**	**Mode Description**
SWITCHED OFF			Module supplied but switched Off
Switched Off		40 uA	
IDLE mode			Standby mode; no call in progress
AT+CFUN=1	WCDMA	16	Normal mode; full functionality of the module
	GSM	16	
	LTE	16	
AT+CFUN=4		10	Disabled TX and RX; modules is not registered on the network
AT+CFUN=5	WCDMA	1.7	DRx9
	GSM	1.9	
Operative mode (LTE)			
LTE (0dBm)		203	LTE data call channel BW 5MHz,RB=1, TX = 0dBm)
LTE (22dBm)		540	LTE data call (channel BW 5MHz,RB=1, TX = 22dBm)
Operative mode (WCDMA)			
WCDMA Voice		185	WCDMA voice call (TX = 10dBm)
WCDMA HSDPA (0dBm)		100	WCDMA data call (RMC, TX = 0dBm)
WCDMA HSDPA (22dBm)		390	WCDMA data call (RMC, TX = 22dBm)
Operative mode (GSM)			
GSM TX and RX mode			
GSM900 PL5		290	GSM Voice Call
DCS1800 PL0		170	
GPRS 4TX + 1RX			
GSM900 PL5		410	GPRS Sending data mode
DCS1800 PL0		320	
EDGE 4TX + 1RX			

GSM900 PL5	255	EDGE Sending data mode
DCS1800 PL0	240	

* Worst/best case depends on network configuration and is not under module control.

TIP:

The electrical design for the Power supply must be made ensuring that it will be capable of a peak current output of at least 2A.

In GSM/GPRS mode, RF transmission is not continuous and it is packed into bursts at a base frequency of about 216 Hz, and the relative current peaks can be as high as about 2A. Therefore the power supply has to be designed in order to withstand 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; this will reflect on all the audio paths producing an audible annoying noise at 216 Hz; if the voltage drops during the peak, current absorption is too much. The device may even shut down as a consequence of the supply voltage drop.

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

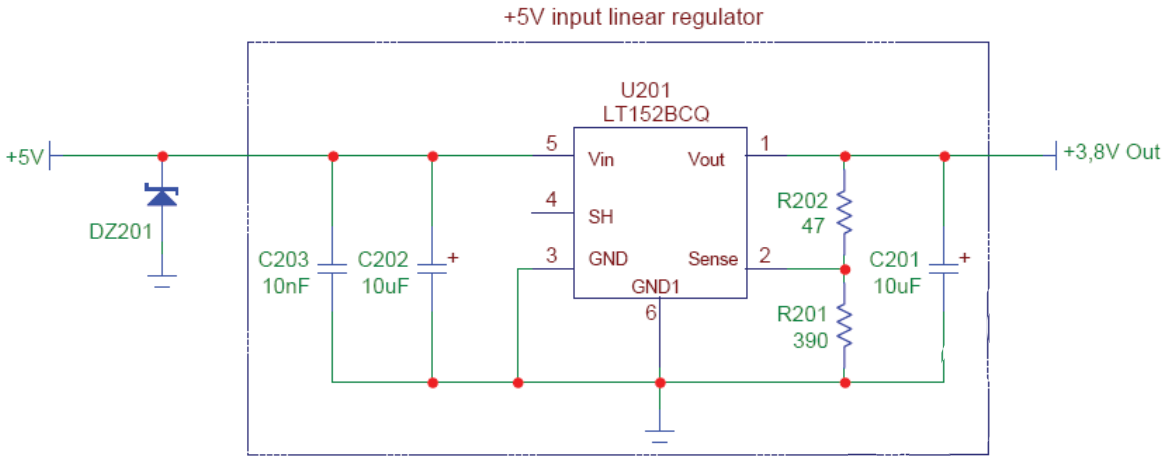
The electrical design of the power supply depends strongly on the power source where this power is drained. We will distinguish them into three categories:

- +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 is 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 must 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 LE920, a 100µF 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 must be inserted close to the power input, in order to save LE920 from power polarity inversion.

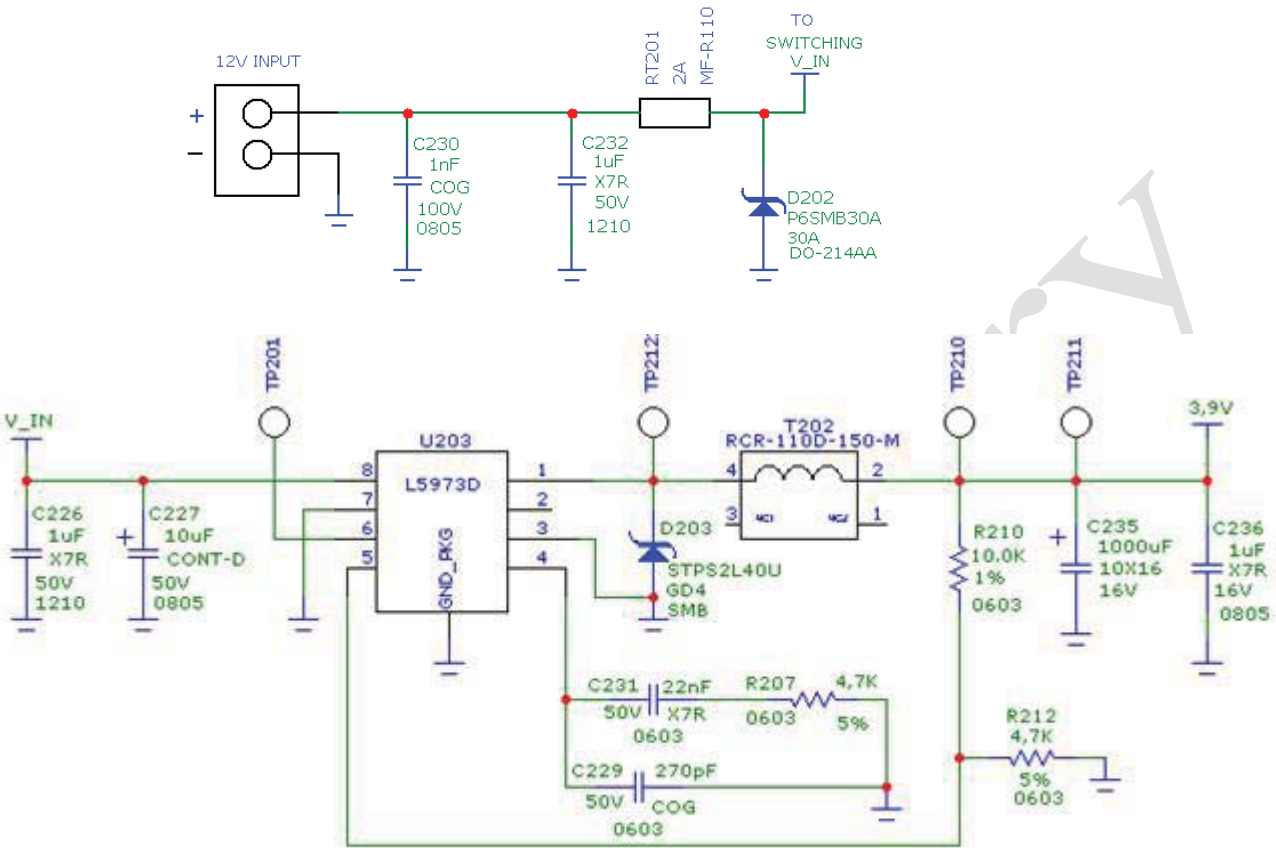
An example of linear regulator with 5V input is:



5.2.1.2. + 12V Input Source Power Supply Design Guidelines

- The desired output for the power supply is 3.8V, hence due to the big difference between the input source and the desired output, a linear regulator is not suited and must not be used. A switching power supply will be preferable because of its better efficiency especially with the 2A peak current load represented by LE920.
- When using a switching regulator, a 500kHz or more switching frequency regulator is preferable because of its smaller inductor size and its faster transient response. This allows the regulator to respond quickly to the current peaks absorption.
- In any case, the frequency and Switching design selection is related to the application to be developed due to the fact the switching frequency could also generate EMC interferences.
- For car PB battery the input voltage can rise up to 15.8V and this must be kept in mind when choosing components: all components in the power supply must withstand this voltage.
- 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 for this.
- Make sure the low ESR capacitor on the power supply output (usually a tantalum one) is rated at least 10V.
- For Car applications a spike protection diode must be inserted close to the power input, in order to clean the supply from spikes.
- A protection diode must be inserted close to the power input, in order to save LE920 from power polarity inversion. This can be the same diode as for spike protection.

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



Switching regulator

5.2.1.3. Battery Source Power Supply Design Guidelines

- The desired nominal output for the power supply is 3.8V and the maximum allowed voltage is 4.2V, hence a single 3.7V Li-Ion cell battery type is suited for supplying the power to the Telit LE920 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 LE920 and damage it.

NOTE:

Do not use any Ni-Cd, Ni-MH, and Pb battery types directly connected with LE920. Their use can lead to overvoltage on LE920 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 must be inserted close to the power input, in order to save LE920 from power polarity inversion. Otherwise the battery connector must 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.

5.2.2. Thermal Design Guidelines

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

- Average current consumption during HSPA transmission @PWR level max in LE920: 640mA (TBD)
- Average current consumption during class12 GPRS transmission @PWR level max: 680mA (TBD)
- Average GPS current during GPS ON (Power Saving disabled) : 65mA (TBD)

NOTE:

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

NOTE:

The thermal design for the Power supply must be made keeping an average consumption at the max transmitting level during calls of 640mA(HSPA)/680mA(GPRS) rms plus 65mA rms for GPS in tracking mode.

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 in transmission for short periods of time (let us say few minutes) and then remains for quite a long time in idle (let us 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 for 640mA (HSPA)/680mA (GPRS) maximum RMS current. There could even be a simple chip package (no heat sink).

Moreover in 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 640mA (HSPA) /680mA (GPRS) (being usually around 250mA).

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.

For the heat generated by the LE920, you can consider it to be during transmission 2W max during class12 GPRS upload. This generated heat will be mostly conducted to the ground plane under the LE920; you must ensure that your application can dissipate heat.

In the WCDMA/HSPA mode, since LE920 emits RF signals continuously during transmission, you must pay special attention how to dissipate the heat generated.

The current consumption will be up to about 640mA in HSPA (630mA in WCDMA) continuously at the maximum TX output power (23dBm). Thus, you must arrange the PCB area as large as possible under LE920 which you will mount. You must mount LE920 on the large ground area of your application board and make many ground vias to dissipate the heat.

The peak current consumption in the GSM mode is higher than that in WCDMA. However, considering the heat sink is more important in case of WCDMA.

As mentioned before, a GSM signal is bursty, thus, the temperature drift is more insensible than WCDMA. Consequently, if you prescribe the heat dissipation in the WCDMA mode, you don't need to think more about the GSM mode.

5.2.3. Power Supply PCB Layout Guidelines

As seen in the electrical design guidelines, the power supply must have a low ESR capacitor on the output to cut the current peaks and a protection diode on the input to protect the supply from spikes and polarity inversion. The placement of these components is crucial for the correct working of the circuitry. A misplaced component can be useless or can even decrease the power supply performances.

- The Bypass low ESR capacitor must be placed close to the Telit LE920 power input pads, or in the case the power supply is a switching type, it can be placed close to the inductor to cut the ripple if the PCB trace from the capacitor to LE920 is wide enough to ensure a drop-less connection even during the 2A current peaks.
- The protection diode must be placed close to the input connector where the power source is drained.
- The PCB traces from the input connector to the power regulator. IC must be wide enough to ensure no voltage drops to occur when the 2A current peaks are absorbed. Note that this is not made in order to save power loss but especially to avoid the voltage drops on the power line at the current peaks frequency of 216 Hz that will reflect on all the components connected to that supply (also introducing the noise floor at the burst base frequency.) For this reason while a voltage drop of 300-400 mV may be acceptable from the power loss point of view, the same voltage drop may not be acceptable from the noise point of view. If your application does not have audio interface but only uses the data feature of the Telit LE920, then this noise is not so disturbing and power supply layout design can be more forgiving.
- The PCB traces to LE920 and the Bypass capacitor must be wide enough to ensure no significant voltage drops to occur when the 2A current peaks are absorbed. This is a must for the same above-mentioned reasons. Try to keep this trace as short as possible.
- The PCB traces connecting the Switching output to the inductor and the switching diode must be kept as short as possible by placing the inductor and the diode very close to the power switching IC (only for switching power supply). This is done in order to reduce the radiated field (noise) at the switching frequency (usually 100-500 kHz).
- The use of a good common ground plane is suggested.
- The placement of the power supply on the board must be done in a way to guarantee that the high current return paths in the ground plane are not overlapped to any noise sensitive circuitry as the microphone amplifier/buffer or earphone amplifier.

- The power supply input cables must be kept separately from noise sensitive lines such as microphone/earphone cables.

6. Antenna(s)

The antenna connection and board layout design are the most important parts in the full product design and they strongly reflect on the product's overall performances. Read carefully and follow the requirements and the guidelines for a proper design.

6.1. GSM/WCDMA/LTE Antenna Requirements

The antenna for a Telit LE920 device must fulfill the following requirements:

GSM / WCDMA/ LTE Antenna Requirements		
Frequency range	Depending by frequency band(s) provided by the network operator, the customer must use the most suitable antenna for that/those band(s)	
Bandwidth	**LE920-EU**	**LE920-NA**
	GSM850 : 70 MHz GSM900 : 80 MHz GSM1800(DCS) : 170 MHz GSM1900(PCS) : 140 MHz WCDMA band I(2100) : 250 MHz WCDMA band III(1800) : 170 MHz WCDMA band VIII(900) : 80 MHz LTE Band I(2100) : 250 MHz LTE band III(1800) : 170 MHz LTE Band VII(2600) : 190 MHz LTE Band VIII(900) : 80 MHz LTE Band XX(800) : 71 MHz	GSM850 : 70 MHz GSM900 : 80 MHz GSM1800(DCS) : 170 MHz GSM1900(PCS) : 140 MHz WCDMA band I(2100) : 250 MHz WCDMA band II(1900) : 140 MHz WCDMA band IV(1700) : 445 MHz WCDMA band V(850) : 70 MHz WDCMA band VI(800): 70MHz LTE Band I(2100) : 250 MHz LTE Band II(1900) : 140 MHz LTE Band IV(1700) : 445 MHz LTE Band V (850) : 70 MHz LTE Band XVII(700) : 42 MHz
Gain	Max Ant. Gain 2.01dBi	
Impedance	50 Ohm	
Input power	> 33dBm(2 W) peak power in GSM > 24dBm Average power in WCDMA & LTE	
VSWR absolute max	<= 10:1	
VSWR recommended	<= 2:1	

When using the Telit LE920, since there's no antenna connector on the module, the antenna must be connected to the LE920 antenna pad (AD1) by means of a transmission line implemented in the PCB.

In the case that the antenna is not directly connected at the antenna pad of the LE920, then a PCB line is required in order to connect with it or with its connector.

This transmission line shall fulfill the following requirements:

Antenna Line on PCB Requirements	
Characteristic Impedance	50Ohm
Max Attenuation	0.3dB
Coupling with other signals shall be avoided	
Cold End (Ground Plane) of antenna shall be equipotential to the LE920 ground pads	

Furthermore if the device is developed for the US and/or Canada market, it must 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 LE920 module. Antennas used for this OEM module must not exceed 3dBi gain for mobile and fixed operating configurations.

6.2. GSM/WCDMA/LTE Antenna – PCB line Guidelines

- Make sure that the transmission line's characteristic impedance is 50ohm.
- Keep line on the PCB as short as possible since the antenna line loss shall be less than around 0.3dB.
- Line geometry should have uniform characteristics, constant cross section, avoid meanders and abrupt curves.
- Any kind of suitable geometry/structure can be used for implementing the printed transmission line afferent the antenna.
- If a Ground plane is required in line geometry, that plane has to be continuous and sufficiently extended so the geometry can be as similar as possible to the related canonical model.
- Keep, if possible, at least one layer of the PCB used only for the Ground plane; If possible, use this layer as reference Ground plane for the transmission line.
- It is wise to surround (on both sides) of the PCB transmission line with Ground. Avoid having other signal tracks facing directly the antenna line track.
- Avoid crossing any un-shielded transmission line footprint with other tracks on different layers.
- The Ground surrounding the antenna line on PCB has to be strictly connected to the main Ground plane by means of via holes (once per 2mm at least) placed close to the ground edges facing line track.
- Place EM noisy devices as far as possible from LE920 antenna line.
- Keep the antenna line far away from the LE920 power supply lines.
- If EM noisy devices are present on the PCB hosting the LE920, such as fast switching ICs, take care of shielding them with a metal frame cover.
- If EM noisy devices are not present around the line use of geometries like Micro strip or Grounded Coplanar Waveguide are preferred since they typically ensure less attenuation when compared to a Strip line having same length.

6.3. GSM/WCDMA/LTE Antenna – Installation Guidelines

- Install the antenna in a place covered by the GSM/WCDMA 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 must not be installed inside metal cases;
- Antenna must be installed also according Antenna manufacturer instructions.

6.4. Antenna Diversity Requirements

This product is including an input for a second RX antenna to improve the radio sensitivity. The function is called Antenna Diversity.

ANTENNA REQUIREMENTS		
Frequency range	Depending by frequency band(s) provided by the network operator, the customer shall use the most suitable antenna for that/those band(s)	
Bandwidth	**LE920-EU**	**LE920-NA**
	WCDMA band I(2100) : 250 MHz WCDMA band III(1800) : 170 MHz WCDMA band VIII(900) : 80 MHz LTE Band I(2100) : 250 MHz LTE band III(1800) : 170 MHz LTE Band VII(2600) : 190 MHz LTE Band VIII(900) : 80 MHz LTE Band XX(800) : 71 MHz	WCDMA band I(2100) : 250 MHz WCDMA band II(1900) : 140 MHz WCDMA band IV(AWS) : 445 MHz WCDMA band IV(850) : 445 MHz WCDMA band V(850) : 70 MHz WDCMA band VI(800): 55MHzLTE Band I(2100) : 250 MHz LTE Band II(1900) : 140 MHz LTE Band IV(1700) : 445 MHz LTE Band V (850) : 70 MHz Band XVII(700) : 42 MHz
Impedance	50Ω	
VSWR recommended	≤ 2:1	

When using the Telit LE920, since there's no antenna connector on the module, the antenna must be connected to the LE920 antenna pad (AU9) by means of a transmission line implemented on the PCB.

In the case that the antenna is not directly connected at the antenna pad of the LE920, then a PCB line is required in order to connect with it or with its connector.

The second Rx antenna should not be located in the close vicinity of main antenna. In order to improve Diversity Gain, Isolation and reduce mutual interaction, the two antennas should be located at the maximum reciprocal distance possible, taking into consideration the available space into the application.

6.5. GPS/GNSS Antenna Requirements

LE920 supports only passive antenna and includes an internal LNA inside (13.5dB gain typ.).

It is recommended to use antennas as follow:

- An external passive antenna (GPS only)
- An external passive antenna, GNSS pre-Filter

NOTE:

The external GNSS pre-Filter shall be required for GLONASS application.

GNSS pre-Filter requirement shall fulfill the following requirements.

- Source and Load Impedance = 50Ohm
- Insertion Loss (1575.42 – 1576.42MHz) = 1.4dB (Max)
- Insertion Loss (1565.42 – 1585.42MHz) = 1.4dB (Max)
- Insertion Loss (1597.5515 – 1605.886MHZ) = 2.0dB (Max)

WARNING:

The LE920 software is implemented differently depending on the configurations of an external device. Please refer to the AT command User Guide in detail.

6.5.1. Combined GPS/GNSS Antenna

The use of combined RF/GPS/GNSS antenna is NOT recommended. This solution could generate extremely poor GPS/GNSS reception and also the combined antenna requires additional diplexer and adds a loss in the RF route.

In addition, the combination of antennas requires an additional diplexer, which adds significant power losses in the RF path.

6.5.2. Linear and Patch GPS/GNSS Antenna

Using this type of antenna introduces at least 3dB of loss if compared to a circularly polarized (CP) antenna. Having a spherical gain response instead of a hemispherical gain response could aggravate the multipath behaviour & create poor position accuracy.

6.5.3. Front End Design Considerations

When using the Telit LE920, since there's no antenna connector on the module, the antenna must be connected to the LE920 through the PCB with the antenna pad.

In the case that the antenna is not directly connected at the antenna pad of the LE920, then a PCB line is required.

This line of transmission shall fulfill the following requirements:

Antenna Line on PCB Requirements	
Characteristic Impedance	50Ohm
Max Attenuation	0.3dB
Coupling with other signals shall be avoided	
Cold End (Ground Plane) of antenna shall be equipotential to the LE920 ground pads	

Furthermore if the device is developed for the US and/or Canada market, it must comply with the FCC and/or IC requirements.

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

6.5.4. GPS/GNSS Antenna - PCB Line Guidelines

- Ensure that the antenna line impedance is 50ohm.
- Keep line on the PCB as short as possible to reduce the loss.
- Antenna line must have uniform characteristics, constant cross section, avoid meanders and abrupt curves.
- Keep one layer of the PCB used only for the Ground plane; if possible.
- Surround (on the sides, over and under) the antenna line on PCB with Ground. Avoid

having other signal tracks directly facing the antenna line track.

- The Ground around the antenna line on PCB has to be strictly connected to the main Ground plane by placing vias once per 2mm at least.
- Place EM noisy devices as far as possible from LE920 antenna line.
- Keep the antenna line far away from the LE920 power supply lines.
- If EM noisy devices are around the PCB hosting the LE920, such as fast switching ICs, take care of shielding of antenna line by burying it inside the layers of PCB and surround it with Ground planes; or shield it with a metal frame cover.
- If you do not have EM noisy devices around the PCB of LE920, use a Micro strip line on the superficial copper layer for the antenna line. The line attenuation will be lower than a buried one.

6.5.5. GPS/GNSS Antenna – Installation Guidelines

- The LE920, due to its sensitivity characteristics, is capable of performing a fix inside 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 manufacture instructions.

7. Logic Level Specifications

Where not specifically stated, all the interface circuits work at 1.8V CMOS logic levels.

The following table shows the logic level specifications used in the Telit LE920 interface circuits:

NOTE:

Do not connect LE920's digital logic signal directly to OEM's digital logic signal of with level higher than 2.7V for 1.8V CMOS signals.

For 1.8V CMOS signals:

Absolute Maximum Ratings - Not Functional

Parameter	LE920	
	Min	Max
Input level on any digital pin when on	-0.3V	+2.16V
Input voltage on analog pins when on	-0.3V	+2.16 V

Operating Range - Interface levels (1.8V CMOS)

Level	LE920	
	Min	Max
Input high level	1.5V	2.1V
Input low level	-0.3V	0.5V
Output high level	1.35V	1.8V
Output low level	0V	0.45V

8. USB Port

The LE920 module includes a Universal Serial Bus (USB) transceiver, which operates at USB low-speed (1.5Mbits/sec), USB full-speed (12Mbits/sec) and USB high-speed (480Mbits/sec).

It is compliant with the USB 2.0 specification and can be used for diagnostic monitoring, control and data transfers.

The USB_DPLUS and USB_DMINUS signals have a clock rate of 480MHz. The signal traces should be routed carefully. Trace lengths, number of vias and capacitive loading should be minimized. The impedance value should be as close as possible to 90 Ohms differential.

The table below describes the USB interface signals:

Signal	LE920 Pad No.	Usage
USB_VBUS	A18	Power sense for the internal USB transceiver .
USB_D-	F19	Minus (-) line of the differential, bi-directional USB signal to/from the peripheral device
USB D+	D19	Plus (+) line of the differential, bi-directional USB signal to/from the peripheral device

9. Serial Ports

The serial port on the Telit LE920 is the interface between the module and OEM hardware.

Two serial ports are available on the module:

- MODEM SERIAL PORT 1(Main)
- MODEM SERIAL PORT 2 (Auxiliary) -TBD

Several configurations can be designed for the serial port on the OEM hardware.

The most common are:

- RS232 PC com port;
- Microcontroller UART @ 1.8V (Universal Asynchronous Receive Transmit) ;
- Microcontroller UART @ 5V or other voltages different from 1.8V.

Depending on 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 does not need a level translation is the 1.8V UART.

The serial port 1 on LE920 is a +1.8V UART with all the 7 RS232 signals. It differs from the PC-RS232 in signal polarity (RS232 is reversed) and levels.

The Serial port 2 is a +1.8V Auxiliary UART.

The levels for LE920 UART are the CMOS levels:

Absolute Maximum Ratings -Not Functional

Parameter	LE920	
	Min	Max
Input level on any digital pin when on	-0.3V	+2.16 V
Input voltage on analog pins when on	-0.3V	+2.16 V

Operating Range - Interface levels

Level	LE920	
	Min	Max
Input high level	1.5V	2.1V
Input low level	-0.3V	0.5V
Output high level	1.35V	1.8V
Output low level	0V	0.45V

9.1. Modem Serial Port 1

Serial port 1 on the LE920 is a +1.8V UART with all 7 RS232 signals.

It differs from the PC-RS232 in the signal polarity (RS232 is reversed) and levels.

RS232 Pin Number	Signal	LE920 Pad Number	Name	Usage
1	DCD - dcd_uart	AE18	Data Carrier Detect	Output from the LE920 that indicates the carrier presence
2	RXD - Tx_uart	AF19	Transmit line *see Note	Output transmit line of the LE920 UART
3	TXD - Rx_uart	AH19	Receive line *see Note	Input receive of the LE920 UART
4	DTR - dtr_uart	AC18	Data Terminal Ready	Input to the LE920 that controls the DTE READY condition
5	GND	A6, A12, B13, B15….	Ground	ground
6	DSR - dsr_uart	AG18	Data Set Ready	Output from the LE920 that indicates the module is ready
7	RTS - rts_uart	AA18	Request to Send	Input to the LE920 that controls the Hardware flow control
8	CTS - cts_uart	AK19	Clear to Send	Output from the LE920 that controls the Hardware flow control
9	RI - ri_uart	AJ18	Ring Indicator	Output from the LE920 that indicates the Incoming call condition

NOTE:

In order to avoid a back powering effect it is recommended to avoid having any HIGH logic level signal applied to the digital pins of the module when is powered OFF or during an ON/OFF transition.

TIP:

For 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.

NOTE:

According to V.24, RX/TX signal names are referred to the application side, therefore on the LE920 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 LE920 serial port and vice versa for RX.

9.2. Modem Serial Port 2

Serial port 2 on the LE920 is a +1.8V UART with only the RX and TX signals.

The signals of the LE920 serial port are:

PAD	Signal	I/O	Function	Type	COMMENT
AB19	TXD_AUX	O	Auxiliary UART (TX Data to DTE)	1.8V	
AD19	RXD_AUX	I	Auxiliary UART (RX Data to DTE)	1.8V	

NOTE:

In order to avoid a back powering effect it is recommended to avoid having any HIGH logic level signal applied to the digital pins of the module when is powered OFF or during an ON/OFF transition.

9.3. RS232 Level Translation

In order to interface the Telit LE920 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 0/1.8V 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 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 drivers and receivers 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 0-1.8V UART to the RS232 level. The receiver is the translator from the RS232 level to 0-1.8V UART.

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

- 5 drivers
- 3 receivers

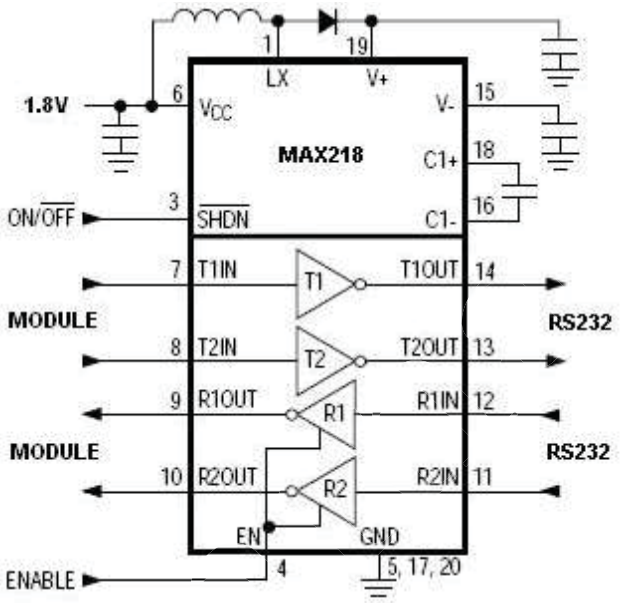
NOTE:

The digital input lines working at 1.8V CMOS have an absolute maximum input voltage of 2.7V; therefore the level translator IC shall not be powered by the +3.8V supply of the module. Instead, it must be powered from a +1.8V (dedicated) power supply.

This is because in this way the level translator IC outputs on the module side (i.e. LE920 inputs) will work at +3.8V interface levels, damaging the module inputs.

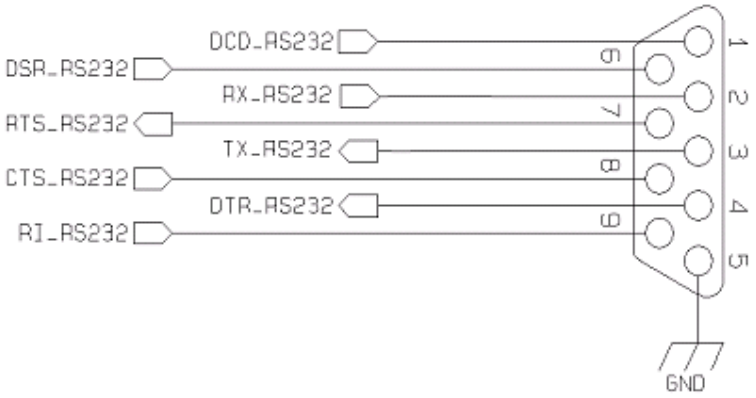
An example of RS232 level adaption circuitry could be accomplished using a MAXIM transceiver (MAX218).

In this case the chipset is capable of translating directly from 1.8V to the RS232 levels (Example on 4 signals only).



NOTE:
In this case has to be taken in account the length of the lines on the application to avoid problems in case of High-speed rates on RS232.

The RS232 serial port lines are usually connected to a DB9 connector with the following layout: signal names and directions are named and defined from the DTE point of view



10. Audio Section Overview

The LE920 module support digital audio interface.

10.1. Digital Audio

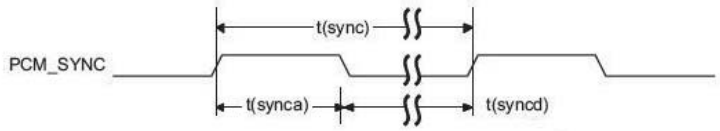
LE920 module can be connected to external codec through digital interface.

The product is providing one Digital Audio Interface (DVI) on the following Pins:

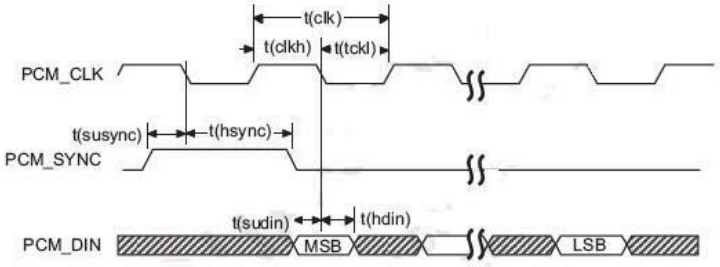
PAD	Signal	I/O	Function	Type	COMMENT
D11	DVI_WA0	I/O	Digital Audio Interface (WA0)	B-PD 1.8V	PCM_SYNC
C8	DVI_RX	I	Digital Audio Interface (RX)	B-PD 1.8V	PCM_DIN
D9	DVI_TX	O	Digital Audio Interface (TX)	B-PD 1.8V	PCM_DOUT
C10	DVI_CLK	I/O	Digital Audio Interface (CLK)	B-PD 1.8V	PCM_CLK

LE920 DVI supports PCM master 2048khz short frame

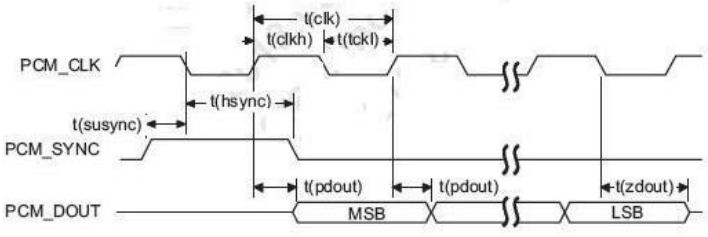
Primary (short sync) PCM interface (2048 kHz clock)



PCM_SYNC timing



PCM_CODEC to LE920 timing



Le920 to PCM_CODEC timing

PCM_CODEC timing parameters

Parameter		Comments	Min	Typ	Max	Unit
t(sync)	PCM_SYNC cycle time		–	125	–	µs
t(synca)	PCM_SYNC asserted time		–	488	–	ns
t(syncd)	PCM_SYNC de-asserted time		–	124.5	–	µs
t(clk)	PCM_CLK cycle time		–	488	–	ns
t(clkh)	PCM_CLK high time		–	244	–	ns
t(clkl)	PCM_CLK low time		–	244	–	ns
t(sync_offset)	PCM_SYNC offset time to PCM_CLK falling		–	122	–	ns
t(sudin)	PCM_DIN setup time to PCM_CLK falling		60	–	–	ns
t(hdin)	PCM_DIN hold time after PCM_CLK falling		60	–	–	ns
t(pdout)	Delay from PCM_CLK rising to PCM_DOUT valid		–	–	60	ns
t(zdout)	Delay from PCM_CLK falling to PCM_DOUT HIGH-Z		–	–	60	ns

11. General Purpose I/O

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

- input
- output
- alternate function (internally controlled)

Input pads can only be read and report the digital value (high or low) present on the pad at the read time; output pads can only be written or queried and set the value of the pad output; an alternate function pad is internally controlled by the LE920 firmware and acts depending on the function implemented.

The following GPIOs are available on the LE920.

PAD	Signal	I/O	Function	Type	Drive Strength
F9	GPIO_01	I/O	Configurable GPIO	BH-PD(*) 1.8V	2 mA
E10	GPIO_02	I/O	Configurable GPIO	BH-PD(*) 1.8V	2 mA
F11	GPIO_03	I/O	Configurable GPIO	BH-PD(*) 1.8V	2 mA
E12	GPIO_04	I/O	Configurable GPIO	BH-PD(*) 1.8V	2 mA
F13	GPIO_05	I/O	Configurable GPIO	BH-PD(*) 1.8V	2 mA
E14	GPIO_06	I/O	Configurable GPIO	BH-PD(*) 1.8V	2 mA
R18	GPIO_07	I/O	Configurable GPIO	BH-PD(*) 1.8V	2 mA
S19	GPIO_08	I/O	Configurable GPIO	BH-PD(*) 1.8V	2 mA
U19	GPIO_09	I/O	Configurable GPIO	BH-PD(*) 1.8V	2 mA
W19	GPIO_10	I/O	Configurable GPIO	BH-PD(*) 1.8V	2 mA

(*) **BH-PD** - Bidirectional digital with CMOS input; High-voltage tolerant; Contains an internal pull-down device.

NOTE:

In order to avoid a back powering effect it is recommended to avoid having any HIGH logic level signal applied to the digital pins of the module when is powered OFF or during an ON/OFF transition.

11.1. Logic Level Specifications

Where not specifically stated, all the interface circuits work at 1.8V CMOS logic levels.

The following table shows the logic level specifications used in the LE920 interface circuits:

For 1,8V signals:

Absolute Maximum Ratings -Not Functional

Parameter	LE920	
	Min	Max
Input level on any digital pin when on	-0.3V	+2.16 V
Input voltage on analog pins when on	-0.3V	+2.16 V

Operating Range - Interface levels (1.8V CMOS)

Level	LE920	
	Min	Max
Input high level	1.5V	2.1V
Input low level	-0.3V	0.5V
Output high level	1.35V	1.8V
Output low level	0V	0.45V

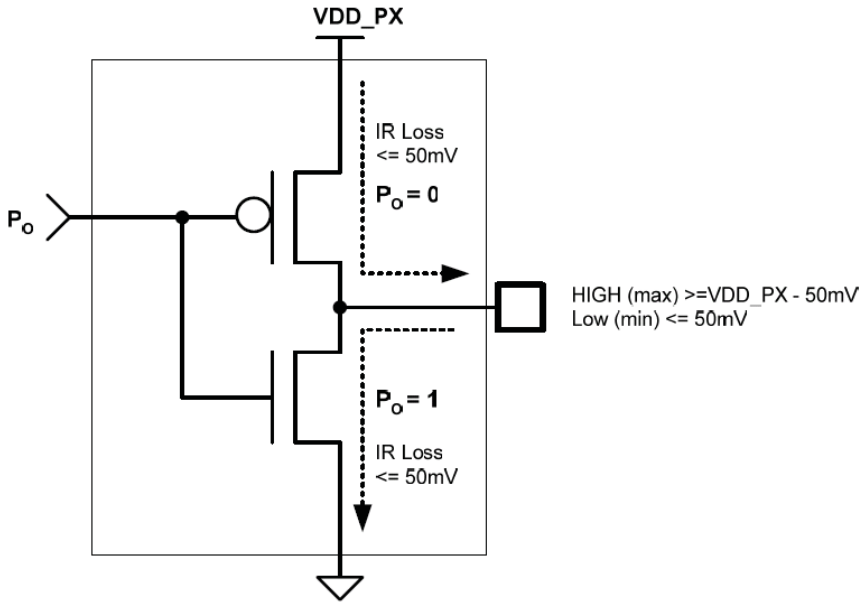
11.2. Using a GPIO Pad as Input

The GPIO pads, 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 1.8V CMOS levels of the GPIO.

If the digital output of the device is connected with the GPIO input, the pad has interface levels different from the 1.8V CMOS. It can be buffered with an open collector transistor with a 47KΩ pull-up resistor to 1.8V.

11.3. Using a GPIO Pad as Output

The GPIO pads, when used as outputs, can drive 1.8V CMOS digital devices or compatible hardware. When set as outputs, the pads have a push-pull output and therefore the pull-up resistor may be omitted.



output PAD equivalent circuit

11.4. Using the Temperature Monitor Function

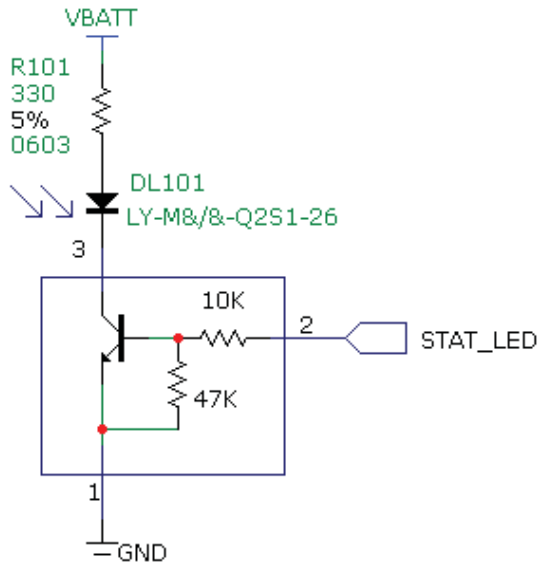
11.4.1. Short Description

The Temperature Monitor is a function of the module that permits to control its internal temperature and if properly set (see the #TEMPMON command on AT Interface guide) it raises to High Logic level a GPIO when the maximum temperature is reached.

11.5. Indication of Network Service Availability

The STAT_LED pin status shows information on the network service availability and call status. In the LE920 modules, the STAT_LED usually needs an external transistor to drive an external LED. Because of the above, the status indicated in the following table is reversed with respect to the pin status:

LED status	Device Status
Permanently off	Device off
Fast blinking (Period 1s, Ton 0,5s)	Net search / Not registered / turning off
Slow blinking (Period 3s, Ton 0,3s)	Registered full service
Permanently on	a call is active



11.6. RTC Bypass Out

The VRTC pin brings out the Real Time Clock supply, which is separate from the rest of the digital part, allowing having only RTC going on when all the other parts of the device are off. To this power output a backup capacitor can be added in order to increase the RTC autonomy during power off of the battery.

NOTE:

NO devices must be powered from this pin.

11.7. VAUX Power Output

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

Operating Range – VAUX power supply

	Min	Typical	Max
Output voltage	1.75V	1.80V	1.85V
Output current			100mA
Output bypass capacitor (Inside the module)			1µF

12. ADC section

12.1. ADC Converter

12.1.1. Description

The on board ADCs are 8-bit converters. They are able to read a voltage level in the range of 0-2 volts applied on the ADC pin input and store and convert it into 8 bit word.

	Min	Max	Units
Input Voltage range	0	1.7	Volt
AD conversion	-	8	bits
Resolution	-	< 6.6	mV

The LE920 module provides 3 Analog to Digital Converters.

12.1.2. 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

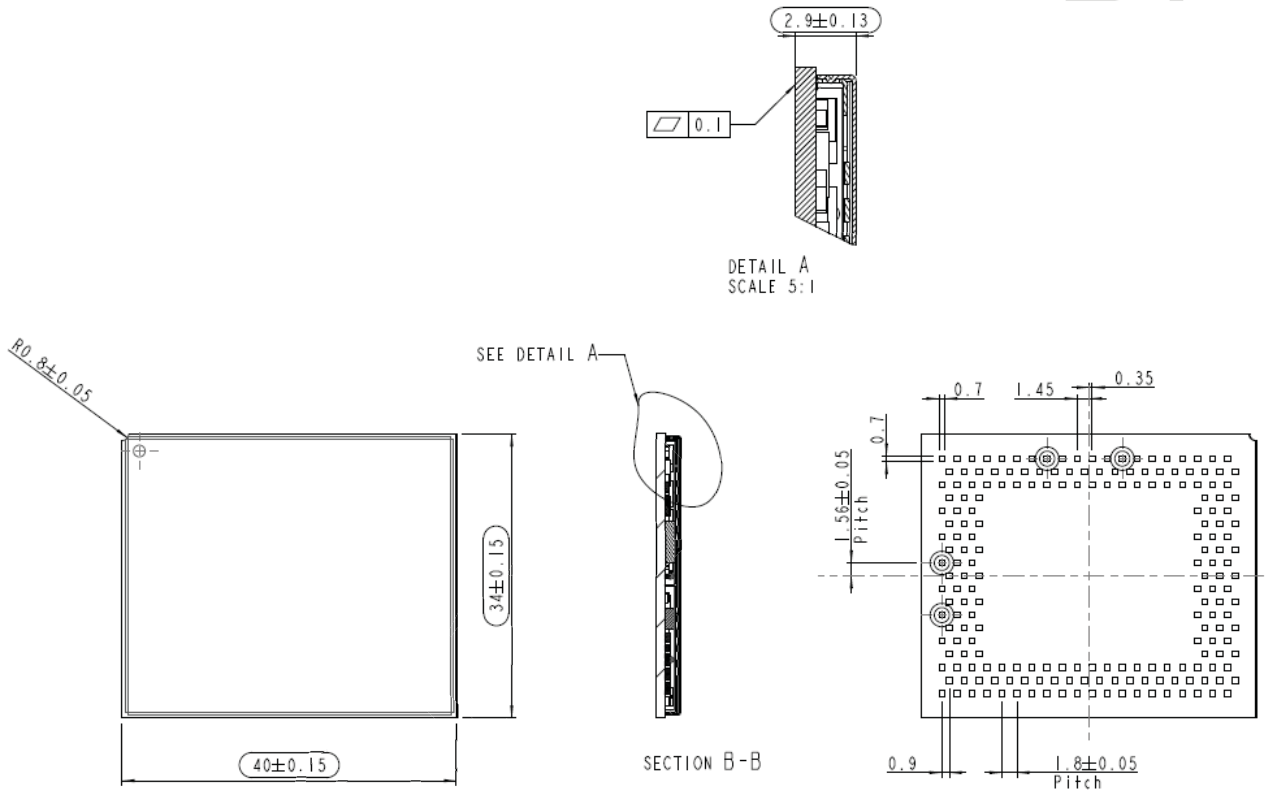
Refer to SW User Guide or AT Commands Reference Guide for the full description of this function.

13. Mounting the module on your board

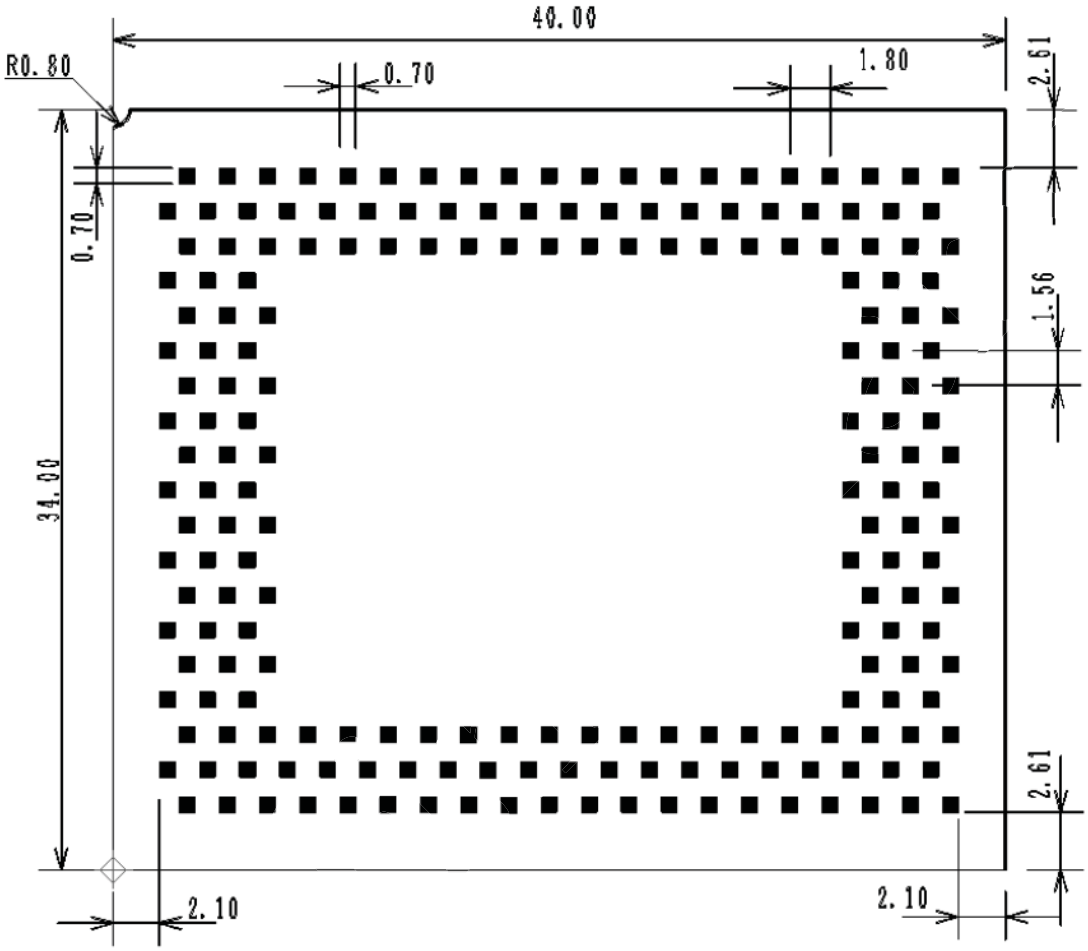
13.1. General

The LE920 modules have been designed in order to be compliant with a standard lead-free SMT process.Module

13.2. Finishing & Dimensions



13.3. Recommended foot print for the application



198 pads

Top View

In order to easily rework the LE920 it is suggested to consider on the application having a 1.5 mm placement inhibit area around the module.

It is also suggested, as a common rule for an SMT component, to avoid having a mechanical part of the application in direct contact with the module.

NOTE:

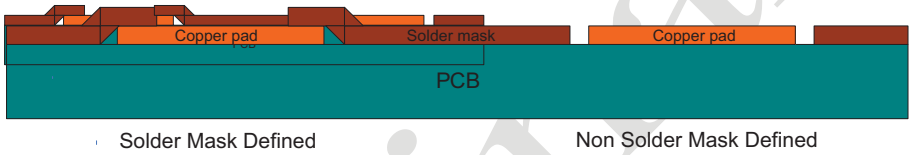
In the customer application, the region under WIRING INHIBIT (see figure) must be clear from signal or ground paths.

13.4. Stencil

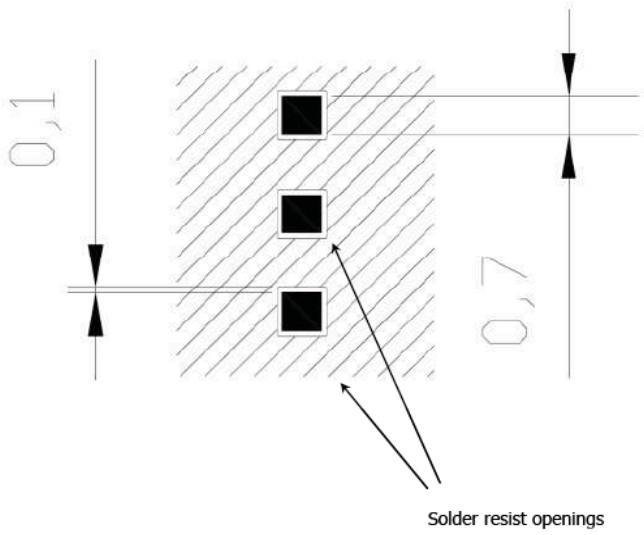
Stencil's apertures layout can be the same as the recommended footprint (1:1). A suggested thickness of stencil foil is greater than 120 µm.

13.5. PCB Pad Design

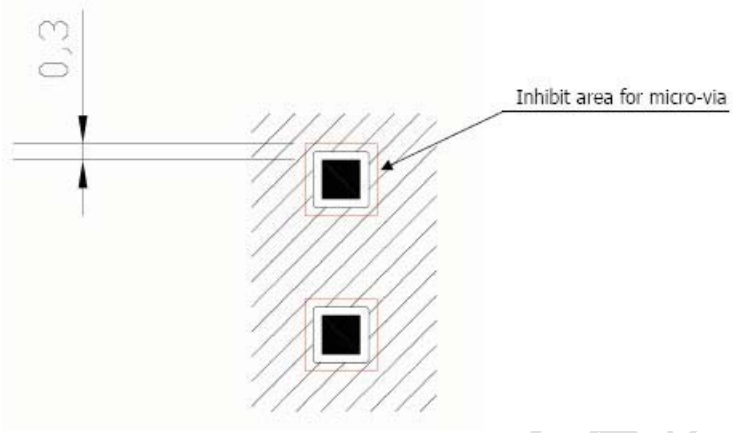
Non solder mask defined (NSMD) type is recommended for the solder pads on the PCB.



13.6. Recommendations for PCB Pad Dimensions (mm)



It is not recommended to place via or micro-via not covered by solder resist in an area of 0,3 mm around the pads unless it carries the same signal of the pad itself (see following figure).



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

Recommendations for PCB Pad Surfaces:

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

The PCB must be able to resist the higher temperatures which are occurring at the lead-free process. This issue should be discussed with the PCB-supplier. Generally, the wettability of tin-lead solder paste on the described surface plating is better compared to lead-free solder paste.

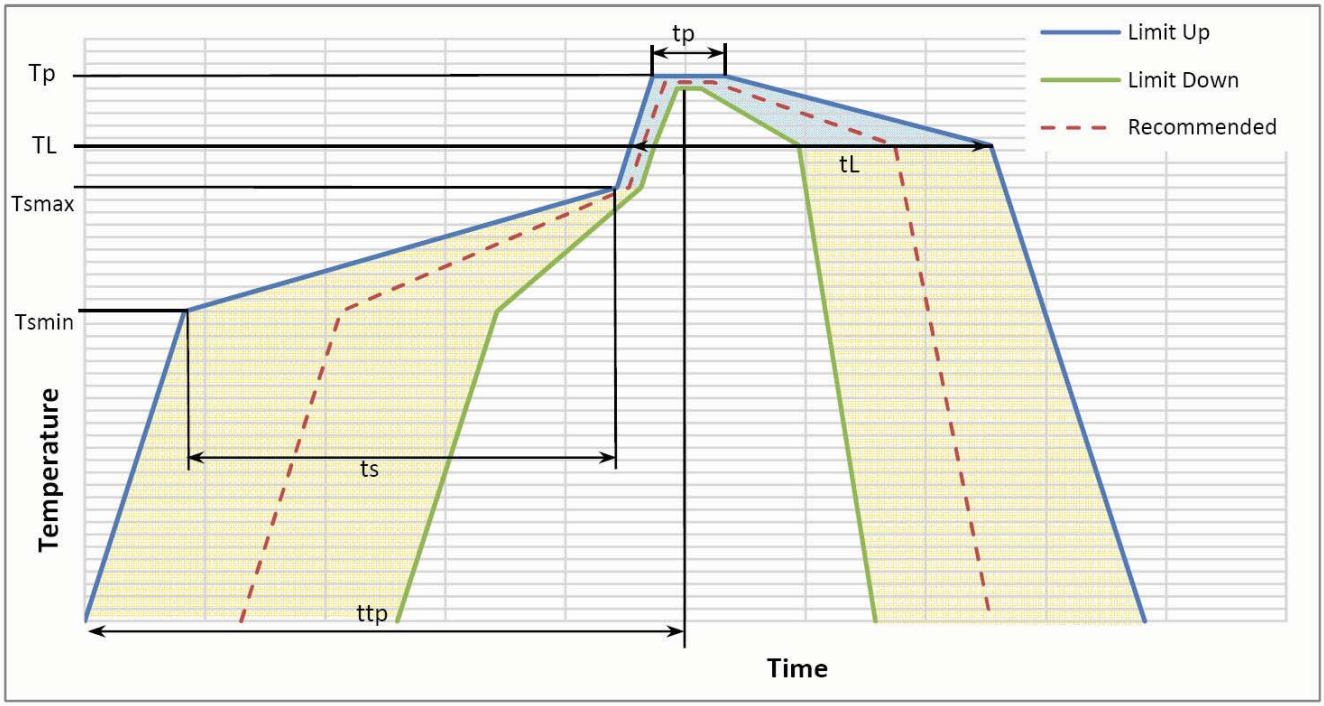
13.7. Solder Paste

Solder Paste	Lead free
	Sn/Ag/Cu

We recommend using only “no clean” solder paste in order to avoid the cleaning of the modules after assembly.

13.7.1. Solder Reflow

Recommended solder reflow profile:



Profile Feature	Pb-Free Assembly
Average ramp-up rate (T_L to T_P)	3°C/second max
Preheat – Temperature Min (Tsmin) – Temperature Max (Tsmax) – Time (min to max) (ts)	 150°C 200°C 60-180 seconds
Tsmax to TL – Ramp-up Rate	 3°C/second max
Time maintained above: – Temperature (TL) – Time (tL)	 217°C 60-150 seconds
Peak Temperature (Tp)	245 +0/-5°C
Time within 5°C of actual Peak Temperature (tp)	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.

WARNIG:

The LE920 module withstands one reflow process only.

14. Application guide

14.1. Debug of the LE920 in production

To test and debug the mounting of LE920, we strongly recommend to foresee test pads on the host PCB, in order to check the connection between the LE920 itself and the application and to test the performance of the module connecting it with an external computer. Depending on the customer application, these pads include, but are not limited to the following signals:

- TXD
- RXD
- ON/OFF
- RESET
- GND
- VBATT
- TX_TRACE
- RX_TRACE
- PWRMON
- USB_VBUS
- USB_D+
- USB_D-

14.2. Bypass capacitor on Power supplies

When a sudden voltage is asserted to or cut from the power supplies, the steep transition makes some reactions such as the overshoot and undershoot.

This abrupt voltage transition can affect the device not to work or make it malfunction.

The bypass capacitors are needed to alleviate this behavior and it can be affected differently according to the various applications. The customers have to pay special attention to this when they design their application board.

The length and width of the power lines need to be considered carefully and the capacitance of the capacitors need to be selected accordingly.

The capacitor will also avoid the ripple of the power supplies and the switching noise caused in TDMA system like GSM.

Specially the suitable bypass capacitor must be mounted on the Vbatt & Vbatt_PA (Pads AP17,AP19,AR18,AS17,AS19,AT18,AU17,AU19) and USB_VBUS (Pad A18) lines in the application board.

The recommended values can be presented as:

- 100uF for Vbatt
- 10uF for USB_VBUS

The customers still have to consider that the capacitance mainly depends on the conditions of their application board.

Generally more capacitance is required as the power line is longer.

14.3. SIM interface

The resistor value on SIMIO pulled up to SIMVCC should be defined accordingly in order to be compliant to 3GPP specification.

6.8kohm resistor can be recommended but it may depend on the application design.

Refer to the following document for the detail:

- Telit_SIM_interface_and ESD_protection_Application_note_r1

14.4. EMC recommendations (TBD)

LE920 signals are provided by some EMC protections. In any case the accepted levels are different on the pins. The characteristics are described in the following Table:

Pad	Signal	I/O	Function	Contact	Air
Power Supply					
AP17,AP19, AR18,AS17, AS19,AT18, AU17,AU19	VBATT_PA And VBATT	-	Main power supply	± 8KV	± 15KV
SIM Card Interface					
A8	SIMVCC	-	External SIM signal – Power supply for the SIM	± 8KV	± 15KV
B11	SIMRST	O	External SIM signal – Reset	± 8KV	± 15KV
B9	SIMIO	I/O	External SIM signal - Data I/O	± 8KV	± 15KV
A10	SIMCLK	O	External SIM signal – Clock	± 8KV	± 15KV
Miscellaneous Functions					
A18	USB_VBUS	AI	Power sense for the internal USB transceiver	± 8KV	± 15KV
P17	VAUX	-	Power output for external accessories	± 8KV	± 15KV
AS1	ON/OFF	I	Input command for switching power ON or OFF (toggle command).	± 8KV	± 15KV
AP1	RESET	I	Reset input	± 8KV	± 15KV
F17	VRTC	AO	Power supply for RTC block	± 8KV	± 15KV
Antenna					
AD1,AU9,S1	Antenna Pad	AI	Antenna pad for Rosenberger connector	± 8KV	± 15KV

All other pins have the following characteristics:
HBM JESD22-A114-B ± 2000 V
CDM JESD22-C101-C ± 500 V

The Board to Board connector has to be considered as NO TOUCH area.

Appropriate series resistors have to be considered to protect the input lines from overvoltage.

14.5. Download and Debug Port

One of the following options should be chosen in the design of host system in order to download or upgrade the Telit's software and debug LE920 when LE920 is already mounted on a host system.

Users who use both of UART and USB interfaces to communicate LE920

- Must implement a download method in a host system for upgrading LE920 when it's mounted.

Users who use USB interface only to communicate LE920

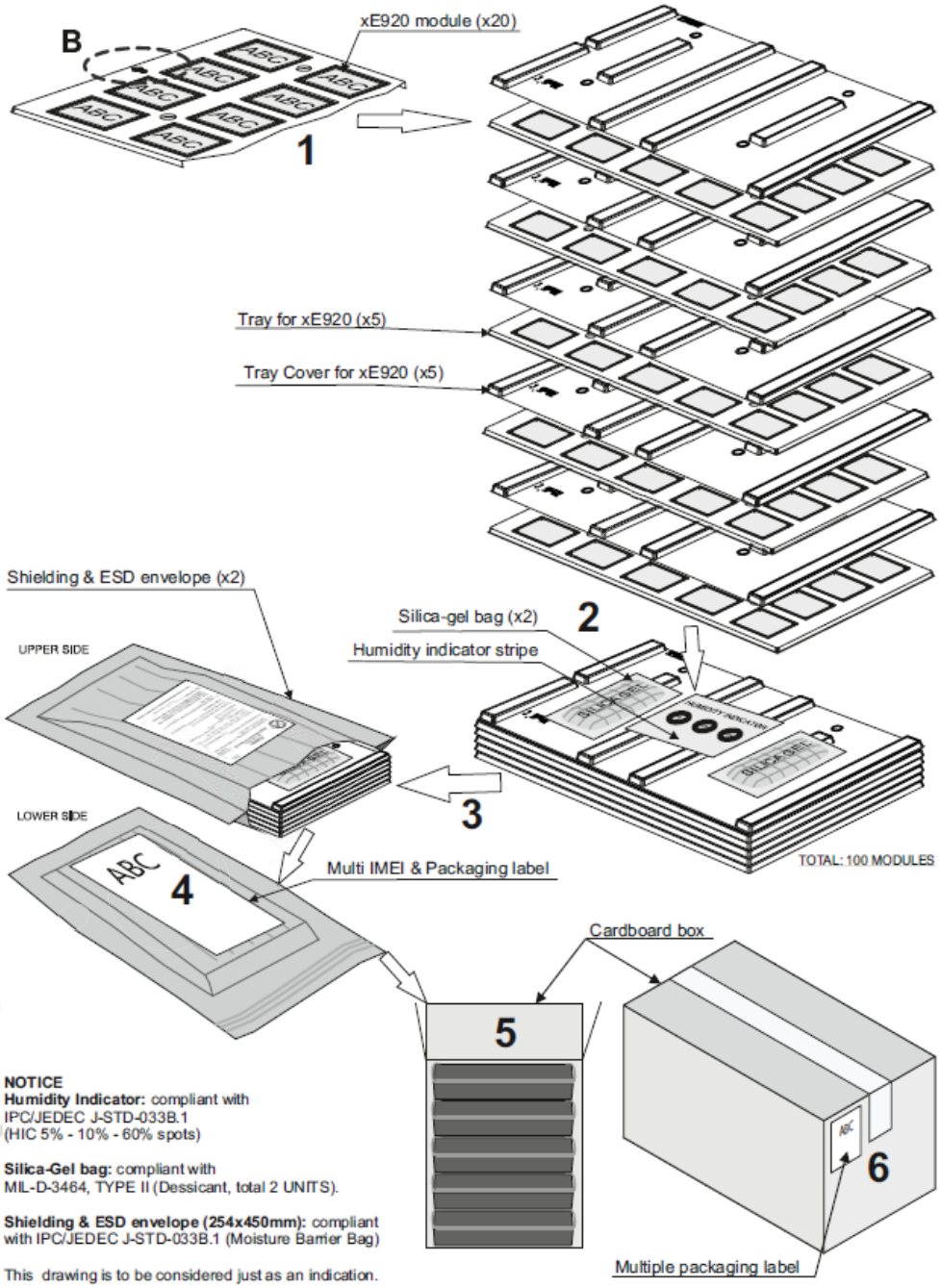
- Must arrange UART port in a host system for debugging or upgrading LE920 when it's mounted.

Users who use UART interface only to communicate LE920

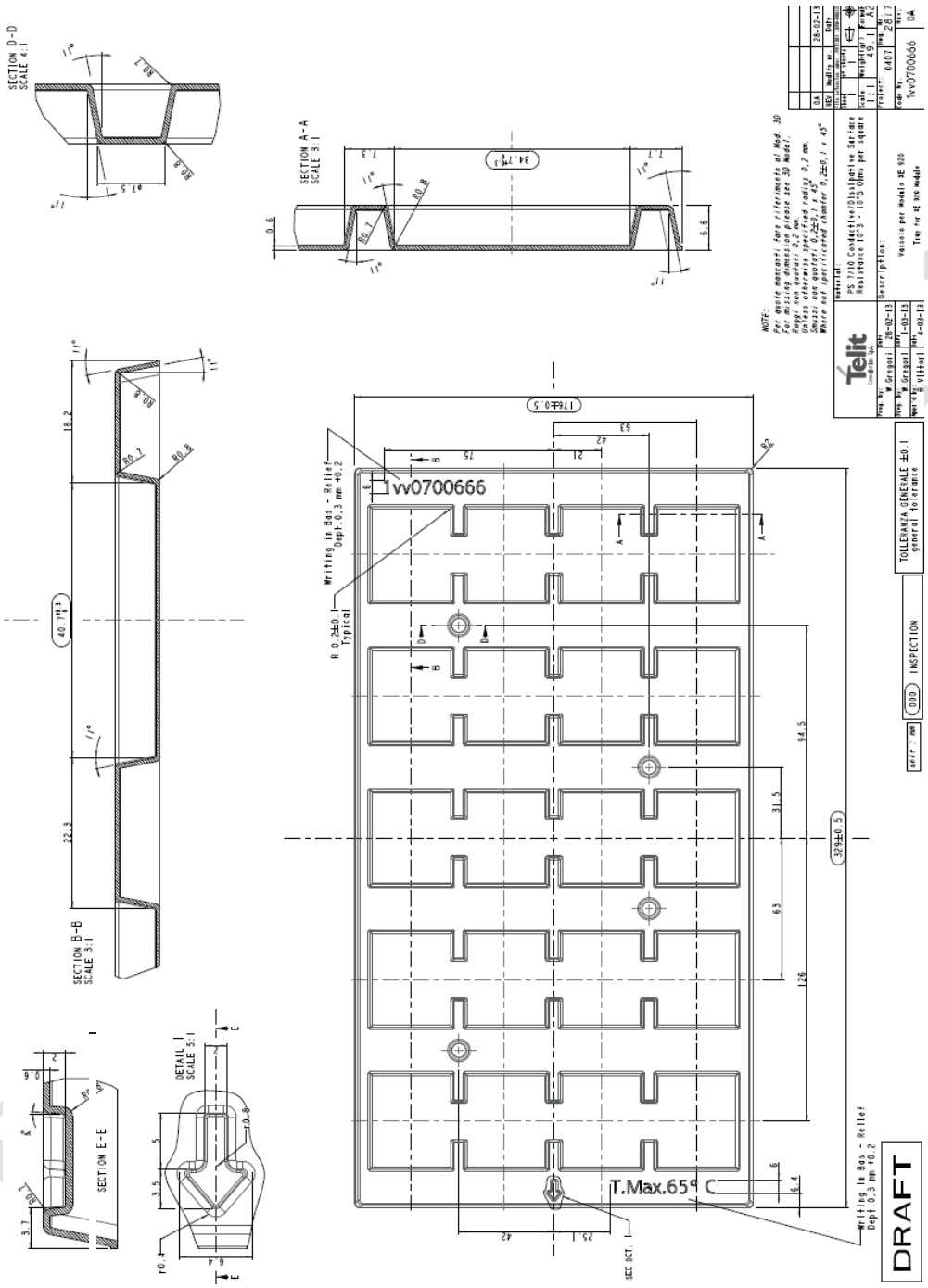
- Must arrange USB port in a host system for debugging or upgrading LE920 when it's mounted.

15. Packing system

The Telit LE920 is packaged on trays. Each tray contains 20 pieces as shown in the following picture:



15.1. Tray Drawing



WARNIG:

These trays can withstand a maximum temperature of 65℃.

15.2. Moisture Sensibility

The LE920 is a Moisture Sensitive Device level 3, in accordance with standard IPC/JEDEC J-STD-020. Observe all of the requirements for using this kind of components.

Calculated shelf life in sealed bag: 4 months at <40°C and <90% relative humidity (RH).

16. Safety Recommendations

READ CAREFULLY

Be sure about that the use of this product is allowed in your 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 be installed with the guarantee of a minimum 20 cm distance from the body. 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 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/rtte/dir99-5.htm

17. Document History

Revision	Date	Changes
0-draft1	2012-10-03	First issue
0-draft2	2012-12-11	- Remove SIM2 interface - Remove external GPS LNA support
0-draft3	2013-03-12	Updated pin-out
0-draft4	2013-05-21	- Update DVI - Adding Current consumption - Adding SHDN_N section - Update Mechanical drawings

FCC Warning

This equipment has been tested and found to comply with the limits for a class B digital device, pursuant to part 15 of the FCC rules. These limits are designed to provide to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the installation, may cause harmful interference to radio communication. However, there is no guarantee that interference

will not occur in a particular installation. if this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:
-Reorient or relocate the receiving antenna
-Increase the separation between the equipment and receiver
-Connect the equipment into an outlet on a circuit different from that to which the receiver is connected
-Consult the dealer or an experienced radio / TV technician for help

You are cautioned that changes or modifications not expressly approved by the party responsible for compliance could void your authority to operate the equipment.

This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions
(1) This device may not cause harmful interference and
(2) this device must accept any interference received, including interference that may cause undesired operation.

IC Statement

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

RF exposure warning: The equipment complies with RF exposure limits set forth for an uncontrolled
environment. The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Avertissement d'exposition RF: L'équipement est conforme aux limites d'exposition aux RF établies pour un incontrôlés environnement. L'antenne (s) utilisée pour ce transmetteur ne doit pas être co-localisés ou fonctionner en conjonction avec toute autre antenne ou transmetteur.

The max allowed antenna gain is :
GSM850: 6.49dBi , GSM1900: 2.01dBi ,
WCDMA II: 8.01dBi , WCDMA IV: 5.00dBi , WCDMA V: 9.42dBi ,
LTE II: 8.01dBi , LTE IV: 5.00dBi , LTE V: 9.54dBi , LTE XVII: 8.80dBi

Label：

“Contains FCC ID：RI7LE920NA
“Contains IC：5131A-LE920NA