WISMO Quik Q24 Series

Application Note

Design of a GSM modem

Reference: **WM_PRJ_Q24_PTS_xxx**
Revision: 003
Date: 04th October 2004

Document Information

Revision	Date	History of the evolution	
001	5th August 2004	Creation of preliminary version.	Cyril TROTIN
002	24th September 2004	First Modifications and adds.	Jean-Paul CIPRIA
003	04th October 2004	No comment from first modification. First Finalization before review.	Jean-Paul CIPRIA

Overview

Warning: this document has to be considered as an extension of documents [1] or [2] and must not be used alone.

This document gives the technical information required for designing a GSM modem based on the use of a WISMO Quik Q2400 or Q2406 or Q2426 module.

Basic application notes related to the design of an application based on a WISMO Quik Q24xx module are described in documents [1] and [2] which represents the reference documents for designers.

Please refer to document [1] or [2] for recommendations about the design of basic interfaces such as:

- **Power supply,**
- **SIM interface,**
- **Audio interface,**
- **Serial link interface,**
- **Radio interface.**

Contents

Tables…

Figures

Cautions

This application note is based on the use of a modular transmitter which is an ESD sensitive device.
This device is to be used for wireless applications.
Information provided herein by WAVECOM is accurate and reliable. However no responsibility is assumed for its use.
Please read carefully the recommendations given in document [1] or [2] for a safe use of a Wireless Equipment.
General information about WAVECOM and its range of products is available at the following internet address: http://www.wavecom.com

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1 REFERENCES

1.1 Reference Documents

[1] WISMO Quik Q2400 module - Customer Design Guidelines
Ref. WM_PRJ_Q24_PTS_004.
[2] WISMO Quik Q2406 and Q2426 modules - Customer Design Guidelines
Ref. WM_PRJ_Q2400_PTS_005.
[3] WISMO Quik Q2400 module – Product Technical Reference
Ref. WM_PRJ_Q24_PTS_00x-.
[4] WISMO Quik Q2406 and Q2426 modules – Product Technical Reference Ref.
WM_PRJ_Q2400_PTS_00x.
[5] ADM3307E/ADM3310E-12E/3315E:15 kV ESD Protected, 2.7V to 3.6V Serial Port
Transceivers with Green Idle™ Data Sheet (Analog Devices)
[6] Specification of the Bluetooth System - Covered Core Package version: 1.2 - Current Master
TOC issued: 05 November 2003
[7] CCITT Rec. G.473, Standard DTMF Wire 600 Ohm telephones, RJ-11 jack
[8] Fastrack modem M1206 - Product Specification - Reference: WM_PRJ_M12_PTS_001 -
Revision: 001 - Date: 3rd April 2003
[9] Q2403 Product Specification - Reference:WM_PRJ_Q2400_PTS_001 - Revision:003 -
Date:6th November 2002
[10] AT Commands Interface Guide.

1.2 Abbreviations

Abbreviation	Definition
AC	**Alternative Current**
AT	**Attention (prefix for modem commands)**
CB	**Cell Broadcast**
CD-ROM	**Compact Disk – Read Only Memory**
CLK	**ClocK**
CMOS	**Complementary Metal Oxide Semiconductor**

Abbreviation	Definition
CPU	Central Processing Unit
CTS	Clear To Send
DC	Direct Current
DCD	Data Carrier Detect
DCE	Data Communication Equipment
DCS	Digital Cellular System
DSR	Data Set Ready
DTE	Data Terminal Equipment
DTMF	Dual Tone Multi Frequency
DTR	Data Terminal Ready
EFR	Enhanced Full Rate
E-GSM	Extended GSM
EMS	Enhanced Messaging Service
EN	Enable
ESD	ElectroStatic Discharges
FR	Full Rate
GND	GrouND
GPIO	General Purpose Input Output
GSM	Global System for Mobile communications
HR	Half Rate
I	Input
I/O	Input / Output
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MAX	MAXimum
MIC	MICrophone
MIN	MINimum
MMI	Man Machine Interface
MO	Mobile Originated
MT	Mobile Terminated
O	Output
PC	Personal Computer
PIN	Personal Identification Number (PIN code)
PLMN	Public Land Mobile Network
RI	Ring Indicator
RDP	Reference Design Package
RST	ReSeT
RTC	Real Time Clock
RTS	Request To Send
RX	Receive
RXD	Receive Data
SIM	Subscriber Identification Module
SMS	Short Message Service
SPI	Serial Peripheral Interface
SPK	SpeaKer
STD	STandarD
TE	Terminal Equipment
TX	Transmit
TXD	Transmit Data

Abbreviation	Definition
TYP	TYPical
USSD	Unstructured Supplementary Service Data
VLCD	Voltage for LCD display

2 GENERAL DESCRIPTION

2.1 Basic features and services

Possible functions of the GSM modem are the following ones:

Features	GSM	DCS
Standard	900 MHz Q2403: EGSM/DCS 900/1800 MHz Q2406: EGSM/DCS/GPRS 900/1800 MHz Q2426: GSM/PCS/GPRS 850/1900 MHz E-GSM compliant. Output power: class 4 (2W). Fully compliant with ETSI GSM phase 2 + small MS.	1800 MHz 1800 : Q2403: EGSM/DCS 1800 : Q2406: EGSM / DCS / GPRS Output power: class 1 (1W). Fully compliant with ETSI GSM phase 2 + small MS.
GPRS	GPRS not supported by Q2400 Class 10. PBCCH support. Coding schemes: CS1 to CS4. Compliant with SMG31bis. Embedded TCP/IP stack (optional).	
Interfaces	RS232 (V.24/V.28) Serial interface supporting: - Autoshutdown controlled by software (AT), - Baud rate (bits/s): 300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600, 115200, - Autobauding (bits/s): 2400, 4800, 9600, 19200, 38400, 57600. Many General Purpose Input/Output gates (GPIOs) available. Audio interface (analog). DC power interface (5.5 V to 32 V).	
SIM	3 V SIM interface. 3 or 5 V versus Q24xx.	
SMS	Text & PDU. Point to point (MT/MO). Cell broadcast.	
OpenAT	OpenAT interface for embedded application. AT command set based on V.25ter and GSM 07.05 & 07.07.	

Features	GSM	DCS
Data	Data circuit asynchronous. Transparent and Non Transparent modes. Up to 14.400 bits/s. MNP Class 2 error correction. V42.bis data compression.	
Fax	Automatic fax group 3 (class 1 and Class 2).	
Audio	Echo cancellation Noise reduction Telephony. Emergency calls. Full Rate, Enhanced Full Rate and Half Rate operation (FR/EFR/HR). Dual Tone Multi Frequency function (DTMF). DTMF Reception seems to be as important as Transmission when modem used like a PABx.	
GSM supplem. services	Call forwarding. Call barring. Multiparty. Call waiting and call hold. Calling line identity. Advice of charge. USSD	
Other	Real Time Clock with calendar	

Table 1: basic services.

2.2 Basic connections

- RF connection to the antenna,
- RS232 serial link connection,
- Audio lines (microphone and speaker) connection,
- DC Power Supply,
- GPIOs connections,
- BOOT and RESET signals connection.

2.3 Other connections

- **Bluetooth (to RS232) connection,**
  The Bluetooth system operates in the 2.4 GHz ISM band.
  This frequency band is 2400 - 2483.5 MHz.
  The Modulation is GFSK (Gaussian Frequency Shift Keying).
  The device is classified into three power classes.
  1 : 100 mW (20 dBm)
  2 : 2.5 mW (4 dBm)
  3 : 1 mW (0 dBm)
  The basic piconet physical 79 channels is divided into time slots, each 625 µs in length.
  The symbol rate is 1 Megabit per second (Mb/s).
  The system employs a frequency hop transceiver to combat interference and fading and provides many FHSS carriers.
  Bluetooth technology provides the effect of full duplex transmission through the use of a Time-Division Duplex (TDD) scheme.
- **CAN (to RS232) connection.**
  CAN can be used in automotive applications.
- **USB (to RS232) interface .**
  USB can be used to transmit data from PDA or PC to Modem.

2.4 optional features and services

- DTMF interface . See Reference Document [7].
  DTMF can be use to interface PABx or PSTN and voice servers.

3 BLOCK DIAGRAM OF THE MODEM FUNCTION

Figure hereunder gives the basic architecture of a GSM/GPRS modem.

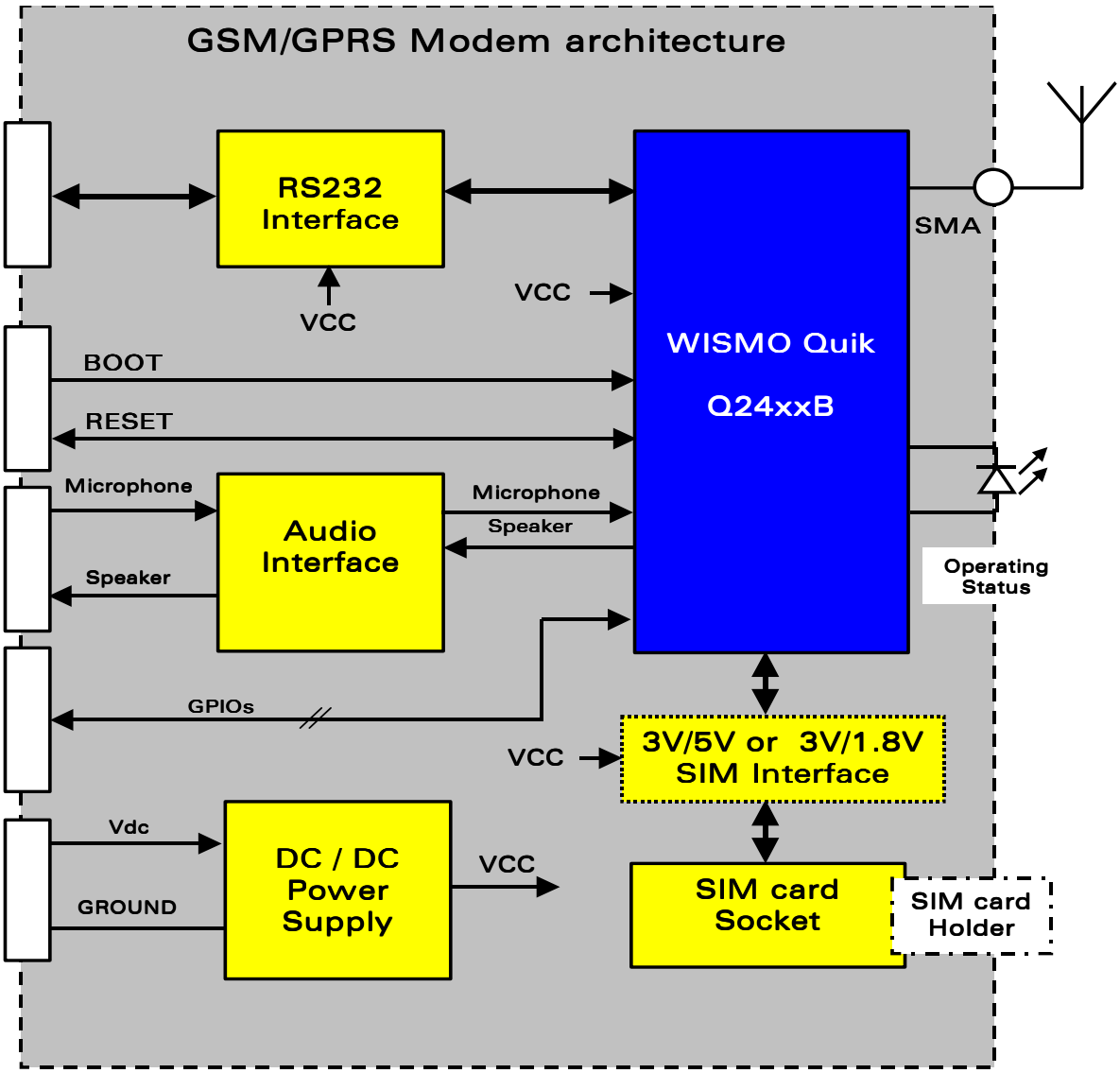


Figure 1: Architecture of a basic GSM/GPRS modem

4 FUNCTIONAL DESCRIPTION

4.1 Power supply interface

4.1.1 WISMO Quick modules specifications

The power supply takes an important part in the performance a GSM modem. Due to the bursted emission in GSM, the power supply must be able to deliver high current peaks in a short time (The rising time is around 10µs. See document [9]).
In communication mode, a GSM/GPRS class 2 terminal emits 577µs radio bursts every 4.615ms, as described figure ().

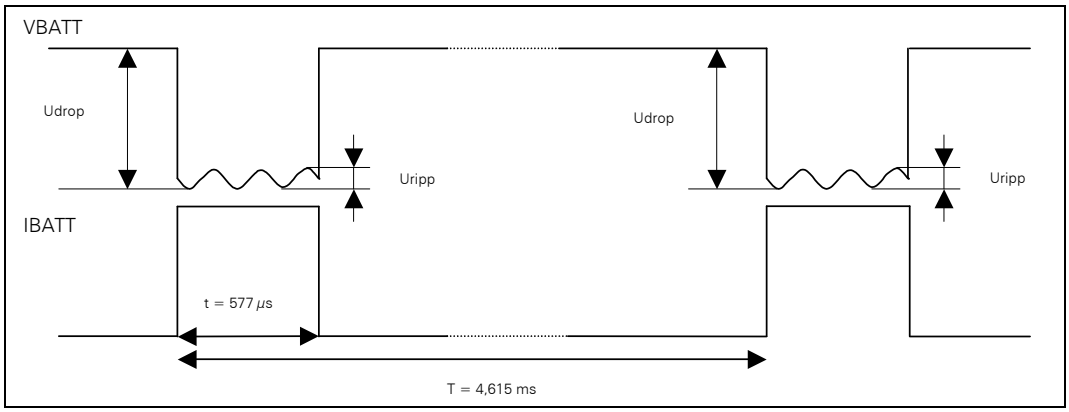


Figure 2: Waveform of Vbatt during a TX burst

In communication mode, a GSM/GPRS class 10 terminal emits 2x 577 µs radio bursts every 4.615ms.

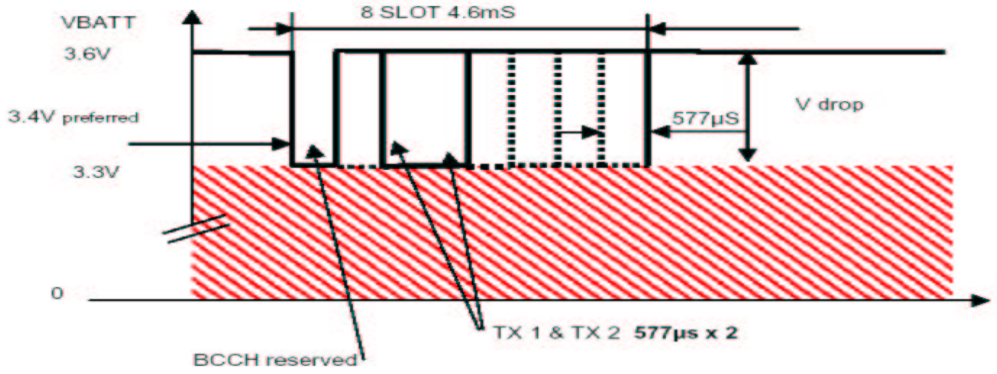


Figure 3: Waveform of Vbatt during several TX bursts

The power supply voltage features given in the table hereunder will guarantee nominal functioning of the module.

		V_{MIN}	V_{NOM}	V_{MAX}	condition
VBATT		3.3 V (1)	3.6 V (2)	4.5 V	See DOC [3] & DOC [4]
I peak (3)	Q2400 Q24x6		1.6 A 1.6 A	1.8 A 1.8 A	See DOC [3] See DOC [4]
I average max (4)	Q2400 Q24x6		250 mA 400 mA	300 mA 510 mA	See DOC [3] See DOC [4]

Tableau 1 : Main power consumption

Notes:
(1): This value has to be guaranteed during the burst (with 2.0 A Peak in GSM mode), this why we define a Vdrop < 300mV, when a Li-ion battery is used.
(2): 3.6 V is a typical value when a Li-ion battery is used. It is possible to increase this value to 3.8 V or more (TBD following the VBATT filtering) to avoid drop under 3.3 V.
(3): I peak during burst in GSM/GPRS 900 MHZ, (Pcl = 5). Values given in table represent consumption of the WISMO QUICK module.
(4): I average max in GSM/GPRS 900 MHZ, (Pcl = 5). Values given in table are only consumption of the WISMO QUICK module.

4.1.2 Power supply design (example)

The solution proposed here is not the only one possible, but it is one validated by Wavecom in a GSM modem.
This PSU is able to supply more than 2 A (in DC mode), this is oversized for the only application of GSM modem but you can use this one to supply an other part of the application. Be careful to this last point, if switching current increases, voltage ripple will increase too.
Regarding voltage ripple defined in DOC[3] and DOC[4], value seems to be a quiet hard to reach (for Freq>200KHz), but don't forget the average current is around 500 mA and in this case of operating the Uripple generated by this type of regulator is not too significant.
Regarding the voltage input, this PSU is defined as hereunder (table)

		V_{MIN}	V_{NOM}	V_{MAX}
Vin		5.5 V (1)		32 V
Vout	VBATT (2) V_{RS232} (3)	3.3 V	4 V 2.8 V	
Iout (DC mode)			> 2 A	

Tableau 2 : PSU main features

Notes :
(1): By removing protection diode and EMI filter, it is possible to reach Vin min=Vin min (L5973)=4.4 V.
(2): VBATT is the voltage supplying the WISMO QUICK module (VBATT+VDD pins). For tis application, VBATT nom is 4 V., because EMI filter are forecasted (on the VBATT line).
(3): V_{RS232} is noted 3V in the schematic. This voltage could be 2.8V or 3V.

4.1.3 Fastrack modem M12 series Power Supply

Supply Voltage	MIN	TYP	MAX	UNIT	Comments
	5		32	V	GSM or DCS
	5.5		32	V	GPRS Class 10

Tableau 3 : Fastrack modem M12 series Power Supply

Fastrack modem M12 series See Reference Document [8]

4.2 RS232 interface

A flexible 6-wire serial interface (UART) is available and allows to send/receive to/from the GSM modem data.
Main performance characteristics of this interface are described in table (1).
The electrical schematic presented figure is designed to fully meet the EIA-232 standard while operating with a single power supply. RS-232 lines contain ESD protection up to ±15 kV.
A power saving mode which is automatically enabled inside the modem when there is no load on the RS232 serial link (no connection to a DTE).

A shutdown facility that reduces the power consumption is also provided. While shutdown facility is enabled:

- All Internal RS232 transmitters are disabled to reduce the power consumption,
- All internal RS232 receivers are shut down except for CT103/TX receiver which can alert the WISMO module in order to make the shutdown facility to be disabled.

These functionalities are essential when the modem is supplied by a battery.

This autoshutdown facility is controlled through an ***AT +WIOW*** command by the GPIO0 internal to the WISMO Quik module:

- GPIO0 = 0: autoshutdown disable (***AT +WIOW=0,0***),
- GPIO0 = 1: autoshutdown enable (***AT +WIOW=0,1***),.

Warning: to make the *AT +WIOW* command to be effective, it is previously necessary to configure the GPIO0 as an output by using the *AT +WIOM* command. See document [10].

Signals available are:

- TX data (CT103/TX),
- RX data (CT104/RX),
- Request To Send (CT105/RTS),
- Clear To Send (CT106/CTS),
- Data Terminal Ready (CT108-2/DTR),
- Data Set Ready (CT107/DSR).

The 2 additional signals are Data Carrier Detect (CT109/DCD) and Ring Indicator (CT125/RI).

However, the use of TX, RX, CTS and RTS signals is mandatory which is not the case for DTR, DSR, DCD and RI signals which can be not used.
DTR, DSR, DCD and RI signals are used to control the transmit and receive data then it is strongly recommended to use it.

Note:
This IC (ADM3307) recommended by Wavecom is not the only one able to realize this functionality. Components around this IC are defined in the datasheet Reference Document [5].

4.3 Audio interface

Two different microphone inputs and two different speaker outputs are provided.
The main MIC (MIC2) input already includes the biasing for an electret microphone allowing an easy connection to a handset.
The auxiliary MIC (MIC1) input does not include an internal bias. MIC1 / SPK1 are then appropriate for a hands free system or a handset with biasing external to the module.
An echo cancellation feature for hands-free application is also available.
In some cases (external access), ESD protection must be added on the audio interface lines.
The connection can be either differential or single-ended but using a differential connection in order to reject common mode noise and TDMA noise is strongly recommended

4.3.1 Main audio interface (MIC2/SPK2)

The main MIC (MIC2) inputs are differential ones and they include the convenient biasing for an electret microphone (0.5 mA and 2 Volts).
Figure (6) shows a typical implementation of audio lines (in differential mode). In case of single ended audio lines and regarding values description and PCB constraints, please refer you to the Customer Design Guidelines Doc [1] or Doc[2].

4.3.2 Auxiliary audio interface (MIC1/SPK1)

In the case of use of an external headset or a hands-free kit, it is possible to connect them to the auxiliary audio interface.
This auxiliary audio interface allows to interface easily an audio amplifier if necessary (ref possible LM4876, LM4894…) . In this case, speaker impedance is generally 8 Ohms.

4.3.3 Speaker:

Type: 10mW, electro-acoustic.
Impedance: 32 to 150 Ohms.
Sensitivity: 110 dB SPL min (0 db = 20 µPa).
Frequency response compatible with the GSM specification.
Possible supplier: Hosiden, Sanyo, Primo, Philips…

4.3.4 Microphone:

Type: 2 V. / 0.5 mA.
Impedance : 2 Kohms.
Sensitivity: -40 dB to –50 dB.
Frequency response compatible with the GSM specification.
Possible supplier: Hosiden, Panasonic…

4.4 SIM interface

The Sim interface is a 3 V. compliant interface but It is possible to manage other voltage (1.8V/5V)) by adding an external circuit (for example LTC1555).
It is possible to interface two SIM cards by adding an external circuit (for example LTC4557

It is recommended to add Transient Voltage Suppressor diodes (TVS) on the signals connected to the SIM socket in order to prevent any Electrostatic Discharge. TVS diodes with low capacitance (less than 10 pF) have to be connected on SIM_CLK and SIM_DATA to avoid any disturbance of the rising and falling edges. This type of diode is mandatory for the Full Type Approval (if an external access is possible). Diodes shall be placed as close as possible to the SIM socket.

If a 6+2 points SIM holder is used (the 2 pts are for SIM presence detection), please refer to Figure.
If a 6 points SIM holder is used (without SIM presence detection), it is necessary to connect/fix SIM_PRES (of WISMO Q24xx) to VCC (R and C are then not connected). This implementation avoid to change the Wismo software (because the management is different).
Figure 10: SIM interface schematic. shows a typical implementation of the SIM interface with a 6+2 points SIM holder.

4.5 Other Interface

4.5.1 GPIO interface

WISMO QUICK modules provide many General Purpose Input / Output lines available for external/internal use. Those GPIOs are 2.8 V CMOS compliant (3.3 V max with serial resistor).

If used outside the GSM modem, it is mandatory to protect them from ESD by TVS diodes (for example ESD DALC208SC6 ST).

If used with an other technology, it is recommended to interface (protect) them with a specific interface:

- Serial resistors when technology CMOS 3.3 V is used.
  3.0 V logic : Between 2.2K and 4.7Kohms can be added on the lines.
  3.3 V logic : Between 4.7 kΩ and 10 kΩ can be added on the lines.
  For higher voltage logics, a resistor bridge or a level shifter IC can be added.
- With specific buffers/level shifters (when level is > 3.3 V and < logic level):

  - as LVC, LVT technology which can drive 2.8 V signals and are 5V tolerant.

  - as dual supply buffer/level shifters (For example SN74LVC2T45).
- Open collector (or open drain) transistors (when level is > 3.3 V or > logic level).

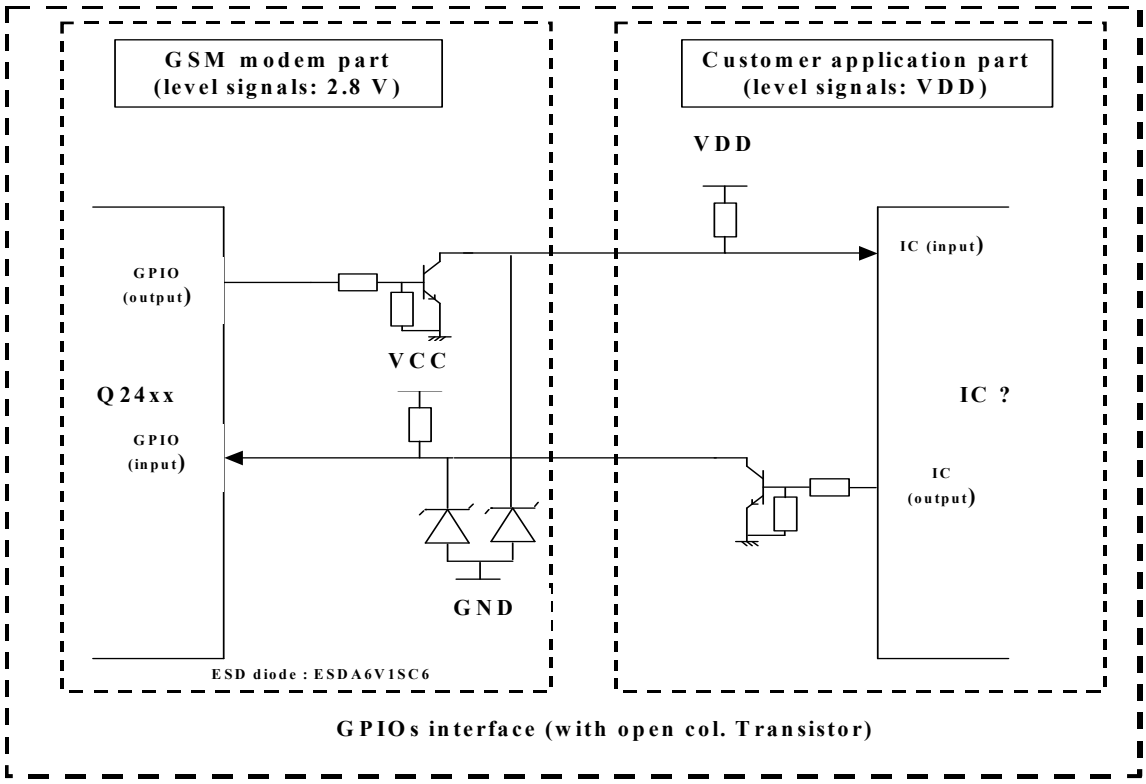


Figure 4: Open collector interface for GPIOs.

4.5.2 RF interface

4.5.2.1 RF line

RF line and cables shall be as short as possible to minimise losses and must have a characteristic impedance of 50 Ohms until F = 2GHz.

4.5.2.2 RF possibilities

3 ways of connecting RF is possible, 50 Ohms coaxial connection, Spring contact area for handset or PDA and 50 Ohms BOARD TO BOARD connection.

- **Co-axial connection (50 Ohms)** : this soldered solution is based on a RG178 coaxial cable and the losses are approximatively 2 dB /metre (max value)

- **Spring contact** : as this solution is well suited for handset, the antenna shall be very close from the module so the RF impedance is not exactly 50 ohms.
  An additional matching network placed on Q24xx module shall be required, this research of the value needed an experience in RF so WAVECOM recommends to work with an antenna manufacturer to develop and to adapt the antenna with the application.

- **IMP BOARD TO BOARD connection (50 Ohms)** : this solution improved the design of a RF line with a characteristic impedance equal to 50 Ohms, this design is tied to the PCB dielectric propriety and the geometric line design.
  For help, a software for RF line impedance calculation can be downloaded from AGILENT web site (AppCAD : http://www.agilent.com/view/rf).
  See IMP Connector. Figure 6

4.5.3 Technical interface

4.5.3.1 BOOT

This input can be used to download a software in the Flash memory of the modem.
This is a backup download procedure only.
The internal boot procedure is started when this pin is low during the reset of the modem:

- BOOT pin 3 = 0, for download mode,
- BOOT pin 3 = 1, for normal mode.

In normal mode this pin has to be left open. In Internal boot mode, low level has to be set through a 1 kΩ resistor. If used, this input has to be driven by an open collector or an open drain output.

It is possible to drive this signal with a button (only accessible by a technician)

4.5.3.2 RESET

This signal is used to force a reset procedure by providing low level during at least 500 µs.
This signal has to be considered as an emergency reset only. A reset procedure is automatically driven by an internal hardware during the power-up sequence.
This signal can also be used to provide a reset to an external device. It then behaves as an output. If no external reset is necessary this input can be left open, if used (emergency reset), it has to be driven by an open collector or an open drain output:

- RESET pin 14 = 0, for Modem Reset,
- RESET pin 14 = 1, for normal mode.

Please, refer to Doc[1]/ Doc[3] or Doc[2]/ Doc[4] to have more information regarding this signal.

It is possible to drive this signal with a push button (only accessible by a technician)

5 PCB ROUTING CONSTRAINTS

5.1 Vbatt :

Since the maximum peak current can reach 2A Wavecom strongly recommends a large width for the layout of the power supply signal.
The routing must be done in such a way that the total impedance line must be inferior or equal to 10 mOhms @ 217Hz.

5.2 EMI definition :

EMI stands for ElectroMagnetic Interferences.
All the sensitive signals are listed to take EMI precautions.
Avoid current loop.
Sensitive signals must be to isolate and protected with ground.

	RF POINTS TO CHECK
RF TRACK	- Short lines
	- 50 ohms until 2Ghz
VBATT TRACK	- Impedance line <10mOHM@217Hz
	- 2mm large width of the track
3 RF WAYS	- Spec antenna
	- Measures method and layout
Exclusive Zone	- Free space near RF connection
	- Not another RF functions
	- Not BF function with high current
	- Do not use antenna switching circuit between the module and the external antenna .
AUDIO ZONE	- Not filter or amp AUDIO near RF part

Tableau 4 : RF points to check

	GPC 60 POINTS TO CHECK
SIM ROUTE	- EMI routing
	- short line possible
	- SIM_CLK isolated
ESD ROUTE	- Avoid long track between diode and component to
AUDIO ROUTE	- EMI routing
	- Not GND AUDIO ONLY FOR SINGLE ENDED HEADSET
ADC ROUTE	- EMI routing

Tableau 5 : GPC 60 points to check

6 MECHANICAL CONSTRAINTS

Mechanicals Constraints depend with PCB implantation and used technologies.
Refer to the Product Technical Document.

7 SAFETY PRECAUTIONS

Safety Precautions depend with Power Supplies, RF, mechanical and technologies used.
Refer to the Product Technical Document.

8 RECOMMENDED TEST POINTS

It is important to have Test Point to make relevant measurements to check, monitor or maintain devices.

9 RECOMMENDED SUPPLIERS

9.1 GSM antenna

GSM antennas and support for antenna adaptation can be obtained from manufacturers such as:
AMC Centurion. http://www.amccenturion.se/home/home.asp
MOTECO. To verify. No web site found.
AMPHENOL. http://www.amphenol-socapex.com/
GALTRONICS. http://www.galtronics.com/
RADIALL/LARSEN. http://www.radiall.com/intro.htm
RANGESTAR/tyco. No web site found.

9.2 Antenna connector

9.2.1 SMA connector

Figure 5 : SMA Connector

9.2.2 IMP RF Connector

Figure 6 : IMP RF Connector

9.2.3 Connection Table

Function connector	Type	Ref. supplier	opposite connector examples
RF connector	SMA	RADIALL R284310085	RADIALL R125073
SIM card holder		MOLEX 52828-0611	
Power Supply connector	Micro-Fit (4 pins)	MOLEX 43045-0409	MOLEX 43025-0400
Serial link AUDIO link BOOT RESET	SUB D High Density (15 pins)	JST KSEY-15S-3B6L18-13	ITT CANNON ZDEA-15P-SB or JST KEC-15P with contact JK-SP2143

Tableau 6 : Connectors Table

10 APPENDIX

10.1 Power supply schematic

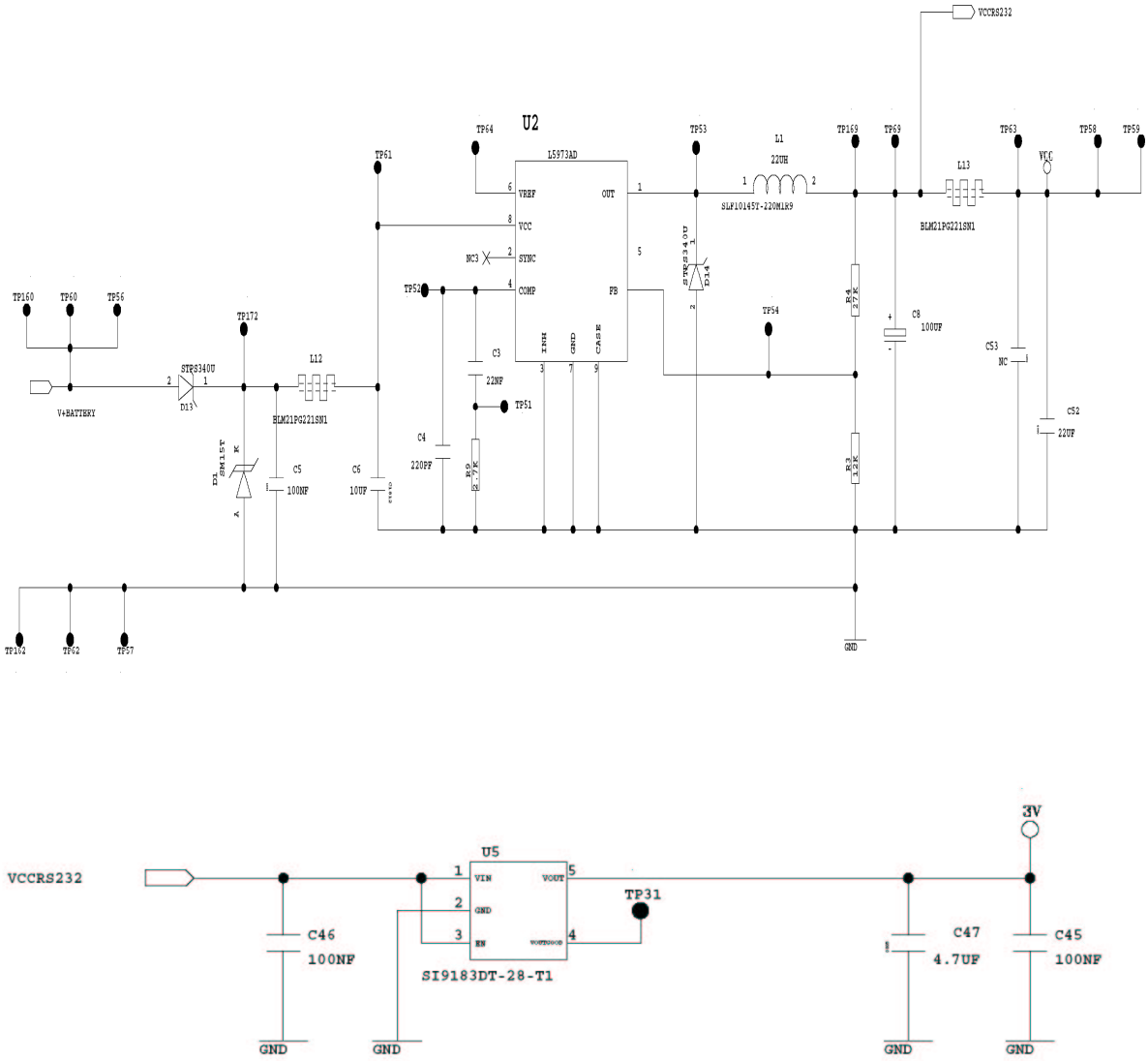


Figure 7: PSU schematic.

10.2 RS232 schematic

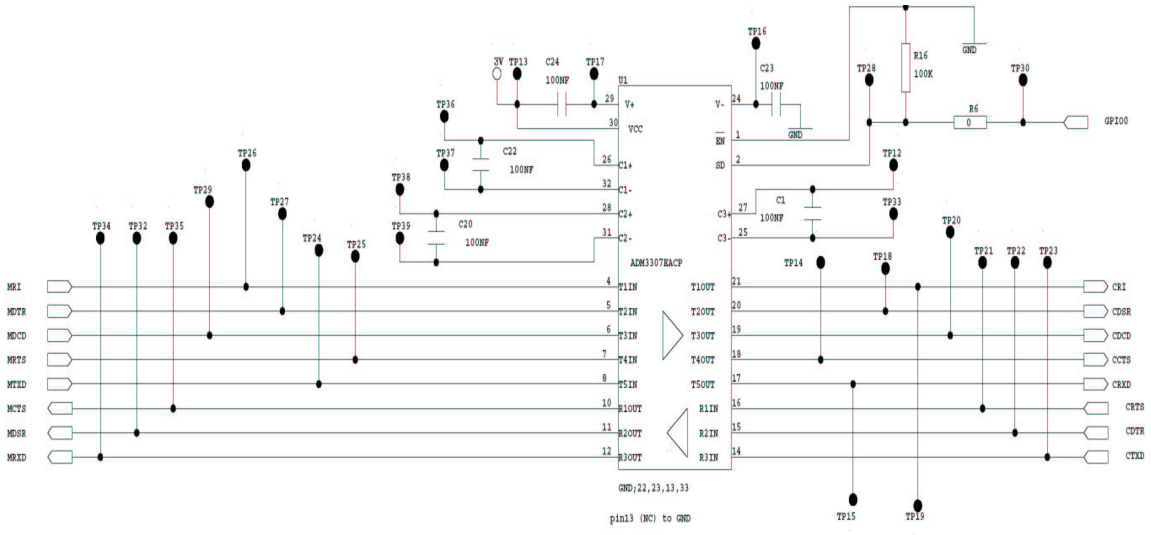


Figure 8: RS232 interface schematic.

Note:
If not used, RS232 inputs have to be tied to VCC through pull up resistors (100Kohms)

10.3 Audio filter schematic

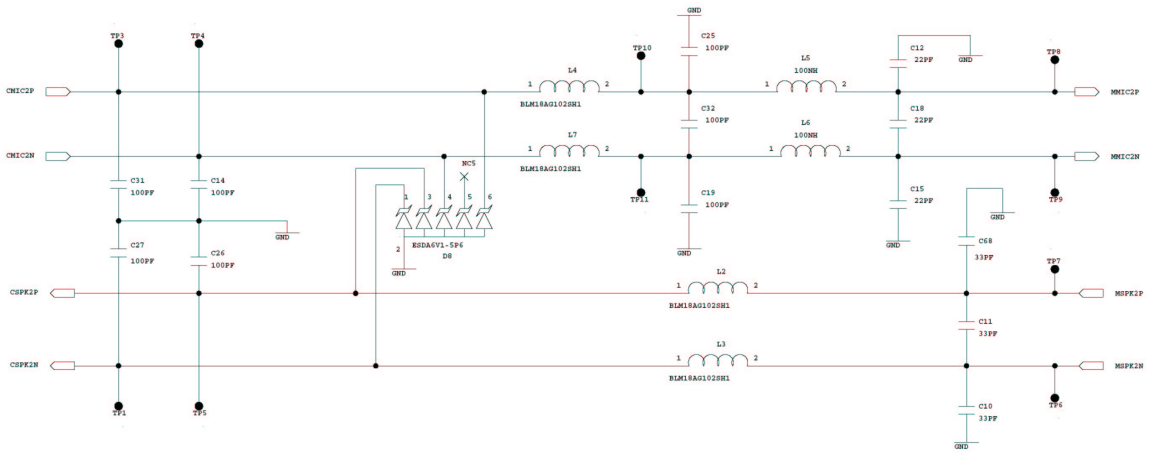


Figure 9: Audio filter schematic.

10.4 SIM schematic

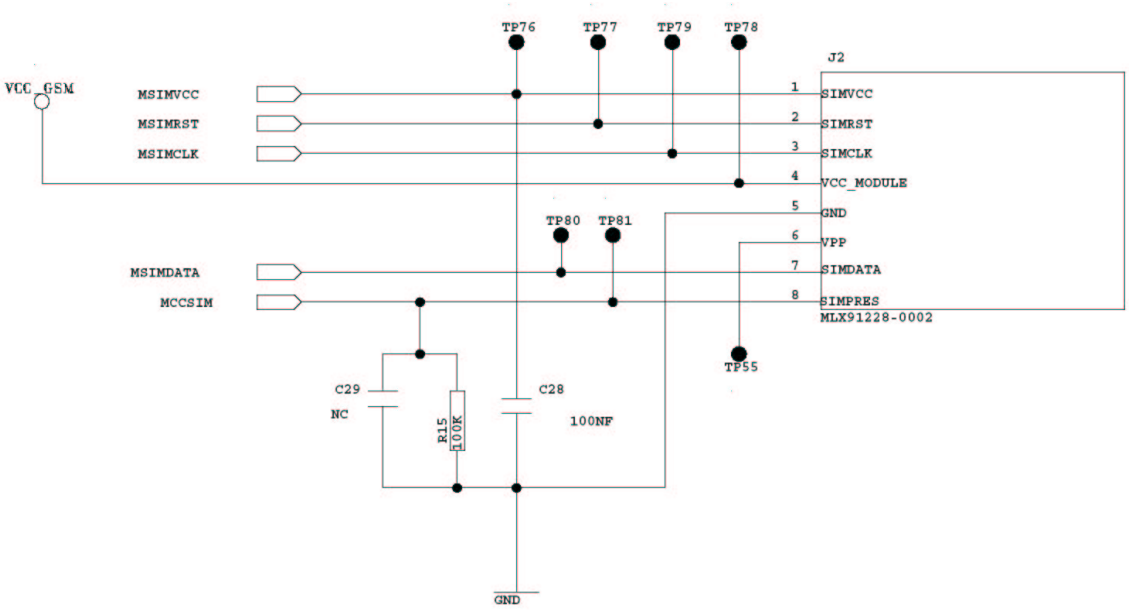


Figure 10: SIM interface schematic.

Remarks:
It is important to protect SIM inputs against Electrical Shocks.
If the SIM layout can be accessed then protect it with ESD protection.

10.5 Q24xx module schematic

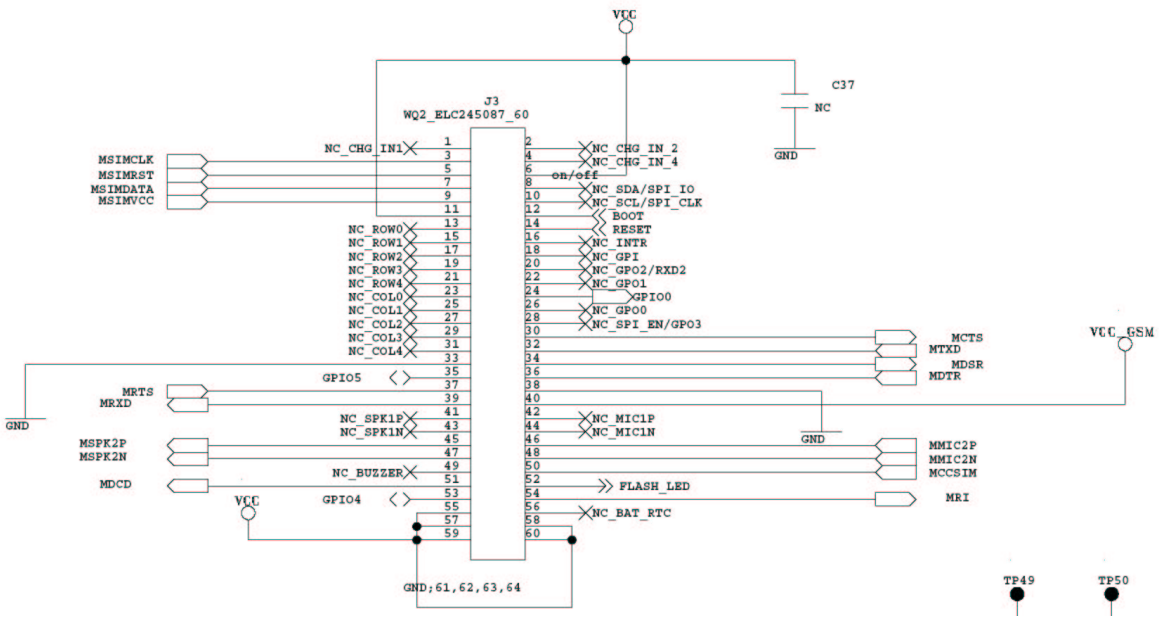
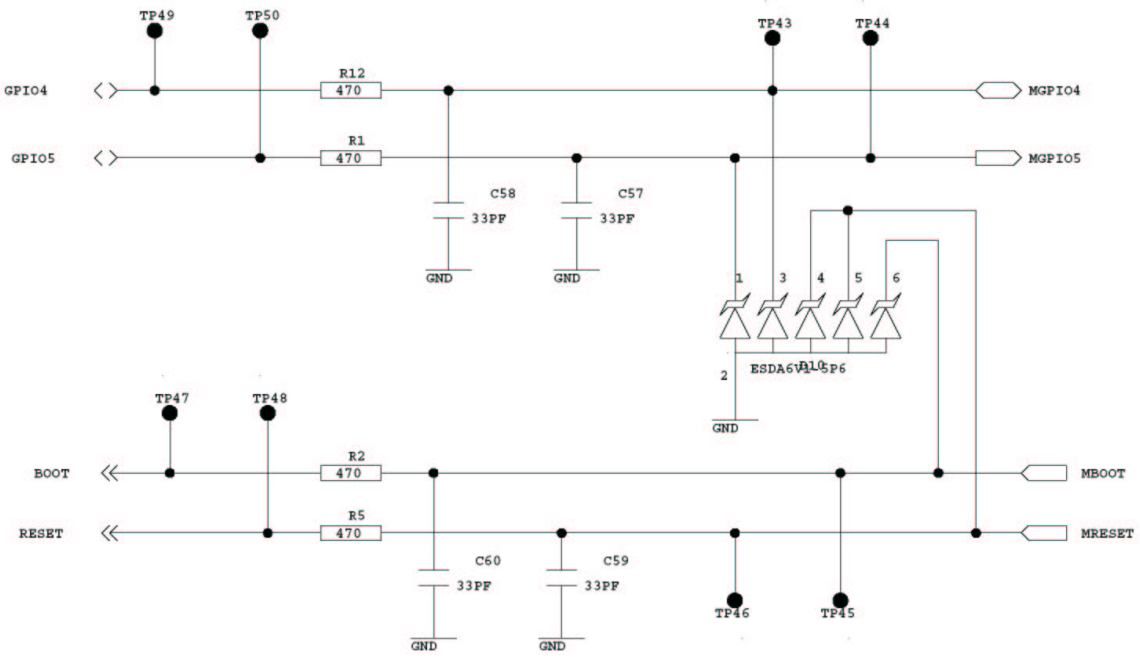


Figure 11: Q24xx schematic.

10.6 miscellaneous schematic



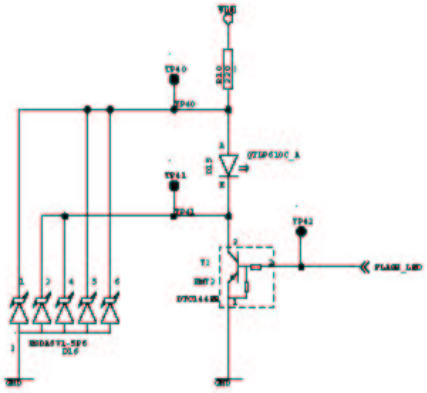


Figure 12: Miscellaneous schematic.

Note:
GPIOs and “technical” lines contain resistors and capacitors to prevent undesirable disturbances. In fact, it depends on application dedicated to these IOs.

10.7 BoM of the previous schematics

INDEX	FUNCTION	VALUE	INFO	SUPPLIER	DEVICE
C1	CAPACITOR	100NF	16V		C0402
C3	CAPACITOR	22NF			C0402
C4	CAPACITOR	220PF			C0402
C5	CAPACITOR	100NF	50V		C0805
C6	CAPACITOR	10UF	50V		C1812
C8	CAPACITOR	150UF	6.3V	AVX	TANTAL_D
C10	CAPACITOR	33PF			C0402
C11	CAPACITOR	33PF			C0402
C12	CAPACITOR	22PF			C0402
C14	CAPACITOR	100PF			C0402
C15	CAPACITOR	22PF			C0402
C18	CAPACITOR	22PF			C0402
C19	CAPACITOR	100PF			C0402
C20	CAPACITOR	100NF	16V		C0402
C22	CAPACITOR	100NF	16V		C0402
C23	CAPACITOR	100NF	16V		C0402
C24	CAPACITOR	100NF	16V		C0402
C25	CAPACITOR	100PF			C0402
C26	CAPACITOR	100PF			C0402
C27	CAPACITOR	100PF			C0402
C28	CAPACITOR	100NF			C0402
C31	CAPACITOR	100PF			C0402
C32	CAPACITOR	100PF			C0402
C38	CAPACITOR	100NF			C0402
C45	CAPACITOR	100NF			C0402
C46	CAPACITOR	100NF			C0402
C47	CAPACITOR	10UF			C0805
C52	CAPACITOR	22UF	6.3V		C0805
C57	CAPACITOR	33PF			C0402
C58	CAPACITOR	33PF			C0402
C59	CAPACITOR	33PF			C0402
C60	CAPACITOR	33PF			C0402
C68	CAPACITOR	33PF			C0402
D1	TRANSIL			ST	SM15T33A
D8	ESD DIODE			ST	ESDA6V1-5P6
D10	ESD DIODE			ST	ESDA6V1-5P6
D13	SHOTKEY	STPS340U		ST	STPS340U
D14	SHOTKEY	STPS340U		ST	STPS340U
D15	LED			FAIRCHILD	LED
D16	ESD DIODE			ST	ESDA6V1-5P6
J1	MICRO_FIT		5A	MOLEX	43045-0409
J2	CONNECTOR SIM			MOLEX	91228-0002

J3	60 PIN SMD CONNECTOR			ELCO	C60_P05_2R
J4	SUBD15KS-FC		HIGH DENSITY	JST	KSEY-15S-3B6L19
L1	INDUCTOR	10UH		TDK	L_SLF10145
L2	FERRITE BEAD			MURATA	BLM18AG102SH1
L3	FERRITE BEAD			MURATA	BLM18AG102SH1
L4	FERRITE BEAD			MURATA	BLM18AG102SH1
L5	INDUCTOR	100NH		MURATA	L0603
L6	INDUCTOR	100NH		MURATA	L0603
L7	FERRITE BEAD			MURATA	BLM18AG102SH1
L12	FERRITE BEAD	220		MURATA	BLM21PG221SN1
L13	FERRITE BEAD	220		MURATA	BLM21PG221SN1
R1	RESISTOR	470			R0402
R2	RESISTOR	470			R0402
R3	RESISTOR	27K			R0402
R4	RESISTOR	56K			R0402
R5	RESISTOR	470			R0402
R6	RESISTOR	NC			R0402
R7	RESISTOR	68K			R0402
R8	RESISTOR	1M			R0402
R9	RESISTOR	4.7K			R0402
R10	RESISTOR	330			R0603
R12	RESISTOR	470			R0402
R15	RESISTOR	100K			R0402
R16	RESISTOR	100K			R0402
T2	TRANSISTOR			ROHM	DTC144EE
U1	DRIVER RS232				ADM3307EACP
U2	SWITCHING REGULATOR		35V IN	ST	L5973AD
U5	LDO	2.8V		VISHAY	SI9183DT-28-T1
VH	RESISTOR	1K			R0402