OM12000 (ATOP) HW user manual

Info	Content
Document type	documentation
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Summary

1. Document purpose

Purpose

Purpose of this document isto provide an uszer manual for OM12000 by describing Telebox Mini HW, which serves as reference HW platform for NXP SW development and demo within context of ATOP (OM12000) 2.5G project.

Scope

This document is intended for all (HW/SW engineers, customers) who need detailed understanding of Telebox Mini v3.x HW implementation and schematics.

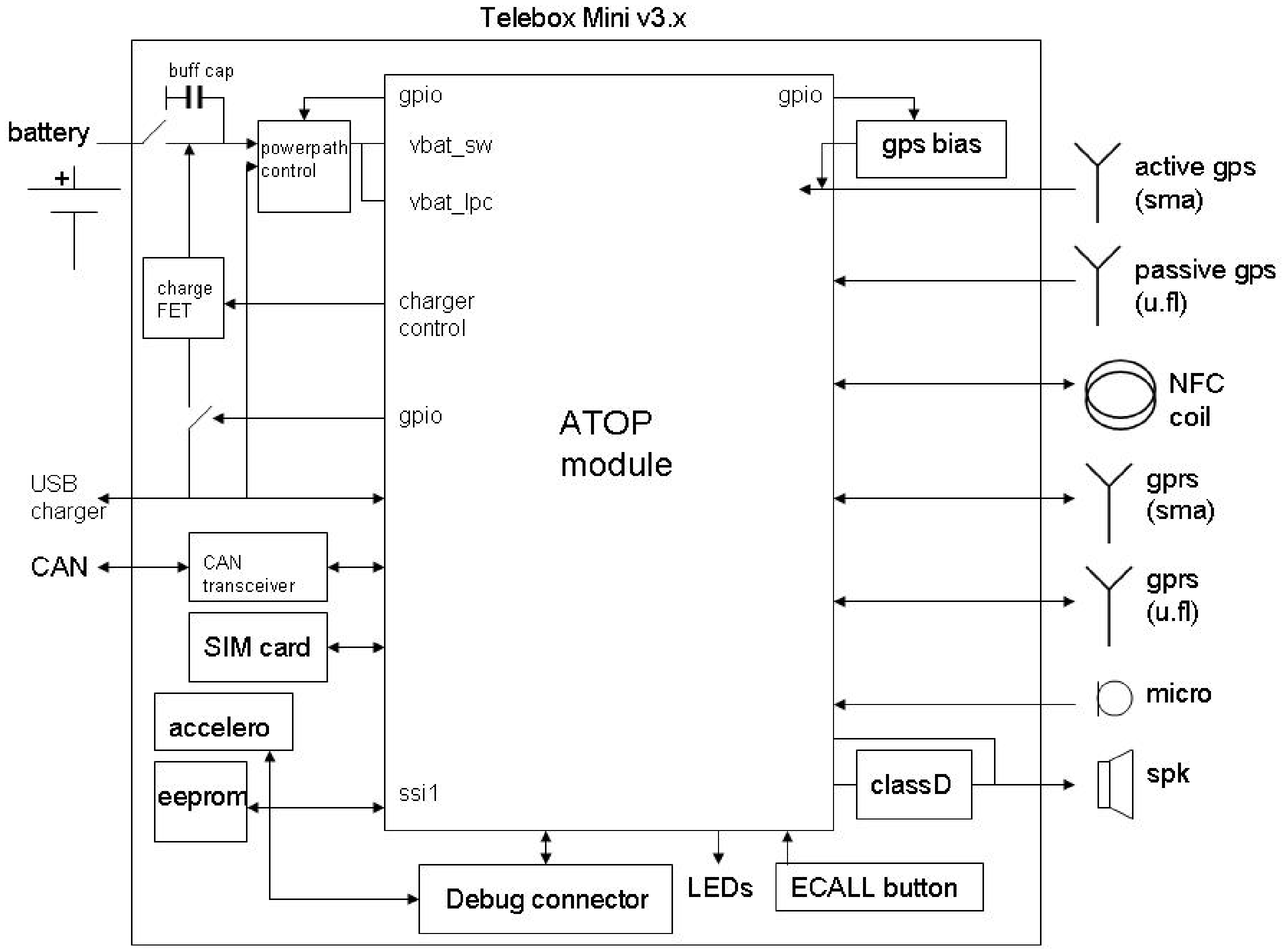
Support

For HW questions, issue or any problem, please contact customer support.

History

The Telebox Mini has already some history.
This new version 3.x which accommodates B2 ATOP version, and also some major changes are implemented in the power supply circuitry.
Since this Telebox Mini aims to be a prototype for SW development and demo, there are a lot of jumper stuff options for test purpose which customers don't need to copy. The default stuff option is indicated in the schematics by adding "**dnp**" "do not place" markers on components not stuffed by default.
Main mechanical dimensions of this demo pcb were defined in order to fit in the small blue demobox GEPRO 8023 from ELPAC.
As a result layout design and component choice had some restriction to fulfil the tight pcb area restriction.

2. Blockdiagram & photos




ATOP B2
Rel: 0.4
36/09
000014
NXP Semiconductors

3. Powersupply & battery charger

The ATOP SiP module basically has 4 powersupply inputs:

- V_BATT_SW:

supplies baseband PNX, frontend GPRS poweramp, NFC part, and GPS part (via onboard LDO's controlled by PNX)

- V_BAT_RTC_PNX:

supplies baseband RTC function (if not connected externally, internally supplied/bypassed by V_BATT)

- V_BATT_LPC:

supplies microcontroller LPC (via onboard LDO 3V0, default ON)

R67 allows for currentmeasurement on LPC domain

- V_BATT_RTC:

supplies RTC function of microcontroller LPC

The ATOP also has some powersupply outputs, generated by baseband PMU function:

- V_SIM:

SIM card interface

- V_PERM, VREF :

for reference only, should not be externally loaded

- V_IO (2V8):

for reference only, should not be externally loaded (supplies baseband digital interface including SSI, GPIO, DAI, JTAG and debug)

Presence of V_IO can be detected on the microcontroller LPC via R53 on GPIO LPC_uart1_CTS P0.17

- VDD_3V0:

This is the output voltage of the onboard LDO supplying the microcontroller LPC.

This supply can be used in the application , but with limited currentload since shared with microcontroller consumption.

(The LDO, LDS3985M30, is a 3V / 300mA output current regulator. The onboard microcontroller LPC2368 has max 125mA at maximum activity according datasheet)

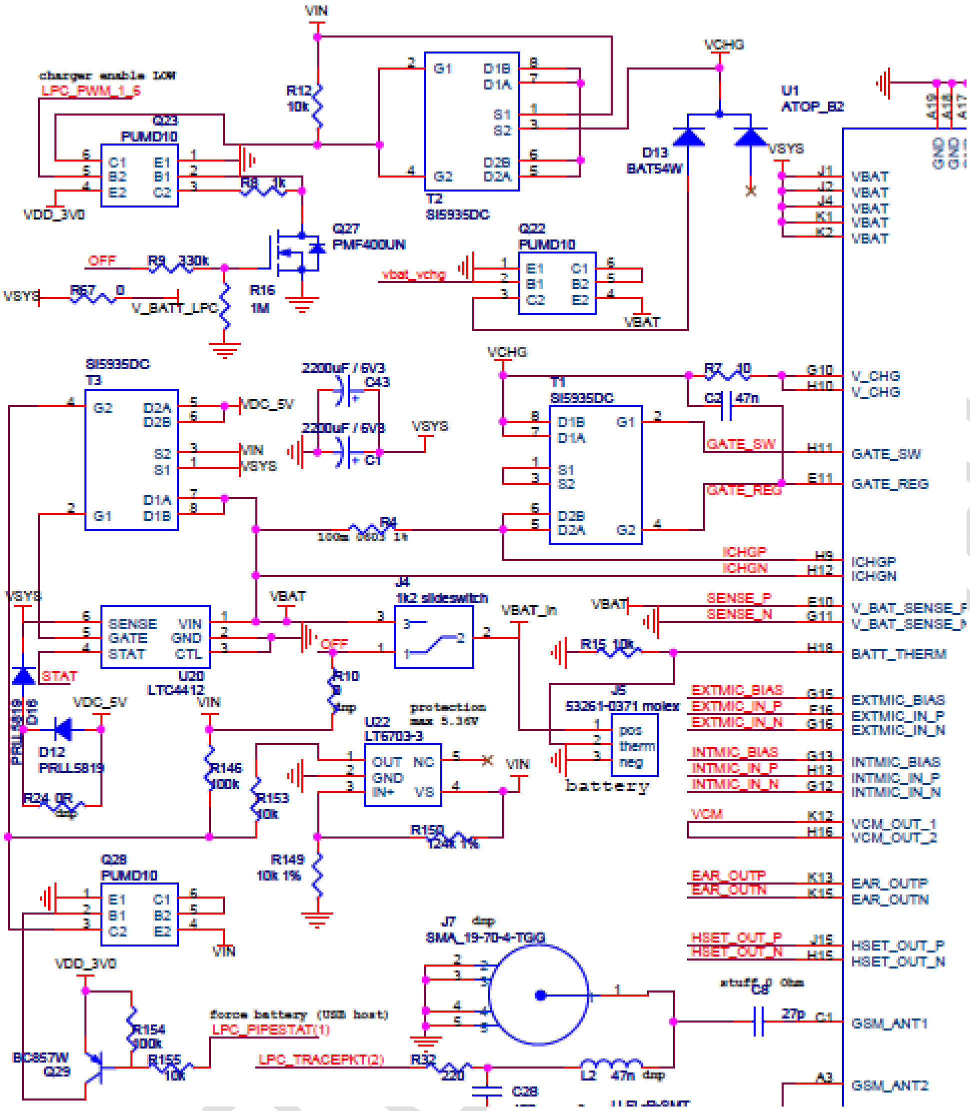


Figure 1 :extract of schematics Telebox Mini v3.0 : powersupply & battery charger

Main supply of the design is provided by the Li-polymer battery , in this case PLF323450 from Varta Microbattery, typical capacity 570mAh. (connector J5)

Since this battery sample has no built-in NTC thermistor , R15 10k has been added to allow the baseband PNX charger function detect the battery presence.

Slideswitch J4 allows total disconnection of the battery from the system to avoid possible battery drain (on the shelve) or manually switch ON/OFF the system by the user.

Capacitors C1 and C43 provide extra energy buffer to compensate, during GPRS transmission slots, possible battery voltage drop due to all kind of V_BATT resistance (total path from battery up to supply pin of GPRS frontend poweramp) like connection wires, slideswitch, powerpath FET, pcb trace and internal battery impedance.

The value actually implemented/needed on customer boards depends on requirements and implementation.

The battery level can be measured via resistive divider R49 / R50, connected to the ADC input of the ATOP microcontroller LPC.

Powerpath controller LTC4412:

VSYS is the main supply connected to VBAT pins of ATOP module.

LTC4412 controls the source for this VSYS, 2 options :

- battery
- external supply/adaptor

Whichever of these 2 input supplies has the highest level will be connected to VSYS.

The external supply VIN is attached to the system via either mini USB connector or solderpad PAD1. (stuff option via R157/R159)

VBAT of the ATOP has a maximum limit of 4.8V.

Other devices on the Telebox Mini (CAN, LPC VBUS and classD) have also maximum limits on 5.5V.

In order to fulfil these limitation some extra circuitry has been added :

a) Diodes D16 and D12 create some voltage drop , which will depend on the current to VSYS, on it's turn dependent on application.

D12 can be bypassed by R24 in case the system current is high enough. We target to have LTC4412 switched always for VIN path, if external supply is present (for this we need for worst case, meaning when fully charged battery, minimum 4.2V at SENSE pin of LTC4412)

b) Comparator/zener U22 will enable the path VIN_to_VDC_5V (2^{nd} FET of dual FET T3) as long as VIN is smaller then 5.36V, so that after diode voltage drop VSYS is less than 4.8V. Output pin1 of U22 will pulldown the gate and as such enable the PFET.

In order to be able to fulfil maximum allowed current drain from USB hosts (USB_spec: initially during enumeration max 100mA … maximum current negotiable upto 500mA) dual bipolar transistor Q28 (internal resistors) and Q29 is added.

This allows , in Telebox Mini applications were external supply is connected to a real USB host bus with current limitation, and VIN R157 option is stuffed, the LPC FW to control and force the powerpath controller LTC4412 to connect VSYS to battery source, in case system current is expected to increase above the negotiated allowed max USB host currentdrain.

The PNP part of Q28 will short the Gate_Source resistor R146 of VIN_to_VDC_5V FET T3_2 when the GPIO LPC_PIPESTAT(1) P2.2 is pulled LOW.

Default after reset of LPC (input/pullup mode GPIO) this “disable” function is OFF, in USB applications the system startup current should be limited to 100mA…

<u>Charger function:</u>

The ATOP baseband PNX has an integrated charger function which needs only some external FET Si5935DC, T1 (dual FET package of which one FET is charge ON/OFF control with bodydiode such to avoid any reverse current when OFF, the other FET is analog controlled for chargecurrent levelsetting) and series resistor R4 (100mOhm) to measure chargecurrent.

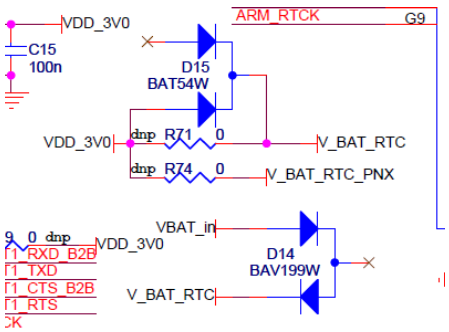
<u>Important remark:</u>

- make sure the chargecurrent amplitude, programmed in baseband flash memory, is compatible with maximum allowed chargecurrent specified in the datasheet of the applied battery!
- In order to avoid overheating the charger dual FET T1 (dissipation of 2^{nd} FET is equal to product (delta VIN – VBAT) * I_charge limit VIN of the external attached charger adaptor to 5V!

(some precautions (cooling copper area) have been taken to reduce the thermal resistance Rth_ja of T1, but physical pcb area limitation of Telebox Mini limits cooling efficiency)

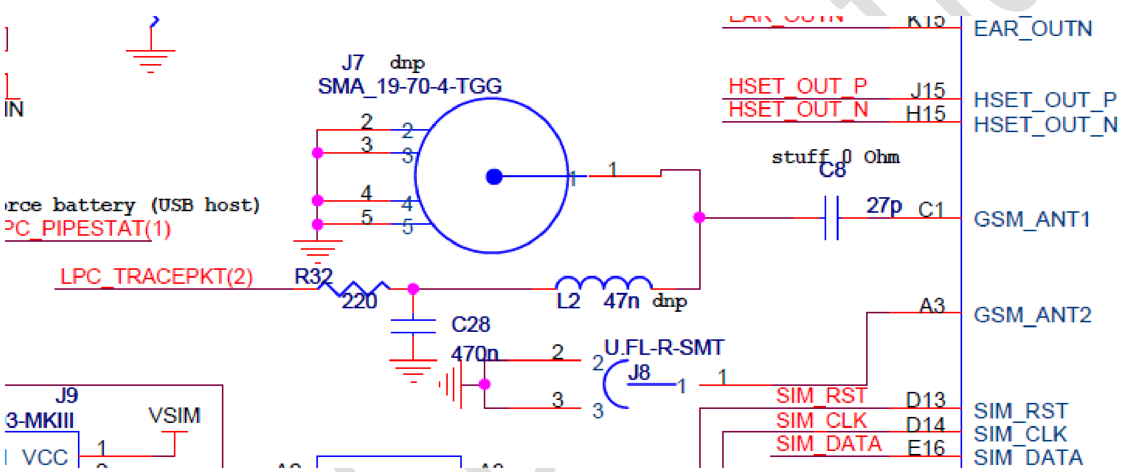
<u>RTC backup from battery:</u>

In order to keep RTC of LPC alive when main supply is off (external supply disconnected and slideswitch J4 in OFF state) the LPC RTC circuitry will be kept supplied by VBAT_in (=directly connected to battery) via dual_series diode D14 (D15 prevents reverse current to VDD_3V0). See next stuffing option:



4. RF Antenna connections

GPRS



Onboard the ATOP module there is an antenna RF switch in front of the poweramp. The Telebox Mini offers 2 ways for connecting a 50 ohm GPRS quad-band antenna.

GSM_ANT1: SMA jack J7 (SMA 19-70-4-TGG Multicomp)

R

GSM_ANT2: UFL jack J8 (U.FL-R-SMT Hirose)

This path is meant to accommodate some internal gprs antenna inside the product housing by means of 50 ohm U.FL cable assembly.

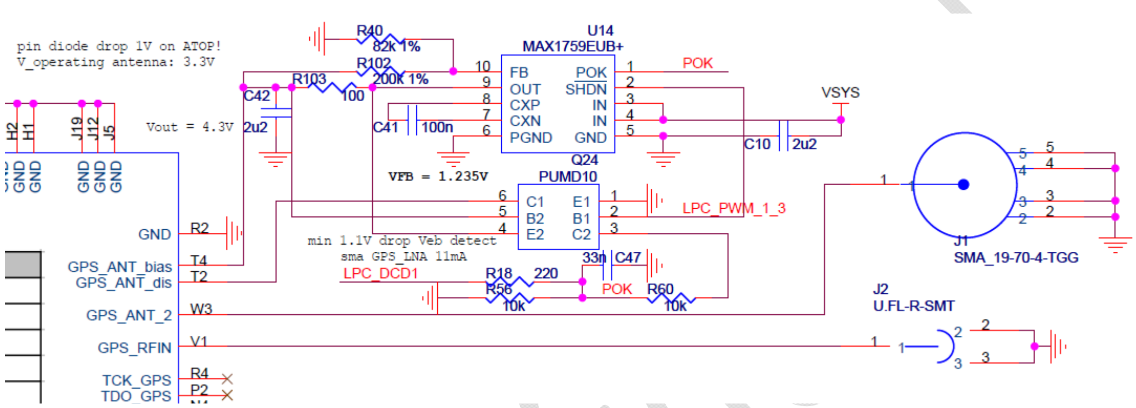
Microcontroller GPIO 'GSM_ANT_SWITCH' P1.0 selects either of the paths:

GPIO P1.0	GSM_ANT1	GSM_ANT2

1	OFF	ON
0	ON	OFF

Remark: for development this quadband GPRS antenna is used on GSM_ANT1 SMA: MC0114015-FME-BU-W, manufactured MC-Technologies http://www.mc-technologies.net/en/wireless_modules/antennen-und-zubehoer/index.php

GPS



The ATOP module has an onboard LNA which accommodates for a passive GPS antenna.

This input of the LNA is connected to the U.FL connector J2.

This path is meant to accommodate some internal GPS antenna inside a mechanical prototype housing by means of 50 ohm U.FL cable assembly.

In order to connect some external active GPS antenna , connector J1 accomodates for a (longer) 50 ohm SMA cable. In this option, we use input GPS_ANT_2 which bypasses the onboard LNA. The onboard LNA is disabled by pulling its input low via the npn part of Q24 (controlled by GPIO LPC_PWM_1_3 P3.26).

The bias supply for the active antenna is provided via the chargepump U14 MAX1759, configured for Vout = 4.3V. Since there is a PIN diode in the path with drop of about 1V, this leaves about 3.3V for the antenna supply. To accommodate for other supply requirements R102/R40 can be changed accordingly.

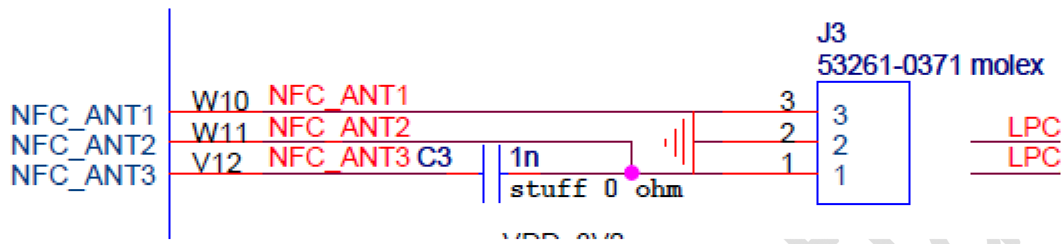
GPIO P3.26 will exclusively activate either the onboard LNA or the chargepump bias supply according following truth table:

GPIO P3.26	Internal LNA/passive GPS	Bias supply/active GPS
1	OFF	ON
0	ON	OFF

Remark: for development following active GPS patch antenna is used:

GAACZ-A, , 5m cable , 3-5V, manufactured by Active Robots Ltd. http://www.active-robots.co.uk/active-gps-antenna-p-552.html

NFC



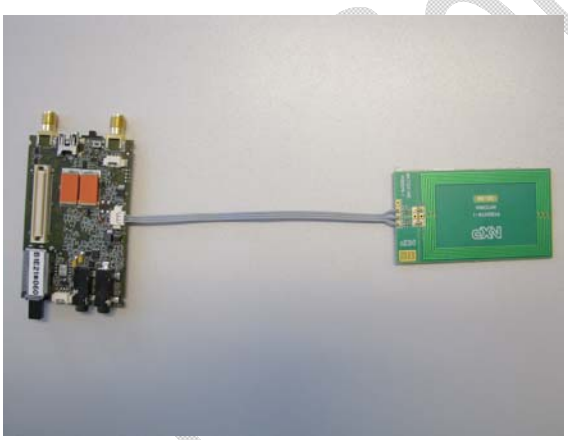
The ATOP module has a NFC reader function onboard.

Connector J3, Molex 53261-0371, accommodates for the NFC coil.

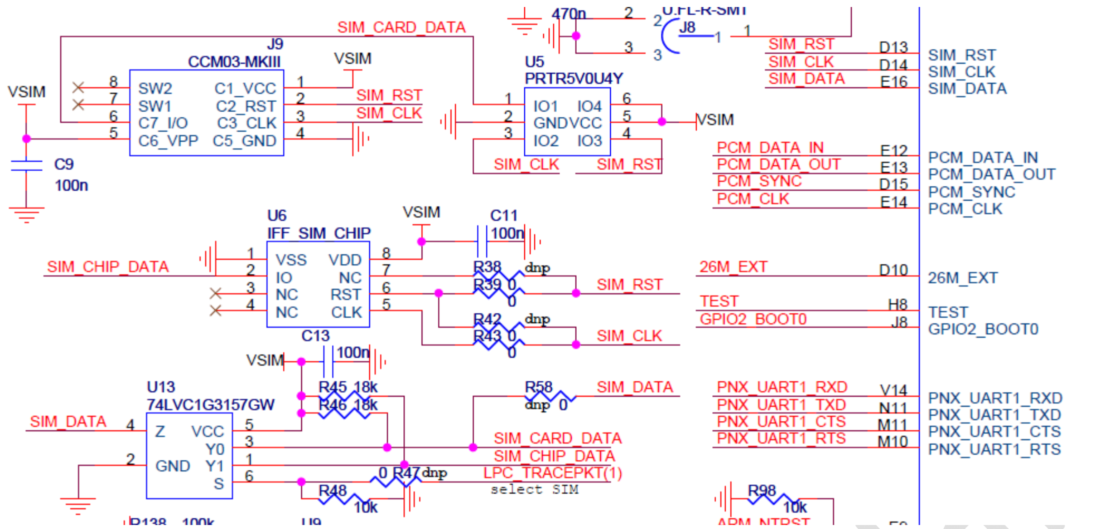
Stuff option C3 is for RF test , for normal use it is stuffed with 0 ohm jumper.

The cable connecting the Telebox Mini with the antenna coil should be maximum 10cm.

Remark : for development a NXP reference coils design is used.



5. SIM card



Connector J9, CCM03-MK3 from C&K, accommodates for SIM card insertion.

U5, PRTR5V0U4Y NXP, provides ESD protection.

The Telebox Mini has a stuff option to accommodate a pcb soldered SIM chip (U6).

(R38/R42 allow for possible future pinchange)

In order to switch access between both SIM card options, analog mux U13 multiplexes the SIM data lines by GPIO control LPC_tracepkt(1) P2.6.

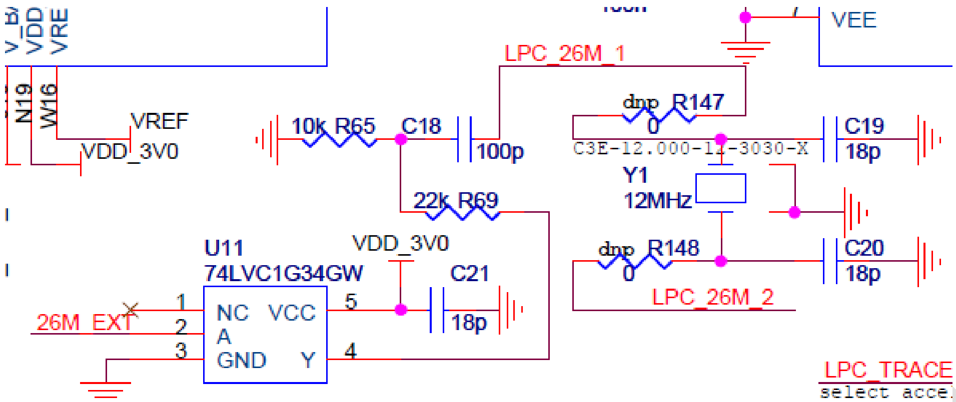
Default stuff option R48 / ~~R47~~ selects connector J9.

R58 allows bypass/i.e. not to stuff the mux.

If R47 and/or U6 would be stuffed following truth table would hold:

GPIO P2.6	SIM card	SIM chip
1	OFF	ON
0	ON	OFF

6. Clock microcontroller

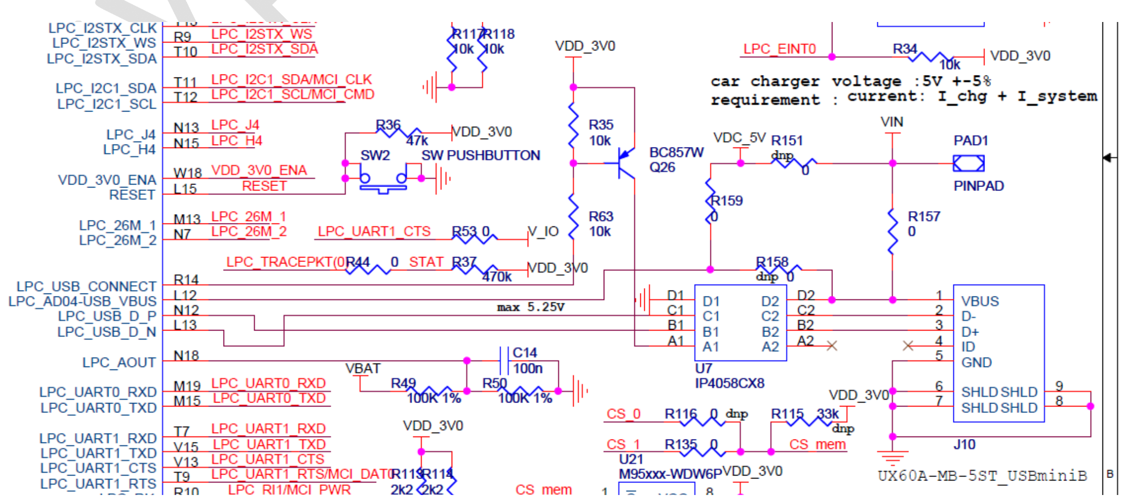


There are 2 options on the Telebox Mini to source an external clock to the microcontroller LPC. 26M_EXT is a 26MHz output clock from the ATOP baseband. Buffer U11 buffers the clock signal , while R69/R65 resistive divider matches max voltage swing specified by the LPC.

Another option for sourcing the LPC external clock is using the 12MHz crystal Y1 with the LPC own internal mainoscillator. (required for USB or HS CAN feature implementation with more stringent clock jitter requirements)

For this option: stuff R147 / R148 and remove AC coupling C18.

7. USB



The ATOP microcontroller LPC has a USB2.0 full speed device controller onboard which can be accessed by mini-B USB connector J10.

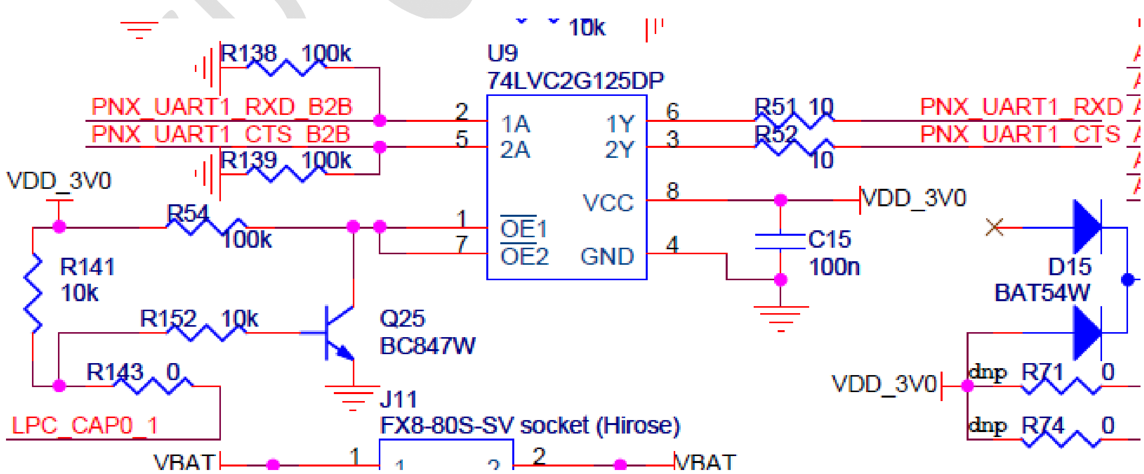
U7 provides ESD protection with integrated pi-type filter, 33ohm series resistors and 1k5 pullup resistor (connected to Q26 for delayed device detect signalling option).

Also this USB connector is used as battery charger input.

Please refer to chapter 3 'powersupply and battery charger', regarding stuffoptions R157/R158/R159 and maximum USB host drain current limitations!

It is possible to wake up the microcontroller LPC from powerdown mode by event detection on any GPIO from port 0 or 2. To allow wake up event from USB charger cable insert detection , R44 connects LTC4412 'STAT' signal to GPIO LPC_tracepkt(0) P2.5. When USB_miniB connector is used as charger input, STAT will be pulled LOW when charger is present.

8. PNX uart buffer

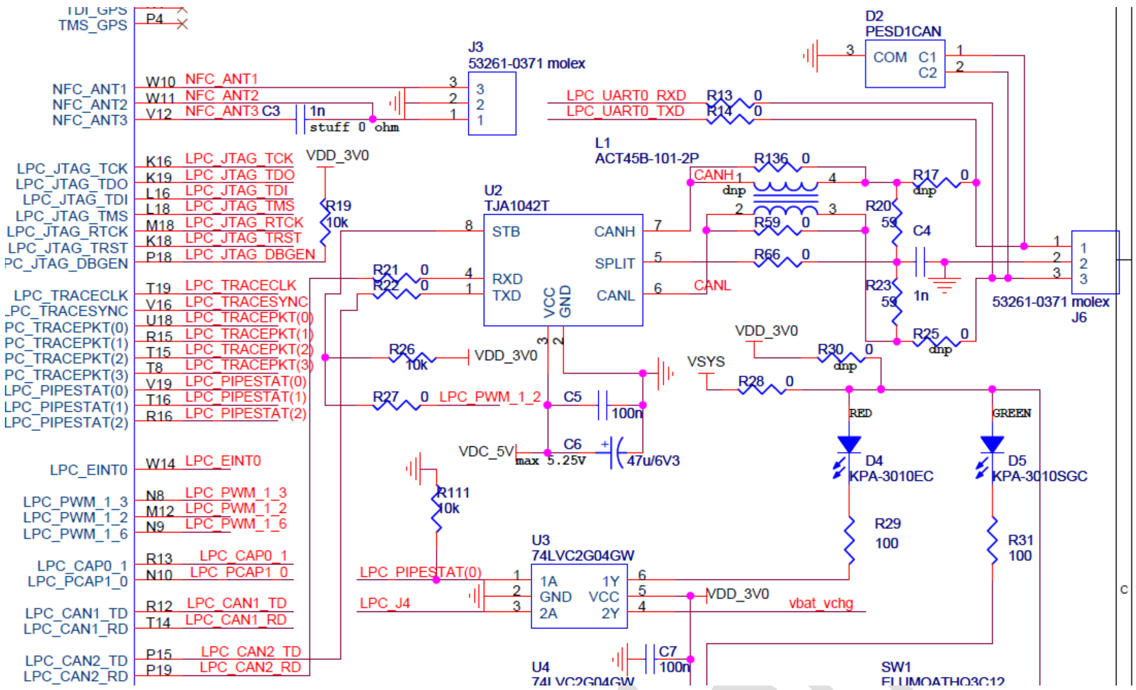


In order to properly startup the baseband , there should not be any parasitic supply current present on the PNX pins before sending “power ON” command via LPC SW. So any input current should be avoided for all PNX IO pins (pcm, analog,…)

In order to avoid RS232 transceiver on the PNX uart lines could unintentionally supply current, a buffer U9 has been inserted on the Telebox Mini to allow proper control by the microcontroller LPC via GPIO LPC_CAP0_1 P1.27.

GPIO P1.27	PNX uart
1	Enabled
0	Disabled

9. CAN transceiver



The ATOP microcontroller LPC has 2 CAN controllers onboard (CAN2.0, 1Mbit/s).

Telebox Mini accommodates one CAN controller with a high speed CAN transceiver, U2 TJA1042T, with some common mode choke option and ESD protection.

The CAN interface is only functional when VDC_5V is applied to the system (either via USB or via external powersupply). When not powered, the transceiver has ideal passive behaviour, not disturbing eventually connected CAN bus.

GPIO LPC_PWM_1_2 P3.25 can control standby status of the transceiver.

In standby mode there is possibility for remote wake-up capability via the CAN bus.

Besides CAN interface, the 3p J6 Molex 53261-0371 connector can also accommodate for connection to the microcontroller LPC uart 0 port.

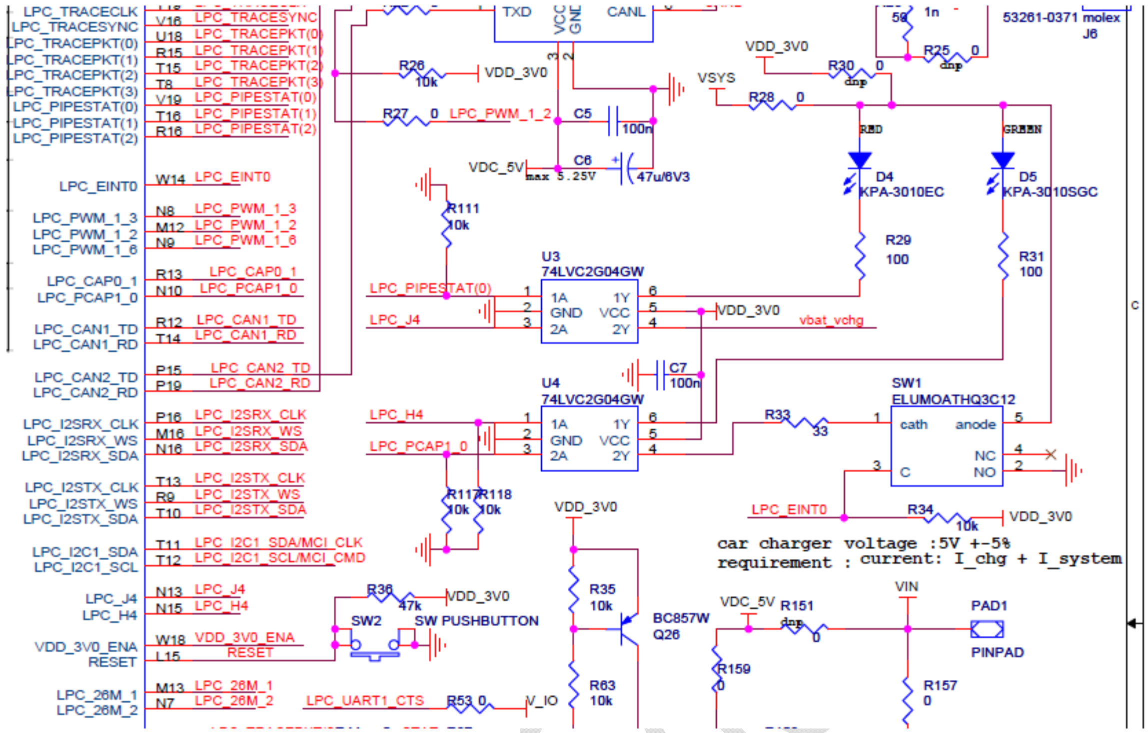
This would allow flashing new code to LPC from outside the blue mechanical box (EINT_0, needed to bring LPC in flash mode, is available at the illuminated pushbutton SW1)

Stuff option J6 connection:

-R13/R14 : LPC_uart0

-R17/R25: CAN2

10. LED's and buttons



Reset switch

Tact switch SW2 on the side of the board allows manual resetting the system.

Ecall button

Illuminated push button SW1 is intended as manual input from the user to initiate an Ecall. GPIO LPC_EINT0 P2.10 is low when the button is pushed. Since it is part of port2, this button is capable to wake up a powered down system. The button also has an integrated red LED to allow user interaction.

LED's

1 red LED D4 and 1 green/red LED D5 are available for user interface.

In all cases the LED's are ON when the GPIO is set HIGH (U3/U4 are buffering invertors)

Following table provides an overview of GPIO connections to the LED's

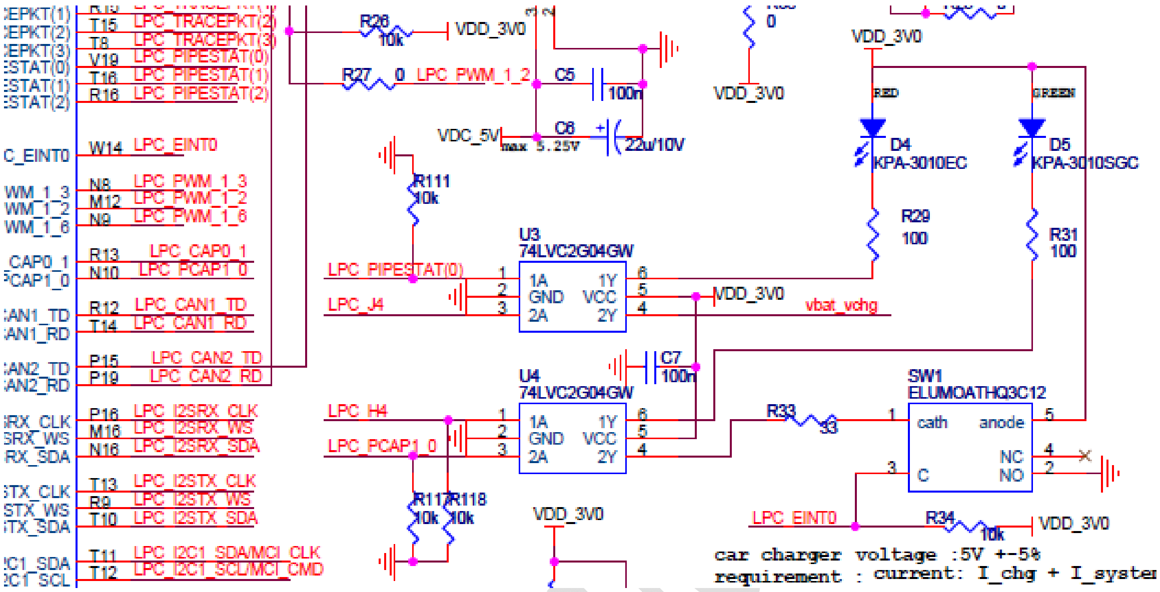
Red LED D4	GPIO P2.1
Green LED D5	GPIO P1.18
Red Ecall button LED	GPIO P1.28

V3.2 changes:

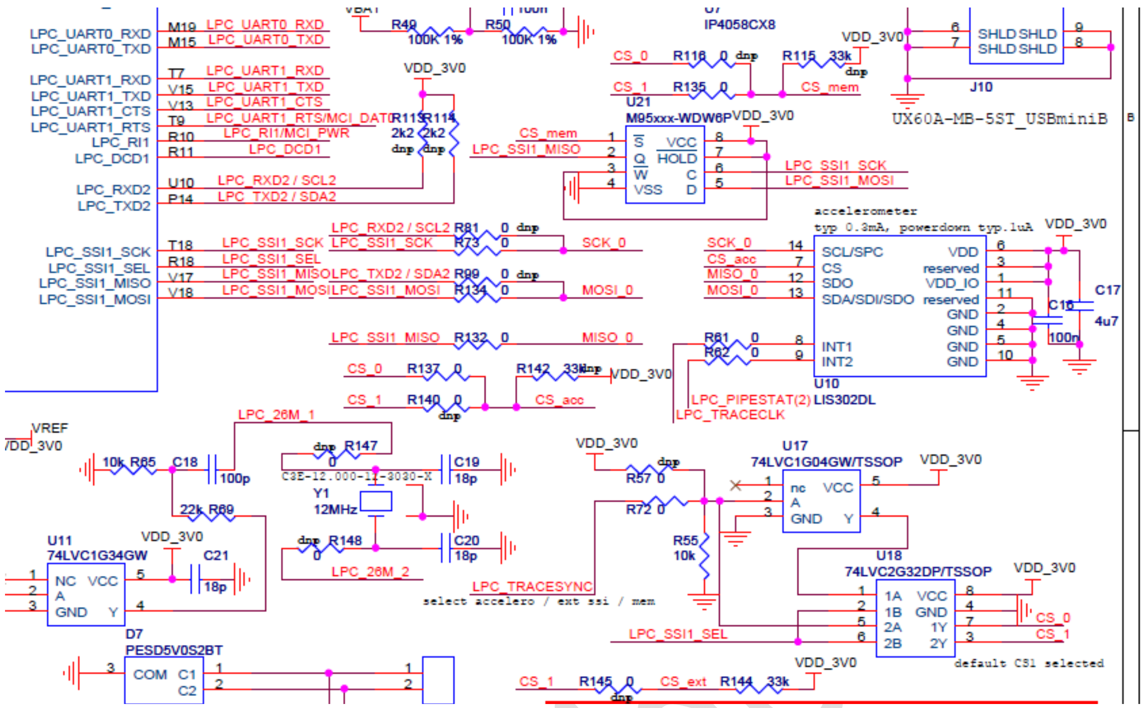
Removed stuff option R28/R30 for supply of LED's.

Since Vsys will be higher then 3V, U3 and U4 are not able to disable LED current …

Following updated schematics:



11. Accelerometer / Eeprom / SSI1 serial interface



One synchronous serial interface SSI1 of ATOP microcontroller LPC is available for external device/user application (for instance to connect some serial display via the debugconnector J11)

Onboard the Telebox Mini a 3D digital output accelerometer U10 LIS302DL (ST) is stuffed and connected with this SSI1 port as well as a SPI EEPROM U21 M95xxx.

The accelerometer has 2 configurable interrupt output lines, that allow wake up of a powered down ATOP system (even when accelero itself in powerdown mode).

INT1	GPIO P2.0
INT2	GPIO P2.3

GPIO LPC_tracesync P2.4 selects which device (CS0 or CS1) is connected with SSI1 port. The CS line is muxed by the 2-input OR gate U18 (invertor U17 either selects CS_0 or CS_1)

GPIO P2.4	CS1	CS0
0	OFF	ON
1	ON	OFF

Via resistors stuff options different combinations can be implemented for connection to CS0 or CS1 of SSI1 interface chipselect :

Default stuffing:

- Accelero (CS_acc) : CS0
- Eeprom (CS_mem) : CS1
- External via debug connector (CS_ext): not connected

Another stuffoption (via R81/R99) allows for connecting the accelero in I2C mode (this way making SSI1 also available for debuginterface connector at the same time)

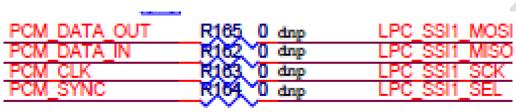
Default:

Accelero in SPI mode

<u>V3.2 changes:</u>

a)

In order to allow linking baseband BB_PCM audio output with SSI1 channel of the microcontroller, a special stuffing option has been added . (R162/163/164/165)



Since in this usecase, baseband PCM needs to be bus master , LPC should be configured as slave SSI1.

In order to avoid possible conflicts with the other slave SSI1 peripherals (chipselects CS0 and CS1, SPI_memory U21 CS_mem and SPI_accelero U10 CS_acc) , both CS should be disconnected from the bus :

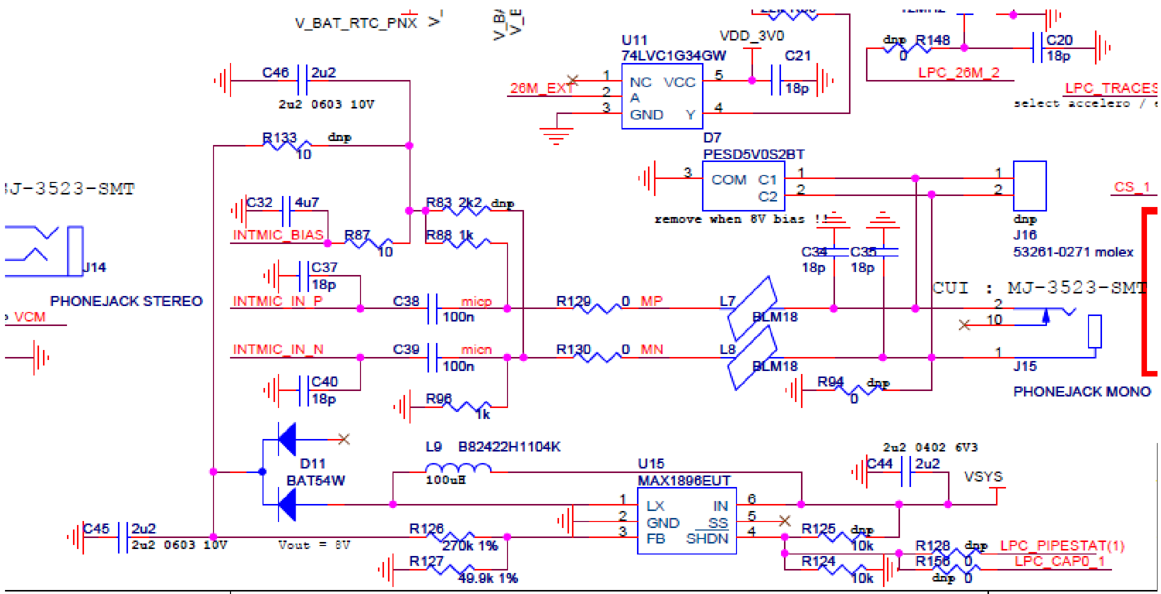
Remove R116/R135 , stuff R115 (memory)

Remove R137/R140 , stuff R142 (accelero)

Also don’t use external CS_ext , don’t stuff R145 (default)

12. Audio connections

Analog audio in



The ATOP baseband PNX has two microphone input ports :

EXTMIC_BIAS/EXTMIC_IN_P/EXTMIC_IN_N : not connected

INTMIC_BIAS/INTMIC_IN_P/INTMIC_IN_N : implemented on Telebox Mini with necessary passive components and protection

Default stuff option provides for the differential connection mode. Connector J15 accomodates for a standard 3.5mm mono plug electret microphone. In case a small electret microphone would be integrated in the mechanical housing, provision has been made for a smaller 2p connector J16 Molex 53261-0271. (J16 <> 3.5mm J15/J14 can only exclusively be stuffed !)

In case higher bias supply is needed (like for instance automotive AKG Q400 series preamplified mouse microphone) , an extra DCDC convertor is added U15 MAX1896, default configured for 8V. In this case place R133 and remove R87 (also remove protection diode D7 since it will clip at 5V)

Enable pin of U15 can be SW controlled via 2 possible GPIO's , P2.2 possibly conflicting with 'USB force battery supply', or P1.27 possibly conflicting with PNX_uart buffer control. To enable the DCDC, set the GPIO HIGH. Default this SW control is not stuffed.

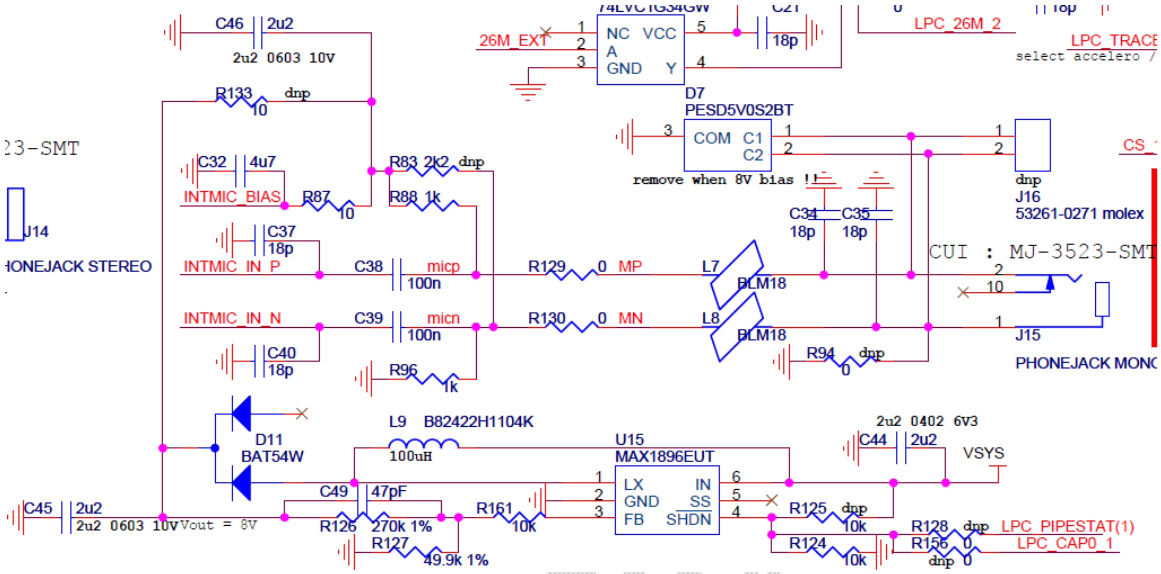
In case voltage swing output of preamplified micro would be too large, resistors R129/R130 could be resistive divider.

V3.2 changes :

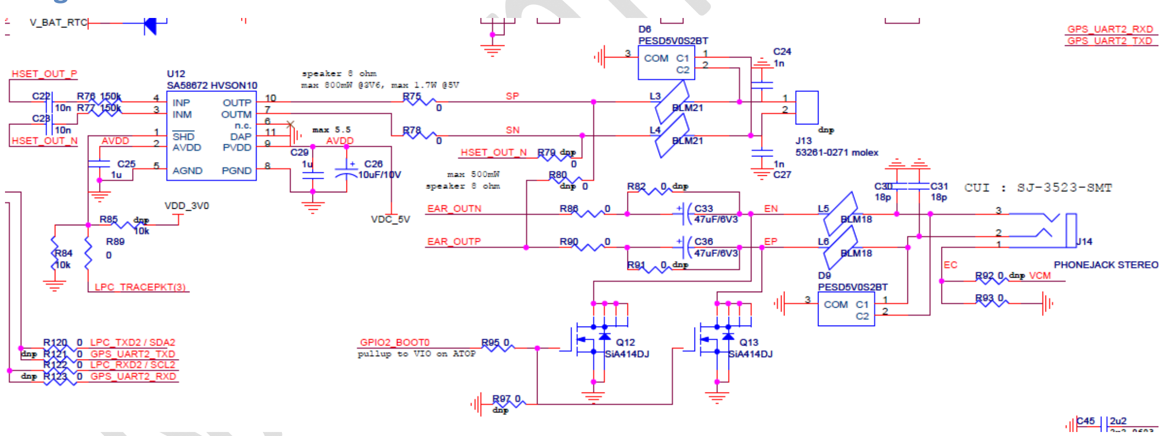
a)

To make U15 stable when loaded , R161/C49 are required.

Following updated schematics:



Analog audio out



The ATOP baseband PNX provides some analog output channels.

12.1.1 Earphone

Telebox Mini has implemented earphone output channel EAR_OUTN/EAR_OUTP with necessary passive components and protection.

Two stuff options are implemented :

- audio referenced to common mode VCM (avoids large capacitors, but could be problem when connecting to external device with input reference to GND level)
- AC-coupled outputs, reference GND

In the latter case , some annoying poweron ‘plop’ can be heared. This can be avoided by keeping the outputs to GND level during poweron (Q12 and Q13 are small footprint , and have very low ON resistance to minimize plop level). Control of the ‘antiplop’ transistors is done by baseband GPIO2_BOOT0 (has pullup resistor on ATOP module)

The common mode option should be preferred since the bodydiodes of Q12/Q13 will create some harmonic distortion at larger output swing. Nevertheless the other option is stuffed by default to avoid possible unintentionally conflict VCM <> GND.

Connector J14 provides accommodation for a standard 3.5mm stereo plug.

12.1.2 Speaker

The ATOP baseband PNX provides option to source an 8 ohm speaker with max 500mW output power. For this: remove R86/R90/R75/~~R87~~R78 and stuff R79/R80.

If this powerlevel is not sufficient for the application , Telebox Mini provides with an external class D audio amplifier SA58672 from NXP, which could provide up to 1.7W/8ohm when supplied from VDC_5V . Class D feature only available when external supply connected !

The amplifier enable pin can be SW controlled by GPIO LPC_tracepkt(3) P2.8, set HIGH to enable.

Speaker connector J13: 2p Molex 53261-0721.

V3.2 changes:

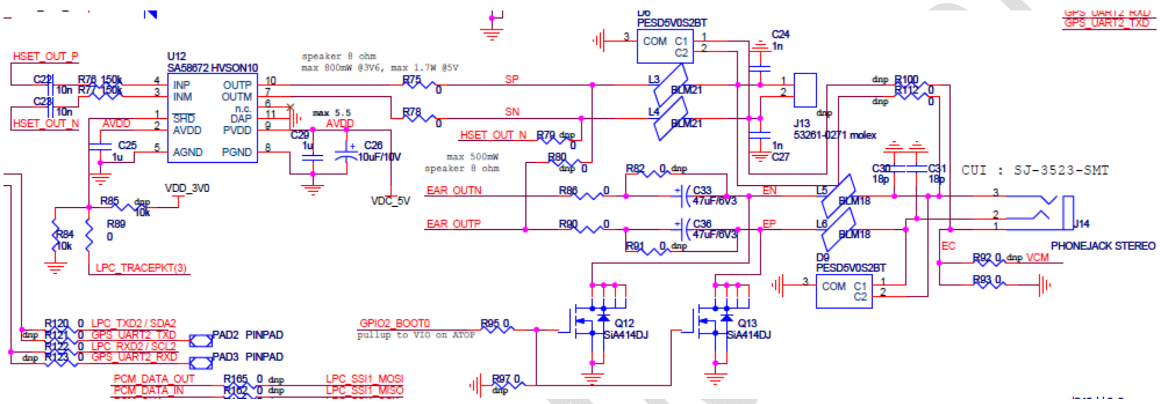
a)

In order to have speaker output accessible on the 3.5mm jack connector J14 (=earphone output default) some stuffing option is added : R100/R112.

For this usecase following stuffing should be applied :

- Remove L5 /L6/R92/R93
- Stuff R100/R112

Following updated schematics:



13. Board technology

The Telebox Mini is targeted to be a HW platform for SW development and demo vehicle. It is a prototype, not intended to be mass production ready.

As such it is not advised to run very large quantity batches, there will be yield issues.

Also possibly not fully optimized for cost and assembly machine limitations.

Maximum effort has been done to keep the outline mechanical dimensions as small as possible, integrating all features described above and still fitting the blue demo box GEPRO 8023.

EDA tool being used is ORCAD schematic Capture and Layout v10.5.0.

DRC (design rule check) global spacing settings are set at 70um.

Standard VIA dimensions used are (padsize 0.4mm/drillhole 0.2mm) diameter.

Outline pcb dimensions : 65mm x 42.8mm

(4 halve-circle cut-outs, for mechanical spacer with 2mm screws : in long side of the pcb at horizontal coordinates x=3 and x=62 and both y=0 and 42.8)

Pcb thickness : 1.2mm

Number of layers: 6 :

1 .top

2 .gnd

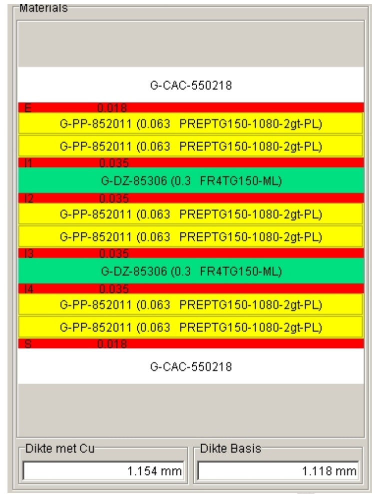
3 .pwr

4 .in1

5 .in2 (=gnd2)

6 .bot

Stack buildup technology used:



Regarding the impedance control for 50 ohm RF antenna traces located on layer 1.top, layer 5. in2 is used as reference ground in order to keep RF trace wide enough to lower losses (instead of using layer 2.gnd). All other layers in between have been kept free of traces and copper around the transmission lines.

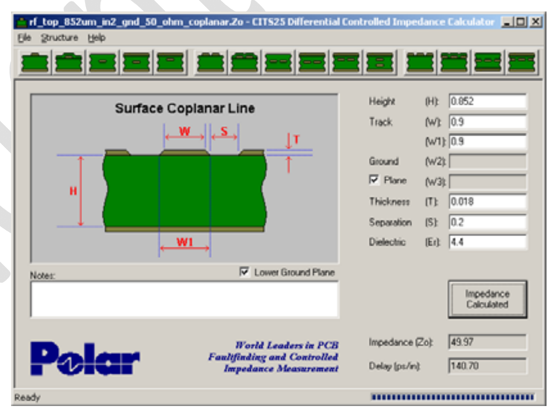
Trace width : 0.9mm

GND clearance copperfill : 0.2mm

sum thickness of layers buildup: 0.852mm

Er = 4.4

copper thickness 18um >>> results in about 50 ohm :



14. Comments User Manual

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.

The FCC requires the user to be notified that any changes or modifications made to this device that are not expressly approved by NXP Semicondcutors, could void the user's authority to operate the equipment

15. FCC Class statement

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 reasonable protection against harmful interference in are sidential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, we cannot 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 or television technician for help.