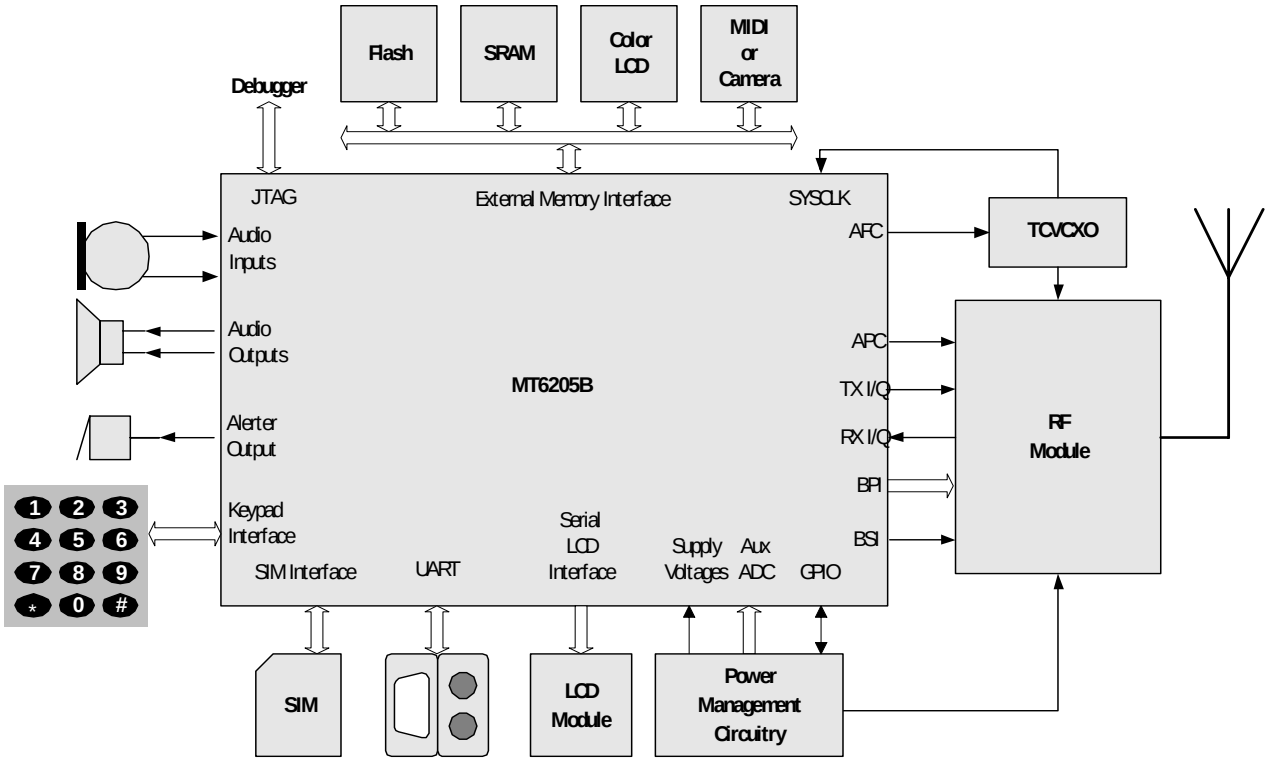
Circuit Analysis

4 Circuit Description

4.1 Base Band overview

MT6218B is a highly integrated baseband processor optimized specially for multi-media enabled GSM terminal. Combining the 32-bit ARM7TDMI™ RISC processor core, proprietary low-power digital signal processor, user interface, radio control, audio codec, baseband codec, and other GSM specific analog and digital hardware, the MT6218B completes the best single-chip solution for GSM phone with multi-media function.

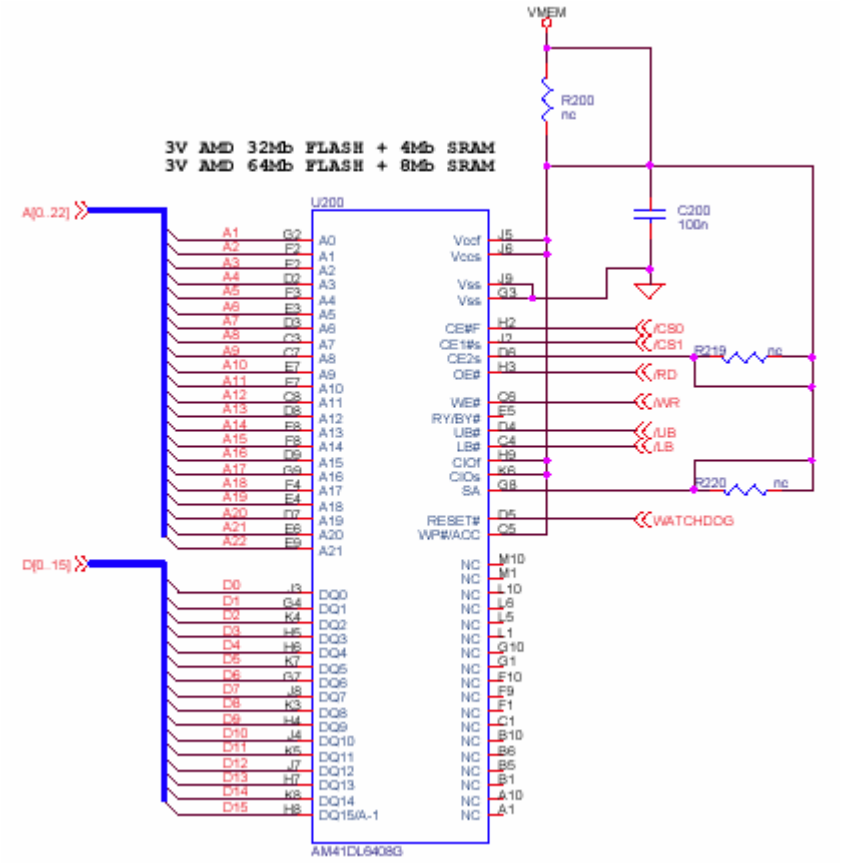
MT6305 is a power management IC optimized specially for MT6218B baseband processor. It provides the seven high efficiency LDOs, power on sequence, SIM level shift, charging function and some peripherals to reduce part counts.



4.2 External Memory Interface

With the External Memory Interface, the MT6218B can supports varieties of SRAM and Flash in the market and multi-media devices with parallel interface, such as color LCD panel, MIDI synthesizer and Digital Still Camera etc.

In this project, we control the AMD combo memory (AM41DL6408G – 3V 64Mb Flash + 8Mb SRAM), Color LCM, and YAMAHA MA3 Melody IC by external memory interface.



4.3 User Interface

For user interactions, the MT6218B brings together all necessary peripheral blocks for a value-added GSM phone. It comprises the Keypad Scanner, SIM Controller, dual channels UART, Alerter, Real Timer Clock, PWM, Serial LCD Controller and General Purpose Programmable I/Os.

Keypad Scanner:

The keypad can be divided into two parts: one is the keypad interface including 5 columns and 5 rows; the other is the key detection block which provides key pressed, key released and de-bounce mechanism. This keypad can detect one or two key-pressed simultaneously. Due to the keypad interface, more than two keys pressed simultaneously will get the wrong information.

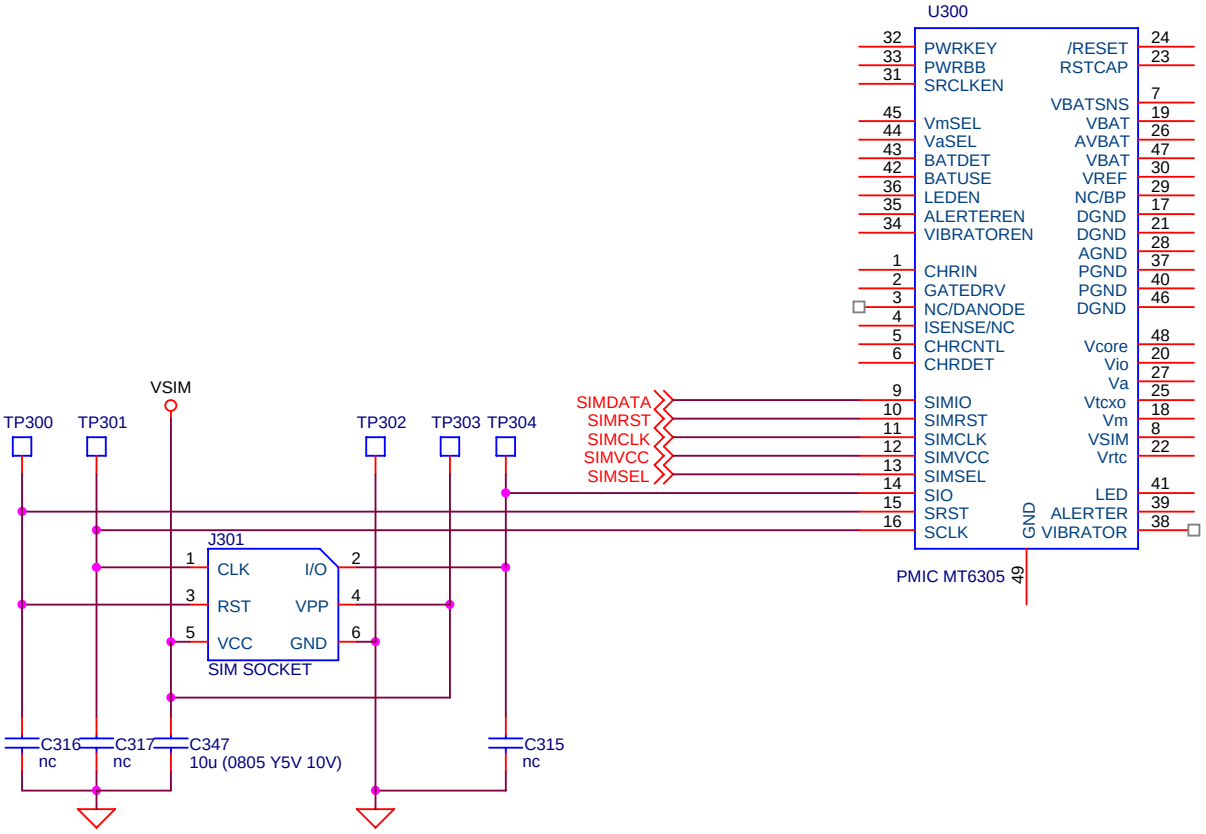
MT6218 key mapping:

	Column 0	Column 1	Column 2	Column 3	Column 4
Row 0	SEND		UP SIDEKEY	DOWN SIDEKEY	POWER
Row 1	UP	1	2	3	
Row 2	DOWN	4	5	6	
Row 3	LEFT	7	8	9	LEFT SOFT KEY
Row 4	RIGHT	*	0	#	RIGHT SOFT KEY

SIM Controller:

The MT6218Bcontains a dedicated smart card interface to allow the MCU access to the SIM card. It can operate via 5 terminals, using SIM VCC, SIMSEL, SIMRST, SIMCLK and SIMDATA. The SIMVCC is used to control the external voltage supply to the SIM card and SIMSEL determines the regulated smart card supply voltage. SIMRST is used as the SIM card reset signal. Besides, SIMDATA and SIMCLK are used for data exchange purpose.

MT6305 provide the SIM Level shift Between the SIM controller and SIM card.



Dual channels UART:

The MT6218B has two UARTs. Besides a full-functional UART, there is another simplified UART for displaying debugging messages. The UARTs provide full duplex serial communication channels between the MT6218 and external devices.

Alerter:

The output of Alerter has two sources: one is the enhanced PWM output signal, which is implemented embedded in Alerter module; the other is PDM signal from DSP domain directly.

MT6218 doesn't use this function.

Real Timer Clock:

The Real Time Clock (RTC) module provides time and data information. It works on the 32.768KHz oscillator with independent power supply. When the MS is power off, a dedicated regulator (1.5V) is used to supply the RTC

block. If the main battery is not present, the backup supply such as a small mercury cell battery or a large capacitor is used. In addition to provide timing data, alarm interrupt is generated and it can be used to power up the base-band core through the BBWAKEUP pin. Also, regulator interrupts corresponding to the seconds; minutes, hours and days can be generated whenever the time counter value reaches a maximum. The year span is supported up to 2127. The maximum day of month values are stored in the RTC block, which depend on the leap year condition.

PWM:

Two generic pulse-width modulators are implemented to generate pulse sequences with programmable frequency and duty cycle for LCD backlight or charging purpose. The duration of the PWM output signal is Low as long as the internal counter value is greater than or equals to the threshold value.

MT6218 use these two PWM pins to control the color backlight and keypad LEDs. It can control the brightness of the color LCM backlight to save current consumption.

PWM

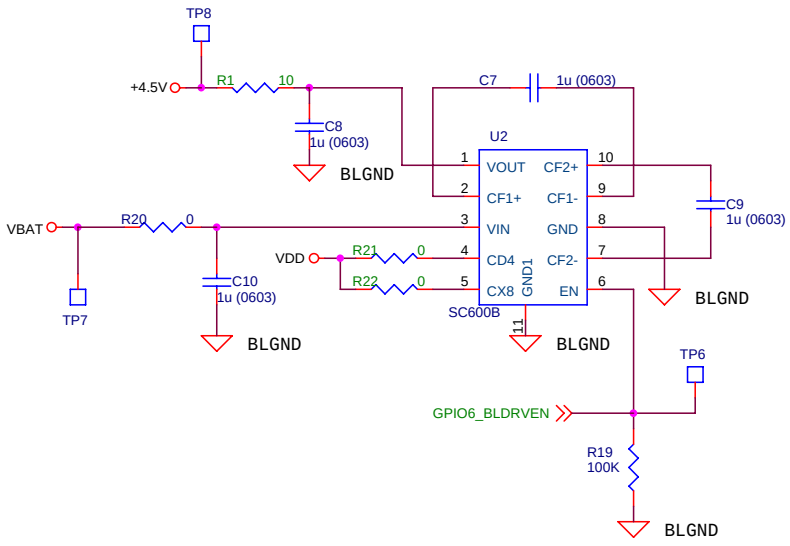
PWM1	KPLED_PWM	Keypad PWM control
PWM2	GPO1_BLEN_PWM	Main LCD backlight PWM control

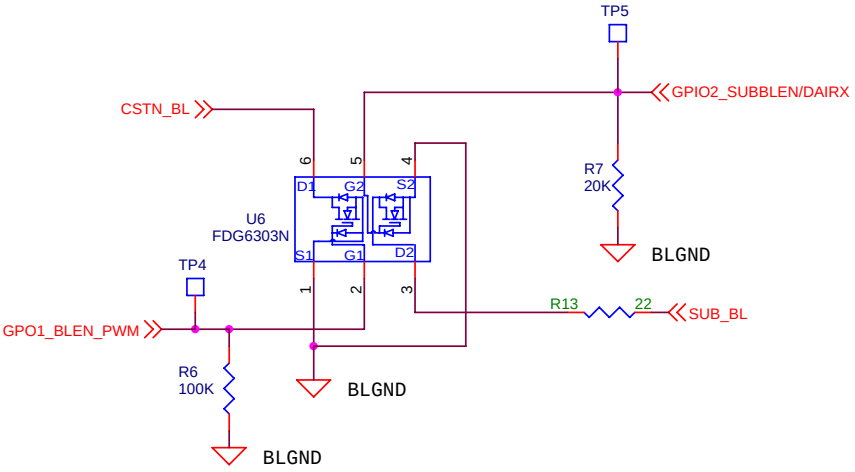
LCD Backlight:

SC600B is the charge pump LED driver. The wide input range is matched for Li-ion battery applications. One two tiny ceramic capacitors are required, and the inductorless implementation provides a reduced-EMI solution. Its output current is up to120mA with fixed 4.5V.

MT6218 only uses two parallel white LEDs as main display backlight. Set R1=10 ohm to limit the SC600B output current as 50mA(max). MCU can control the SC600B EN pin to enable/disable its output and use PWM to control U6 NMOS to change brightness of the main display backlight.

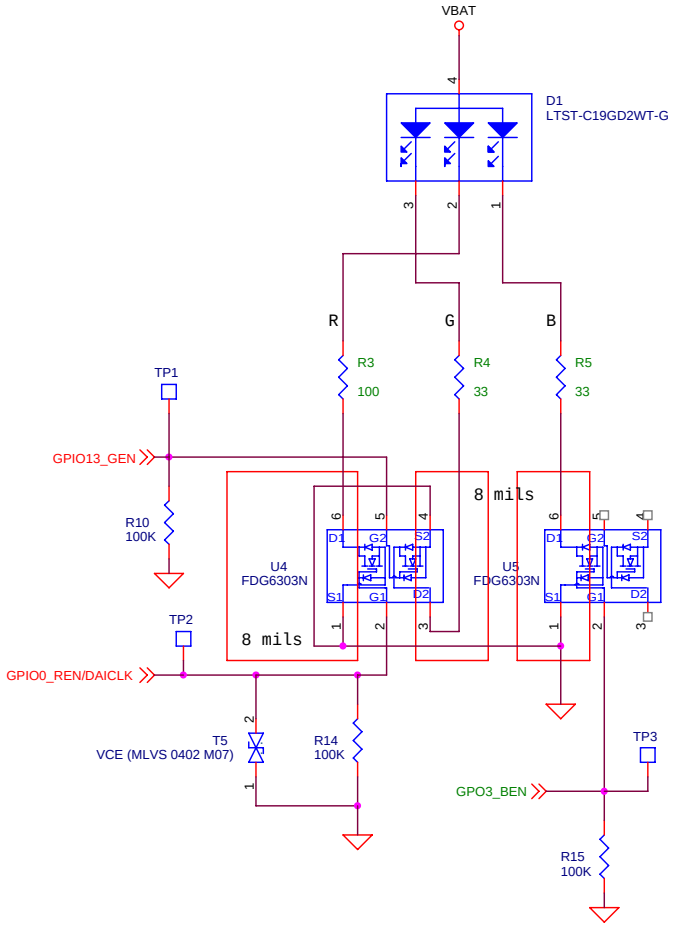
In the sub-LCM backlight, MT6218 just use the GPIO to control U6 NMOS to on/off sub-LCM backlight (two parallel blue LEDs) and set R13=22 ohm to limit LED current as 50mA(max).





RGB LED Indicator:

MT6218 uses three GPIO pins to control U4 and U5 NMOS to on/off the RGB indicator. Set R3, R4, and R5 to limit the current 20mA(max).



LCD Controller:

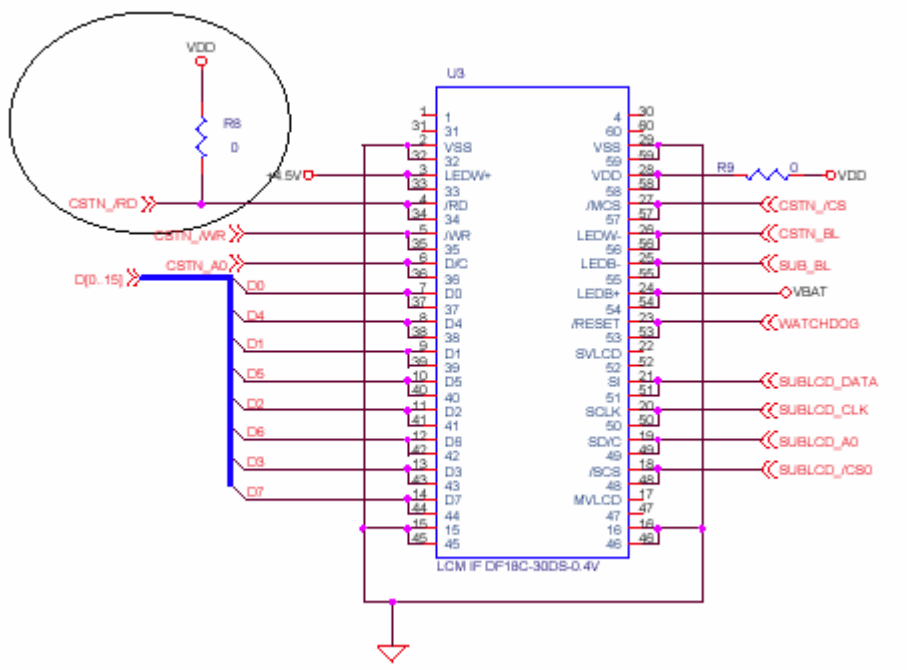
A specific LCD DMA controller is implemented to allow MCU to access the external parallel or serial LCD module and to improve the data throughput for color LCD applications.

For parallel LCD modules, this special DMA controller reuses the external memory interface to access them and 8080 type interface is supported. It can transfer the display data from the internal SRAM or external SRAM/Flash Memory to the off-chip LCD module. Provide the external SRAM Is the display data source, a special simultaneous read/write mode is provided to speed up the data transfer again.

For serial LCD modules, the interface performs parallel to serial conversion and both 8- and 9- bit serial interface is supported. Data read is not available with the serial interface.

MT6218 main display is parallel interface and sub-LCD is 8-bit serial interface used four pins – LCD_CS#, LCD_DATA, LCD_CLK and LCD_A0 – to enter commands and data.

Main display CSTN_#RD pin must be pulled high.



General Purpose Programmable I/Os:

MT6218B offers 22 general-purpose I/O pins and 4 general-purpose output pins. By setting the control registers, MCU software can control the direction, the output value and read the input values on these pins. Besides, these GPIOs and GPOs are multiplexed with other functionalities to reduce the pin count.

MT6218 GPIOs and GPOs setting:

GPIO

MODE	PIN NAME	Normal mode setting

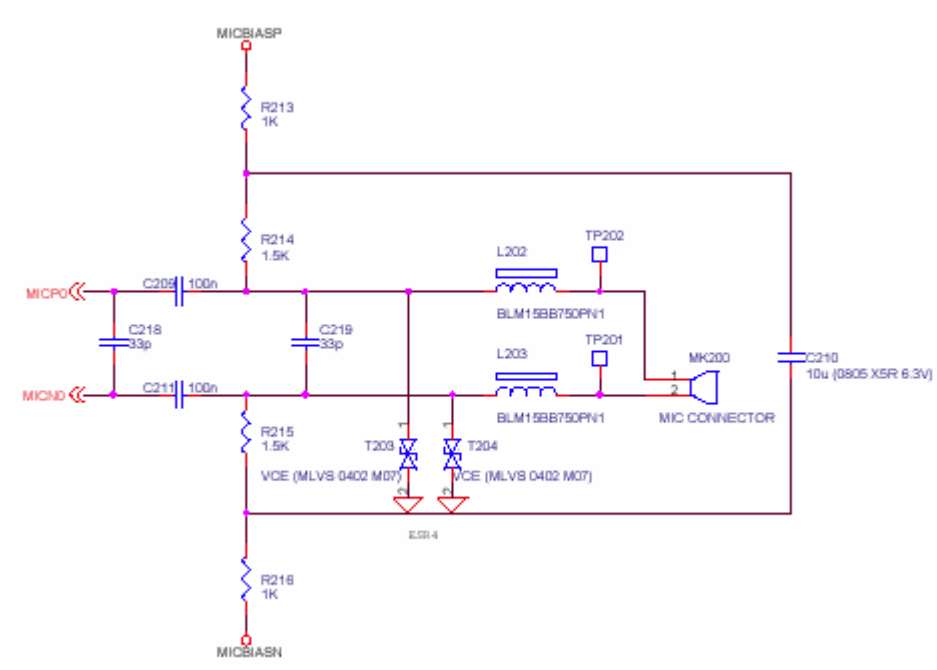
GPIO0	GPIO0_REN/DAICLK	RED LED control
GPIO1	GPIO1_OPOFFB/DAITX	External AMP control
GPIO2	GPIO2_SUBBLEN/DAIRX	Sub LCD backlight control
GPIO3	GPIO3_UART_EN/DAIRST	UART connected to audio jack enable control After power on, GPIO3 must be setting "Low" status
GPIO6	GPIO6_BLDRVEN	Main LCD backlight driver control
GPIO12	GPIO12_CHRCNTL	Charging control
GPIO13	GPIO13_GEN	GREEN LED control
GPIO15	GPIO15_VIBEN	Vibrator control
GPO3	GPO3_BEN	BLUE LED control : H enable (GPO out)

4.4 Audio Interface

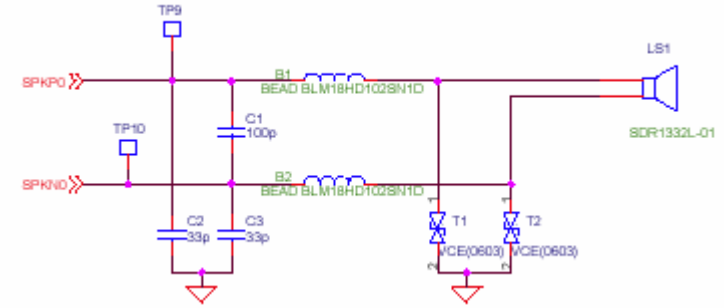
Two microphone inputs with one low noise amplifier as well as two audio output with two power amplifiers are contained. Incorporating with on-chip mixed-signal Audio Front-End, this complete architecture allows for easy audio interfacing with direct connection to the audio transducers. In addition, the MT6218B gives also the flexibility for developer to modify the frequency response of digital filter in compensating the effects from acoustic devices.

In the normal mode, microphone and receiver are designed as differential type to reduce common mode noise.

Microphone: (Differential mode: MICBIASP=2.2V, MICBIASN=0.3V)



Receiver:



In the headset mode, the microphone and receiver are designed as single-end type. It must be more careful to deal with traces when layout to reduce the noise. Single-end microphone bias MICBIASP=1.91V.

4.5 Radio Interface

Providing a well-organized interface with the radio part, the MT6218B integrates programmable AFC (Automatic Frequency Control), APC (Automatic Power Ramping Control), the Parallel (BPI) and Serial (BSI) RF control circuitry and on-chip mixed-signal Base-band Front-End. It carries out also gain and offset calibration mechanisms and filters with programmable coefficients to fulfill the MODEM function. The approach is also towards combining a high resolution 13-bit D/A Converter with VCXO or crystal to reduce the overall system cost. Besides, to remove the necessary of external current –driving component, the driving strength of some BPI output is designed to be configurable. Accompanying with RF Tools, the MT6218B based system provides developer with flexibility for efficient customization as well as comprehensive compatibility control on RF modules.

MT6119 and MT6218B RF interface:

Pin Name	BB PIN NAME
VAFC	AFC
VAPC	APC
HB_TX	BPI_BUS0
LB_TX	BPI_BUS1
BANDSW_GSM	BPI_BUS3
BANDSW_DCS	BPI_BUS4/GPIO4
PA_EN	BPI_BUS5/GPIO5
BPI7/VCO_EN	BPI_BUS7/BSI_CS1/GPIO7
SCLK	BSI_CLK
LE	BSI_CS0
SDATA	BSI_DATA
IB	BUPAIN, BDLAIN
I	BUPAIP, BDLAIP

QB	BUPAQN, BDLAQN
Q	BUPAQP, BDLAQP
VCXO_EN	SRCLKENA/GPO2
26MHz	SYSCLK
AVDD	Va
VBAT	VBAT
PMIC_VTCXO	VTCXO

4.6 Debug Function

The JTAG interface enables in-circuit debugging of software program with the embedded ARM7TDMI core. With this standardized debugger interface, the MT6218B provides developers with a wide set of options for choosing ARM development kits from supports of thirty parties.

4.7 Power Management

The MT6218B offers various low-power features helping reduce system power consumption including Pause Mode of 32KHz clocking at Standby State, Power Down Mode for individual peripherals and Processor Sleep Mode. Fabricated in low-leakage CMOS process, together with the low-power features, the overall system can achieve ultra low power consumption.

4.8 MT6305 Power Management System overview

1. Handles all GSM Base-band Power Management
2. 2.8V to 5.5V VBAT Input range
3. Charger input up to 15V
4. Seven Low Dropout Regulators (Core, Digital IO, Analog, Crystal Oscillator, Real-Time Clock, Memory, SIM) optimized for specific GSM sub-systems
5. High operation efficiency and low stand-by current
6. Li-Ion and NiMH battery charge function
7. SIM card interface provides the level shift between SIM card and microprocessor
8. Three open-drain output switched to control the LED, Alerter and Vibrator
9. Thermal overload protection
10. Under voltage lock-out protection
11. Over voltage protection
12. Power-on Reset and Start-up Timer

Low Dropout Regulator (LDOs) and Reference:

Digital Core LDO (Vcore): a regulator that could source 200mA (max) with 1.8V out voltage. It supplies the MT6218B base-bad circuitry.

Digital IO LDO (Vio): a regulator that could source 100mA (max) with 2.8V output voltage. It supplies the MT6218B base-band circuitry and some other digital peripherals like LCM VDD, hall sensor IC and Melody IC VDD.

Analog LDO (Va): a regulator that could source 150mA (max) with 2.8V output voltage. It supplies the analog sections of the MT6218B base-band circuitry and MT6119 RF VCC.

TCXO LDO (Vtcxo): a regulator that could source 20mA (max) with 2.8V output voltage. It supplies the temperature compensated crystal oscillator, which needs its own ultra low noise supply and very good ripple rejection ratio.

RTC LDO (Vrtc): a regulator that could source 200uA (max) with 1.5V output voltage. It charges up a capacitor-type backup coin cell to run the real-time clock module. The LDO features te reverse current protection and is optimized for ultra low quiescent current since it is always on except battery voltage below 2.5V.

Memory LDO (Vm): a regulator that could source 150mA (max) with 1.8V or 2.8V output voltage selection based on the supply specs of memory chips. MT6218 uses the 2.8V memory chips. Besides this, melody and LCM data interface are 2.8V system.

SIM LDO (Vsim): a regulator that could source 20mA (max) with 1.8V or 3.0V output voltage selection based on the supply specs of subscriber identity modules (SIM) card. The LDO is controlled independently of the others LDO.

Reference Voltage Output (Vref): the reference voltage output is a low noise, high PSRR and high precision reference. For accurate specs of every LDO output voltage, avoid loading the reference voltage and bypass it to GND with 100nF minimum.

SIM Card Interface:

It meets all ETSI and IMT-2000 SIM interface requirements. It provides level shifting needs for low voltage GSM controller to communicate with either 1.8V or 3V SIM cards. All SIM cards contain a clock input, a reset input, and bi-directional data input/output.

Vibrator, Alerter, LED Switches:

Three built-in open-drain output switches drive the vibrator motor, alerter beeper and LEDs in the handset. Each switch is controlled by base-band chipset with enable pins. And all the open-drain output switches are high impedance when disable.

But in the MT6218 project, it doesn't have alerter.

We can set R300 to limit keypad eight parallel blue LEDs' current and set R306 to limit the vibrator's current.

Power Sequence:

It is possible to start the power on sequence in three different ways:

1. **Pulling PWRKEY (S300) low** is the normal way of turning on the handset.
   This will turn on Vcore, Vio, Vm LDOs as long as the PWRKEY is held low. The Vtcxo and Va LDOs is turned on when SRCLKEN is high. The microprocessor then starts and pulls PWRBB high after which PWRKEY (KBC4, KBR0) can be released.
2. **Pulling PWRBB high** is the case when the alarm in the RTC expires.

3. **CHRIN exceeds Chr_Det threshold** – Applying an external supply on CHRIN will also turn the handset on.

If handset can't power on by PWRKEY, we can check whether the U306 SMT is good and LDOs output are right when PWRKEY low.
If handset can't power on by alarm, we must check 32.768K and monitor the PWRBB pin whether it goes high.
If handset can't power on by charger, we must check the F1 fuse whether it is open and LDOs output are right.

Reset:
The RESET pin is held low at initial power-up, and the reset delay timer is started. At power-off, RESET will be kept low.
C300 determine the RESET delay time. When it is 100nF, it delays about 200ms.

Under-voltage Lockout (UVLO):
It prevents startup when initial voltage of the main battery is below the 3.2V threshold.

Deep Discharge Lockout (DDLO):
It has two functions.

1. To turn off the Vrtc LDO.
2. To shut down the handset when the software fails to turn off the phone when the battery drops below 3.0V

Over-temperature Protection:
If the die temperature of MT6305 exceeds 165^{o}C, the MT6305 will disable all the LDOs except the RTC LDO.

Over-voltage protection:
Once the battery voltage exceeds 4.3V of Li-ion battery (5.1V of NiMH battery), a hardware over voltage protection (OV) should be activated and turn off the charger block of MT6305.

Battery Charger:
MT6305 can be used with Li-ion and NiMH batteries. But MT6218 project is used with Li-ion battery only. So, BATUSE pin is set low for Li-ion battery.

If the adapter voltage exceeds the battery voltage by 3.75%, the CHRDET output will go high. If the adapter is then removed and the voltage at the CHRIN pin drops to only 2.5% above the VBAT pin, CHRDET goes low.
When battery put in the handset, BATDET pin must be connected with battery and pulled down. If it contacts not well, MT6305 will be disable the charging function because it thinks no battery in.

MT6305 charges the battery in three phases: ***pre-charging, constant current mode charging, and constant voltage mode charging.***

Pre-charging:
When the battery voltage is below the UVLO threshold, the charge current is in the pre-charging mode. There are two steps in this mode. While the battery voltage is deeply discharged below 2V, a 10mA trickle current of MT6305 charges the battery internally. When the battery voltage exceeds 2V, the pre-charge current is enabled, which allows 10mV (typically) across the external current sense resistor. This pre-charge current can be calculated:

$$I_{PRE\_CHARGING} = \frac{V_{SENSE}}{R1} = \frac{10mV}{R1} \sim 30mA$$

Constant current mode charging:

Once the battery voltage has exceeded the UVLO threshold the charger will switch to the constant current charging mode. The MT6305 allows 160mV (typically) across the external current sense resistor. This constant current can be calculated.

$$I_{CONSTANT} = \frac{V_{SENSE}}{R1} = \frac{160mV}{R1} \sim 485mA$$

Constant voltage mode charging:

This mode is only applied to Li-ion battery charging. If the battery has reached the final charge voltage, a constant voltage is applied to the battery and keeps it at 4.2V. The charge termination is determined by the baseband chip internally, which will pull the CHRCNTL low to stop the charger.

Pulsed Charging Algorithm

MT6305 is available to pulsed top-off charging algorithm by the CHRCNTL pin. The control signal is from base-band chipset to limit the charging duty cycle. This charging algorithm combines the efficiency of switch-mode chargers with the simplicity and low cost of linear chargers.

•Charger function

- Batuse (L=Li-ion, H=Ni-Mh)
- Batdet (L=charger enabled),

  PMIC auto disable charging function if illegal battery is found
- Precharge function (Li-ion/Ni-MH)

  Precharge current = 10mV/Rsense
- CC mode charging (Li-ion/Ni-MH)

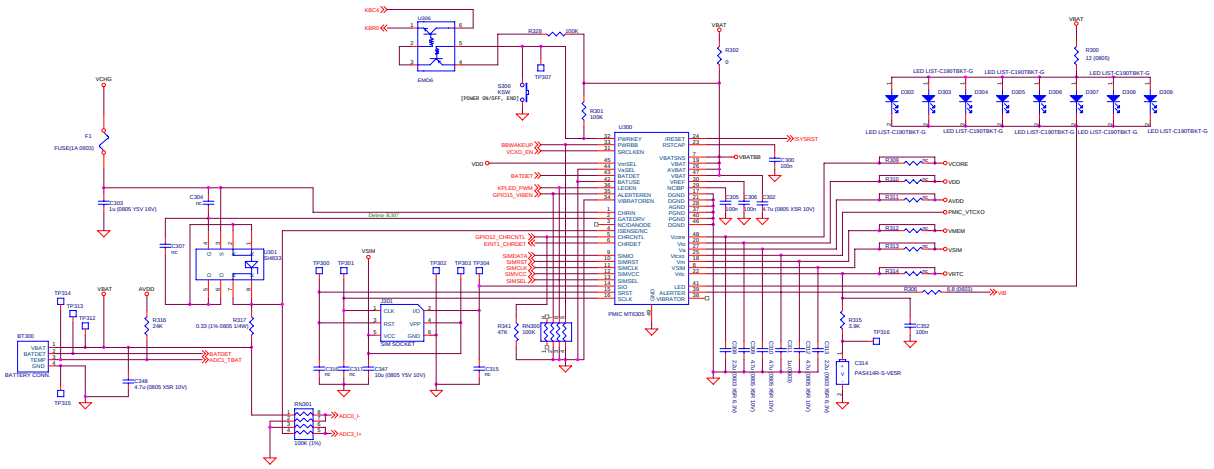
  CC mode charging current = 160mV/Rsense
- CV mode charging (only for Li-ion)

  Vbat is kept to 4.2V
- OV function (5usec)

  4.3 V (Li-ion), 5.1V (Ni-MH)

MT6218 charging circuit includes the F1 Fuse, U301 PMOS with diode, R317 0.33ohm, and RN301 resistor array.

1. F1 Fuse: we select 1A fuse to protect over current charging.
2. U301 PMOS with diode: It prevents the battery from discharging through the PMOS's body diode into the charger's internal circuits. CHRCNTL pin controls the gate of PMOS to pulse charging.
3. R317 0.33ohm: It limits charging current to prevent it over 1C because the charger output current tolerance is too large.
4. RN301 resistor array: It steps down the voltage of R317 to ADC pins. We can calculate the charging current and battery voltage from ADC values (ADC0_I-, ADC3_I+) to know charging status.
5. Battery's temperature is monitored by ADC1_TBAT. One thermistor 10K ohm is in the battery. It will change based on the temperature. Battery can be charged in the 0^{o}~50^{o}.



MT6305 Pin Description:

PIN	NAME	FUNCTION
1	CHRIN	Charger Input Voltage
2	GATEDRV	Gate Drive Output
3,29	NC	
4	ISENSE	Charger Current Sense Input
5	CHRCNTL	Microprocessor Control Input Signal for Gate Drive, Internal Pull Low to DGND
6	CHRDET	Charger Detect Output
7	BATSNS	Battery Input Voltage Sense
8	VSIM	SIM Supply
9	SIMIO	Non-Level-Shifted Bidirectional Data I/O
10	SIMRST	Non-Level-Shifted SIM Reset Input, Internal Pull High to VIO
11	SIMCLK	Non-Level-Shifted SIM Clock Input
12	SIMVCC	SIM Enable
13	SIMSEL	High for Vsim=3.0V, Low for Vsim=1.8V
14	SIO	Level-Shifted SIM Bidirectional Data Input/Output
15	SRST	Level-Shifted SIM Reset Output
16	SCLK	Level-Shifted SIM Clock Output
17,21,46	DGND	Digital Ground
18	VM	Memory Supply
19	VBAT	Battery Input Voltage
20	VIO	Digital IO Supply
22	VRTC	Real Time Clock Supply
23	RSTCAP	Reset Delay Time Capacitance
24	/RESET	System Reset, Low Active
25	VTCXO	TCXO Supply
26	AVBAT	Battery Input Voltage for Analog Block Circuits
27	VA	Analog Supply
28	AGND	Analog Ground
30	VREF	Reference Voltage Output
31	SRCLKEN	VTCXO and VA Enable
32	PWRKEY	Power on/off Key, Internal Pull High to VBAT

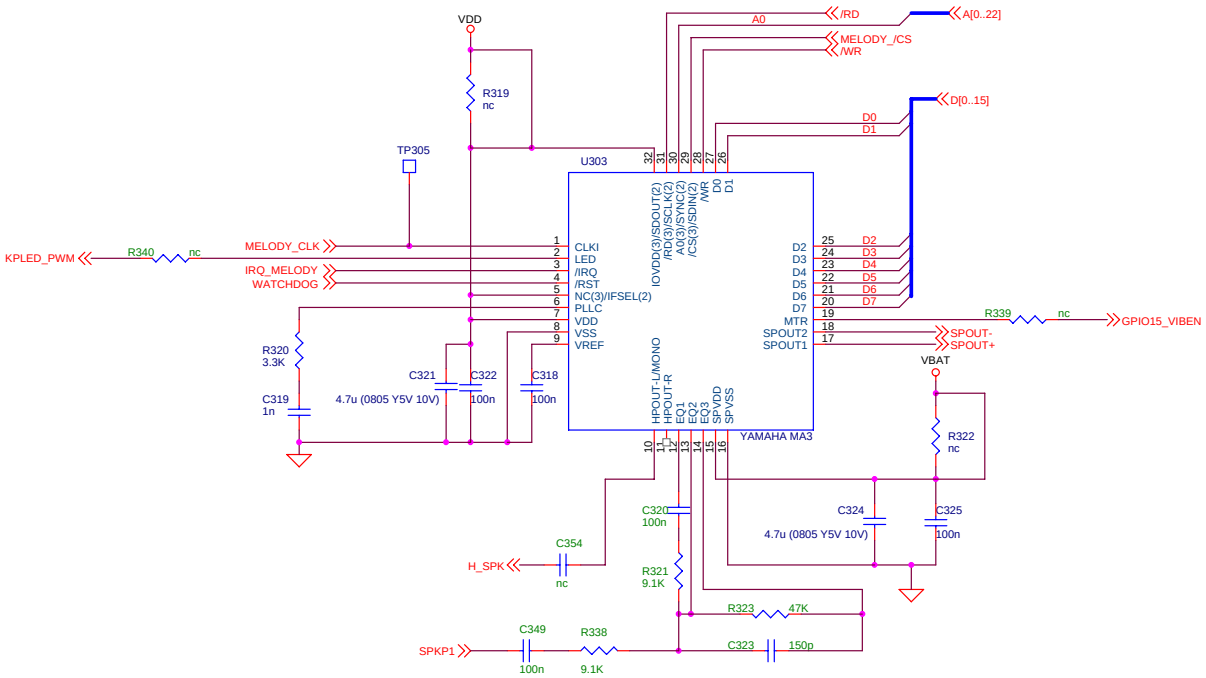
33	PWRBB	Power on/off Signal from Microprocessor
34	VIBRATOREN	Vibrator Driver Enable, Internal Pull Low to DGND
35	ALERTEREN	Alerter Driver Enable, Internal Pull Low to DGND
36	LEDEN	LED Driver Enable, Internal Pull Low to DGND
37,40	PGND	Power Ground
38	VIBRATOR	Vibrator Driver Input
39	ALERTER	Alerter Driver Input
41	LED	LED Driver Input
42	BATUSE	Battery Type Selection, High for NiMH, Low for Li-ion, Internal Pull Low to DGND
43	BATDET	Battery Detect Input, Low for Battery Connected, Internal Pull High for Battery Disconnected
44	VASEL	High for VA enabled with VTCXO, Low for VA enabled with VD, Internal Pull Low to DGND
45	VMSEL	High for Vm=2.8 V, Low for Vm=1.8V, Internal Pull High to VIO
47	VBAT	Battery Input Voltage
48	VCORE	Digital Core Supply

4.9 YAMAHA YMU762C Melody

YMU762C (U303) is a synthesizer LSI for mobile phones that realize advanced game sounds. This LSI has a built-in speaker amplifier.

U303 has two power inputs. One is VDD=2.8V for digital block. The other is VBAT for speaker amplifier. R320=3.3K and C319=1nF are for built-in PLL. R318=100nF is for analog reference voltage =1/2*VDD=1.4V. C349, R338, R323, and C323 determine the handfree mode equalizer gain (5.16X), low pass and high pass frequency.

C320, R321, R323, and C323 determine the melody mode equalizer gain (5.16X), low pass and high pass frequency.

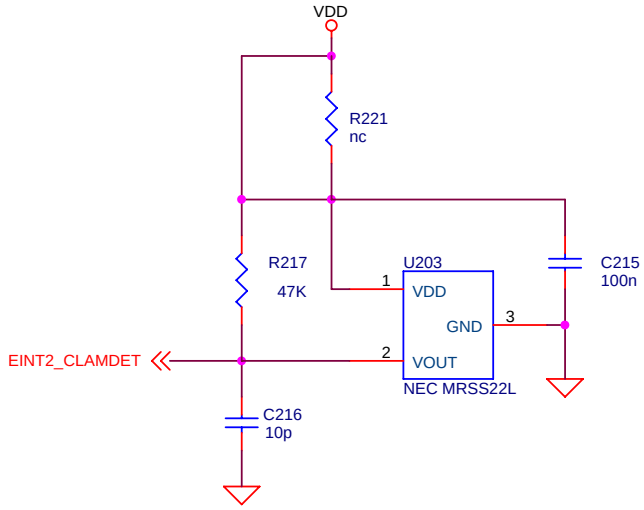


4.10 Hall Sensor IC

This chip includes a Hall-voltage generator, small-signal amplifier, a latch, and a MOSFET output.

	Output Voltage (Vout)
When power switch is ON	>2.7V
When magnetic field is applied	<0.3V
When magnetic field is applied	>2.7V

Direction of applied magnetic field



4.11 Auxiliary ADC Unit

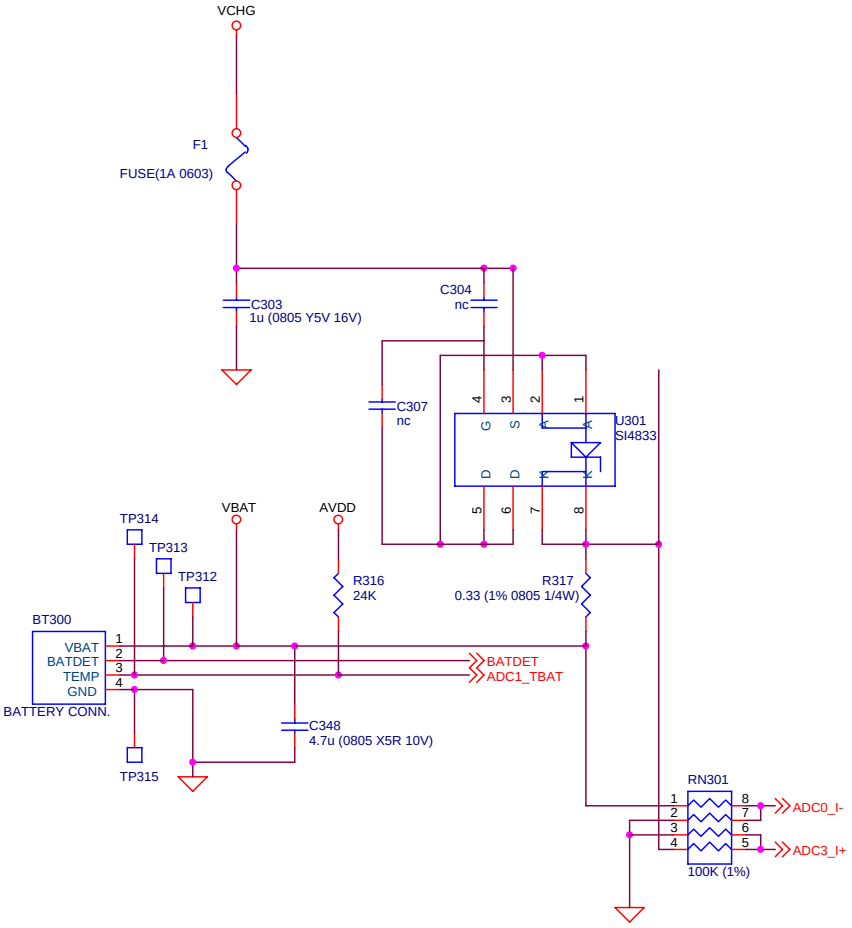
The auxiliary ADC unit is used to monitor the status of battery and charger, identify the plugged peripheral, and perform temperature measurement. There provides 5 input channels for diversified application in this unit.

In the MT6218 project, three ADC channels are used.

1. Two channels (ADC0, ADC3) for charging current sensing and battery voltage monitor
2. One channel (ADC1) for battery' temperature monitor.

Its register is 10 bits. Max input voltage depends on AVDD (2.8V). So its resolution is equal to 2.734mV/bit.

Because the charging voltage and battery voltage are over the 2.8V, we add RN301 resistor array to reduce the voltage to 1/2*Vchr and 1/2*Vbat. Because the resistor's tolerance and chipset ADC channel's tolerance, we need to calibrate ADC unit in the factory. We change the battery voltage from 3.4V to 4.2V to calibrate ADC0 and ADC3. Then ADC1 is refer to ADC0.


VCHG
F1
FUSE(1A 0603)
C303
1u (0805 Y5V 16V)
C304
nc
C307
nc
U301
SI4833
G
S
A
A
D
D
K
K
4
3
2
1
5
6
7
8
TP314
TP313
TP312
VBAT
AVDD
R316
24K
R317
0.33 (1% 0805 1/4W)
BT300
VBAT
BATDET
TEMP
GND
BATTERY CONN.
BATDET
ADC1_TBAT
C348
4.7u (0805 X5R 10V)
TP315
RN301
ADC0_I-
ADC3_I+
100K (1%)