MTH
Mobile Technology for Human

Hardware Design

MGM-312E_HW_UGD_V1.1

Hardware Design guide document

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1 Introduction

1.1 Scope

This document describes the hardware interface of the MGM-312E module that connects to the specific application.

1.2 Reference documents

[REF1] MH2600 Datasheet.
[REF2] MGM-312-EVB-UGD

2 MGM-312E Overview

MGM-312E is a Quad-band GSM/GPRS/EDGE engine that works on GSM850, GSM900, DCS1800 and PCS1900. MGM-312E provides GPRS/EDGE multi-slot class 12 capability and supports the coding schemes CS1~4, MCS1~9.

MGM-312E is integrated with the TCP/IP protocol. Extended TCP/IP AT commands are developed for customers to use the TCP/IP protocol easily, which is very useful for those data transfer applications.

2.1 MGM-312E Key Features

MGM-312E module supports R99 GSM/GPRS/EDGE protocol stack.

- ✓ Power supply: 3.3V~4.8V
- ✓ Temperature range: -30°C ~+80°C (Normal operation)
- ✓ Power saving: 1.6mA(battery power, MFS=9)
- ✓ Quad band support: GSM 850Mhz, EGSM 900Mhz, DCS 1800Mhz, PCS 1900Mhz
  Compliant to GSM Phase2/2+
- ✓ Transmit Power
  GMSK:
  - Class 4, 2W at GSM850, EGSM900
  - Class 1, 1W at DCS1800, PCS1900

  8PSK:
  - Class E2, 0.5W at GSM850, EGSM900
  - Class E2, 0.4W at DCS1800, PCS1900
- ✓ GPRS multi slot class 12
- ✓ Coding schemes CS1~CS4, MCS1~9
- ✓ Mobile station class B
- ✓ DATA transfer:
  - GPRS bit rate: Down-link: 85.6kbps (max), 53.6kbps (typ.)
    Up-link: 42.8kbps (max), 26.8kbps (typ.)
  - EDGE bit rate: Down-link: 236.8kbps (max)
    Up-link: 236.8kbps (max)
- ✓ Encryption algorithms A5/1, A5/2, A5/3
- ✓ Integrate the TCP/IP protocol
- ✓ CSD, USSD support
- ✓ SMS, FAX(Group3, Class1) support
- ✓ 1.8V/3.0V SIM card support
- ✓ External antenna: antenna pad and connector

- ✓ Audio speech codec: HR, FR, EFR, AMR
- ✓ Echo cancellation, Noise Suppression
- ✓ Serial port: Full modem interface.(with control and status lines), 1200bps to 115200bps
- ✓ GPIO, I2C, SPI, USB, support
- ✓ Keypad support (5x5 matrix)
- ✓ SIM application toolkit support
- ✓ Real time clock support
- ✓ Physical characteristic: size: 40mm x 33mm x 3mm
- ✓ Firmware upgradeable by UART port

2.2 MGM-312E Functional Diagram

MGM-312E module's inner diagram is listed as follows.

- ✓ GSM baseband [MH2600]
- ✓ MCP[Nor flash 32Mbit, psram 16Mbit]
- ✓ GSM RF part[RF transceiver, RF frontend module, SAW filter]
- ✓ Antenna connector
- ✓ 60pin board to board connector
- ✓ Power management

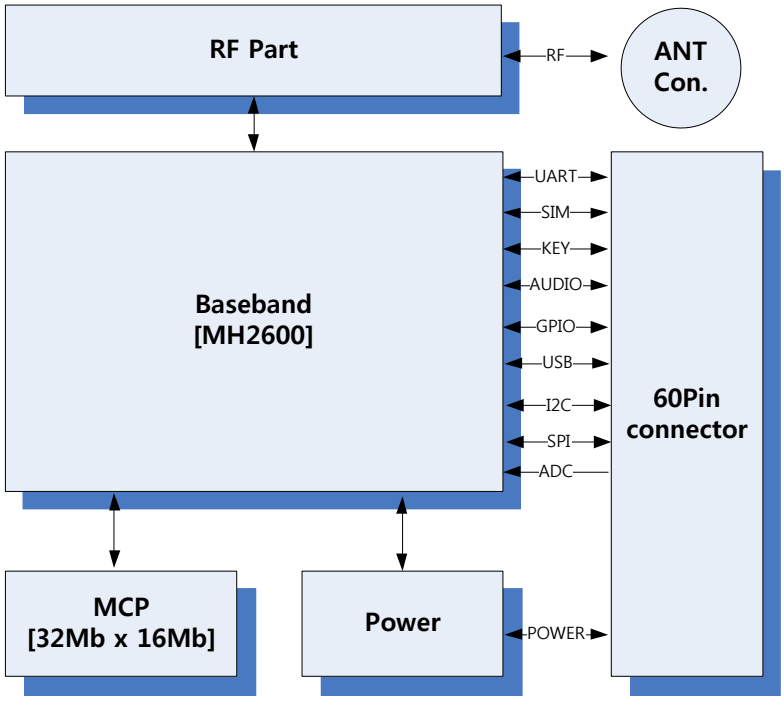


Figure 1 MGM-312E Functional diagram

2.3 MGM-312E Evaluation Board

MTH supplies the MGM_EVB Kit for the easy applying MGM-312E module to applications.
On MGM_EVB Kit, the 2 serial ports and all GPIO are pulled out by 2.54mm Pitch standard connector, so it's easy for debugging, and designed to be tested as attaching on the realizing applications.
For the details of module, see the document of "MGM-312E-EVB-UGD".

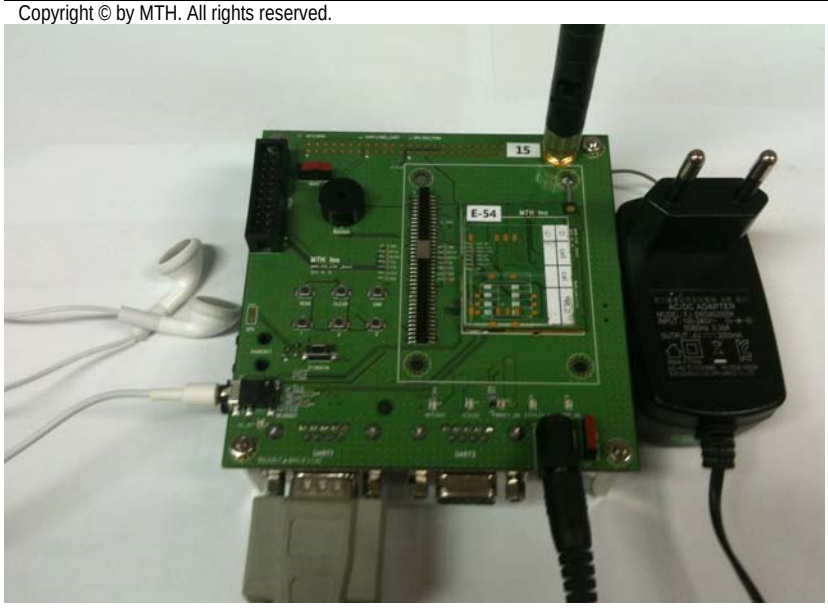


Figure 2 EVB and accessory equipment

3 Application Interface

MGM-312E module's interface signals are connected with 60pin board-to-board connector.
Since the pin number of board-to-board is limited, several signals are multiplexed.
The multiplexed signal is set up by default option on the stage of module production and can be changed by the customer's request.

3.1 MGM-312E Pin Description

Pin name	Pin number	I/O	Description	Comment
Power				
VBAT	1,2,3,4,5, 6,7,8	I	Power supply	3.3V~4.8V
VRTC	15	I/O	Power supply for RTC	It is recommended to connect with a RTC back-up battery or a capacitor
VDD_EXT	17	O	2.8V output power supply	If it is unused, keep open.
GND	9,10,11,12, 13,14,50,51			
Power on/off				
PWRKEY	34	I	PWRKEY should be pulled up at least 1 second and then released to power on/off the module	VIL = 0.9V(max) VIH = 2.6V(min) VImax = battery VImin = 0V It has pulled down internally(100KR,GND)
Audio interfaces				
MIC1P	53	I	Differential audio input	If these pins are unused, keep open
MIC1N	55			

SPK1P	54	O	Differential audio output	
SPK1N	56			
MIC2P	57	I	Differential audio input	
MIC2N	59			
SPK2P	58	O	Differential audio output	
SPK2N	60			
Status				
NETLIGHT	30	O	Network status	
SPI interface(LCD interface) / USB interface				
SPI1_CLK / USB_DM	20	I/O	**Defaults are as USB and GPIO** , they can be multiplexed as SPI	If these pins are unused, keep open
SPI1_DATA / USB_DP	18	I/O		
SPI1_SDIO / USB_DET	24	I/O		
SPI1_CS / GPIO20	22	O		
SPI1_RST / GPIO21	26	O		
Keypad interface / GPIOs / I2C1 / I2C2 / Etc.				
ROW0/GPIO54/I2C1_SDA	27	I/O	**Defaults are as KEYPAD**	
ROW1/GPIO53/I2C1_SCK	29	I/O		
ROW2/GPIO60/SIM2_RST/	31	I/O		
ROW3/GPIO19/SIM2_CLK	33	I/O		
ROW4/GPIO18/SIM2_DATA	35	I/O		
COL0/GPIO49/HS_DET	37	I/O		
COL1/GPIO55/I2C2_SDA	39	I/O		
COL2/GPIO56/I2C2_SCK	41	I/O		
COL3/GPIO16/DBG_CTS	43	I/O		
COL4/GPIO14/DBG_RTS	45	I/O		
Serial port				
RXD	40	I	Receive data	This pin should be pulled up to 2.8V externally
TXD	42	O	Transmit data	If these pins are unused, keep open (voltage Level: 2.8V)
RTS	44	I	Request to send	
CTS	46	O	Clear to send	
RI	48	O	Ring indicator	
DCD	28	O	Data carry detect	
DTR	38	I	Data terminal Ready	
Debug interface				
DBG_TXD / GPIO17	49	O	Serial interface for debugging or GPS interface	If these pins are unused, keep open.
DBG_RXD / GPIO15	47	I		
SIM interface				
SIM_VDD	19	O	Voltage supply for SIM card. Support 1.8V or 3.0V SIM card	All signals of SIM interface. If SIM_PRESENCE is unused, just keep open
SIM_DATA	21	I/O	SIM data in/out	
SIM_CLK	23	O	SIM clock	
SIM_RST	25	O	SIM reset	
SIM_PRESENCE / GPIO44	16	I/	SIM card detection	
ADC				
ADC0	52	I	General purpose analogy to digital converter. Input voltage: 0V~2.8V	If it is unused, keep open.
Pulse With Modulation				
BUZZER	36	O	PWM output	If it is unused, keep open.

3.2 Power Supply

The power supply is one of the key issues in the design of a GSM terminal.

Due to the bursted emission in GSM/GPRS, the power supply must be able to on the supply voltage must not exceed a certain limit.

In communication mode, a GSM/GPRS terminal transmits 577us (1TX) or 1154us (2TX) radio bursts every 4.615ms, as described in the diagram hereunder.

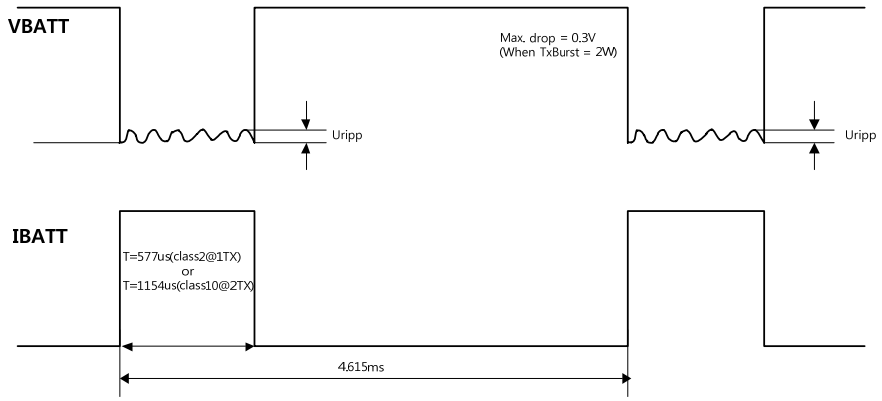


Figure 3 Waveform of the max drop and ripple authorized for VBATT

The power supply voltage features given in the table hereafter will guarantee the nominal operation of the module

	Vmin	Vnom	Vmax	Condition
VBATT	3.3V*	3.6V	4.8V	Uripple ≤ 50mVpp for f < 200kHz Uripple ≤ 2mVpp for f>200kHz

(*): This value has to be guaranteed during the burst (with 2.0A peak in GSM mode)

The transmitting burst will cause voltage drop and the power supply must be able to provide sufficient current up to 2A. For the VBAT input, a bypass capacitor (low ESR) such as a 100uF is strongly recommended; this capacitor should be placed as close as possible to MGM-312E VBAT pins.

There are 3 ways of supplying power to MGM-312E.

- ✓ To connect battery directly.
- ✓ To use linear regulator.
- ✓ To use DC-DC converter.

For low voltage drop of VBAT, it's suggested to connect battery directly or use DC-DC convertor. The PCB traces from the VBAT pins to the power supply must be wide enough (at least 60mil) to decrease voltage drops in the transmit burst. The power IC and the bypass capacitor should be placed to the module as close as possible.

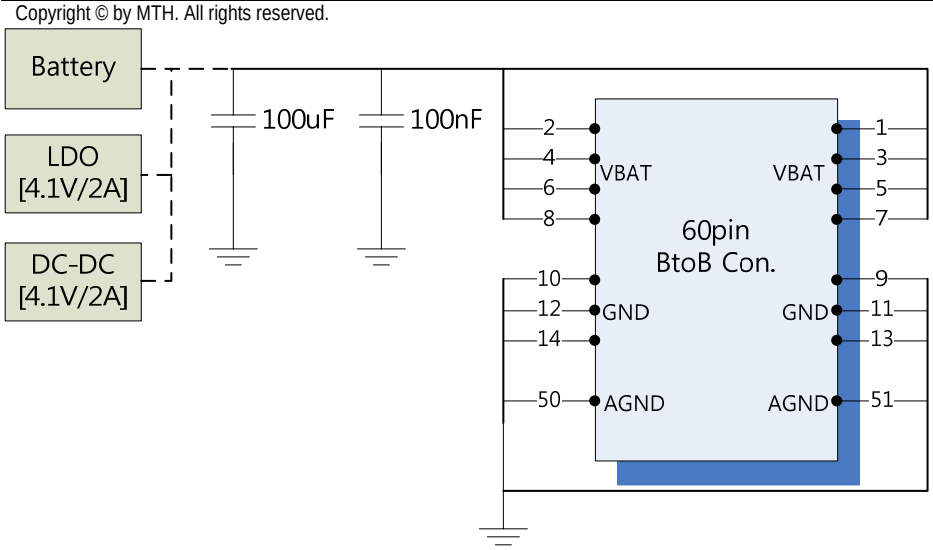


Figure 4 Reference circuit of the Power supply

3.3 Power Up and Power down Scenarios

3.3.1 Power up MGM-312E

For the power up of MGM-312E module, PWRKEY pin is used.
To switch on the power of module, it's enough for pulling up the PWRKEY pin just about 1sec.
PWRKEY is already pulled down by 100KΩ resistance in module, so the pulling down on outside is not needed, and you can see the reference circuit below.

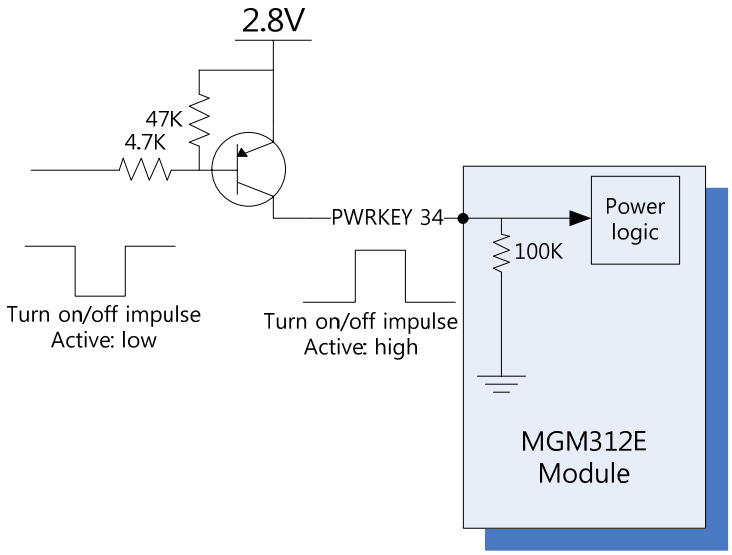


Figure 5 Powered up/down module using transistor

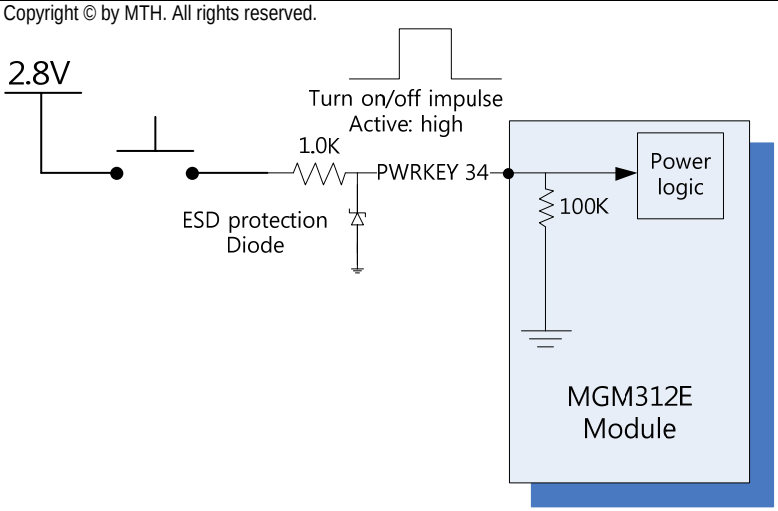


Figure 6 Powered up/down module using button

The power on scenario is described on the picture below.

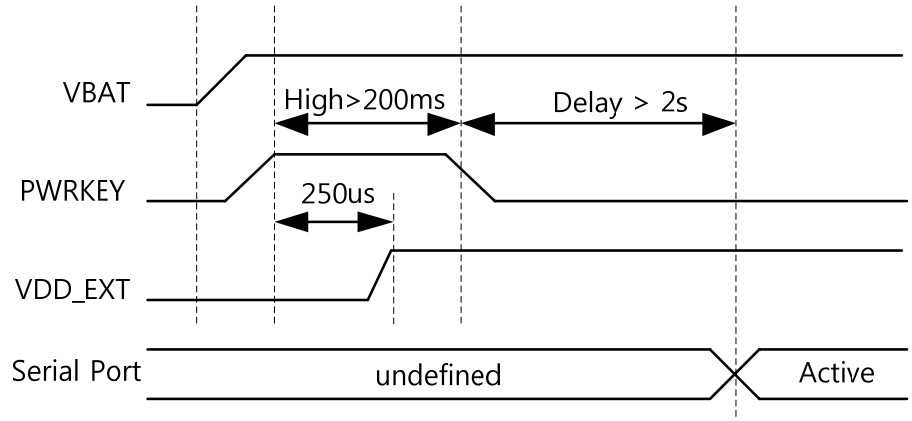


Figure 7 Timing of the power up

When the power up of MGM-312E is done, the module will send powered up command by 115,200bps baud rate.

3.3.2 Power down MGM-312E

The way of power down MGM-312E is described here below.

- Normal power down procedure: power down MGM-312E by the PWRKEY pin.
- Normal power down procedure: power down MGM-312E by AT command " AT+CPOWN=1"
- Abnormal power down: over-voltage or under-voltage automatic power down
- Abnormal power down: over-temperature or under-temperature automatic power down

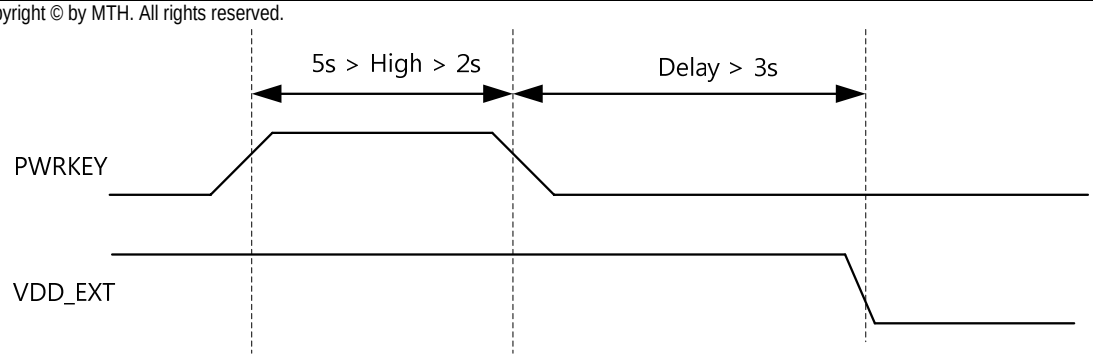


Figure 8 Timing of the power down by PWRKEY

The process of MGM-312E's power down contains the work of safe logging off the connected network status and safe power off the working part of module on software.

On the case of normal down mode, AT commands cannot be executed any more, and only the RTC is still active, power down mode can also indicated by STATUS pin, which is at low level at this time,

Power down of MGM-312E by AT Command;
MGM-312E module can be power down by AT command. "AT+CPOWD=1".
This procedure makes the module log off from the network.

For detail about the AT command "AT+CPOWD", please refer to AT Command document

3.4 Power Saving

MGM-312E has two sleep modes

- ✓ Mode1: enabled by hardware pin DTR
- ✓ Mode2: enabled by serial port regardless of the DTR

In sleep mode, the current consumption of the module is very low.

Sleep Mode1 (AT+CSCLK=1)

User can control MGM-312E module to enter or exit the sleep mode1 (AT+CSCLK=1) by DTR signal. When DTR is in high level and without interrupt (on air and hardware such as GPIO interrupt or data in serial port), MGM-312E will enter sleep mode1 automatically. In this mode, MGM-312E can still receiver paging or SMS from network but the serial port is not accessible.

Note: For MGM-312E, it is requested to set AT command "AT+CSCLK=1" and to ensure DTR at high level to enable the sleep mode1; the default value is 0, which can not make the module to go into sleep mode.

Wake Up MGM-312E form Sleep Mode1 (AT+CSCLK=1)

When MGM-312E is in sleep mode1 (AT+CSCLK=1), the following methods can wake up the module:

- Pull down DTR pin.
  The serial port will be active after DTR pin is pulled to low level for about 50ms.
- Receiver a voice or data from network.
- Receiver a SMS from network.

Sleep Mode2 (AT+CSCLK=2)

In this mode, MGM-312E will continuously monitor the serial port data signal. When there is no data transfer over 5seconds on the RXD signal and there is no on air and hardware interrupts (such as GPIO interrupt), MGM-312E will enter sleep mode 2 automatically. In this mode, MGM-312E can still receiver paging or SMS from network but the serial port is not accessible.

Wake Up MGM-312E form Sleep Mode1 (AT+CSCLK=2)

When MGM-312E is in sleep mode2 (AT+CSCLK=2), the following methods can wake up the module:

- Send data to MGM-312E via main serial port
- Receiver a voice or data call form network
- Receiver a SMS from network

3.5 RTC backup

The RTC pin of MGM-312E will be current input when VBAT is not supplied, and will be current output when VBAT is supplied and backup battery is low.

The RTC power supply of the module can be provided by an external capacitor or a battery through the VRTC. The following figures show various reference circuits for RTC back up.

External capacitor backup

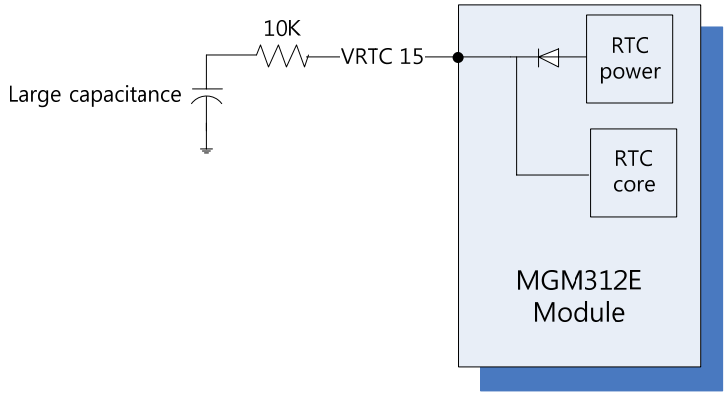


Figure 9 RTC supply from large capacitance capacitor

Rechargeable backup battery

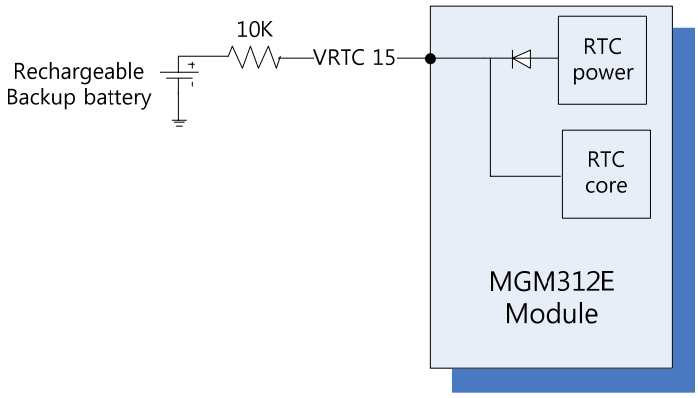


Figure 10 RTC supply from rechargeable backup battery

Coin type rechargeable backup battery is recommended, such as XH414H-IV01E from SEIKO can be used.
Typical charge-discharge curves for this battery are shown in the following figure.

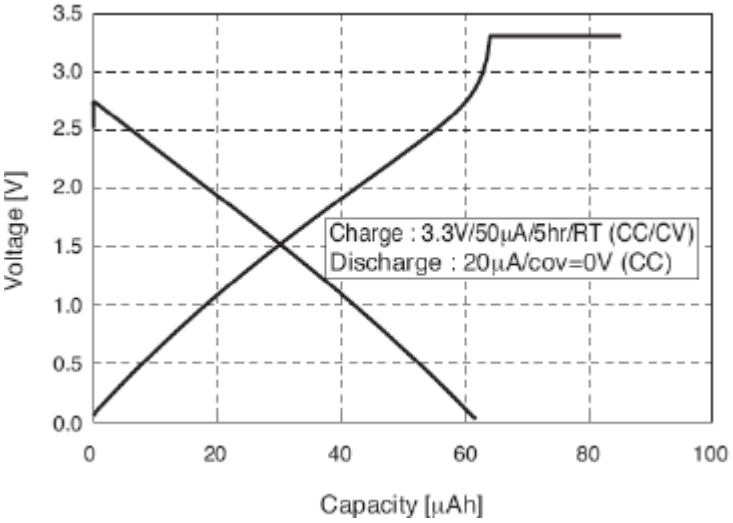


Figure 11 SEIKO XH414H-IV01E Charge-Discharge Characteristic

3.6 Serial interface

MGM-312E provides two UART serial ports. One is the main serial port and the other is the debug port. The module is designed as a DCE (Data Communication Equipment). The following figure shows the connection between module and client (DTE).

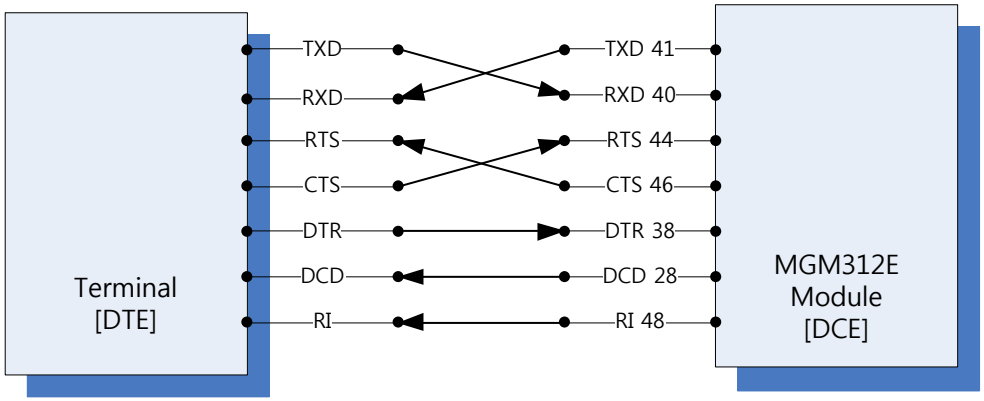


Figure 12 Connection of the serial interfaces

If only 4-wire serial interface are used in user's application, other pins should be kept open. Please refer to following figure.

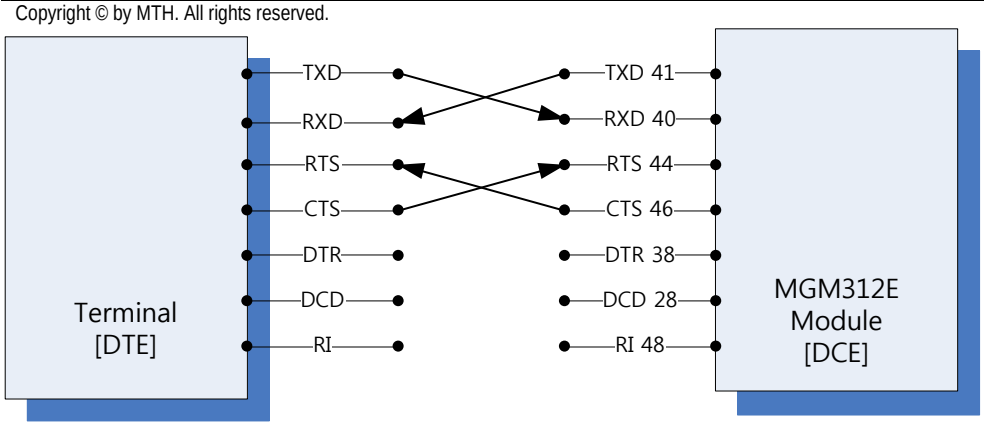


Figure 13 Connection of RXD, TXD and RTS, CTS only

If sleep mode is need in this situation, the user need to connect the DTR signal as well, or only sleep mode2 can be used.

To use Debug and UART2 serial port, the connection can be as follows.
UART2 serial port baud rate is 115200bps, and only using TXD, RXD signal is available.
DBG_RTS, DBG_CTS signal is multiplexed with KEYPAD COL4 and COL3 signal, and the default value is KEYPAD. To use DBG_RTS, DBG_CTS, it can be changed by the request of customer.

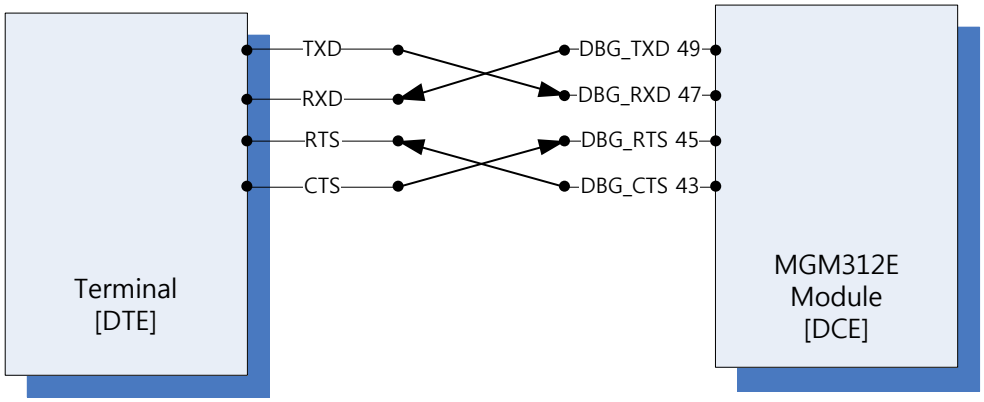


Figure 14 Connection of Debug serial interface

Function of serial port;

- Full modem device.
- Contains data line TXD and RXD, hardware flow control lines RTS and CTS, status lines DTR, DCD and RI
- Serial port can be used for CSD FAX, GPRS service and AT communication. It can also be used for multiplexing function.
- Serial port supports the following baud rates:
  1200,2300.4800,9600,19200,38400,57600,115200bps

The serial port support the CMOS level. If user connects the module to the computer, the level shifter should be added between the DCT and DTE

3.7 Audio interface

The chapter describes the implementation of:

- Main Microphone

- Main Receiver
- Headset

A typical design of these features can be represented as follows:

Main receiver;
Speaker outputs of the MGM-312E Audio (SPK1P and SPK1N) signals can be directly connected to a receiver.

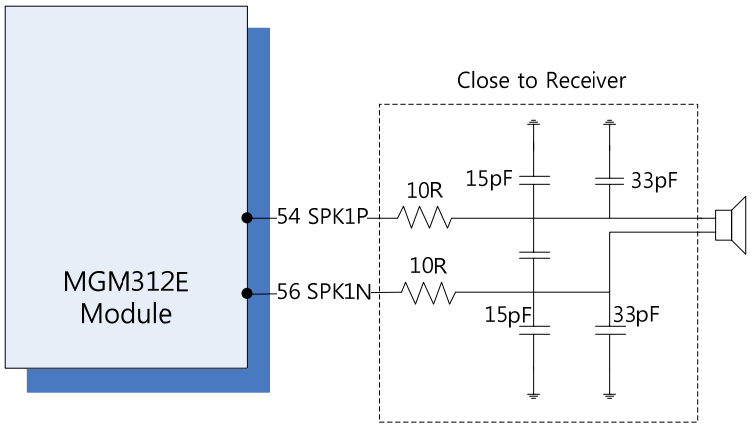


Figure 15 Receiver reference circuit

10R, are recommended for the first version of handset design. Depending an audio quality tests, these components could be used to implement LC filter or removed if they are not necessary.

The main receiver outputs must be loaded to 16Ω and can directly drive a 32Ω or 16 Ω speaker. To be compliant with MGM-312E and general GSM requirements, it is strongly recommended to meet the following characteristics:

Parameter	Symbol	Min	Typ	Max	Unit
Impedance	Zspk		16 or 32		Ω
Input Power	Prms		0.2	0.3	W
Input Voltage	Vrms				Vrms
Sound Pressure Level	SPL		77		dB

Main microphone;

Since MIC1P and MIC1N signals integrate a biasing source through the MGM-312E module. It is more convenient to use these inputs to interface the main microphone.
These differential signals can be directly connected to a standard electric microphone (2V-0.5mA)

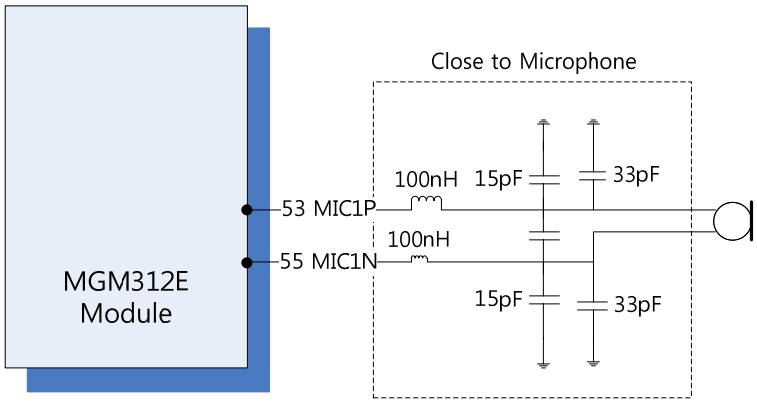


Figure 16 Microphone reference circuit

For the Microphone reference circuit, 100nH Inductors are recommended for the first version of handset design. Depending on audio quality tests, these components could be used to implement a LC filter or removed if they are not necessary.

Microphone selection;

To be compliant with MGM-312E and general GSM requirements, it is strongly recommended to meet the following characteristics:

Parameter	symbol	Min	Typ	Max	Unit
Input impedance	Zi		2.2		KΩ
Power Supply	Vpol		2		V
Internal Capacitor(1)	Ci		33 and 15		pF
Sensitivity(2)	S				dB

Note (1): To suppress TDMA noise, it is mandatory to use microphone with tow internal decoupling capacitors:

- *33pF for 900MHz filtering.*
- *15pF for 1800MHz filtering.*

Note (2): As the distance between mouth and microphone is bigger than with the main microphone, the sensitivity of the microphone has to be higher.

Ear microphone headset;
For a headset using a differential receiver connection, the recommended circuit is shown below:

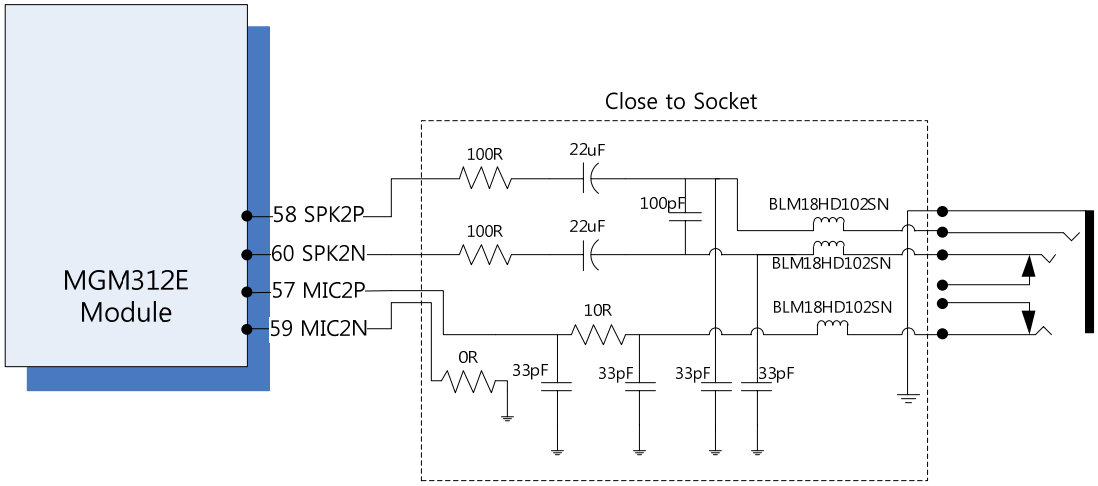


Figure 17 Ear microphone reference circuit

3.8 SIM Card interface

It is possible to manage dual voltage (1.8V/3.0V) or single voltage only SIM cards with a MGM-312E module using the internal level shifter.

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

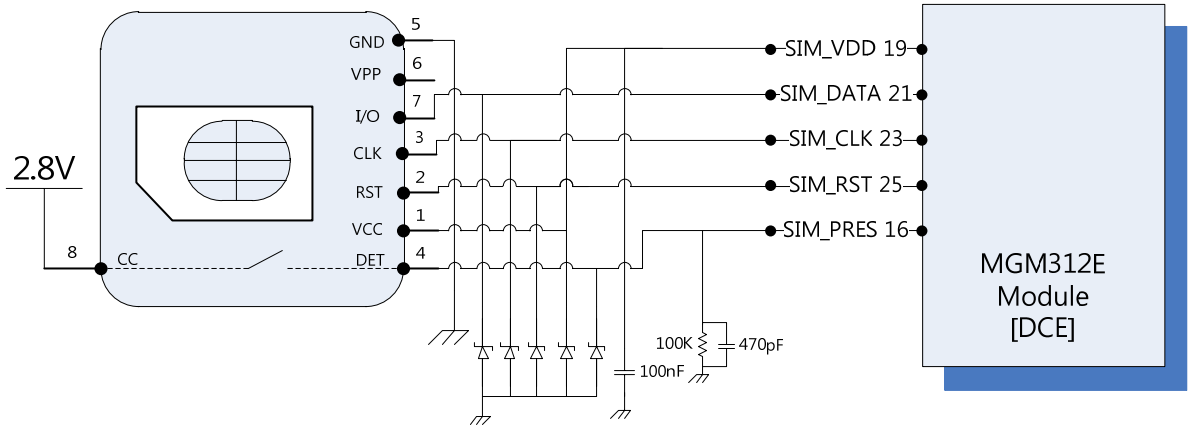


Figure 18 SIM Socket for module application

This example of SIM socket implementation is given for module application, with the CC signal connected to the SIM_PRES input.

For another application, the SIM_PRES signal is not mandatory.

The capacitor (100nF) on SIM_VCC (pin1 of the SIM socket) must be placed as close as possible to the SIM socket.

3.9 SPI interface

MGM-312E provides a serial LCD display interface. It could also be used as SPI interface in the embedded AT application.

Note: This function is not supported in the standard firmware. If user wants this function, the firmware must be customized. Please contact MTH for more details.

3.10 ADC

An Analogy to Digital Converter is available on the MGM-312E module. This convertor has a 12-bit resolution, ranging from 0.2V to 2.8V

Typical application;

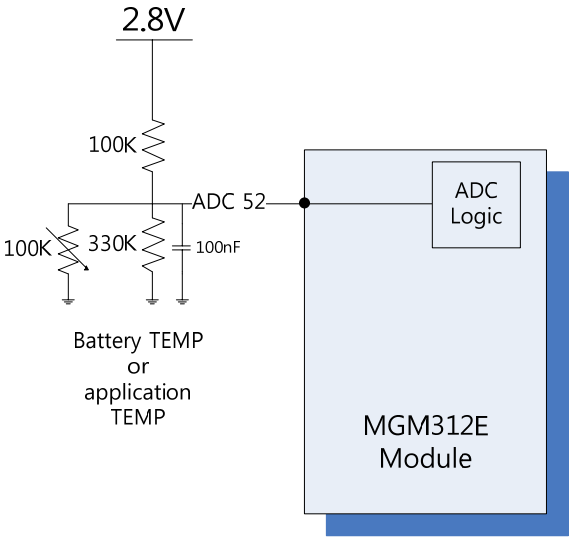


Figure 19 Battery TEMP or Application TEMP ADC input (with NTC=100K)

This battery TEMP ADC input is used to check the temperature of a battery or application product. Voltage applied on ADC input must be included between 0.2V and 2.8V. As a consequence for a 100K NTC, A 330K resistor must be used. This resistor is also used in order to get the voltage linear in relation to the temperature as shown in the figure below:

Temperature (°C)	R NTC (kΩ)	Req (kΩ)	BAT_TEMP (v)
-40	4221.283	306.1	2.11
-30	2146.996	286	2.07
-20	1136.590	255.7	2.01
-10	624.987	215.9	1.91
0	355.975	171.2	1.77
10	209.489	128.1	1.57
20	127.057	91.7	1.34
25	100	76.7	1.21
30	79.222	63.9	1.09
40	50.677	43.9	0.85
50	33.195	30.2	0.65
60	22.224	20.8	0.48
70	15.184	14.5	0.35
80	10.566	10.2	0.26

Note: NTC(Murata, NCP15WF104D)

3.11 RI

RI Behaviours:

State	RI response
Standby	High
Voice call Data call	The pin is changed to low. When any of the following events occurs, the pin will be changed to high: ✓ Establish the call ✓ Hang up the call
SMS	The pin is changed to low, and kept low for 120ms when a SMS is received. Then it is changed to high.
URC	The pin changed to low, and kept low for 120ms when some URCs are reported. Then it is changed to high.

Note: URC is Unsolicited result Code

The behaviour of the RI pin is shown in the following figure when the module is used as a receiver.

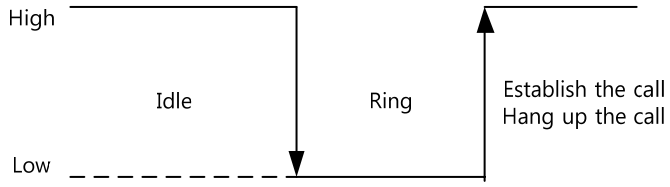


Figure 20 RI behaviour of data calling as a receiver

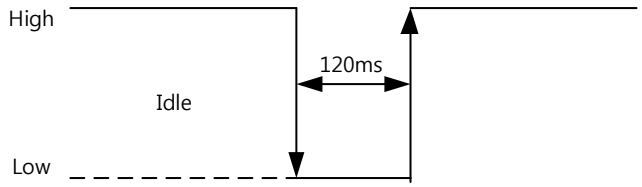


Figure 21 RI behaviour of URC or receive SMS

However, if the module is used as caller, the RI will remain high, Please refer to the following figure.

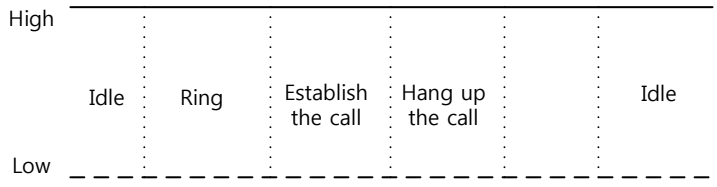


Figure 22 RI behaviour as a caller

3.12 Network Status Indication

The HETLIGHT pin can be used to drive a network status indication LED.

- ✓ Off: Not running.
- ✓ 64ms On / 800ms Off: Not registered network.
- ✓ 64ms On / 3000ms Off: Registered to the network.
- ✓ 64ms On / 300ms Off: GPRS/EDGE communication established.

A reference circuit is recommended in the following figure:

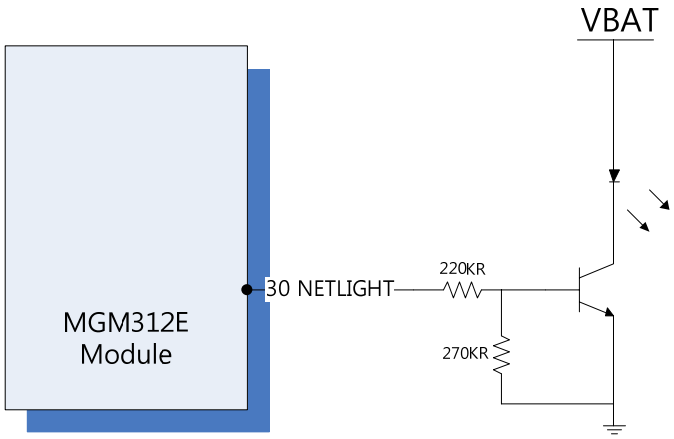


Figure 23 Reference circuit of NETLIGHT

3.13 Keypad Interface

This interface provides 10 connections:

- 5 rows (ROW0 to ROW4)
- 5 columns (COL0 to COL4)

Digital scanning and debouncing are done within the MGM-312E modules. No discrete components like R, C (Resistor, Capacitor) are needed.

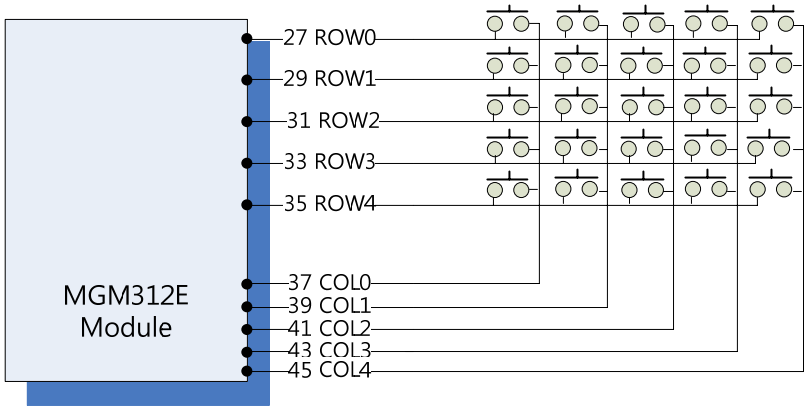


Figure 24 Keypad interface

Note: This function is not supported in the standard firmware. If user wants this function, the firmware must be customized. Please contact MTH for more details.

3.14 Buzzer

Feature of buzzer:

- ✓ 10-bit resolution for buzzer tone frequency generation from 200Hz to 5KHz
- ✓ Tone frequency error <1% for all standard piano tones from 200Hz to 5KHz
- ✓ Tone level control from 2dB down to -24dB in +4dB steps
- ✓ Audio mute

The buzzer output a square wave at the desired tone frequency. The tone frequencies are programmable from 200Hz to 5kHz and can be re-programmed on-the-fly to generate monophonic audio ring tones or alert tones. The tone level can be adjusted over a 24dB range in 4dB steps, or it can be muted.

3.15 Two-wire bus interface [I2C]

The two-wire bus includes a clock signal (SCL) and a DATA signal (SDA) complying with a standard two-wire bus (I2C compatible).

For two-wire bus complains, two pull-up resistors must be added on the application board on the SDA and SCL signals (between 2.2KR and 4.7KR).

Typical implementation:

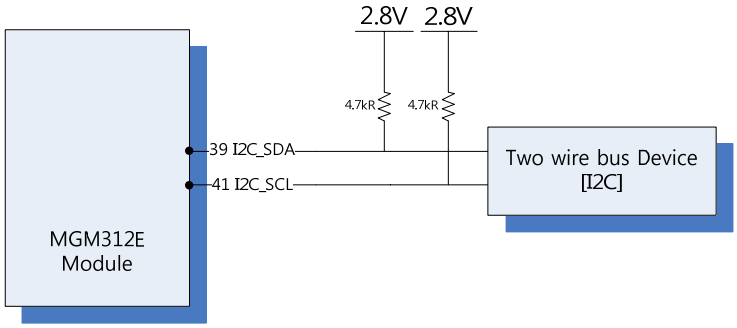


Figure 25 Two-wire bus interface [I2C]

3.16 USB Interface

The MGM-312E module integrates a USB interface, complying with USB2.0 protocol.

The USB port of the MGM-312E module runs on 3.3V voltage.

The USB_DET is connected to the external interruption pin of the module (DISP_D/C) to detect the plug of the USB cable.

For a USB port connection, the recommended circuit is shown below:

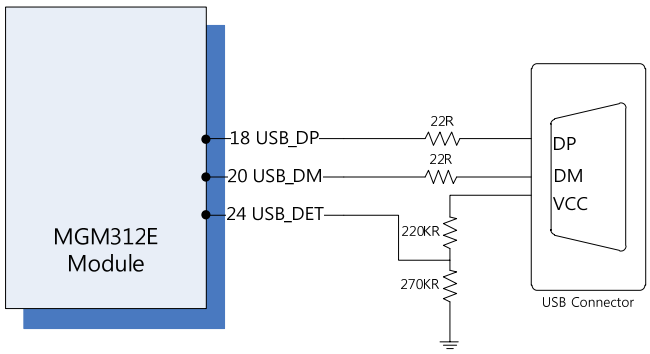


Figure 26 USB interface

Note: DISP_D/C signal of the module is multiplexed USB_DET.

3.17 Radio interface

Antenna recommendations

Antenna must fulfil following requirements:

- ✓ Frequency bands:

Band	Transmit band (Tx)	Receive band (Rx)
GMS850	824~849MHz	869~894MHz
E-GSM900	880~915MHz	925~960MHz
DCS1800	1710~1785MHz	1805~1880MHz
PCS1900	1850~1910MHz	1930~1990MHz

- ✓ RF impedance: 50 Ohms
- ✓ VSWR: max 2:1
- ✓ Gain: 0dBi typical

3.18 PCB design

General rules and constraints

Clock and other high frequency digital signals (e.g. serial buses) should be routed as far as possible from the MGM-312E analog signals.

If the application design makes it possible, all analog signals should be separated from digital by a Ground line on the PCB.

Power supply routing constraints

- ✓ It is important to take care of the ground track or the ground plane which supplies the module. The track or the plane used must support current peaks as for the VBAT track.
- ✓ If the ground track between the module and the power supply is a ground plane, it must not be parcelled out.
- ✓ Since the maximum peak current can reach 2A, MTH strongly recommends a large width for the layout of the power supply signal (to minimize voltage losses between the external power supply and the module supply).
- ✓ MGM-312E power pins should be gathered in a same piece of copper
- ✓ The routing must be done in such a way that the total impedance line must be $\leq$ 10mΩ (Printed line + Vias holes + Battery power supply contact).
- ✓ Some signals such as VBAT require EMI/RFI decoupling. For that, use 33pF capacitor close to the module, or a serial ferrite bead (or both to get better results). In case a ferrite bead is used, the recommendations given for the power supply connection must be carefully followed (high current capacity and low impedance).
- ✓ If these design rules are not followed, phase error (peak) and power loss could occur.

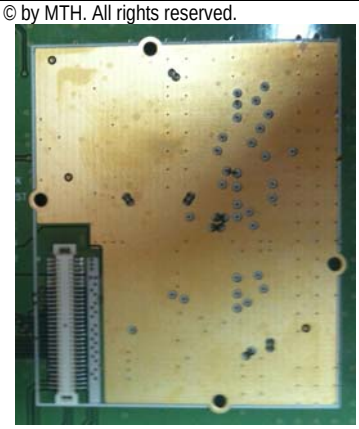


Figure 27 Solder mask open (The shield can space of MGM-312E)

Shielding

- ✓ The MGM-312E module's top side shielding is metal, and connected with the inner ground.
- ✓ The metal shielding can should be connected to PCB and soldered.

SIM interface routing constraints

- ✓ For the SIM interface, length of the track between the MGM-312E module and the SIM connector should be as short as possible. Maximum length recommended 1s 10cm.
- ✓ ESD protection is mandatory on the SIM lines if access from outside of the SIM connector is possible.
- ✓ The capacitor on SIM_VCC signal (100nF) must be placed as close as possible to the MGM-312E module on the PCB

Audio circuit routing constraints

- ✓ When laying out the PCB, it is advisable to keep the audio circuit away from the VBAT line and GSM antenna line (to avoid TDMA noise)
- ✓ The positive and negative PCB tracks of speaker and microphone should keep in parallel all the time as close as possible.
- ✓ Avoid routing any digital line or power line underneath audio lines as shown hereunder.

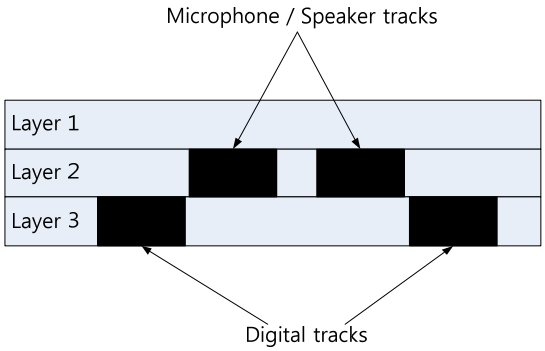


Figure 28 Avoid placing digital line underneath audio lines

4 Electrical, Reliability and Radio Characteristics

The absolute maximum ratings stated in following table are stress ratings under non-operating conditions. Stresses beyond any of these limits will cause permanent damage to MGM-312E

4.1 Absolute maximum Ratings

Symbol	Parameter	Min	Typ	Max	Unit
VBAT	Power supply voltage			5.5	V
V_i	Input voltage	-0.3		3.1	V
I_i	Input current			10	mA
I_o	Output current			10	mA

4.2 Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit
VBAT	Power supply voltage	3.3	4.0	4.8	V
T_{oper}	Operating temperature	-40	+25	+85	°C
T_{stg}	Storage temperature	-45		+90	°C

4.3 Digital Interface Characteristics

Symbol	Parameter	Min	Typ	Max	Unit
I_{ih}	High level input current	-10		10	uA
I_{il}	Low level input current	-10		10	uA
V_{ih}	High level input voltage	2.4			V
V_{il}	Low level input voltage			0.4	V
V_{oh}	High level output voltage	2.7			V
V_{ol}	Low level output voltage			0.1	V

4.4 SIM Card Interface Characteristics

Symbol	Parameter	Min	Typ	Max	Unit
I_{ih}	High level input current	-10		10	uA
I_{il}	Low level input current	-10		10	uA
V_{ih}	High level input voltage	1.4			V
		2.4			V
V_{il}	Low level input voltage			0.4	V
				2.4	V
V_{oh}	High level output voltage	1.7			V
		2.7			V
V_{ol}	Low level output voltage			0.1	V
				0.1	V

4.5 VRTC Characteristics

Symbol	Parameter	Min	Typ	Max	Unit
$V_{rtc\text{-}in}$	VRTC input voltage	2.5	3.0	3.3	V

I_{rtc-in}	VRTC input current		2		uA
$V_{rtc-out}$	VRTC output voltage		3.0		V
$I_{rtc-out}$	VRTC output current		10		uA

4.6 Current Consumption (VBAT = 3.8V)

Symbol	Parameter	Conditions			Value	Unit
I_{VBAT}	VBAT current	Power down mode			40	uA
		Sleep mode	MFS = 9		1.6	mA
			MFS = 5		2.1	mA
			MFS = 2		3.5	mA
		Voice call	GSM 850 EGSM 900	PCL=5	250	mA
				PCL=12	110	
				PCL=19	80	
			DCS 1800 PCS 1900	PCL=0	180	
				PCL=7	94	
				PCL=15	76	
		Data mode GPRS[1Rx, 1Tx]	GSM 850 EGSM 900	PCL=5	235	mA
				PCL=12	102	
				PCL=19	74	
			DCS 1800 PCS 1900	PCL=0	190	
				PCL=7	90	
				PCL=15	70	
		Data mode GPRS[4Rx, 1Tx]	GSM 850 EGSM 900	PCL=5	273	mA
				PCL=12	145	
				PCL=19	120	
			DCS 1800 PCS 1900	PCL=0	205	
				PCL=7	130	
				PCL=15	110	
		Data mode GPRS[3Rx, 2Tx]	GSM 850 EGSM 900	PCL=5	440	mA
				PCL=12	185	
				PCL=19	125	
			DCS 1800 PCS 1900	PCL=0	320	
				PCL=7	155	
				PCL=15	120	
		Data mode GPRS[1Rx, 4Tx]	GSM 850 EGSM 900	PCL=5		mA
				PCL=12		
				PCL=19		
			DCS 1800 PCS 1900	PCL=0		
				PCL=7		
				PCL=15		
		Data mode EDGE[4Rx, 1Tx]	GSM 850 EGSM 900	PCL=5		mA
				PCL=12		
				PCL=19		
			DCS 1800 PCS 1900	PCL=0		
				PCL=7		
				PCL=15		
		Data mode EDGE[3Rx, 2Tx]	GSM 850 EGSM 900	PCL=5		mA
				PCL=12		
				PCL=19		
			DCS 1800 PCS 1900	PCL=0		
				PCL=7		
				PCL=15		
		Data mode EDGE[1Rx, 4Tx]	GSM 850 EGSM 900	PCL=5		
				PCL=12		

				PCL=19		mA
			DCS 1800 PCS 1900	PCL=0		
				PCL=7		
				PCL=15		
$I_{VBAT-peak}$	Peak current	During Tx bust			2	A

4.7 ESD (Electro-Static Discharge)

	Contact discharge	Air discharge
VBAT/GND	±5KV	±10KV
Board-to-Board Connector	±2KV	±8KV

Note: Temperature: 25℃, Humidity: 45%

4.8 Radio Characteristics

The following table shows the module conducted output power, it is followed by the 3GPP TS 05.05 technical specification requirement.

MGM-312E module conducted RF output power:

For the module's output power, the following should be noted:

At EGSM900 and GSM850 band, the module is a class 4 device, so the module's output power should not exceed 33dBm.

At DCS1800 and PCS1900 band, the module is a class 1device, so the module's output power should not exceed 30dBm.

Frequency	Max	Min
GSM/GPRS		
GSM850/EGSM900	33dBm ±2dB	5dBm ±5dB
DCS1800/PCS1900	30dBm ±2dB	0dBm ±5dB
EDGE		
GSM850/EGSM900	27dBm ±2dB	5dBm ±5dB
DCS1800/PCS1900	26dBm ±2dB	0dBm ±5dB

MGM-312E module RF Receiver Sensitivity:

The following table shows the modules conducted receive sensitivity, it is tested under static condition.

Frequency	Receive sensitivity (Typ)	Receive sensitivity (Max)	Unit
GSM 850	-108	-109	dBm
EGSM 900	-108	-109	dBm
DCS 1800	-108	-109	dBm
PCS 1900	-108	-109	dBm

5 Mechanics

The following sections describe the mechanical dimensions of MGM-312E and give recommendations for integrating MGM-312E into the host application.

5.1 Mechanical Dimensions

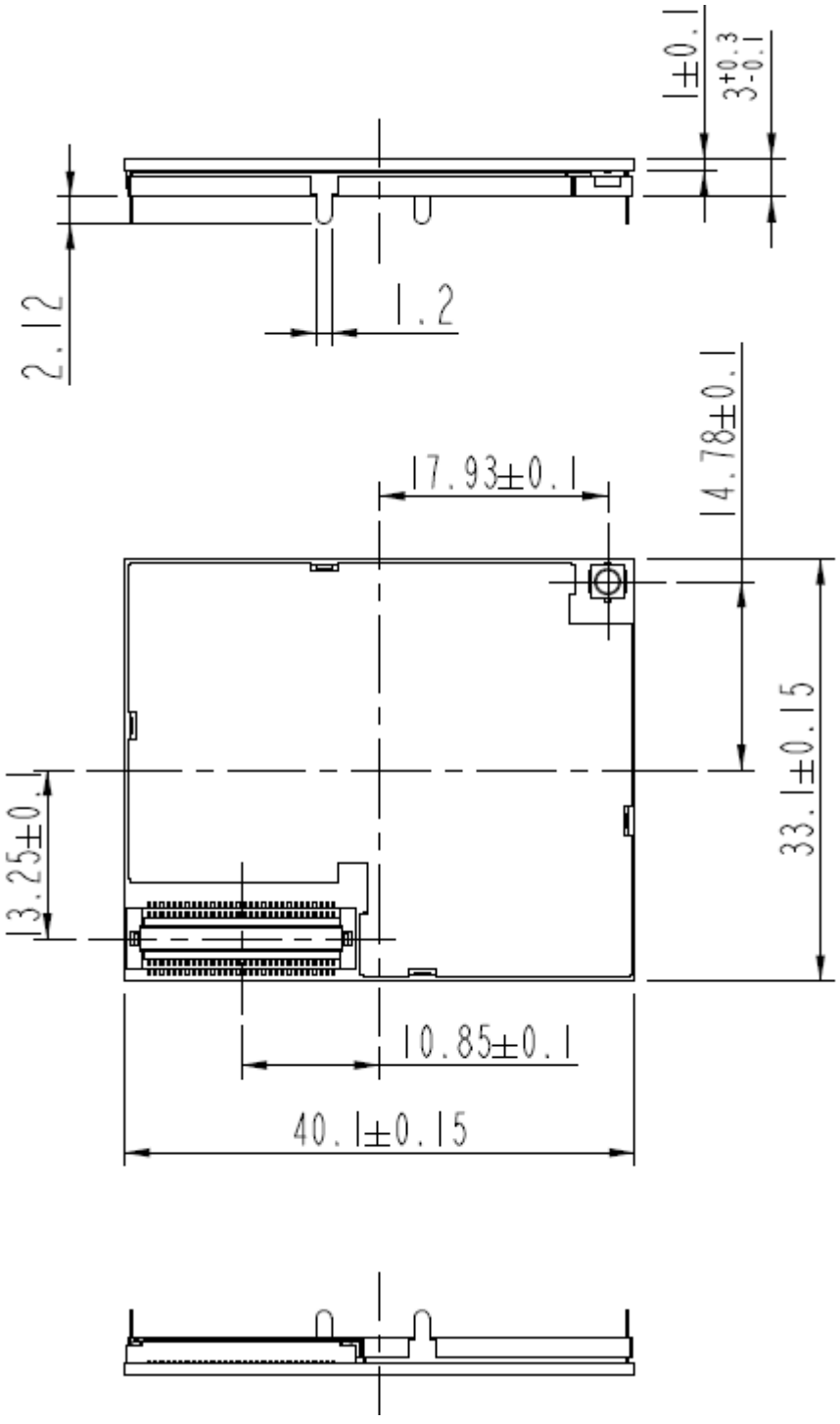


Figure 29 Top and Side mechanical dimension of MGM-312E (Unit: mm)

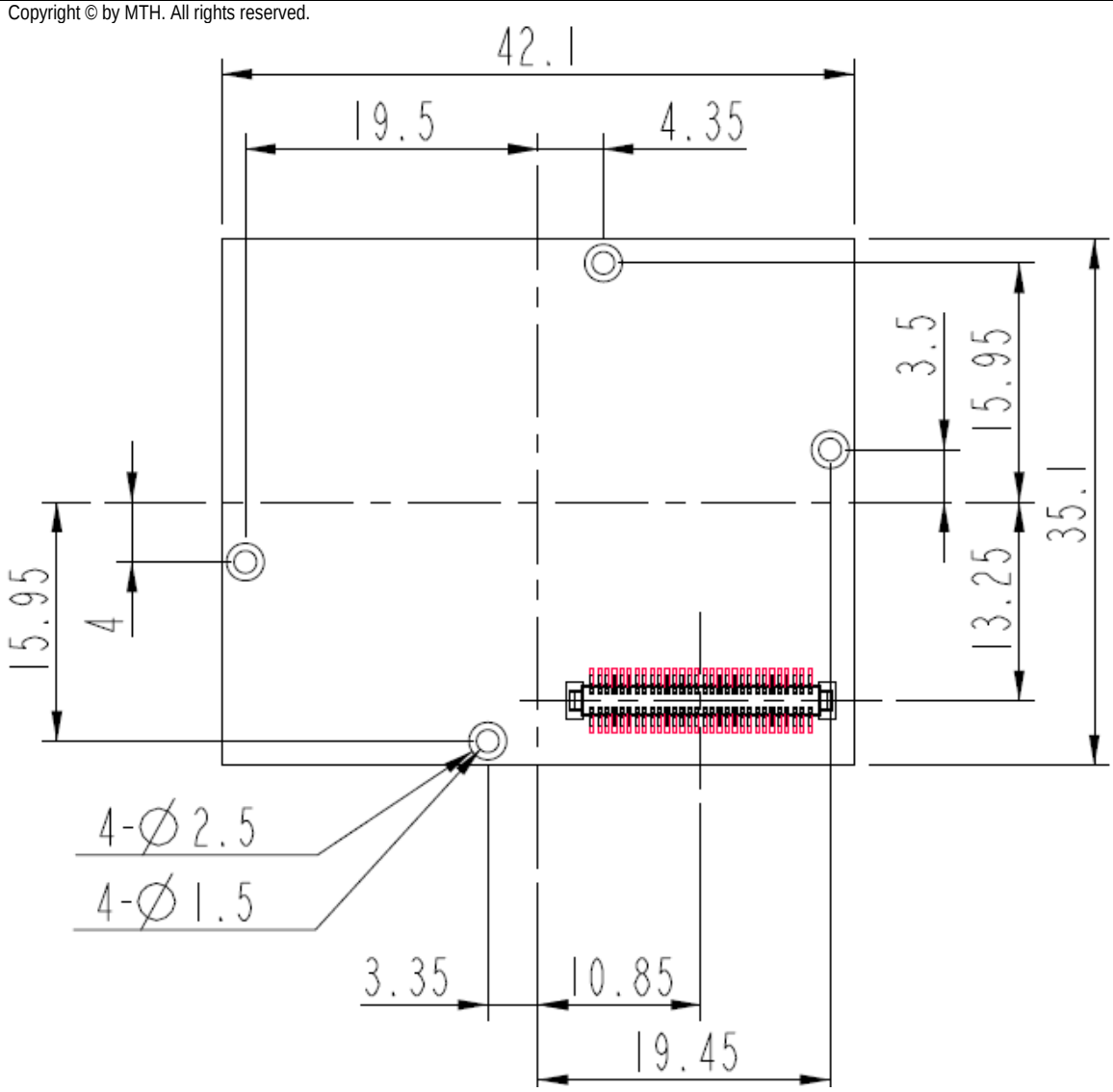


Figure 30 Recommended PCB footprint outline (Unit: mm)

5.2 Install the MGM-312E onto the host device.

There are many ways to properly install MGM-312E in the host device. An efficient approach is to mount the MGM-312E PCB to a frame, plate, rack or chassis.

For proper grounding it is strongly recommended to use the ground plane on the back side in addition to the six GND pins of the board-to-board connector. To avoid short circuits ensure that the remaining sections of the MGM-312E PCB do not come into contact with the host device.

To prevent mechanical damage, be careful not to force, bend or twist the module. Be sure it is positioned flat against the host device.

Follow the steps below to properly install MGM-312E:

1) The board-to-board connector (section5.3) should be aligned before tightening.
2) Plug one end of the RF cable to the Hirose U.FL-R-SMT connector (section5.4) on the MGM-312E module.

Furthermore, in order to send or receive data, connect an external RF antenna to the SMA connector at the front of the host device.

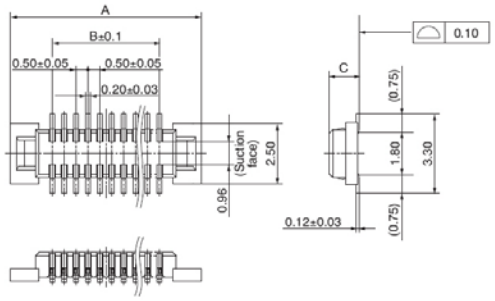
5.3 Board-to-board connector

Use the connector AXK6F60347YG (vended by PANASONIC) to fix the MGM-312E onto the customer platform.
http://www.panasonic-electric-works.se/pewn/en/html/boardtoboard_connectors.php

CAD Data

Dimension table (mm)

No. of contacts	A	B
10	5.50	2.00
12	6.00	2.50
14	6.50	3.00
16	7.00	3.50
18	7.50	4.00
20	8.00	4.50
22	8.50	5.00
24	9.00	5.50
26	9.50	6.00
30	10.50	7.00
32	11.00	7.50
34	11.50	8.00
36	12.00	8.50
40	13.00	9.50
44	14.00	10.50
50	15.50	12.00
60	18.00	14.50
70	20.50	17.00
80	23.00	19.50
100	28.00	24.50

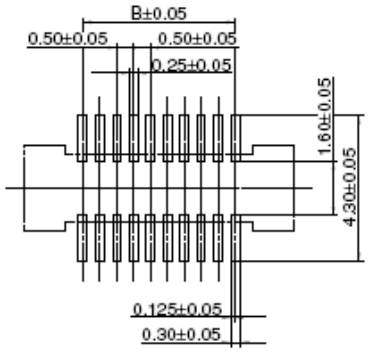


General tolerance: ±0.2

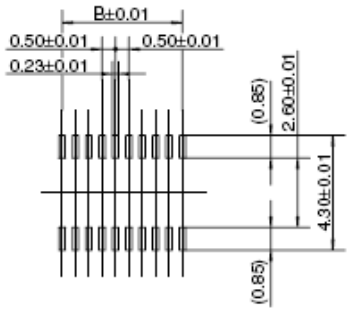
Mated height	C
1.5 mm, 2.0 mm	1.25
2.5 mm	1.75

Figure 31 AXK6F60347YG board-to-board connector

Recommended PC board pattern
(TOP VIEW)



Recommended metal mask pattern
Metal mask thickness: Here, 150 µm
(Opening area ratio: 58%)



Recommended metal mask pattern
Metal mask thickness: Here, 120 µm
(Opening area ratio: 72%)

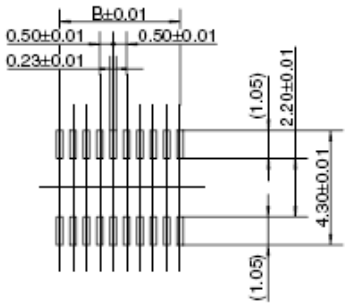


Figure 32 AXK6F60347YG PCB footprint outline (Unit: mm)

5.4 RF connector

The RF connector in the MGM-312E module side is an ultra small surface mount connectors (Part Number: U.FL-R-SMT, vended by HRS). It has high performance with wide frequency range.
http://www.hirose-connectors.com

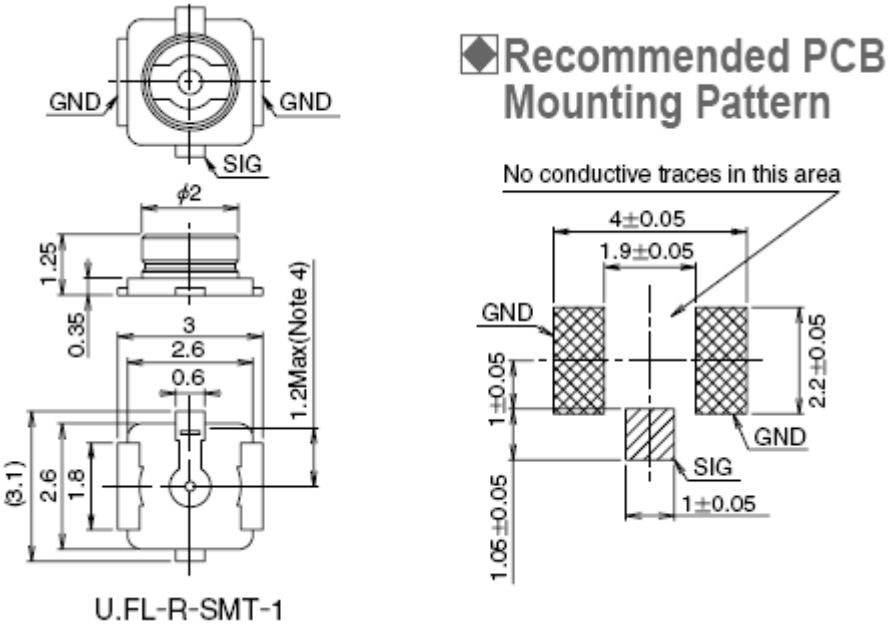


Figure 33 U.FL-R-SMT

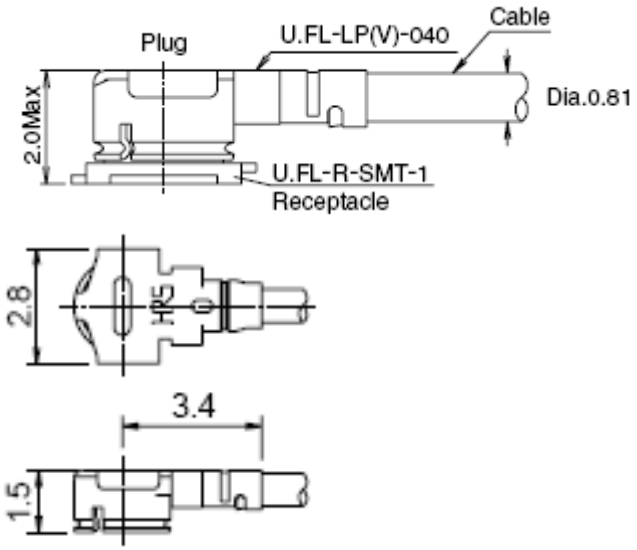


Figure 34 U.FL series RF adapter cable

5.5 Top View of the MGM-312E

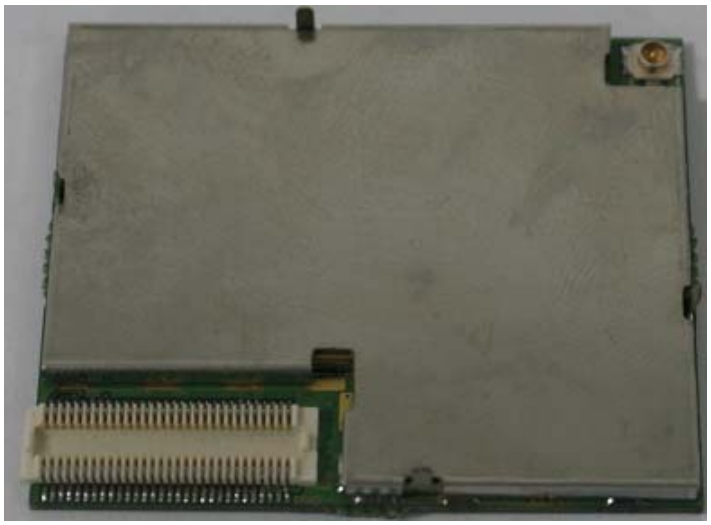


Figure 35 MGM-312E module Top view

5.6 PIN Assignment of MGM-312E

Pin No.	Pin name	I/O	Pin No.	Pin name	I/O
1	VBAT	I	2	VBAT	I
3	VBAT	I	4	VBAT	I
5	VBAT	I	6	VBAT	I
7	VBAT	I	8	VBAT	I
9	GND		10	GND	
11	GND		12	GND	
13	GND		14	GND	
15	VRTC	I/O	16	SIM_PRESENCE	I
17	VDD_EXT	O	18	DISP_DATA/USB_DP	I/O
19	SIM_VDD	O	20	DISP_CLK/USB_DM	I/O
21	SIM_DATA	I/O	22	DISP_CS	O
23	SIM_CLK	O	24	DISP_DC/USB_DET	I
25	SIM_RST	O	26	DISP_RST	O
27	ROW0/GPIO54/I2C1_SDA	I/O	28	DCD	O
29	ROW1/GPIO53/I2C1_SCK	I/O	30	NETLIGHT	O
31	ROW2/GPIO60/EXTINT15	I	32	GPIO0/BOOT	I
33	ROW3/GPIO19	I/O	34	PWRKEY	I
35	ROW4/GPIO18	I/O	36	BUZZER	O
37	COL0/GPIO49/HS_DET	I/O	38	DTR	I
39	COL1/GPIO55/I2C2_SDA	I/O	40	RXD	I
41	COL2/GPIO56/I2C2_SCK	I/O	42	TXD	O
43	COL3/GPIO16/DBG_CTS	O	44	RTS	I
45	COL4/GPIO14/DBG_RTS	I	46	CTS	O
47	DBG_RXD/GPIO15	I	48	RI	O
49	DBG_TXD/GPIO17	O	50	GND	
51	GND		52	ADC0	I
53	MIC1P	I	54	SPK1P	O
55	MIC1N	I	56	SPK1N	O
57	MIC2P	I	58	SPK2P	O
59	MIC2N	I	60	SPK2N	O

Note: The red signal of multiplexed signals is only supporting on standard firmware by the default value.

6 Regulatory Notes

The conducted power of module is 31.17dBm [850 MHz] and 28.11dBm [1900MHz]. And, the maximum antenna gains to comply with RF exposure and radiated power limits are 5.9dBi [850MHz] and 4.9dBi [1900MHz].

FCC Radiation Exposure Statement:
This device complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. To comply with FCC RF exposure compliance requirements, the antenna 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.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This device is intended only for OEM integrators under the following conditions:

1) The antenna must be installed such that 20 cm is maintained between the antenna and users.
2) The transmitter module may not be co-located with any other transmitter or antenna.

As long as 2 conditions above are met, further transmitter test will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

IMPORTANT NOTE:
In the event that these conditions cannot be met (for example, co-location with another transmitter), then the FCC authorizations are no longer considered valid and the FCC ID cannot be used on the final product. In these circumstances, the
OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining separate FCC authorizations.

INFORMATION TO USER:
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 a residential 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, 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 technician for help.

7 Document History

Revision	Date	Change Description	Author
001	14 Sep 11	Creation	

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