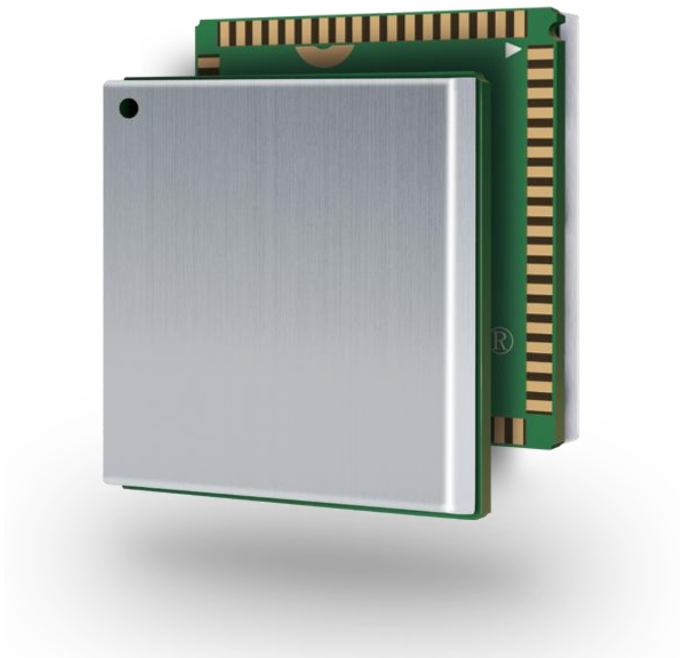
M80

Quectel Cellular Engine



Charging Application Notes

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0. Revision history

Revision	Date	Author	Description of change
1.0	2011-12-26	Ray XU	Initial

1. Introduction

This document defines M80 charging function. It can help customers quickly understand the charging function interface and electrical details of M80. Associated with M80 HD document and EVB user guide, user can use M80 module to design charging applications rapidly.

M80 provides excellent charging function for rechargingable Li-Ion or Lithium Polymer battery.

Table 1: Pin definition of the charging

Item	No.	I/O	Description.
GATDRV	74	O	Charging current control
CHGLDO	73	I	Charging power supply source
CHGDET	72	I	Charging detect
ISENSE	71	I	Current sense
BATSNS	70	I	VBAT voltage sense

The features of charging function are shown as below:

- Pulse charging
- Up to 30V maximum endure charging input voltage
- Up to 10.5V maximum charging over voltage protect (OVP)
- 4.5V minimum charging voltage
- Up to 800mA maximum charging current
- 4.2V completed charging threshold voltage
- Adjustable charging current
- BJT+N-MOSFET combination

Note：The default charging voltage is 5V and all the test data base on the 5V charging voltage.

2. Charging application

2.1. Reference circuit

Charging reference circuit is shown in Figure 1.

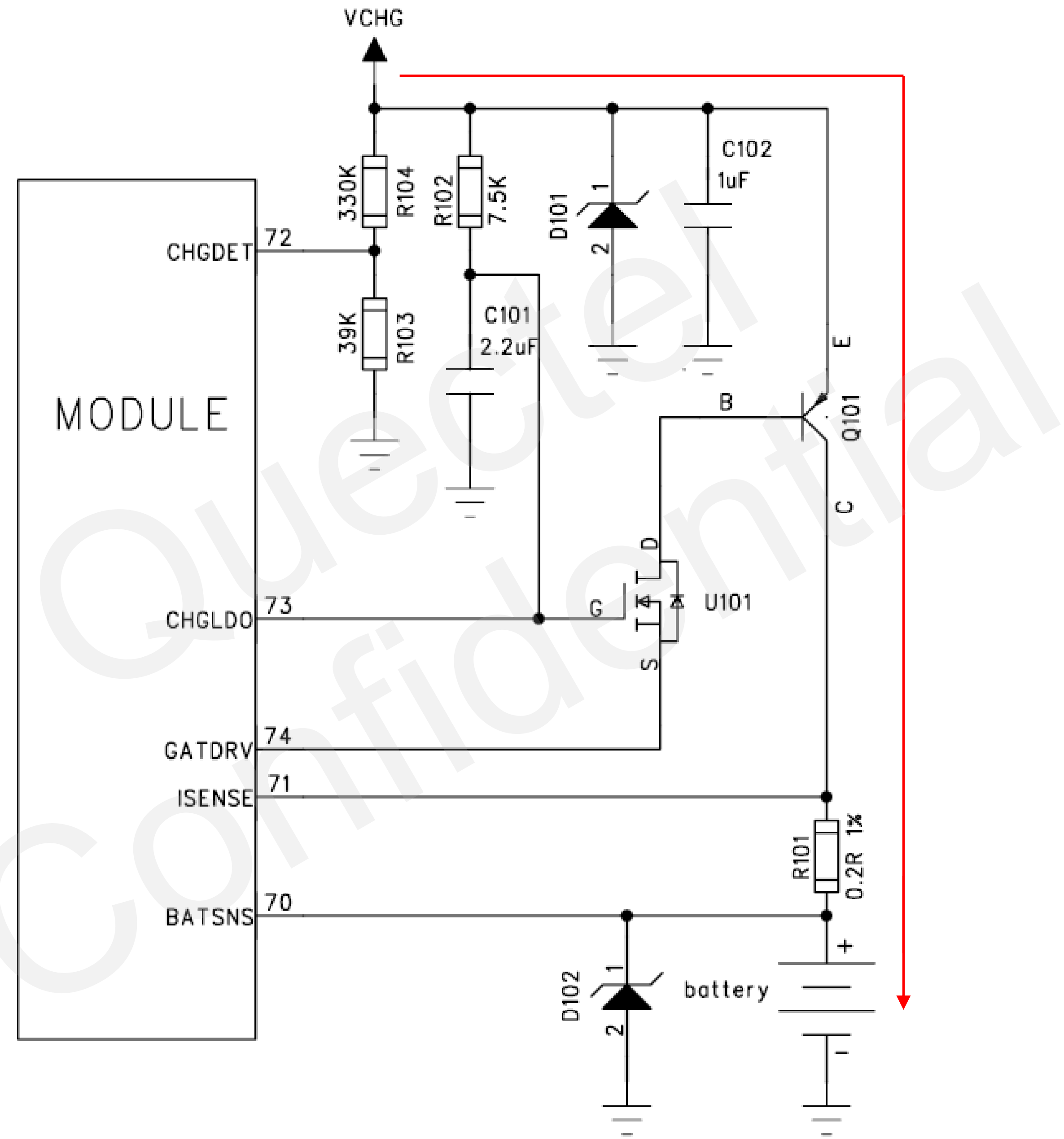

Figure 1: Charging reference circuit

The main charging current path of circuit above is shown as the red line. Q101 is a power BJT, charging current travels from emitter to collector of Q101. Module outputs control signal via

GATDRV to switch on/off U101 periodically, then U101 has a further control on/off Q101 to achieve pulse charging, meanwhile GATDRV will adjust the charging current in different charging stage. R103&R104 act as a voltage divider of VCHG to inform the module that the charger is inserted through CHGDET pin. CHGLDO pin supplies power for the internal charging module and its voltage level is 2.8V. R101, a sense resistor, is used to monitor the battery voltage and charging current in real-time. D101 and D102 are used as ESD protection.

2.2. Key component selection

The selection of key components should meet the following requirements.

Q101

- Continuous collector current should be bigger than charging current.
- Maximum total dissipation should be bigger than 1W.
- V_{CE} (collector-emitter) should be larger than 30V.
- hFE (DC current gain) is from 100 to 300 at Ic=0.5A.

U101

- V_{GS} threshold< 1.5V@I_d=0.1mA
- V_{DS}>30V
- $R_{DS(ON)}$<10ohm@I_d=10mA,V_{GS}=2.5V

R101

- Package size: 0805
- Tolerance: 1%
- Value:0.2ohm

C102

- Maximum endure voltage depends on the VCHG voltage.

The main recommended components are shown as Table 2.

Table 2: Recommended component

Part Number	Quality	Location	Brand
NSS35200MR6T1G	1	Q101	ON
MBT35200MT1G			ON
PBSS5350D			NXP
PT236T30E2			Presemi
PNM723T703E0-2	1	U101	Presemi
RL0805FR-7W0R2L	1	R101	Yageo

RL0805FR-070R2L			Yageo
WW08XR200FTL			Walsin
0805W8F200LT5E			UniOhm

2.3. Layout design rules

The following layout rules must be followed in designing the circuit.

Layout notes

- CHGLDO decouple capacitor should be close to module.
- The charging path from VCHG to battery should be more than 40mil.
- Q101 should be located as close as possible to module.
- C101 should be located as close as possible to CHGLDO pin.
- Current sense resistor should be close to battery and the trace should be more than 40mil.
- The pad of U101, a power BJT, should be connected to large copper to get a good thermal performance.
- The trace of BATSNS pin should not be shared with main VBAT trace.

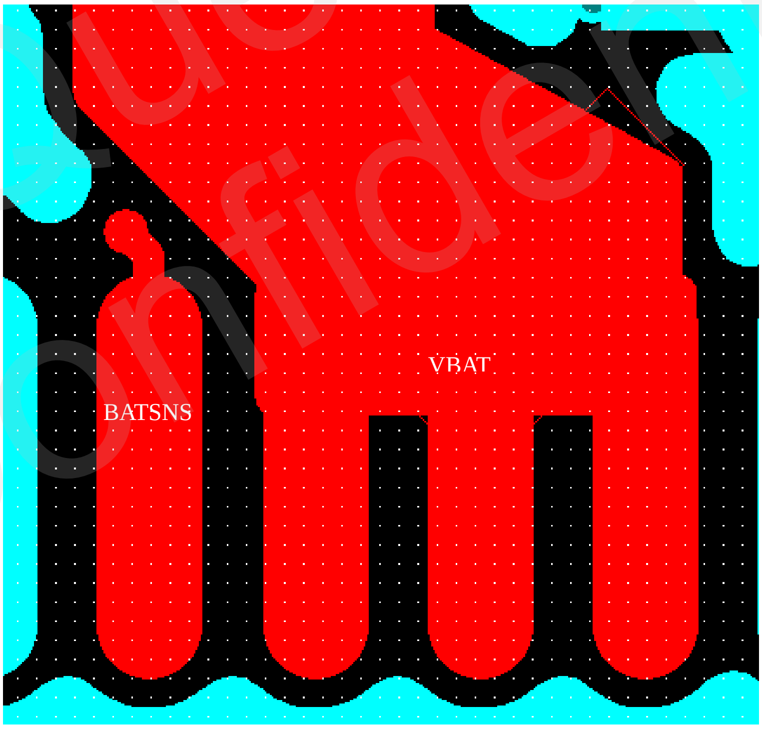

Figure 2: Layout reference

- BATSNS and ISENSE should be routed as differential trace to avoid common interference. The width of BATSNS and ISENSE is recommended as 4mil.

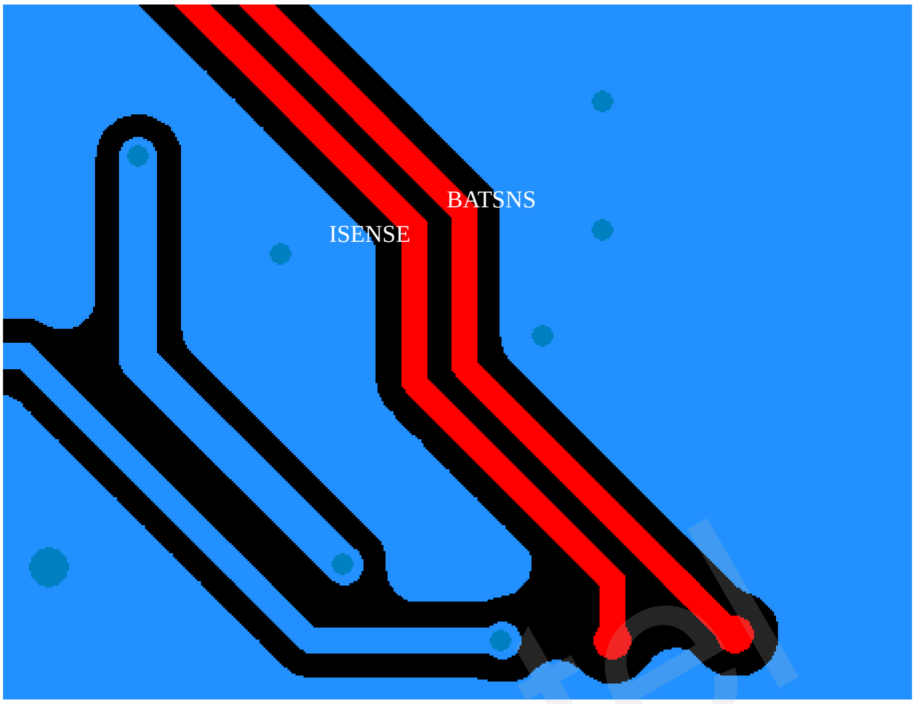

Figure 3: Layout reference

2.4. Charging procedure

Normally, there are four main states in the whole charging procedure.

- Pre-charging mode
- Constant current mode
- Top-off mode
- Re-charging mode

Pre-charging mode:

When the battery voltage is in the under-voltage lock-out protection (UVLO) state, the charger works in pre-charging mode and there are two stages in this mode. When the battery voltage is under 2.2V, the charger works in PRECC0 and its charging current ranges from 50mA to 120mA. When the battery voltage is less than 3.3V and more than 2.2V, the charger works in PRECC1 and its charging current ranges from 150mA to 200mA.

Pre-charging mode terminates when the battery voltage reaches 3.3V. Both PRECC0 and PRECC1 charging are controlled by the module hardware. But there is a difference between PRECC0 and PRECC1. PRECC0's charging current is constant while PRECC1 is pulse charging.

Constant current mode:

When the battery voltage is higher than 3.3V, the module enters constant current mode. Constant current mode is controlled by the software in the pulse charging. The charging current is determined by software and there are eight different choices for the customer: 70mA, 200mA, 400mA, 450mA, 550mA, 650mA, 700mA, 800mA. The default charging current is 650mA in constant current mode. Constant current mode terminates when the battery voltage reaches 4.05V.

Top-off mode:

When the battery voltage is more than 4.05V, the module enters top-off mode. Top-off mode is controlled by the software. The charging current in top-off mode is the same as the constant current mode. While in top-off mode, the period of pulse charing is much shorter. The module will terminate charging when the battery voltage reaches 4.2V, however, the battery voltage will drop when charging stops, so the module will restart charging twice in this mode when the battery voltage drops to 4.1V.

Re-charging mode:

The module will continue to monitor the battery voltage after top-off mode. When the battery voltage drops to 4.1V again, the module will restart charging function. We call this stage re-charging mode. When the battery voltage reaches 4.2V once more, the charging process is finished. The charging process is shown in Figure 4.

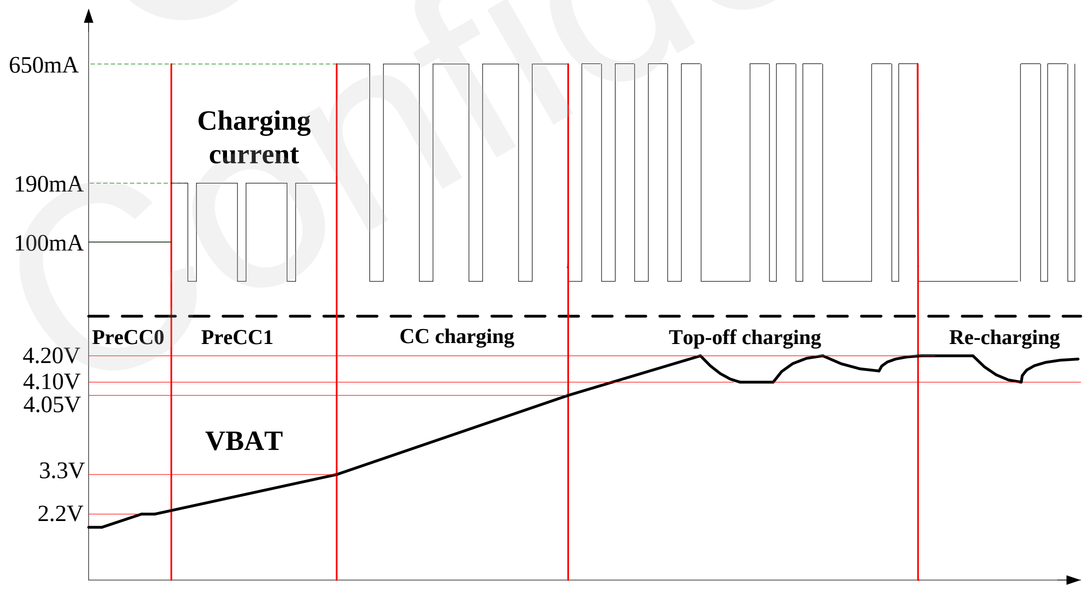

Figure 4: Normal charging process diagram

3. Charging operation modes

The battery can be charged in various working modes such as SLEEP, TALK and GPRS DATA, which is named as charging mode. The battery can be charged in POWER DOWN mode as well. It is named as GHOST mode. The following table gives the differences between Charging mode and GHOST mode.

Table 3: Charging operation modes

	Operation	**Features**
Charging Mode	Connect charger to the module's VCHG pin after connecting battery to VBAT pin of the module and put the module in one of Normal operation modes, including: SLEEP, IDLE, TALK, GPRS STANDBY, GPRS READY and GPRS DATA mode, etc.	The module is fully operational.
GHOST Mode	Connect charger to module's VCHG pin while the module is in POWER DOWN mode. Or power down the module in Charging mode.	Battery can be charged in GHOST mode. The module is not registered to GSM network. Only a few AT commands are available as listed in Table 4.

When the module is in the GHOST mode, AT commands listed in Table 4 can be used. For further instruction, please refer to ***document [1]***.

Table 4: AT Commands available in the GHOST mode

AT command	**Function**
AT+QPOWD	Power down the module
AT+CBC	Indicate charging state and voltage
AT+CFUN	Start or close the protocol The module will transfer from GHOST mode to Charging mode via AT command "AT+CFUN=1".

4. Battery characteritics

The module has optimized the charging algorithm for the Li-Ion or Lithium Polymer battery that meets the characteristics listed below. To use the module's charging algorithm properly, it is recommended that the battery pack is compliant with these specifications, as it is important for the AT command "AT+CBC" to monitor the voltage of battery properly, or the "AT+CBC" may return incorrect battery capacity value.

- The maximum charging voltage of the Li-Ion battery pack is 4.2V and the capacity is greater than 500mAh.
- The battery pack should have a protection circuit to avoid overcharging, over-discharging and over-current.
- The build-in power management chipset of the module monitors the supply voltage constantly. Once the Under-voltage is detected, the module will power down automatically. Under-voltage thresholds are specific to the battery pack.
- The internal resistance of the battery and the protection circuit should be as low as possible. It is recommended that the battery internal resistance should not exceed 70mΩ and the internal resistance including battery and protection circuit of battery pack should not exceed 130mΩ.
- The battery pack must be protected from reverse pole connection.
- The Li-Ion/Polymer battery charging protection parameter is required as the following table.

Table 5: Recommended battery protect circuit parameter

Item	Min.	Typ.	Max.
Over-charging Protect Threshold (V)	4.25	4.3	4.35
Released Voltage from Over-charging (V)	4.1		4.2
Over-discharging Protect Threshold (V)	2.2		2.35
Released Voltage from Over-discharging (V)	2.35	2.4	2.45

The following is the specification of the recommended battery pack.

Table 6: Specification of the battery pack

Item	Remark
Normal Voltage	3.7V
Capacity	Minimum 800mAh
Charging Voltage	4.20~4.23V

Max Charging Current	1.2C
Max Discharging Current	2C
Charging Method	Pulse charging
Internal Resistance	≤130mΩ
Over-charging Protect Threshold (V)	4.28 ±0.025
Released Voltage from Over-charging (V)	4.08 ±0.05
Over-discharging Protect Threshold (V)	2.3±0.1
Released Voltage from Over-discharging (V)	2.4±0.1

The data tested in M80-EVB is illustrated as below. Because the test tool, different component, tolerance of the module and other factors, the test data will not conform to the specification completely. But these tolerence are allowed, since it will not affect the charging function.The actual whole charging procedure is shown as below:

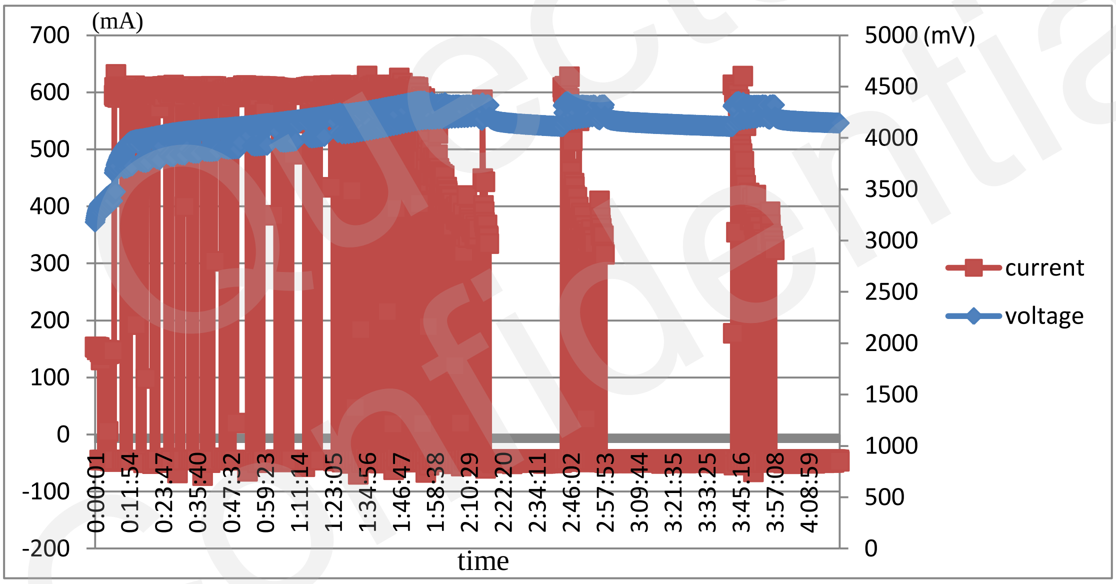

Figure 5: Normal charging process diagram in real time

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