PHAT-GSM TECHNICAL DESCRIPTION

GSM Module Series

Document: pHAT-GSM Technical Description

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About the Document

History

Revision	Description	Date	Author
Draft A	Create	27/4/19	DIO
Issue 1	First release	14/6/19	-
Issue 2	Update (Added signal quality request to python test application)	20/9/19	-
Issue 3	Added Raspberry-Pi Kernal workaround and Python 3 setup	25/1/23	-

Contents

Page No.

Tables

Figures

1 Introduction

This document defines the pHAT-GSM GSM module and describes the hardware interface that is connected to the customer's to the customers Raspberry-Pi application.
This document can help customers quickly understand module interface specifications, electrical and mechanical details, as well as other related information of the module. Associated with the quick start guide and demo software, customers can use this document to easily set up the module.

2 Product Concept

2.1 General Description

The Designer Systems pHAT-GSM is a quad-band GSM/GPRS module that works on frequencies GSM850MHz, EGSM900MHz, DCS1800MHz and PCS1900MHz supporting GPRS class 12 data and Small-Message-System (SMS) functionality. Specifically designed for the Raspberry-Pi Zero user (can also be used on all the other Raspberry-Pi variants) the pHAT-GSM features I2C communication to leave the Raspberry-Pi UART for other functions eg. sensors etc.

pHAT-GSM features full AT command control over the embedded I2C to UART bridge allowing the Raspberry-Pi to create GPRS sessions with uplink and downlink transfers at up to 85.6kbps to support standard Internet service protocols.

The compact form factor, low power consumption and extended temperature range make pHAT-GSM a best choice for M2M and M2H applications when using the Raspberry-Pi modules.

The module fully complies with the RoHS/RED directive of the European Union

2.2 Key Features

The following table describes the key features of the pHAT-GSM.

Table 1: Key Features

Features	Details
Power Supply	• Supply Voltage: 4.5 ~ 5.5VDC • Typical Supply Voltage: 5.0VDC
Power Consumption	• 10mA @ 12VDC Idle • 50mA @ 12VDC Peak
Frequency Bands	850/900/1800/1900MHz
Output Power	• Class 4 (2W @ 850/900MHz) • Class 1 (1W @ 1800/1900MHz)
Sensitivity	• GSM850: -109dBm typ. • ESM950: -109dBm typ. • DCS1800: -109dBm typ. • PCS1900: -109dBm typ.
Data Support	• GPRS Class 12: 85.6kbps upload and download • Integrated TCP/IP protocol
USSD Support	Supported
SIM Card	Micro SIM(3.0/1.8V)
Indication	Blue STATUS LED
Controls	Power ON/OFF button (also GPIO controllable)
I^2C Speed	400kHz max.
Environmental	• Operating Temperature -20℃ to 85℃ • Storage Temperature -30℃ to 125℃
Dimensions	65 x 30 x 4mm
Weight	9.8g approx.

3 Application

3.1 Installation

The module should be attached to the Raspberry-Pi board using a 20+20 2.54mmP pin header/socket (not supplied).

3.1.1 SIM Card and Antenna

Insert a standard 2G capable micro SIM card into the card connector identified as 'SIM CARD' and attach the supplied PCB antenna to the U.FL connector identified as 'ANTENNA', ensuring that the antenna is located away from any metal objects.

3.2 Operation

When power is applied to the pHAT-GSM, from the connected Raspberry-Pi board, it is possible to either manually power-up the module, by depressing the button identified as 'POWER' for > 1 second, or by setting the GPIO23 (pin 16) high for > 1 second. The module will power-up, indicated by the STATUS indicator flashing, and will register on to the network provider defined by the inserted SIM card.
Once registered the pHAT-GSM will await incoming AT commands allowing configuration, SMS send/receive and GPRS data communication.

3.3 Indication

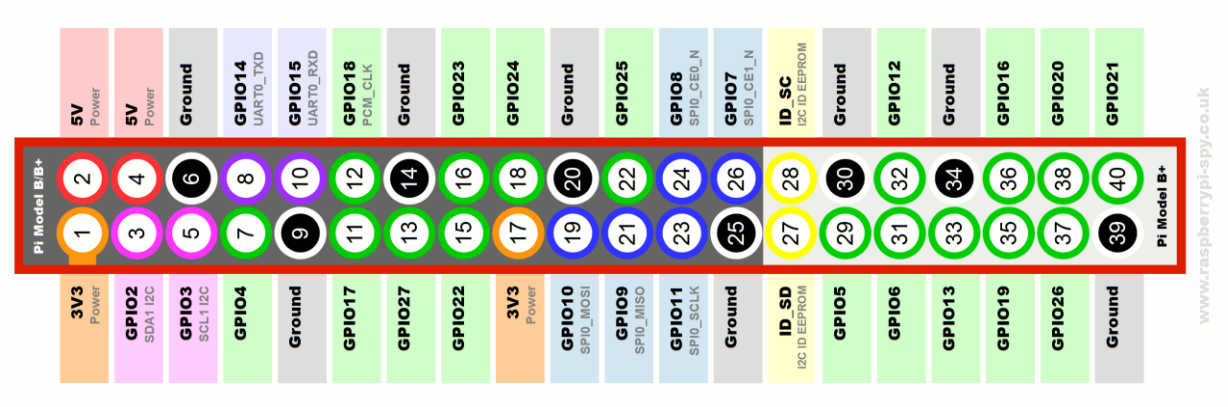
The STATUS indicator is used to provide visual feedback of the current GSM condition. There are four (4) conditions as follows.

Table 2: Status Indication

Indication	Description
OFF	Powered down
Flashing fast	Not registered to a network
Flashing once every 3 seconds	Registered to a network
Flashing very fast	GPRS session in-progress

These conditions will change as the GSM network status and modes change.

3.4 Pin Assignment



3.5 Power Supply

3.5.1 Power Supply Pins

The pHAT-GSM provides a supply input and multiple ground connections on the 20+20 header that connect to the 5.0V supply on the Raspberry-Pi board. The table below describes the module supply and ground pins.

Table 3: Power Supply Pins

Pin Name	Pin No	Description	Min	Typ.	Max	Unit
V+	2, 4	Power Supply	4.5	5.0	6.0	V
Ground	6,9,14,20, 25,30,34, 39	Power Ground				

3.6 Antenna Interface

3.6.1 Antenna Connector

The pHAT-GSM provides a 50Ω (ohm) impedance U.FL antenna connector that should be connected to an external Quad-band antenna. A suitable antenna is supplied.

Table 4: Antenna Connector

Pin Name	Pin No	I/O	Description	Comment
GSM_ANT	Inner	RF	GSM Antenna RF feed	
GND	Outer	RF	GSM Antenna RF ground	

3.7 GPIO Interface

3.7.1 GPIO Interface Pins

The pHAT-GSM provides a power control (PWR_ONOFF) connection on the 20+20 header that connects to GPIO23 on the Raspberry-Pi board. The table below describes the module GPIO pins.

Table 5: GPIO Interface Pins

Pin Name	Pin No	I/O	Description	Comment
GPIO23	16	DIO	Modem PWR_ONOFF	3.3V level

The PWR_ONOFF GPIO line can be used to control the modem power in applications where manual power on/off is not possible. Activating GPIO23 as a set output for > 1 second holds the modem power on/off line low allowing modem power-on or > 1.5 seconds for power-off.

3.8 I^2C Interface

3.8.1 I^2C Interface Pins

The pHAT-GSM provides I^2C data (SDA), clock (SCL) and interrupt (INT) connections on the 20+20 header that connect to the SDA, SCL and GPIO24 on the Raspberry-Pi board. The table below describes the module I^2C pins.

Table 6: I^2C Interface Pins

Pin Name	Pin No	I/O	Description	Comment
SDA	3	DIO	I2C Data	3.3V level
SCL	5	CO	I2C Clock	3.3V level
INT	18	DIO	Interrupt (GPIO24)	3.3V level

The pHAT-GSM does NOT have I^2C pullups but relies on the pullups present on the Raspberry-Pi board. When not connecting to a Raspberry-Pi board external pullups of 4.7Kohms should be connected on SDA and SCL to a 3.3V supply.

3.8.2 I^2C Communication

The pHAT-GSM uses an I^2C to UART bridge (NXP SC16IS750) to communicate between the Raspberry-Pi and the modem UART interface. This frees the Raspberry-Pi UART interface to be used with other serial devices. The default UART baud rate is 115200 bps which maximises data throughput between the Raspberry-Pi and modem.

3.9 Configuration

The Raspberry-Pi system configuration is undertaken by downloading and installing device tree overlay files and modifying system files to install the pHAT-GSM as a serial device.

3.9.1 File Installation

Download the product file: https://www.designersystems.co.uk/download/phat-gsm.zip and extract. The following files are included:

phat-gsm_test.py	-	Python modem test application
phat-gsm.dtbo	-	DTBO overlay file

Copy the phat-gsm.dtbo file to the /boot/overlays folder using the following command:

```
sudo cp phat-gsm.dtbo /boot/overlays/
```

3.9.2 System Tools Update and File Modification

Install the I^2C tools using the following command:

```
sudo apt-get install i2c-tools
```

Modify the /boot/config.txt file using the following command:

```
sudo nano /boot/config.txt
```

Check that the following command lines are present and add those that are missing:

```
dtparam=i2c_arm=on,i2c_arm_baudrate=400000
dtoverlay=phat-gsm
```

Press CTRL+O then return to save the file and CTRL+X to exit and then modify the /etc/modules file using the following command:

```
sudo nano /etc/modules
```

Check that the following line is present and add if missing:

```
sc16is7xx
```

Press CTRL+O then return to save the file and CTRL+X to exit and then enter the following command to reboot:

```
sudo reboot
```

3.9.3 Hardware Testing

To check that the pHAT-GSM hardware is working the I²C port communication can be checked by entering the following command:

```
i2cdetect -y 1
```

This will list all the connected I²C devices. The pHAT-GSM should show 'UU' at address 40: d (0x4D) as follows:

```
     0  1  2  3  4  5  6  7  8  9  a  b  c  d  e  f
00:          -- -- -- -- -- -- -- -- -- -- -- -- --
10: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40: -- -- -- -- -- -- -- -- -- -- -- -- -- UU -- --
50: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60: -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70: -- -- -- -- -- -- -- --
```

Additionally you should be able to list the new serial device using the following command:

```
ls -l /dev/ttyS*
```

This should return a list of serial devices, one of which should be ttySC0.

If no serial devices are listed it could be that the Raspberry-Pi Kernel you are running has a problem with the SC16IS750 I2C DTBO overlay file.

In this case re-edit the /boot/config.txt file again using the following command:

```
sudo nano /boot/config.txt
```

Change the following line:

```
dtoverlay=phat-nbiot
```

to the following:

```
dtoverlay=sc16is750-i2c,addr=0x4d,int_pin=24,fixed-
clock=14745600
```

Press CTRL+O then return to save the file and CTRL+X to exit and then enter the following command to reboot:

```
sudo reboot
```

3.9.4 Modem Testing

To check that the pHAT-GSM modem is working we have produced a small Python program that sends a software version request command and signal level request to the modem and displays the reply. To use this test program PySerial needs to be installed, which allows access to serial ports in Python.

Firstly install the Python dependencies by entering the following command:

```
sudo apt-get install python-smbus, python-dev, python-rpi.gpio
```

Or for Python 3 only systems by entering the following command:

```
sudo apt-get install python3-smbus, python3-dev, python3-
rpi.gpio
```

Additionally 'pip' installer is required to install some additional python modules so enter the following command to download get-pip.py:

```
curl https://bootstrap.pypa.io/get-pip.py -o get-pip.py
```

Then run get-pip.py to download and install pip by entering the following command:

```
sudo python get-pip.py
```

Or for Python 3 only systems by entering the following command:

```
sudo python3 get-pip.py
```

Install 'PySerial' using pip by entering the following command:

```
sudo pip install pyserial
```

Then install 'termcolor' by entering the following command:

```
sudo pip install termcolor
```

The test program can now be started by entering the following command:

```
python phat-gsm_test.py
```

The following output should be seen:

```
GPIO Initialised...

Starting modem...
```

```
Tests running...

Modem send: AT+CGMR
Modem receive: AT+CGMR

Modem receive: Revision:1418B06SIM800C24

Modem receive: OK

Modem send: AT+CSQ
Modem receive: AT+CSQ

Modem receive: +CSQ: 21,0

Modem receive: OK
```

If the above is not shown go back to Hardware Testing and check that ttySC0 is listed as a serial device.

This Python program can be used as a starting point to create your own GSM connected application

3.10 Basic AT Commands

The pHAT-GSM uses the standard 3GPP TS 27.00x AT command set for communication. Below is a description of some of the most useful basic commands.

3.10.1 AT+CREG Request Network Registration Status

On command receipt replies with current network registration status.

AT+CREG?

Replies with:

+CREG: 0,<stat>
OK

Parameter

<stat>	Decimal digit, 0 ~ 5	0 Not registered not searching 1 Registered to home network 2 Not registered but searching 3 Registration denied 4 Unknown 5 Registered, roaming

3.10.2 AT+CSQ Request Network Signal Quality

On command receipt replies with current network signal.

AT+CSQ

Replies with:

+CSQ: <rssi>,<ber>
OK

Parameter

<rssi>	Decimal digits, 0 ~ 99	0 -115 dBm or less 1 -111 dBm 2..30 -110…-54 dBm 31 -52 dBm or greater 99 Not known
<ber>	Decimal digits, 0 ~ 7	0…7 Quality value

	99 Not known

3.10.3 AT+CCID Request ICCID (SIM number)

On command receipt replies with SIM number (ICCID).

AT+CCID

Replies with:

+CCID: <iccid>
OK

Parameter

<iccid>	Hexadecimal digits, eg. 89314404000225088625	SIM number

3.11 Full AT Command Description

All other AT commands may be found within the modem AT Command Manual which can be downloaded here:
www.designersystems.co.uk/download/SIM800C_Serial_AT_Command_Manual_V1.05.pdf

4 Electrical Characteristics

4.1 Absolute Maximum Ratings

Absolute maximum ratings for power supply and voltage on digital pins of the module are listed in the following table.

Table 7: Absolute Maximum Ratings

Parameter	Min.	Max.	Unit
Power Supply Voltage (V+)	-0.3	6.0	V
Input Voltage on SDA, SCL and INT	-0.3	3.6	V
Storage temperature	-45	100	°C

4.2 Operating Conditions

Normal operational conditions are listed in the following table.

Table 8: Normal Operating Conditions

Parameter	Min.	Typ.	Max.	Unit
Power Supply Voltage (V+)	4.5	5.0	5.5	V
Input voltage on SDA, SCL and INT		3.3		V
Peak Supply Current			1	A
Operating Temperature	-20	25	85	°C

4.3 Current Consumption

Normal values for current consumption are listed in the following table.

Table 9: Current Consumption

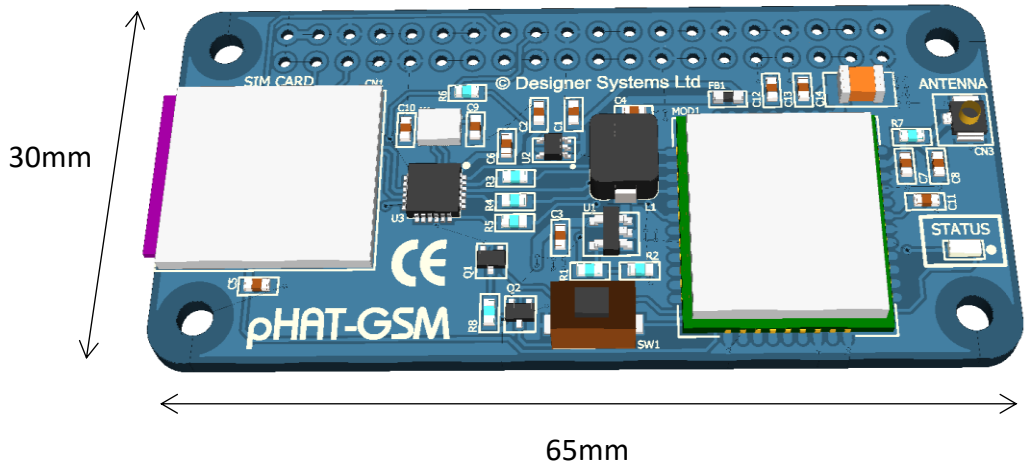
Parameter	Min.	Typ.	Max.	Unit
Supply Current – Modem OFF		2		mA
Supply Current – Network registration			80	mA
Supply Current – Idle (no sleep mode)		12		mA
Supply Current – GPRS session (EGSM900)		400		mA

5 Mechanical

5.1 Dimensions

Mechanical drawing – all dimensions in millimetres.

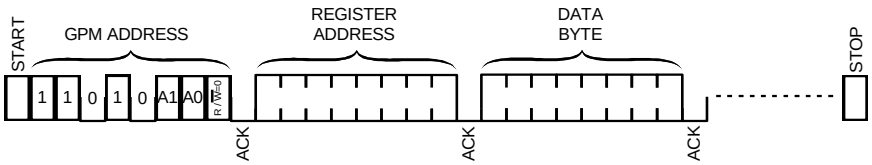
Figure 1: Dimensions



6 References

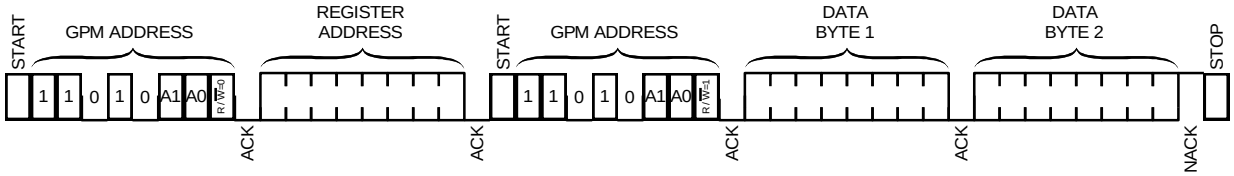
6.1 I²C protocols

Figure 2: I²C Write protocol



Multiple bytes may be written before the 'STOP' condition. Data is written into registers starting at 'REGISTER ADDRESS', then 'REGISTER ADDRESS' +1, then 'REGISTER ADDRESS' +2 etc.
Each byte transfer is acknowledged 'ACK' by the pHAT-GSM until the 'STOP' condition.

Figure 3: I²C Read protocol



'DATA BYTE 1 & 2' are register values returned from the GPM. Each byte written is acknowledged 'ACK' by the GPM , every byte read is acknowledged 'ACK' by the I2C Master. A Not-acknowledge 'NACK' condition is generated by the I2C Master when it has finished reading.

7 Appendix

Table 10: Related Documents

Document Name	Remark
SIM800C_Hardware_Design_V1.04.pdf	More information about the SIM800C modem used in this product
SIM800C_Serial_AT_Command_Manual_V1.05.pdf	More information about the SIM800C AT command set

Table 11: Terms and Abbreviations

Abbreviation	Description
GSM	Global System for Mobile Communications
SMS	Small Message System
GPRS	General Packet Radio Service
ESD	Electrostatic Discharge

8 Compliance

WEEE Consumer Notice

This product is subject to Directive 2012/19/EC of the European Parliament and the Council of the European Union on Waste of Electrical and Electronic Equipment (WEEE) and, in jurisdictions adopting that Directive, is marked as being put on the market after August 13, 2005, and should not be disposed of as unsorted municipal/public waste. Please utilise your local WEEE collection facilities in the disposition and otherwise observe all applicable requirements. For further information on the requirements regarding the disposition of this product in other languages please visit www.designersystems.co.uk

RoHS Compliance

This product complies with Directive 2011/65/EC (RoHS 2) and 2015/863/WU (RoHS 3) of the European Parliament and the Council of the European Union on the Restriction of Hazardous Substances (RoHS) which prohibits the use of various heavy metals (lead, mercury, cadmium, and hexavalent chromium), polybrominated biphenyls (PBB) and polybrominated diphenyl ethers (PBDE), Bis(2-Ethylhexyl) phthalate (DEHP), Benzyl butyl phthalate (BBP), Dibutyl phthalate (DBP) and Diisobutyl phthalate (DIBP).

REACH Compliance

This product complies with Regulation 1907/2006 covering the Registration, Evaluation, Authorisation and restriction of Chemicals (REACH). Designer Systems Ltd confirms that none of its products or packaging contain any of the 174 Substances of Very High Concern (SVHC) on the REACH Candidate List in a concentration above the 0.1% by weight allowable limit.

RED Compliance

This product complies with the Radio Equipment Directive 2014/53/EU (RED) for health and safety, electromagnetic compatibility (EMC) and efficient use of the radio spectrum.