AN1373

Using PIC32 MCUs to Develop GSM/GPRS/GPS Solutions

Authors: *Adam Folts*
Microchip Technology Inc.,
with contributions from u-blox AG

INTRODUCTION

Technologies that allow both wireless and wired systems to communicate with other devices of the same ability are referred to as Machine-to-Machine (M2M). M2M uses a device to capture an event, which is then relayed through a network to an application that translates the event into meaningful information. A common application of M2M is fleet management, where vehicle tracking is wirelessly transmitted to a central monitoring office over cellular networks.

There are many popular M2M applications, one of which is a utility meter. One of the major benefits of a M2M-based utility meter over a traditional one, is immediate operational efficiency from reading and programming meters remotely, which eliminates the need to physically visit the meter.

Another application becoming more popular with M2M technology is in-car GPS navigation. With this technology, consumers now have a complete GPS navigation system in their vehicles. This technology can be used to track a driver's current location, or provide a map for directions. Also, the consumer can make an emergency call from the same device that is doing the tracking. Businesses can use this technology for parking lots to know how long a vehicle has been parked and to charge it accordingly.

The Microchip M2M PICtail™ Plus Daughter Board (referred to as the M2M Board) developed by u-blox AG, was designed to connect directly to the PICtail™ interface of the Multimedia Expansion Board (MEB), but can also be used with any PIC32 microcontroller.

This application note describes a reference design that enables the implementation of GSM/GPRS/GPS connectivity using a PIC32 microcontroller (MCU), the M2M Board, and the MEB.

Feature Overview

The M2M PICtail Plus Daughter Board contains many features, including GSM, GPRS, and GPS.

- Global System for Mobile Communication (GSM)

  GSM is a popular world-wide standard for mobile telephone systems. GSM includes technologies in both signaling and speech channels, which are digital; therefore, GSM is considered a *Second Generation* (i.e., 2G) mobile phone system. This facilitates the wide-spread implementation of data communication applications into the system. GSM also implements a Short Message Service (SMS), called text messaging.

- General Packet Radio Service (GPRS)

  GPRS is a service on 2G and 3G cellular communication systems (GSM). GPRS provides data rates of 56-114 kbps, which provides users with the capability to connect to the Internet.

- Global Positioning System (GPS)

  GPS is a space-based navigation system that provides reliable location and time information in all weather conditions and at all times, and anywhere on or near the Earth when and where there is an unobstructed line of sight to four or more GPS satellites. It is freely accessible by anyone with a GPS receiver.

Functionality

The main functionality of the M2M Board is accomplished using two communications modules from u-blox A, which is a company that specializes in GSM/GPS ICs. For more information, visit www.u-blox.com.

The M2M Board was designed to connect to Microchip's MEB. The MEB uses Microchip's PIC32 starter kit collection as the primary controller source. This suite makes it easy to start and implement embedded controller projects due to its:

- Built-in debugger
- USB power source
- On-board header for easy attachment to PCBs
- PIC32 device with high-speed performance and no peripheral loss

HARDWARE DESCRIPTION

As previously mentioned, the M2M Board is built around two controller modules, the LEON-G200 and the NEO-6Q, which are available from u-blox AG.

The LEON-G200 is a Quad Band GSM/GPRS data and voice module. Communications to the module are through AT commands. The UART module on the PIC32 device handles the AT commands. The LEON-G200 handles the GPS communications to the NEO-6Q module. The module also contains 1 MB of non-volatile memory that can be used for storing local or Internet files.

The NEO-6Q GPS module uses the u-blox six-positioning engine for its GPS positions support. In this hardware setup, it acts as a slave to the LEON-G200, but can be a stand-alone module with its own set of AT commands. For more information on these two modules and a list of AT commands, visit www.u-blox.com.

A block diagram of the reference design is provided in Figure 1.

The M2M Board connects to expansion slot header J5 of the MEB. Figure 1 illustrates the connector pins. Descriptions of each pin are listed in Table 1.

FIGURE 1: SCHEMATIC OF CONNECTOR TO MEB

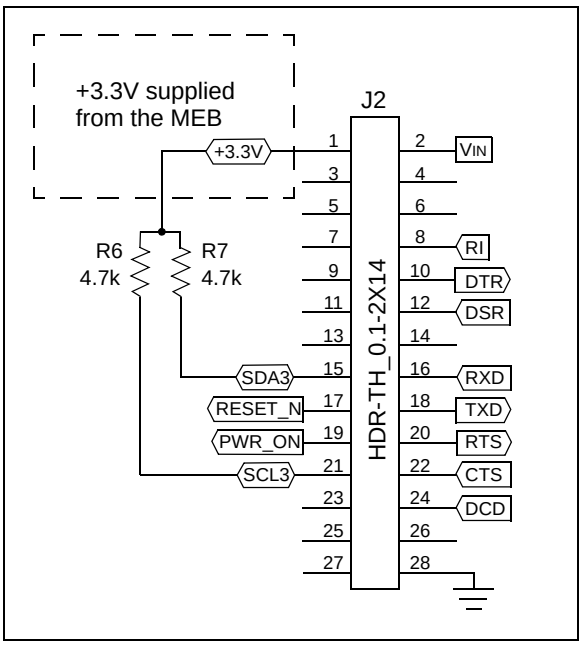
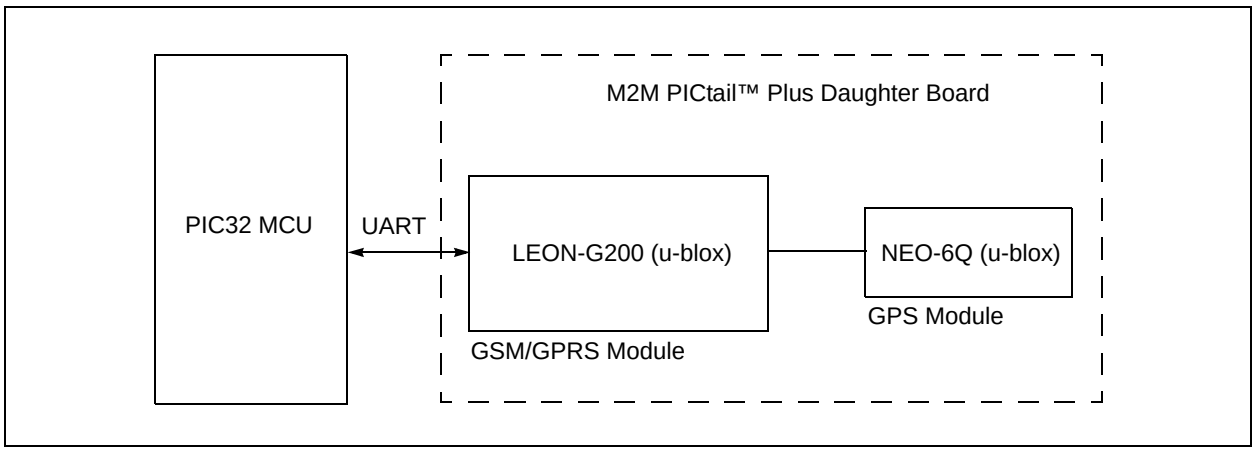


FIGURE 2: REFERENCE DESIGN BLOCK DIAGRAM



The M2M board also implements the following:

- SAW filter

  The filter is located in front of the LNA to improve the GPS interference immunity (outband interference from collocation of near field Wireless communication). The SAW-LNA-SAW chain is implemented for best immunity and performance.

- SIM holder

  The holder is used for the SIM card, which enables GPRS/GSM communication evaluation.

- RF SMA Connector

  The connector is located in front of antenna detection and switch circuitry, which allows automatic hardware detection and connection onto a GPS external antenna. Using an external GPS external antenna is optional and allows for better GPS performance under poor GPS conditions.

Figure 3 provides a detailed diagram of the M2M Board.

FIGURE 3: M2M PICtail™ PLUS DAUGHTER BOARD BLOCK DIAGRM

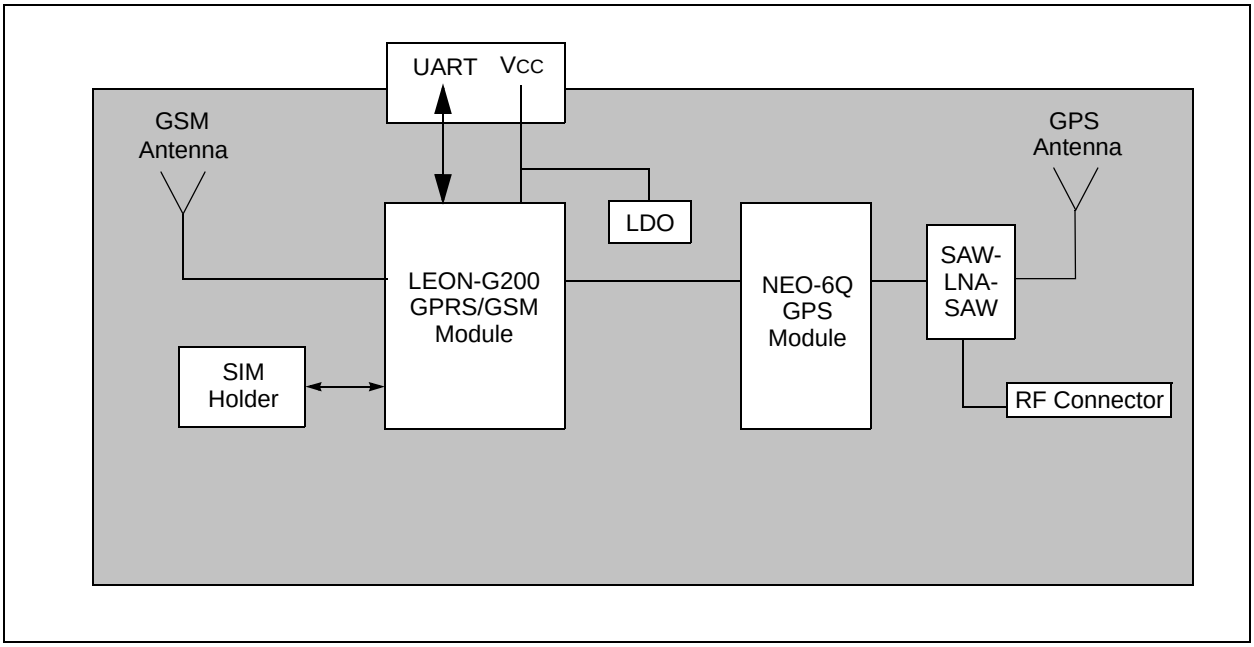


TABLE 1: MEB CONNECTOR PIN DESCRIPTIONS

Connector Pin Name	MEB Pin Name	Description
RI	WIFI_SDO	UART ring indicator
DTR	WIFI_SDI	UART data terminal ready
DSR	WIFI_SCK	UART data set ready
RXD	SDI3A	UART receive data
TXD	SDO3A	UART transmit data
RTS	SCK3A	UART ready to send
CTS	SS3A/RF12	UART clear to send
DCD	WIFI_CS	UART data carrier detect
PWR_ON	C2OUT/AN9	Turns the device on/off
RESET_N	RA10	Holds the device in reset

As seen in Table 1, most of the communication to the LEON-G200 is handled through the UART.

The MEB communicates to the M2M Board through the UART. The baud rate can be an auto baud rate, and most of the common baud rates are acceptable.

The PIC32 family of devices offer the same peripherals as seen on previous Microchip devices.

See **"References"** for links to information on the hardware and the PIC32 device used in this reference design.

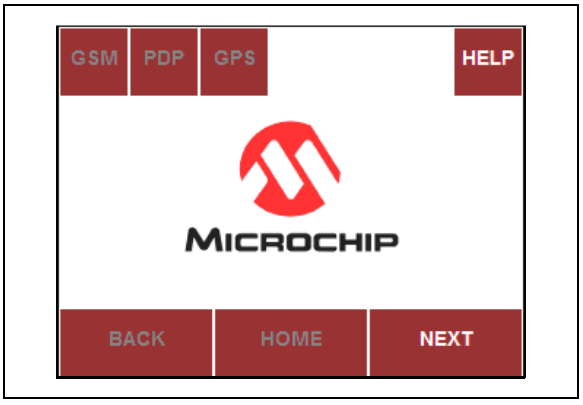
DEMONSTRATION DESCRIPTION

This section describes in detail what is contained in the GSM/GPRS/GPS demonstration. Some of the images may contain different graphics than those shown in this application note, but the basic functionality of the demonstration is still present.

The MEB contains a 3.2" QVGA touch screen display, making the demonstration easy to follow, and shows how each service is set up. The Debug output of the PIC32 Starter Kit can be used to see which u-blox commands are being used throughout the demonstration.

The demonstration starts with the initialization of all GSM/GPS/GPRS services. Notice in Figure 4 that most buttons seem disabled except for HELP and NEXT. Selecting NEXT initializes the M2M Board setup. The M2M Board requires a SIM card with a data plan to be inserted into the back of it in order for the GSM/GPRS demonstrations to function. The initialization step has three screens that initialize GPS, GPRS, and GPS technologies, one at a time. Some technologies require some time (10-30 seconds) for their service provider to respond.

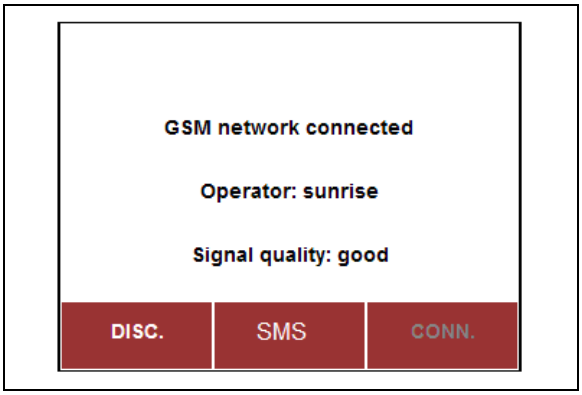
FIGURE 4: MAIN DEMO SCREEN



The GSM demonstration shows the current signal strength and the service provider. With this demonstration, the user can also send a text message by selecting the SMS button, as shown in Figure 5. Once SMS is selected, the user will be taken to a screen where they can enter a phone number. Once the number is entered and a SIM card is inserted into the M2M Board, a message from the M2M Board will be sent to that phone number.

By default, the M2M demonstration has SMS receiving turned ON. This means that if a text message is sent to the board, the demo will pause and show the number and message received, and then return to the demo.

FIGURE 5: GSM DEMO SCREEN



The GPRS demo (see Figure 6) shows to which IP address the device is connected. This screen initiates the basic Internet connection needed to create demonstrations, such as an e-mail service, simple Web browsing, and any other 2G phone feature involving an Internet connection.

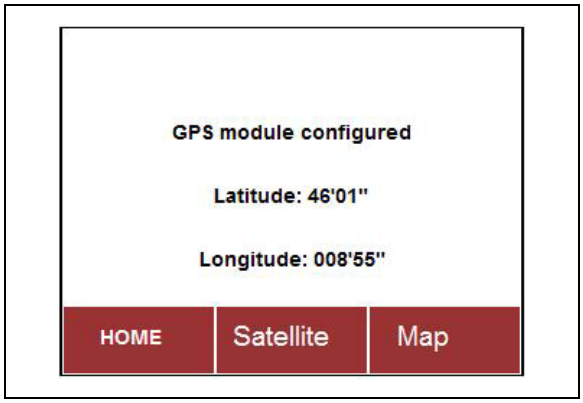
FIGURE 6: GPRS DEMO SCREEN

The GPS demonstration shows the current longitude and latitude coordinates, as shown in Figure 7.

The Email button will become enabled when an active SIM card is present with data services available. By selecting the Email button, the user will be sent to a screen where an e-mail address can be entered, and if an e-mail server has been set up correctly, an e-mail can be sent. Refer to the `BYTE acdEmailSetup()` function to change the email server name. The M2M board does not support SSL-based SMTP servers. The Map button will remain enabled until GPS data is available.

Note:	GPS data is not ready until the LED labeled TIMEPULSE on the M2M Board is blinking green.

FIGURE 7: GPS DEMO SCREEN



The map demo uses HTTP requests and the on-board 1 MB of memory to receive and store an image from the Internet. The image is from Google Maps and shows the current GPS location of the M2M Board. The demo only shows a static image of the current location, and is not configured for navigation. GSM, GPRS, and GPS capabilities need to be active for this demo to be enabled. Make sure the SIM card attached is active and that data services are available.

FIGURE 8: MAP DEMO SCREEN

GSM/GPRS/GPS STACK DESCRIPTION

The GSM/GPRS/GPS stack was built around u-blox communication commands. The basic commands can be found on the u-blox AG website at: www.u-blox.com.

This section describes in detail the high-level commands listed in Table 2, which are needed to interface with the GSM/GPRS/GPS stack. Detailed descriptions of each function are provided following the table.

TABLE 2: ENUMERATOR AND FUNCTION DESCRIPTIONS

Structure	Enumerator	Description
UBX_STATUS	UBX_S_SYSTEM_CONFIGURED	u-blox high-level interface is configured.
	UBX_S_SYSTEM_NOT_CONFIGURED	u-blox high-level interface is not configured.
	UBX_S_BOARD_POWERED	C16-G26Q plug-in board is powered-on.
	UBX_S_BOARD_NOT_POWERED	C16-G26Q plug-in board is powered-off.
	UBX_S_BOARD_PRESENT_LEONG200	C16-G26Q plug-in recognized as LEON-G200.
	UBX_S_BOARD_PRESENT	C16-G26Q plug-in board is present.
	UBX_S_BOARD_NOT_PRESENT	C16-G26Q plug-in board is not present.
	UBX_S_SIM_PRESENT	SIM card is present.
	UBX_S_SIM_NOT_PRESENT	SIM card is not present.
	UBX_S_PIN_ENABLED	PIN on SIM card is enabled.
	UBX_S_PIN_NOT_ENABLED	PIN on SIM card is not enabled.
	UBX_S_GSM_CONFIGURED	GSM module is configured.
	UBX_S_GSM_NOT_CONFIGURED	GSM module is not configured.
	UBX_S_GSM_NETWORK_REGISTRED	GSM network is registered.
	UBX_S_GSM_NETWORK_NOT_REGISTRED	GSM network is not registered.
	UBX_S_PDP_CONFIGURED	GPRS is configured.
	UBX_S_PDP_NOT_CONFIGURED	GPRS is not configured.
	UBX_S_PDP_SERVICE_REGISTRED	GPRS service is available.
	UBX_S_PDP_SERVICE_NOT_REGISTRED	GPRS service is not available.
	UBX_S_GPS_CONFIGURED	GPS is configured.
	UBX_S_GPS_NOT_CONFIGURED	GPS is not configured.
	UBX_S_GPS_POWERED	GPS is powered on.
	UBX_S_GPS_NOT_POWERED	GPS is powered off.
	UBX_S_GPS_ASSIST_LOCAL	GPS with local aiding.
	UBX_S_GPS_ASSIST_NONE	GPS without local aiding.
	UBX_S_GPS_ASSIST_OFFLINE	GPS AssistNow is off-line.
	UBX_S_GPS_ASSIST_ONLINE	GPS AssistNow is on-line.
UBX_ERROR	UBX_E_OK	Success.
	UBX_E_ERROR	Error, handling is required.
	UBX_E_WARNING	Warning, can be ignored.
UBX_GPS_ASSIST_MODE	UBX_GPS_ASSIST_LOCAL	Power-on GPS with local aiding (use GSM cell info where possible).
	UBX_GPS_ASSIST_OFFLINE	Power-on GPS with AssistNow off-line (use 14 days almanac).
	UBX_GPS_ASSIST_ONLINE	Power-on GPS with AssistNow on-line.
HTTP_REQUESTS	HEAD	Head command.
	GET	Get command.
	DELETE	Delete command.
	PUT	Put command.
	POST_FILE	Post file command.
	POST_DATA	Post data command.

Stack API Functions

UBX_ERROR ubxConfigureBoard(void)

Description

This function configures the C16-G26Q plug-in board.

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

Example

See Example 1.

UBX_ERROR ubxConfigureGps(void)

Description

This function configures the GPS module.

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

Example

See Example 3.

UBX_ERROR ubxConfigureGsm(void)

Description

This function configures the GSM network.

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

Example

See Example 2.

UBX_ERROR ubxConfigurePdp(char *apn)

Description

This function configures the GPRS service depending on the operator's access point name.

Parameters

[in] *apn* Operator's Access Point Name (APN)

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

Example

See Example 4.

UBX_ERROR ubxConfigureSystem(UINT32 freq)

Description

This function configures the u-blox high-level interface.

Precondition

u-blox high-level interface should *not* be already configured

Parameters

[in] *freq* System (core) frequency

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

Example

```
#include <plib.h>

#include "libubx.h"
#include "libp32.h"

UBX_ERROR rc;

rc = ubxConfigureSystem(SYSTEM_FREQ);

if (rc != UBX_E_OK)
{
    return;
}

DBPRINTF("System core is running at %d Hz\n", p32GetSystemClock());
DBPRINTF("Peripheral bus is running at %d Hz\n", p32GetPeripheralBusClock());
```

UBX_ERROR ubxGetBoardPowerStatus(void)

Description

This function returns the status of the C16-G26Q plug-in board power.

Returns

- UBX_S_BOARD_POWERED
- UBX_S_BOARD_NOT_POWERED

UBX_STATUS ubxGetBoardStatus(void)

Description

This function returns the status of the C16-G26Q plug-in board.

Returns

- UBX_S_BOARD_PRESENT_LEONG200
- UBX_S_BOARD_PRESENT
- UBX_S_BOARD_NOT_PRESENT

UBX_STATUS ubxGetGpsAssistStatus(void)

Description

This function returns the current aiding mode of the GPS module.

Returns

- UBX_S_GPS_ASSIST_LOCAL
- UBX_S_GPS_ASSIST_NONE
- UBX_S_GPS_ASSIST_OFFLINE
- UBX_S_GPS_ASSIST_ONLINE

UBX_STATUS ubxGetGpsPowerStatus(void)

Description

This function returns the power status of the GPS module.

Returns

- UBX_S_GPS_POWERED
- UBX_S_GPS_NOT_POWERED

UBX_STATUS ubxGetGpsStatus(void)

Description

This function returns the status of the GPS module.

Returns

- UBX_S_GPS_CONFIGURED
- UBX_S_GPS_NOT_CONFIGURED

UBX_ERROR ubxGetGsmNetworkOperator(char* netop)

Description

This function returns the name of the GSM network operator.

Parameters

`[out]` *netop* GSM network operator, null-terminated string

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

UBX_ERROR ubxGetGsmNetworkSignal(UINT32 *netss, char *netss_text)

Description

This function returns the signal strength of the GSM network.

Parameters

`[out]` *netss* GSM network signal strength, integer [0...5]

`[out]` *netss* GSM network signal strength, null-terminated string

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

UBX_STATUS ubxGetGsmNetworkStatus(void)

Description

This function returns the status of the GSM network registration.

Returns

- UBX_S_GSM_NETWORK_REGISTRED
- UBX_S_GSM_NETWORK_NOT_REGISTRED

Example

See Example 2.

UBX_STATUS ubxGetGsmStatus(void)

Description

This function returns the status of the GSM network.

Returns

- UBX_S_GSM_CONFIGURED
- UBX_S_GSM_NOT_CONFIGURED

Example

See Example 2.

UBX_ERROR ubxGetPdpServiceAddress(char *ipadd)

Description

This function returns the IP address from GPRS service (current context).

Parameters

`[out]` *ipadd* GPRS service address, null-terminated string

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

UBX_STATUS ubxGetPdpServiceStatus(void)

Description

This function returns the status of the GPRS services.

Returns

- UBX_S_PDP_SERVICE_REGISTRED
- UBX_S_PDP_SERVICE_NOT_REGISTRED

UBX_STATUS ubxGetPdpStatus(void)

Description

This function returns the status of the GPRS module configuration.

Returns

- UBX_S_PDP_CONFIGURED
- UBX_S_PDP_NOT_CONFIGURED

UBX_STATUS ubxGetPinStatus(void)

Description

This function returns the status of the PIN code.

Returns

- UBX_S_PIN_ENABLED
- UBX_S_PIN_NOT_ENABLED

UBX_STATUS ubxGetSimStatus(void)

Description

This function returns the status of the SIM card.

Returns

- UBX_S_SIM_PRESENT
- UBX_S_SIM_NOT_PRESENT

UBX_STATUS ubxGetSystemStatus(void)

Description

This function returns the status of the u-blox high-level interface.

Returns

- UBX_S_SYSTEM_CONFIGURED
- UBX_S_SYSTEM_NOT_CONFIGURED

Example

```
#include <plib.h>

#include "libubx.h"

UBX_ERROR rc;

rc = ubxConfigureSystem(SYSTEM_FREQ);

if (ubxGetSystemStatus() != UBX_S_SYSTEM_CONFIGURED)
{
    return;
}

DBPRINTF("\nSystem configured\n");
```

UBX_ERROR ubxPowerOffBoard(void)

Description

This function turns off power to the C16-G26Q plug-in board.

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

UBX_ERROR ubxPowerOffGps(void)

Description

This function turns off power to the GPS module.

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

UBX_ERROR ubxPowerOnBoard(void)

Description

This function turns on power to the C16-G26Q plug-in board.

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

UBX_ERROR ubxPowerOnGps(UBX_GPS_ASSIST_MODE mode)

Description

This function turns on power to the GPS module.

Parameters

`[in]` *mode* GPS aiding mode

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

Example

See Example 3.

UBX_ERROR ubxRegisterGsmNetwork(void)

Description

This function registers to the GSM network.

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

Example

See Example 2.

UBX_ERROR ubxRegisterPdpService(void)

Description

This function registers to GPRS services.

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

Example

See Example 4.

UBX_ERROR ubxSendGsmShortMessage(char *gsmsn, char *sms)

Description

This function sends an SMS (text message) via the GSM network.

Parameters

[in]	*gsmsn*	GSM subscriber number
[in]	*sms*	Short message (160 character maximum)

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

UBX_ERROR ubxUnregisterGsmNetwork(void)

Description

This function unregisters from the GSM network.

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

UBX_ERROR ubxUnregisterPdpService(void)

Description

This function unregisters from the GPRS services.

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

UBX_ERROR ubxUpdateGpsContext(GPS_CONTEXT context)

Description

This function updates a GPS data context (read only selected message).

Parameters

`[in]` *context* GPS data context to update

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

Example

```
#include <stdlib.h>
#include <plib.h>

#include "libubx.h"
#include "libgps.h"

 UBX_ERROR rc;
 GPS_DATA_GGA *gga;

 rc = ubxUpdateGpsContext(GPS_C_GGA);
 gga = gpsGetGGA();

 DBPRINTF("Altitude: %i m/sl\n", atoi(gga->alt));
 DBPRINTF("Latitude: %f %s\n", atof(rmc->lat), rmc->lat_ns);
 DBPRINTF("Longitude: %f %s\n", atof(rmc->lon), rmc->lon_ew);
```

UBX_ERROR ubxUpdateGpsFullContext(void)

Description

This function updates all GPS data context (read all messages).

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

Example

```
#include <stdlib.h>
#include <plib.h>

#include "libubx.h"
#include "libgps.h"

UBX_ERROR rc;
GPS_DATA_GSV *gsv;
GPS_DATA_RMC *rmc;

rc = ubxUpdateGpsFullContext();
gsv = gpsGetGSV();
rmc = gpsGetRMC();
DBPRINTF("Number of satellites used for tracking: %d\n", atoi(gsv->nst));
DBPRINTF("Latitude: %f %s\n", atof(rmc->lat), rmc->lat_ns);
DBPRINTF("Longitude: %f %s\n", atof(rmc->lon), rmc->lon_ew);
```

UBX_ERROR ubxVerifyPin(char *pin)

Description

This function verifies the Pin code.

Parameters

[in] *pin* Pin code (null-terminated string)

Returns

- UBX_E_OK
- UBX_E_ERROR
- UBX_E_WARNING

BYTE acdEmailSetup()

Description

This function sets up initial communications with an SMTP server. The M2M Board does not have SSL capabilities. The sender of the e-mail is also setup here.

Returns

BYTE showing return value of SMTP request. Value is 0 if no error.

BYTE acdSendEmail(char *Recipient, char *Subject, char *Message)

Description

This function sends an e-mail.

Parameters

[in]	*Recipient*	character string of the e-mail to send the e-mail to
[in]	*Subject*	character string of the subject of the e-mail
[in]	*Message*	character string of the message of the e-mail

Returns

BYTE value showing return value of SMTP request, value is 0 if no error.

BYTE acdHTTPRequest(BYTE requesttype, char *Servername, char *FileLocation, char *Filename)

Description

This function sends an e-mail.

Parameters

[in]	*requesttype*	BYTE defining HTTP request type (HEAD, GET, DELETE, PUT, POST_FILE, POST_DATA)
[in]	*Servername*	Character string of server name
[in]	*FileLocation*	Character string of server file location
[in]	*Filename*	Character string of M2M file to save the file from HTTP server to LEON-G200 memory

Returns

BYTE value showing return value of HTTP request. Value is 0 if no error.

`int acdReadM2MFile(char *Filename, unsigned char *File)`

Description

This function sends an e-mail.

Parameters

[in]	*FileName*	Character string of Filename of local file
[in]	*File*	Character string of File in PIC memory

Returns

Integer value showing BYTE length of file read from M2M memory.

Stack API Usage Examples

EXAMPLE 1: INITIALIZING THE M2M PICtail™ PLUS DAUGHTER BOARD

```
ubxConfigureBoard();
```

EXAMPLE 2: INITIALIZING GSM

```
ubxConfigureGsm();

    if (ubxGetSimStatus() == UBX_S_SIM_PRESENT)  //Check to see SIM card is present
        {
            ubxRegisterGsmNetwork();
            break;
        }

    if (ubxGetGsmNetworkStatus() == UBX_S_GSM_NETWORK_REGISTRED)
        {
            acdSMSSetup();       //Setup SMS Reading
        }
```

EXAMPLE 3: INITIALIZING GPS

```
ubxConfigureGps();
ubxPowerOnGps(UBX_GPS_ASSIST_OFFLINE);
```

EXAMPLE 4: INITIALIZING GPRS

```
if (ubxGetGsmNetworkStatus() != UBX_S_GSM_NETWORK_REGISTRED)
    {
        ubxConfigurePdp(UBX_CONFIG_APN);
        break;
    }
```

EXAMPLE 5: USING SMTP (SENDING AN E-MAIL)

```
acdEmailSetup();     //Sets up the SMTP server (generic is Yahoo server)
acdSendEmail(EmailAddress,"Microchip M2M Board Message","This is a message from Microchip's
             M2M Board.");
```

EXAMPLE 6: USING HTTP

```
acdHTTPRequest(GET,                  //Type of HTTP request
               "maps.google.com",    //HTTP server
               temp,                 //file location on server
               "Map");               //Read Google Maps JPEG
```

EXAMPLE 7: READING FROM MEMORY

```
“fileLength =”acdReadM2MFile("Map", &PIC32MapMemoryLocation[0])     //Reads file from M2M Board
                                                                    //to PIC32 memory
```

GRAPHICS LIBRARY DESCRIPTION

The demonstration uses the Microchip Graphics Library, version 2.11, which is a powerful library that makes creating a Graphical User Interface (GUI) such as this one fast and easy. The Microchip Graphics Library is free and available for download from: www.microchip.com/MAL.

REFERENCES

LEON-G200 and NEO-6Q Communications Modules (www.u-blox.com)

LEON-G100 G200 *"2G GPS/GPRS AT Commands Manual"* GSM.G1-SW-09002 (www.u-blox.com)

M2M PICtail™ Plus Daughter Board (www.microchip.com)

Multimedia Expansion Board (MEB) (www.microchip.com/meb)

PIC32 device family (www.microchip.com/PIC32)

APPENDIX A: SOURCE CODE

Software License Agreement

The software supplied herewith by Microchip Technology Incorporated (the “Company”) is intended and supplied to you, the Company’s customer, for use solely and exclusively with products manufactured by the Company.

The software is owned by the Company and/or its supplier, and is protected under applicable copyright laws. All rights are reserved. Any use in violation of the foregoing restrictions may subject the user to criminal sanctions under applicable laws, as well as to civil liability for the breach of the terms and conditions of this license.

THIS SOFTWARE IS PROVIDED IN AN “AS IS” CONDITION. NO WARRANTIES, WHETHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING, BUT NOT LIMITED TO, IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE APPLY TO THIS SOFTWARE. THE COMPANY SHALL NOT, IN ANY CIRCUMSTANCES, BE LIABLE FOR SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES, FOR ANY REASON WHATSOEVER.

All of the software covered in this application note is available as a single WinZip archive file. This archive can be downloaded from the Microchip corporate Web site at:

www.microchip.com

APPENDIX B: SCHEMATICS

FIGURE B-1: LEON-G200 MODULE AND ANTENNA

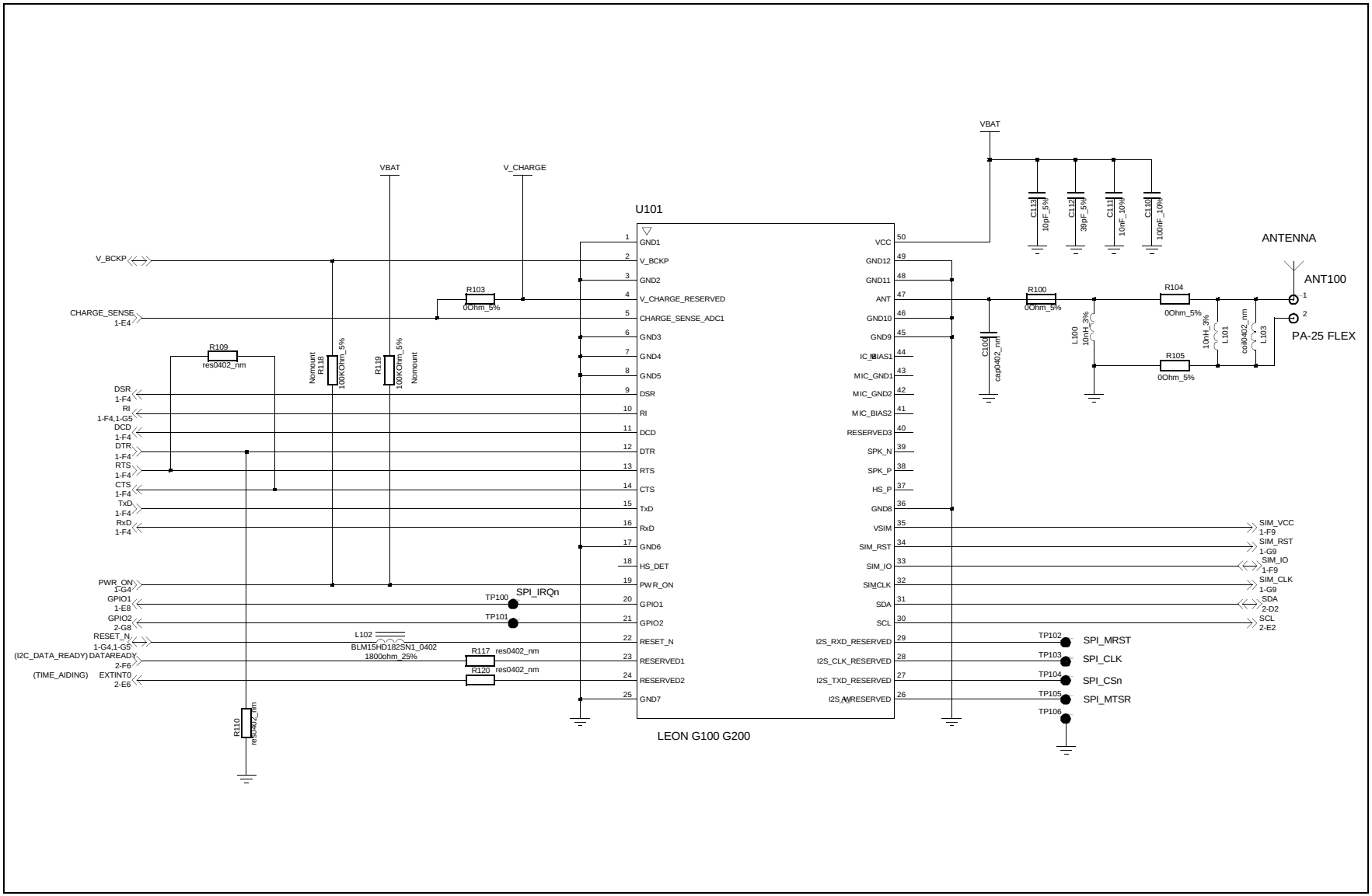


FIGURE B-2: POWER BOARD HEADER

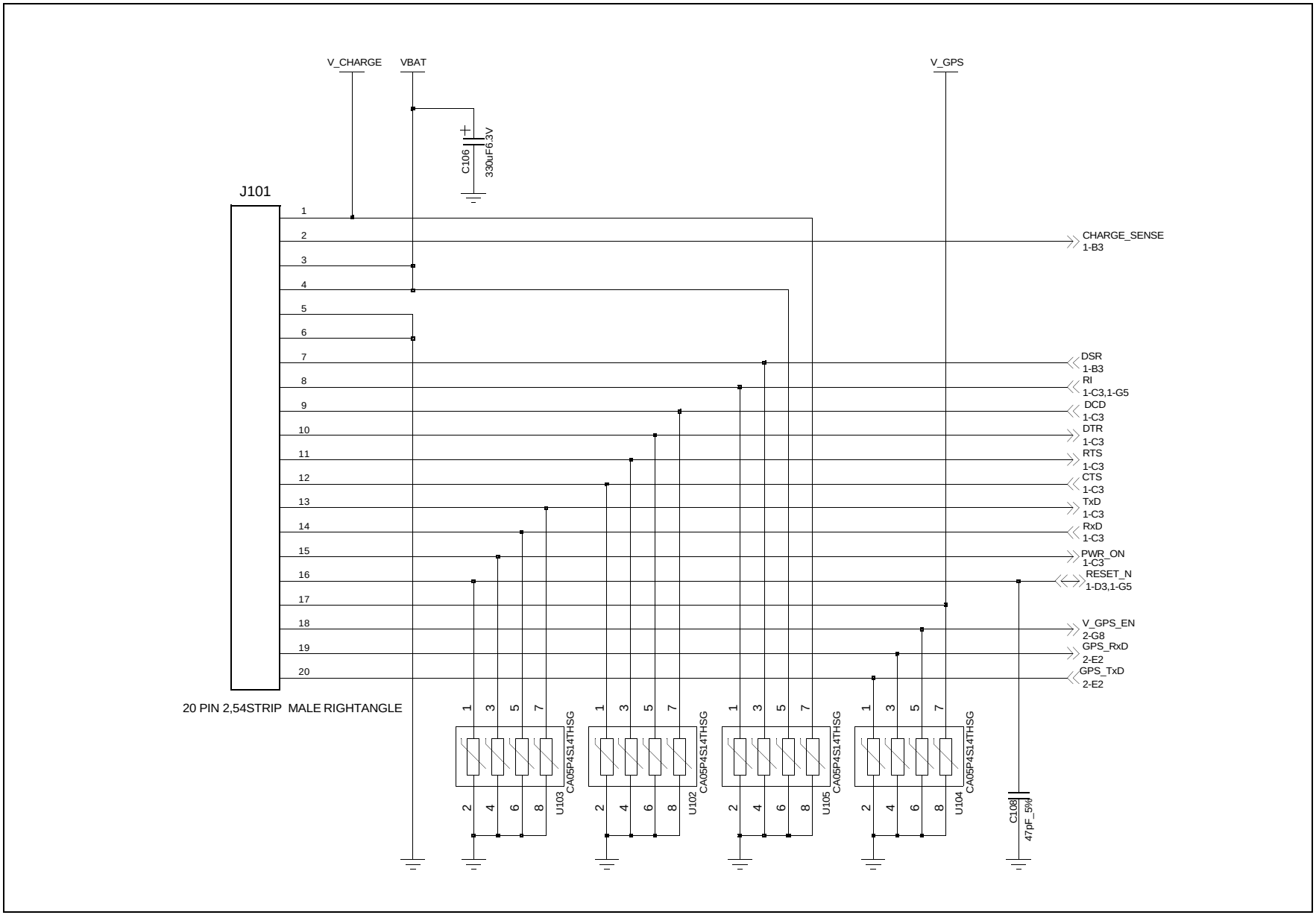


FIGURE B-3: SIM CARD HOLDER

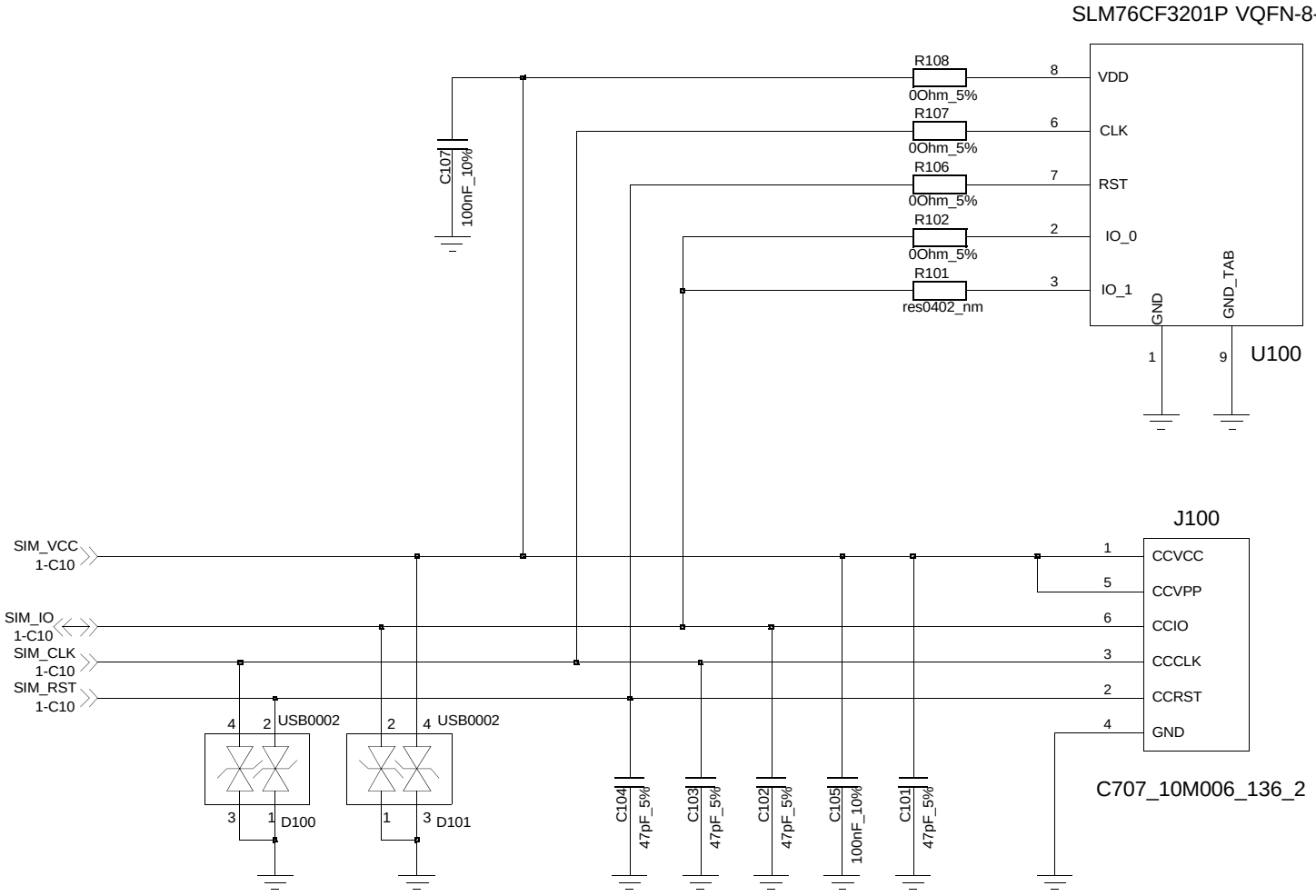


FIGURE B-4: AMPLIFIER CIRCUIT

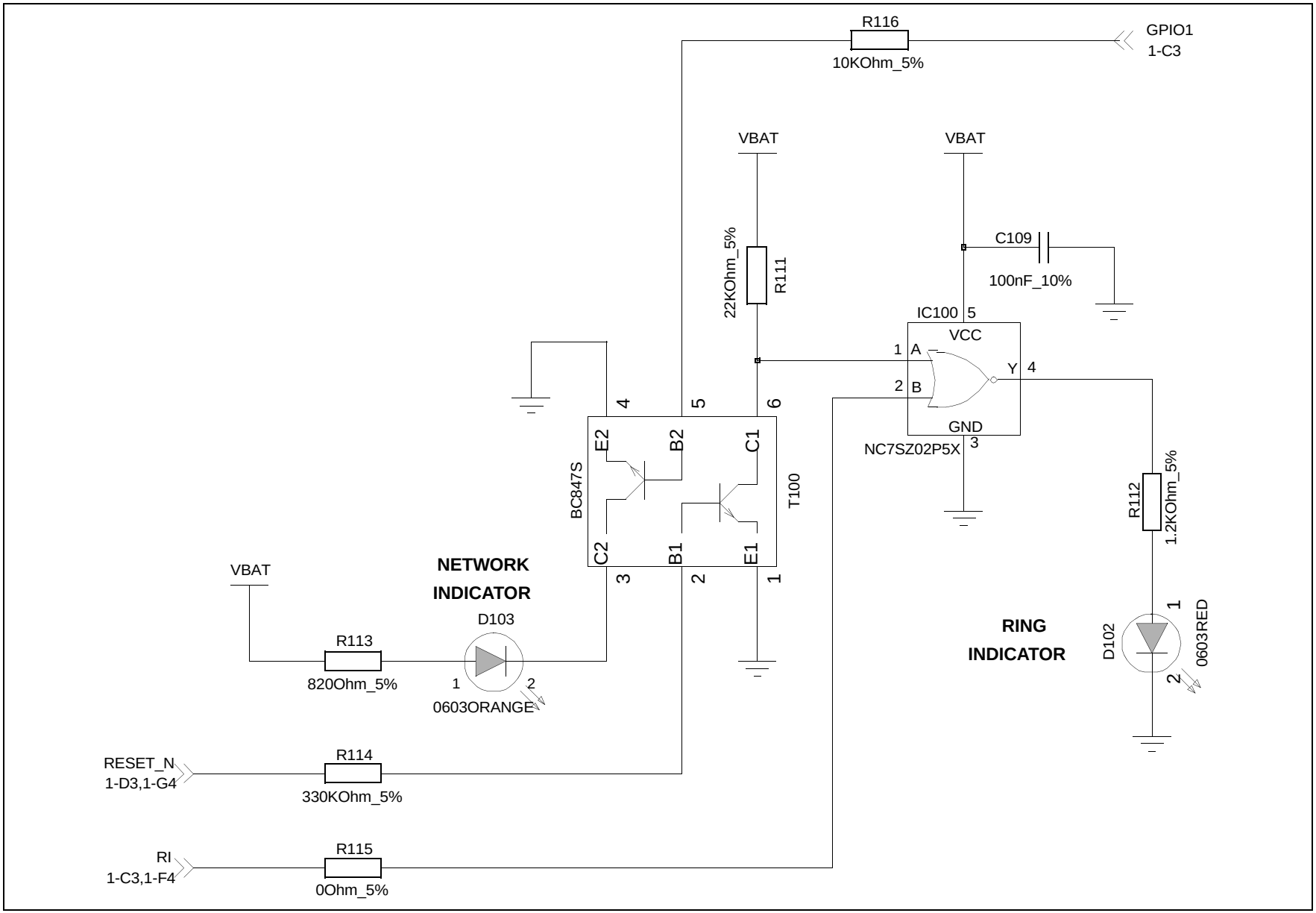


FIGURE B-5: NEO-6Q GPS MODULE AND ANTENNA

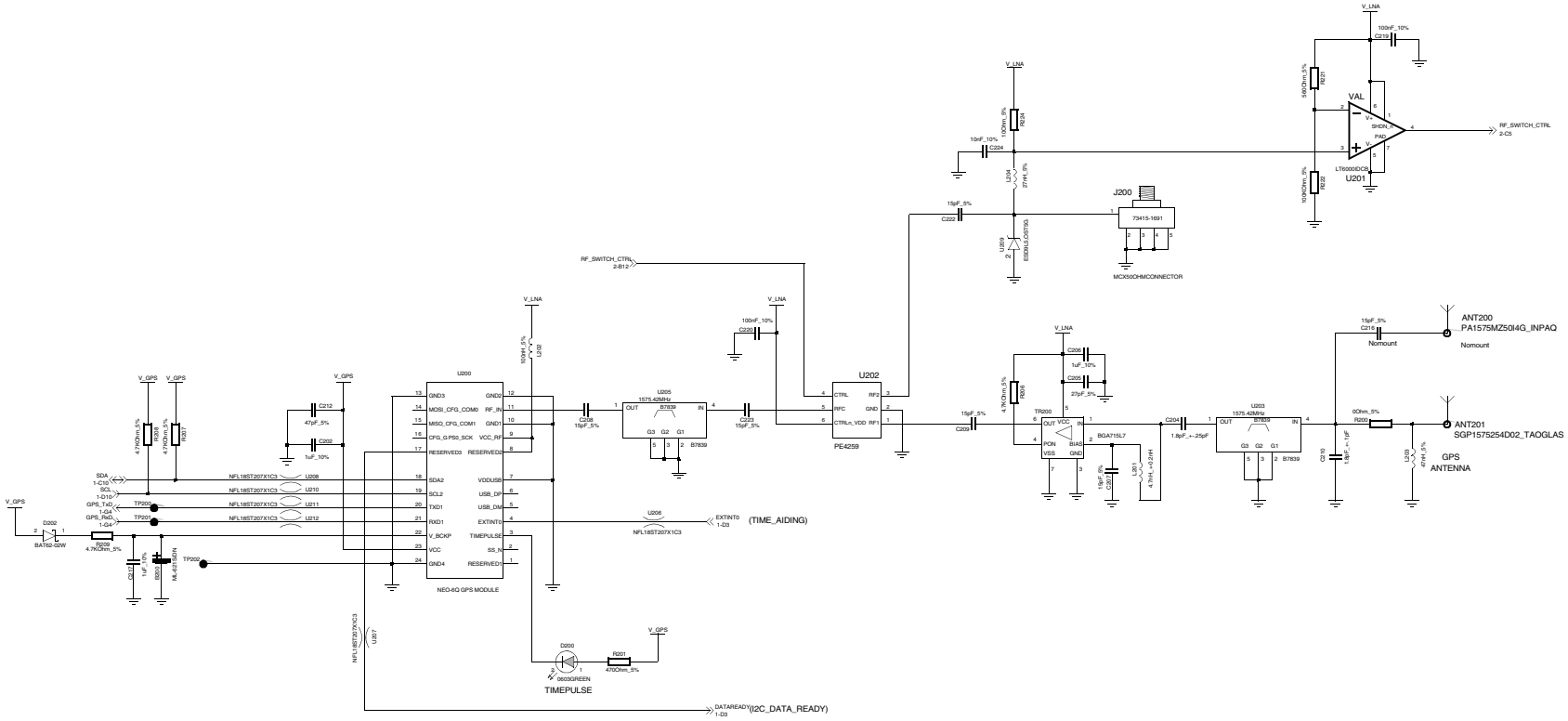


FIGURE B-6: VOLTAGE REGULATOR CIRCUIT

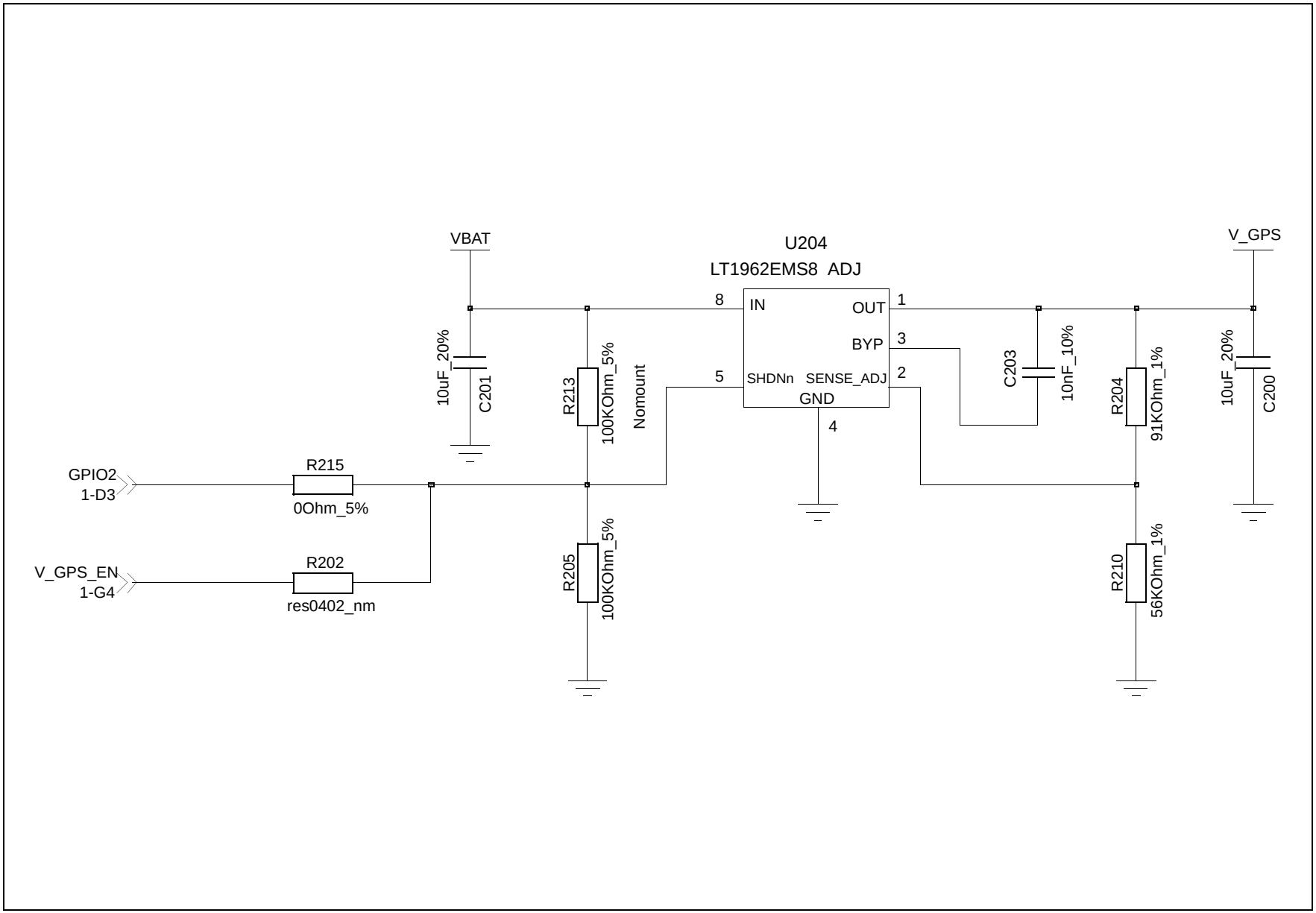
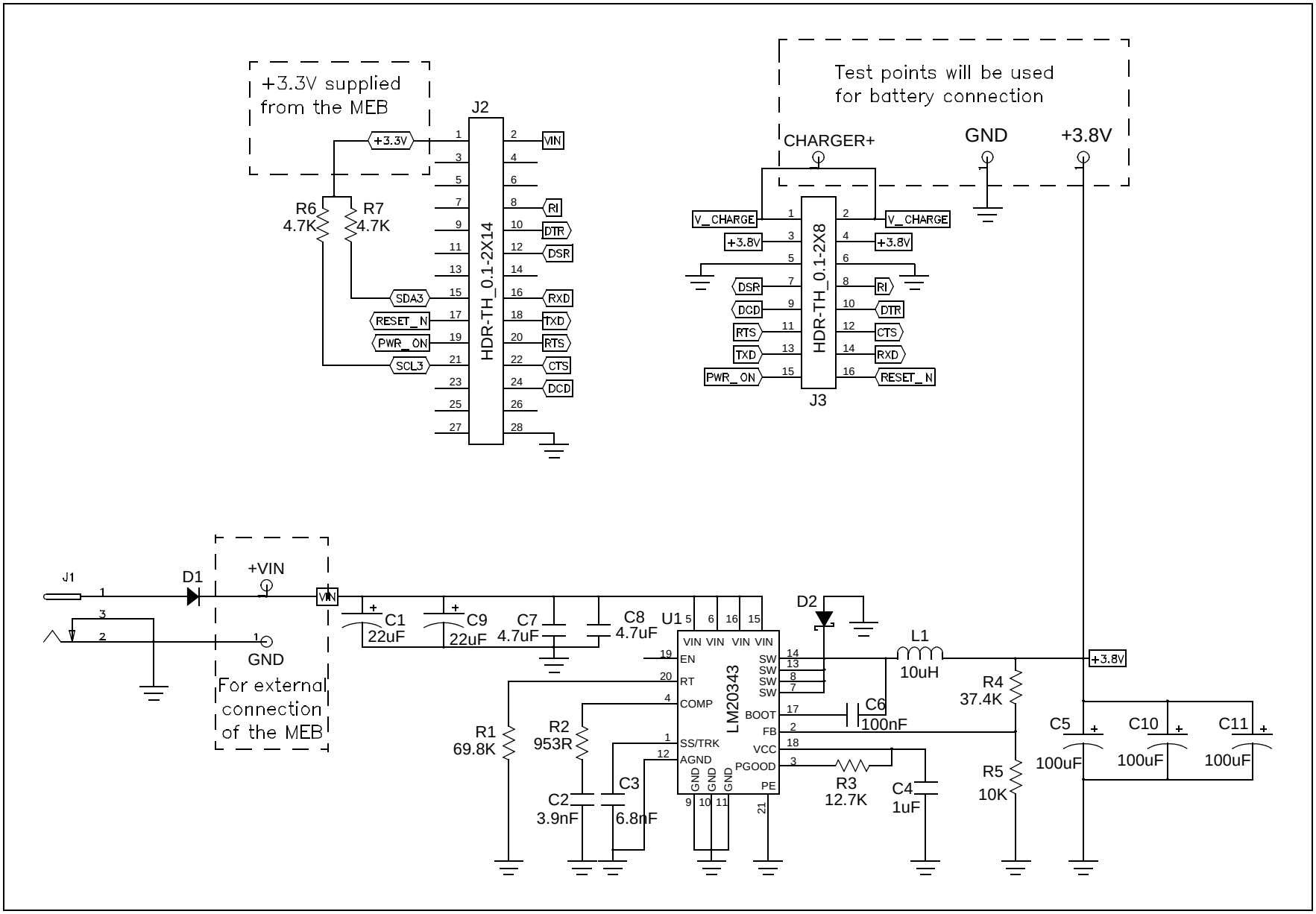
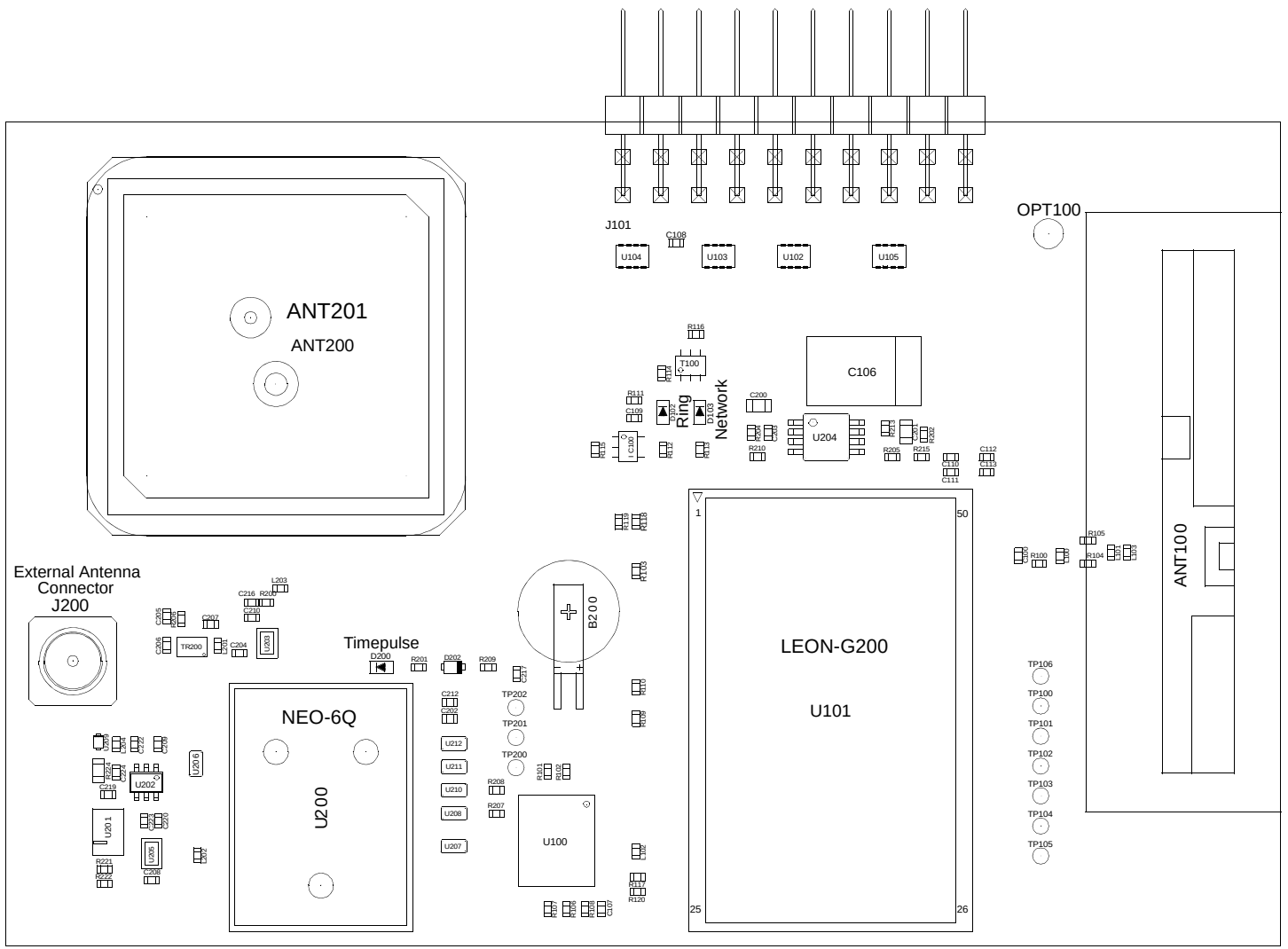


FIGURE B-7: GSM/GPS POWER SUPPLY DAUGHTER BOARD



APPENDIX C: LAYOUT

FIGURE C-1: M2M BOARD LAYOUT (TOP ASSEMBLY)



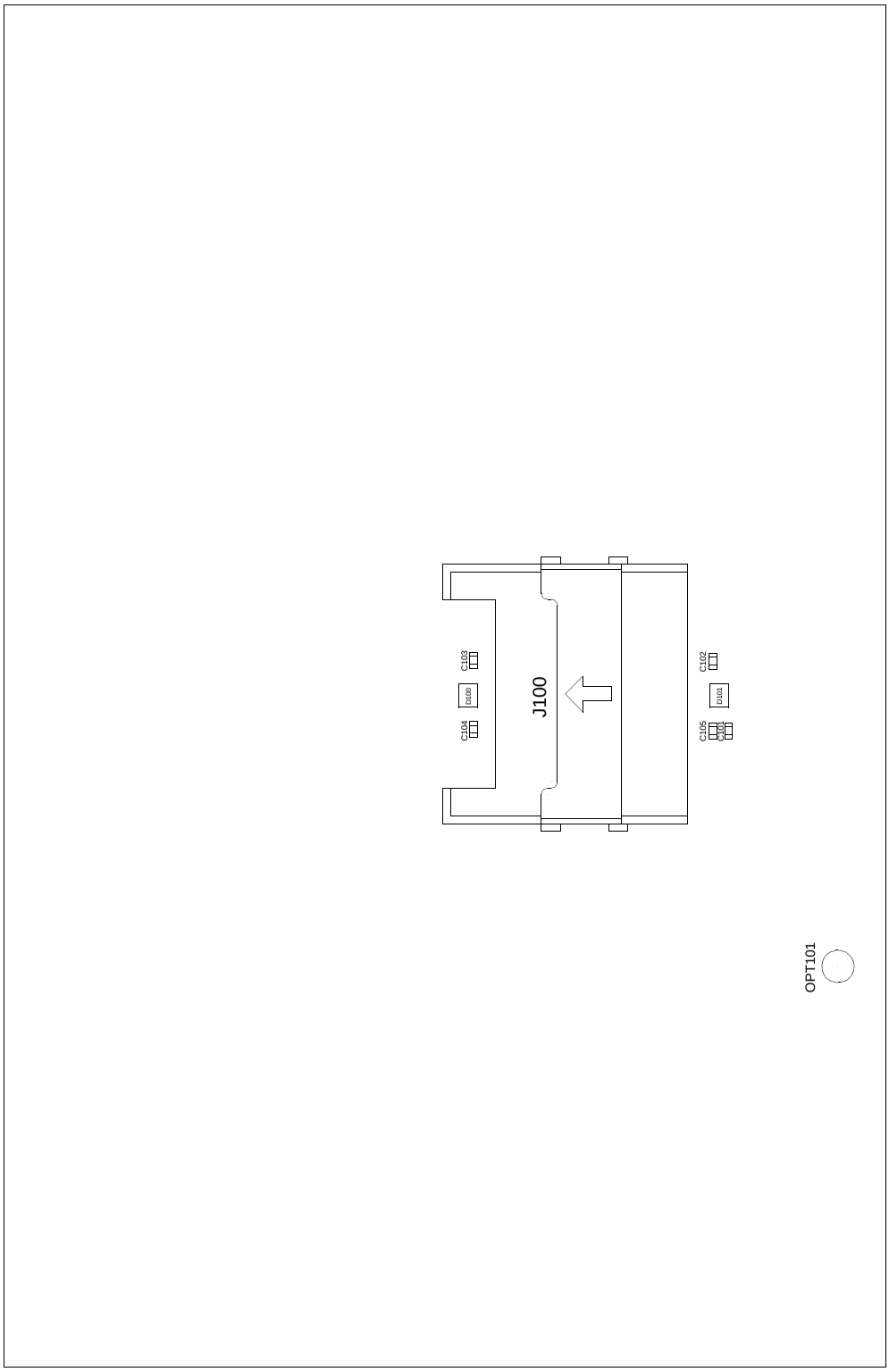
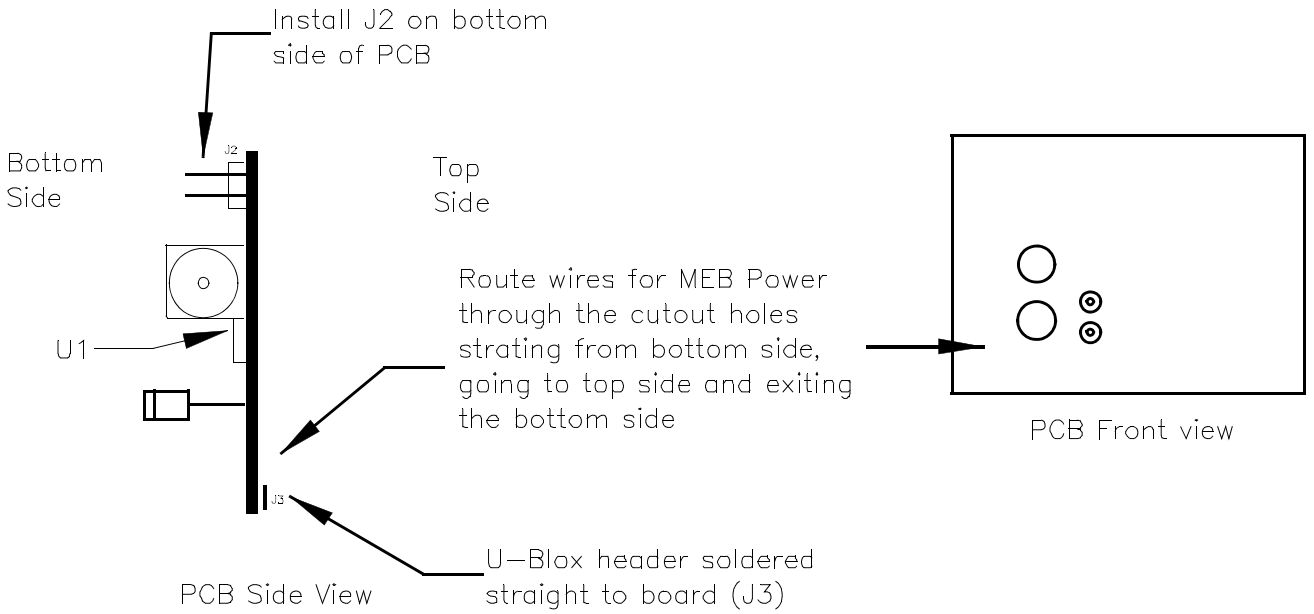
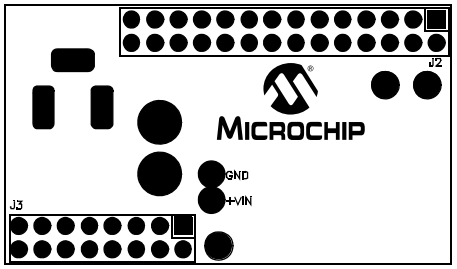


FIGURE C-2: M2M BOARD LAYOUT (BOTTOM ASSEMBLY)

FIGURE C-3: GSM/GPS POWER SUPPLY DAUGHTER BOARD LAYOUT





Note the following details of the code protection feature on Microchip devices:

- Microchip products meet the specification contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is one of the most secure families of its kind on the market today, when used in the intended manner and under normal conditions.
- There are dishonest and possibly illegal methods used to breach the code protection feature. All of these methods, to our knowledge, require using the Microchip products in a manner outside the operating specifications contained in Microchip's Data Sheets. Most likely, the person doing so is engaged in theft of intellectual property.
- Microchip is willing to work with the customer who is concerned about the integrity of their code.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of their code. Code protection does not mean that we are guaranteeing the product as "unbreakable."

Code protection is constantly evolving. We at Microchip are committed to continuously improving the code protection features of our products. Attempts to break Microchip's code protection feature may be a violation of the Digital Millennium Copyright Act. If such acts allow unauthorized access to your software or other copyrighted work, you may have a right to sue for relief under that Act.

Trademarks

Printed on recycled paper.

ISBN: 978-1-60932-923-5

QUALITY MANAGEMENT SYSTEM
CERTIFIED BY DNV
ISO/TS 16949:2002

Microchip received ISO/TS-16949:2002 certification for its worldwide headquarters, design and wafer fabrication facilities in Chandler and Tempe, Arizona; Gresham, Oregon and design centers in California and India. The Company's quality system processes and procedures are for its PIC® MCUs and dsPIC® DSCs, KEELOQ® code hopping devices, Serial EEPROMs, microperipherals, nonvolatile memory and analog products. In addition, Microchip's quality system for the design and manufacture of development systems is ISO 9001:2000 certified.

Worldwide Sales and Service

AMERICAS

Corporate Office
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

Atlanta
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

Boston
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

Chicago
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

Cleveland
Independence, OH
Tel: 216-447-0464
Fax: 216-447-0643

Dallas
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

Detroit
Farmington Hills, MI
Tel: 248-538-2250
Fax: 248-538-2260

Indianapolis
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453

Los Angeles
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608

Santa Clara
Santa Clara, CA
Tel: 408-961-6444
Fax: 408-961-6445

Toronto
Mississauga, Ontario,
Canada
Tel: 905-673-0699
Fax: 905-673-6509

ASIA/PACIFIC

Asia Pacific Office
Suites 3707-14, 37th Floor
Tower 6, The Gateway
Harbour City, Kowloon
Hong Kong
Tel: 852-2401-1200
Fax: 852-2401-3431

Australia - Sydney
Tel: 61-2-9868-6733
Fax: 61-2-9868-6755

China - Beijing
Tel: 86-10-8528-2100
Fax: 86-10-8528-2104

China - Chengdu
Tel: 86-28-8665-5511
Fax: 86-28-8665-7889

China - Chongqing
Tel: 86-23-8980-9588
Fax: 86-23-8980-9500

China - Hong Kong SAR
Tel: 852-2401-1200
Fax: 852-2401-3431

China - Nanjing
Tel: 86-25-8473-2460
Fax: 86-25-8473-2470

China - Qingdao
Tel: 86-532-8502-7355
Fax: 86-532-8502-7205

China - Shanghai
Tel: 86-21-5407-5533
Fax: 86-21-5407-5066

China - Shenyang
Tel: 86-24-2334-2829
Fax: 86-24-2334-2393

China - Shenzhen
Tel: 86-755-8203-2660
Fax: 86-755-8203-1760

China - Wuhan
Tel: 86-27-5980-5300
Fax: 86-27-5980-5118

China - Xian
Tel: 86-29-8833-7252
Fax: 86-29-8833-7256

China - Xiamen
Tel: 86-592-2388138
Fax: 86-592-2388130

China - Zhuhai
Tel: 86-756-3210040
Fax: 86-756-3210049

ASIA/PACIFIC

India - Bangalore
Tel: 91-80-3090-4444
Fax: 91-80-3090-4123

India - New Delhi
Tel: 91-11-4160-8631
Fax: 91-11-4160-8632

India - Pune
Tel: 91-20-2566-1512
Fax: 91-20-2566-1513

Japan - Yokohama
Tel: 81-45-471- 6166
Fax: 81-45-471-6122

Korea - Daegu
Tel: 82-53-744-4301
Fax: 82-53-744-4302

Korea - Seoul
Tel: 82-2-554-7200
Fax: 82-2-558-5932 or
82-2-558-5934

Malaysia - Kuala Lumpur
Tel: 60-3-6201-9857
Fax: 60-3-6201-9859

Malaysia - Penang
Tel: 60-4-227-8870
Fax: 60-4-227-4068

Philippines - Manila
Tel: 63-2-634-9065
Fax: 63-2-634-9069

Singapore
Tel: 65-6334-8870
Fax: 65-6334-8850

Taiwan - Hsin Chu
Tel: 886-3-6578-300
Fax: 886-3-6578-370

Taiwan - Kaohsiung
Tel: 886-7-213-7830
Fax: 886-7-330-9305

Taiwan - Taipei
Tel: 886-2-2500-6610
Fax: 886-2-2508-0102

Thailand - Bangkok
Tel: 66-2-694-1351
Fax: 66-2-694-1350

EUROPE

Austria - Wels
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

Denmark - Copenhagen
Tel: 45-4450-2828
Fax: 45-4485-2829

France - Paris
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

Germany - Munich
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

Italy - Milan
Tel: 39-0331-742611
Fax: 39-0331-466781

Netherlands - Drunen
Tel: 31-416-690399
Fax: 31-416-690340

Spain - Madrid
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

UK - Wokingham
Tel: 44-118-921-5869
Fax: 44-118-921-5820

02/18/11