G2M5477
Preliminary Data Sheet

Document Version 0.14a

Disclaimer

While the information provided in this document is believed to be accurate, it is under development and G2 Microsystems reserves the right to make changes without further notice to the product described herein to improve reliability, function, or design, and makes no guarantee or warranty concerning the accuracy of said information, nor shall it be responsible for any loss or damage of whatever nature resulting from the use of, or reliance upon, such information. G2 Microsystems makes no warranties of any kind, whether express, implied or arising by custom or course of trade or performance, and specifically disclaims the implied warranties of title, non infringement, merchantability, or of fitness for a particular purpose.

Trademarks

Document Number: DS-0008

Icon Version: 0.1.0

Release Date: February 2009.

Contacting us

Via email: info@g2microsystems.com

Via the web: www.g2microsystems.com

About this Data Sheet

This document is intended for:

- Icon developers planning to use a host processor to communicate with the G2M5477 Icon software over a serial interface.
- G2M5477 developers planning to develop custom applications for the module.

This document provides preliminary information on the G2M5477 Module from G2 Microsystems. Separate documents should be read in conjunction with this data sheet.

Icon developers should read the *Icon Programmer's Reference Manual* [1] and the *Icon API Reference*, [2]. G2M5477 developers should read the *G2C547 Programmer's Reference Manual* [3], and *G2C547 Application Programming Interface Reference* [4] documents. See Chapter 13, References, for details of reference documents.

Organization

This data sheet is organized into the following chapters:

- Chapter 1, General Description – overview
- Chapter 2, Features – features and benefits
- Chapter 3, Block Diagram
  system-level description
- Chapter 4, Functional Description
- Chapter 5, Interface, Connections and Mechanical
- Chapter 6, Electrical Specifications – absolute maximum ratings, operating conditions, power consumption, and package thermal data
- Chapter 7, RF Performance
- Chapter 8, Firmware Features
- Chapter 9, Application Information
- Chapter 10, Qualification
- Chapter 11, Design Guidelines
- Chapter 12, Development Kit
- Chapter 13, References
- Chapter 15, Revision History and Glossary
  document history, and acronyms, abbreviations, and units of measure used in this data sheet

Contents

1 General Description

The G2M5477 is a complete Wi-Fi and networking solution incorporating an RF power amplifier and antenna, a 32-bit CPU, operating system, TCP/IP network stack, crypto accelerator, power management subsystem, real-time clock and versatile sensor interface. The module enables designers to rapidly embed Wi-Fi and networking functionality into virtually any device. It is compatible with standard pick-and-place equipment.

Ultra-low power usage and flexible power management maximize lifetime in battery-operated devices. A wide operating temperature range allows use in indoor and outdoor environments.

G2M5477 developers have access to feature-rich analog and digital interfaces that allow for straightforward connection of environmental sensors and external control.

The G2M5477 is suitable for applications in areas such as:

- Real Time Locating Systems (RTLS)
- Wireless Audio
- Industrial and Home Automation
- Health and Fitness Monitoring
- Telemetry
- Security

As the module is capable of independently maintaining a low-power wireless network connection, the G2M5477 is suitable for Wi-Fi enabled remote controls, headphones, portable Internet radios, toys and other battery-operated devices. Even in mains-powered devices, the G2M5477 provides cost and time-to-market benefits as a self-contained Internet-enabling solution. It can communicate data over any existing Wi-Fi infrastructure using industry standard protocols. The G2M5477 has an operating temperature range from -30°C to +85°C.

The G2M5477 comes pre-programmed with Icon, a full-featured application that provides a host microcontroller with access to Wi-Fi and networking functionality via a serial communication interface. G2 provides the complete source for a host driver. With a few simple API calls to the driver, a host microcontroller can use the module to connect to a Wi-Fi network and communicate data via standard internet protocols.

Alternatively, G2M5477 developers can build applications using the G2C547 API, which provides lower level access to the RFID and sensor capabilities of the module.

At the core of the module is the G2C547 SoC, which includes a SPARC V8 processor, and on-board ROM containing the eCos operating system, LWIP TCP/IP protocol suite, security software and hardware drivers.

The module includes 8Mbits of flash memory. On reset, the G2C547 loads an application from flash memory into on-board RAM and executes the program. G2M5477 developers are provided with at least 64Kbytes of RAM for application code and supporting data structures.

The host to module UART interface runs at 115200 bps by default. Ten GPIO ports provide general purpose digital input and output. The GPIO ports can be driven by the CPU or mapped for other purposes. Eight sensor pins provide analog input and output, allowing the connection of external sensors and outputs from internal sources such as the auxiliary DAC.

The module provides an internal Wi-Fi antenna and provides a U.FL connection for an external antenna.

When in low-power sleep mode the module minimizes battery usage, but is still able to respond to certain events, including internal timers and events on the sensor and RFID interfaces. Applications that make efficient use of the sleep state can extend battery life to multiple years.

When awake, the module can run multi-threaded eCos applications and exchange data via the Wi-Fi interface.

The G2M5477 can interface to an inexpensive 8- or 16-bit microprocessor, reducing the system cost of applications with moderate processing requirements.

The G2M5477 is ideal for the vast range of applications that require long battery life, moderate processing power, moderate data throughput and occasional Wi-Fi connectivity.

The G2M5477 is certifiable for FCC modular approval for use in the Unites States, and CE approval for use in Europe and other countries (certification expected by February 2009).

The G2M5477 module has been designed to provide designers with a simple Wi-Fi solution: ease of integration and programming, vastly reduced development time, minimum system cost, long battery life and maximum value in a range of applications.

2 Features

Wi-Fi

- Complete 2.4 GHz IEEE 802.11b/g Wi-Fi transceiver
- 802.11i security suite with WEP-40, WEP-104, WPAv1-PSK, WPA2-PSK, and WPA transitional modes
- High throughput - 4 Mbit/s sustained TCP/IP with WPA2
- Wi-Fi certifiable with support for WPA2 Enterprise, WMM QoS and WMM Power Save

CPU

- User-programmable 32-bit SPARC V8 clocked at 44 MHz
- On-board ROM contains eCos operating system, LWIP TCP/IP suite, security software and drivers

Interfaces

- Up to 10 general-purpose I/Os (GPIOs)
- SPI master, SDIO client (with SD-SPI slave mode), and UART interfaces

EMC Resilient

- IEC-61000-4-2: unattended recovery from EMC shocks in hostile electromagnetic environments

RFID (EPC) and RTLS

- EPCglobal Class 1 Generation-2 transceiver, with both read and write capability
- ISO 24730-2 compliant 2.4GHz DSSS transmitter and FSK magnetic receiver

Protocols

- Supports Cisco CCX-tag protocols
- Supports Internet protocols including UDP, TCP and HTTP via the included LWIP stack

Sensor Interface

- 14-bit ADC offering 35us conversion time with 0.01% linearity for analog transducers such as temperature and humidity sensors
- Auxiliary 8-bit DAC
- Low-power interface for monitoring push-buttons, accelerometers, security seals and motion sensors

Power Usage and Management

- Ultra-low-power sleep state, in which a range of wake reasons can be detected
- Keep alive doze state with instant transition to wake state
- On-board power regulators operate from alkaline, lithium manganese, lithium iron disulphide and other battery types
- Transitions from asleep to CPU-active in 1.7ms; CPU active to network connection in less than 35ms (typ)
- Consumes 4uA current when asleep, 90mW power with Wi-Fi enabled

Physical

- Operates from -30°C to +85°C
- Available in trays suitable for standard pick-and-place machines
- Physical dimensions: 20mm x 37mm x 3.7 mm

Software

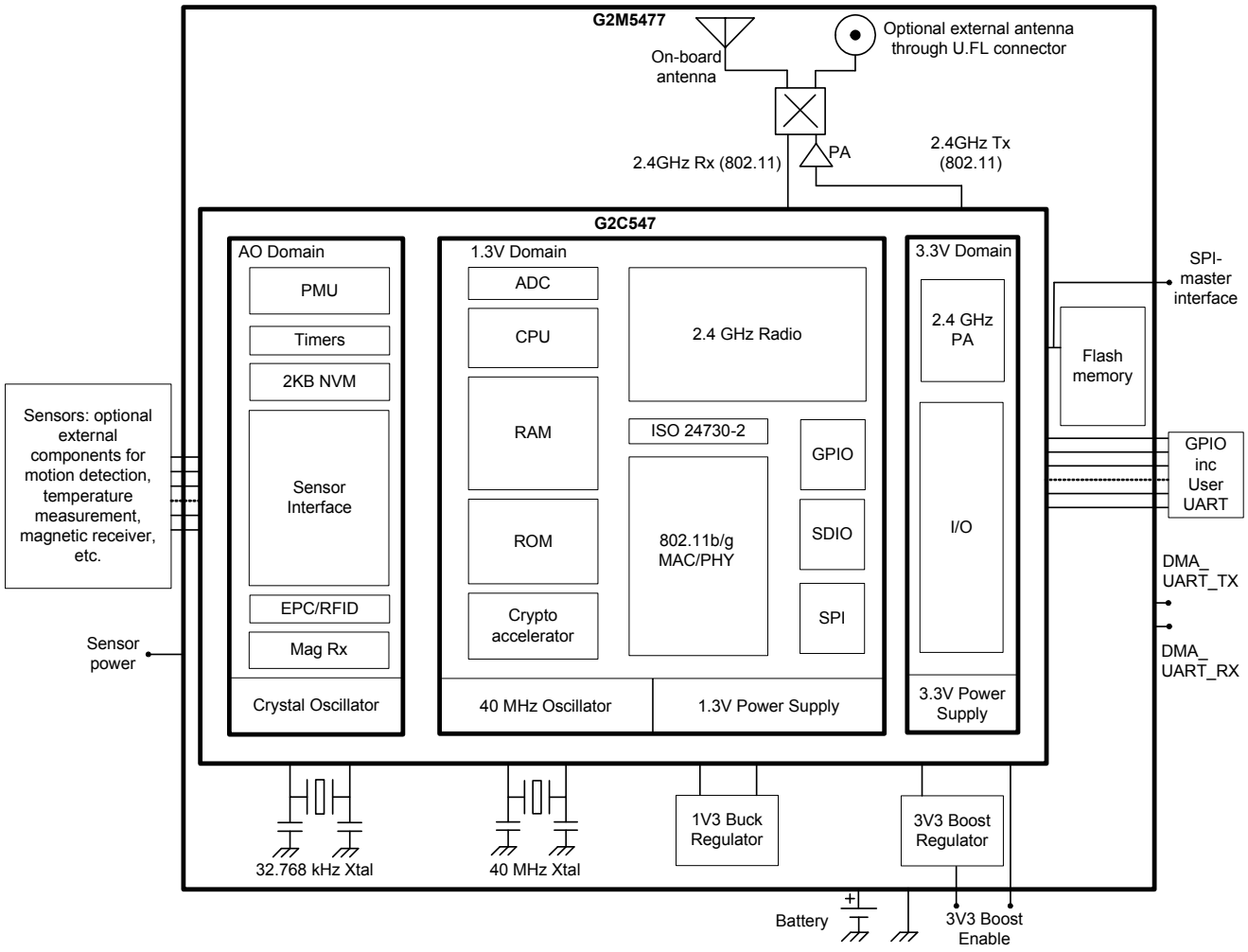
- Includes Icon software providing a serial-API UART interface to a wide range of functions, including secure Wi-Fi authentication and network operations such as DHCP, DNS, UDP and TCP/IP.

2.1 Benefits

- Multi-year battery life
- Industry-leading Wi-Fi power consumption
- Design is complete, avoiding RF design and layout issues
- Ships pre-calibrated and pre-tested, avoiding expensive NRE for calibration and production test procedures
- Uses existing Wi-Fi and EPC RFID infrastructure for low TCO
- Hosted architecture - For G2M5477 developers, a full network stack on-board enables development of a low system-cost wireless internet product
- Supports a client architecture with an external 8- or 16-bit host microcontroller for shortest development time and lowest system cost
- Pre-loaded with Icon software offering simple Wi-Fi connectivity

3 Block Diagram

Figure 3-1: G2M5477 Architecture



The core of the G2M5477 module is the G2C547 chip, designed with three separate power domains to provide lower power consumption and flexible power management. A single battery, via on-board voltage regulation, supplies power to the three parts of the chip as shown in Figure 3-1:

1. The Always On (“AO”) domain is continuously powered, and provides a small number of essential functions which are always available.
2. The 1.3V domain is powered as required from a buck regulator, and provides the core functionality of the G2M5477.
3. The 3.3V domain is powered as required, from a boost regulator or directly from the battery, and supplies the I/O pins, supply outputs and the 2.4GHz power amplifier.

When only the AO is powered, the module is *asleep*. When the 1.3V domain is also powered, the module is *awake*. The 3.3V domain is enabled only when the module is *awake*.

For more details of the chip architecture, see the G2C547 Datasheet, [5].

3.1 Power

The G2M5477 can be powered by an external regulator or a range of batteries. The module includes a 3.3V Boost Regulator, for use with batteries that supply a voltage lower than 3.0V.

3.2 System Power States

The G2M5477 operates in one of two main power states: *asleep*, in which the module has limited functionality (enough to detect wake events) but very low battery drain, and *awake,* in which all of the functionality of the module is available (in particular the operating system, eCos, is running) and battery drain is higher. Additionally, while *awake* the CPU can put itself into a *doze* state, where the 1.3V domain stays up, but the CPU clock is suspended (until a wake event happens).

3.2.1 *Asleep* (low-power)

When *asleep,* **only** the AO domain is powered, and the PMU controls operation. This is the low-power state of the G2M5477, in which it draws only microwatts of power. The CPU and all other components of the 1.3V domain are unavailable (and do not maintain their internal state). Within the AO domain, the RFID and Magnetic receivers can be enabled as required, at the expense of increased power consumption.

The functions available when *asleep* are simple - mostly detecting reasons to wake the CPU:

- decrement timers and detect expiry
- detect state change of the switch sensors
- monitor the sampled comparator and detect when external parameters pass preset thresholds
- detect motion via the motion sensor
- receive and act on magnetic receiver data
- receive and act on RFID reader commands
- respond to assertion of the FORCE_AWAKE pin
- respond to battery brownout (low voltage)
- respond to IEC-61000-4-2 EMC events

3.2.2 *Awake*

When *awake*, the 1.3V domain is powered (as well as the AO domain), and the 40MHz oscillator runs. On waking, the module boots the eCos operating system from ROM, after which the CPU loads and executes a user application from Flash memory. At this point all functionality of the module is available, in addition to that available when *asleep*. The module can:

- Load and execute programs from flash memory
- Use the Wi-Fi radio
- Read and write flash memory
- Read and write NVM
- Encrypt and decrypt data
- Go to *sleep*
- Transmit ISO 24730-2 data (DSSS and FSK/OOK)
- Take measurements using the sensor interface
- Use the GPIO, SPI, SDIO, and UART interfaces
- Configure PMU: RFID, mag receiver, sensors, etc.

3.2.3 Dozing

When *awake*, the module may *doze* - in which the 1.3V domain remains powered but the CPU is not clocked. The module uses less power in this state than when *awake*, and can respond very quickly to interrupt sources (the module wakes from *doze* in 45ns, compared to milli-seconds to wake from *sleep*). All memory and register contents are preserved while the module is *dozing*.

Section 6.6, Power Consumption shows the power used by the module in each of these states.

3.2.4 Waking Up

A wake event received when the module is asleep wakes the module. When a wake event occurs, the CPU boots the eCos operating system from ROM, loads an application from flash memory and executes it.

3.2.5 Force Awake

For debugging and development, the G2M5477 may be ‘forced awake’ by asserting the FORCE_AWAKE pin for at least 245us. This generates a non-maskable wake-event. While the FORCE_AWAKE pin remains asserted the module is prevented from sleeping or dozing.

3.3 Module Resets

The G2M5477 is reset by any of the following events:

- An internal power-on reset, generated automatically when power is supplied. This is intended for initializing the module when a new battery is connected;
- An external power-on reset, generated by pulling the RESET_L pin low;

- A software power-on reset, generated from software; or
- A reset triggered by a critical event, which can be:
  - — a brownout, generated if the supply voltage drops below the minimum operating voltage; or
  - — an IEC-61000 EMC consistency failure.

3.3.1 Brownout Detection

The G2M5477 includes a brownout detector to hold the module in reset if the battery voltage falls below the minimum operating voltage.

When the G2M5477 wakes from a brownout-induced shutdown, the cause of the shutdown is indicated to the CPU. The application can then select the appropriate response.

3.3.2 EMC Resilience (IEC 61000-4-2)

The G2M5477 protects a number of critical internal configuration registers with logic to detect corruption from an EMC event. If such an internal inconsistency is detected, a non-maskable critical event resets the module.

4 Functional Description

The subsystems of the G2M5477 are:

- The Power Management Unit (PMU), which controls the module when *asleep* and aggregates all interrupts and wake reasons to the CPU whether *awake* or *asleep*. The NVM provides always-on memory that is accessible by both the PMU and (when awake) the CPU.
- The CPU, which executes the operating system and user applications, from which the rest of the module is configured and controlled, including the PMU.
- The Wi-Fi interface, including the ISO 24730-2 transmitter
- The cryptographic accelerator
- The ISO 24730-2 magnetic receiver
- The RFID transceiver
- The sensor interface
- The digital interfaces - SPI, SDIO client, User and DMA UART
- Oscillators and power supplies
- IEC-61000-4-2 EMC recovery, and brownout detector

4.1 PMU and NVM

The PMU manages the oscillators and power supplies, controls the G2M5477 when asleep, and aggregates all interrupts to the CPU whether awake or asleep. When asleep, the interrupts collected by the PMU also act as potential wake events - waking the module from sleep.

The PMU monitors wake events from the AO timers, the sensor interface, RFID and the ISO 24730-2 magnetic receiver. Current loop sensors can be used to wake on voltage changes on SDIO or User UART lines. Although the PMU controls the G2M5477 while asleep, and manages the power state transitions between asleep, awake, and doze, its configuration comes from the CPU.

The term NVM is used in this context to refer to memory in the Always On domain. Memory contents are lost when power is disconnected.

An NVM backup is maintained in flash memory and loaded automatically on power-up.

4.2 The CPU

The CPU is a SPARC V8 32-bit design, clocked at 44 MHz.

On waking, the CPU boots the eCos operating system from ROM. The boot code then loads an application from external flash memory into RAM and executes it.

Developers writing applications for the module are provided with the ability to debug applications, program the flash, and control the module with the DMA UART. The DMA UART connects to the G2C547 Debug UART. See the G2C547 PRM, [3], for further details on the G2C547 Debug UART.

4.2.1 General Purpose I/O

The module has ten GPIO pins, each of which can be driven by the CPU, or from a secondary function such as the SDIO client or User UART. Pins GPIO_10 and GPIO_11 are used for the User UART, as indicated in Table 5-2. Up to four GPIO pins can be configured as edge or level-sensitive interrupt sources. These are active only when the CPU is awake.

As of release 0.0.1 of the Icon software, only GPIO_10 and GPIO_11 are available for use as a User UART interface. Future versions of Icon will provide general read and write access to GPIO pins.

G2M5477 developers have unlimited access to GPIO functionality.

4.3 Wi-Fi Network Interface

The Wi-Fi Network Interface provides all functions necessary to connect to, and communicate with, a standard 802.11b/g Wi-Fi network. The Wi-Fi interface consists of:

- A firmware API in ROM that includes functions for channel scan, connection, communications, and PHY layer management.
- An 802.11b/g MAC and baseband PHY.
- A 2.4GHz radio transceiver.
- A cryptographic accelerator to assist with Wi-Fi security.
- An ISO-24730-2 2.4GHz transmitter. Although not part of Wi-Fi, the ISO-24730-2 transmitter shares the Wi-Fi 2.4GHz Transmit radio path.

Icon developers have access to the Wi-Fi Network Interface via a high-level API that issues commands over the serial interface. Example API functions include g2_start_scan, g2_set_ssid, g2_conn_connect, g2_conn_send, g2_conn_receive, etc. Refer to the Icon Programmer's Reference Manual, [1], for further information.

G2M5477 developers have access to lower level functions in the G2C547 ROM via a firmware API. Refer to the G2C547 PRM, [3], for further details.

4.3.1 Wi-Fi MAC/PHY

The G2M5477 Wi-Fi MAC/PHY plus API provides a complete solution for Wi-Fi compliant 802.11b/g operation. It supports DCF and peer-to-peer operation, with a wide range of security suites - including WEP, TKIP, WPA1, and WPA2-PSK. See the G2C547 Programmer's Reference Manual, [3], for details of the Wi-Fi API.

4.3.2 Cryptographic Accelerator

The cryptographic subsystem provides hardware acceleration for AES-128, RC4, MD5, SHA-1, CRC-32, and TKIP 'Michael'.

The AES-128 block provides 128-bit AES encryption in Electronic Code Book (ECB), Counter, and Cipher-Block Chaining (CBC) modes. All other common AES modes can be created using ECB mode.

For further information on the use of the cryptographic accelerator, see the G2C547 Programmer's Reference Manual, [3].

4.3.3 2.4GHz Radio

A 2.4 GHz radio transceiver that includes a 2.4GHz synthesizer is used for Wi-Fi and ISO 24730-2 operation. The reference for the synthesizer is the on-board 40MHz crystal.

4.4 Sensor Interface

The sensor interface provides:

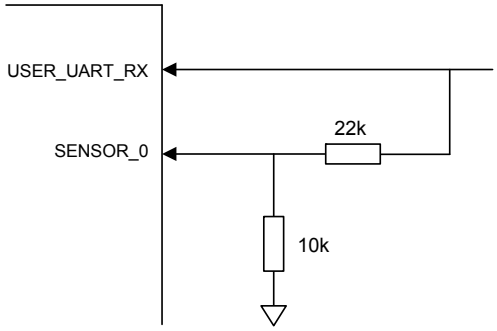
- four switch sensors
- a motion sensor for use with external ball-in-tube
- a pulsed comparator
- an auxiliary DAC
- an ADC - the Sampled Measurement Unit (SMU)
- a current generator, for measurement purposes

The switch sensors, motion sensor, and pulsed comparator are all in the AO domain, and available when *awake* or *asleep*; the SMU ADC is in the 1.3V domain and available only when awake. The sensor elements share the eight sensor interface pins.

When *asleep*, the sensor interface can be used to detect events such as a switch opening or closing, motion, or an analog voltage moving outside a preset window. When *awake*, the SMU can digitize analog signals (e.g. audio) and make high-precision analog measurements.

As of release 0.0.1, Icon support for the sensor interface is limited to using SENSOR_0 to generate a wake-on-serial event to wake the module from low-power sleep mode. To enable this functionality, a resistive-divider should be externally connected as shown below.

Figure 4-1: SENSOR_0 resistive divider



G2M5477 developers are provided with access via API calls to the entire sensor interface functionality.

4.5 Magnetic Receiver

The magnetic receiver receives and decodes ISO-24730-2-encoded data. It supports up to three axes, automatically searching for an axis that provides valid data.

The receiver can be configured to wake the module in a variety of different ways. These options simplify software design and reduce power consumption to extend battery life.

To use the magnetic receiver, G2M5477 developers must purchase a software development kit from G2 Microsystems.

4.6 RFID (EPC) Transceiver

The AO domain contains an EPCglobal Generation-2 Class-1 RFID transceiver. This transceiver can receive and decode the full set of EPC Generation 2 Class 1 mandatory commands, in North American, European and Asian radio frequency bands (860-960MHz). The RFID interface can be used to read from and write to NVM. It supports one or two external antennas.

To use the RFID EPC transceiver, G2M5477 developers must purchase a software development kit from G2 Microsystems.

4.7 Serial Interfaces

The G2M5477 has four serial interfaces:

- A standard User UART.
- A high-speed DMA UART (also referred to as the Debug UART in G2C547 documentation)
- A SPI master
- An SDIO client including a SPI-slave

4.7.1 User UART

The User UART interface can support 2 and 4-line UART protocols. The G2M5477 logic levels do not match those of the RS232 standard, so external-level translators are required to meet the RS-232 UART standard. Hardware support is included for RTS, CTS, SRX, and STX functions.

The UART interface supports baud rates of 2400, 4800, 9600, 19200, 38400, 115200 & 230400 bit/s.

A note for developers interfacing with Icon: the User UART is the only serial interface supported by Icon version 0.1.0. The Icon-supported configuration for the UART is 2-wire 115200 bit/s, 8-N-1. Refer to the Icon Programmer's Reference Manual, [1], for further information.

4.7.2 DMA UART

The DMA_UART_TX and DMA_UART_RX pins provide a high-speed DMA UART interface to the G2M5477 and a debug interface to the G2C547 CPU.

The high-speed DMA UART interface will be available for use in a future release of the Icon software.

G2M5477 developers typically do not connect the DMA UART Interface in the final product. Rather, this interface is the primary debug interface during development. The DMA UART interface is described in greater detail in the G2C547 Programmer's Reference Manual, [3], where it is referred to as the CPU Debug interface.

4.7.3 SPI Master

The SPI master interface is used principally to access on board flash memory. It can also be used to drive additional SPI devices. The dedicated SPI chip-select output is connected only to the on-board flash memory and is controlled directly from hardware. A secondary hardware controlled SPI chip select output can be mapped to any one of the module GPIO pins. Further SPI devices can be supported by using GPIO pins as chip-selects under software control.

The SPI interface features:

- Full-duplex synchronous serial data transfer
- Variable length of transfer word up to 128 bits
- MSB first data transfer
- Rx and Tx on rising or falling edge of serial clock independently
- SPI clock speed configurable from 86kHz to 44MHz

Note that the 3.3V supply powers the SPI I/O pins. The cautions in Section 6.1 regarding external drive to the GPIO pins apply to the SPI pins.

To use the SPI master interface to control external SPI-slave devices, G2M5477 developers must purchase a software development kit from G2 Microsystems.

4.7.4 SDIO Client

An SDIO client interface supporting SD-SPI, SD-1 and SD-4 modes provides a high speed data interface to the G2M5477, operating at up to 100Mbit/s. The SDIO client supports a single function - "Function 1" - a memory interface. The interface is overlaid on GPIO-4 through GPIO-9. A FIFO provides buffering between an external device and G2M5477 system RAM.

To use the SDIO interface to communicate with an external microprocessor, G2M5477 developers must purchase a software development kit from G2 Microsystems.

4.8 Power Supplies

The G2M5477 is designed to operate from a wide range of batteries including alkaline, lithium manganese dioxide, lithium-thionyl chloride, nickel-metal hydride, nickel-cadmium and lithium iron disulphide (Energizer Lithium AA-size 1.5V: http://data.energizer.com/PDFs/l91.pdf).

The AO domain is powered continuously by on-board linear regulation of the battery voltage, which must remain in the range 2.0 V to 3.7 V.

4.8.1 3.3V Voltage Regulation

The 3.3V voltage regulation topology depends on the battery chemistry and arrangement used to power the G2M5477. A battery that provides less than 3.0 V over its lifetime requires the module boost regulator to be enabled by shorting the 3V3_REG_CTRL_IN and 3V3_REG_CTRL_OUT pins, as shown in the circuit of Figure 4-2.

Warning: The boost regulator must not be operated above 3.3 V. Figure 4-2 is not suitable for a battery with output voltage greater than 3.3 V

A battery that supplies a voltage greater than 3.0V over its lifetime can drive the module directly, as in Figure 4-3.

Figure 4-2: Power Supply for Battery 2.0 V to 3.3 V

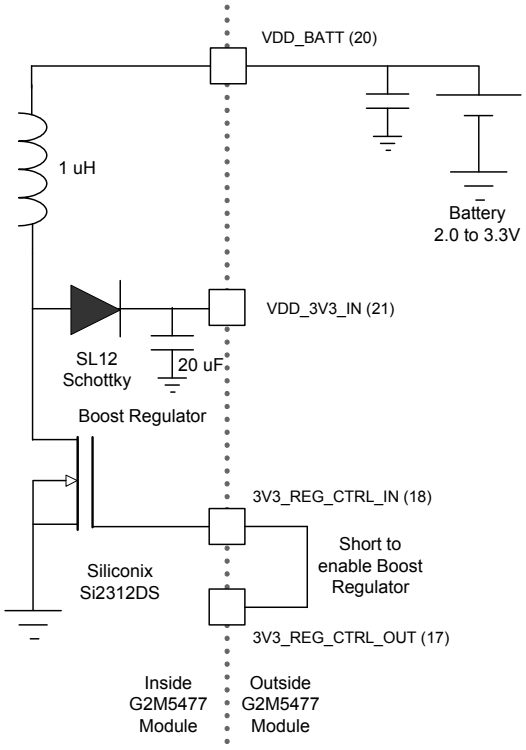
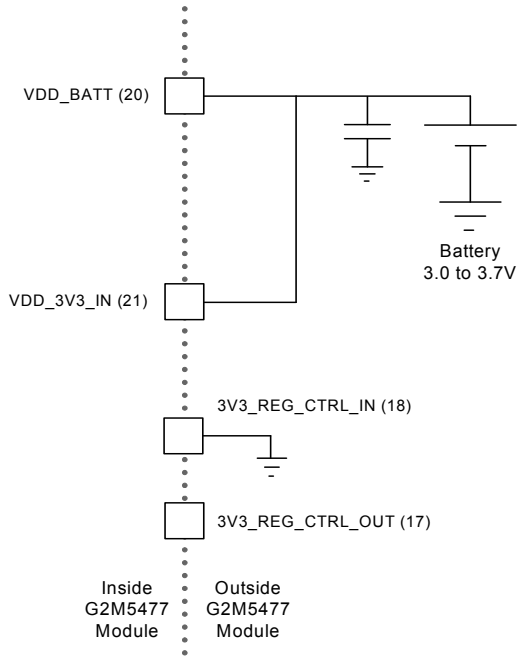


Figure 4-3: Power Supply for Battery 3.0 V to 3.7 V



4.8.2 Use with Supercapacitors

The G2M5477 can be powered by a lithium coin cell. Coin cells are unable to provide the high currents required when the module is awake, so a suitable supercapacitor must be used to provide these currents. Some supercapacitors use two lower-voltage supercapacitors in series. The G2M5477 provides a SUPERCAP_BALANCE pin to share the balance across these capacitors. This pin divides the supply voltage to avoid damaging stresses to the supercapacitor. The pin consumes a lower quiescent current than would be consumed by a pair of resistors.

The Icon software imposes a power requirement that cannot be met by a lithium coin cell and supercapacitor.

To use a lithium coin cell and supercapacitor power supply, G2M5477 developers must purchase a software development kit from G2 Microsystems and develop a custom application that does not exceed the power limitations of the supply.

5 Interface, Connections and Mechanical

The following sections discuss pin groupings, pin types, and pin descriptions. Connections with G2C547 pins are provided for G2M5477 developers only.

5.1 Pin Types

Table 5-1 introduces the types of pins of the G2M5477.

There are several kinds of pins:

- The pins of the general-purpose inputs and outputs GPIO[0..14], the SPI bus interface (SPI_MOSI etc.), and the DMA UART (referred to as the “digital” pins).
- RESET_L (referenced to VDD_BATT).
- FORCE_AWAKE (a control input to the AO domain).
- The sensor interface pins (SENSOR_IF[0..7] and the RFID antenna pins
- RF connector.
- Power

Table 5-1: Pin Types

Type	Description	Reset State
Gnd	Ground.	
I	Digital input with ~83K pull-down. 3.3V tolerant	Pull-down
I/O	Digital input/output (bidirectional) 8mA drive, ~83K pull-down. 3.3V tolerant	Pull-down
I/O-24	Digital input/output (bidirectional) 24mA drive, no pull-down. 3.3V tolerant	Z
O	Digital output, 8mA drive, ~83K pull-down. 3.3V tolerant	Pull-down
T	Digital output, 8mA drive, no pull-down. 3.3V tolerant	Z
P	Power. Power pins are used to supply power and to control the power supply configuration	
A-1v2	Analog. 1.2V tolerant.	
A-3v3	Analog, 3.3V tolerant	
RF	RF input and output. Impedance 50 Ohms	
C	Control input. 3.3V tolerant	

5.2 G2M5477 Module Pins

Table 5-2: G2M5477 Module Pins

Pin	Name	Function	Type, Voltage	Icon Support	G2C547 Pin Connection
44-36		Ground	Gnd, 0V	Power	GND_SLUG
35	NC	-	-	-	-
34	SENSOR_0	Sensor interface. Icon supports SENSOR_0 for wake-on-serial	A-1v2, 1.2V max	Yes	SENSOR_IF0
33	SENSOR_POWER	Voltage output from module for powering external sensors	A-3v3, 1.2-3.3V	No[c]	POWER_SENSORS
32	SENSOR_3	Sensor interface	A-1v2, 1.2V max	No[a]	SENSOR_IF3

Table 5-2: G2M5477 Module Pins

Pin	Name	Function	Type, Voltage	Icon Support	G2C547 Pin Connection
31	SENSOR_2	Sensor interface	A-1v2, 1.2V max	No[a]	SENSOR_IF2
30	SENSOR_1	Sensor interface	A-1v2, 1.2V max	No[a]	SENSOR_IF1
29	GPIO_4	GPIO	I/O-24, 3.3V	No[b]	GPIO_4
28	GPIO_5	GPIO	I/O-24, 3.3V	No[b]	GPIO_5
27	GPIO_6	GPIO	I/O-24, 3.3V	No[b]	GPIO_6
26	GPIO_7	GPIO	I/O-24, 3.3V	No[b]	GPIO_7
25	GPIO_8	GPIO	I/O-24, 3.3V	No[b]	GPIO_8
24	GPIO_9	GPIO	I/O, 3.3V	No[b]	GPIO_9
23	DMA_UART_RX	DMA Serial UART RX	I, 3.3V	No[c]	CPU_DEBUG_RX
22	DMA_UART_TX	DMA Serial UART TX	T, 3.3V	No[c]	CPU_DEBUG_TX
21	VDD_3V3_IN	3.3V power	P Do not connect when boost regulator is in use. Input, 3.0-3.7V when boost regulator is not used.	Power	VDD_3V3_RING
20	VDD_BATT	Battery input voltage	P 2.0-3.3V when boost regulator is in use. 3.0-3.7V when boost regulator is not used.	Power	VDD_BATT_DIRTY
19	GND	Ground	Gnd, 0V	Power	-
18	3V3_REG_CTRL_IN	3V3 boost regulator switch control input	C, Connect to 3V3_REG_CTRL_OUT to enable boost regulator Connect to GND to disable boost regulator	Power	-
17	3V3_REG_CTRL_OUT	3V3 boost regulator switch control output	A-1v2, Connect to 3V3_REG_CTRL_IN to enable boost regulator Leave unconnected to disable boost regulator	Power	SREG_3V3_CTRL
16	SPI_MISO	SPI master data in	I, 3V3	No[c]	SPI_MISO
15	SPI_SCLK	SPI clock	O, 3V3	No[c]	SPI_SCLK
14	SPI_MOSI	SPI master data out	O, 3V3	No[c]	SPI_MOSI
13	USER_UART_TX	User UART Tx (GPIO_10)	I/O, 3.3V	Yes	GPIO_10
12	USER_UART_RX	User UART Rx (GPIO_11)	I/O, 3.3V	Yes	GPIO_11
11	GPIO_12	GPIO	I/O, 3.3V	No[b]	GPIO_12
10	GPIO_13	GPIO	I/O, 3.3V	No[b]	GPIO_13
9	FORCE_AWAKE	Force the CPU to wake	C, 3.3V	No[a]	FORCE_AWAKE
8	SUPERCAP_BALANCE	Balance the centre pin voltage on stacked supercaps	A-3v3, 3.3V	No[c]	SUPERCAP_BALANCE
7	EPC_ANT_B	EPC port B	A-1v2, 1.2V max	No[c]	RFID_ANT_B
6	EPC_ANT_A	EPC port A	A-1v2, 1.2V max	No[c]	RFID_ANT_A
5	RESET_L	Module reset. Active low	C, 3.3V	Yes	POWERONRESET_L
4	SENSOR_7	Sensor interface	A-1v2, 1.2V max	No[a]	SENSOR_IF7
3	SENSOR_5	Sensor interface	A-1v2, 1.2V max	No[a]	SENSOR_IF5
2	SENSOR_4	Sensor interface	A-1v2, 1.2V max	No[a]	SENSOR_IF4

Table 5-2: G2M5477 Module Pins

Pin	Name	Function	Type, Voltage	Icon Support	G2C547 Pin Connection
1	SENSOR_6	Sensor interface	A-1v2, 1.2V max	No[a]	SENSOR_IF6
H1	EXTERNAL ANTENNA CONNECTOR	U.FL connector	RF	Yes	
A1	INTERNAL ANTENNA	SMT PCB-style Antenna: antenova Rufa Right: 3030A5887-01 www.antenova.com/?id=744		Yes	

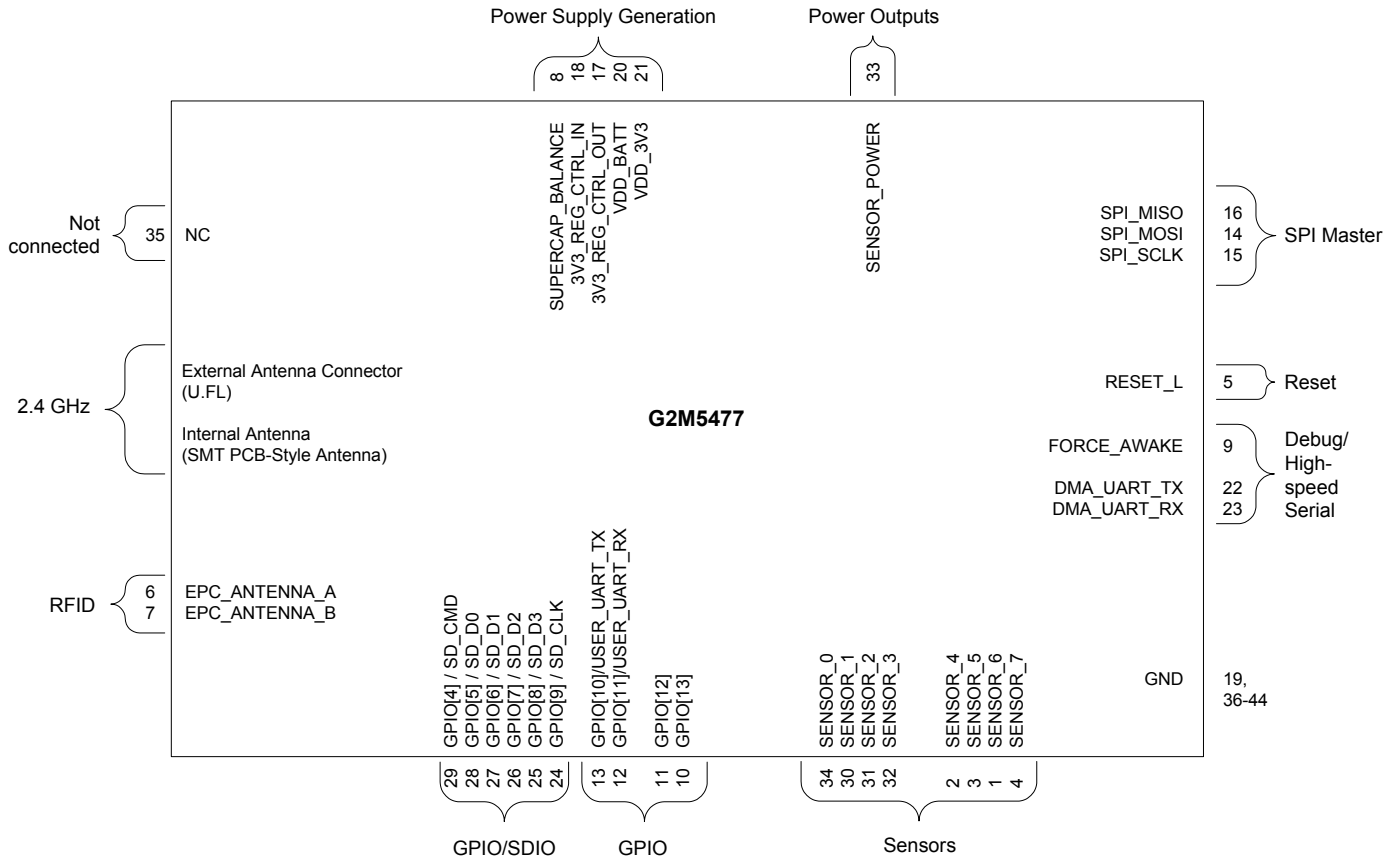
a. Connect to signal ground directly
b. Connect to signal ground via a 10k pulldown resistor
c. Leave disconnected

5.3 Pin Grouping

The interfaces to the G2M5477 consist of:

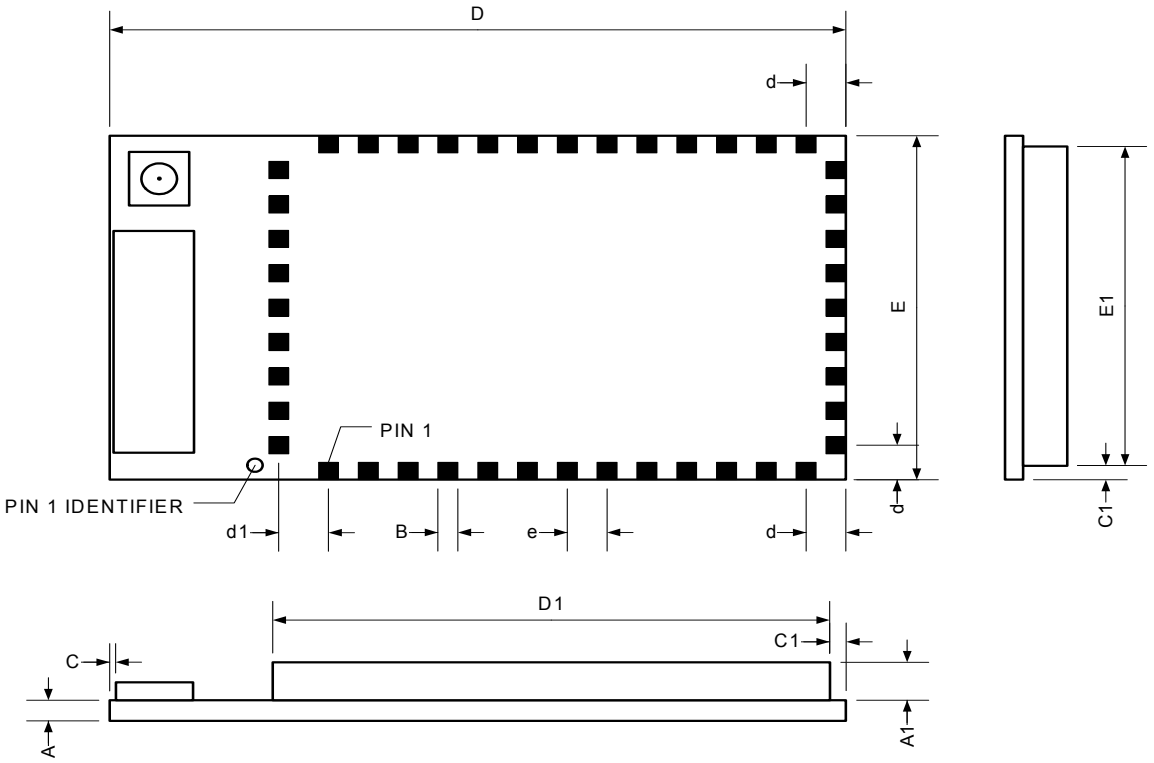
- *Power Supply Generation*: The G2M5477 supports a wide range of battery types and 2 power supply configurations.
- *SPI master:* connected to the on-board flash memory, the SPI master interface can be used to control additional SPI-slave devices.
- *Debug*: reset, control, and DMA UART for high-speed serial and software debug.
- *Sensors:* to external sensors for measuring analog parameters (e.g. temperature, humidity, shock), and sensing security seals, motion and other parameters.
- *GPIO:* to general-purpose digital devices. GPIO can also control switches, or provide a user UART and SDIO.
- *RFID Antennas:* up to two ~900MHz antenna for emulating EPCglobal Generation-2 RFID tags.
- *RF:* to external antennas, Wi-Fi Tx/Rx and ISO 24730-2 Tx.

Figure 5-1: Pin Logical Grouping



5.4 Physical Dimensions

Figure 5-2: Physical Dimensions



Common Dimensions
(Units of measure = mm)

SYMBOL	MIN	NOM	MAX	NOTE
A		1.2		
A1		2.25		
B		1		
C		0.2		
C1		0.4		
D		37		
D1	28.05	28.1	28.15	
E		20		
E1	18.65	18.7	18.5	
d		2		
d1		2.5		
e		2		

6 Electrical Specifications

6.1 Absolute Maximum Ratings

Table 6-1: Absolute Maximum Ratings

Parameter	Min.	Typ.	Max.	Units	Test Conditions/Comments
Vbatt	2.0		3.7	V	
Rfmax – Maximum RF input		10		dBm	To U.FL connector.
VHBM – ESD tolerance, human body model		2		kV	
Input voltage for pins types: Analog 3V3 Power 3V3 O, T, I, I/O, I/O-24	-0.3		See note	V	Note: The voltage should not exceed 3.7V, and should be no more than 0.3V greater than the voltage on the VDD_3V3_IN pin. Note that this voltage changes depending on the state of the module. Refer to Section 4.8, Power Supplies for a discussion of power supply operation.
Input voltage for analog pin type: Analog 1V2			See note	V	TBD
Input voltage for analog pin type: RF	0		0	V	This pad is an RF input or output, and is a DC short to ground. No voltage should be placed on it.
Input voltage on control pins FORCE_AWAKE and RESET_L	-0.3		3.7	V	

Warning: I/O voltages must adhere to Table 6-1 to avoid damage and to Table 6-4 or Table 6.5 as appropriate for correct operation.

6.2 Recommended Operating Conditions

Table 6-2: Recommended Operating Conditions

Parameter	Min.	Typ.	Max.	Units	Test Conditions/Comments
Vbatt – Battery voltage (1)	2.0		3.3	V	Using power supply configuration of Figure 4-2.
Vbatt – Battery voltage (2)	3.0		3.7	V	Using power supply configuration of Figure 4-3.
Operating temperature	-30		+85	C	Applies to all specifications unless otherwise noted.

6.3 Package Thermal Specifications

Table 6-3: Thermal Specifications

Parameter	Min.	Typ.	Max.	Units	Test Conditions/Comments
Package + enclosure thermal resistance		20		°C/W	

6.4 Digital Pin Parameters

Table 6-4: Digital Input, Output, Input/Output or Tristate Pin Parameters

Parameter	Min.	Typ.	Max.	Units	Test Conditions/Comments
I_{OH} – DC pin current output - high Digital I/O 8mA drive	8			mA	Output voltage = VDD_3V3_IN – 0.4V. VDD_3V3_IN = 3.0V to 3.7V.
I_{OL} – DC pin current output - low Digital I/O 8mA drive	8			mA	Output voltage = 0.4V. VDD_3V3_IN = 3.0V to 3.7V.
I_{OH} – DC pin high current output - high Digital I/O 24mA drive	24			mA	Output voltage = VDD_3V3_IN – 0.4V. VDD_3V3_IN = 3.0V to 3.7V.
I_{OL} – DC pin high current output - low Digital I/O 24mA drive	24			mA	Output voltage = 0.4V. VDD_3V3_IN = 3.0V to 3.7V.
V_{IH} – DC pin input logic level - high			2.3	V	VDD_3V3_IN = 3V3
V_{IL} – DC pin input logic level - low	1.0			V	VDD_3V3_IN = 3V3
R_{GPIO}– Pull-down resistance on GPIO 8mA pins		83		k Ohms	
I_{CR} – Maximum crowbar current on current loop sensor inputs		2		uA	Input voltage 0-1.2V
Timing skew on pins GPIO[0..14]				ns	

6.5 Control Signal Parameters

Table 6-5: Control Signal Parameters

Parameter	Min.	Typ.	Max.	Units	Test Conditions/Comments
t_{reset}	160			us	Min pulse width for reset assertion
t_{force_awake}	31			us	Min pulse width for force_awake assertion
Vil (RESET_L)		0.3 Vdd_batt			
Vih (RESET_L)		0.5 Vdd_batt			
Vil (FORCE_AWAKE)	0.15		0.5	V	
Vih (FORCE_AWAKE)	0.6		1.0		

6.6 Power Consumption

6.6.1 Asleep

Table 6-6: Power Consumption when ASLEEP (Vbatt=2.75V)

Parameter	Min.	Typ.	Max.	Units	Test Conditions/Comments
Current consumption when asleep; room temperature.		4		uA	Temperature < 30°C. RFID and magnetic receiver disabled. 32kHz crystal oscillator disabled, all digital pins pulled to ground.
Current consumption when asleep; full temperature range.				uA	Temperature < 85°C. RFID and magnetic receiver disabled.
Supply current for magnetic receiver		190		uA	When enabled. Note the magnetic receiver is intended to operate with a 1% duty cycle.
Time for magnetic receiver to wake and check if signal is present		5.4		ms	

Table 6-6: Power Consumption when ASLEEP (Vbatt=2.75V)

Parameter	Min.	Typ.	Max.	Units	Test Conditions/Comments
RFID incremental supply current per RFID antenna.		2		uA	No reader present, when in 'listen' state.
RFID incremental supply current		50		uA	Reader present, RFID receiver in 'on' state.
Sampled comparator supply current		4		uA	When enabled.
32768Hz crystal oscillator supply current		1		uA	When enabled.

6.6.2 Awake

Table 6-7: Power Consumption when AWAKE (Vbatt=3.3V)

Parameter	Min.	Typ.	Max.	Units	Test Conditions/Comments
Program load		70		mW	Does not include power to flash memory.
Program execution		65		mW	
Doze		50		mW	
Wait for Rx		90		mW	
Rx Wi-Fi with CCK/DSSS (1,2,5.5,11 Mbit/s)		125		mW	Averaged over packet of 1023 bytes.
Rx Wi-Fi with OFDM (6, 9... 54 Mbit/s)		130		mW	
Tx Wi-Fi at +18 dBm		700		mW	1, 2, 5.5, or 11 Mbit/s.
Tx ISO24730-2 DSSS at +18 dBm		700		mW	

6.6.3 Wakeup Timing and Energy Considerations

Table 6-8: Wakeup Timing and Energy Consumption

Parameter	Min.	Typ.	Max.	Units	Test Conditions/Comments
Time from wakeup event to program load start				ms	Min without boost regulator, and "Fast Boot" mode Max with boost regulator, and no "Fast Boot"
Energy consumed from wakeup event to program load start				mJ	This includes booting eCos.
Time to load program from flash		0.25		ms/Kbyte	SPI clock = 44MHz.

6.7 Sensor Interface

See the G2C547 Datasheet, [5], for details of the sensor interface.

6.8 External Power Supplies

SENSOR_POWER corresponds to G2C547 POWER_SENSORS. See the G2C547 Datasheet, [5], for details.

7 RF Performance

The G2M5477 is pre-calibrated. No user calibration is required.

7.1 2.4GHz Radio

7.1.1 2.4GHz Synthesizer

Table 7-1: Synthesizer Parametric Specifications

Parameter	Value	Test Conditions/Comments
Channels supported	1-14	
ISO-24730 center frequency	2441.75 MHz	

7.1.2 Wi-Fi Receiver

Table 7-2: Wi-Fi Receiver Performance Specifications

Parameter	Min.	Typ.	Max.	Units	Condition
Receive sensitivity for 10% packet error rate for 1000 byte packet, measured using a cabled connection to port H1		-70		dBm	54Mbit/s
		-72		dBm	48Mbit/s
		-77		dBm	36Mbit/s
		-79		dBm	24Mbit/s
		-82		dBm	18Mbit/s
		-82		dBm	12Mbit/s
		-87		dBm	9Mbit/s
		-89		dBm	6Mbit/s
		-84		dBm	11Mbit/s
		-87		dBm	5.5Mbit/s
		-89		dBm	2Mbit/s
		-90		dBm	1Mbit/s
RSSI resolution		0.25		dB	
RSSI variation over temperature and battery voltage 2V0 - 3V7		3		dB	
Maximum input level for 10% PER		-20		dBm	802.11b/g specification
Input return loss		-12		dB	Differential input from 2400 to 2500MHz.

7.1.3 Wi-Fi Transmitter

Table 7-3: Wi-Fi Transmitter Performance Specifications

Parameter	Min.	Typ.	Max.	Units	Condition
Tx Power		+18		dBm	
Tx EVM		-28		dB	

8 Firmware Features

The G2C547 firmware provides the infrastructure required by an application program for a low-power 802.11b/g device.

API features include:

- an embedded operating system (eCos)
- a TCP/IP stack (LWIP)
- start-up code
- an application loader
- interrupt handling
- power saving features
- device drivers

The G2M5477 module comes pre-installed with the Icon application, which provides a serial interface for networking functions. For more details see Chapter 9, Application Information.

Icon developers may fulfill all application requirements using Icon commands. G2M5477 developers requiring lower level access to the firmware functions should refer to *G2C547 Programmer's Reference Manual (PRM)*, [3], and *G2C547 Application Programming Interface (API) Reference* [4].

9 Application Information

The G2M5477 Module comes pre-installed with Icon, an application that provides a command line interface to module functions.

Icon uses the UART interface for communication with the host controller.
Icon provides commands to handle wireless networking procedures, including authentication and association, security and encryption and data transfer using UDP and TCP protocols.

Icon also provides access to the module high level event interface, via the eCos operating system. This makes it unnecessary to perform low-level polling to determine when to respond to module state changes.

For more details, see *Icon Programmer's Reference Manual (PRM)*, [1].

10 Qualification

This section is to contain information on:

- testing and quality assurance
- Operational temperature range qualification
- ESD resilience

Certification information is separate.
More detail will be provided in a later revision of this document.

11 Design Guidelines

This section is to provide guidelines for incorporating the G2M5477 module in a customer-designed device. It covers issues such as:

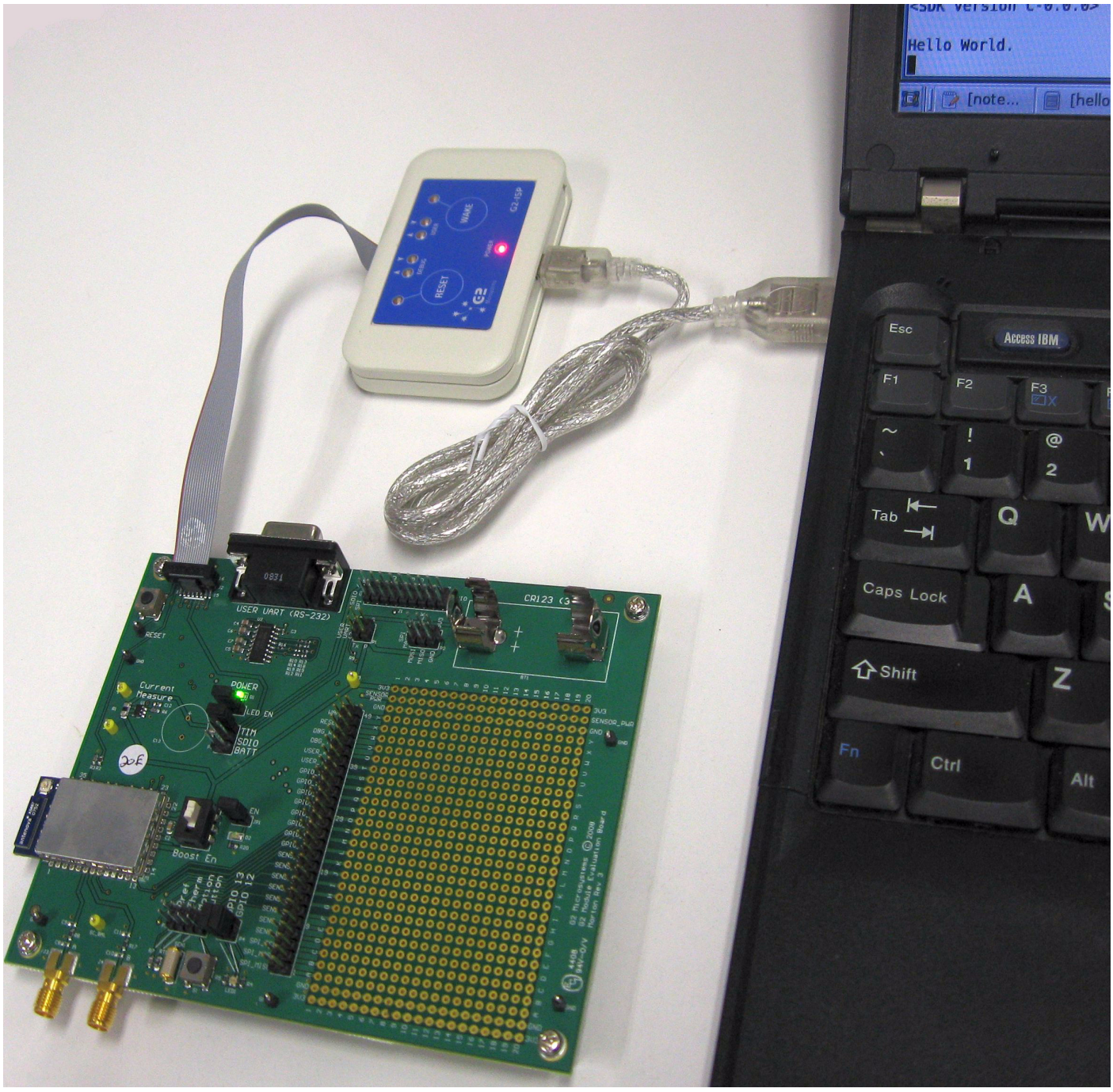
- Pads
- Layout
- Reflowing
- How the internal antenna is affected by a nearby ground plane

More detail will be provided in a later revision of this document.

12 Development Kit

The G2M5477 Module Development Kit (MDK) provides a hardware and software platform for testing and developing G2M5477 applications.

For more information refer to *Getting Started with the G2M5477 MDK*, [6].



13 References

Throughout this data sheet, references to other documents are listed. The following documents provide additional material:

13.1 Icon Developers

1. Icon Programmer's Reference Manual (PRM)
   G2 Microsystems 2008
2. Icon API Reference
   G2 Microsystems 2008

13.2 G2M5477 Developers

3. G2C547 Programmer's Reference Manual (PRM) - G2 Microsystems 2008
4. G2C547 Application Programming Interface (API) Reference - G2 Microsystems 2008
5. G2C547 Datasheet - G2 Microsystems 2008

13.3 MDK Users

6. Getting Started with the G2M5477 MDK
   G2 Microsystems 2008
7. G2M5477 Users Guide
   G2 Microsystems 2008

13.4 Standards and Excellence

8. EPCglobal - Class 1 Generation 2 UHF RFID Protocol Version 1.09 - http://www.epcglobalinc.org/standards
9. IEEE Std 802.11 - 2007 - http://ieeexplore.ieee.org/xpl/standards.jsp
10. SPARC V8 Architecture Manual - http://www.sparc.org/standards/V8.pdf

14 Compliance

14.1 FCC Compliance

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.

14.1.1 Troubleshooting

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 to an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician.

This device complies with Part 15 of the FCC Rules.

14.1.2 Conditions

Operation is subject to the following two conditions:

- This device may not cause harmful interference
- This device must accept any interference received, including interference that may cause undesired operation.

14.1.3 Markings

To satisfy FCC exterior labeling requirements, the following text must be placed on the exterior of the end product.

Contains Module FCC ID: U3O-G2M5477

Any similar wording that expresses the same meaning may be used.

14.1.4 FCC Warning

Modifications

Modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment under FCC Rules.

Radio Frequency Exposure

Table 14-1: Radio Frequency Exposure

Property (Units of Measurement)	Value
Antenna Gain (dBi)	2.0
Numeric Gain (numeric)	1.58
Max Allowable Peak Power (dBm)	+23.76
Max Allowable Peak Power (mW)	237.7
Calculated Safe Distance at 1 mW/cm$^{2\ (cm)}$	5.5
Minimum Separation Distance	20[a]

a. Note: for mobile or fixed location transmitters the minimum separation distance is 20cm, even if calculations indicate the MPE distance to be less,

This equipment has been evaluated in accordance with the FCC bulletin 56 "Hazards of radio frequency and electromagnetic fields" and bulletin 65 "Human exposure to radio frequency and electromagnetic fields".

A distance **greater than or equal to 20 cm from the device** should be maintained for safe operation in an uncontrolled environment.

15 Revision History and Glossary

Table 15-1: **Document Revision History**

Version	Date	Description
0.01	October 2008	First draft
0.02-0.10	November 2008	Corrections and additions
0.11	December 2008	Release
0.12	December 2008	Corrections

Glossary

Table 15-2: **Acronyms and Abbreviations**

Term	Definition
ADC	Analog-to-digital converter
AES	Advanced encryption standard
AGC	Automatic gain control
AO	Always on
API	Application programming interface
DAC	Digital to Analog Converter.
DCF	Distributed Coordination Function - see 802.11 specification
DSSS	Direct sequence spread spectrum
EPC	Electronic product code
FET	Field effect transistor
FSK	Frequency shift keying
GPIO	General-purpose input/output
IEEE 802.11b/g	The 802.11b/g standard for wireless local area networks (WLANs) - often called Wi-Fi - is part of the 802.11 series of WLAN standards from the Institute of Electrical and Electronics Engineers (IEEE). 802.11b/g is backward compatible with 802.11. The G2M5477 implements the IEEE 802.11b/g transmit and receive functions.
MAC	Medium access controller. Part of the 802.11 transceiver.
MDS	Minimum detectable signal
MRM	Mobile resource management
NRE	Non-Recurring Engineering costs
NVM	Always On Memory
OOK	On-off keying
PCB	Printed circuit board
PHY	Physical layer processor. Part of the 802.11 transceiver.

Table 15-2: **Acronyms and Abbreviations** *(Cont.)*

Term	Definition
PMU	Power management unit. A section of the G2M5477 that controls which parts of the module are active at any time.
QFN	Quad-flat no-lead package
RSSI	Received signal strength indication. Measurement of signal strength used by wireless systems to estimate the location of the clients.
RTLS	Real-time locating systems
Rx	Receive
SHA	Secure hash algorithm
SMU	Sampled measurement unit
SoC	System on a chip
SPI	Serial peripheral interface. A standard serial interface used for DRAMs and other components.
TCO	Total Cost of Ownership
TCP/IP	TCP/IP (transmission control protocol/internet protocol) is the basic communication language or protocol of the Internet.
Tx	Transmit
WLAN	Wireless local area network
WMM	Wireless Multi-Media. “WMM” is a registered trademark of the Multimedia Alliance, of which G2 is a member. The Wireless Multimedia Alliance generates specifications and practices which, if followed, lead to greater satisfaction with IEEE 802.11-compliant items.
Wi-Fi	Wireless fidelity. A registered trademark of the Wi-Fi alliance for certain types of wireless local area networks (WLAN) that use specifications conforming to IEEE 802.11.