

## Integrated Transceiver Modules for ZigBee / 802.15.4 (900 MHz) Development Kit Available

### FEATURES

- 750mW output power
- Long range
- Up to 1Mbps RF data rate
- Miniature footprint: 0.9" x 1.63"
- Multiple antenna options
- Dual antennas
- Agency Approvals: FCC and IC
- Powerful Atmel 256k ATXMEGA256A3U with 802.15.4 MAC or ZigBee Stack
- LSR serial interface based on 802.15.4 MAC
- Low power operation
- RoHS compliant
- Streamlined development with LSR design services.
- License options available to purchase design or integrate design.

### APPLICATIONS

- Security
- Lighting Control
- HVAC Control
- Sensor Networks
- Medical
- Industrial Automation

### DESCRIPTION

The SiFLEX02-R2-HP module is a high performance 900MHz IEEE 802.15.4 radio (AT86RF212B & RF amplifier circuit) and microcontroller (ATXMEGA256A3U) in a cost effective, pre-certified footprint.



The module comes preloaded with the LSR host serial interface running on top of the Atmel 802.15.4 MAC.

Full debug and programming capabilities are included to develop custom applications. Easily load the ZigBee stack or 802.15.4 MAC onto the module and create your own network.

Need to get to market quickly? Not an expert in 802.15.4 or ZigBee? Need a custom antenna? Would you like to own the design? Would you like a custom design? Not quite sure what you need? Do you need help with your host board? LSR Design Services will be happy to develop custom hardware or software, integrate the design, or license the design so you can manufacture yourself. Contact us at [sales@lsr.com](mailto:sales@lsr.com) or call us at 262-375-4400.

### ORDERING INFORMATION

| Order Number | Description                                                                                                                                                                                                                     |
|--------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 450-0127     | SiFLEX02-R2-HP Module with U.FL connectors for external antennas (Tray) SPQ = 25, MOQ = 50                                                                                                                                      |
| 450-0128     | SiFLEX02-R2-HP Module with castellated RF traces for off board antenna. Note: See Antenna Options section for more details. (Tray) SPQ = 25, MOQ = 1,000<br>NOTE: Non-standard part. Contact LSR directly for more information. |
| 450-0132     | SiFLEX02-R2-HP U.FL Development Kit                                                                                                                                                                                             |

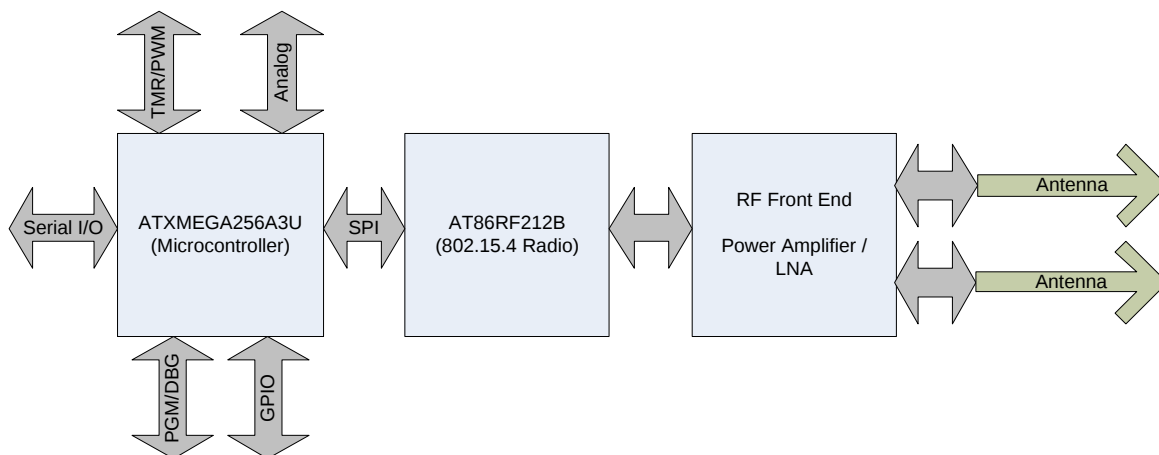
**Table 1 Orderable SiFLEX02-R2-HP Model Numbers**

## MODULE ACCESSORIES

|                                                                                    | Order Number    | Description                                                |
|------------------------------------------------------------------------------------|-----------------|------------------------------------------------------------|
|   | <b>001-0002</b> | 900 MHz Dipole Antenna with Reverse Polarity SMA Connector |
|  | <b>080-0001</b> | U.FL to Reverse Polarity SMA Bulkhead Cable 105mm          |

**Table 2 Module Accessories**

## BLOCK DIAGRAM



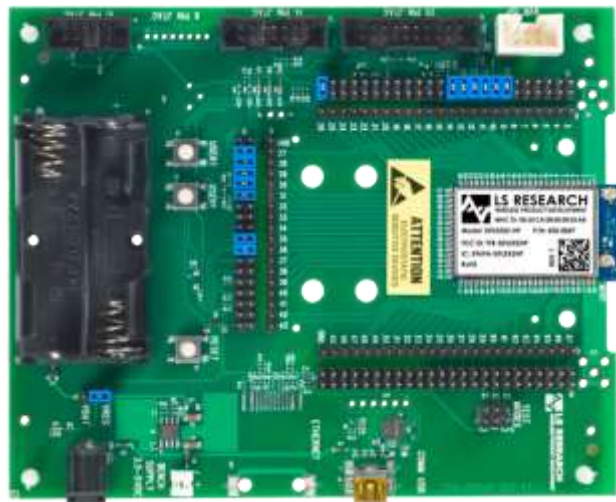
**Figure 1 SiFLEX02-R2-HP Module Block Diagram – High-Level**

## DEVELOPMENT KIT

The SiFLEX02-R2-HP Development Kit can be used out of the box to evaluate RF range performance with the simple press of a button.

Users interested in further investigating the performance and capabilities of the SiFLEX02-R2-HP Module can use the ModFLEX™ Test Tool. This PC-based software can demonstrate just how easy it is to send & receive data, collect performance data, change channels, power levels, or addresses using the LSR Serial Host Protocol with another microcontroller.

More advanced users can use the development board to create and debug their own software for the SiFLEX02-R2-HP module using the 802.15.4 MAC or ZigBee stack from Atmel.



**Figure 2 SiFLEX02-R2-HP Development Board**

| Part Number | Description            |
|-------------|------------------------|
| 450-0132    | SiFLEX02-R2-HP Dev Kit |

## Kit Contents

- ModFLEX™ Development Board with SiFLEX02-R2-HP Module with external antennas (x2)
- USB Cable (x2)
- AA Batteries (x4)
- Software & Technical Information CD

## TABLE OF CONTENTS

|                                                 |           |
|-------------------------------------------------|-----------|
| <b>FEATURES .....</b>                           | <b>1</b>  |
| <b>APPLICATIONS.....</b>                        | <b>1</b>  |
| <b>DESCRIPTION .....</b>                        | <b>1</b>  |
| <b>ORDERING INFORMATION .....</b>               | <b>1</b>  |
| <b>MODULE ACCESSORIES.....</b>                  | <b>2</b>  |
| <b>BLOCK DIAGRAM.....</b>                       | <b>3</b>  |
| <b>DEVELOPMENT KIT.....</b>                     | <b>3</b>  |
| Kit Contents .....                              | 3         |
| <b>MODULE PINOUT AND PIN DESCRIPTIONS .....</b> | <b>6</b>  |
| <b>MODULE OVERVIEW.....</b>                     | <b>10</b> |
| Microcontroller .....                           | 10        |
| Radio .....                                     | 12        |
| RF Front End (Power Amplifier and LNA).....     | 13        |
| Antenna Options .....                           | 14        |
| <b>OPERATING MODES TRUTH TABLE .....</b>        | <b>15</b> |
| <b>MODES OF OPERATION .....</b>                 | <b>16</b> |
| Host Microcontroller .....                      | 16        |
| Software Stacks .....                           | 16        |
| <b>DEVELOPMENT TOOLS .....</b>                  | <b>18</b> |
| AVR Studio.....                                 | 18        |
| WinAVR .....                                    | 18        |
| AVR JTAGICE mkII.....                           | 18        |
| AVRISP mkII.....                                | 18        |
| IAR Embedded Workbench for Atmel AVR .....      | 18        |
| <b>ELECTRICAL SPECIFICATIONS .....</b>          | <b>19</b> |
| Absolute Maximum Ratings .....                  | 19        |
| Recommended Operating Conditions .....          | 19        |
| General Characteristics.....                    | 20        |
| RF Characteristics .....                        | 21        |

|                                                       |           |
|-------------------------------------------------------|-----------|
| <b>SOLDERING RECOMMENDATIONS .....</b>                | <b>24</b> |
| Recommended Reflow Profile for Lead Free Solder ..... | 24        |
| <b>CLEANING .....</b>                                 | <b>25</b> |
| <b>OPTICAL INSPECTION .....</b>                       | <b>25</b> |
| <b>REWORK .....</b>                                   | <b>25</b> |
| <b>SHIPPING, HANDLING, AND STORAGE .....</b>          | <b>25</b> |
| Shipping .....                                        | 25        |
| Handling .....                                        | 25        |
| Moisture Sensitivity Level (MSL) .....                | 25        |
| Storage .....                                         | 25        |
| Repeating Reflow Soldering .....                      | 26        |
| <b>AGENCY STATEMENTS .....</b>                        | <b>27</b> |
| <b>MECHANICAL DATA.....</b>                           | <b>33</b> |
| PCB Footprint.....                                    | 33        |
| General Module Dimensions.....                        | 34        |
| <b>COMPATIBILITY.....</b>                             | <b>35</b> |
| <b>TRAY PACKAGING (MM).....</b>                       | <b>36</b> |
| <b>MODULE REVISION HISTORY .....</b>                  | <b>37</b> |
| Rev 1.0.....                                          | 37        |
| <b>CONTACTING LSR.....</b>                            | <b>38</b> |

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### Figure 3 Module Pinout

| Module Pin | Name          | MCU Pin | Type  | Description                                                                                                       |
|------------|---------------|---------|-------|-------------------------------------------------------------------------------------------------------------------|
| 1          | GND           | N/A     | GND   | Ground                                                                                                            |
| 2          | GND           | N/A     | GND   | Ground                                                                                                            |
| 3          | GND           | N/A     | GND   | Ground                                                                                                            |
| 4          | NC            | N/A     | NC    | No Connect                                                                                                        |
| 5          | NC            | N/A     | NC    | No Connect                                                                                                        |
| 6          | VPA           | N/A     | PWR   | RF Power Amplifier Supply Voltage<br>For 750mW output power provide 4.0VDC<br>For .5W output power provide 3.3VDC |
| 7          | VPA           | N/A     | PWR   | RF Power Amplifier Supply Voltage<br>For 750mW output power provide 4.0VDC<br>For .5W output power provide 3.3VDC |
| 8          | NC            | N/A     | NC    | No Connect                                                                                                        |
| 9          | JTAG TMS      | 10      | I/O   | General-purpose digital I/O (PB4), Analog input, JTAG TMS                                                         |
| 10         | JTAG TDI      | 11      | I/O   | General-purpose digital I/O (PB5), Analog input, JTAG TDI                                                         |
| 11         | JTAG TCK      | 12      | I/O   | General-purpose digital I/O (PB6), Analog input, JTAG TCK                                                         |
| 12         | JTAG TDO      | 13      | I/O   | General-purpose digital I/O (PB7), Analog input, JTAG TDO                                                         |
| 13         | JTAG/PDI/JRST | 56      | I/O   | PDI/PDI_DATA                                                                                                      |
| 14         | nRESET        | 57      | Input | RESET/PDI_CLOCK                                                                                                   |
| 15         | PA0           | 62      | I/O   | General-purpose digital I/O, Analog input, Analog REF A                                                           |
| 16         | NC            | N/A     | NC    | No Connect                                                                                                        |
| 17         | PA2           | 64      | I/O   | General-purpose digital I/O, Analog input, Analog comparator 2                                                    |
| 18         | PA1           | 63      | I/O   | General-purpose digital I/O, Analog input, Analog comparator 1                                                    |
| 19         | PA7           | 5       | I/O   | General-purpose digital I/O, Analog input, Analog comparator output                                               |
| 20         | PA4           | 2       | I/O   | General-purpose digital I/O, Analog input                                                                         |
| 21         | PA5           | 3       | I/O   | General-purpose digital I/O, Analog input                                                                         |
| 22         | PA6           | 4       | I/O   | General-purpose digital I/O, Analog input                                                                         |
| 23         | PB1           | 7       | I/O   | General-purpose digital I/O, Analog input                                                                         |
| 24         | PB2           | 8       | I/O   | General-purpose digital I/O, Analog input                                                                         |
| 25         | PB3           | 9       | I/O   | General-purpose digital I/O, Analog input                                                                         |
| 26         | VCC - 3V3DC   | VCC     | VCC   | Supply Voltage                                                                                                    |
| 27         | PF3           | 49      | I/O   | General-purpose digital I/O, Output Compare, UART Tx                                                              |
| 28         | PF2           | 48      | I/O   | General-purpose digital I/O, Output Compare, UART Rx                                                              |
| 29         | PF1           | 47      | I/O   | General-purpose digital I/O, Output Compare, UART XCK0                                                            |

The information in this document is subject to change without notice.

| Module Pin | Name         | MCU Pin | Type | Description                                                      |
|------------|--------------|---------|------|------------------------------------------------------------------|
| 30         | PF0          | 46      | I/O  | General-purpose digital I/O, Output Compare                      |
| 31         | PE5          | 41      | I/O  | General-purpose digital I/O, Output Compare, UART XCK1, SPI MOSI |
| 32         | PE4          | 40      | I/O  | General-purpose digital I/O, Output Compare, SPI SS              |
| 33         | PE3          | 39      | I/O  | General-purpose digital I/O, Output Compare, UART Tx             |
| 34         | PE2          | 38      | I/O  | General-purpose digital I/O, Output Compare, UART Rx             |
| 35         | PC3, UART TX | 19      | I/O  | General-purpose digital I/O, Output Compare, UART Tx             |
| 36         | PC2, UART RX | 18      | I/O  | General-purpose digital I/O, Output Compare, UART Rx             |
| 37         | PC1          | 17      | I/O  | General-purpose digital I/O, Output Compare, IIC SCL             |
| 38         | PC0          | 16      | I/O  | General-purpose digital I/O, Output Compare, IIC SDA             |
| 39         | PF5          | 51      | I/O  | General-purpose digital I/O                                      |
| 40         | PF6          | 54      | I/O  | General-purpose digital I/O                                      |
| 41         | PF7          | 55      | I/O  | General-purpose digital I/O                                      |
| 42         | PA3          | 1       | I/O  | General-purpose digital I/O, Analog input                        |
| 43         | NC           | N/A     | NC   | No Connect                                                       |
| 44         | GND          | N/A     | GND  | Ground                                                           |
| 45         | NC           | N/A     | NC   | No Connect                                                       |
| 46         | NC           | N/A     | NC   | No Connect                                                       |
| 47         | NC           | N/A     | NC   | No Connect                                                       |
| 48         | NC           | N/A     | NC   | No Connect                                                       |
| 49         | NC           | N/A     | NC   | No Connect                                                       |
| 50         | NC           | N/A     | NC   | No Connect                                                       |
| 51         | NC           | N/A     | NC   | No Connect                                                       |
| 52         | NC           | N/A     | NC   | No Connect                                                       |
| 53         | NC           | N/A     | NC   | No Connect                                                       |
| 54         | NC           | N/A     | NC   | No Connect                                                       |
| 55         | NC           | N/A     | NC   | No Connect                                                       |
| 56         | PE1          | 37      | I/O  | General-purpose digital I/O, Output Compare, IIC SCL             |
| 57         | PE0          | 36      | I/O  | General-purpose digital I/O, Output Compare, IIC SDA             |
| 58         | PC4          | 20      | I/O  | General-purpose digital I/O, Output Compare, SPI SS              |
| 59         | PC7          | 23      | I/O  | General-purpose digital I/O, Output Compare, UART Tx, SPI SCK    |
| 60         | PC6          | 22      | I/O  | General-purpose digital I/O, Output Compare, UART Rx, SPI MISO   |

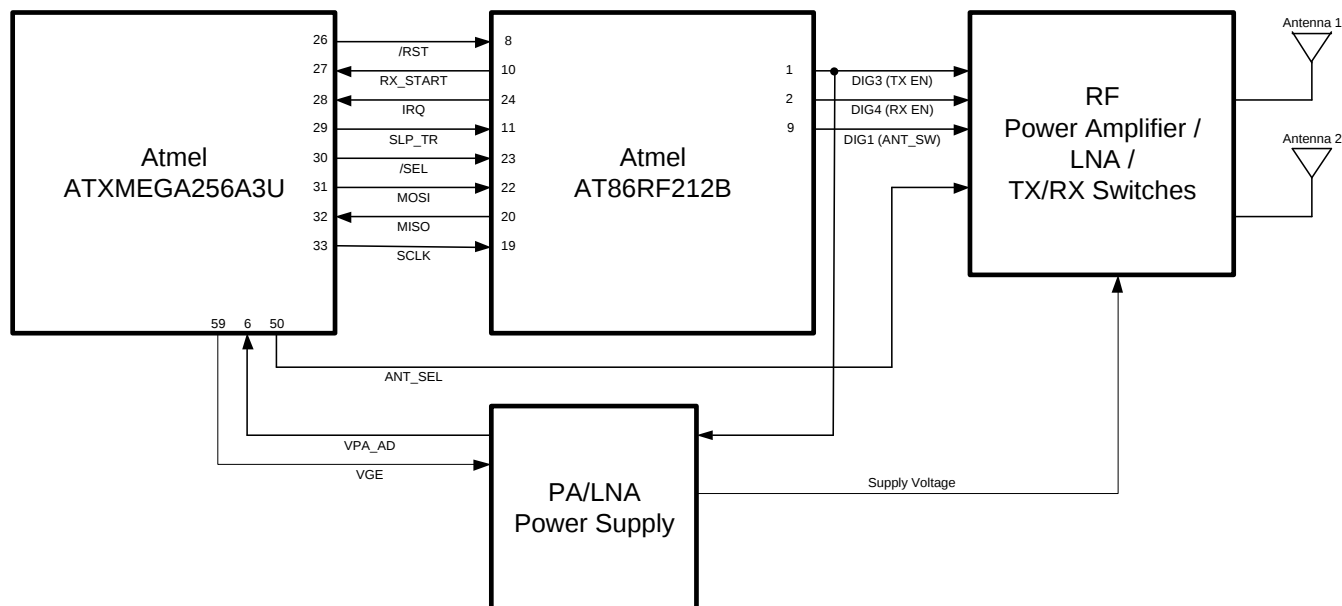
The information in this document is subject to change without notice.

| Module Pin | Name | MCU Pin | Type | Description                                                      |
|------------|------|---------|------|------------------------------------------------------------------|
| 61         | PC5  | 21      | I/O  | General-purpose digital I/O, Output Compare, UART XCK1, SPI MOSI |
| 62         | NC   | N/A     | NC   | No Connect                                                       |
| 63         | NC   | N/A     | NC   | No Connect                                                       |
| 64         | NC   | N/A     | NC   | No Connect                                                       |
| 65         | NC   | N/A     | NC   | No Connect                                                       |
| 66         | NC   | N/A     | NC   | No Connect                                                       |
| 67         | GND  | N/A     | GND  | Ground                                                           |
| 68         | GND  | N/A     | GND  | Ground                                                           |
| 69         | GND  | N/A     | GND  | Ground                                                           |

**Table 3 SiFLEX02-R2-HP Module Pin Descriptions**

## MODULE OVERVIEW

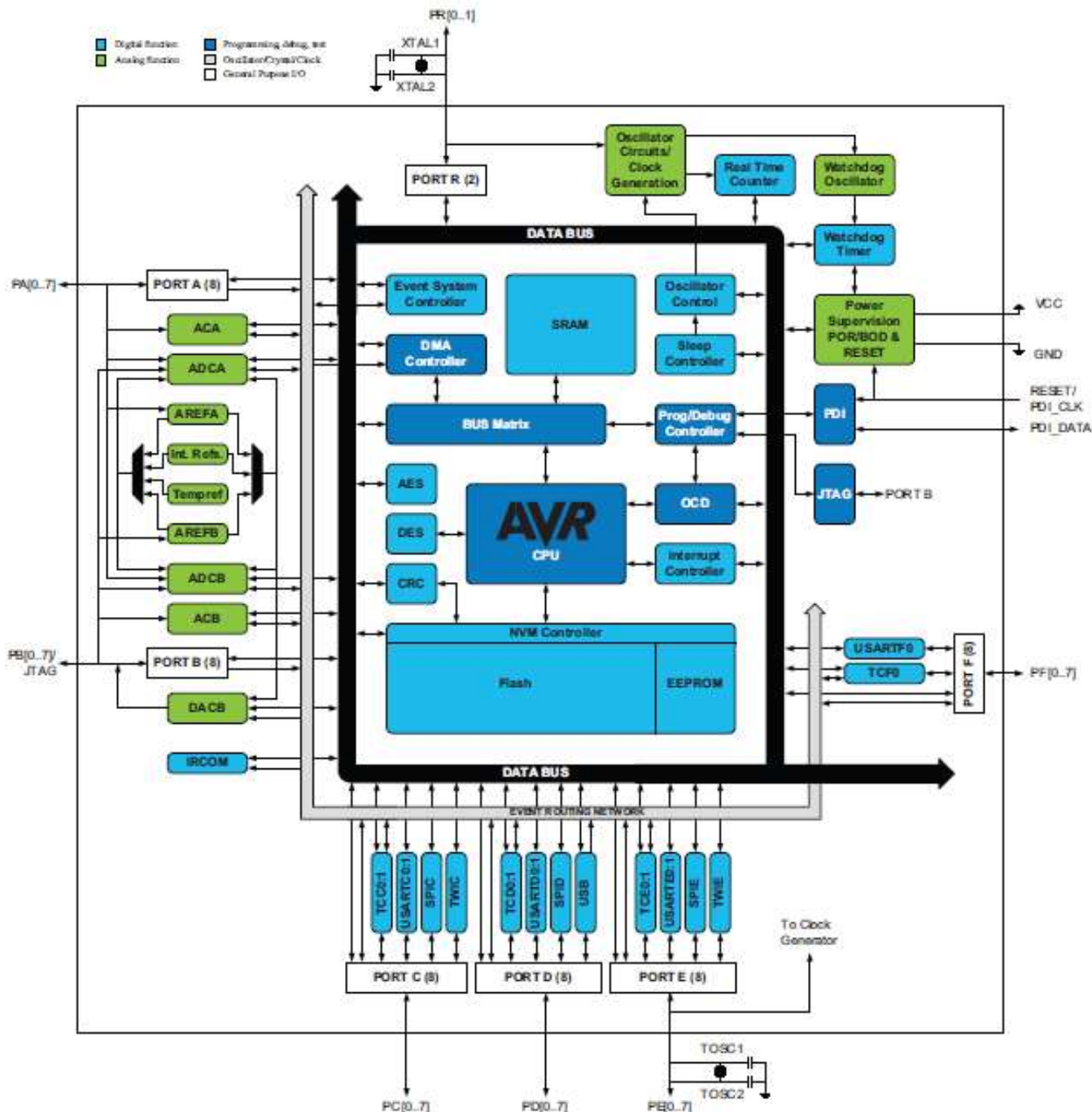
Figure 4 shows the internal interconnects of the ICs on the SiFLEX02-R2-HP module. Consult the respective IC datasheets for details, or contact LSR sales to purchase the SiFLEX02-R2-HP module schematics as part of LSR's ModFLEX™ design program. For a high-level block diagram of the SiFLEX02-R2-HP module, see Figure 1.



**Figure 4 SiFLEX02-R2-HP Module Block Diagram – Internal Interconnects**

## Microcontroller

The AVR XMEGA A3U is a family of low power, high performance and peripheral rich CMOS 8/16-bit microcontrollers based on the AVR® enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the XMEGA A3U achieves throughputs approaching 1 Million Instructions Per Second (MIPS), thus allowing the system designer to optimize power consumption versus processing speed. Figure 5 shows a block diagram of the ATXMEGA256A3U.



**Figure 5 ATXMEGA256A3U Block Diagram**

The AVR CPU combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction, executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs many times faster than conventional single-accumulator or CISC based microcontrollers.

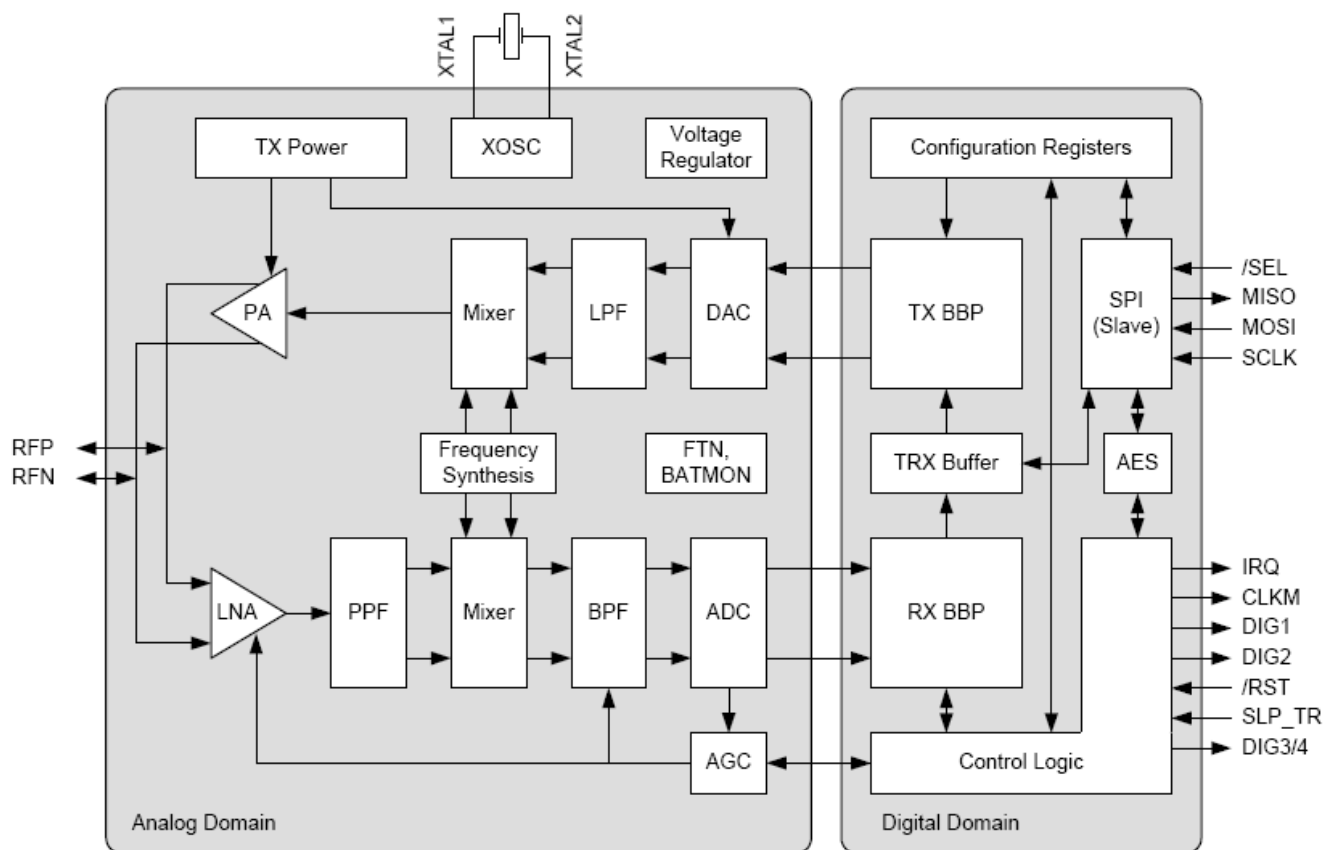
The AVR XMEGA A3U devices have five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, DMA Controller, Event System, Interrupt Controller and all peripherals to continue functioning. The Power-down mode saves the SRAM and register contents but stops the oscillators, disabling all other functions until the next TWI or pin-change interrupt, or Reset. In Power-save mode, the asynchronous Real Time Counter continues to run, allowing the application to maintain a timer base while the rest of the device is sleeping. In Standby mode, the Crystal/Resonator Oscillator is kept running while the rest of the device is sleeping. This allows very fast start-up from external crystal combined with low power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run. To further reduce power consumption, the peripheral clock for each individual peripheral can optionally be stopped in Active mode and Idle sleep mode.

## Radio

The AT86RF212B is a low-power, low-voltage 900 MHz transceiver specially designed for low-cost IEEE 802.15.4, ZigBee™, and high data rate ISM applications. For the sub-1 GHz bands, it supports a low data rate of 40kbps of the IEEE 802.15.4-2003 standard and provides an optional data rate 250kbps using O-QPSK, according to IEEE 802.15.4-2006. Furthermore hardware accelerators improve overall system power efficiency and timing.

The receiver path is based on a low-IF architecture. After channel filtering and down conversion the low-IF signal is sampled and applied to the digital signal processing part. Communication between transmitter and receiver is based on direct sequence spread spectrum with different modulation schemes and spreading codes. The AT86RF212B supports the IEEE 802.15.4-2006 standard mandatory BPSK modulation and optional O-QPSK modulation in the 900 MHz band. For applications not necessarily targeting IEEE compliant networks the radio transceiver supports proprietary High Data Rate Modes based on O-QPSK.

The AT86RF212B features hardware supported 128 bit security operation. The standalone AES encryption/decryption engine can be accessed in parallel to all PHY operational modes. Configuration of the AT86RF212, reading, and writing of data memory as well as the AES hardware engine are controlled by the SPI interface and additional control signals.



**Figure 6 AT86RF212B Block Diagram**

### RF Front End (Power Amplifier and LNA)

The SiFLEX02-R2-HP module contains a high performance RF Front End, containing both a RF Power Amplifier as well as a LNA. It is capable of 750mW output power, providing miles of range in outdoor applications.

The signals DIG3 and DIG4 from the RF212B radio are used for transmit enable (TXEN) and receive enable (RXEN) respectively. When transmitting the DIG3 signal will be high and DIG4 will be low, which is controlled by the RF212. When receiving DIG3 will be low and DIG4 is high. In order to configure this functionality, the PA\_EXT\_EN bit in register TRX\_CTRL\_1 (0x04) of the RF212B needs to be set as a one. In addition the bits PA\_LT[1] and PA\_LT[0] in register RF\_CTRL\_0 (0x16) should both be set to one to maximize the PA lead time to 8usec.

When putting the module to sleep the PA\_EXT\_EN bit should be set as zero. Upon wakeup the PA\_EXT\_EN should be set back to one.

## Antenna Options

The SiFLEX02-R2-HP module includes multiple antenna options. The module's regulatory certification has been completed with the following antenna:

- LSR 001-0002 900 MHz Dipole Antenna with Reverse Polarity SMA Connector and LSR 080-0001 U.FL to Reverse Polarity SMA Bulkhead Cable (105mm in length)

The SiFLEX02-R2-HP RF castellations for off board antennas are not covered in the modular certification. If a host board is designed that will utilize off board antennas via the RF castellated antenna connections, an additional certification will be required. LSR is equipped with a certification lab and can assist in getting this done at a very reasonable cost in a short period of time.

An adequate ground plane is necessary to provide good efficiency. The ground plane of the host board on which the module is mounted increases the effective antenna ground plane size and improves the antenna performance.

The environment the module is placed in will dictate the range performance. The non-ideal characteristics of the environment will result in the transmitted signal being reflected, diffracted, and scattered. All of these factors randomly combine to create extremely complex scenarios that will affect the link range in various ways.

It is also best to keep some clearance between the antennas and nearby objects. This includes how the module is mounted in the product enclosure. Unless the items on the following list of recommendations are met, the radiation pattern can be heavily distorted.

Whichever antenna is used, it is best to keep a few things in mind when determining its location.

- Never place ground plane or copper trace routing underneath the antenna.
- LSR recommends keeping metal objects as far away from the antenna as possible. At a very minimum keep the antenna at least 5 cm from any metallic objects, components, or wiring. The farther the antenna is placed from these interferers, the less the radiation pattern and gain will be perturbed.
- Do not embed the antenna in a metallic or metalized plastic enclosure.
- If located within a plastic enclosure, keep the enclosure at least 1 cm from the antenna.

**OPERATING MODES TRUTH TABLE**

| Mode                                    | VGE | LNA_EN | ANT_SW | ANT_SEL |
|-----------------------------------------|-----|--------|--------|---------|
| Sleep                                   | 0   | 0      | 0      | 0       |
| Transmit – Ant J3, RF1                  | 1   | X      | 1      | X       |
| Transmit – Ant J4, RF2                  | 1   | X      | 0      | X       |
| Receive with LNA Disabled – Ant J3, RF1 | 1   | 1      | X      | 1       |
| Receive with LNA Disabled – Ant J4, RF2 | 1   | 1      | X      | 0       |
| Receive with LNA Enabled – Ant J3, RF1  | 1   | 0      | X      | 1       |
| Receive with LNA Enabled – Ant J4, RF2  | 1   | 0      | X      | 0       |

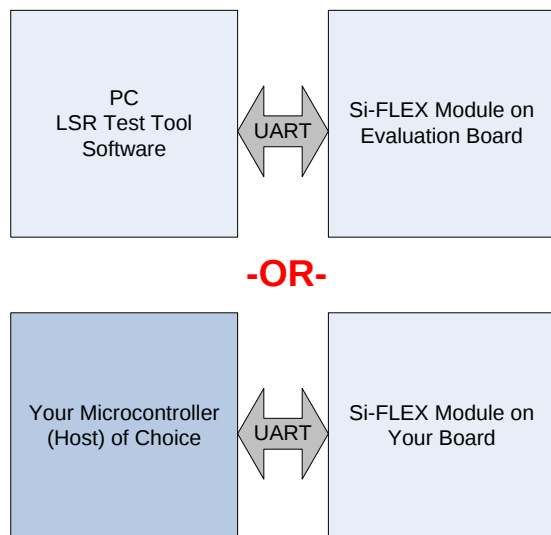
Note: X = Don't Care

**Table 4 Operating Modes Truth Table**

## MODES OF OPERATION

- With a host microcontroller
- With the Atmel 802.15.4 MAC
- With the Atmel ZigBee stack

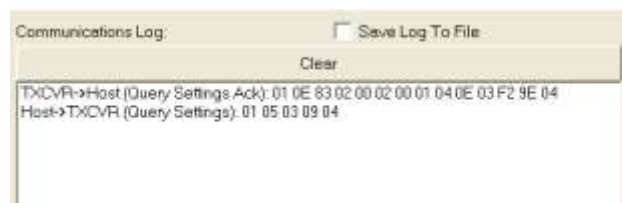
### Host Microcontroller



**Figure 7 Host Microcontroller Modes of Operation**

Out of the box the SiFLEX02-R2-HP module contains an 802.15.4 based application that uses a host serial processor. This allows features of the module to be explored with the LSR PC based test tool, or controlled with a host microcontroller. The advantage of this method is simplicity; all major features of using the radio are simplified into a simple serial message, taking the burden of becoming a radio expert off the developer.

Use the Communications Log in the ModFLEX™ Test Tool software and serial host protocol documents to see the messages in action. It will help you become familiar with the serial commands and how to implement them on your own microcontroller.



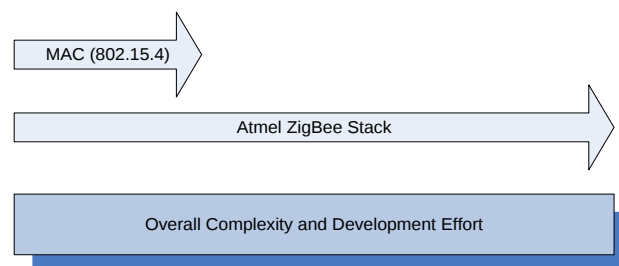
**Figure 8 ModFLEX™ Test Tool Communications Log**

Some examples of serial commands that can be used with the SiFLEX02-R2-HP Module:

- Set/Query RF channel
- Set/Query RF power
- Set/Query device address
- Transmit RF data or notification RF data received
- Go to Sleep

### Software Stacks

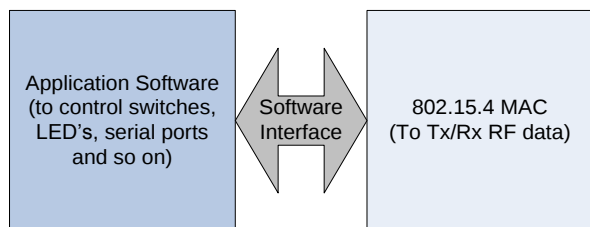
There are two software stacks provided by Atmel to streamline development:



**Figure 9 SiFLEX02-R2-HP Compatible Stacks**

### 802.15.4 MAC

- Use for applications requiring point-to-point or star network topology.
- Advantages: Quick learning curve, minimize software development, easy to deploy in the field
- Disadvantages: No mesh networking

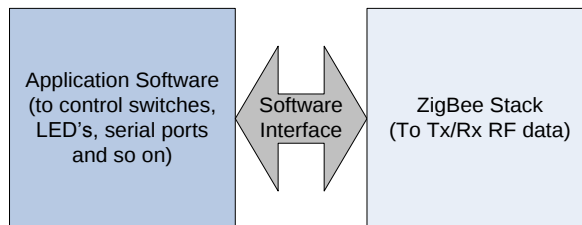


**Figure 10 SiFLEX02-R2-HP with 802.15.4 MAC**

### Atmel ZigBee Stack

- Use when mesh networking is required.
- Advantages: Covers a large area with a ZigBee network.

- Disadvantages: Large learning curve, more software development, complexity



**Figure 11 SiFLEX02-R2-HP with Atmel ZigBee Stack**

## DEVELOPMENT TOOLS

### AVR Studio

AVR Studio® is an Integrated Development Environment (IDE) for writing and debugging AVR® applications. AVR Studio includes an assembler, simulator, and in-circuit debugger.

AVR Studio is the Integrated Development Environment (IDE) developed by Atmel for writing and debugging Atmel AVR applications.

### WinAVR

WinAVR is a suite of executable, open source software development tools for the Atmel AVR series of RISC microprocessors hosted on the Windows platform. It includes the GNU GCC compiler for C/C++.

WinAVR contains all the tools for developing on AVR family microcontrollers from Atmel. This includes avr-gcc (compiler), avrdude (programmer), avr-gdb (debugger), and more.

### AVR JTAGICE mkII

Custom firmware development can be done on the SiFLEX02-R2-HP module using development tools available through Atmel. Shown in **Error! Reference source not found.**, a JTAGICE mkII interface is required. It plugs into the ModFLEX™ Development Board, and can easily be adapted to other hardware. See the Atmel website for more information and ordering options.



Figure 12 JTAGICE mkII

### AVRISP mkII

Another option for in-circuit programming is the AVRISP mkII from Atmel, Figure 13. The AVRISP mkII combined with AVR Studio® can program new AVR 8-bit RISC microcontrollers with ISP Interface.



Figure 13 AVRISP mkII

### IAR Embedded Workbench for Atmel AVR

Another option is IAR Embedded Workbench for Atmel AVR. IAR Embedded Workbench for AVR is an integrated development environment for building and debugging embedded applications. Visit the IAR Systems website for additional information.

## ELECTRICAL SPECIFICATIONS

The majority of these characteristics are based on the use of the Atmel IEEE 802.15.4 MAC loaded with the generic application firmware written by LSR. Custom firmware may require these values to be re-characterized by the customer.

### Absolute Maximum Ratings

| Rating                                      | Min  | Max            | Unit |
|---------------------------------------------|------|----------------|------|
| Power supply voltage ( $V_{CC}$ )           | 0    | 3.6            | V    |
| Power Amplifier supply voltage ( $V_{PA}$ ) | 0    | 4.5            | V    |
| Voltage on any pin with respect to ground   | -0.3 | $V_{CC} + 0.3$ | V    |
| RF input power                              |      | +10            | dBm  |
| Operating temperature range                 | -40  | +85            | °C   |
| Storage temperature                         | -50  | +150           | °C   |

Table 5 Absolute Maximum Ratings<sup>1</sup>

### Recommended Operating Conditions

| Characteristic                              | Min | Typ | Max  | Unit |
|---------------------------------------------|-----|-----|------|------|
| Power supply voltage ( $V_{CC}$ )           | 2.5 | 3.3 | 3.50 | Vdc  |
| Power Amplifier supply voltage ( $V_{PA}$ ) | 3.0 | 4.0 | 4.25 | Vdc  |
| Ambient temperature range                   | -40 | 25  | 85   | °C   |

Table 6 Recommended Operating Conditions

Operation of  $V_{CC}$  below 3.0v will result in a significant reduction in RF output power.

Module will NOT transmit, if  $V_{PA} > 4.25V$ .

<sup>1</sup> Under no circumstances should exceeding the maximum ratings specified in the Absolute Maximum Ratings section be allowed. Stressing the module beyond these limits may result permanent damage to the module that is not covered by the warranty.

## General Characteristics

| Parameter                      | Min | Typ  | Max   | Unit   |
|--------------------------------|-----|------|-------|--------|
| RF frequency range (Note 1, 2) | 906 |      | 924   | MHz    |
| RF data rate                   | 40  |      | 1000  | kbps   |
| Host data rate                 | 1.2 | 19.2 | 921.6 | kbps   |
| Flash memory                   |     | 256  |       | kBytes |
| RAM                            |     | 16   |       | kBytes |
| EEPROM                         |     | 4    |       | kBytes |

**Table 7 General Characteristics**

Note 1: The frequency range needs to be restricted to 915 to 924 MHz (channels 6-10) to meet Australian/New Zealand standards.

Note 2: Due to the band pass filter, receiver sensitivity is reduced by approximately 1dB on channels 1, 2, 8, 9, and 10 (906MHz, 908MHz, 920MHz, 922MHz, and 924MHz). This improves receiver performance in the presence of interferers on channels 3, 4, 5, 6, and 7 (910MHz, 912MHz, 914MHz, 916MHz, and 918MHz).

## Power Consumption

( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 3.3\text{V}$ ,  $V_{PA} = 4.0\text{V}$ ,  $f_c = 906\text{-}924\text{MHz}$ ,  $R_{load} = 50\Omega$ )

| Parameter                | Test Conditions    | Min | Typ | Max | Unit          |
|--------------------------|--------------------|-----|-----|-----|---------------|
| Transmit mode - $V_{PA}$ | Maximum power step |     | 450 | 600 | mA            |
| Transmit mode - $V_{CC}$ |                    |     | 50  |     | mA            |
| Receive mode - $V_{PA}$  |                    |     |     | 1   | uA            |
| Receive mode - $V_{CC}$  |                    | 27  | 39  | 48  | mA            |
| Sleep mode - $V_{PA}$    |                    |     |     | 1   | $\mu\text{A}$ |
| Sleep mode - $V_{CC}$    |                    |     | 2   | 5   | uA            |

**Table 8 Power Consumption**

## DC Characteristics – General Purpose I/O

| Parameter         | Test Conditions                                   | Min                | Typ | Max                | Unit |
|-------------------|---------------------------------------------------|--------------------|-----|--------------------|------|
| Logic input low   |                                                   | -0.3               |     | $0.2 \cdot V_{CC}$ | V    |
| Logic input high  |                                                   | $0.8 \cdot V_{CC}$ |     | $V_{CC} + 0.3$     | V    |
| Logic output low  | $I_{OUT} = 15\text{mA}$<br>$V_{CC} = 3.3\text{V}$ |                    | 0.4 |                    | V    |
| Logic output high | $I_{OUT} = -8\text{mA}$<br>$V_{CC} = 3.3\text{V}$ |                    | 2.9 |                    | V    |

**Table 9 DC Characteristics – General Purpose I/O**

## RF Characteristics

### Transmitter Characteristics

( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 3.3\text{V}$ ,  $V_{PA} = 4.0\text{V}$ ,  $f_c = 906\text{-}924\text{ MHz}$ )

| Parameter                                     | Test Conditions     | Min | Typ | Max | Unit  |
|-----------------------------------------------|---------------------|-----|-----|-----|-------|
| Nominal max output power (40kbps)             | 750mW (Notes: 1, 2) | 26  | 27  | 29  | dBm   |
| Nominal max output power (250kbps and higher) | 750mW (Notes: 1, 2) | 27  | 28  | 29  | dBm   |
| Programmable output power range               | 22 Steps            | 15  |     | 28  | dBm   |
| Harmonics (2fo)                               |                     |     | -50 |     | dBm   |
| Harmonics (3fo)                               |                     |     | -55 |     | dBm   |
| Error vector magnitude                        |                     |     | 10  | 35  | % rms |

**Table 10 Transmitter RF Characteristics**

Note 1: In accordance with FCC Part 15.247(e) and RSS 210 A8.2(b), the peak power spectral density should not exceed +8 dBm in any 3 KHz band.

Note 2: In accordance with Australian/New Zealand 4268 : 2008, the peak power spectral density should not exceed +14dBm in any 3 KHz band in the 915 to 928 MHz frequency band.

**RF Output Power and Transmit Current**  
 (T<sub>A</sub> = 25°C, V<sub>CC</sub> = 3.3V, V<sub>PA</sub> = 4.0V, f<sub>c</sub> = 914 MHz)

| Host Protocol<br>RF Power<br>Level | AT86RF212<br>PHY_TX_PWR<br>Register Value | BPSK into 50 ohms at U.FL |                                     |
|------------------------------------|-------------------------------------------|---------------------------|-------------------------------------|
|                                    |                                           | RF Output<br>Power (dBm)  | Typical Current<br>Consumption (mA) |
| 21                                 | 0xE7                                      | 27.9                      | 465                                 |
| 20                                 | 0xE7                                      | 27.9                      | 454                                 |
| 19                                 | 0xE7                                      | 27.8                      | 442                                 |
| 18                                 | 0xE8                                      | 27.6                      | 425                                 |
| 17                                 | 0xE8                                      | 27.2                      | 393                                 |
| 16                                 | 0x42                                      | 26.5                      | 365                                 |
| 15                                 | 0x43                                      | 26.2                      | 346                                 |
| 14                                 | 0x23                                      | 26.0                      | 338                                 |
| 13                                 | 0x23                                      | 25.5                      | 318                                 |
| 12                                 | 0x24                                      | 25.1                      | 304                                 |
| 11                                 | 0x66                                      | 24.3                      | 281                                 |
| 10                                 | 0x04                                      | 24.3                      | 277                                 |
| 9                                  | 0x05                                      | 23.3                      | 254                                 |
| 8                                  | 0x06                                      | 22.4                      | 236                                 |
| 7                                  | 0x07                                      | 21.5                      | 219                                 |
| 6                                  | 0x08                                      | 20.6                      | 207                                 |
| 5                                  | 0x08                                      | 19.9                      | 198                                 |
| 4                                  | 0x09                                      | 18.9                      | 188                                 |
| 3                                  | 0x0A                                      | 18.0                      | 181                                 |
| 2                                  | 0x0B                                      | 17.2                      | 177                                 |
| 1                                  | 0x0C                                      | 16.2                      | 173                                 |
| 0                                  | 0x0D                                      | 15.3                      | 171                                 |

**Table 11 RF Power Settings**

### Receiver Characteristics

( $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 3.3\text{V}$ ,  $V_{PA} = 4.0\text{V}$ ,  $f_c = 906\text{-}924\text{ MHz}$ )

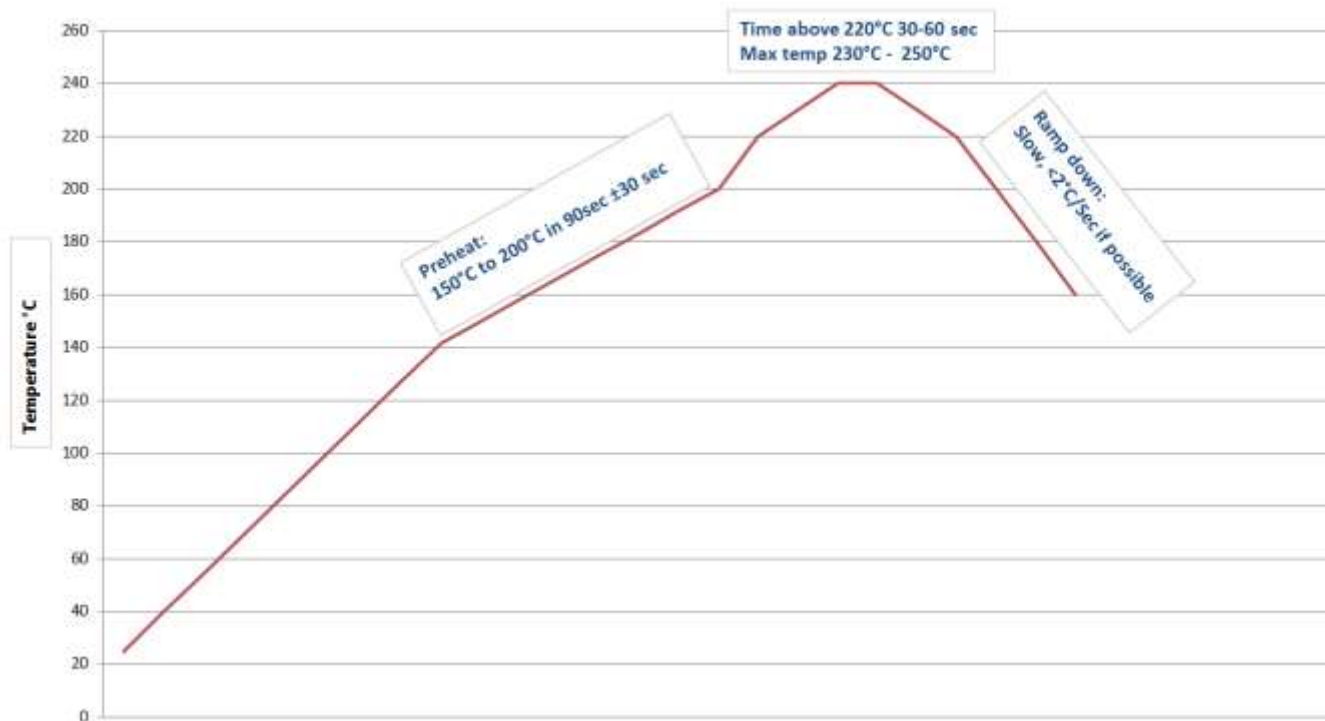
| Parameter                        | Test Conditions | Min | Typ    | Max | Unit |
|----------------------------------|-----------------|-----|--------|-----|------|
| Receiver Sensitivity<br>@ 1% PER | BPSK 40kbit/s   |     | < -104 |     | dBm  |
| Saturation Level<br>@ 1% PER     | BPSK 40kbit/s   |     | -2     |     | dBm  |

**Table 12 Receiver RF Characteristics**

For additional details regarding the electrical specifications, refer to the ATXMEGA256A3U and AT86RF212B datasheets on the Atmel website.

## SOLDERING RECOMMENDATIONS

### Recommended Reflow Profile for Lead Free Solder



**Note:** The quality of solder joints on the castellations ('half vias') where they contact the host board should meet the appropriate IPC Specification. See IPC-A-610-D Acceptability of Electronic Assemblies, section 8.2.4 Castellated Terminations."

## CLEANING

In general, cleaning the populated modules is strongly discouraged. Residuals under the module cannot be easily removed with any cleaning process.

- Cleaning with water can lead to capillary effects where water is absorbed into the gap between the host board and the module. The combination of soldering flux residuals and encapsulated water could lead to short circuits between neighboring pads. Water could also damage any stickers or labels.
- Cleaning with alcohol or a similar organic solvent will likely flood soldering flux residuals into the RF shield, which is not accessible for post-washing inspection. The solvent could also damage any stickers or labels.
- Ultrasonic cleaning could damage the module permanently.

## OPTICAL INSPECTION

After soldering the Module to the host board, consider optical inspection to check the following:

- Proper alignment and centering of the module over the pads.
- Proper solder joints on all pads.
- Excessive solder or contacts to neighboring pads, or vias.

## REWORK

The module can be unsoldered from the host board if the Moisture Sensitivity Level (MSL) requirements are met as described in this datasheet.

**Never attempt a rework on the module itself, e.g. replacing individual components. Such actions will terminate warranty coverage.**

## SHIPPING, HANDLING, AND STORAGE

### Shipping

Bulk orders of the SiFLEX02-R2-HP modules are delivered in trays of 25.

### Handling

The SiFLEX02-R2-HP modules contain a highly sensitive electronic circuitry. Handling without proper ESD protection may damage the module permanently.

### Moisture Sensitivity Level (MSL)

Per J-STD-020, devices rated as MSL 4 and not stored in a sealed bag with desiccant pack should be baked prior to use.

Devices are packaged in a Moisture Barrier Bag with a desiccant pack and Humidity Indicator Card (HIC). Devices that will be subjected to reflow should reference the HIC and J-STD-033 to determine if baking is required.

If baking is required, refer to J-STD-033 for bake procedure.

### Storage

Per J-STD-033, the shelf life of devices in a Moisture Barrier Bag is 12 months at <40°C and <90% room humidity (RH).

Do not store in salty air or in an environment with a high concentration of corrosive gas, such as Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, or NO<sub>x</sub>.

Do not store in direct sunlight.

The product should not be subject to excessive mechanical shock.

## Repeating Reflow Soldering

Only a single reflow soldering process is encouraged for host boards.

## AGENCY STATEMENTS

### Federal Communication Commission Interference Statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

**FCC CAUTION: Any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment.**

## Industry Canada Statements

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.

This device has been designed to operate with the antennas listed below, and having a maximum gain of 2.0 dB. Antennas not included in this list or having a gain greater than 2.0 dB are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

*LSR 001-0002 900 MHz Dipole Antenna with Reverse Polarity SMA Connector and LSR 080-0001 U.FL to Reverse Polarity SMA Bulkhead Cable (105mm in length)*

Son fonctionnement est soumis aux deux conditions suivantes: (1) cet appareil ne peut pas provoquer d'interférences et (2) cet appareil doit accepter toute interférence, y compris les interférences qui peuvent causer un mauvais fonctionnement du dispositif.

Pour réduire le risque d'interférence aux autres utilisateurs, le type d'antenne et son gain doivent être choisis de façon que la puissance isotrope rayonnée équivalente (e.i.r.p) ne dépasse pas celle admise pour une communication réussie.

Cet appareil a été conçu pour fonctionner avec les antennes énumérées ci-dessous, et ayant un gain maximum de 2,0 dB. Antennes pas inclus dans cette liste ou ayant un gain supérieur à 2,0 dB sont strictement interdites pour une utilisation avec cet appareil. L'impédance d'antenne requise est de 50 ohms.

*LSR 001-0002 900 MHz Antenne dipôle avec inversion de polarité Connecteur SMA et LSR 080-0001 U.FL à inversion de polarité SMA traversée de câble (105 mm de longueur)*

## **OEM Responsibilities to comply with FCC and Industry Canada Regulations**

The SiFLEX02-HP Module has been certified for integration into products only by OEM integrators under the following conditions:

This device is granted for use in Mobile only configurations in which the antennas used for this transmitter must be installed to provide a separation distance of at least 20cm from all person and not be co-located with any other transmitters except in accordance with FCC and Industry Canada multi-transmitter product procedures.

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

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

Le module SiFLEX02-HP a été certifiée pour l'intégration dans les produits que par les intégrateurs OEM dans les conditions suivantes:

Ce dispositif est accordé pour une utilisation dans des configurations mobiles seule dans laquelle les antennes utilisées pour cet émetteur doit être installé pour fournir une distance de séparation d'au moins 20cm de toute personne et ne pas être co-localisés avec les autres émetteurs, sauf en conformité avec FCC et Industrie Canada, multi-émetteur procedures produit.

Tant que les deux conditions précitées sont réunies, les tests de transmetteurs supplémentaires ne seront pas tenus. Toutefois, l'intégrateur OEM est toujours responsable de tester leur produit final pour toutes les exigences de conformité supplémentaires requis avec ce module installé (par exemple, les émissions appareil numérique, les exigences de périphériques PC, etc.)

**NOTE IMPORTANTE: Dans le cas où ces conditions ne peuvent être satisfaites (pour certaines configurations ou de co-implantation avec un autre émetteur), puis la FCC et Industrie autorisations Canada ne sont plus considérés comme valides et l'ID de la FCC et IC numéro de certification ne peut pas être utilisé sur la produit final. Dans ces circonstances, l'intégrateur OEM sera chargé de réévaluer le produit final (y compris l'émetteur) et l'obtention d'un distincte de la FCC et Industrie Canada l'autorisation.**

## End Product Labelling

The SiFLEX02-HP Module is labeled with its own FCC ID and IC Certification Number. If the FCC ID and IC Certification Number are not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. In that case, the final end product must be labeled in a visible area with the following:

**“Contains Transmitter Module FCC ID: TFB-SIFLEX2HP”**

**“Contains Transmitter Module IC: 5969A-SIFLEX2HP”**

or

**“Contains FCC ID: TFB-SIFLEX2HP”**

**“Contains IC: 5969A-SIFLEX2HP”**

The OEM of the SiFLEX02-HP Module must only use the approved antenna(s) listed above, which have been certified with this module.

The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module or change RF related parameters in the user manual of the end product.

**The user manual for the end product must include the following information in a prominent location:**

This device is granted for use in Mobile only configurations in which the antennas used for this transmitter must be installed to provide a separation distance of at least 20cm from all person and not be co-located with any other transmitters except in accordance with FCC and Industry Canada multi-transmitter product procedures.

Le SiFLEX02-HP Module est étiqueté avec sa propre ID de la FCC et IC numéro de certification. Si l'ID de la FCC et IC numéro de certification ne sont pas visibles lorsque le module est installé à l'intérieur d'un autre appareil, puis l'extérieur de l'appareil dans lequel le module est installé doit également afficher une étiquette mentionnant le module ci-joint. Dans ce cas, le produit final doivent être étiquetés dans un endroit visible de ce qui suit:

**Module émetteur Contient FCC ID: TFB-SIFLEX2HP**

**Module émetteur Contient IC: 5969A-SIFLEX2HP**

ou

**Contient FCC ID: TFB-SIFLEX2HP**

**Contient IC: 5969A-SIFLEX2HP**

Le constructeur d'équipements de l'SiFLEX02-HP module ne doit utiliser l'antenne approuvée (s) ci-dessus, qui ont été certifiés avec ce module.

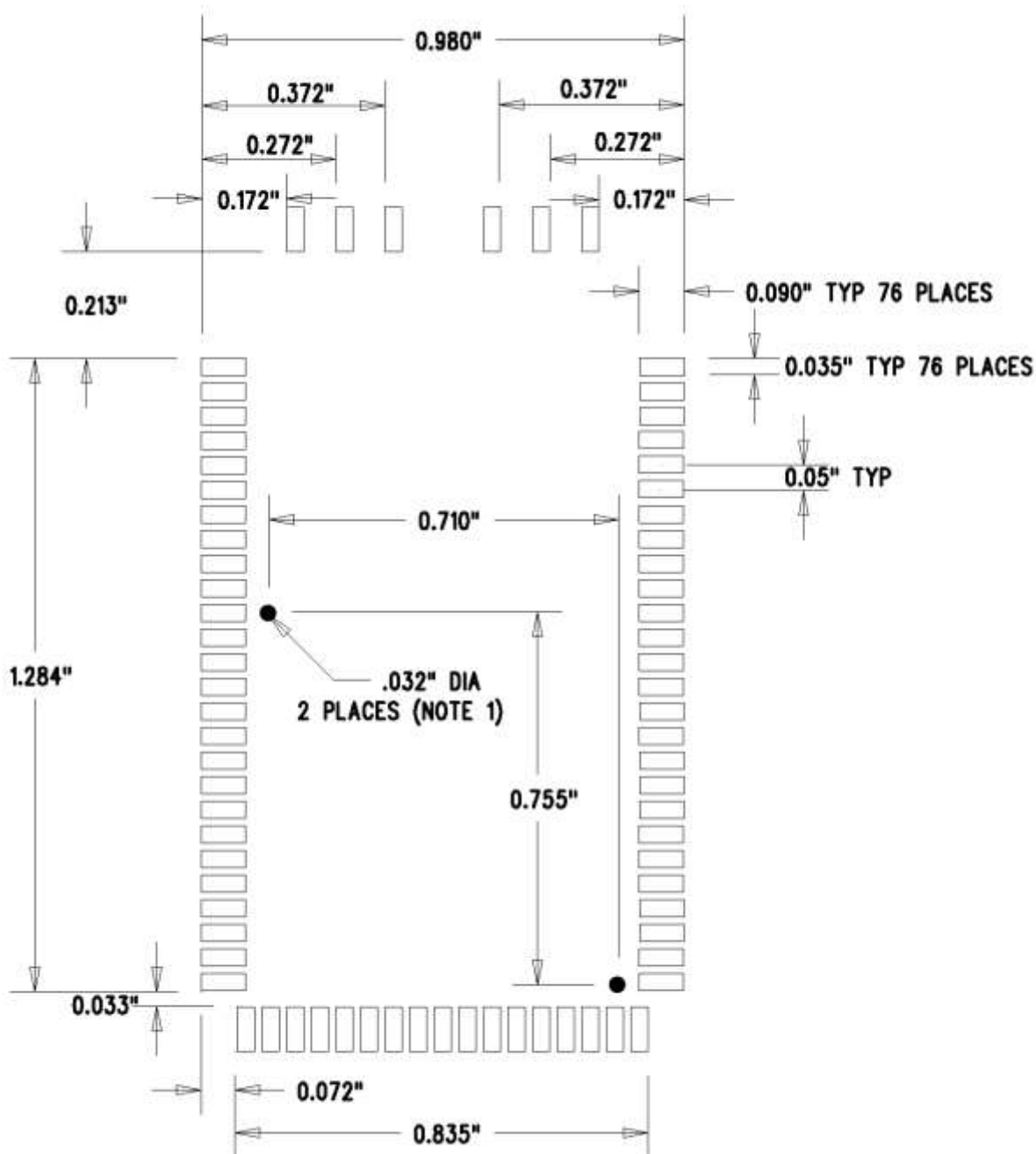
L'intégrateur OEM doit être conscient de ne pas fournir des informations à l'utilisateur final quant à la façon d'installer ou de supprimer ce module RF ou RF changer les paramètres liés au mode d'emploi du produit final.

**Le manuel d'utilisation pour le produit final doit comporter les informations suivantes dans un endroit bien en vue:**

Ce dispositif est accordé pour une utilisation dans des configurations mobiles seule dans laquelle les antennes utilisées pour cet émetteur doit être installé pour fournir une distance de séparation d'au moins 20cm de toute personne et ne pas être co-localisés avec les autres émetteurs, sauf en conformité avec FCC et Industrie Canada, multi-émetteur procédures produit.

## MECHANICAL DATA

### PCB Footprint



#### Notes:

- 1 – Optional alignment holes are for use with fixture placement and hand soldering operations.
- 2 – See LSR wiki <http://wiki.lsr.com> for additional information.

**Figure 14 PCB Footprint**

## General Module Dimensions

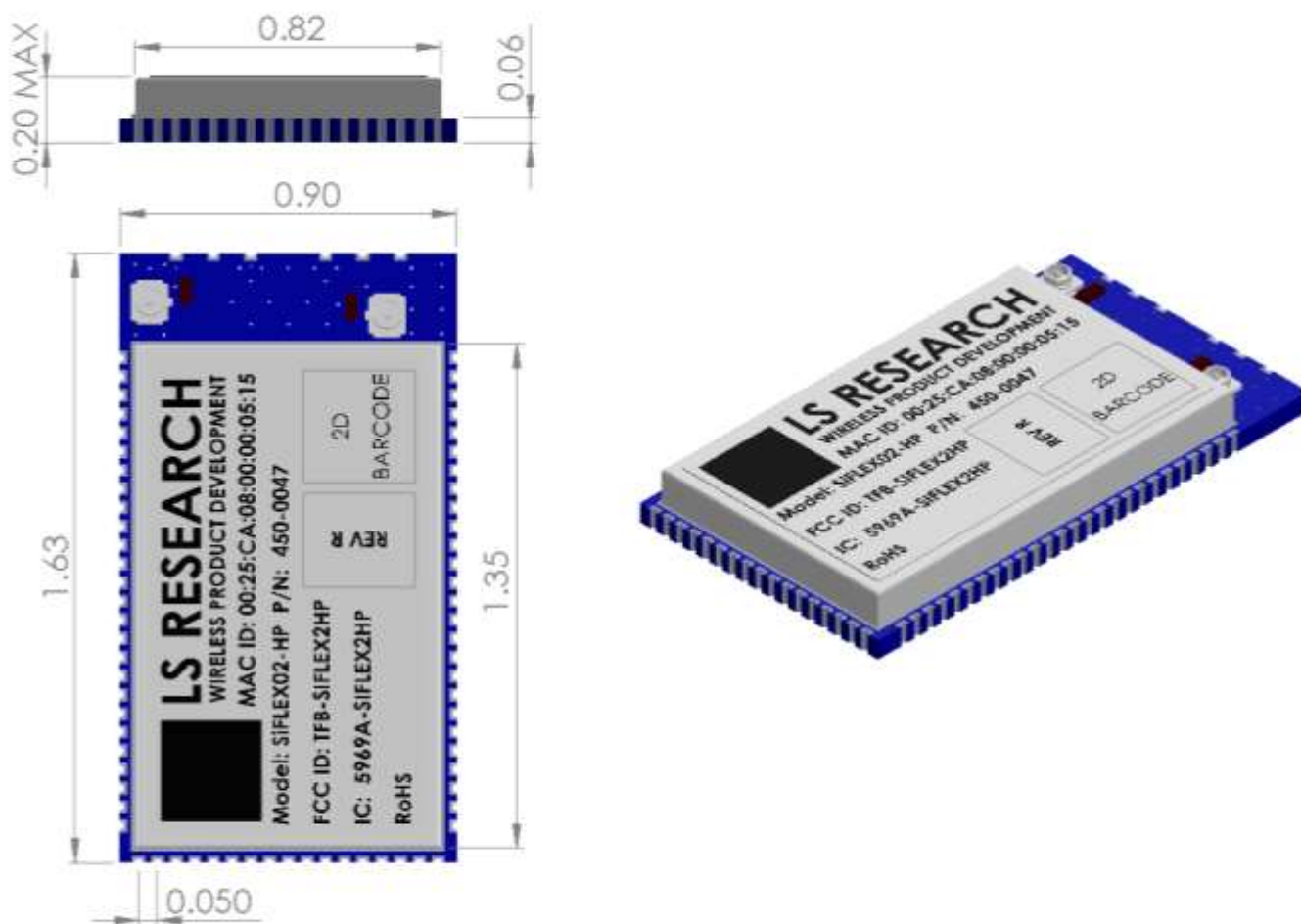


Figure 15 Basic dimensions

## COMPATIBILITY

To maintain compatibility with other ModFLEX™ family transceiver modules it is important to use the module pins in your application as they are designated in Figure 16. Since the available GPIO and peripherals vary per micro, not all pins may be populated. For example on SiFLEX02-R2-HP module pins 45-55 are not available (due to the number of GPIO available on the ATxMega256A3U).

All attempts are made to lay out modules starting with the lowest number in the peripheral (ADC, TMR/PWM, GPIO) series. For example if there are only two ADC's available they will be brought out to ADC1 and ADC2 (module pins 20 and 21).

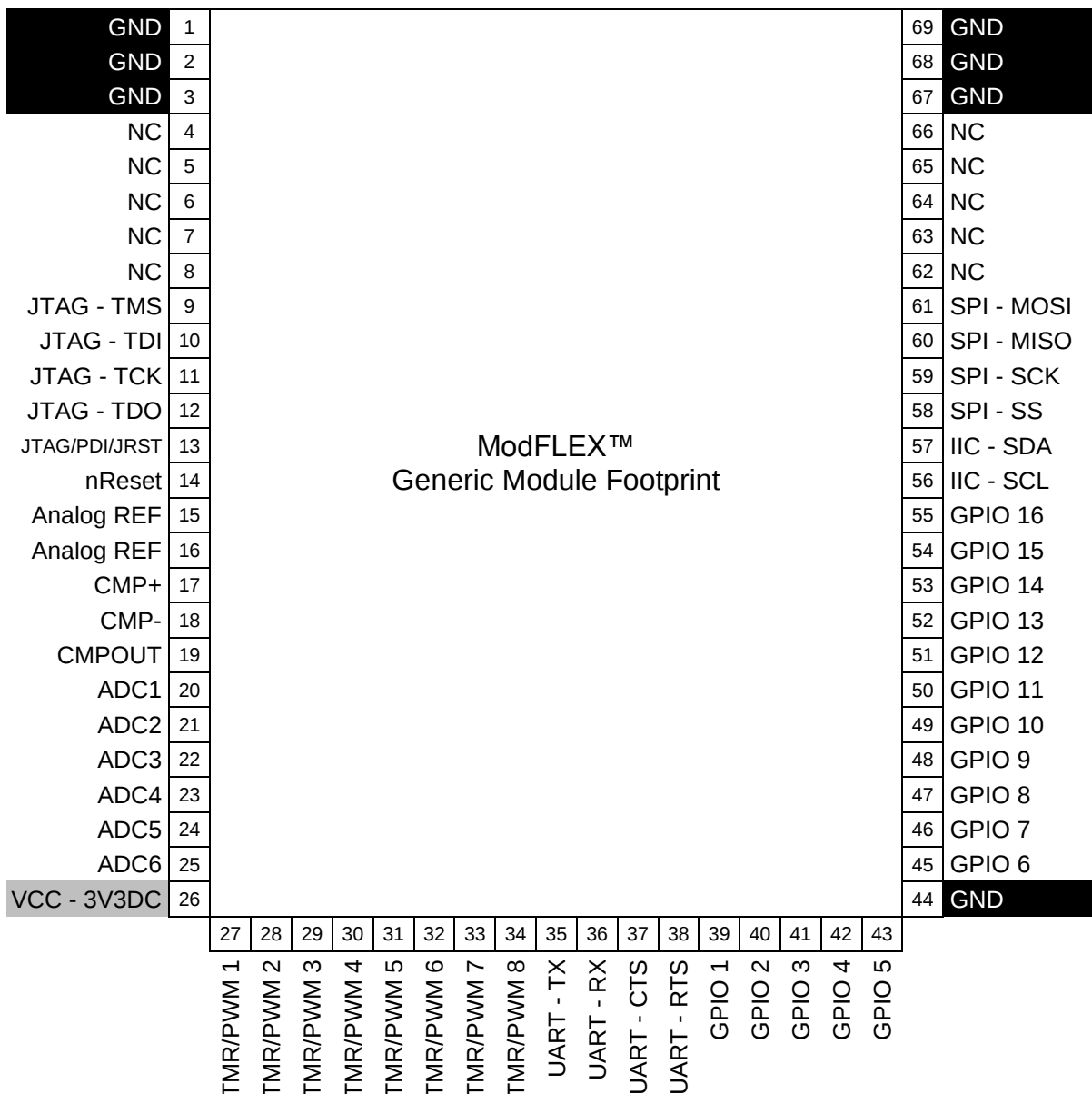
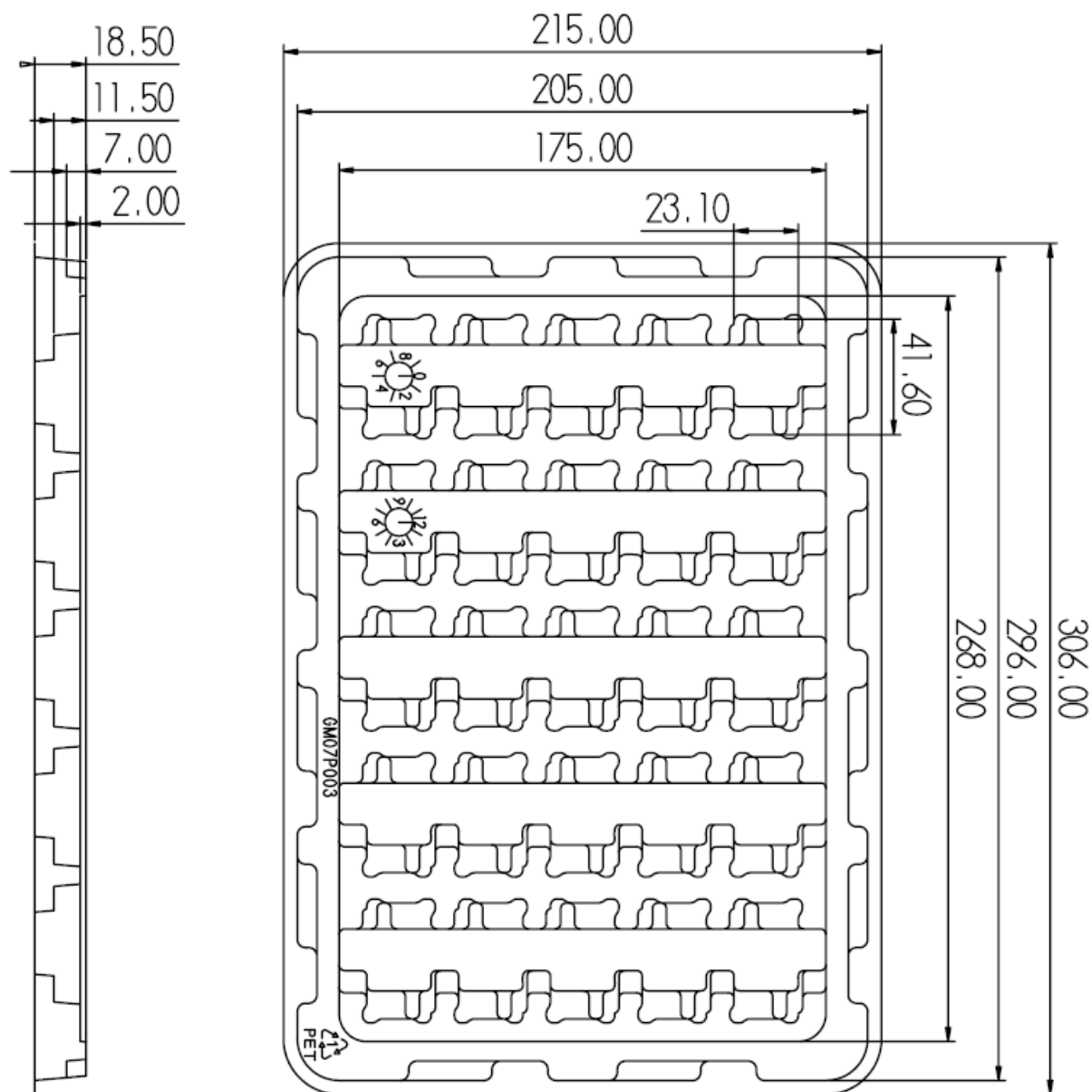


Figure 16 ModFLEX™ Generic Module Footprint

**TRAY PACKAGING (MM)**



**Figure 17 ModFLEX Tray Specification**

## MODULE REVISION HISTORY

### Rev 1.0

- Initial production release.

Part Number: 450-0127

U.FL Module



00:25:CA:08:XX:XX:XX = MAC ID

2D Barcode Format is Data Matrix Standard

XX:XX:XX:XX = unique portion of MAC ID that  
changes for each module

Part Number: 450-0128

RF Castellation Module



00:25:CA:08:XX:XX:XX = MAC ID

2D Barcode Format is Data Matrix Standard

XX:XX:XX:XX = unique portion of MAC ID that  
changes for each module

---

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