Sterling-LWB Module

APPLICATION GUIDE

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1 Introduction

1.1 Purpose & Scope

The purpose of this document is to provide details regarding the design and integration of certified antennas to the Sterling-LWB module. It covers all four certified off module antenna options, which consist of a ceramic chip, LSR dipole, LSR FlexNotch, and LSR FlexPIFA antenna. It will inform the designer as to the required PCB details required to retain the LSR modular certification for the Sterling-LWB module.

1.2 Applicable Documents

- *Sterling-LWB Datasheet (330-0190)*
- *LSR 2.4 GHz Dipole Antenna Datasheet (330-0016)*
- *LSR U.FL to RPSMA Cable Datasheet (330-0018)*
- *LSR 2.4 GHz FlexPIFA Antenna Datasheet (330-0149)*
- *LSR 2.4 GHz FlexNotch Antenna Datasheet (330-0150)*

1.3 Revision History

Date	ECN	Change Description	Revision
6/22/2016	102-2016	Initial release	1.0
10/10/2016	177-2016	Host PCB requirements updated	2.0
11/30/2016	196-2016	Dimensioning updates	3.0
12/23/2021		Added New Reference Designs and notes for EMC Compliance	4.0

Table 1 Revision History

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2 Sterling-LWB Modules

The Sterling-LWB Base Module is a System in Package (SIP) module. The Sterling-LWB U.FL and Chip Antenna modules serve a as a both a module, which can be assembled into an end product, or can be used as a reference design PCBs for integrating the SIP module into an end product.

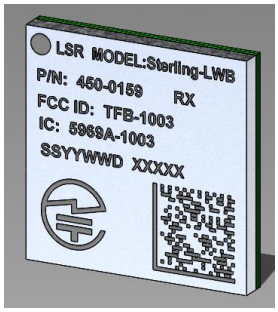
	Part Number	Description
	LSR 450-0159 LSR 450-0159R LSR 450-0159C	Sterling-LWB SIP Module Sterling-LWB SIP Module, Tape & Reel Sterling-LWB SIP Module, Cut Tape
	LSR 450-0148 LSR 450-0148R LSR 450-0148C	Sterling-LWB Module, U.FL Sterling-LWB Module, U.FL Tape & Reel Sterling-LWB Module, U.FL Cut Tape
	LSR 450-0152 LSR 450-0152R LSR 450-0152C	Sterling-LWB Module, Chip Antenna Sterling-LWB Module, Chip Antenna Tape & Reel Sterling-LWB Module, Chip Antenna Cut Tape

Table 2 Sterling-LWB Modules

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3 Sterling-LWB Accessories

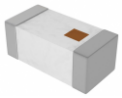
	Part Number	Description
	Johanson 2450AT18D0100	2.4 GHz Ceramic Chip Antenna
	LSR 001-0014	2.4 GHz FlexPIFA Antenna with U.FL Cable
	LSR 001-0015	2.4 GHz FlexNotch Antenna
	LSR 001-0001	2.4 GHz Dipole Antenna with Reverse Polarity SMA Connector
	LSR 080-0001	U.FL to Reverse Polarity SMA Bulkhead Cable 105 mm

Table 3 Sterling-LWB Module Accessories

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4 Sterling-LWB Module PCB Layout Requirements

Since the modules and their associated set of approved antennas has been certified by the FCC and Industry Canada (IC) as a Modular Radio, the end user is authorized to integrate these modules into an end-product, and is solely responsible for the Unintentional Emissions levels produced by the end-product.

In order to preserve the Modular Radio certifications, the integrator of the module must abide by the PCB layout recommendations outlined in the following paragraphs. Any divergence from these recommendations will invalidate the modular radio certifications and require the integrator to re-certify the module and/or end-product.

The module must be used with one of the approved antennas:

1. Johanson Technology 2450AT18D0100 Ceramic Chip Antenna.
2. LSR 001-0014 2.4 GHz FlexPIFA Antenna w/U.FL cable.
3. LSR 001-0015 2.4 GHz FlexNotch Antenna w/U.FL cable.
4. LSR 001-0001 center-fed 2.4 GHz dipole antenna and 080-0001 U.FL to Reverse Polarity SMA connector cable.

When using the modules and or the reference designs that support the off module U.FL connector(s), you may use a substitute antenna if the antenna gain is less than or equal to +2 dBi. It may be possible to use a substitute chip antenna, however there are restrictions so please contact LSR for guidance prior to making any chip antenna substitutions.

In addition to the Sterling-LWB Base SIP Module, LSR provides FCC Modular Certified reference design modules. The reference design modules are impedance-controlled PCBs that utilize microstrip trace design to route RF signals from the Sterling-LWB SIP module to the Antennas and coaxial connectors.

Please use the latest CAD files from the LSR web site when incorporating the Sterling-LWB module into a new design. CAD files are provided in native Mentor Graphics PADS PCB and PADS Logic formats, as well as ASCII, Gerber, and PDF formats. CAD files can also be translated to most popular CAD package. Contact LSR Tech support for CAD translation.

Visit the LSR web site **http://www.lsr.com** for current PCB and Schematic CAD files.

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5 Sterling-LWB Reference Design Modules

The LSR Sterling-LWB Module is supplied as a SIP package. LSR also offers two additional modular variants supplied on a carrier board. These modules function both as the reference design for the Sterling-LWB Module and as an all-inclusive module which can be assembled onto the end users host board. Depending on the user's antenna and footprint needs, there is a module variant to suite most application requirements.

LSR recommends that for simplicity of both the host PCB design, as well as the manufacturing process, that either the Chip Antenna or U.FL RF Connector version of the modules be used in your design.

This section describes the details of the host PCB requirements. In order to use the modular certification for the LSR Sterling-LWB SIP Module and variants for your design, it is critical that the reference designs are correctly followed.

To integrate LSR Sterling-LWB SIP Module into a design using a chip antenna, the full 4-layer Chip Antenna PCB reference design is shown in Figure 1, and Bill of Materials Table 4. Visit **http://www.lsr.com.** For the latest Schematics and CAD files.

To integrate LSR Sterling-LWB SIP Module into a design using external U.FL connector, the full 4-layer U.FL (external antenna) PCB reference design is shown in Figure 4 and Bill of Materials Table 6. **http://www.lsr.com.** For the latest Schematics and CAD files.

It is not required to replicate the entire design, but what is required is the circuitry and layout as it pertains to the antenna configuration being used in your design as shown in Figure 1 and Figure 4.

Each of the LSR Sterling-LWB modules use a high speed SDIO interface for communication between the host and the module. SDIO is quite sensitive to local sources of electrical noise that may exist as a result of improper PCB layout design thus the SDIO interface requires special attention when routing lines on the host PCB. SDIO paths should receive the highest priority when routing to proactively minimizing trace length to mitigate transmission line effects. All of the requirements for proper SDIO implementation is beyond the scope of this document, however some of the high level requirements and recommendations are:

- 50 ohm line impedance is required for all SDIO lines.
- Placing zero ohm resistor in-line on all SDIO lines to allow for line tuning (if required) on the host board.
- Keep all SDIO trace delay times as equal as possible

For further information regarding the SDIO interface, see the most recent SDIO Physical Layer Specification provided by the SD Card Association.

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5.1 Sterling-LWB SIP Module with Chip Antenna Reference Design #1

When integrating the Sterling-LWB SIP module (LSR Part Number 450-0159) into a host PCB that uses the certified Chip Antenna, the PCB layout shown in Figure 1 should be followed. It is acceptable to either populate or remove the U.FL circuitry J1 on any of the designs. Visit **http://www.lsr.com** for current PCB and Schematic CAD files.

Keep in mind that when specifying parts for the design, the RF components that cannot be substituted are shown in Table 4.

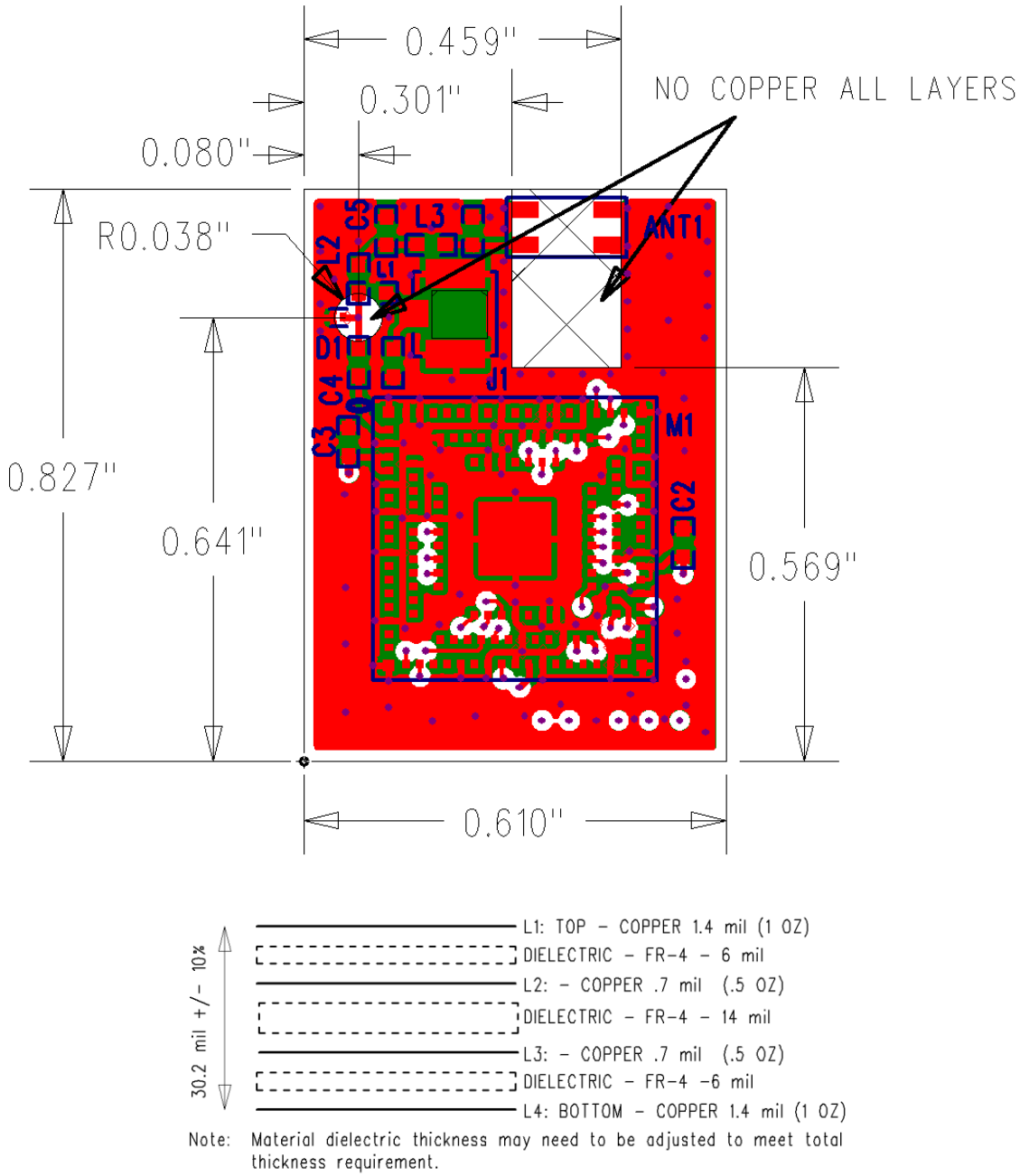

Figure 1 SIP Module with Chip Antenna Reference Design

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Visit the LSR web site **http://www.lsr.com** for current PCB and Schematic CAD files.

Qty	PCB Ref	POP Optional	Value	Tolerance	Manufacturer	Mfg Part Number
1	ANT1				Johanson	2450AT18D0100
1	C1	NP	1.0pF	+/- 0.25pF	Murata	GRM1555C1H1R0CA01
2	C2 C3		2.2uF	+/- 20%	Kemet	C0402C225M9PAC
1	C4		10pF	+/- 5%	Murata	GRM1555C1H100JA01
1	C4	ALTERNATE	10pF	+/- 5%	Murata	GJM1555C1H100JB01
1	C5		2.7pF	±0.25pF	Murata	GJM1555C1H2R7CB01
1	C6	NP	2.0pF	+/- 0.25pF	Murata	GJM1555C1H2R0CB01
1	D1				Infineon	ESD108B1CSP0201XTSA1
1	J1	NP			Hirose	U.FL-R-SMT-1#
1	L2		2.0nH	+/- 0.1nH	Murata	LQP15MN2N0B02
1	L2	ALTERNATE	2.0nH	+/- 0.1nH	AVX	HLQ022R0BTTR
1	L1	NP	2.0nH	+/- 0.1nH	Murata	LQP15MN2N0B02
1	L1	NP (ALT)	2.0nH	+/- 0.1nH	AVX	HLQ022R0BTTR
1	L3		2.7nH	+/- 0.1nH	Murata	LQP15MN2N7B02
1	L3	ALTERNATE	2.7nH	+/- 0.1nH	AVX	HLQ022R7BTTR
1	M1				LSR	450-0159

*** RF Critical Components That Cannot be Substituted**

Table 4 SIP Module with Chip Antenna Reference Design BOM

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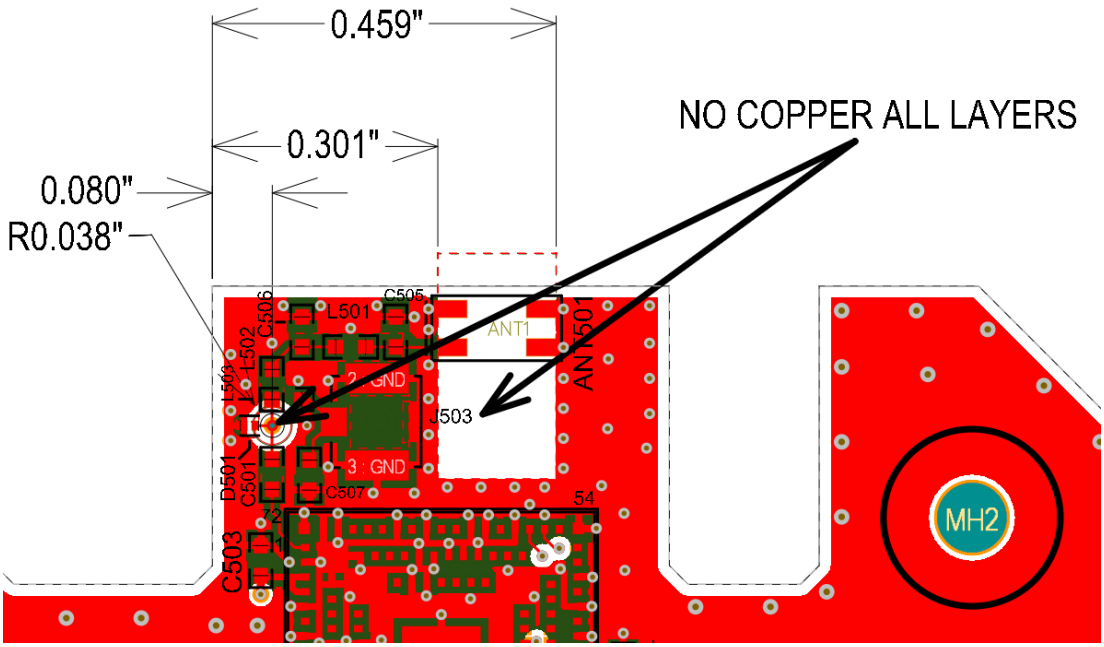
5.2 Sterling-LWB SIP Module with Chip Antenna and U.FL Reference Design #2



Layer	Name	Material	Thickness	Constant
	Top Overlay			
	Top Solder	Solder Resist	0.30mil	3.5
1	Top Layer		1.40mil	
	Dielectric 1	PP-007	3.31mil	4.2
2	Layer 1		1.40mil	
	Dielectric1	FR-4	48.38mil	4.8
3	Layer 2		1.40mil	
	Dielectric 2	PP-007	3.31mil	4.2
4	Bottom Layer		1.40mil	
	Bottom Solder	Solder Resist	0.30mil	3.5
	Bottom Overlay			

Figure 2 SIP Module with Chip Antenna and U.FL Reference Design

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Qty	PCB Ref	POP Optional	Value	Tolerance	Manufacturer	Mfg Part Number
1	ANT501				Johanson	2450AT18D0100
1	C505	NP	1.0pF	+/- 0.25pF	Murata	GRM1555C1H1R0CA01
2	C503 C504		2.2uF	+/- 20%	Kemet	C0402C225M9PAC
1	C501		10pF	+/- 5%	Murata	GRM1555C1H100JA01
1	C501	ALTERNATE	10pF	+/- 5%	Murata	GJM1555C1H100JB01
1	C506		2.7pF	±0.25pF	Murata	GJM1555C1H2R7CB01
1	C507	NP	2.0pF	+/- 0.25pF	Murata	GJM1555C1H2R0CB01
1	D501				Infineon	ESD108B1CSP0201XTSA1
1	J503	NP			Hirose	U.FL-R-SMT-1#
1	L502		2.0nH	+/- 0.1nH	Murata	LQP15MN2N0B02
1	L502	ALTERNATE	2.0nH	+/- 0.1nH	AVX	HLQ022R0BTTR
1	L503	NP	2.0nH	+/- 0.1nH	Murata	LQP15MN2N0B02
1	L503	NP (ALT)	2.0nH	+/- 0.1nH	AVX	HLQ022R0BTTR
1	L501		2.7nH	+/- 0.1nH	Murata	LQP15MN2N7B02
1	L501	ALTERNATE	2.7nH	+/- 0.1nH	AVX	HLQ022R7BTTR
1	U501				LSR	450-0159

*** RF Critical Components That Cannot be Substituted**

Table 5 SIP Module with Chip Antenna Reference Design #2 BOM

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5.3 Sterling-LWB Chip Antenna Module Variant Host PCB

When implementing the Chip Antenna Module (LSR Part Number 450-0152), the host PCB layout shown Figure 3 should be followed. A development board and all design files are available for the Sterling-LWB Chip Antenna Module. Visit **http://www.lsr.com** for current PCB and Schematic CAD files.

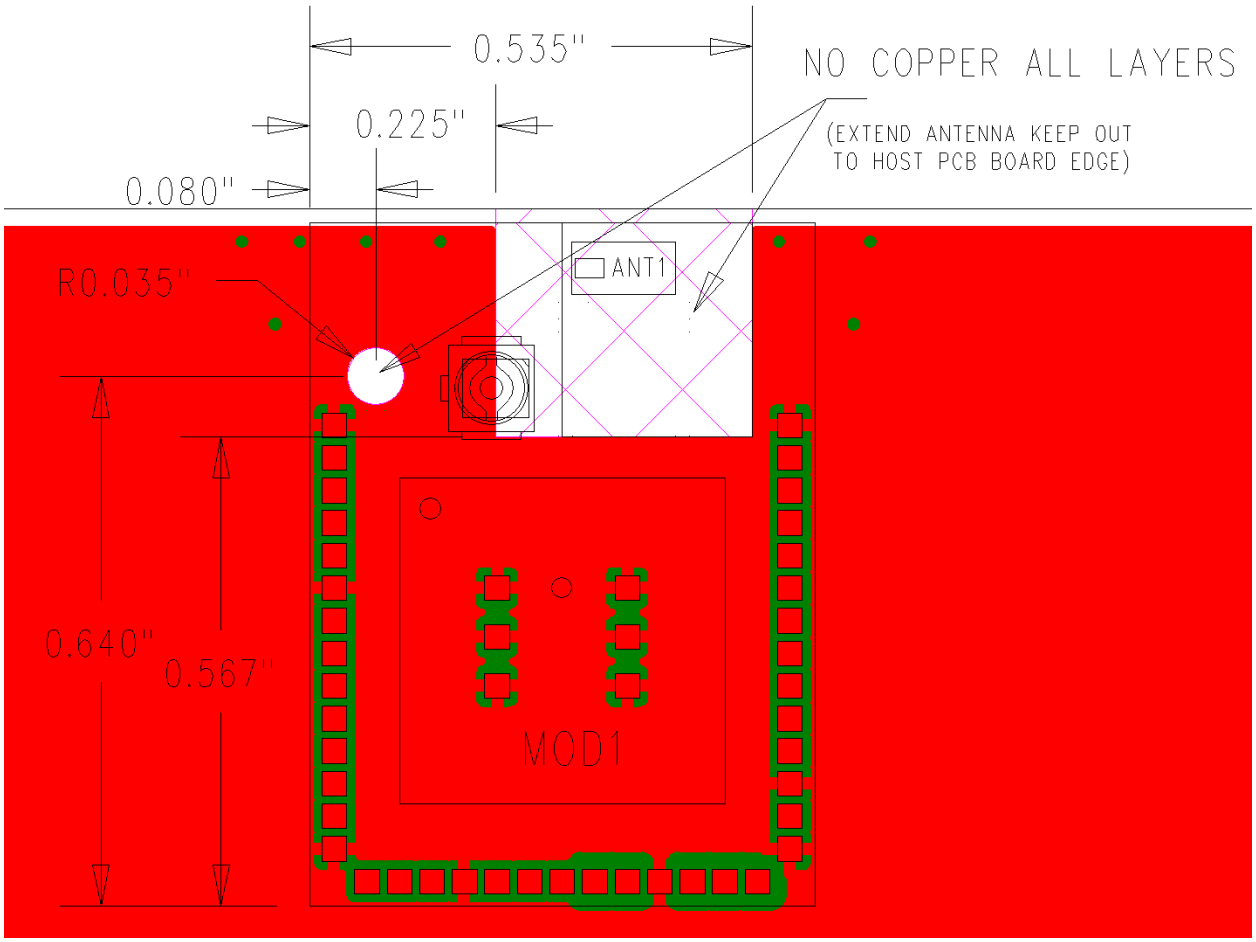

Figure 3 Host PCB for Sterling-LWB Chip Antenna Module Variant

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5.4 Sterling-LWB SIP Module with U.FL Reference Design (External Antenna)

When integrating the Sterling-LWB SIP module (LSR Part Number 450-0159) into a host PCB that uses a U.FL connector (External Antenna), the PCB layout shown in Figure 4 should be followed. Visit **http://www.lsr.com** for current PCB and Schematic CAD files.

Keep in mind that when specifying parts for the design, the RF components that cannot be substituted are shown in Table 6.

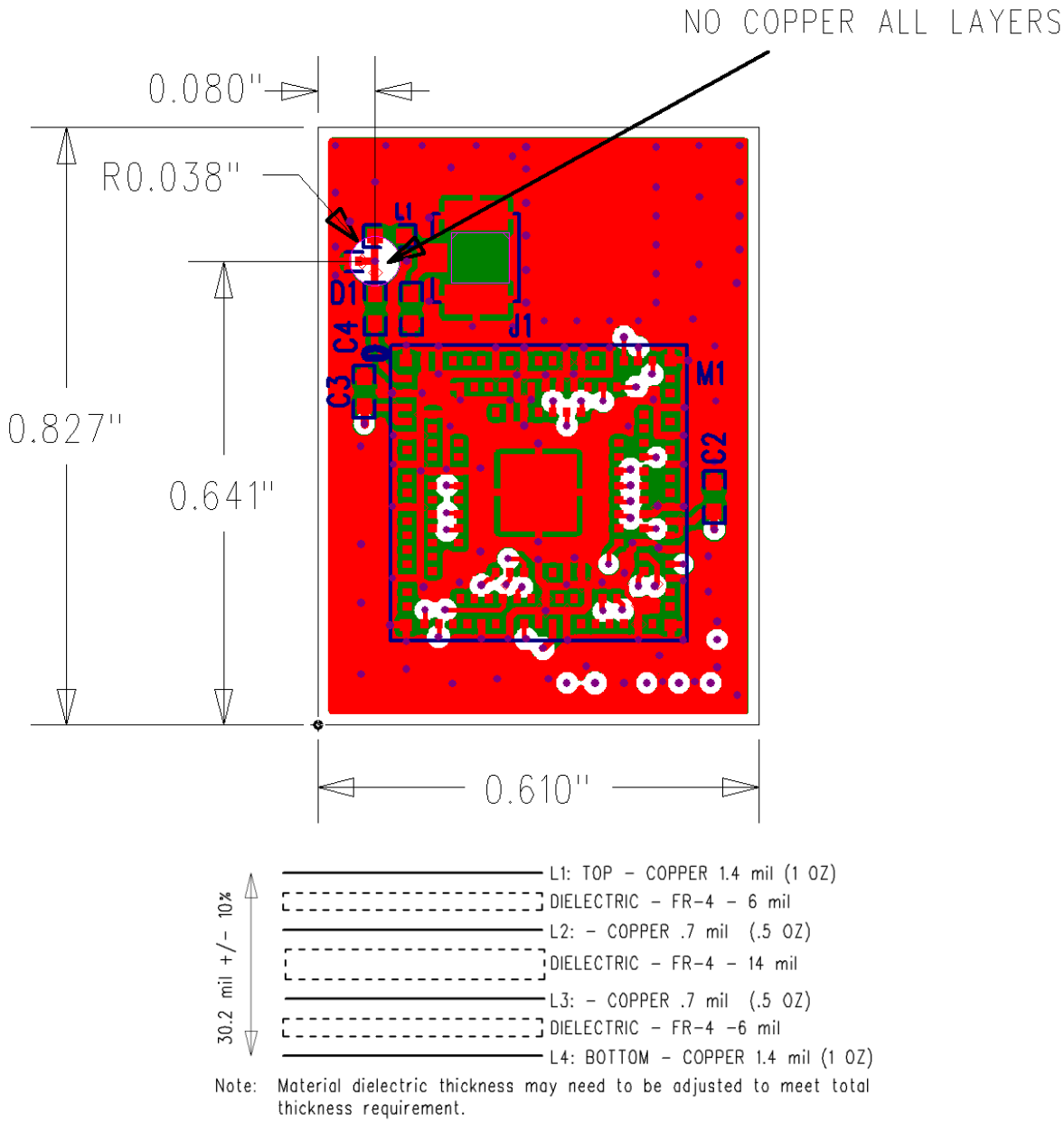

Figure 4 SIP Module with U.FL (External Antenna) Reference Design

*Note: For a reference design which integrates both U.FL and chip antenna modules, follow the Host PCB design for the hip antenna module (*Figure 1*).*

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Visit the LSR web site http://www.lsr.com for current PCB and Schematic CAD files.

Qty	PCB Ref	POP Optional	Value	Tolerance	Manufacturer	Mfg Part Number
1	ANT1	NP			Johanson	2450AT18D0100
1	C1	NP	1.0pF	+/- 0.25pF	Murata	GRM1555C1H1R0CA01
2	C2 C3		2.2uF	+/- 20%	Kemet	C0402C225M9PAC
1	C4		10pF	+/- 5%	Murata	GRM1555C1H100JA01
1	C4	ALTERNATE	10pF	+/- 5%	Murata	GJM1555C1H100JB01
1	C5	NP	2.7pF	±0.25pF	Murata	GJM1555C1H2R7CB01
1	C6		2.0pF	+/- 0.25pF	Murata	GJM1555C1H2R0CB01
1	D1				Infineon	ESD108B1CSP0201XTSA1
1	J1				Hirose	U.FL-R-SMT-1#
1	L2	NP	2.0nH	+/- 0.1nH	Murata	LQP15MN2N0B02
1	L2	NP (ALT)	2.0nH	+/- 0.1nH	AVX	HLQ022R0BTTR
1	L1		2.0nH	+/- 0.1nH	Murata	LQP15MN2N0B02
1	L1	ALTERNATE	2.0nH	+/- 0.1nH	AVX	HLQ022R0BTTR
1	L3	NP	2.7nH	+/- 0.1nH	Murata	LQP15MN2N7B02
1	L3	NP(ALT)	2.7nH	+/- 0.1nH	AVX	HLQ022R7BTTR
1	M1				LSR	450-0159

Table 6 SIP Module with U.FL (External Antenna) Reference Design BOM

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5.5 Sterling-LWB U.FL Module Variant Host PCB

When integrating the U.FL Module (LSR Part Number 450-0148), the host PCB layout shown Figure 5 in should be followed. A development board and all design files are available for the Sterling-LWB U.FL Module. Visit **http://www.lsr.com** for current PCB and Schematic CAD files.

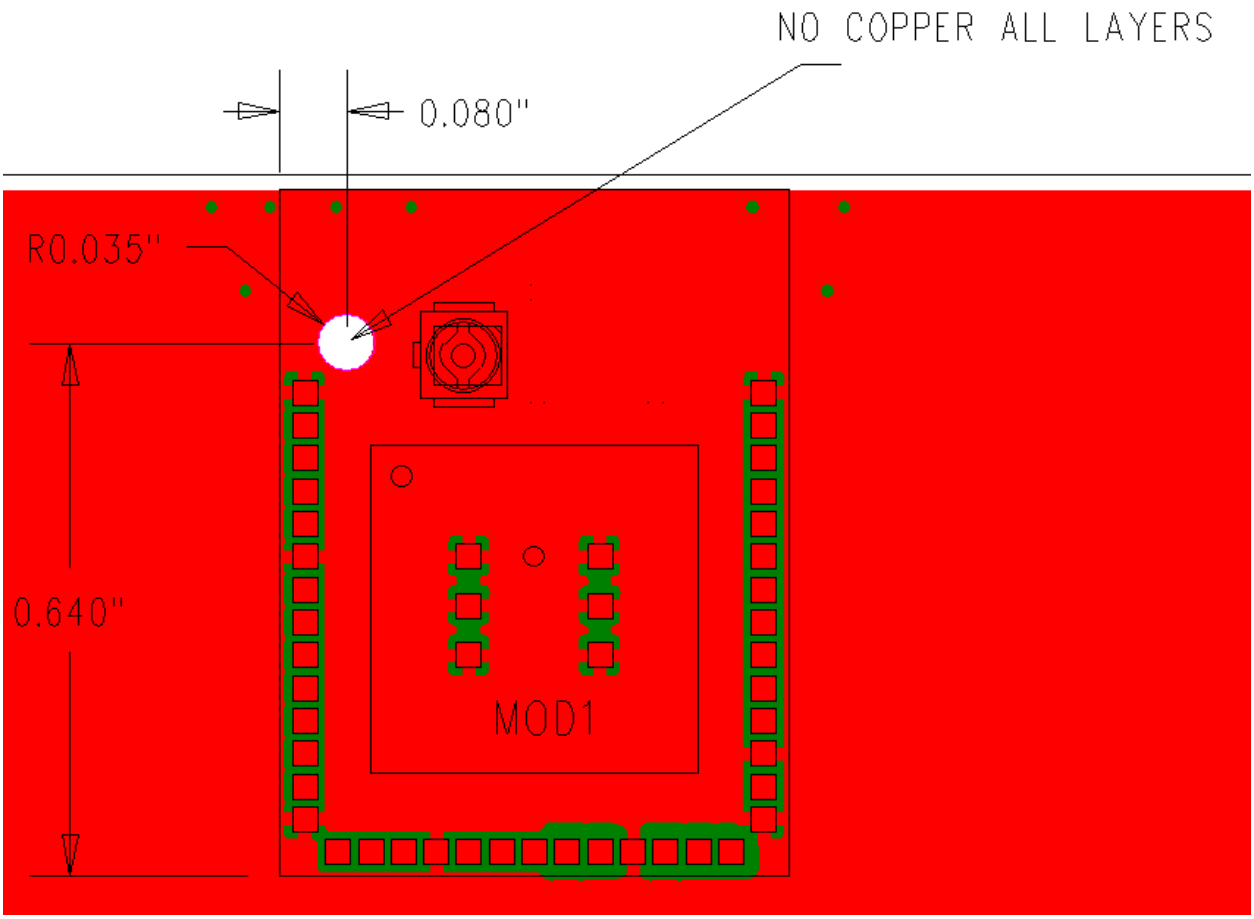

Figure 5 Host PCB for Sterling-LWB U.FL Module Variant

Note: For a host PCB which integrates both U.FL and chip antenna modules, follow the Host PCB design for the chip antenna module (Figure 3).

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6 Sterling-LWB Approved Antenna Specifications

6.1 External Antenna Connector

Either the LSR 2.4 GHz Dipole Antenna with Reverse Polarity SMA Connector and U.FL to SMA Cable, the LSR 2.4 GHz FlexPIFA, or the 2.4 GHz FlexNotch Antenna are used in conjunction with the Hirose PCB mounted U.FL connector to provide an externally mounted antenna solution for the Sterling-LWB module.

6.1.1 U.FL Connector Drawing

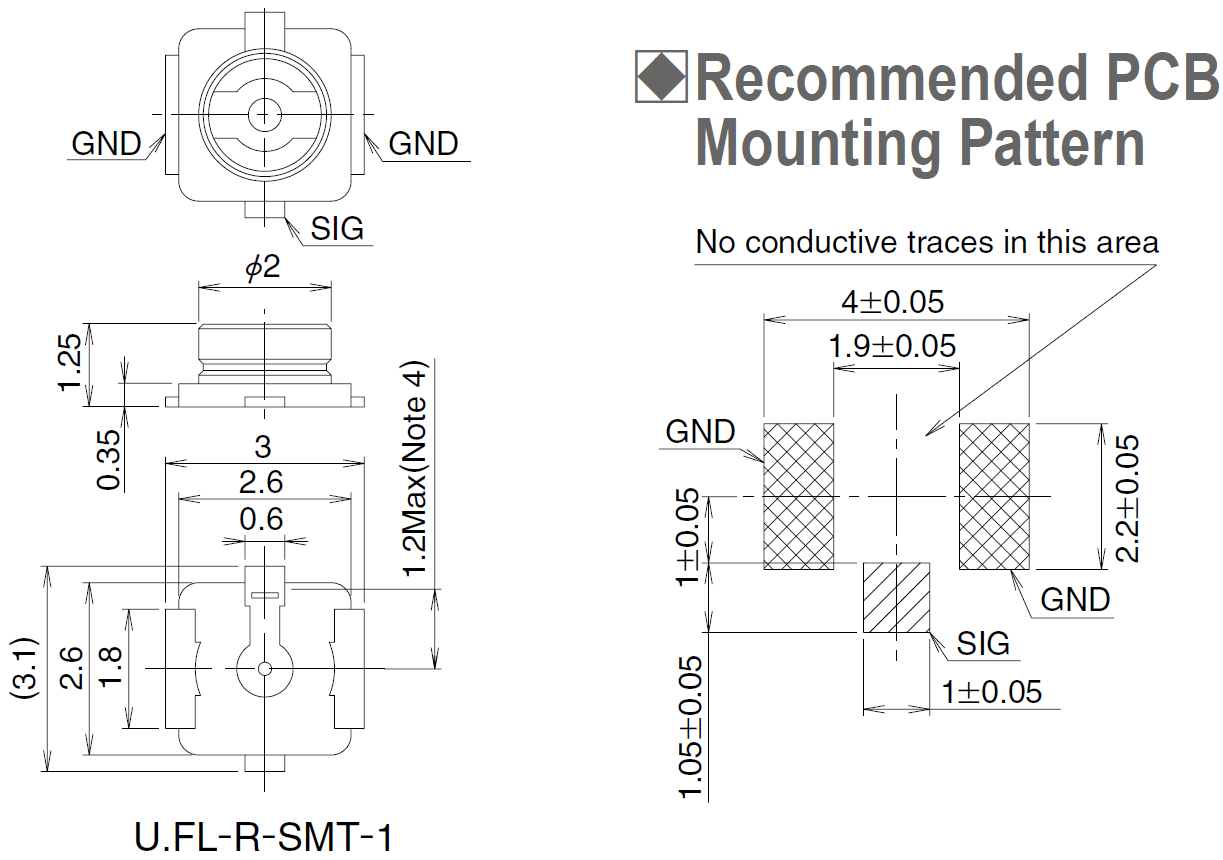

Figure 6 U.FL Connector Drawing

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6.2 Chip Antenna Specifications

The Johanson 2450AT18D0100 Ceramic Chip Antenna provides an off-module, PCB mounted, antenna solution for the Sterling-LWB module. The antenna on the Sterling-LWB evaluation platform is positioned on the PCB to allow maximum performance while using a minimum amount of board space.

6.2.1 Mechanical Dimensions

Mechanical Specifications

	In	mm
L	0.126 ± 0.008	3.20 ± 0.20
W	0.063 ± 0.008	1.60 ± 0.20
T	0.047 ± 0.008	1.20 ± 0.20
a	0.012 ± .004/-.008	0.30 ± 0.1/-0.2
b	0.020 ± 0.008	0.50 ± 0.20

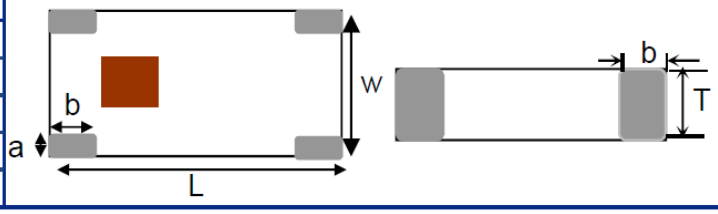

Figure 7 Chip Antenna Dimensions

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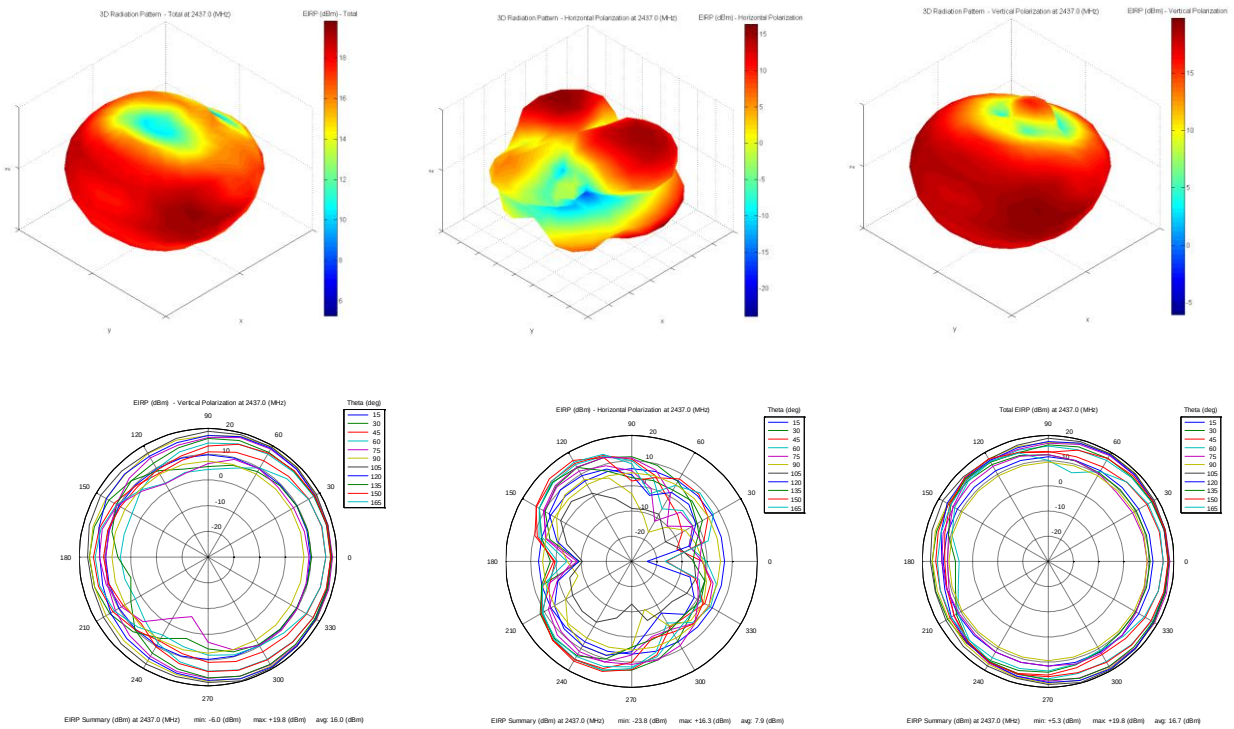
6.3 Chip Antenna Typical Radiation Patterns



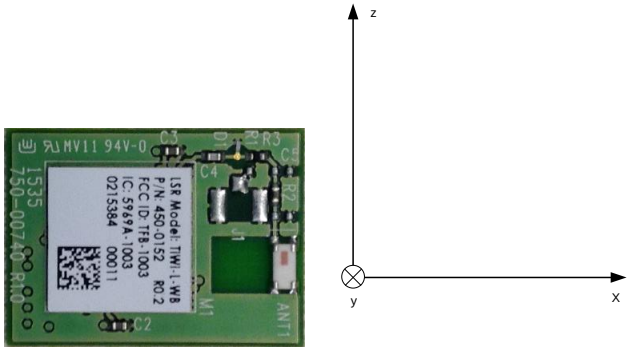


Figure 8 Chip Antenna Typical Radiation Patterns, Orientation Axis shown. 2D-Patterns in standard Spherical Coordinate System (r,θ,ϕ)

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6.4 LSR FlexPIFA Antenna Specifications

Specification	Value
Manufacturer and Part Number	LSR 001-0014
Peak Gain	2.0 dBi
Type	Flexible Planar Inverted F Antenna (FlexPIFA)
Polarization	Linear
Frequency	2400-2480 MHz

Table 7 LSR FlexPIFA Antenna Specifications

6.4.1 LSR 2.4 GHz FlexPIFA Mechanical Dimensions

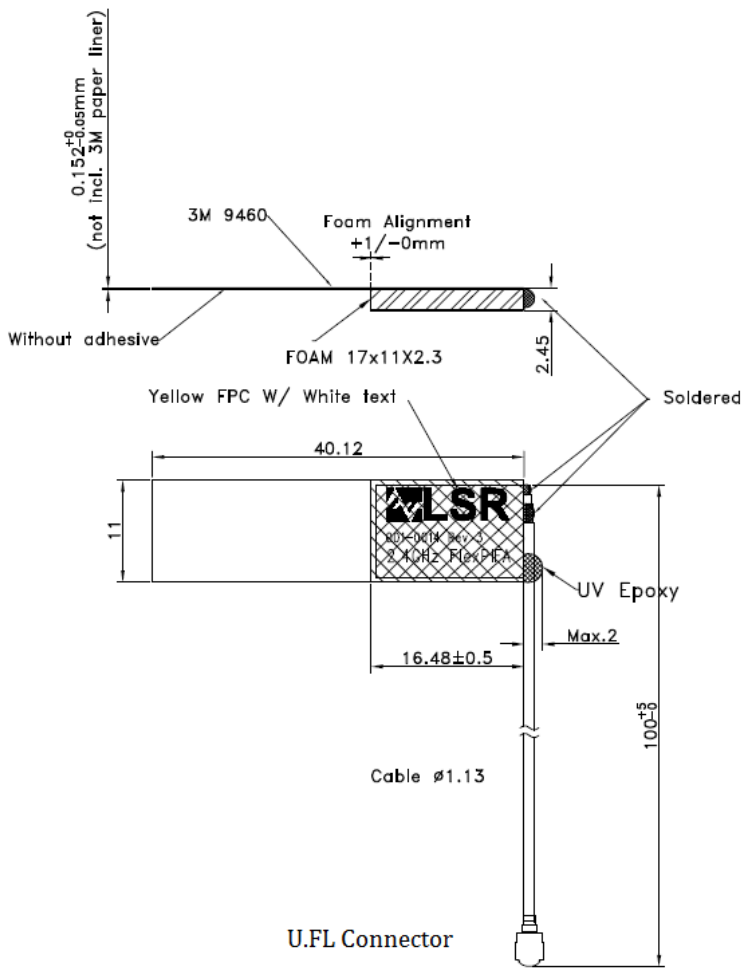

Figure 9 LSR 2.4 GHz FlexPIFA Antenna Dimensions

Visit the LSR web site **http://www.lsr.com** for further information on the LSR FlexPIFA Antenna.

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6.5 LSR FlexNotch Antenna Specifications

Specification	Value
Manufacturer and Part Number	LSR 001-0015
Peak Gain	2.0 dBi
Type	Flexible Notch Antenna (FlexNotch)
Polarization	Linear
Frequency	2400-2480 MHz

Table 8 LSR FlexNotch Antenna Specifications

6.5.1 LSR 2.4 GHz FlexNotch Mechanical Dimensions

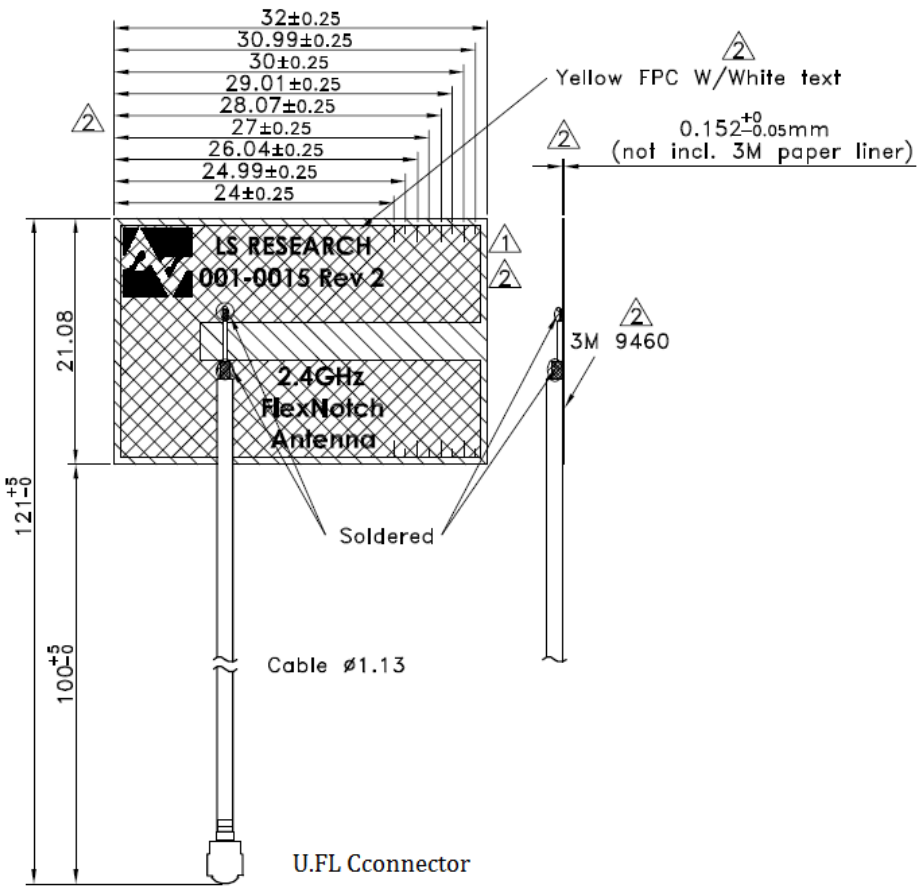

Figure 10 LSR 2.4 GHz FlexNotch Antenna Dimensions

Visit the LSR web site **http://www.lsr.com** for further information on the LSR FlexNotch Antenna.

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6.6 LSR Dipole Antenna Specifications

The LSR 2.4 GHz Dipole Antenna is used in conjunction with the LSR U.FL to Reverse Polarity SMA Cable, and the Hirose PCB mounted U.FL connector (Figure 6), to provide an externally mounted antenna solution for the Sterling-LWB module.

Specification	Value
Manufacturer and Part Number	LSR 001-0001
Gain	2.0 dBi
Impedance	50 ohms, Nominal
Type	Dipole
Polarization	Linear Vertical
VSWR	≤2.5：1, Maximum
Frequency	2400-2500MHz
Weight	13g
Size	105 mm x 10 mm
Antenna Color	Black

Table 9 Dipole Antenna Specifications

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6.6.1 Mechanical Dimensions

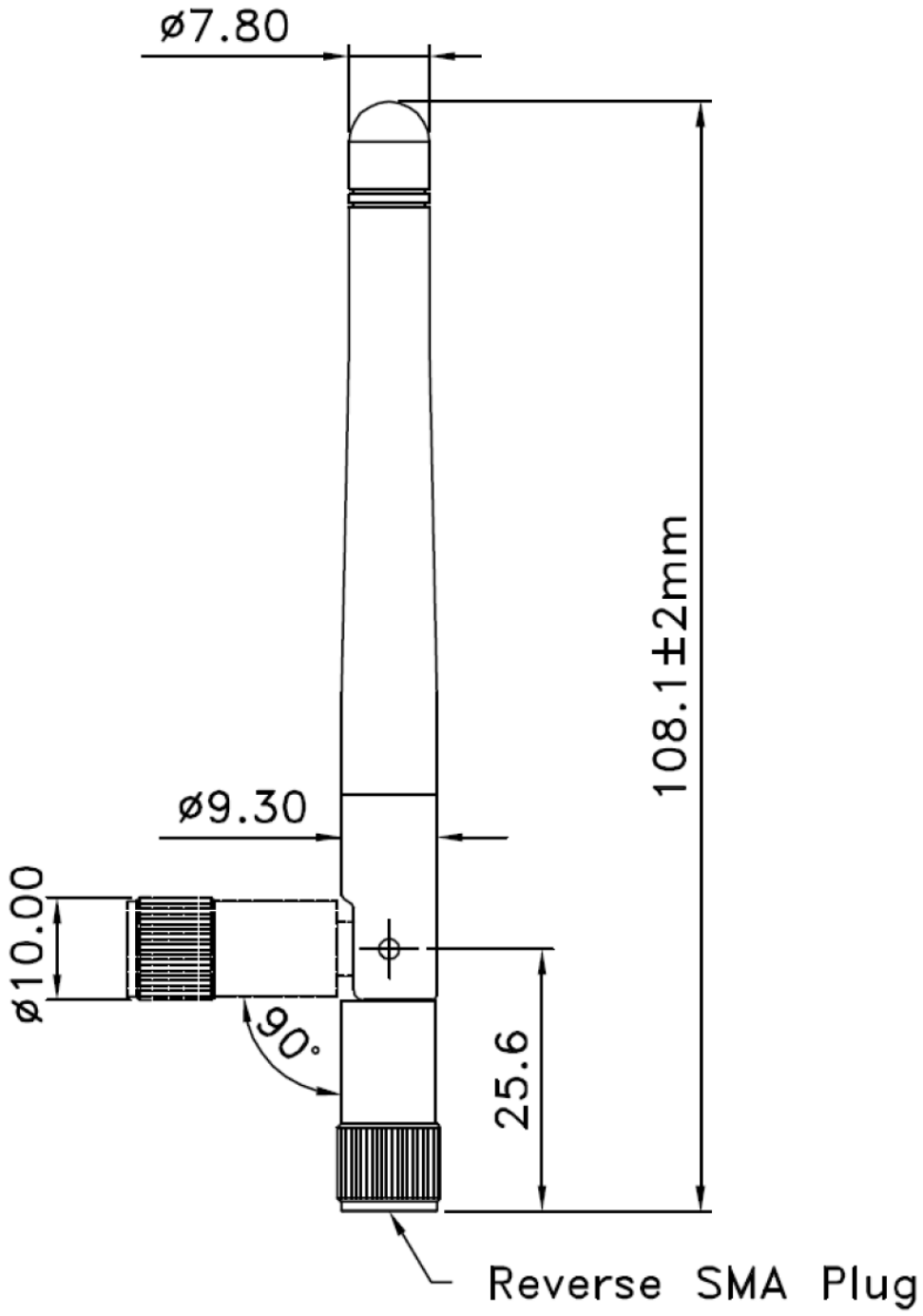

Figure 11 LSR 2.4 GHz Dipole Antenna Dimensions

Visit the LSR web site **http://www.lsr.com** for further information on the LSR Dipole Antenna

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7 EMC Compliance

7.1 Summary

The Sterling-LWB module has been tested and approved as a Modular Radio in accordance with the appropriate FCC and IC standards. The supporting test data may be found in the modular test report.

Since this module and its associated set of approved antennas have been certified as a Modular Radio, this allows the end user to integrate this module into an end-product without the requirement of re-certifying the radio module. The module-integrator is responsible for the unintentional conducted and radiated emissions and must ***verify*** that the integrated product is compliant with the rules associated with unintentional radiators. FCC also expects integrators to do spot checking of transmitter tests as necessary based upon KDB 996369 D04. The module integrator is also required to maintain an engineering record of the verification testing and declare on the product through proper labeling and marking that the device is compliant with these particular rules.

The installed module's FCC ID and IC numbers need to be clearly marked on the product with the following verbiage "Contains FCC ID: TFB-1003" and "Contains IC: 5969A-1003".

7.2 Module Integration Considerations - Antenna Systems

The module must be used with one of the approved antennas:

1) LSR 001-0001 2.4 GHz center-fed dipole antenna and LSR 080-0001 U.FL to Reverse Polarity SMA connector cable.
2) LSR 001-0014 2.4 GHz FlexPIFA antenna.
3) LSR 001-0015 2.4 GHz FlexNotch antenna.
4) Johanson 2450AT18D0100 chip antenna.

The antenna should be placed such that it is minimally disturbed by the product's packaging material. The incorporation of the largest practical free-space clearance around the antenna is important for maximizing overall performance. Further, the antenna must be placed such that at least a 20 cm separation distance is maintained from the antenna to all other radio transmitters.

7.3 Module Integration Considerations - Substitute Antenna Systems

The module's certification is only valid for the list of approved antennas presented in section 6. When using the U.FL connector, you may use a substitute antenna if the peak antenna gain is to equal or less than +2.0 dBi. It may be possible to use a substitute chip antenna however there are restrictions so please contact LSR for guidance prior to making any chip antenna substitutions.

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7.4 Module Integration Considerations - Circuit Implementation

It is recommended that all connection PCB (printed circuit board) traces to the power supply and digital control terminal be as short as possible. Though not necessarily required in all cases, it is a best practice to provide an optional shunt capacitor placement at the module pin on all active and routed power supply and digital control lines. Further, a series damping resistor placement should be incorporated between the module pin/shunt capacitor node and the source/sink of the digital control signals. This provides for effective bypassing and decoupling of digital lines from the radio module, in the event that the application circuit has longer power supply and digital routing.

7.5 Module Integration Considerations - Top Assembly

In addition to the recommendations given for the antenna systems and the module placement onto a product PCB, it is recommended that all wiring and interconnect systems within the product not be routed anywhere close the module and its associated circuitry on the PCB, doing so could change the emission characteristics of the module.

7.6 Testing Requirements for End-Product

Once the module is integrated and the end-product is realized, the end-product must be tested and follow the verification process for Unintentional Conducted and Radiated Emissions in accordance to the FCC and IC guidelines. The module needs to be powered and placed in the receive mode for this test. The receiver must be tuned to its lowest frequency channel, mid-frequency channel, and highest frequency channel. The supporting test data does not need to be submitted to the FCC or IC.

The implementation of the module in a specific end-product should also be reviewed to ensure compliance with the FCC and IC requirements for SAR and MPE.

In a portable application the minimum separation distance to the user is 29 mm.

In a mobile application the minimum separation distance to the user is 20cm.

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8 Contacting LSR

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