

# SABLE-X MODULE

## *APPLICATION GUIDE*



Last updated  
May 13, 2015

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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 SaBLE-x module. It covers the on-module PCB trace antenna as well as several off-module antennas (Dipole, FlexPIFA, and FlexNotch). It will inform the designer as to the required PCB layout details, and provide expected performance specifications.

### **1.2 Applicable Documents**

- *SaBLE-x Module Datasheet (330-0166)*
- *SaBLE-x Development Board User Guide (330-0168)*
- *LSR U.FL to RPSMA Cable Datasheet (330-0018)*
- *LSR 2.4 GHz Dipole Antenna Datasheet (330-0016)*
- *LSR 2.4 GHz FlexPIFA Antenna Datasheet (330-0149)*
- *LSR 2.4 GHz FlexNotch Antenna Datasheet (330-0150)*

## 2 PCB Trace Antenna

The PCB trace antenna is integral to the SaBLE-x 450-0119 module, such that the end user does not incur the added cost of adding an external antenna to their end product.


	LSR Part Number	Description
 <p>LSR Model: SaBLE-x P/N: 450-0119-R1 FCC ID: TFB-1002 IC: 5969A-1002 20F0700001</p> <p>750-00500-R1.0 94V-0</p>	450-0119	SaBLE-x Module with PCB Trace Antenna

Table 1 PCB Trace Antenna Overview





### 2.1 PCB Trace Antenna Specifications

Specification	Value
Peak Gain	0 dBi
Type	PCB Trace
Polarization	Linear Vertical
Frequency	2400-2500MHz

Table 2 PCB Trace Antenna Specifications

### 3 Dipole Antenna

The LSR 2.4 GHz Dipole Antenna can be used in conjunction with the LSR U.FL to Reverse Polarity SMA Cable, and the Hirose PCB mounted U.FL connector, to provide an externally mounted antenna solution for the SaBLE-x 450-0144 module.

	Part Number	Description
	450-0144	SaBLE-x Module, External Antenna Port
	001-0001	2.4 GHz Dipole Antenna with Reverse Polarity SMA Connector
	080-0001	U.FL to Reverse Polarity SMA Bulkhead Cable 105 mm
	Hirose U.FL-R-SMT(10)	PCB Mounted U.FL Connector

**Table 3 Dipole Antenna Overview**

### 3.1 Dipole Antenna Specifications

Specification	Value
Gain	+2 dBi
Impedance	50 ohms
Type	Dipole
Polarization	Linear Vertical
VSWR	≤2.5 : 1, Maximum
Frequency	2400 - 2500MHz
Weight	13g
Size	105mm x 10mm
Antenna Color	Black
Operating Temp	-40°C to +85°C

**Table 4 Dipole Antenna Specifications**

### 3.2 Mechanical Dimensions

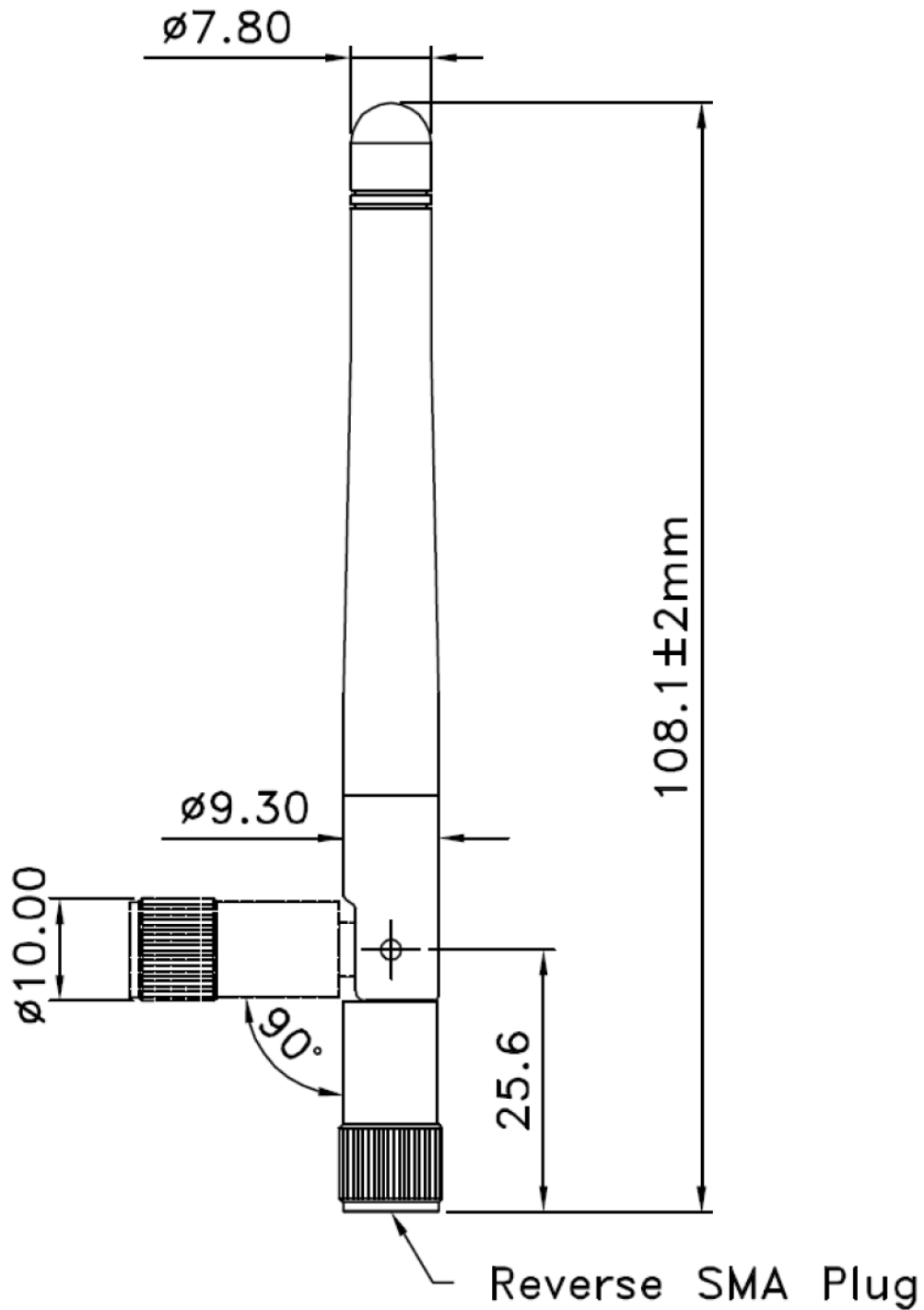





Figure 1 Dipole Antenna Dimensions

## 4 FlexPIFA Antenna

The LSR 2.4 GHz FlexPIFA Antenna can be used in conjunction with the Hirose PCB mounted U.FL connector, to provide an externally mounted antenna solution for the SaBLE-x 450-0144 module.

	Part Number	Description
	450-0144	SaBLE-x Module, External Antenna Port
	001-0014	2.4 GHz FlexPIFA Antenna with Integrated Cable
	Hirose U.FL-R-SMT(10)	PCB Mounted U.FL Connector

**Table 5 FlexPIFA Antenna Overview**

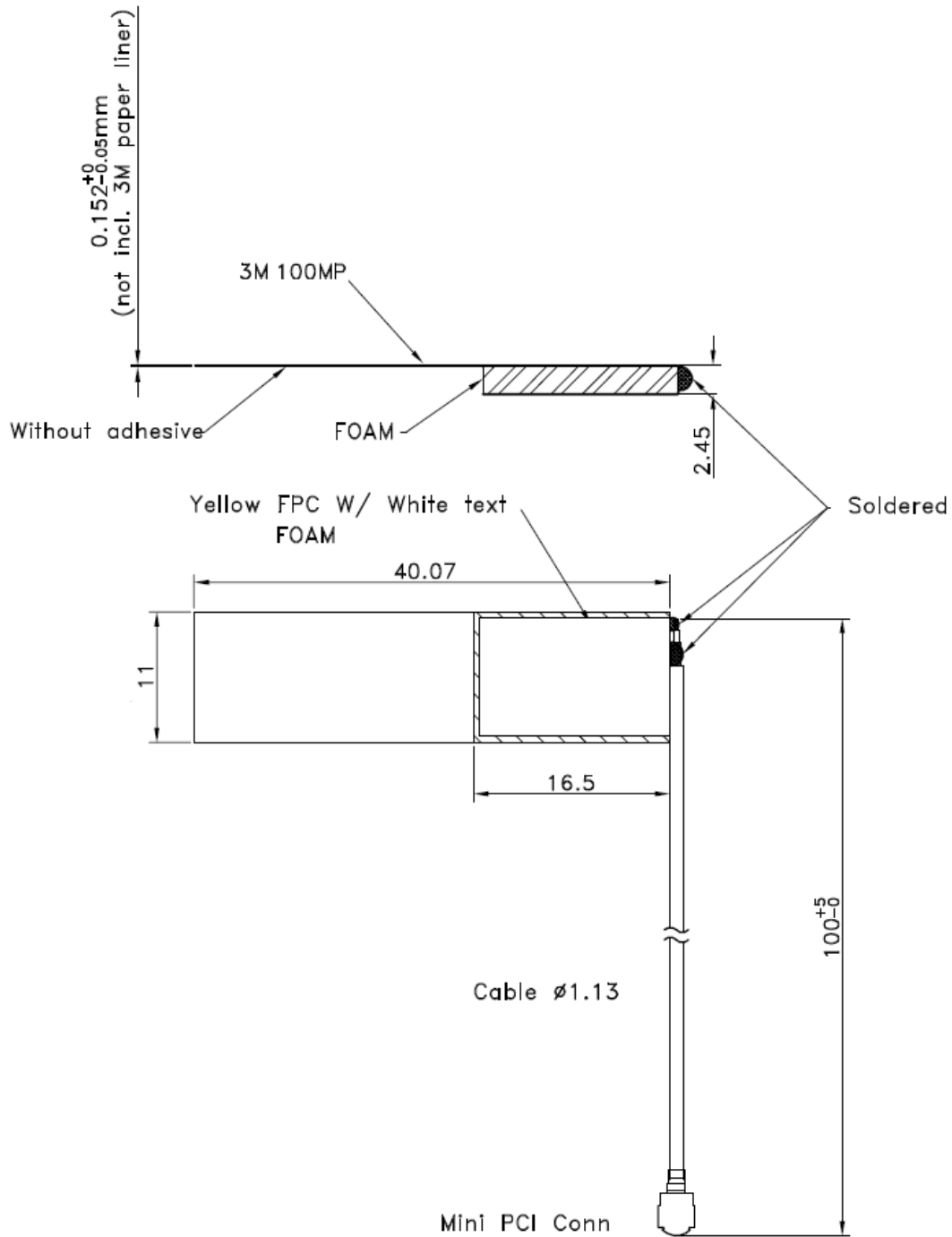


## 4.1 FlexPIFA Antenna Specifications

Specification	Value
Gain	+2 dBi
Efficiency	>60%
Impedance	50 ohms
Type	Flexible Planar Inverted F Antenna (FlexPIFA)
Polarization	Linear
VSWR	< 2.5:1, 2400 - 2480 MHz
Frequency	2400 - 2480 MHz
Weight	1.13g
Size	40.1mm x 11mm x 2.5mm
Antenna Color	Clear Yellow
Adhesive	3M 100MP
Operating Temp	-40°C to +85°C

**Table 6 FlexPIFA Antenna Specifications**




## 4.2 FlexPIFA Mechanical Dimensions



**Figure 2 FlexPIFA Antenna Mechanical Dimensions**

## 5 FlexNotch Antenna

The LSR 2.4 GHz FlexNotch Antenna can be used in conjunction with the Hirose PCB mounted U.FL connector, to provide an externally mounted antenna solution for the SaBLE-x 450-0144 module.

	Part Number	Description
 <p>LSR Model: SaBLE-x P/N: 450-0144-R1 FCC ID: TFB-1002 IC: 5969A-1002 20F0700001</p>	450-0144	SaBLE-x Module, External Antenna Port
 <p>LS RESEARCH 001-0015 Rev 2 2.4GHz FlexNotch Antenna</p>	001-0015	2.4 GHz FlexNotch Antenna with Integrated Cable
	Hirose U.FL-R-SMT(10)	PCB Mounted U.FL Connector

**Table 7 FlexNotch Antenna Overview**

## 5.1 FlexNotch Antenna Specifications

Specification	Value
Gain	+2 dBi
Efficiency	>70%
Impedance	50 ohms
Type	Flexible Notch
Polarization	Linear
VSWR	< 2.5:1, 2400 - 2480 MHz
Frequency	2400 - 2480 MHz
Weight	0.85g
Size	32.0mm x 21.08mm
Antenna Color	Clear Yellow
Adhesive	3M 100MP
Operating Temp	-40°C to +85°C

**Table 8 FlexNotch Antenna Specifications**

## 5.2 FlexNotch Antenna Mechanical Dimensions

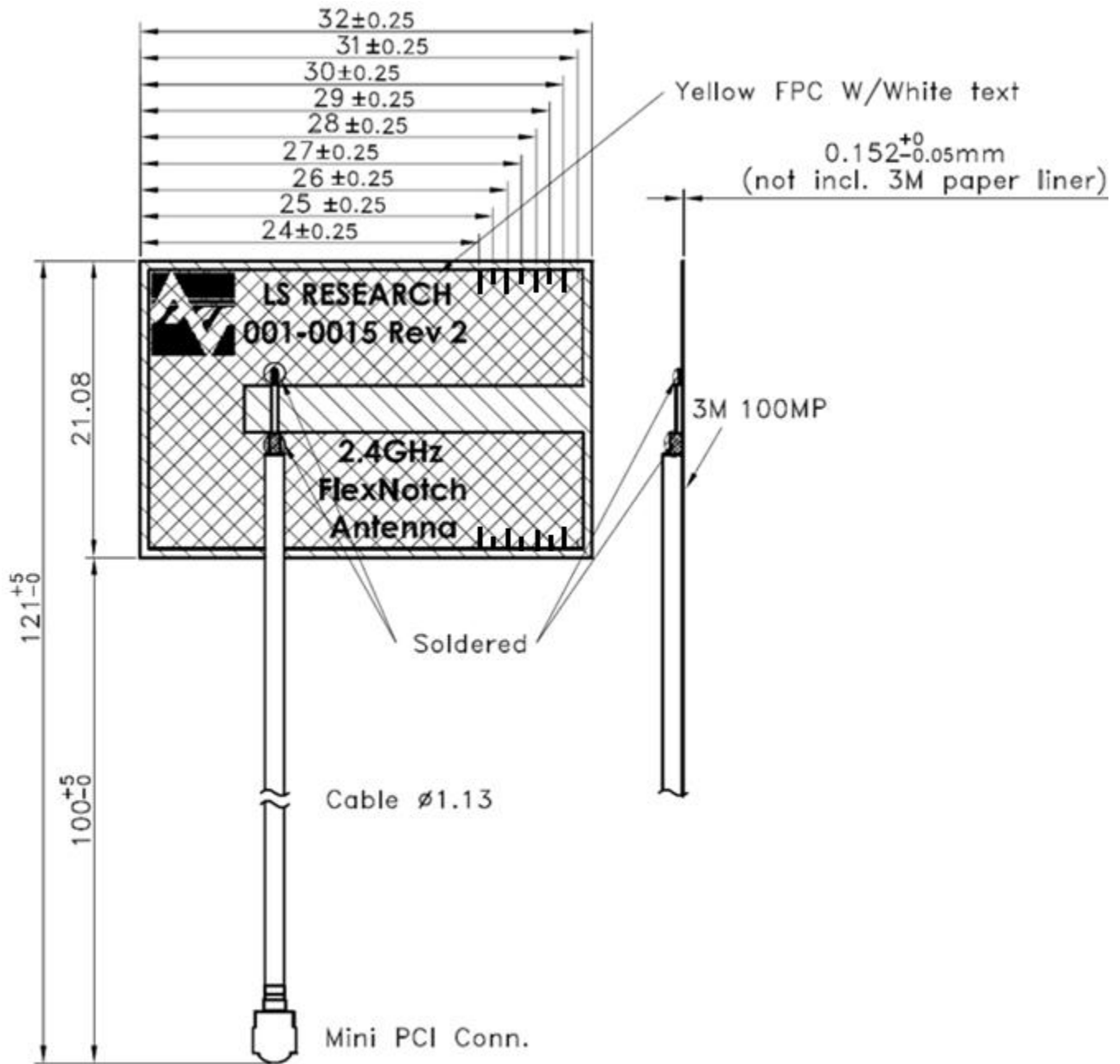


Figure 3 FlexNotch Antenna Mechanical Dimensions

## 6 PCB Layout Requirements

Since this module and its 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 this module 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. On module PCB trace antenna.
2. LSR 001-0001 center-fed 2.4 GHz dipole antenna and 080-0001 U.FL to Reverse Polarity SMA connector cable.
3. LSR 001-0014 2.4 GHz FlexPIFA Antenna.
4. LSR 001-0015 2.4 GHz FlexNotch Antenna.

When using the external antenna version of the module (450-0144), and the reference design that supports the off module U.FL connector, you may use a substitute antenna if the antenna gain is less than or equal to +2 dBi.

LSR provides a FCC Modular Certified reference design which utilizes a controlled impedance PCB that uses microstrip trace design to route the RF signal from the SaBLE-x module to an external coaxial connector. The external coaxial connector and associated microstrip PCB trace is optional when the application is using the On Module PCB Trace Antenna version of the module (450-0119).

In order to use the modular certification for your design, it is critical that the reference design is correctly followed. The full PCB reference design is shown in Figure 4, Schematic Figure 7, and Bill of Materials Table 9. 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 as shown in Figure 5 and Figure 6.

### **PCB Trace Antenna Implementation**

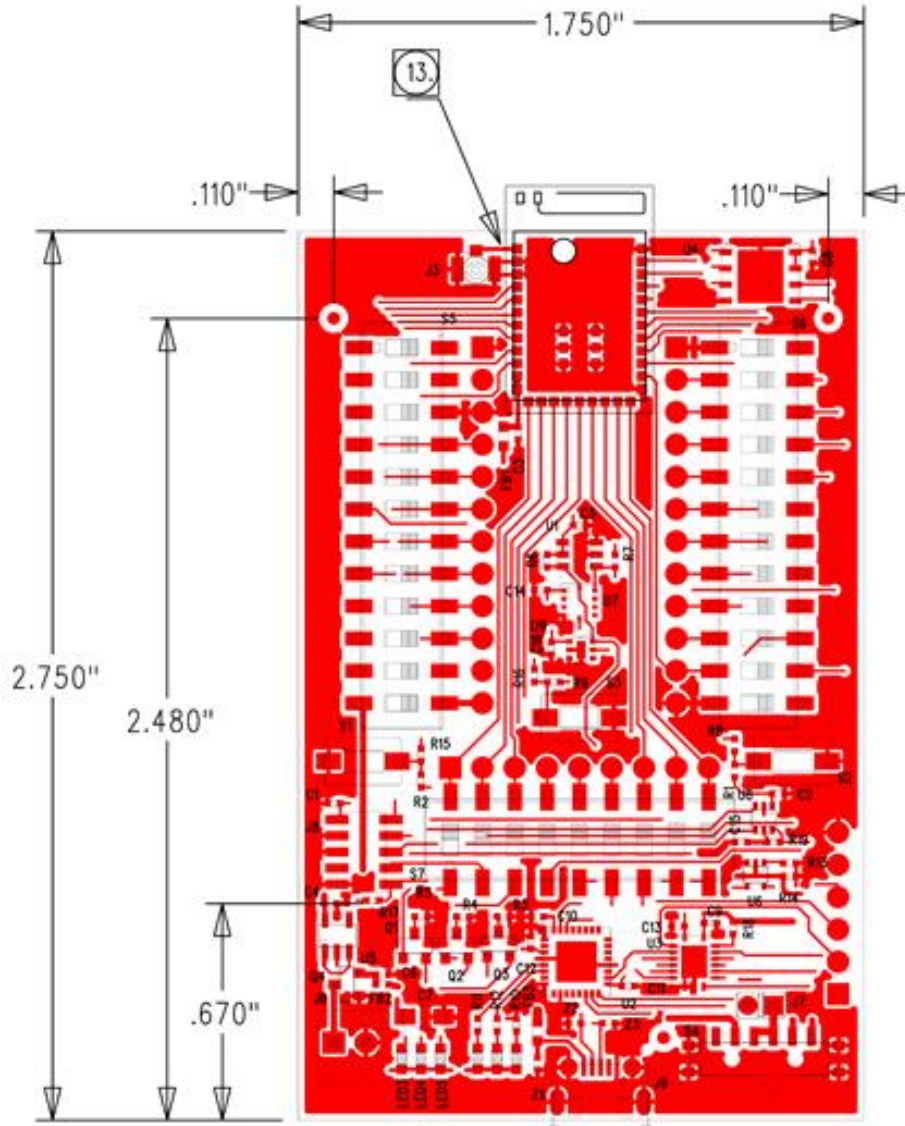
When using the PCB Trace Antenna version of the module (Part Number 450-0119), the PCB layout shown in Figure 4, Figure 5, and Figure 6 should be followed. It is acceptable to keep the U.FL circuitry J3, or it may be removed from the PCB to save component cost. By keeping the external U.FL circuitry, the design can accommodate both antenna versions of the module. To minimize the influence of de-tuning to the module PCB trace antenna, it is recommended to extend the antenna end of the module off the edge of the host PCB. Another alternative is to have a cutout notched in the host PCB such that there is no PCB underneath the antenna end of the module.

### **External Antenna Implementation (Dipole, FlexPIFA, or FlexNotch)**

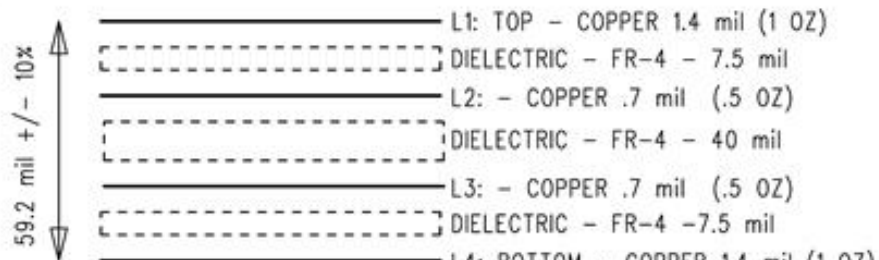
When using the External Antenna Port version of the module (Part Number 450-0144), and one of the three certified 2.4 GHz antennas (Dipole Antenna and U.FL to RPSMA Cable, FlexPIFA, or FlexNotch), the PCB layout shown in Figure 4 should be followed. The U.FL connector J3 must be populated, and a controlled impedance microstrip trace ran between the module RF output pad and the U.FL connector as shown in the Reference Design PCB Figure 4, Figure 5, and Figure 6) and the Schematic Figure 7.

Please use the latest CAD files from the LSR web site when incorporating the SaBLE-x 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.



**13.** 50 OHM +/- 10% CONTROLLED IMPEDANCE 13 mil WIDE MICROSTRIP TRACES



Note: Material dielectric thickness may need to be adjusted to meet total thickness requirement.

**Figure 4 Reference Design PCB**



Antenna Must Extend Beyond Host PCB Or  
A Cut Out Provided On Host PCB

No Copper on Host PCB  
80 mil Dia.

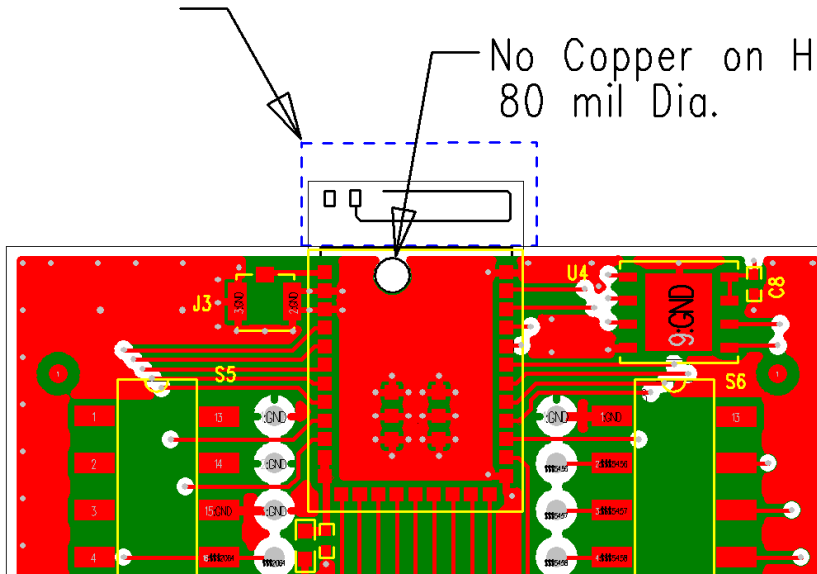


Figure 5 Host PCB Details

Note the “No Copper” keep out requirement on the host PCB shown in Figure 5 above.

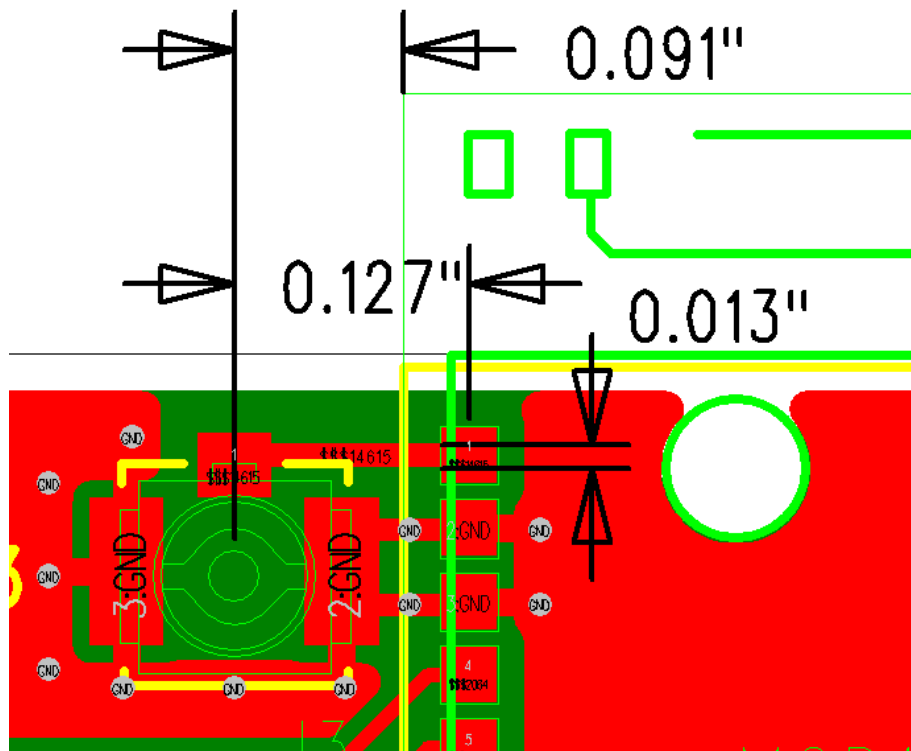


Figure 6 External Antenna Connector and Host PCB RF Trace Details

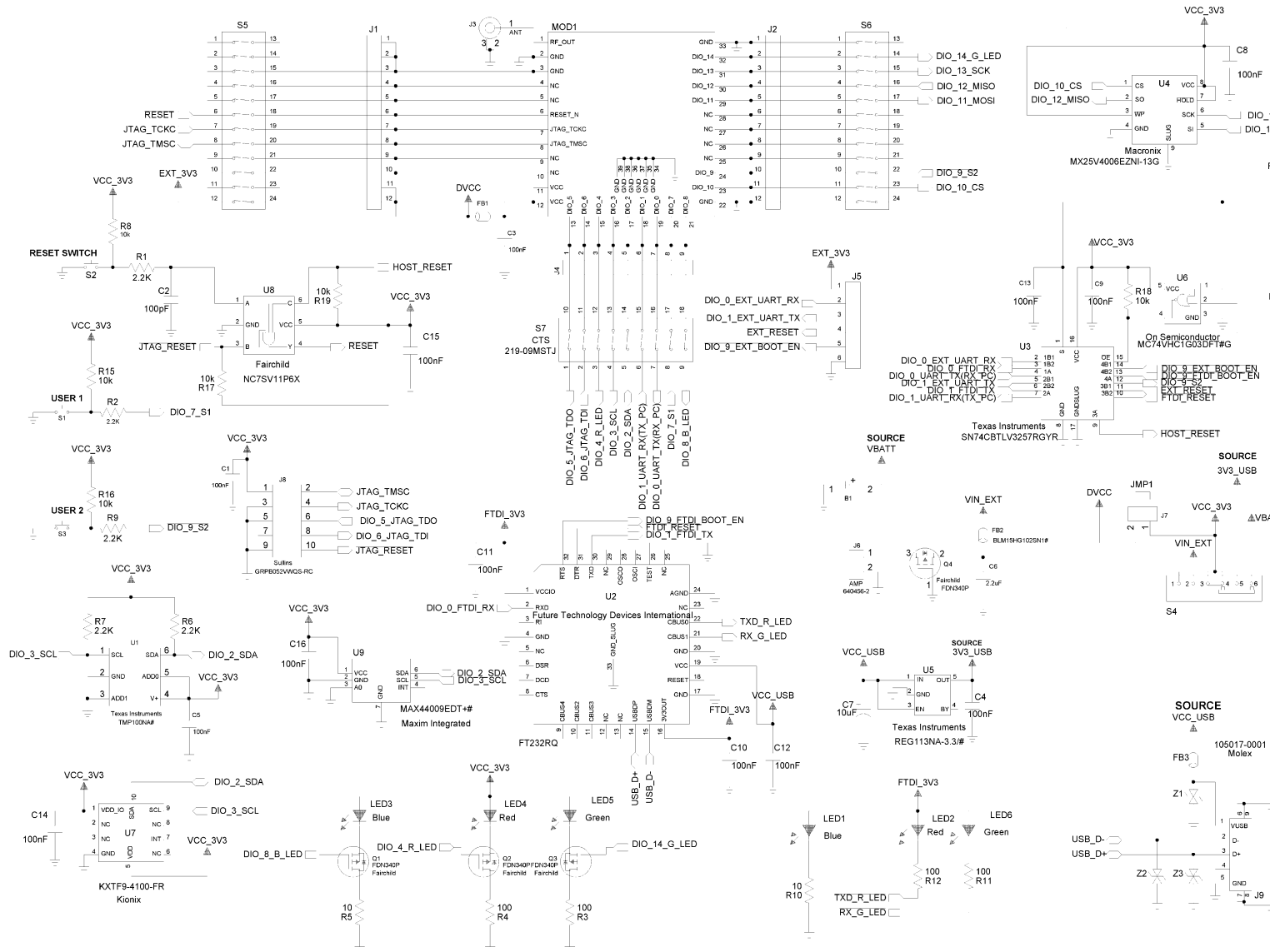
Notes for Integrating PCB Trace Antenna Module (450-0119):

1. To minimize the influence of de-tuning to the module PCB trace antenna, it is recommended to extend the antenna end of the module off the edge of the host PCB.
2. An alternative to cantilevering the antenna outside the edge of the host PCB is to have a cutout notched in the host PCB, such that there is no PCB underneath the antenna end of the module.
3. The ground plane from the host PCB, and metal of any type, should be kept a minimum of .5" from the antenna circuitry to the left, top, and right of the dashed line shown in Figure 5.

Notes for Integrating External Antenna Module (450-0144):

1. In order to accommodate a design that can support either antenna version of the module, the designer should follow the notes for integrating a PCB trace antenna from above.

## 6.1 Reference Design Schematic



**Figure 7 Reference Design Schematic**

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

## 6.2 Reference Design BOM

Qty	PCB Ref	Value	Tolerance	Manufacturer	Mfg Part Number
1	B1			Memory Protection Devices	BU2032SM-G
13	C1 C3 C4 C5 C8 C9 C10 C11 C12 C13 C14 C15 C16	100nF	+/- 10%	Murata	GRM155R71C104KA88#
1	C2	100pF	+/- 5%	Murata	GRM1555C1H101JA01#
1	C6	2.2uF	+/- 20%	Kemet	C0402C225M9PAC#
1	C7	10uF	+/- 10%	Kemet	T491A106K016AT#
1	FB1			Murata	BLM18HE152SN1#
1	FB2			Murata	BLM15HG102SN1#
1	FB3			Taiyo Yuden	FBMH1608HL601-#
2	J1 J2			Samtec	ESQ-112-24-G-S
1	J3			Hirose	U.FL-R-SMT-1#
1	J4			Samtec	ESQ-109-24-G-S
1	J5			Samtec	ESQ-106-24-G-S
1	J6			AMP	640456-2
1	J7			Sullins	PRPN021PAEN-RC
1	J8			Sullins	GRPB052VWQS-RC
1	J9			Molex	105017-0001
1	JMP1			Sullins	SPN02SXCN-RC
2	LED1 LED3			Kingbright	APTD1608QBC/D
2	LED2 LED4			Kingbright	APTD1608SURCK
2	LED5 LED6			Kingbright	APTD1608CGCK
1	MOD1			LSR	450-0119 or 450-0144
1	PCB1				
5	Q1 Q2 Q3 Q4 Q5			Fairchild	FDN340P
1	Q6			Fairchild	BSS138
5	R1 R2 R6 R7 R9	2.2K	5%	KOA	RK73B1ET#222J
2	R3 R11	68	5%	KOA	RK73B1ET#680J
2	R4 R12	680	5%	KOA	RK73B1ET#681J
2	R5 R10	180	5%	KOA	RK73B1ET#181J
10	R8 R13 R14 R15 R16 R17 R18 R19 R20 R21	10k	5%	Vishay	RCG040210K0JN#
3	S1 S2 S3			Panasonic	EVQPNF04M
1	S4			Copal	CUS-14TB
2	S5 S6			CTS	219-12MSTJ
1	S7			CTS	219-09MSTJ
1	U1			Texas Instruments	TMP100NA#
1	U2			Future Technology Devices International	FT232RQ
1	U3			Texas Instruments	SN74CBTLV3257RGYR
1	U4			Macronix	MX25V4006EZNI-13G
1	U5			Texas Instruments	REG113NA-3.3/#

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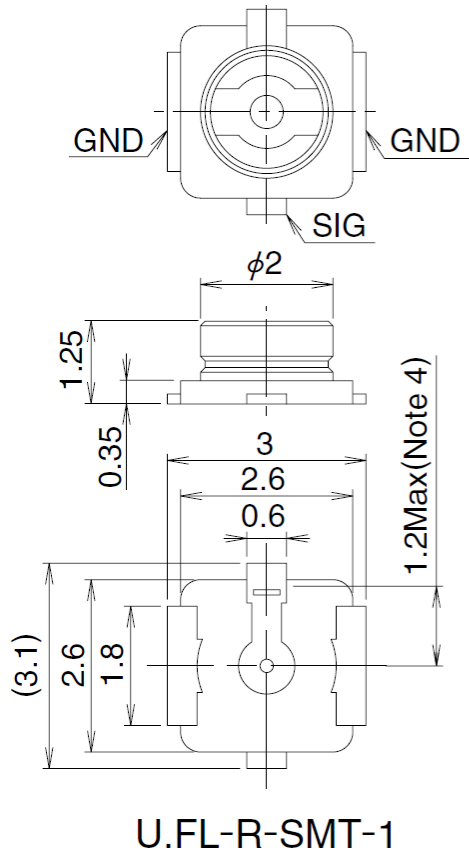
1	U6			On Semiconductor	MC74VHC1G03DFT#G
1	U7			Kionix	KXTF9-4100-FR
1	U8			Fairchild	NC7SV11P6X
1	U9			Maxim Integrated	MAX44009EDT+#
3	Z1 Z2 Z3			Epcos	B72590D0050H1#

**Notes:**

# designates manufacturer packaging option.

**Table 9 Reference Design Development Board BOM**

### 6.3 U.FL Connector Drawing



### ◆ Recommended PCB Mounting Pattern

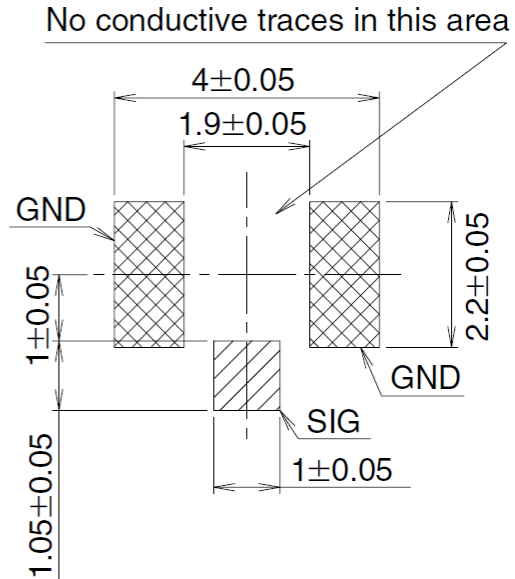


Figure 8 U.FL Connector Drawing

## 7 EMC Compliance

### 7.1 Summary

The SaBLE-x 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. 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 module integrator is responsible for using the patch file that corresponds to the antenna configuration and region for EMC compliance.

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-1002" and "Contains IC: 5969A-1002".

The SaBLE-x has been certified for use in a portable configuration, which allows a transmitting device to be used with any part of its radiating structure in direct contact with the user's body or within 20 cm of the body of a user or bystanders under normal operating conditions.

### 7.2 Module Integration Considerations - Antenna Systems

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

1. On module PCB trace antenna.
2. LSR 001-0001 center-fed 2.4 GHz dipole antenna and LSR 080-0001 U.FL to Reverse Polarity SMA connector cable.
3. LSR 001-0014 2.4 GHz FlexPIFA antenna.
4. LSR 001-0015 2.4 GHz FlexNotch 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 4. However, substitute antennas may be used in place of the approved antenna only if the antennas are of the same type and the peak gain is less than or equal to the peak gain of the similar approved antenna. Also the antennas should have similar in-band and out-of-band characteristics.

## **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 be not 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 product realized in a mobile or portable configuration, the 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.

## **7.7 SAR Testing Requirements for End-Product**

Since the SaBLE-x radio module was certified in a portable configuration, the end-product does not require SAR testing assuming it is not located within 20 cm of another transmitter.



## 8 Contacting LSR

**Headquarters**

LSR  
W66 N220 Commerce Court  
Cedarburg, WI 53012-2636  
USA  
Tel: 1(262) 375-4400  
Fax: 1(262) 375-4248

**Website**

[www.lsr.com](http://www.lsr.com)

**Technical Support**

[forum.lsr.com](http://forum.lsr.com)

**Sales Contact**

[sales@lsr.com](mailto:sales@lsr.com)

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