Sensor Applications Reference Design

(SARD) User's Guide

Document Number: MC13192SARDUG
Rev. 1.5
07/2005

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About This Book

This guide provides detailed information about the MC13192 Sensor Applications Reference Design (SARD). The SARD provides all the components to evaluate and use an MC13192. It is intended to allow a system engineer or software developer to gain an understanding of the MC13192 and its protocol.

Audience

The guide is intended for software and system engineers who are developing their products or software applications making use of the MC13192 to achieve wireless connectivity capability.

It is assumed that the reader has a good working knowledge of general-purpose microcontrollers (MCU).

Organization

The book is divided into 1 chapter and 1 appendix.

Chapter 1	Introduces the SARD functionality and features.
Appendix A	Provides top and bottom views of the SARD printed circuit board.

Conventions

This section names, describes, and defines the conventions used in the book. This document uses the following conventions:

- OVERBAR is used to indicate a signal that is active when pulled low: for example, $\overline{\text{RESET}}$.
- *Logic level one* is a voltage that corresponds to Boolean true (1) state.
- *Logic level zero* is a voltage that corresponds to Boolean false (0) state.
- To *set* a bit or bits means to establish logic level one.
- To *clear* a bit or bits means to establish logic level zero.
- A *signal* is an electronic construct whose state conveys or changes in state convey information.
- A *pin* is an external physical connection. The same pin can be used to connect a number of signals.
- *Asserted* means that a discrete signal is in active logic state.
  - *Active low* signals change from logic level one to logic level zero.
  - *Active high* signals change from logic level zero to logic level one.
- *Negated* means that an asserted discrete signal changes logic state.
  - *Active low* signals change from logic level zero to logic level one.
  - *Active high* signals change from logic level one to logic level zero.
- LSB means *least significant bit* or *bit*s, and MSB means *most significant bit* or *bit*s. References to low and high bytes or words are spelled out.

Definitions, Acronyms, and Abbreviations

The following list defines the acronyms and abbreviations used in this document. As this template develops, this list will be generated from the document. As we develop more group resources, these acronyms will be easily defined from a common acronym dictionary. Please note that while the acronyms are in solid caps, terms in the definition should be initial capped ONLY IF they are trademarked names or proper nouns.

ISM	Industrial Scientific Medical
PER	packet error rate
RF	radio frequency
Rx	receive
SPI	serial peripheral interface
Tx	transmit

References

The following sources were referenced to produce this book:

1. ESD Style Guide.
2. IEEE® Guide to Software Requirements Specifications, July1984.
3. Embedded Bootloader Reference Manual, 802154EBRM.

Revision History

The following table summarizes revisions to this manual since the previous release (Rev. 1.4).

Revision History

Location	Revision
July, 2005	Added table listing differences between Rev. 2 and Rev. 3 boards. Added picture of the Rev 3 board.

Chapter 1
Introduction and Configuration

This section introduces the MC13192 Sensor Applications Reference Design (SARD) basic components, features, hardware configuration, and applications and programming options.

1.1 Safety Information

Any modifications to this product may violate the rules of the Federal Communications Commission and make operation of the product unlawful.

47 C.F.R. Sec. 15.21

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 or more 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.

47 C.F.R. Sec.15.105(b)

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. The antenna(s) used for this equipment must be installed to provide a separation distance of at least 8 inches (20cm) from all persons.

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.
2. This device must accept any interference received, including interference that may cause undesired operation.
3. This device is susceptible to electrostatic discharge (ESD) and surge phenomenon.

1.2 MC13192 Sensor Applications Reference Design (SARD) Components

The MC13192 Sensor Applications Reference Design (SARD) introduces users to the MC13192 2.4 GHz wireless data transceiver. It includes an RS232 port, background debug module for in-circuit hardware debug, switches, LEDs, and a host MCU and allows the user flexibility in establishing wireless data networks. Figure 1-1 shows Revision 3 of the SARD board.

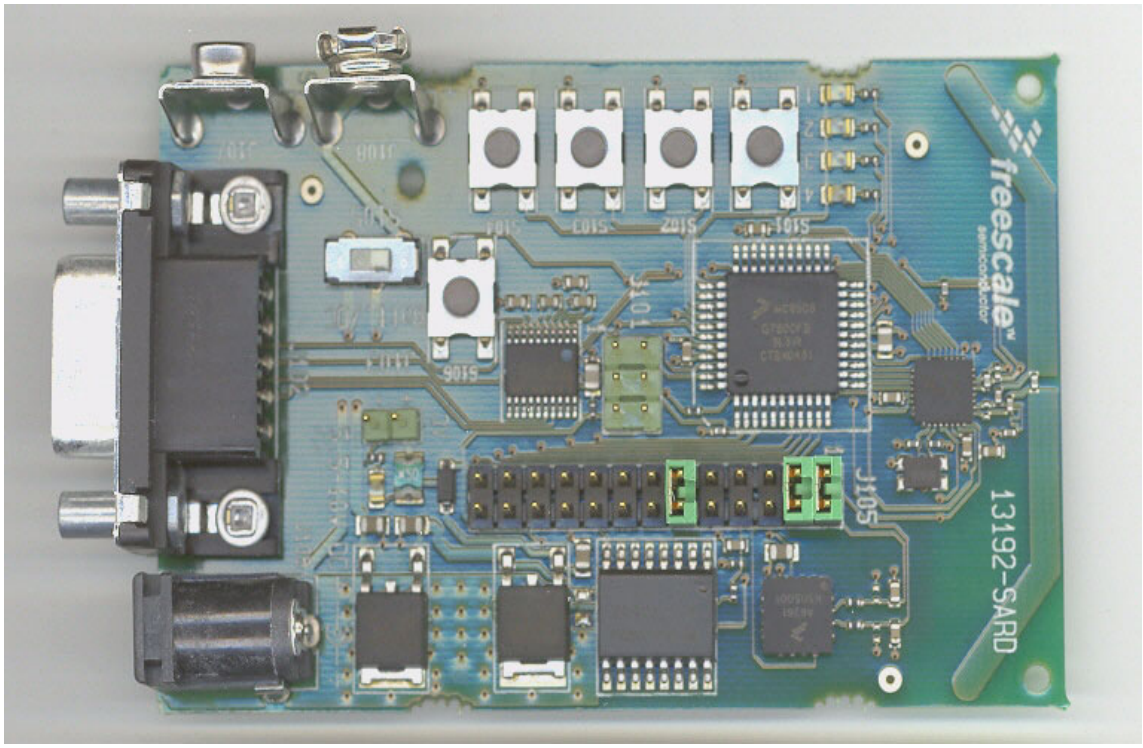

Figure 1-1. SARD Board (Rev 3)

1.2.1 SARD Features

- Provides all hardware required for a complete 2.4 GHz wireless node using IEEE 802.15.4 packet structure.
- One MC13192 2.4 GHz transceiver RF reference design with printed circuit antenna.
- One MC9S08GT60 low-power, low-voltage MCU with 60KB of on-chip Flash.
- Background Debug Module (BDM) programming port for support of Metrowerks CodeWarrior™ Development Studio.
- Provides IEEE 802.15.4 modem.
- Two Accelerometers: MMA6261Q (X and Y axis), MMA1260D (Z axis)
- RS-232 port for interface with a personal computer.
- Four switches and LEDs for control and monitoring.
- Reset switch for program reset.
- Scalable software support:

— Proprietary point-to-point or star networking using Freescale's Simple Medium Access Control (SMAC) software
— IEEE 802.15.4 Standard compliant networking using Freescale's MAC/PHY
— ZigBee™ networking using Freescale's Z-stack software

1.3 Hardware Description

The MC13192 Sensor Applications Reference Design (SARD) provides the hardware required to establish a wireless node using a variety of protocols. Figure 1-2 shows a simplified block diagram of two SARDs connected in a simple point-to-point network. Optional personal computers are shown for control and monitoring.

The SARD is a 2 inch x 3 inch module that comprises a complete network node containing the MC13192, crystal, printed circuit antenna and MCU. Also included are jumper-selectable X-Y and Z Axis Accelerometers, four switches, and four LEDs for monitoring purposes. The SARD derives its power from a 9V battery or a 9V adapter.

NOTE

Do not use a Lithium battery.

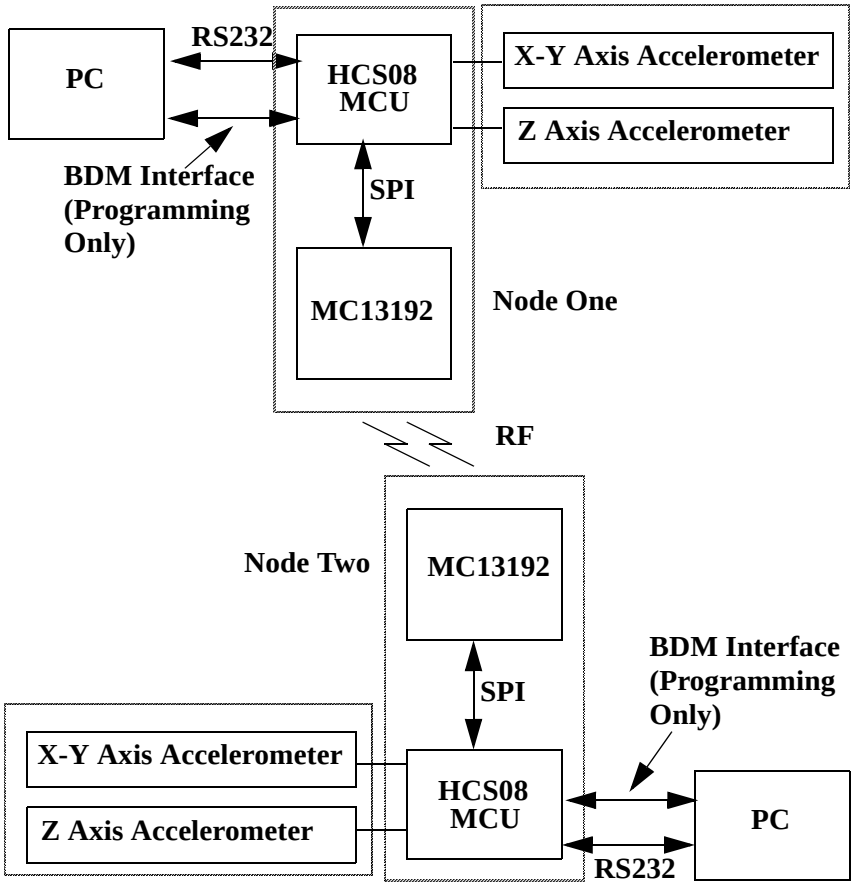

Figure 1-2. Point to Point MC13192 SARD Block Diagram

1.3.1 Differences Between Revision 2 and Revision 3 Boards

Table 1-1. Rev. 2 to Rev. 3 Board Differences

Item	Description
D105	A Power on Reset LED (D105) was added.
C130	A 100pF capacitor (C130) was added an Reset switch for ESD protection.
RF Strip Lines (Receive)	The RF strip lines for the receiver (W101 and W102) were changed. The Z0 120 ohm, 22.5 degree electrical length is equal to a physical length of 4.5mm. This optimizes receive sensitivity.
RF Strip Lines (Transmit)	The RF strip lines for the transmitter (W103 and W104) were changed. The Z0 120ohm, 58 degree electrical length is equal to a physical length of 11.5mm. This optimizes RF output power.
L101 and C131	A filter (L101 and C131) was added on PA out to reduce 2nd and 3rd spurious harmonics.
IC109 and IC108	The LDO ICs 109 and IC108 were changed for output power. Higher current is needed to support a parallel BDM interface.

1.3.2 MC13192 SARD Circuit Description

Figure 1-3 shows the MC13192 SARD schematic. Appendix A includes board layout, including the printed dipole receive and transmit antennas, and Bill of Material information. All circuitry required for a 2.4 GHz wireless node is provided. The heart of the design is the MC13192 2.4 GHz transceiver and the MC9S08GT60 microcontroller. All connections for control of the transceiver by the MCU are provided. Peripherally, four LEDs and switches interfacing with the MCU are provided for control and demonstration purposes.

Three accelerometers are provided. An MMA6261Q (X and Y axis) and an MMA1260D (Z axis) for demonstration purposes. A Background Debug Module (BDM) port is provided for programming using the CodeWarrior™ Development Studio to develop and in-circuit debug code and program the MCU. An RS-232 interface is provided to allow monitoring or programming.

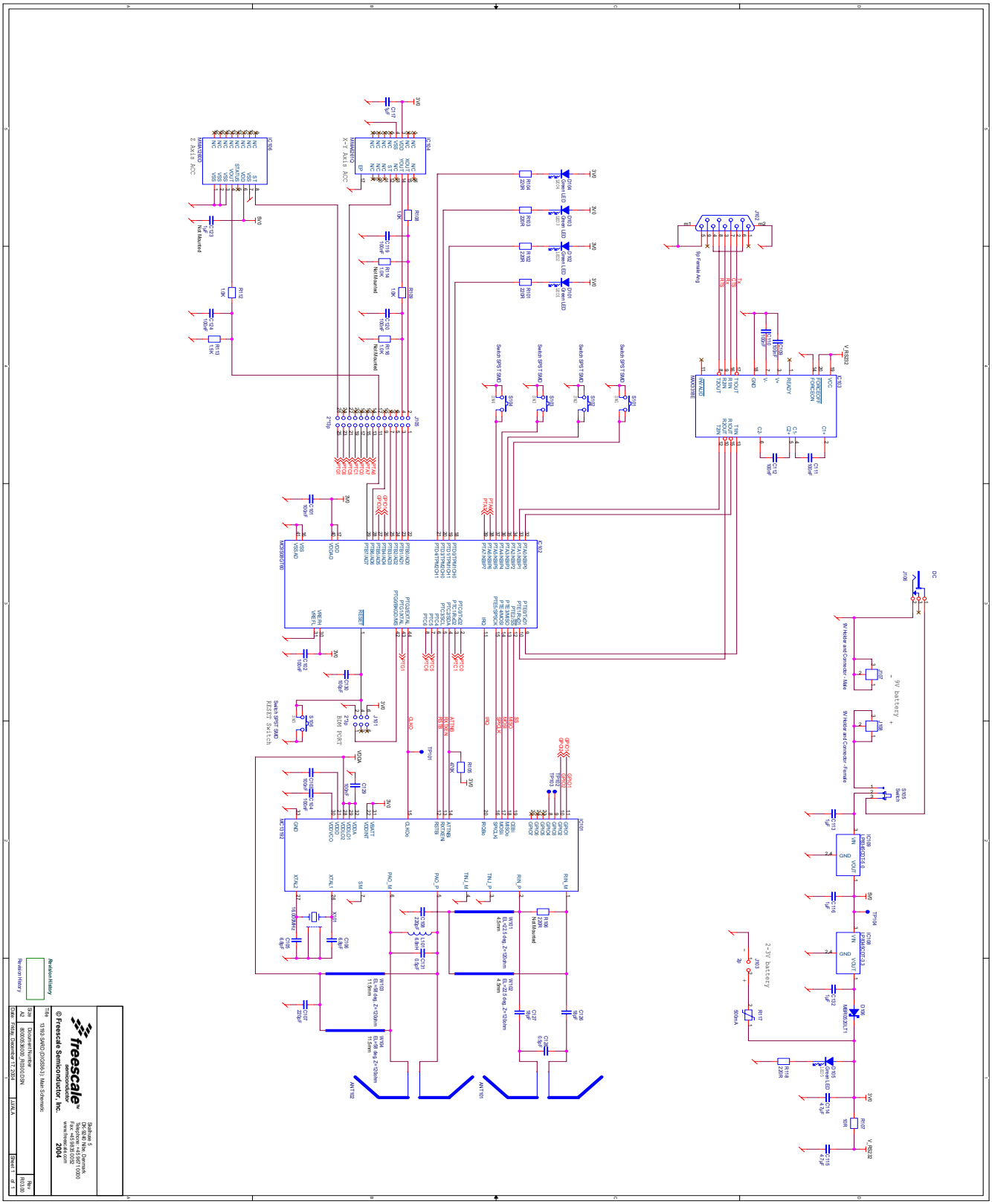

Figure 1-3. MC13192 SARD Schematic

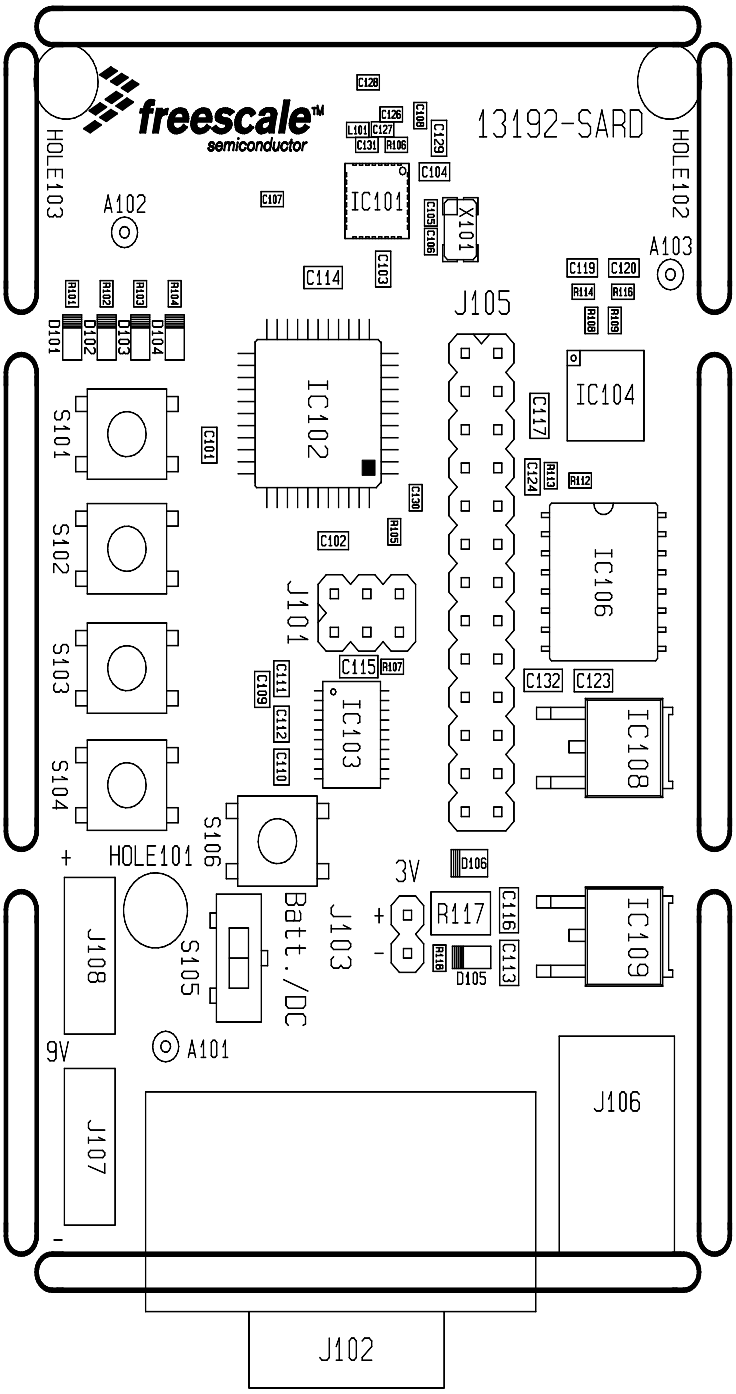

Figure 1-4. SARD Component Layout

1.3.3 RS232 Connector J102

The RS232 port is J102, a DB9 connector. A standard straight-through DB9 serial cable can be used with a PC. The port follows the standard RS232 DCE DB9 convention as shown in Figure 1-5. The RS232 is normally used to connect the SARD to a PC. With an installed bootloader program such as the Sensor Applications Reference Design (SARD) Embedded Bootloader program, described in document number 802154EBRM, it can also be used to program the MCU.

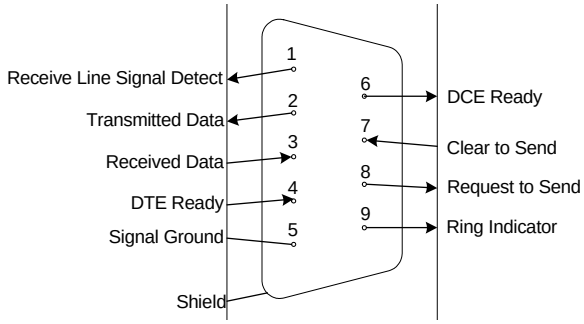

Figure 1-5. DCE-DB9 Female Connector (Looking into the SARD Connector)

1.3.4 Power Capability

The SARD can be powered from a 9 V battery (6LR61) connected to the board-mounted battery terminals or a 9 V adapter connected to the DC connector. See Figure 1-4 for battery terminal and DC connector placement. If the accelerometers are not used, 2.0-3.4 V can be supplied on J103. In this configuration, the accelerometer outputs are indeterminate.

The 9 V adapter used for this product must be the PHIHONG type PSA-05R-090.

NOTE

Do not use a Lithium battery.

1.3.5 LEDs and Switches

D101 through D104 and Switches S101 through S104 are connected to I/O as shown on the SARD schematic in Figure 1-3 and in the SARD board layout in Figure 1-4. These are useful as indicators and control in applications. Connections to MCU ports are listed in Table 1-2. The on-off switch, S105 is labeled on the board.

Table 1-2. LED and Switch Port Connection

LED/Switch	MCU Port	I/O
LED 1, D101	PTD0	Output
LED 2, D102	PTD1	Output
LED 3, D103	PTD3	Output
LED 4, D104	PTD4	Output
RESET, S106	RESET	-----
S101	PTA2	Input
S102	PTA3	Input
S103	PTA4	Input
S104	PTA5	Input

1.3.6 Board Reset Function

A hardware reset can be performed on the SARD in two ways:

- The Reset push button.
- The MCU resets the SARD as part of its startup sequence when power is applied and the On/Off switch is turned on.

In both cases, the reset sequence resets the MCU which, in turn, resets the MC13192.

1.3.7 MCU General Purpose Input/Output (GPIO)

Figure 1-4 shows the MCU GPIO that can be interfaced with external hardware such as sensors. When using the on-board accelerometers, shunts must be installed at PTB0, PTB1, and PTB7, which corresponds to pins 1 and 2, 3 and 4, 11 and 12, of J105, to connect the accelerometer ICs to the MCU. For user defined applications, these shunts can be removed and other hardware attached to the GPIO pins.

1.3.8 BDM Port

Header J101 is a BDM port for use with a P&E BDM-Multilink cable which is available from Metrowerks. The BDM cable is used with CodeWarrior™ Development Studio for the HCS08 to program the MCU flash memory as well as performing in-circuit debugging. See Figure 1-4 for the position of pin 1. The red lead of the BDM cable must align to pin 1 of J101.

When using the parallel port version of the BDM cable, the BDM pod should be powered with a 2 - 5V negative center contact power supply. A 9V battery is not capable of sourcing the current required by the parallel BDM pod during programming and debug.

1.4 Applications and Programming Information

1.4.1 Accelerometer Application Demo

The SARD comes pre-programmed with the accelerometer demo software. See the *Accelerometer Demonstration Quick Start Guide*, document number AN2762 for installation and startup instructions. The receiver is connected to a PC COM port via an RS232 cable. The 9V battery needs to be installed on the battery terminals and the on/off switch turned on. Start the accelerometer GUI software, available from our website, and choose the COM port you are using in the dialog box. Install the 9V battery on the transmitter and turn it on. On the PC screen you can select various ways to display the accelerometer data. One popular way is the cursor mode where you can watch the cursor position move as the transmitter is moved.

1.4.2 Programming the SARD (User Defined Software)

A BDM programmer is used to load the MCU flash memory. Alternatively, the Embedded Bootloader software, described in the, *Embedded Bootloader Reference Manual*, document number 802154EBRM, can be installed and the SARD can be programmed through the RS-232 port.

Appendix A
SARD Board Layout and Bill of Materials

A.1 PCB Layout

Figure A-1 shows the SARD printed circuit board layout.

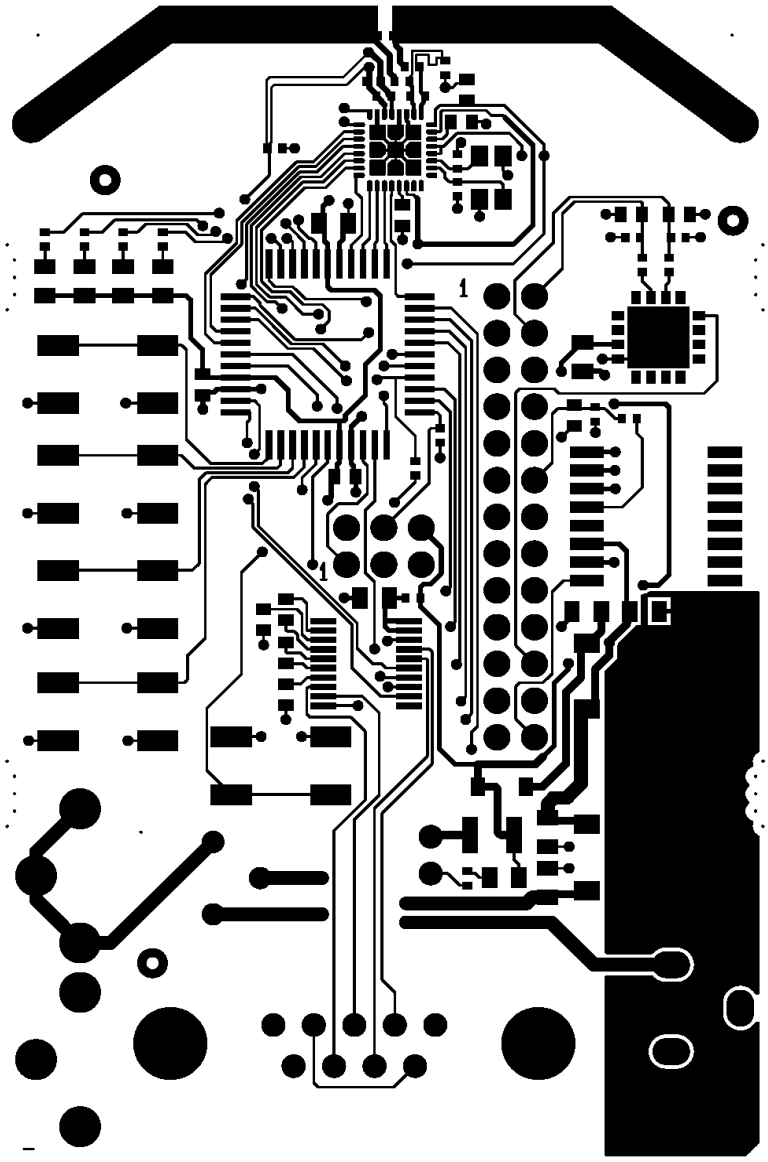

Figure A-1. PCB Layout (Top View)

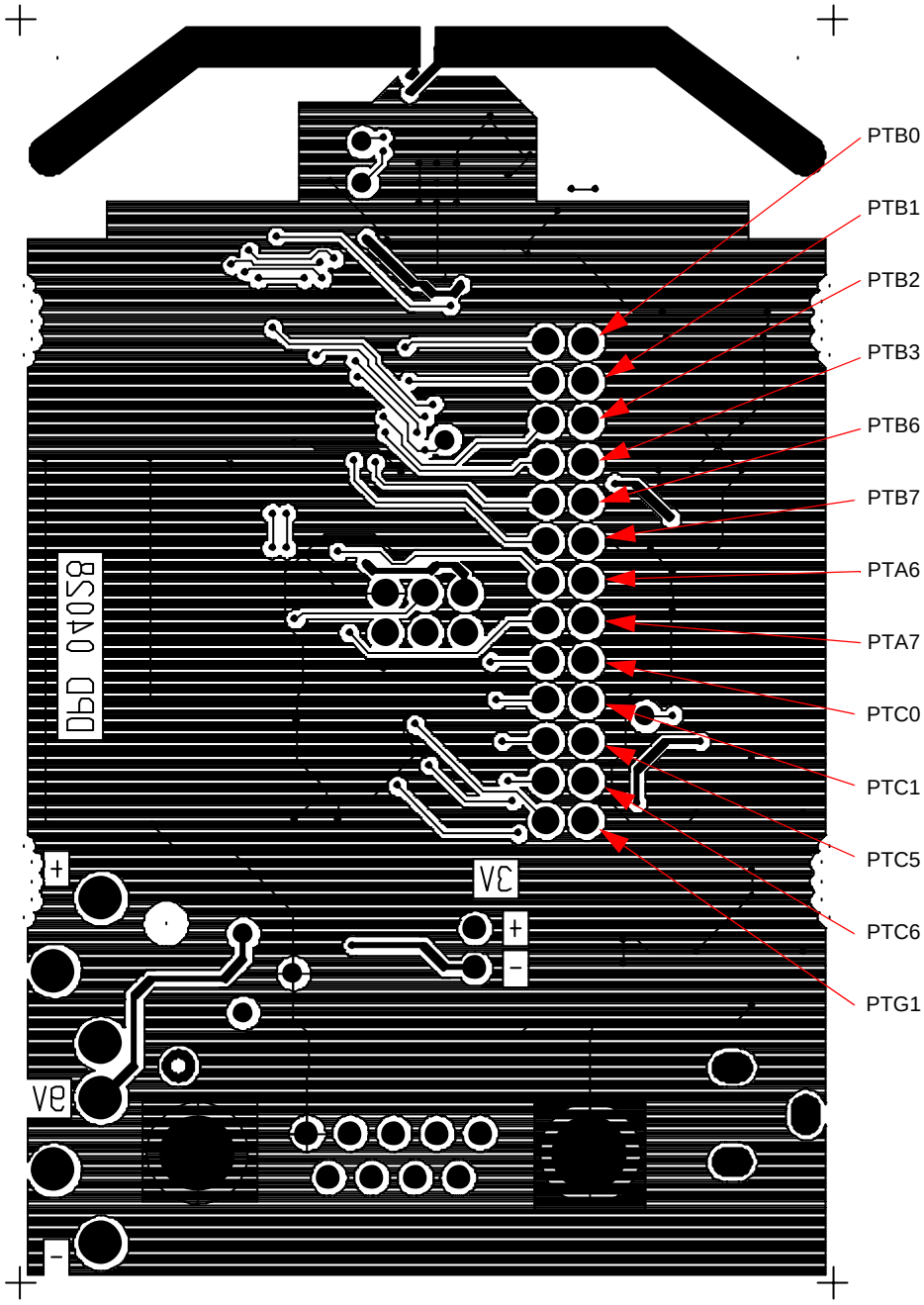

Figure A-2. PCB Layout (Bottom View)

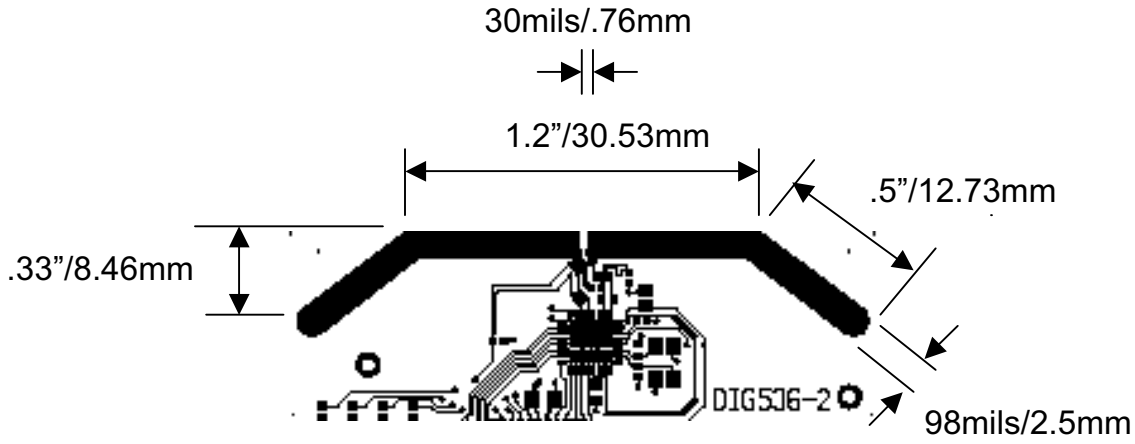

Figure A-3. Printed Circuit Board Antenna Dimensions

Table A-1. Bill of Materials (BOM)

Item	Qty	Part Number	Value	Rating	Tolerance	Mfg.	Mfg. Part Number	Reference ID
1	1	96000310104	(Label) 26x13 mm Test Bar Code	-	-	Digianswer	96000310100	BarCode101
2	12	50620710001	100 nf	16V	10% X7R	Murata	GRM188R71C104KA01D	C101, C102, C103, C104, C109, C110, C111, C112, C119, C120, C124, C129
3	2	50610422001	220 pf	50V	10% X7R	ROHM	MCH155C221KK	C107, C108
4	2	50210310000	10 pf	50V	5% NPO	Murata	GRP1555C1H100JD01E	C105, C106
5	4	50630810001	1.0 µf	10V	± 10% X7R	Murata	GRM21BR71A105KA01L	C113, C116, C117, C132
6	0	50630810001	1.0 µf	10V	± 10% X7R	Murata	GRM21BR71A105KA01L	C123 (not mounted)
7	2	50630847001	4.7 µf	6.3V	± 10% X5R	Murata	GRM21BR60J475KA11K	C114, C115
8	2	50210318000	18 pf	50V	± 5% NPO	Philips	2222 869 15189	C126, C127

Table A-1. Bill of Materials (BOM) (continued)

Item	Qty	Part Number	Value	Rating	Tolerance	Mfg.	Mfg. Part Number	Reference ID
9	1	50210410000	100 pf	50V	± 0.25pf NPO	Murata	GRP1555C1H101J D01E	C130
10	5	41100017001	Green LED			Citizen	CL 170G CD T	D101, D102, D103, D104, D105
11	1	35501319200	MC13192			Freescale	MC13192	IC101
12	1	33100000801	MC9SO8GT60			Freescale	MC9S08GT60CFB	IC102
13	1	31100331800	MAX3318E	-40 to +85 °C		MAXIM	MAX3318EEUP	IC103
14	1	35300626000	MMA6261Q	-20 to +85 °C		Freescale	MMA6261QR2	IC104
15	1	35300126000	MMA1260D	-40 to +105 °C		Freescale	MMA1260D	IC106
16	1	34000834500	LP8345CDT-3.3			National	LP8345CDT-3.3	IC108
17	1	34000834501	LP8345CDT-5.0			National	LP8345CDT-5.0	IC109
18	1	20030400600	2x3 pin			AMP	826632-3	J101
19	1	20010500905	9 pin female angle			AMP	747844-5	J102
20	1	20030400600	2 pin			AMP	0-826629-2	J103
21	1	20030402600	2x13 pin			Samtec	MTSW-113-07-G-D-240	J105
22	1	20110500204	DC			Digi-Key	CP-102A-ND	J106
23	1	20110500100	9V Holder and Connector - Male			Keystone	Cat. No. 593	J107
24	1	20110500101	9V Holder and Connector - Female			Keystone	Cat. No. 594	J108
25	1	71000536030	13192-SARD			Digianswer	DIG536-3 FR4 0.76 mm	PCB101
26	5	61100422000	220 R	62.5mW/25V	5%	YAGEO	RCO2221JR	R101, R102, R103, R104, R118
27	0	61100422000	220 R	62.5mW/25V	5%	YAGEO	RCO2221JR (not mounted)	R106
28	1	62100747000	479 K	62.5mW/25V	1%	ROHM	MCR01MZSF4703	R105
29	1	61100310000	10 R	62.5mW/25V	5%	YAGEO	RC02100JR	R107

Table A-1. Bill of Materials (BOM) (continued)

Item	Qty	Part Number	Value	Rating	Tolerance	Mfg.	Mfg. Part Number	Reference ID
30	3	61100510000	1.0 K	62.5mW/25V	5%	YAGEO	RC02102JR	R108, R109, R112
31	0	61100510000	1.0 K	62.5mW/25V	5%	YAGEO	RC02102JR (Not mounted)	R114, R116
32	1	61100510000	1.5 K	62.5mW/25V	5%	YAGEO	RC02152JR	R113
33	5	24000600100	Switch SPST SMD			ALPS	SKHUAD	S101, S102, S103, S104, S106
34	1	23010400102	Switch			ALPS	SSSS210800	S105
35	1	58130916004	16.000 MHz	20 ppm	20 ppm	KDS	DSX321G	x101
36	1	20110500204	DC			Digi-Key	CP-102A-ND	J106
37	1	22080250000	500mA			Raychem	microSMD050-2	R117
38	1	40010052000	MBR0520LT1	0.5A/20V		On Semi	MBR0520LT1	D106
39	2	50210150000	0.5pF	50V	0.25pF NP0	Ericsson	RJC 463 3020/5	C128, C131
40	1	54710568000	6.8nH		0.3nH	Murata	LQG10A6N8S00	L101