# Inductive Touch Coil EVM (INx+COM)

The Texas Instruments LDC (inductance-to-digital converter) LDCTOUCHCOMCOILEVM board is a collection of sensors that can be used with the LDC2112/LDC2114 evaluation module which uses the INx+COM sensor architecture. The sensor options on the inductive touch coil EVM include different coil geometries which may be suitable for specific applications. The board contains two different types of coil geometries: circular and racetrack.

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## Trademarks

All trademarks are the property of their respective owners.

# 1 Board

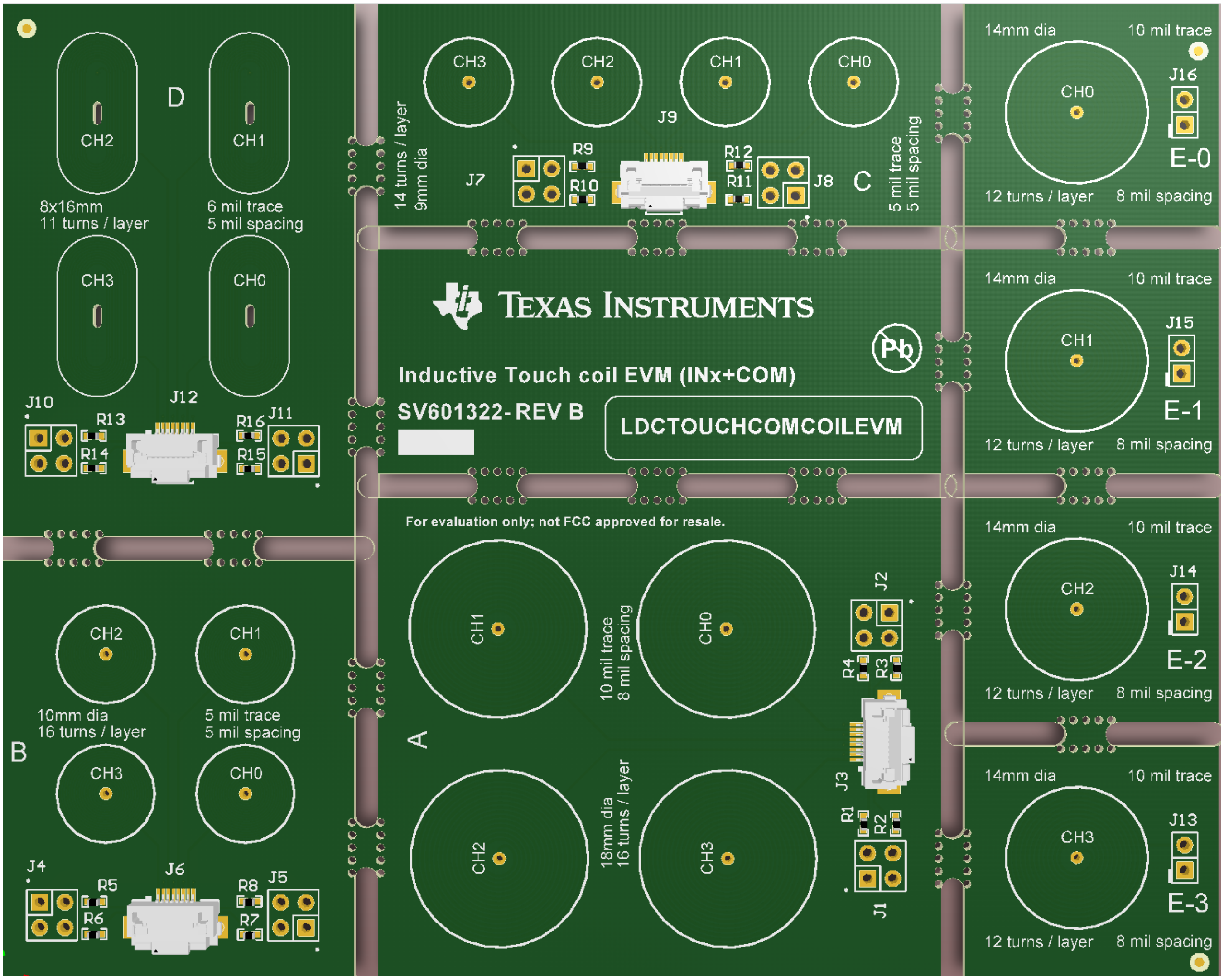


**Figure 1. LDC Reference Coils Board (Top View)**

# 2 Connecting the Sensor EVM to the LDC2114EVM

The LDC2114EVM does not include any example sensors, but can easily be connected to sensors by using either the ZIF connector or soldering wires to the header pins on the PCB. The LDC2114 EVM is compatible with the LDCTOUCHCOMCOILEVM, which contains five sensor designs with four sensors of each design. This coil EVM is shipped together with the LDC2114 EVM, and is also sold separately on TI's estore.

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**NOTE:** Schematics, Layout, and installation instructions for the LDC2114 EVM are described in the LDC2114 EVM User's Guide.

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Sensor capacitors are not populated on the sensor board; they should be populated on the LDC2114EVM instead.

To avoid interference between neighboring coils, it is necessary to separate the coils along the perforations before usage. To connect any of the coils from the LDCTOUCHCOMCOILEVM to the LDC2114EVM, break the desired coil section along the perforation and connect it to the appropriate header of the LDC2114 EVM.

Table 1 shows the connection options for each coil type.

**Table 1. Connection Options**

| LDCTOUCHCOMCOILEVM Coil Type | Connect to LDC2114EVM |
|---|---|
| A | J3 ZIF connector using flat ribbon cable |
| B | J3 ZIF connector using flat ribbon cable |
| C | J3 ZIF connector using flat ribbon cable |
| D | J3 ZIF connector using flat ribbon cable |
| E | J6 2.54mm header using unshielded twisted pair wires |

**NOTE:** When connecting the coil board to the EVM, it is recommended to attach the assembly to a static object using tape or screws. This prevents the cables from moving and potentially changing the output code reading or reporting false triggers.

For further information on LDC sensors and sensor frequency constraints, refer to *LDC Sensor Design* .

## 3 Coil Characteristics

Table 2 describes geometries of each coil.

**Table 2. Coil Characteristics Summary**

| Coil | Shape | Free-Space Inductance (µH) | Connector Type | Dimensions (mm) | Turns / Layer | Layers | Trace Width (mm) | Trace Spacing (mm) |
|---|---|---|---|---|---|---|---|---|
| A | Circular | 8.08 | ZIF, 2.54mm header | 18 | 16 | 2 | 0.25 (10 mil) | 0.20 (8 mil) |
| B | Circular | 4.21 | ZIF, 2.54mm header | 10 | 16 | 2 | 0.13 (5 mil) | 0.13 (5 mil) |
| C | Circular | 2.97 | ZIF, 2.54mm header | 9 | 14 | 2 | 0.13 (5 mil) | 0.13 (5 mil) |
| D | Racetrack | 4.51 | ZIF, 2.54mm header | 8 * 16 | 11 | 2 | 0.15 (6 mil) | 0.13 (5 mil) |
| E | Circular | 3.87 | 2.54mm header | 14 | 12 | 2 | 0.20 (8 mil) | 0.20 (8 mil) |

## 4 Coil Characterization Data

The following graphs show $R_P$ and Q vs. frequency, as well as the self-resonant frequency of the coil. All measurements have been taken without a sensor capacitor, using an Agilent 4395A Network/Spectrum/Impedance Analyzer with an Agilent 43961A RF Impedance Test Kit.

The LDC2114 recommended settings are for the indicated coil operating with a 1 ms sample interval with an Al target 1 mm thick offset by 0.25 mm. The settings assume a total sensor capacitance of 115 pF; optimum system performance may require a different value.

### *4.1 Coil A: 18mm Circular, 16 Turns/layer, 2 Layers, 10mil Trace, 8mil Spacing*

Coil A Free-Space Inductance: 8.08 µH @ 1 MHz

Coil A Inductance with Al target at 0.25 mm distance: 2.77 µH @ 1 MHz

**Table 3. Recommended LDC2114 Configuration for 1 ms sample interval**

| Parameter | Recommended Setting |
|---|---|
| $f_{SENSOR}$ with 115 pF Sensor Capacitance ( 100 pF $C_{SENSOR}$ + 15 pF $C_{PARASITIC}$ ) | 8.85 MHz |
| LCDIV | 2 |
| Sensor Cycle Count | 16 |
| CNTSC | 0 |
| SENSORn_CONFIG Register | 0x30 |
| GAINn setting for 1 mm Al target at 0.25 mm distance with 1 N force | 48 |

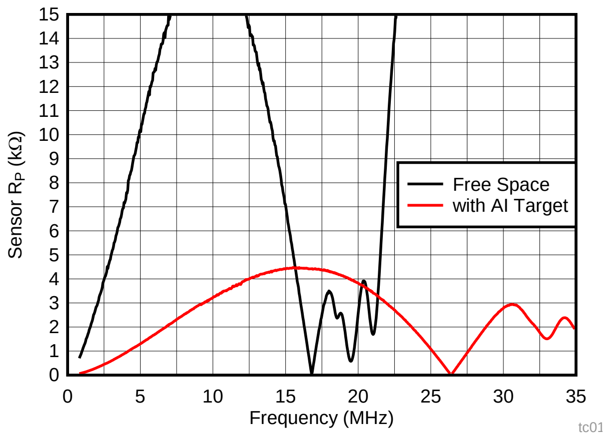


**Figure 2. Coil A: $R_P$ vs. Frequency**

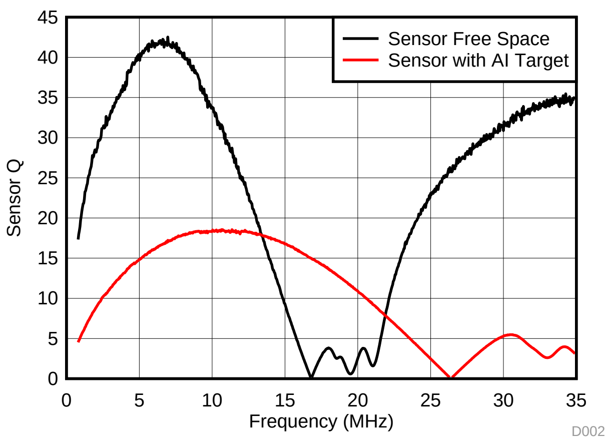


**Figure 3. Coil A: Q vs. Frequency**

## 4.2 Coil B: 10mm Circular, 16 Turns/layer, 2 Layers, 5mil Trace, 5mil Spacing

Coil B Free-Space inductance at 1 MHz: 4.21 µH

Coil B Inductance at 1 MHz with Al target at 0.25 mm distance: 2.16 µH

**Table 4. Recommended LDC2114 Configuration for 1 ms sample interval**

| Parameter | Recommended Setting |
|---|---|
| $f_{SENSOR}$ with 115 pF Sensor Capacitance ( 100 pF $C_{SENSOR}$ + 15 pF $C_{PARASITIC}$ ) | 10.10 MHz |
| LCDIV | 2 |
| Sensor Cycle Count | 19 |
| CNTSC | 0 |
| SENSORn_CONFIG Register | 0x53 |
| GAINn setting for 1 mm Al target at 0.25 mm distance with 1 N force | 56 |

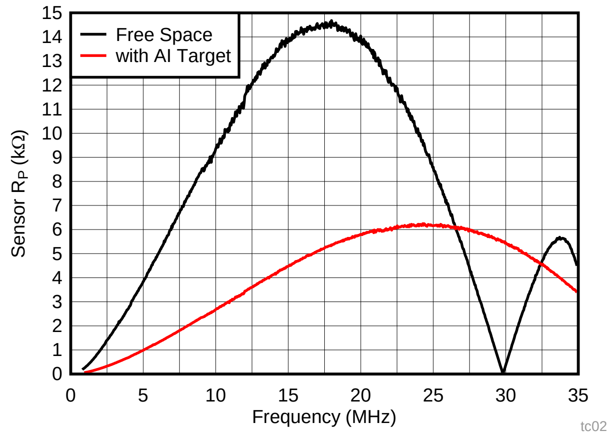


**Figure 4. Coil B: $R_P$ vs. Frequency**

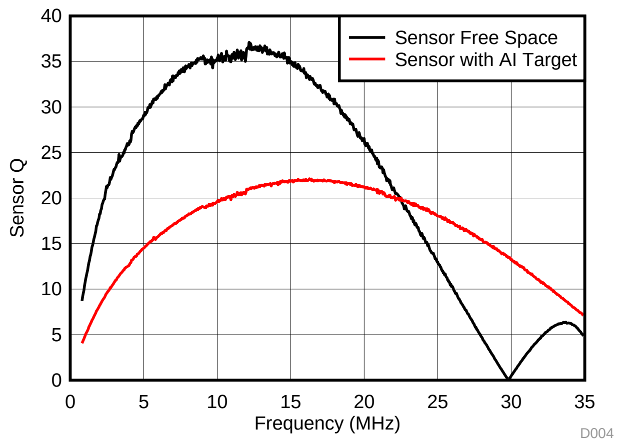


**Figure 5. Coil B: Q vs. Frequency**

### 4.3 Coil C: 9mm Circular, 14 Turns/layer, 2 Layers, 5mil Trace, 5mil Spacing

Coil C Free-Space inductance at 1 MHz: 2.97 µH

Coil C Inductance at 1 MHz with Al target at 0.25 mm distance: 1.58 µH

**Table 5. Recommended LDC2114 Configuration for 1 ms sample interval**

| Parameter | Recommended Setting |
|---|---|
| $f_{SENSOR}$ with 115 pF Sensor Capacitance ( 100 pF $C_{SENSOR}$ + 15 pF $C_{PARASITIC}$ ) | 11.77 MHz |
| LCDIV | 2 |
| Sensor Cycle Count | 22 |
| CNTSC | 0 |
| SENSORn_CONFIG Register | 0x53 |
| GAINn setting for 1 mm Al target at 0.25 mm distance with 1 N force | 62 |

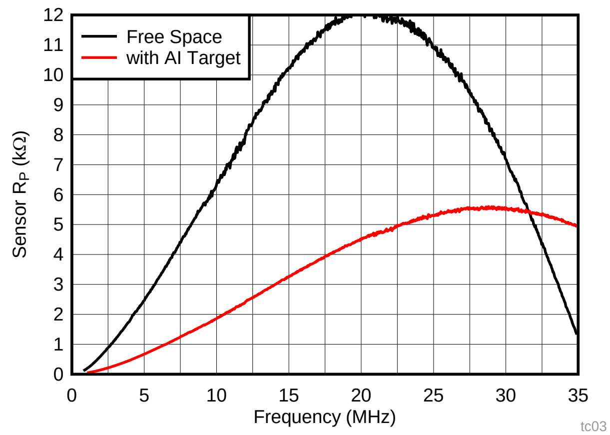


**Figure 6. Coil C: $R_P$ vs. Frequency**

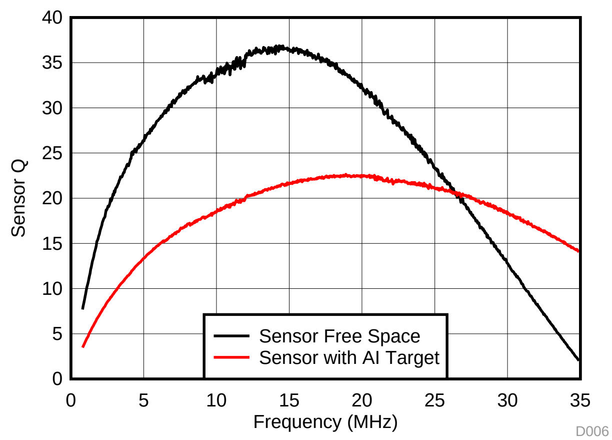


**Figure 7. Coil C: Q vs. Frequency**

## 4.4 Coil D: 8x16mm Racetrack, 11 Turns/layer, 2 Layers, 6mil Trace, 5mil Spacing

Coil D Free-Space inductance at 1 MHz: 4.51 µH

Coil D Inductance at 1 MHz with Al target at 0.25 mm distance: 2.25 µH

**Table 6. Recommended LDC2114 Configuration for 1 ms sample interval**

| Parameter | Recommended Setting |
|---|---|
| $f_{SENSOR}$ with 115 pF Sensor Capacitance ( 100 pF $C_{SENSOR}$ + 15 pF $C_{PARASITIC}$ ) | 9.43 MHz |
| LCDIV | 2 |
| Sensor Cycle Count | 17 |
| CNTSC | 0 |
| SENSORn_CONFIG Register | 0x31 |
| GAINn setting for 1 mm Al target at 0.25 mm distance with 1 N force | 41 |

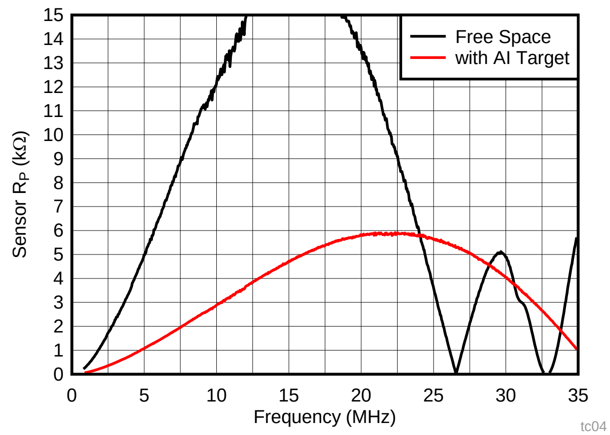


**Figure 8. Coil D: $R_P$ vs. Frequency**

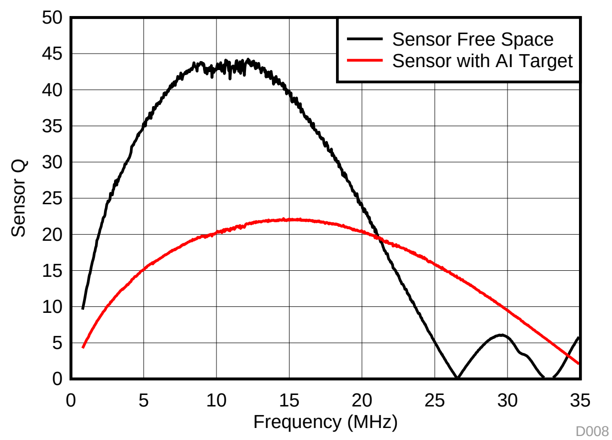


**Figure 9. Coil D: Q vs. Frequency**

### 4.5 Coil E: 14mm Circular, 12 Turns/layer, 2 Layers, 10mil Trace, 8mil Spacing

Coil E Free-Space inductance at 1 MHz: 3.87 µH

Coil E Inductance at 1 MHz with Al target at 0.25 mm distance: 1.55 µH

**Table 7. Recommended LDC2114 Configuration for 1 ms Sample Interval**

| PARAMETER | RECOMMENDED SETTING |
|---|---|
| $f_{SENSOR}$ with 115 pF Sensor Capacitance ( 100 pF $C_{SENSOR}$ + 15 pF $C_{PARASITIC}$ ) | 12.05 MHz |
| LCDIV | 2 |
| Sensor Cycle Count | 23 |
| CNTSC | 0 |
| SENSORn_CONFIG Register | 0x53 |
| GAINn setting for 1 mm Al target at 0.25 mm distance with 1 N force | 50 |

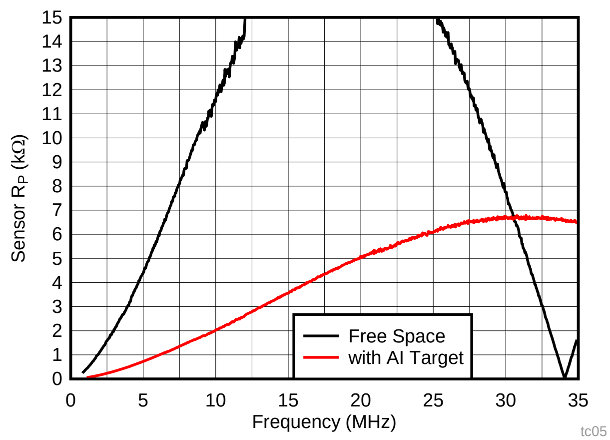


**Figure 10. Coil E: $R_P$ vs. Frequency**

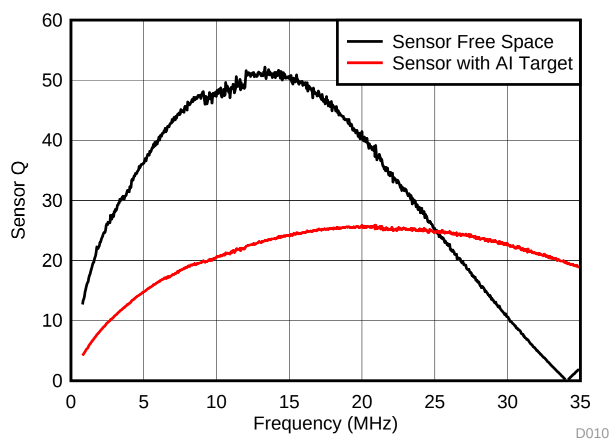


**Figure 11. Coil E: Q vs. Frequency**

# 5 PCB Layout

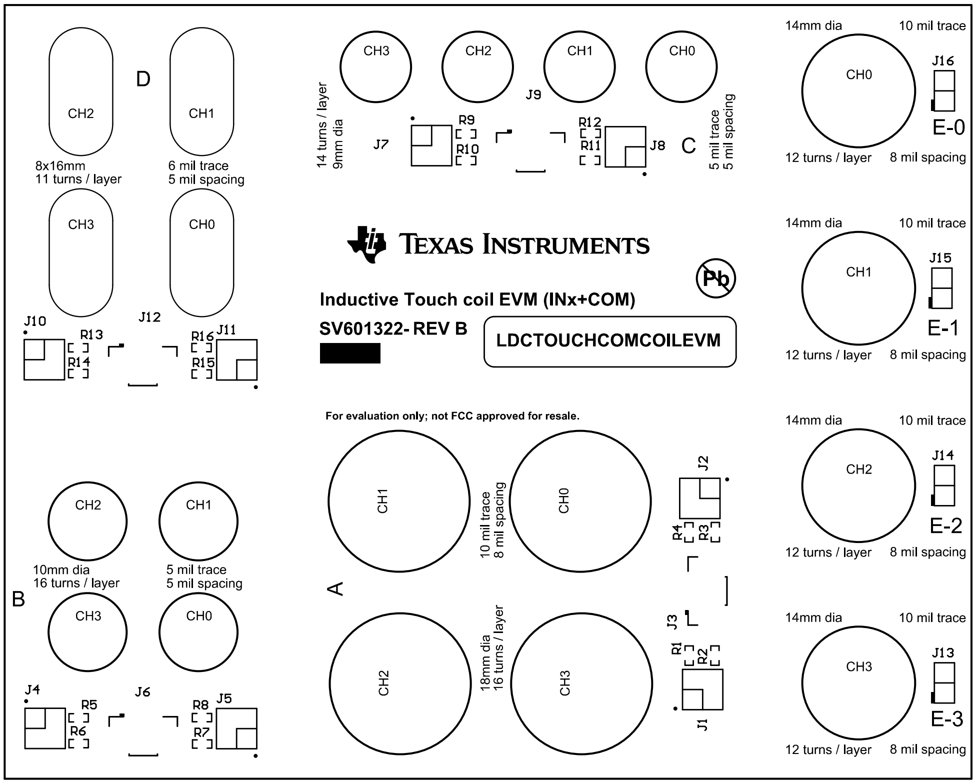


**Figure 12. PCB Layout - Top Silkscreen**

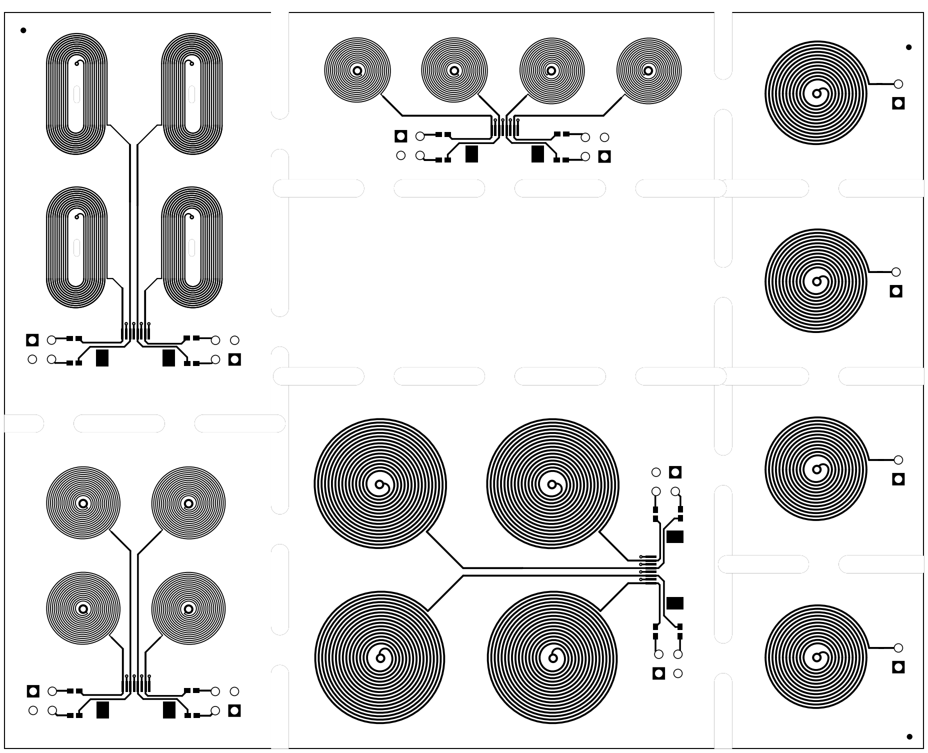

**Figure 13. PCB Layout - Top Layer**

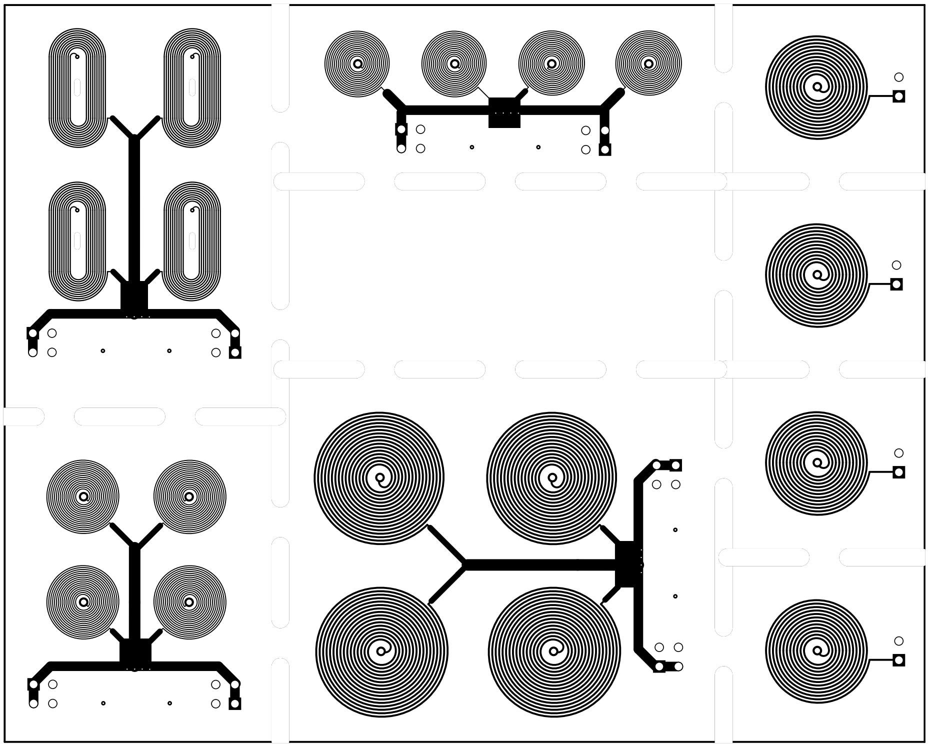

Figure 14. PCB Layout - Bottom Layer

# 6 Schematic

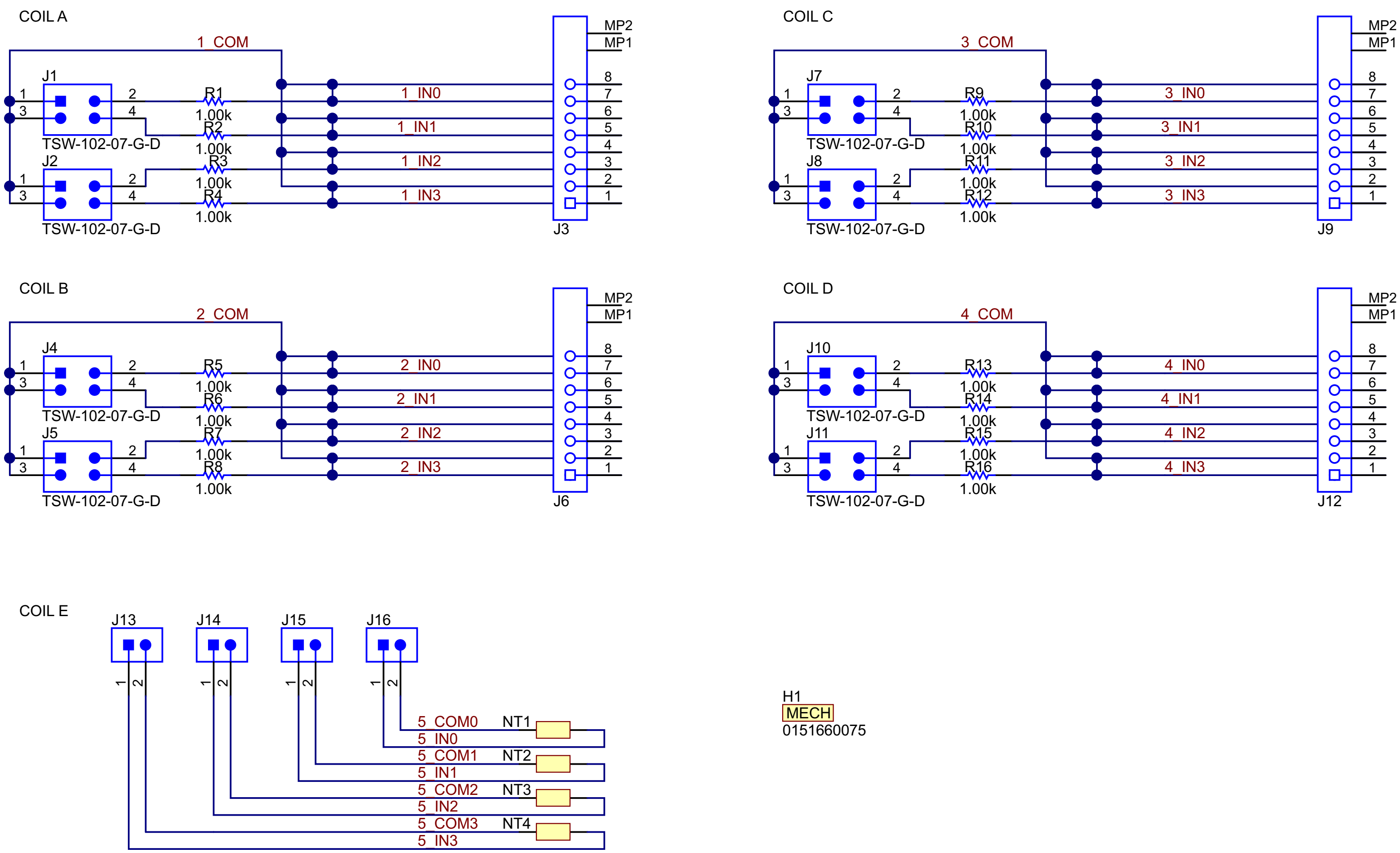




**Figure 15. Schematic**

# 7 Bill of Materials

**Table 8. Bill of Materials**

| DESIGNATOR | QTY | VALUE | DESCRIPTION | PACKAGE REFERENCE | PART NUMBER | MANUFACTURER |
|---|---|---|---|---|---|---|
| !PCB1 | 1 | | Printed Circuit Board | | SV601322 | Any |
| J3, J6, J9, J12 | 4 | | Connector, FFC, Bottom, 0.5mm, 8 Pos, SMT | Connector, 0.5mm, 8 Pos, SMT | 52892-0833 | Molex |
| R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15, R16 | 16 | 1.00k | RES, 1.00 k, 0.1%, 0.063 W, 0402 | 0402 | ERA-2AEB102X | Panasonic |
| H1 | 0 | | FFC 0.50 TYPE A 8 CKTS LGT 51 | | 0151660075 | Molex |
| J1, J2, J4, J5, J7, J8, J10, J11 | 0 | | Header, 100mil, 2x2, Gold, TH | 2x2 Header | TSW-102-07-G-D | Samtec |
| J13, J14, J15, J16 | 0 | | Header, 100mil, 2x1, Gold, TH | 2x1 Header | TSW-102-07-G-S | Samtec |

## Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| Changes from Original (January 2017) to A Revision | Page |
|---|---|
| • Changed $R_P$ Graphs for all sensors | 1 |
| • Added Recommended LDC2114 Settings for all sensor designs | 4 |
| • Changed $R_P$ Graphs for all sensors | 4 |

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   3.1.1 *Notice applicable to EVMs not FCC-Approved:*

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   3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

   **CAUTION**

   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.

   Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

   **FCC Interference Statement for Class A EVM devices**

   *NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.*

**FCC Interference Statement for Class B EVM devices**

*NOTE: 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.*

3.2 *Canada*

3.2.1 *For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210 or RSS-247*

**Concerning EVMs Including Radio Transmitters:**

This device complies with Industry Canada license-exempt RSSs. 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.

**Concernant les EVMs avec appareils radio:**

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

**Concerning EVMs Including Detachable Antennas:**

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. 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 necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

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Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

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If User uses EVMs in Japan, not certified to Technical Regulations of Radio Law of Japan, User is required to follow the instructions set forth by Radio Law of Japan, which includes, but is not limited to, the instructions below with respect to EVMs (which for the avoidance of doubt are stated strictly for convenience and should be verified by User):

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

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3.4.1 *For EVMs subject to EU Directive 2014/30/EU (Electromagnetic Compatibility Directive)*:

This is a class A product intended for use in environments other than domestic environments that are connected to a low-voltage power-supply network that supplies buildings used for domestic purposes. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

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4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

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