1 Description

The RedRock® RR142-1LD2-542/545 and RR142-1LD3-542/545 are multi-channel magnetic sensors with multiple output options ideal for use in medical, industrial, automotive, and consumer applications. Based on patented Tunneling Magnetoresistance (TMR) technology with seamless CMOS integration, the RR142 offers multiple configurations of several parameters to enable applications like proximity sensing, rotary sensing, and level detection.

The RR142-1LD2-542/545 and RR142-1LD3-542/545 feature both digital and analog channels. The RR142 offers an innovative new option to meet the needs of next generation applications. For "wake-up" applications, the analog output functionally is kept inactive until the sensor detects the removal of a nearby magnetic field (B < Brp). Once awakened, the analog circuitry stays on and continues to provide an output signal until sensor is reset (VDD is < $V_{UVLO-FALL}$). This is particularly ideal for battery-powered, high-precision level and proximity sensing.

The RR142 offers a wide supply voltage range from 1.7 up to 5.5 V, ideal for applications from small, wearable battery-powered electronics to industrial machinery. The digital channel features an operate sensitivity of 60 G (6 mT) with an omnipolar magnetic field response and an operating frequency of 12Hz. When in Digital Only mode, the RR142 has the world's lowest current drain (150nA) for an active magnetic sensor operating at that frequency. The analog channel offers a linear voltage output with a wide magnetic sensitivity range from -80 G to +80 G with a sensitivity of 5 mV/V/G and an operating frequency of 25Hz. When in Digital+Analog mode, the digital channel continues to operate at 12Hz and the analog channel operates at 25Hz while drawing a total of 1.2 µA. The RR142 has a wide operating temperature range of -40°C to 85°C (RR142-1LD2-542/545) or -40°C to 125°C (RR142-1LD3-542/545).

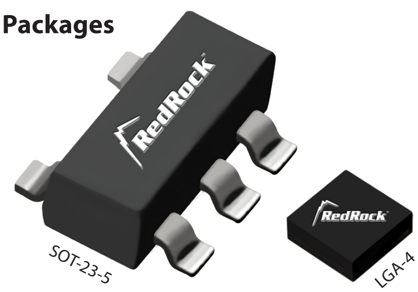
2 Features

- Multi channel Outputs: Digital & Analog
- Operate sensitivity of 60 G
- Linear Analog Sensitivity Range from -80 G to +80 G
- Wide Supply Voltage range of 1.7V – 5.5V
- Lowest Average Current: 150 nA (Digital only mode), 1.2 µA (Digital+Analog mode)
- Omnipolar Response for the Digital Channel with Push-Pull Output
- Linear Analog Voltage Response for the Analog Channel
- Digital Channel Frequency of 12 Hz
- Analog Channel Frequency of 25 Hz
- Temperature Rated up to 125°C
- Critical Performance Specs 100% Production Tested Throughout Complete Temperature Range
- RoHS & REACH Compliant

3 Applications

- Proximity Detection
- Rotary Sensing
- Fluid Level Detection
- Door & Lid Closure Detection
- Utility Meters
- Portable Medical Devices
- Motor Controllers
- Consumer Electronics
- Wake-Up µProcessor

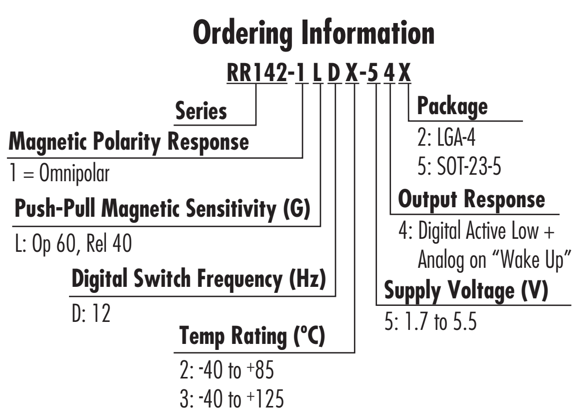
Device Packages



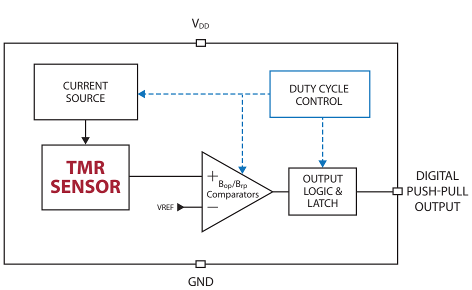
Device Information

Part Series	Package	Body Size (mm)	Temp Rating °C
RR142-1LD2-542	LGA-4	1.45 x 1.45 x 0.44	-40 to +85
RR142-1LD2-545	SOT-23-5	2.9 x 1.6 x 1.2	-40 to +85
RR142-1LD3-542	LGA-4	1.45 x 1.45 x 0.44	-40 to +125
RR142-1LD3-545	SOT-23-5	2.9 x 1.6 x 1.2	-40 to +125

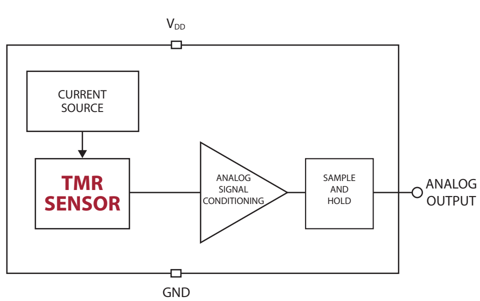
Device Nomenclature



Functional Block Diagram for Digital Channel



Functional Block Diagram for Analog Channel



4 Specifications

4.1 Absolute Environmental Ratings[1]

Parameters	Units	Min	Typ	Max
Operating Temperature (T_{OP}) (RR122-1L12-542/545)	°C	-40		+85
Operating Temperature (T_{OP}) (RR122-1L13-542/545)	°C	-40		+125
Storage Temperature (T_{STG})	°C	-65		+150
Junction Temperature (T_J)	°C	-40		+150
Soldering Temperature (3 cycles, 1 min.) (T_{SOL})	°C			+260
ESD Level Human Body Model (HBM) per JESD22-A114	V	±4000		
ESD Level Charged Device Model (CDM) per JESD22-C101	V	±500		
Maximum Magnetic Field Exposure (B_{MAX})	G			±2000

4.2 Absolute Electrical Ratings[1]

Parameters	Units	Min	Typ	Max
Supply Voltage (V_{DD})	V	-0.3		6.0
Digital Output (Active Low)(V_{OUT_PP})	V	-0.3		V_{DD}
Input and Output Current (V_{IN}/I_{OUT})	mA			±20

4.3 Operating Electrical Characteristics for all RR142 Series Sensors[2]

Parameters	Units	Min	Typ	Max
Supply Voltage (V_{DD})	V	1.7	3.0	5.5
Digital Push-Pull Output Voltage (High)	V	90% V_{DD}		
Digital Push-Pull Output Voltage (Low)	V			10% V_{DD}
Power-On Time (t_{ON})(V_{DD} > 1.7V)	µs		50	75
Under Voltage Lockout Threshold Rising V_{DD} ($V_{UVLO\text{-}RISE}$)	V		1.6	1.64
Under Voltage Lockout Threshold Falling V_{DD} ($V_{UVLO\text{-}FALL}$)	V	1.44	1.53	
Under Voltage Lockout Hysteresis ($V_{UV\text{-}HYST}$)	mV		70	

Notes:

1. Exceeding Absolute Ratings may cause permanent damage to the device. Exposure at the maximum rated conditions for extended periods of time may also affect device reliability.
2. Unless otherwise specified, V_{DD} = 1.7 V to 5.5 V, T_A = -40°C to +85°C (1LD2), -40°C to +125°C (1LD3). Typical values are V_{DD} = 3.0 V and T_A = +25°C.

ESD Note: This product uses semiconductors that can be damaged by electrostatic discharge (ESD). When handling, proper ESD precautions should be taken to avoid performance degradation or loss of functionality. Damage due to inappropriate handling is not covered under warranty.

4 Specifications (cont.)

4.4 Operating Characteristics for RR142-1LD2-542/545 & RR142-1LD3-542/545[1]

Parameters	Units	Min	Typ	Max
DIGITAL CHANNEL				
Digital Switching Frequency (f_{DS})	Hz	7	12	18
Active Mode Time (t_{active})	µs		2.6	
Idle Mode Time (t_{idle})	ms	55	83	142
Operate Point (B_{OPN})	G	53	60	67
Operate Point (B_{OPS})	G	-67	-60	-53
Release Point (B_{RPN})	G	35	40	45
Release Point (B_{RPS})	G	-45	-40	-35
ANALOG CHANNEL				
Operating Frequency (f_{OP})	Hz	15	25	35
Active Mode Time[3] (t_{ACTIVE})	µs		2.6	
Idle Mode Time[3] (t_{IDLE})	ms	7.1	10	16.7
Analog Output Magnetic Field Range (B_{ANA})	G	±54	±80	±100
Analog Output Magnetic Sensitivity @ T = +25ºC (T_A = +25ºC)	mV/V/G	-3.5	-5.0	-6.5
Analog Output Sensitivity @ Full Temperature	mV/V/G		-5.0	
Analog Output Voltage Range (V_{ANA})	V	0.1 x V_{DD}		0.9 x V_{DD}
Analog Output Quiescent (V_{OQ})	%V_{DD}	45	50	55
Analog Output Capacitive Load	pF			10
Analog Output Maximum Drive Capability	µA			±10
SENSOR SUPPLY CURRENT				
Average Supply Current ($I_{DD (AVG)}$)[2], Digital Only @ V_{DD} = 1.7V, f_{DS} = 12 Hz	nA		150	
Average Supply Current ($I_{DD (AVG)}$)[2], Digital Only @ V_{DD} = 3.0V, f_{DS} = 12 Hz	nA		200	
Average Supply Current ($I_{DD (AVG)}$)[2], Digital + Analog @ V_{DD} = 1.7V, f_{DS} = 12 Hz, f_{OP} = 25 Hz	µA		1.3	
Average Supply Current ($I_{DD (AVG)}$)[2], Digital + Analog @ V_{DD} = 3.0V, f_{DS} = 12 Hz, f_{OP} = 25 Hz	µA		1.5	

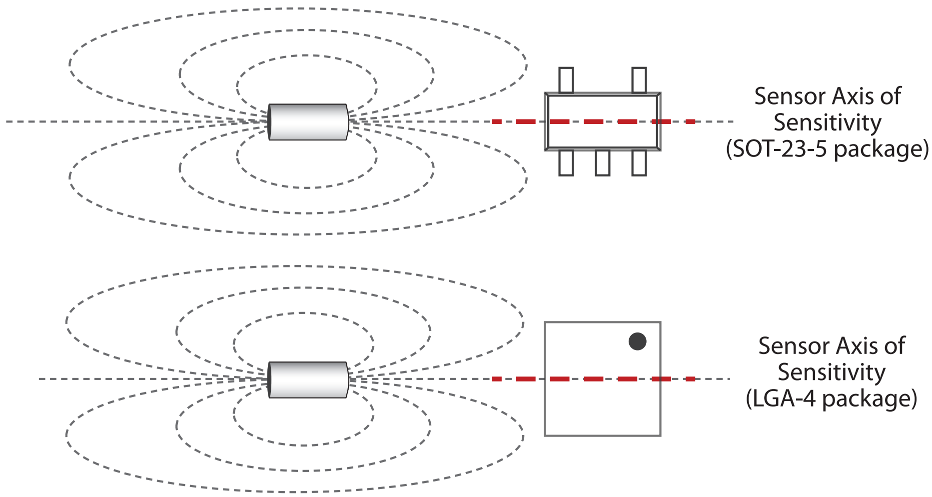
Notes:

1. Unless otherwise specified, V_{DD} = 1.7 V to 5.5 V, T_A = -40ºC to +85ºC (1LD2), -40ºC to +125ºC (1LD3). Typical values are V_{DD} = 3.0 V and T_A = +25ºC.
2. Conditions: t = 10 seconds
3. Active and idle times are based upon internal sample clock frequency.

5 Magnetic Response

For more information please contact Coto Technology at RedRock@cotorelay.com.

5.1 Axis of Sensitivity

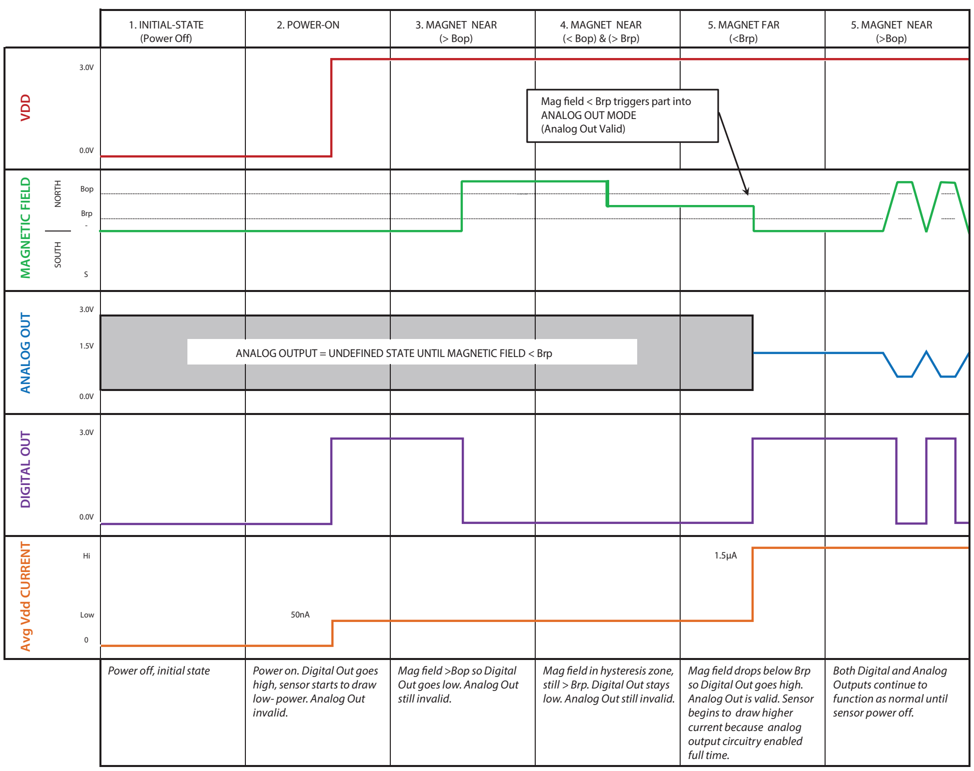


Note: The most straightforward way of aligning a magnet with a TMR sensor is by lining up the magnet's magnetization axis with the sensor's Axis of Sensitivity (as shown above). However, there are many other alignments and orientations that will also achieve proper operation. For any questions, or to learn more, please contact Coto Technology. For tips on proper magnetic orientation see our Applications Note:

download PDF
"How to Replace a Hall Effect Sensor with a TMR Sensor"

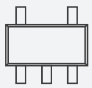
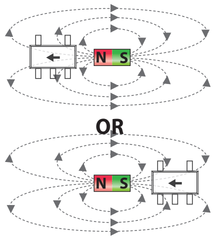
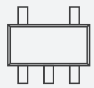
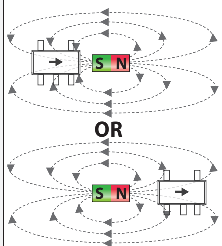
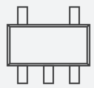
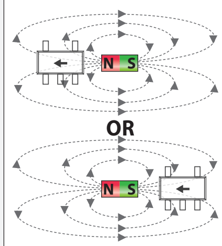
watch our video:
"Replacing Hall Effect Sensors with TMR Sensors – How and Why?"

5.2 RedRock RR142 Series Dual Output Behavior Diagram



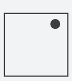
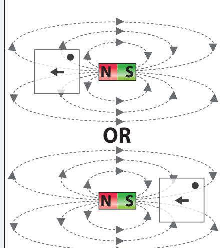
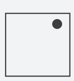
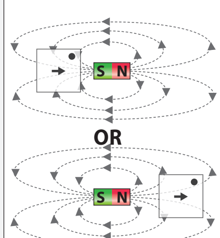
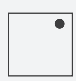
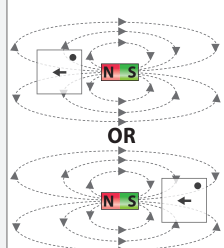
5 Magnetic Response (cont.)

5.3 Magnetic Response Table (SOT-23-5 package)

	Step 1: Sensor is powered without magnetic field.	**Step 2:** Magnet applied, polarity **North**.	**Step 3:** Magnet removed.	**Step 4:** Magnet applied, polarity **South**.	**Step 5:** Magnet removed.	**Step 6:** Magnet applied, polarity **North**.
Scenario						
DIGITAL OMNI-POLAR OUTPUT	HIGH	**LOW** (Activated)	HIGH	**LOW** (Activated)	HIGH	**LOW** (Activated)
ANALOG OUTPUT (ANA OUT)	Undefined	Undefined	$\frac{V_{dd}}{2}$ Output is half of V_{dd}	$\frac{V_{dd}}{2} < V_{out} < V_{dd}$ Output is between half of Vdd and full V_{dd}	$\frac{V_{dd}}{2}$ Output is half of V_{dd}	$0 < V_{out} < \frac{V_{dd}}{2}$ Output is between 0 V and half of V_{dd}

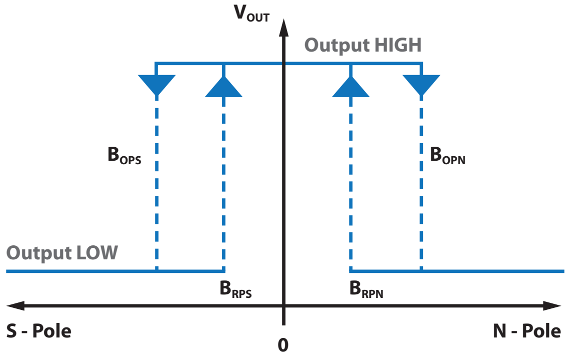
Note: When the RR142 TMR sensor is initially powered ON, the Analog Channel remains inactive until Step 3 (i.e., Field decreases below B_{RP} after being above B_{OP}). See the behavior diagram (section 5.2) for more details.

5.4 Magnetic Response Table (LGA-4 package)

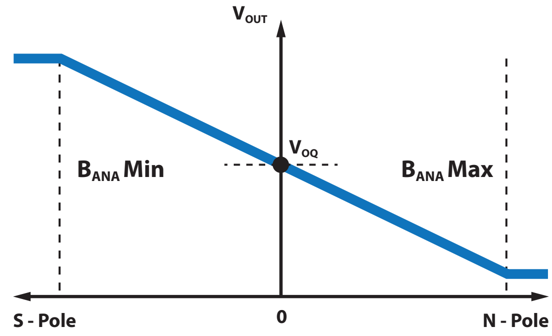
	Step 1: Sensor is powered without magnetic field.	**Step 2:** Magnet applied, polarity **North**.	**Step 3:** Magnet removed.	**Step 4:** Magnet applied, polarity **South**.	**Step 5:** Magnet removed.	**Step 6:** Magnet applied, polarity **North**.
Scenario						
DIGITAL OMNI-POLAR SENSOR OUTPUT	HIGH	**LOW** (Activated)	HIGH	**LOW** (Activated)	HIGH	**LOW** (Activated)
ANALOG OUTPUT (ANA OUT)	Undefined	Undefined	$\frac{V_{dd}}{2}$ Output is half of V_{dd}	$\frac{V_{dd}}{2} < V_{out} < V_{dd}$ Output is between half of Vdd and full V_{dd}	$\frac{V_{dd}}{2}$ Output is half of V_{dd}	$0 < V_{out} < \frac{V_{dd}}{2}$ Output is between 0 V and half of V_{dd}

Note: When the RR142 TMR sensor is initially powered ON, the Analog Channel remains inactive until Step 3 (i.e., Field decreases below B_{RP} after being above B_{OP}). See the behavior diagram (section 5.2) for more details.

5.5 Magnetic Response Diagram - Digital Omnipolar Output

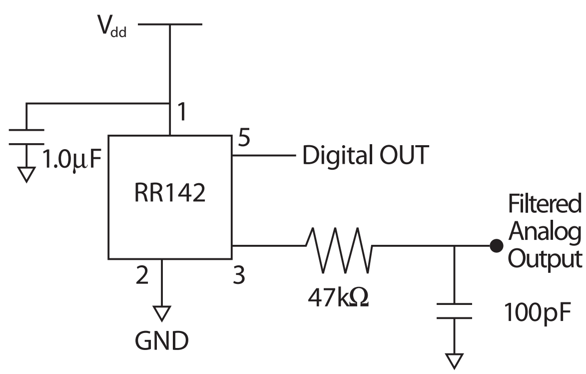


5.6 Magnetic Response Diagram - Analog Omnipolar Output

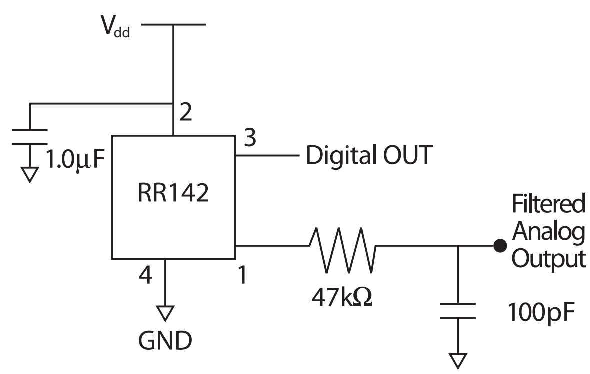


6 Application Information

6.1 Application Circuit (SOT-23-5)

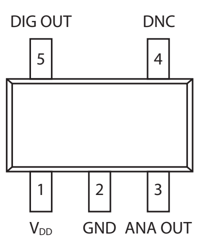


6.2 Application Circuit (LGA-4)



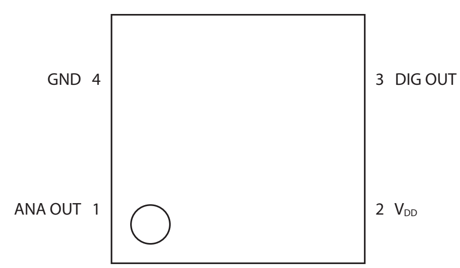
RR142 Output Application Circuit
The output voltage can be connected to an analog input pin on a microcontroller. The analog output voltage is proportional to the strength of an applied magnetic field. A simple RC filter is recommended at the output. A resistor value of 47kΩ and a capacitor value of 100 pF should suffice. A decoupling capacitor with a minimum value of 1.0 µF placed within 10 mm of the sensor is required.

6.3 Package Pinout (SOT-23-5)



SOT-23-5 Package

6.4 Package Pinout (LGA-4)



LGA-4 Package

6.5 Application Examples

The RR142-1LD2-542/545 and RR142-1LD3-542/545 TMR sensors are ideal for use in applications where the linear or rotational position of an object must be detected while consuming the lowest amount of power possible. When the RR142 sensor is initially powered-ON, only the digital channel is activated, and the sensor consumes 150nA, which is often considered a negligible amount of current, and can be used in a battery-powered application without an appreciable drop in the operating life of the device. The RR142 can help applications save power in two ways. First, as with other Coto RedRock ultra-low power TMR sensors, the RR142's digital channel can be used to directly disable a product's circuitry (up to 20mA) until it's needed. Second, since the RR142 analog sensing channel consumes more current than the digital channel, it remains disabled until the magnetic flux density at the sensor rises above the B_{op} threshold, and then decreases below the B_{rp} threshold.

Below are two examples of applications where the RR142 can be used for analog magnetic field sensing while keeping the sensor's current consumption to a minimum.

For more information about the sensor's operating modes, please see Section 5.2. For operating specs, such as the B_{OP}/B_{RP} thresholds, please see Table 4.4.

EXAMPLE 1

One application example is a portable, battery powered, fillable drug dispensing device. These types of devices contain a reservoir where the drug is stored and a moving plunger that dispenses the drug. A diagram of this is shown in Figure 1. The TMR sensor can be positioned near the bottom of the reservoir and a magnet can be placed on the plunger. When the reservoir is empty and the plunger is at the bottom, the magnet is positioned next to the sensor, producing a high magnetic flux density ($B > B_{OP}$) at the center of the sensor. Then, once the reservoir is filled, the plunger and the magnet are pushed upwards. This moves the magnet away from the sensor, decreasing the flux density sensed by it and turning ON the analog channel (once $B < B_{RP}$). As the liquid in the reservoir is dispensed, the analog channel of the RR142 can be used to determine how much liquid is left.

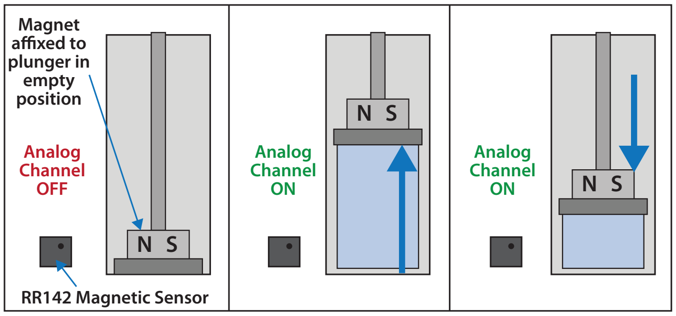


Figure 1: Using an RR142 TMR sensor inside a portable liquid level sensing application (Left): Reservoir Empty, RR142 Analog Sensing channel is OFF (Center): Reservoir gets filled with liquid, moving the plunger to full position. Flux Density at TMR Magnetic Sensor is reduced, turning ON its Analog Sensing channel (Right): As plunger is depressed, the TMR Magnetic Sensor produces an output voltage proportional to magnetic field, which can be used to determine the magnet's position and volume injected.

EXAMPLE 2

Alternatively, the device could be pre-filled with liquid (plunger and magnet positioned at the top of the reservoir) and a secondary magnet can be inserted into the device's packaging. This secondary magnet would maintain a high flux density ($B > B_{OP}$) at the RR142 sensor. Once the device is first removed from its packaging, the sensor moves away from the secondary magnet, making the B at the sensor drop and enabling the analog channel of the RR142 (Once $B < B_{RP}$). From this point onwards, the RR142 can detect the position of the plunger as the liquid in the device is dispensed.

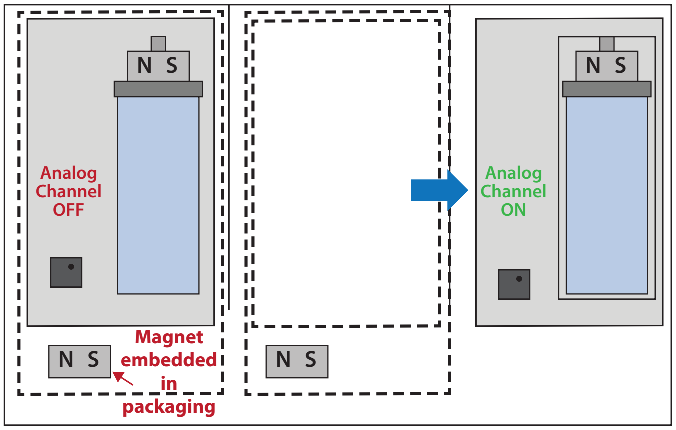
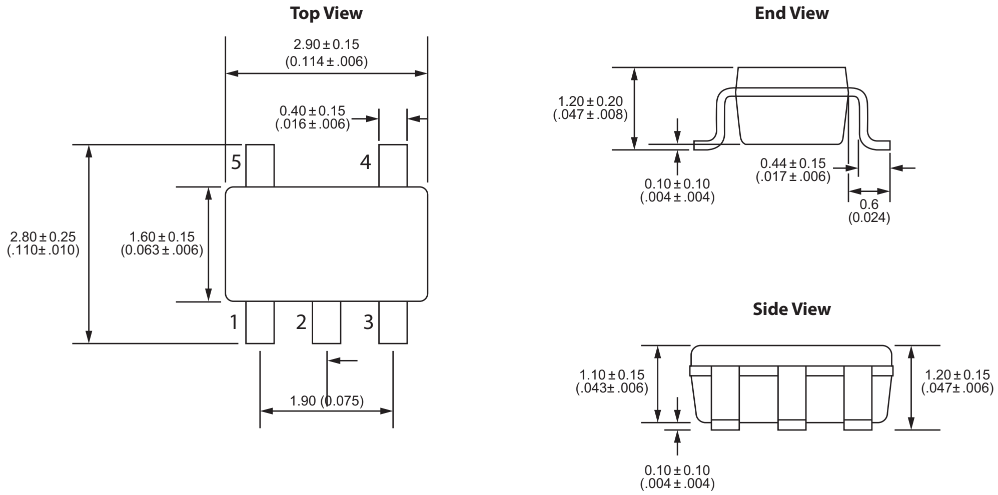


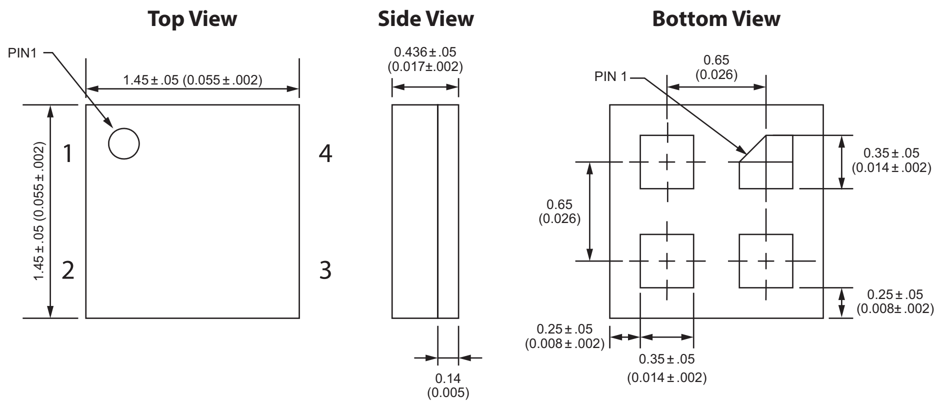
Figure 2 (Left): Portable Liquid level sensing device with magnet embedded in package (Right): Device is removed from packaging, which turns ON the RR142 Analog Channel. From this point onward, the RR142 can detect the position of the magnet mounted on the plunger.

7 Dimensions *Millimeters (Inches)*

7.1 SOT-23-5 Package

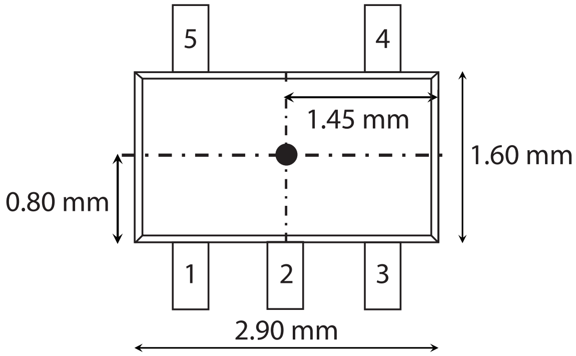


7.2 LGA-4 Package

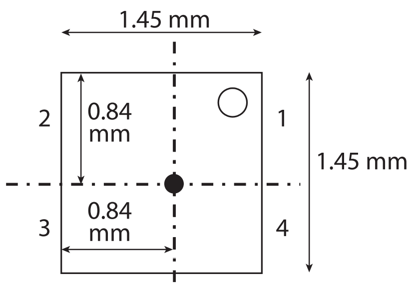


8 TMR Sensor Location

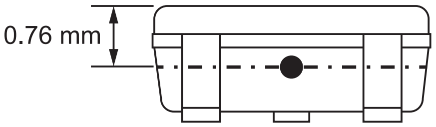
8.1 SOT-23-5 Package



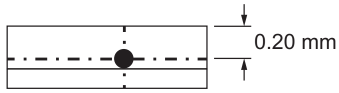
8.2 LGA-4 Package



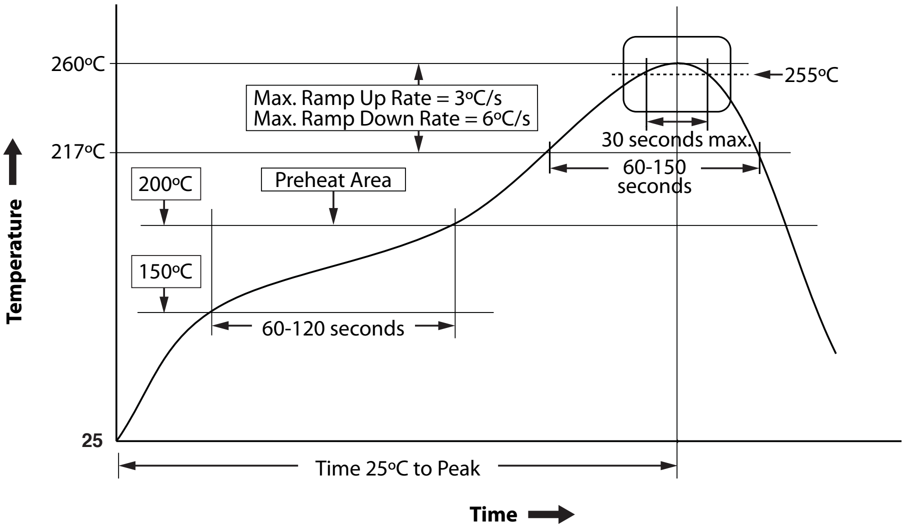
8.3 SOT Package - Side View



8.4 LGA Package - Side View



9 Suggested Pb-Free Reflow Profile

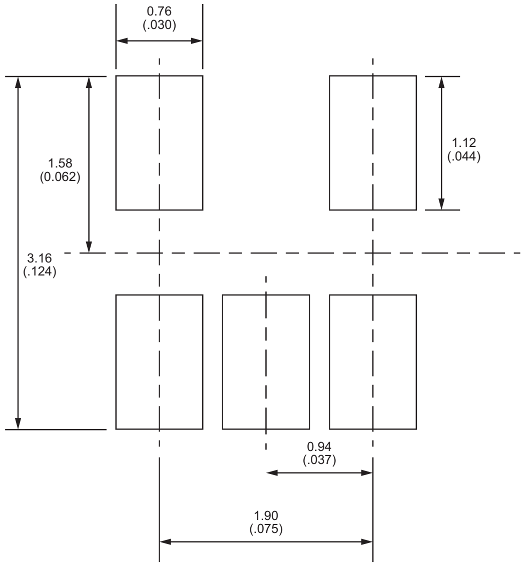


Notes:

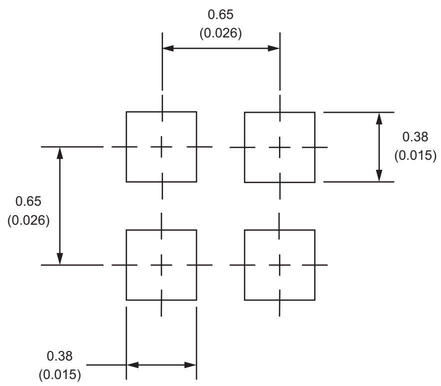
1. Fully compatible with standard no-lead solder profile, 260 ºC for 1 minute max (3 cycles max).
2. Profile shown as example. Users are advised to develop their own board-level profile.
3. Suggested Pb-free reflow profile derived from IPC/JEDEC J-STD-020E.
4. Temperature tolerance: +0 ºC, as measured at any point on the package or leads
5. MSL rating of 1 (SOT-23-5 only) compatible with J-STD-020 or equivalent.
6. MSL rating of 3 (LGA-4 only) compatible with J-STD-020 or equivalent.
7. All temperatures refer to the center of the package, measured on the package body surface that is facing up during assembly reflow (e.g., live-bug). If parts are reflowed in other than the normal live bug assembly reflow orientation (i.e., dead-bug), Tp shall be within ± 2 °C of the live bug Tp and still meet the Tc requirements, otherwise, the profile shall be adjusted to achieve the latter. To accurately measure actual peak package body temperatures, refer to JEP140 for recommended thermocouple use.
8. Reflow profiles in this document are for classification/preconditioning and are not meant to specify board assembly profiles. Actual board assembly profiles should be developed based on specific process needs and board designs and should not exceed the parameters in this table.

10 Suggested Solder Pad Layout

10.1 SOT-23-5 Solder Pad Layout



10.2 LGA-4 Solder Pad Layout



11 TMR Sensor & Switch Packaging

11.1 SOT-23-5 Tape & Reel Packaging

Standard packaging is Tape & Reel containing 3,000 pieces. MSL Rating is 1.

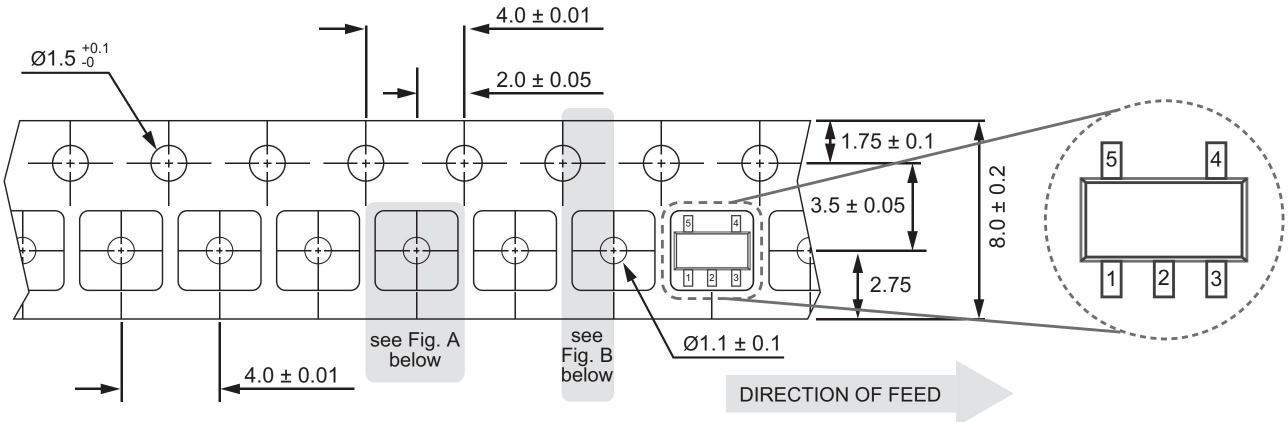


Fig. A

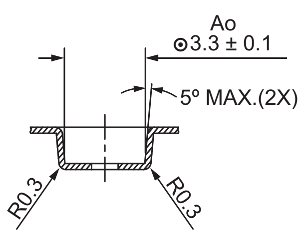
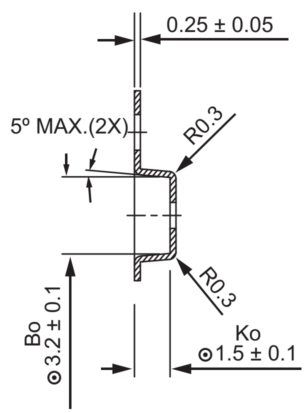
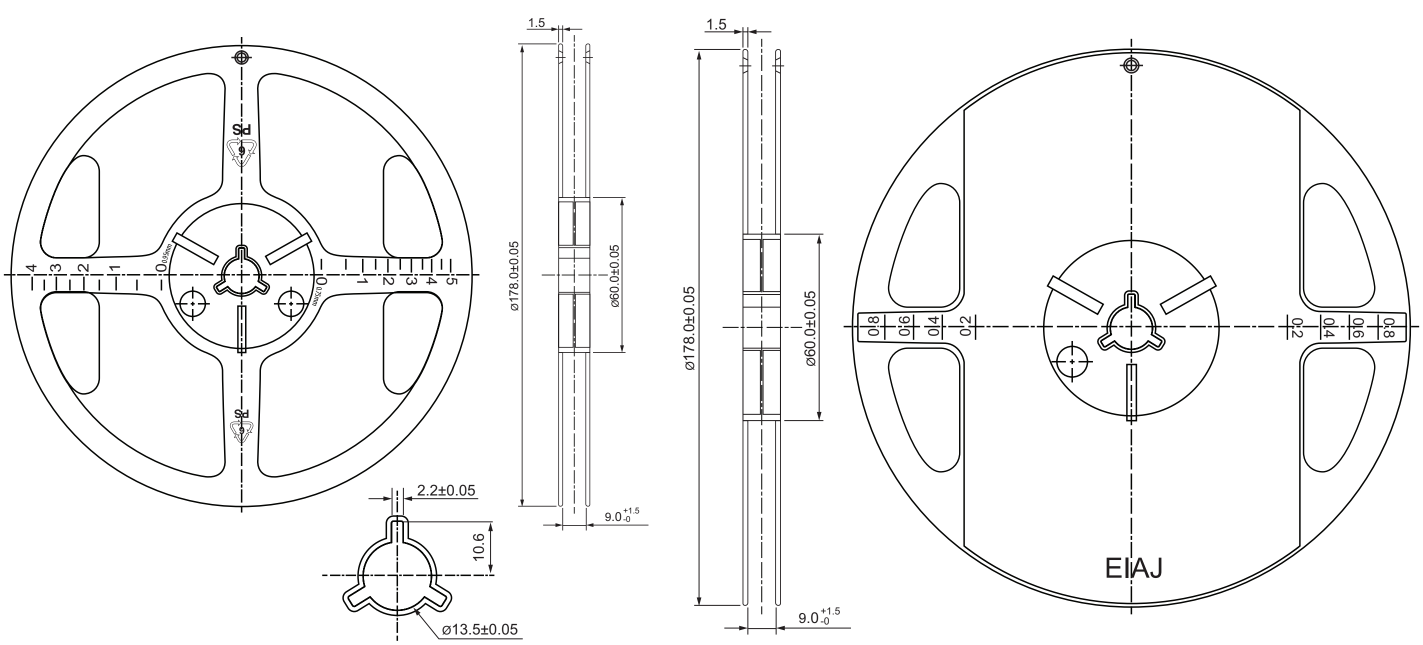


Fig. B





11 TMR Sensor & Switch Packaging

11.2 LGA-4 Tape & Reel Packaging

Standard packaging is Tape & Reel containing 3,000 pieces. MSL Rating is 3.

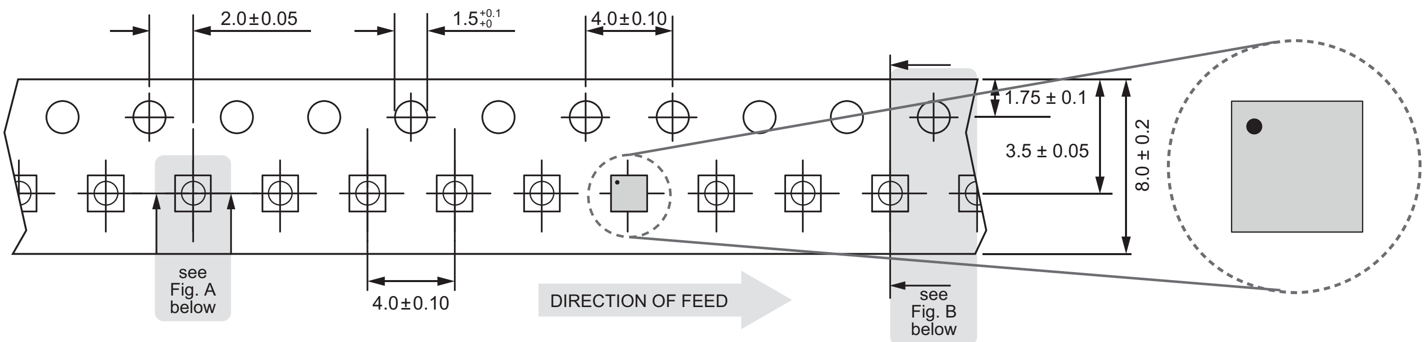


Fig. A

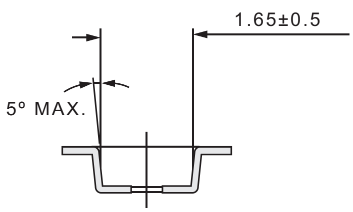
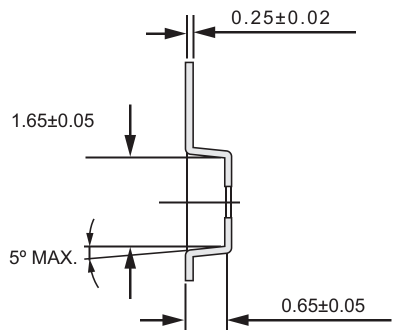
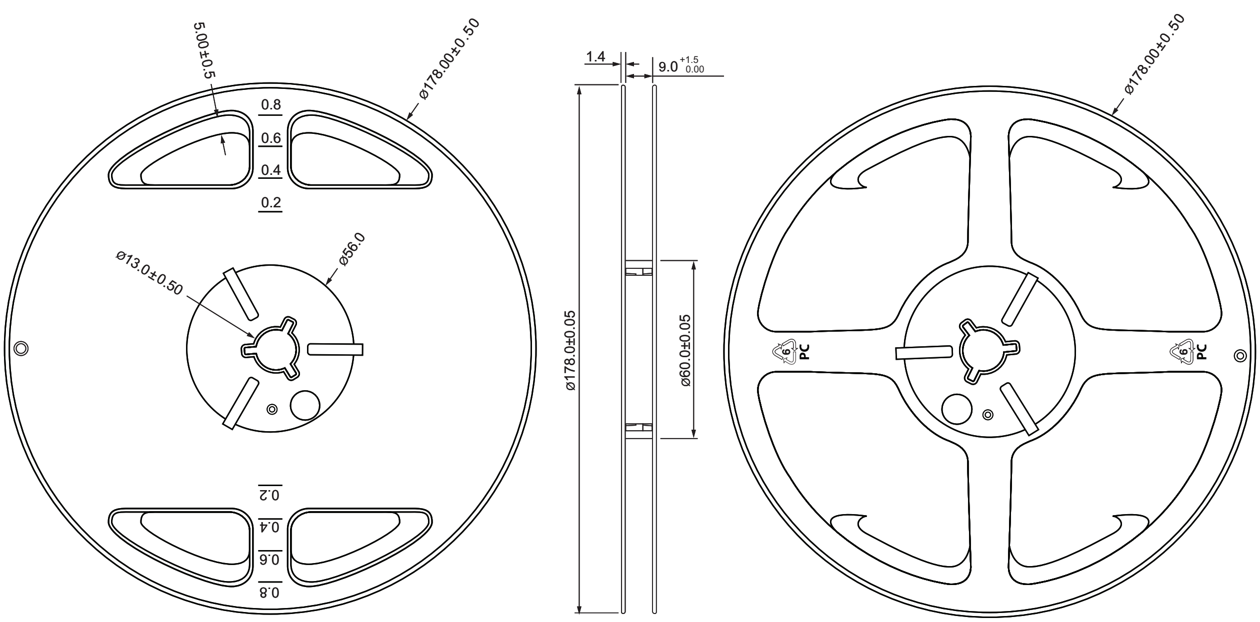


Fig. B



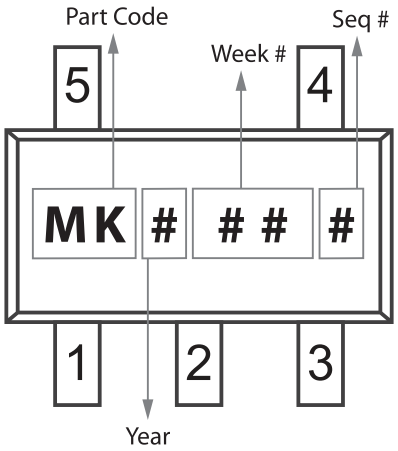


redrock@cotorelay.com | www.cotorelay.com

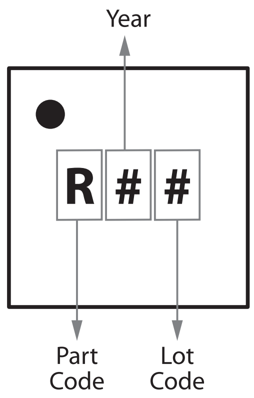
11 TMR Sensor & Switch Packaging

11.3 RedRock Package Codes

RR142-1LD2-545 (SOT-23-5)
RR142-1LD3-545 (SOT-23-5)



RR142-1LD2-542 (LGA-4)
RR142-1LD3-542 (LGA-4)



11.4 RedRock TMR Packaging

Box Dimensions – 14x10x6 inches
- Fits 1 to 3 reels = 3000 to 9000 pcs
- Weight for 3000 pcs = 0.90 kilos
- Weight for 9000 pcs = 1.00 kilos

Box Dimensions – 18x14x12 inches
- Fits 4 to 24 reels = 12000 to 72000 pcs
- Weight for 12000 pcs = 1.50 kilos
- Weight for 72000 pcs = 4.90 kilos

Revision History

	Date	Description
1	07/18/2022	Minor Modifications (Section 5.2, 5.3 & 6)
2	03/09/2023	Product Description Modification (Section 1)
3	03/09/2023	Modification in Operating/Switching Frequency (Section 4.4)
4	03/09/2023	Modification in Average Supply Current Parameters (Section 4.4; 5.2)
5	03/09/2023	Modification in Analog Output Voltage Range Units (Section 4.4)
6	03/09/2023	Modification Magnetic Response Diagram (Section 5.6)
7	03/09/2023	Addition of Application Examples Section (Section 6.5)