Operation

Rev.1.0_00

The S-8473 Series and the S-8474 Series are wireless power ICs.
The S-8473 Series is a receiver control IC (Receiver), and the S-8474 Series is a transmitter control IC (Transmitter).
This application note serves as technical documentation that describes the combined operation and characteristics of the S-8473 Series and S-8474 Series.
Refer to the S-8473 Series and S-8474 Series datasheets for additional details.

Caution 1. Wireless power transfer devices which use the S-8473 Series and S-8474 Series are optimized to operate at LC resonant frequencies of approximately 88kHz to 106kHz. Within the 88kHz to 106kHz LC resonant frequency range, the circuit for detecting the receiver control IC operates, and the transmitter control IC also operates correctly. If the constants of the used coil (L) and capacitor (C) are changed, the LC resonant frequency also will change, so make sure to maintain the LC resonant frequency within the 88kHz to 106kHz range.

2. There is polarity to the receiver coil and transmitter coil in wireless power transfer devices which use the S-8473 Series and S-8474 Series. Combine receiver coils and transmitter coils according to the details in this application note.

2. Operation

This application note describes the combined circuit operation of the S-8473 Series and the S-8474 Series, as shown in **Figure 8.**

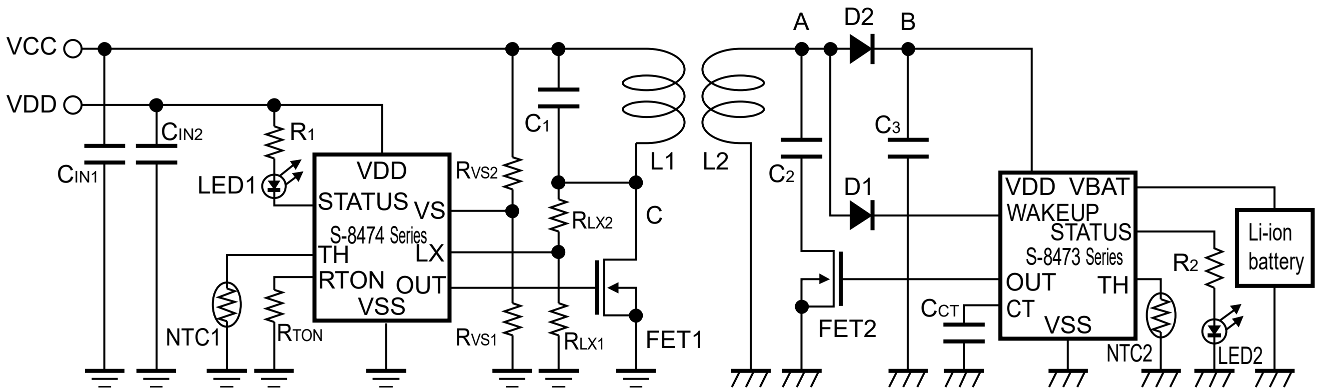


Figure 8 Recommended Circuit

2. 1 Reception detection and operation mode of transmitter

The transmitter has two operation modes: continuous operation mode and intermittent operation mode. Switching between the continuous operation mode and the intermittent operation mode is determined by the reception detection (within 3ms typ. to 5ms typ.) after output start. This result determines the mode within the remaining 25ms typ. The determination of switching between the continuous operation and intermittent operation modes is made repeatedly every 30ms typ. (one cycle). The LED connected to STATUS pin lights up when power reception is detected continuously for 16 cycles. In the same manner, the LED turns off when power reception is not detected continuously for 16 cycles.

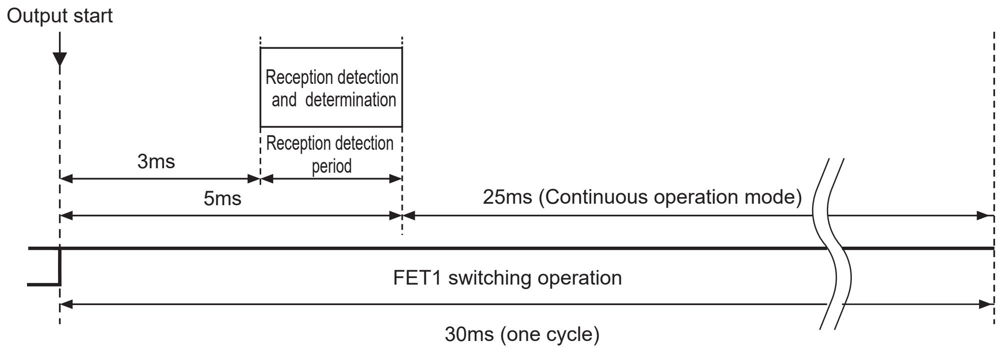


Figure 9 Continuous Operation Mode (typ.)

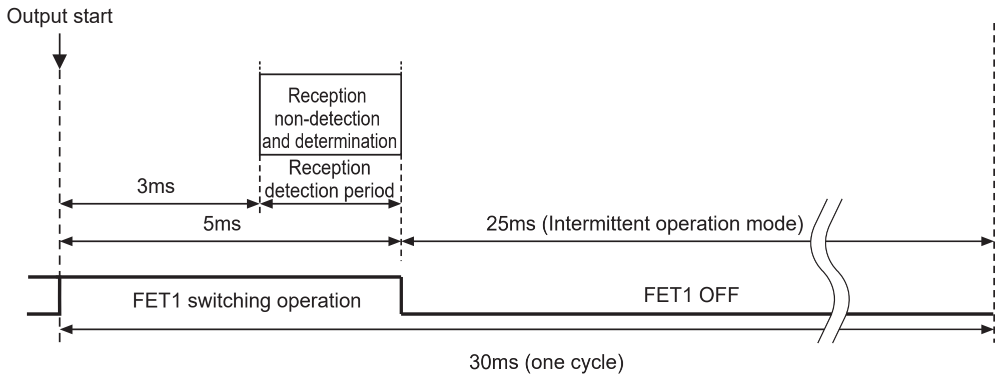


Figure 10 Intermittent Operation Mode (typ.)

2. 2 Reception detection mechanism of transmitter

Reception is detected by comparing the peak values of the transmitter LX pin voltage waveform.
When mutual induction occurs between the transmitter and the receiver, the receiver performs constant voltage control. Thus FET2 turns ON and OFF repeatedly due to switching operation. The switching of FET2 between ON and OFF changes the peak values of the transmitter LX pin voltage.
As shown in **Figure 11**, when the difference between these waveform peak values reaches approximately 0.1V*1 or higher, the transmitter acknowledges that reception has been detected and transitions to continuous operation mode.

Note that in the following cases, the difference between waveform peak values decreases and the transmitter will not transition to continuous operation mode.

- Load is too light
- Load is too heavy
- Presence of the receiver cannot be confirmed
- Distance between coils is too close

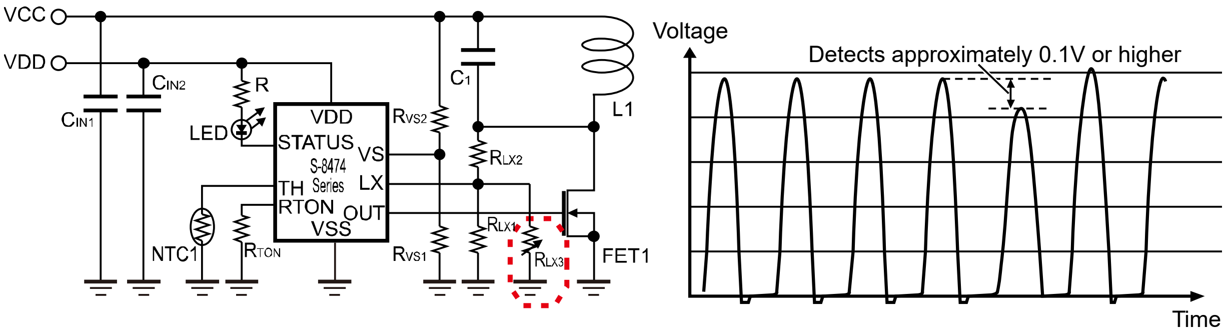


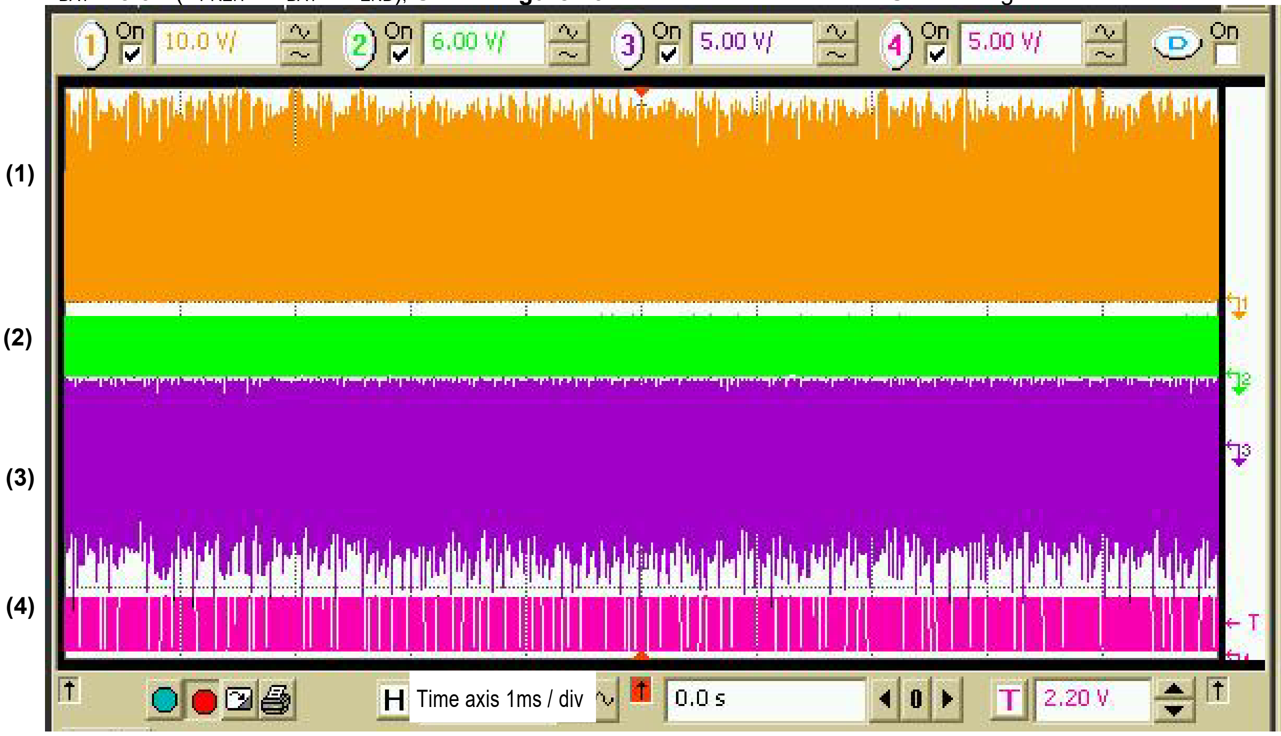
Figure 11 LX Pin Voltage Waveform

***1.** Because the difference between waveform peak values cannot be directly measured, use the following method to find the difference.
Change R_{LX3} from **Figure 11** while synchronizing it to the OUT output and detect the point at which it switches to continuous operation mode.
The peak value difference varies depending on coil wire length and other variables, so use 0.1V as a reference value.

2. 3 Transmitter coil, transmitter FET control, receiver coil, receiver FET control waveforms (Continuous operation mode)

Figure 12 and **Figure 13** show each waveform during continuous operation.

Conditions: Perpendicular distance between coils (d) = 3mm, V_{DD} = 5V, V_{CC} = 9V,
V_{BAT} = 3.6V ($V_{PREH} \leq V_{BAT} < V_{END}$), Circuit: **Figure 26** Evaluation Measurement Circuit Diagram

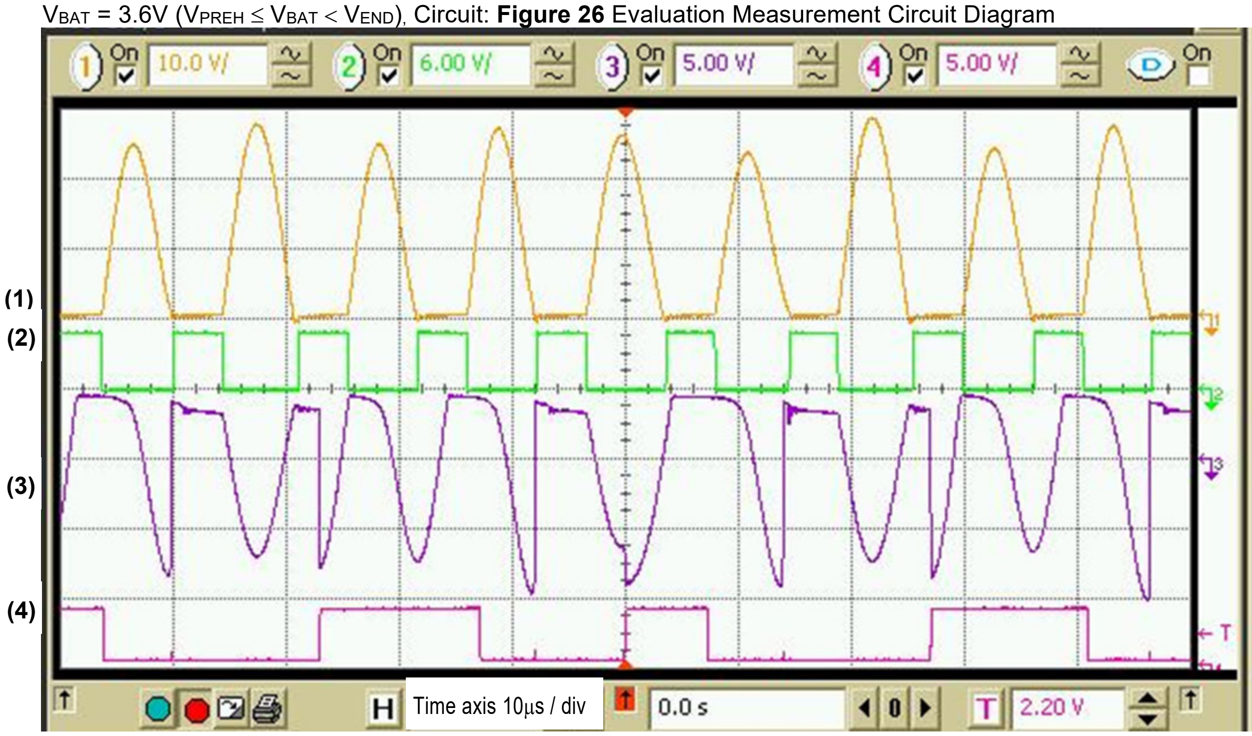


(1) Transmitter coil waveform at point C (10V / div)
(2) Transmitter FET1 gate waveform (6V / div)
(3) Receiver coil waveform at point A (5V / div)
(4) Receiver FET2 gate waveform (5V / div)

Remark V_{PREH}: Precharge completion voltage
V_{END}: Charge completion voltage

Figure 12 Waveforms during Continuous Operation Mode

Conditions: Perpendicular distance between coils (d) = 3mm, V_{DD} = 5V, V_{CC} = 9V,
V_{BAT} = 3.6V ($V_{PREH} \leq V_{BAT} < V_{END}$), Circuit: **Figure 26** Evaluation Measurement Circuit Diagram



(1) Transmitter coil waveform at point C (10V / div)
(2) Transmitter FET1 gate waveform (6V / div)
(3) Receiver coil waveform at point A (5V / div)
(4) Receiver FET2 gate waveform (5V / div)

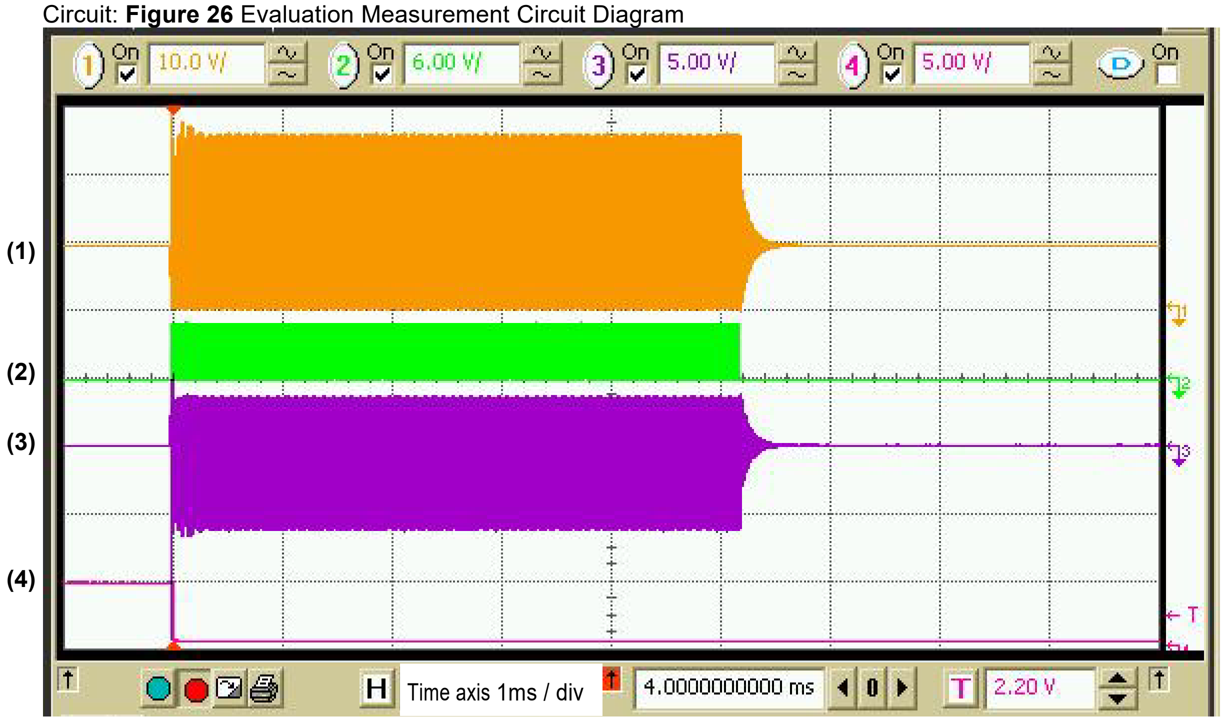
Remark	V_{PREH}:	Precharge completion voltage
	V_{END}:	Charge completion voltage

Figure 13　Waveforms during Continuous Operation Mode (Enlarged Figure)

2. 4 Transmitter coil, transmitter FET control, receiver coil, receiver FET control waveforms (Intermittent operation mode)

Figure 14 and **Figure 15** show each waveform during intermittent operation. If the distance between coils is reduced, the receiver FET2 gate waveform will maintain "L". If the distance is widened, the receiver FET2 gate waveform will maintain "H". For this reason, intermittent operation will be carried out on the transmitter. Similarly, the intermittent operation will be carried out on the transmitter in the case of short-circuit detection, charge operation completion, and non-existence of receiver.

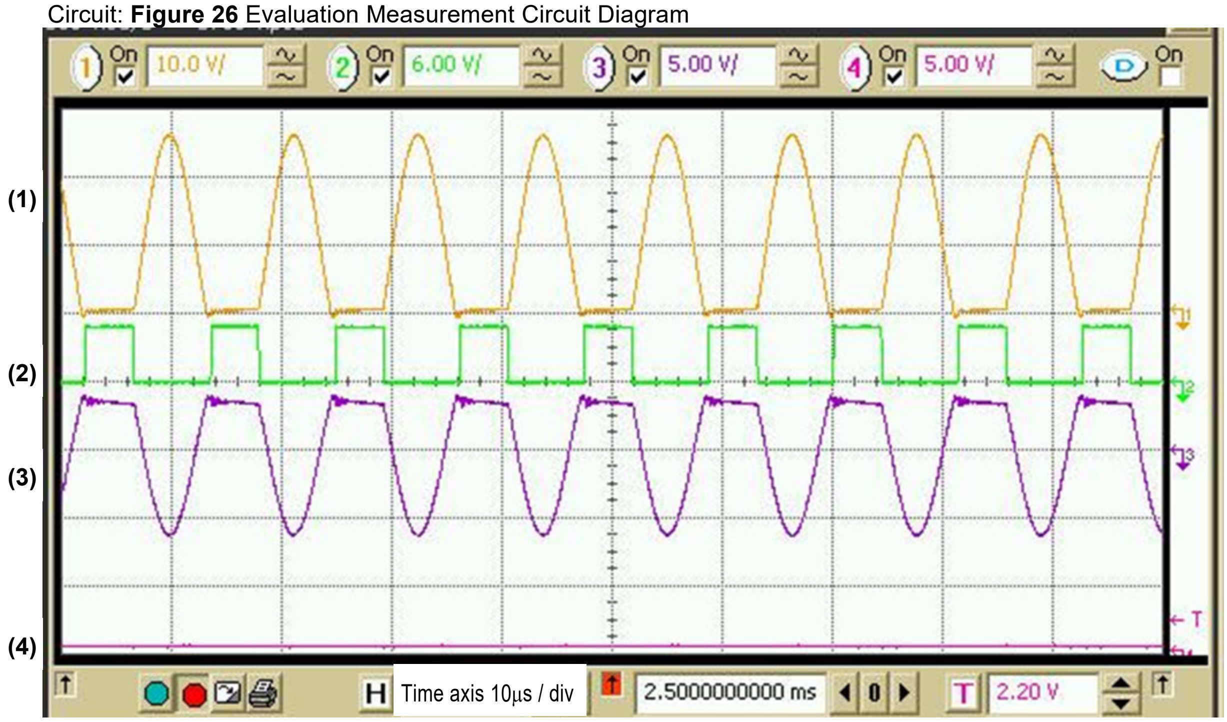
Conditions: Perpendicular distance between coils (d) = 3mm, V_{DD} = 5V, V_{CC} = 9V, V_{BAT} = V_{END},
Circuit: **Figure 26** Evaluation Measurement Circuit Diagram



(1) Transmitter coil waveform at point C (10V / div)
(2) Transmitter FET1 gate waveform (6V / div)
(3) Receiver coil waveform at point A (5V / div)
(4) Receiver FET2 gate waveform (5V / div)

Figure 14 Waveforms during Intermittent Operation Mode

Conditions: Perpendicular distance between coils (d) = 3mm, V_{DD} = 5V, V_{CC} = 9V, V_{BAT} = V_{END},
Circuit: **Figure 26** Evaluation Measurement Circuit Diagram



(1) Transmitter coil waveform at point C (10V / div)
(2) Transmitter FET1 gate waveform (6V / div)
(3) Receiver coil waveform at point A (5V / div)
(4) Receiver FET2 gate waveform (5V / div)

Figure 15 Waveforms during Intermittent Operation Mode (Enlarged Figure)

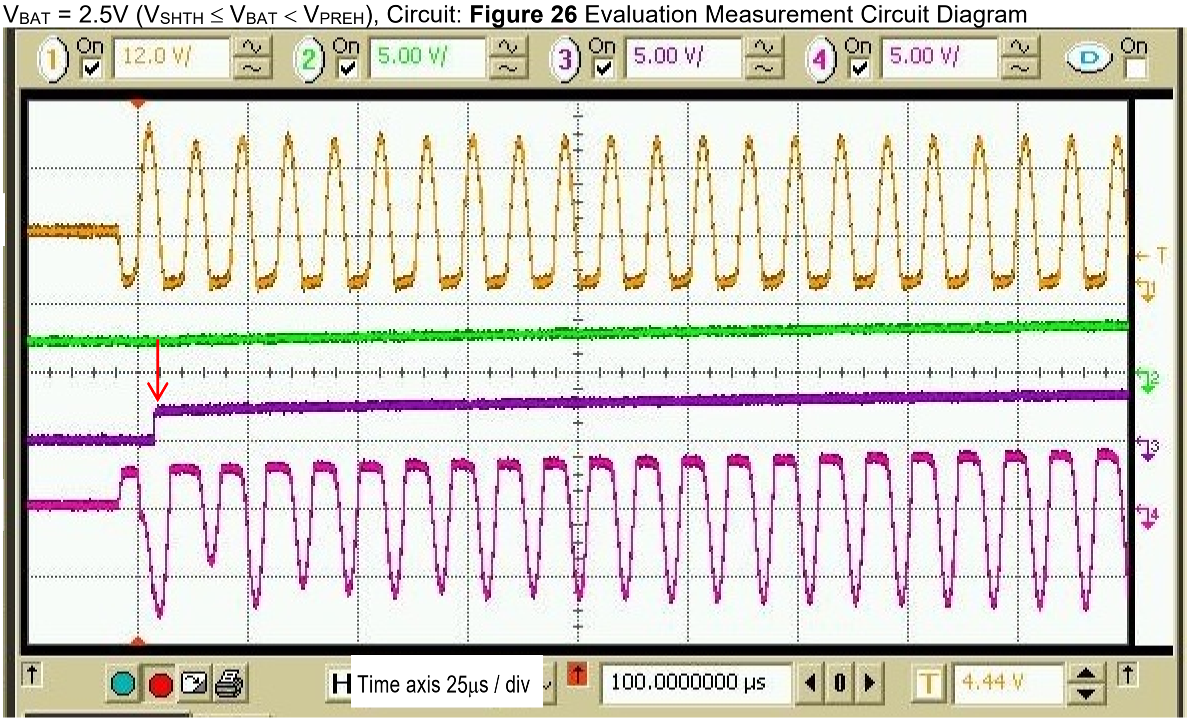
2. 10 Operation of receiver

2. 10. 1 Initial status of reception

Figure 19 shows the LC waveform at point C of the transmitter and each waveform of the receiver in the initial status of reception. The receiver VDD voltage exceeds the UVLO voltage when transmission starts due to mutual induction, FET2 is turned ON at the timing illustrated by the arrow in **Figure 19**. As a result, C_2 becomes connection status and the receiver starts LC resonance.

Conditions: Perpendicular distance between coils (d) = 3mm, V_{DD} = 5V, V_{CC} = 9V,
V_{BAT} = 2.5V ($V_{SHTH} \leq V_{BAT} < V_{PREH}$), Circuit: **Figure 26** Evaluation Measurement Circuit Diagram

(1)
(2)
(3)
(4)



(1) Transmitter LC waveform at point C (12V / div)
(2) Receiver VDD waveform at point B (5V / div)
(3) Receiver FET2 gate waveform (5V / div)
(4) Receiver LC waveform at point A (5V / div)

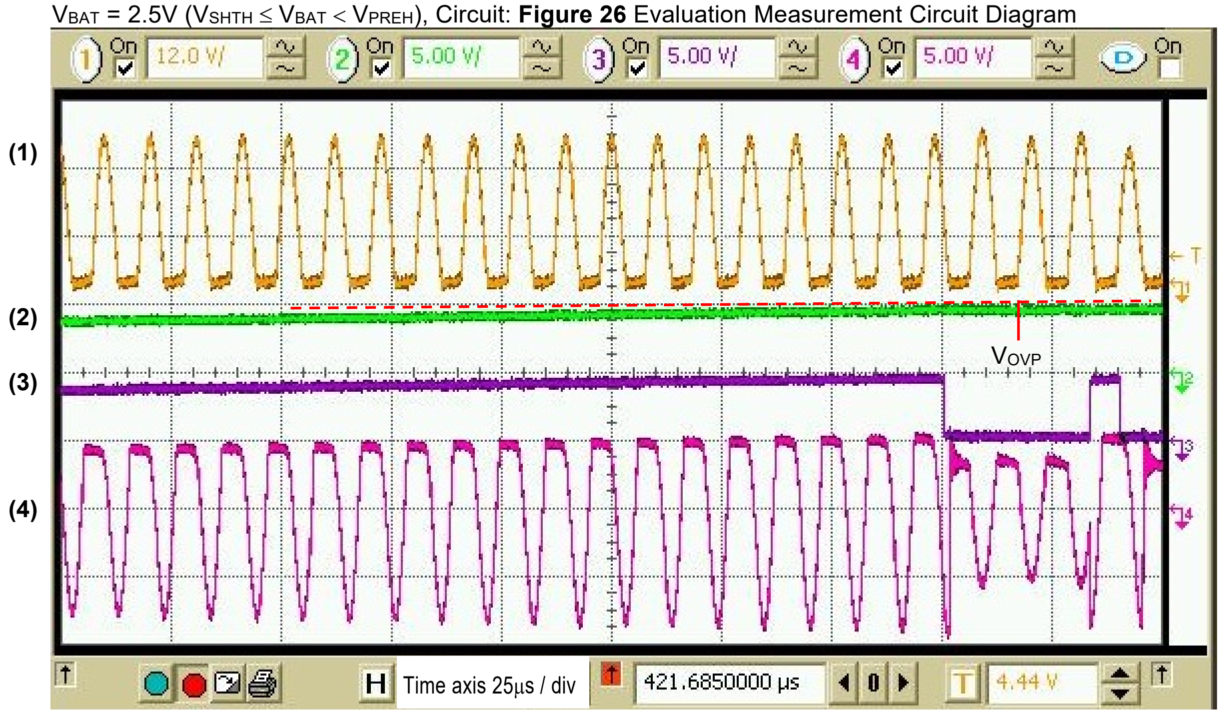
Remark V_{SHTH}: Short-circuit release voltage
V_{PREH}: Precharge completion voltage

Figure 19 Waveform from Startup until Overvoltage Detection Voltage (V_{OVP}) is Reached

2. 10. 2 Status when overvoltage detection voltage (V_{OVP}) is reached during precharge operation

Figure 20 shows each waveform in the status when receiver VDD voltage reaches V_{OVP}. The receiver VDD voltage rises due to the receiver LC resonance which continues from the initial status of reception. When it reaches V_{OVP}, "L" is output from the receiver OUT pin, and receiver FET2 is turned OFF. As a result, C_2 becomes open and the receiver stops LC resonance.

Conditions: Perpendicular distance between coils (d) = 3mm, V_{DD} = 5V, V_{CC} = 9V,
V_{BAT} = 2.5V ($V_{SHTH} \leq V_{BAT} < V_{PREH}$), Circuit: **Figure 26** Evaluation Measurement Circuit Diagram



(1) Transmitter LC waveform at point C (12V / div)
(2) Receiver VDD waveform at point B (5V / div)
(3) Receiver FET2 gate waveform (5V / div)
(4) Receiver LC waveform at point A (5V / div)

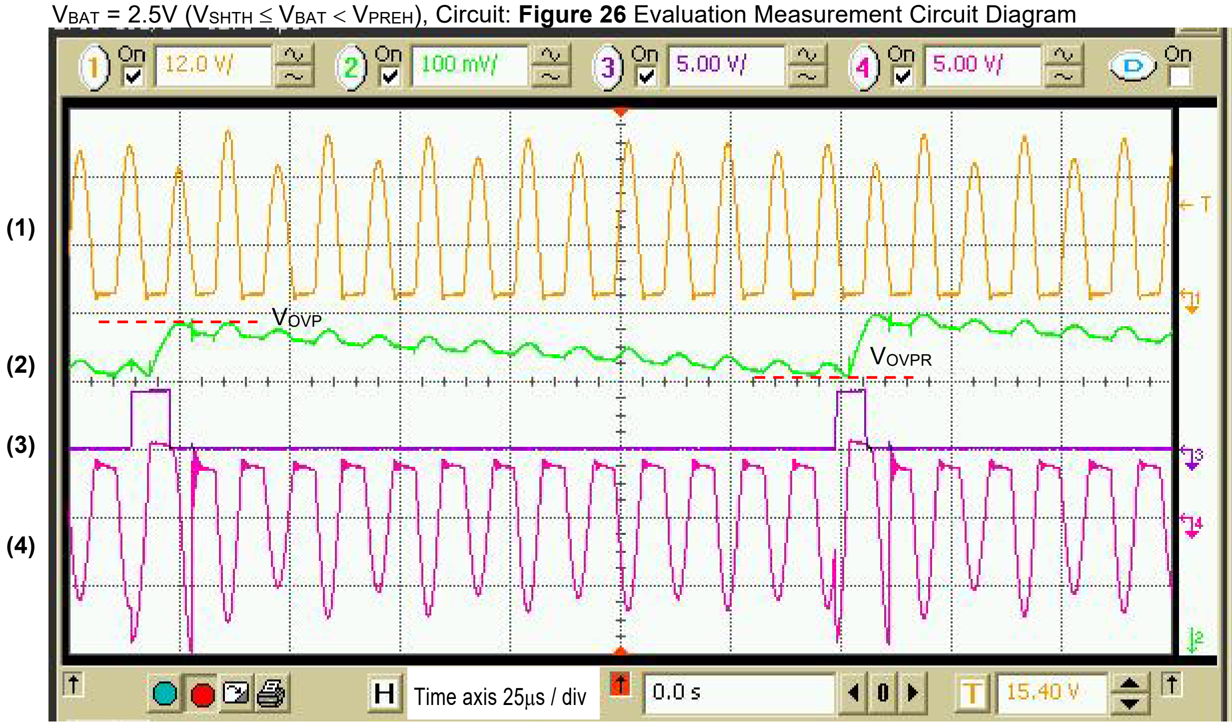
Remark V_{SHTH}: Short-circuit release voltage
V_{PREH}: Precharge completion voltage

Figure 20 Waveform in Status when V_{OVP} is Reached during Precharge Operation

2. 10. 3 Stable status during precharge operation

As shown in "**Figure 6　Relation between Receiver FET2 Control and Receiver VDD Voltage (Conceptual Diagram)**", after receiver VDD voltage (point B) reaches V_{OVP}, it transitions between V_{OVP} and overvoltage release voltage (V_{OVPR}) since receiver FET2 is repeatedly turned ON and OFF.
As shown in **Figure 21**, repeatedly turning receiver FET2 ON and OFF also causes the peak values of the transmitter LC waveform to change and the transmitter to enter the continuous operation mode.

Conditions: Perpendicular distance between coils (d) = 3mm, V_{DD} = 5V, V_{CC} = 9V,
V_{BAT} = 2.5V ($V_{SHTH} \le V_{BAT} < V_{PREH}$), Circuit: **Figure 26** Evaluation Measurement Circuit Diagram



(1) Transmitter LC waveform at point C (12V / div)
(2) Receiver VDD waveform at point B (100mV / div)
(3) Receiver FET2 gate waveform (5V / div)
(4) Receiver LC waveform at point A (5V / div)

Remark V_{SHTH}: Short-circuit release voltage
V_{PREH}: Precharge completion voltage

Figure 21　Waveforms in Stable Status during Precharge Operation

2. 10. 4 Stable status during normal charge operation

If the charge current falls below the charge current threshold (I_{LIM}) during normal charge operation, receiver FET2 is turned ON and "H" is output from the OUT pin. If it exceeds the I_{LIM}, receiver FET2 is turned OFF, and "L" is output from the OUT pin.

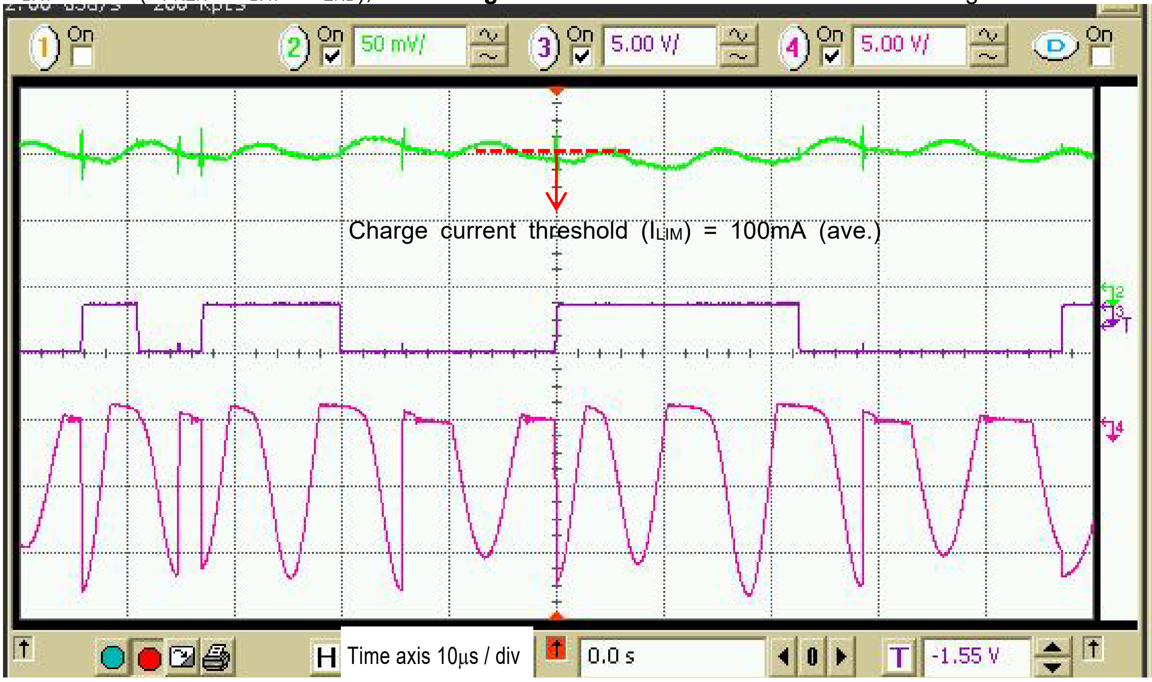
As shown in **Figure 22**, repeating this operation also cause the peak values of the transmitter LC waveform to change and the transmitter to enter the continuous operation mode.

Conditions: Perpendicular distance between coils (d) = 3mm, V_{DD} = 5V, V_{CC} = 9V,
V_{BAT} = 3.6V ($V_{PREH} \leq V_{BAT} < V_{END}$), Circuit: **Figure 26** Evaluation Measurement Circuit Diagram

(2)

(3)

(4)



(2) Charge current I_{BAT} waveform (50mA / div)
(3) Receiver FET2 gate waveform (5V / div)
(4) Receiver LC waveform at point A (5V / div)

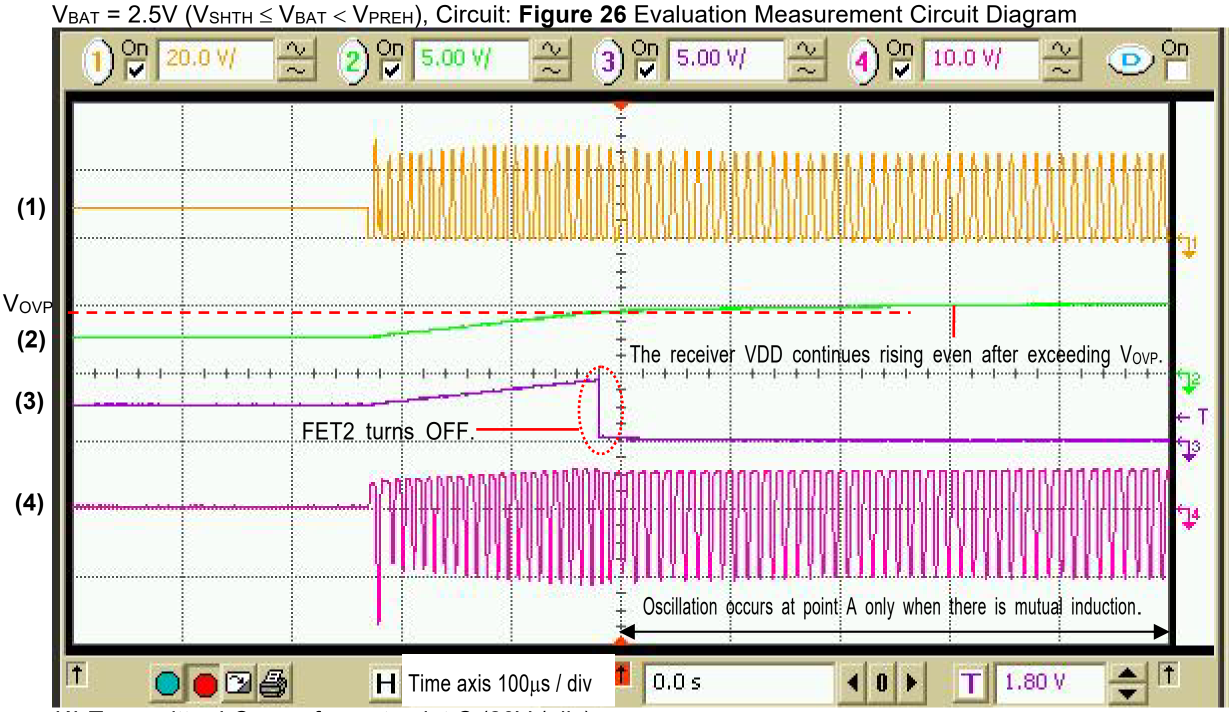
Remark V_{PREH}: Precharge completion voltage
V_{END}: Charge completion voltage

Figure 22 Stable Status Waveform (Waveform GND is Connected to VBAT)

2. 11 Distance between transmitter coil and receiver coil

The coil coupling coefficient changes depending on the distance between the transmitter coil and receiver coil. The coupling coefficient increases if the transmitter coil and the receiver coil are too close together, and even if receiver FET2 is turned OFF, the power is transferred due to mutual induction only. **Figure 23** and **Figure 25** show this phenomenon.
Note as shown in **Figure 23** the receiver VDD voltage may exceed the IC rating if it continues to rise even after exceeding V_{OVP}.

Conditions: Perpendicular distance between coils (d) = 1mm, V_{DD} = 5V, V_{CC} = 9V,
V_{BAT} = 2.5V ($V_{SHTH} \leq V_{BAT} < V_{PREH}$), Circuit: **Figure 26** Evaluation Measurement Circuit Diagram



(1) Transmitter LC waveform at point C (20V / div)
(2) Receiver VDD waveform at point B (5V / div)
(3) Receiver FET2 gate waveform (5V / div)
(4) Receiver LC waveform at point A (10V / div)

Remark V_{SHTH}: Short-circuit release voltage
V_{PREH}: Precharge completion voltage

Figure 23 Voltage Rising due to Mutual Induction Only

When the receiver VDD voltage is at risk of exceeding the IC rating, connect a Zener diode as shown in **Figure 24**.
In that case, the following condition needs to be satisfied.

- V_{OVP} < Breakdown voltage < IC rated voltage

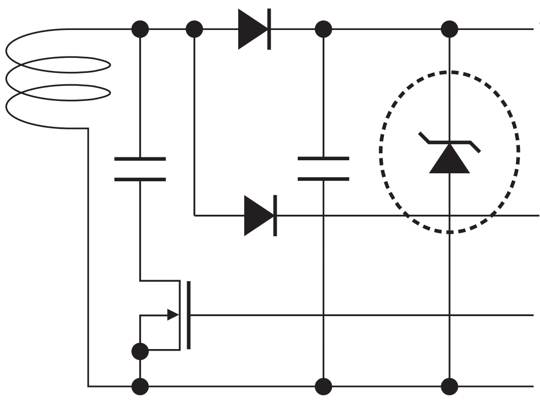
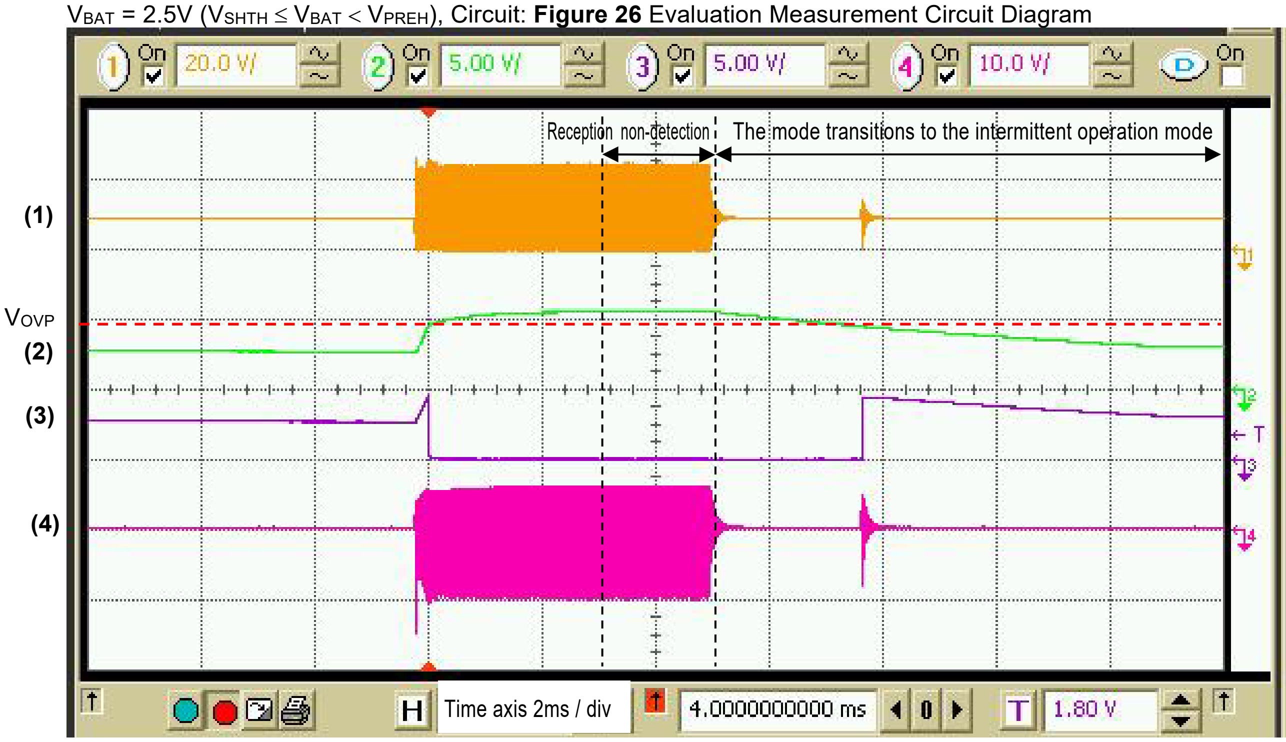


Figure 24

As shown in **Figure 25**, when the receiver VDD voltage reaches V_{OVP} or higher, "L" is output from the receiver OUT pin, and receiver FET2 remains OFF. Note that at this time, since the waveform of the transmitter LC resonance peak values do not change, the transmitter cannot detect the reception and transitions to intermittent operation mode.

Conditions: Perpendicular distance between coils (d) = 1mm, V_{DD} = 5V, V_{CC} = 9V,
V_{BAT} = 2.5V ($V_{SHTH} \leq V_{BAT} < V_{PREH}$), Circuit: **Figure 26** Evaluation Measurement Circuit Diagram



(1) Transmitter LC waveform at point C (20V / div)
(2) Receiver VDD waveform at point B (5V / div)
(3) Receiver FET2 gate waveform (5V / div)
(4) Receiver LC waveform at point A (10V / div)

Remark V_{SHTH}: Short-circuit release voltage
V_{PREH}: Precharge completion voltage

Figure 25 Receiver VDD Voltage Rising due to Mutual Induction and FET2 Gate Waveform

9. Board Design Considerations

- When wiring a board, make a single GND as described in the S-8473 Series and the S-8474 Series datasheets.
- To protect from overheat, be sure to connect an NTC thermistor to the TH pin for its use.
- For VCC in **Figure 47**, do not use a power supply which might cause frequency component amplitude of 1kHz to 110kHz (LC resonant frequency). It may result in a malfunction.
- For VDD in **Figure 47,** do not use a power supply which might cause frequency component amplitude to prevent from malfunction.
- When designing the board in **Figure 47**, for the following reasons, do not place a wiring near the RTON pin, the VS pin, and the TH pin. Layout so that resistor R_{TON} is as close to the RTON pin as possible.
  (1) Due to coil L1 and resonant capacitor (C_1), large voltage fluctuation is generated at point C.
  (2) Since impedance in the RTON pin, the VS pin, and the TH pin is high, they are easily affected by an extraneous signal.
  By connecting C_{RTON} (approximately 100pF to 1000pF) between the RTON pin and GND, C_{VS} (approximately 100pF to 1000pF) between the VS pin and GND and C_{NTC} (approximately 100pF to 1000pF) between the TH pin and GND, the influence of extraneous signal can be reduced.
  When detecting the coil temperature using an NTC thermistor in particular, the detection temperature may shift to the high temperature side as a result of the effect of the coil signal. It is recommended that C_{NTC} be connected between the TH pin and GND.

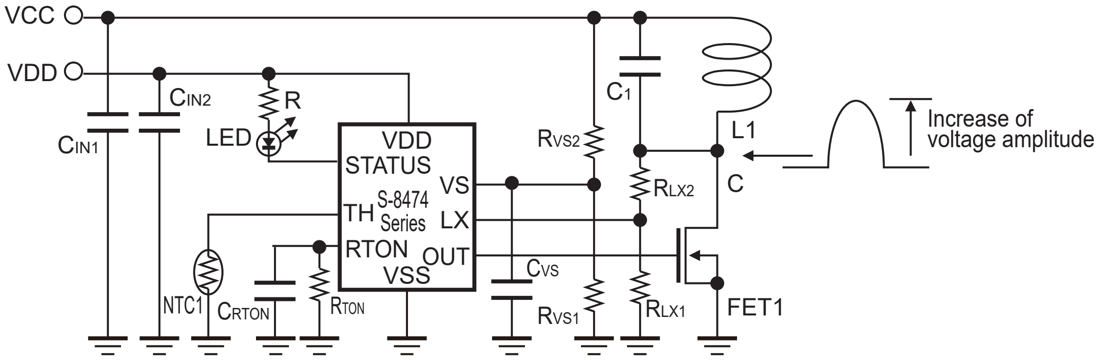


Figure 47

10. Precautions

- The usages described in this application note are typical examples using ABLIC Inc. ICs. Perform thorough evaluation before use.
- When designing for mass production using an application circuit described herein, the product deviation and temperature characteristics of the external components should be taken into consideration. ABLIC Inc. bears no responsibility for any patent infringements related to products using the circuits described herein.
- ABLIC Inc. claims no responsibility for any and all disputes arising out of or in connection with any infringement by products including this IC of patents owned by a third party.

11. Related Sources

Refer to the following datasheets for details of the S-8473 Series and the S-8474 Series.

S-8473 Series Datasheet
S-8474 Series Datasheet

The information described herein is subject to change without notice.
Please contact our sales representatives for information regarding the latest product version / revision.