

Basic Operation of Wireless Power Transfer

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The S-8471 Series and the S-8474 Series are wireless power ICs.

The S-8471 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-8471 Series and S-8474 Series.

Refer to the S-8471 Series and S-8474 Series datasheets for additional details.

- Caution 1. Wireless power transfer devices which use the S-8471 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-8471 Series and S-8474 Series. Combine receiver coils and transmitter coils according to the details in this application note.**

1. Basic Operation of Wireless Power Transfer

1.1 Principle

Wireless power transfer carried out by the S-8471 Series and S-8474 Series refers to non-contact power transfer utilizing electromagnetic induction. The transmitter requires a transmission circuit and a transmitter coil. The receiver requires a reception circuit and a receiver coil.

Power transfer is carried out by aligning the coils at appropriate distance to allow magnetic coupling.

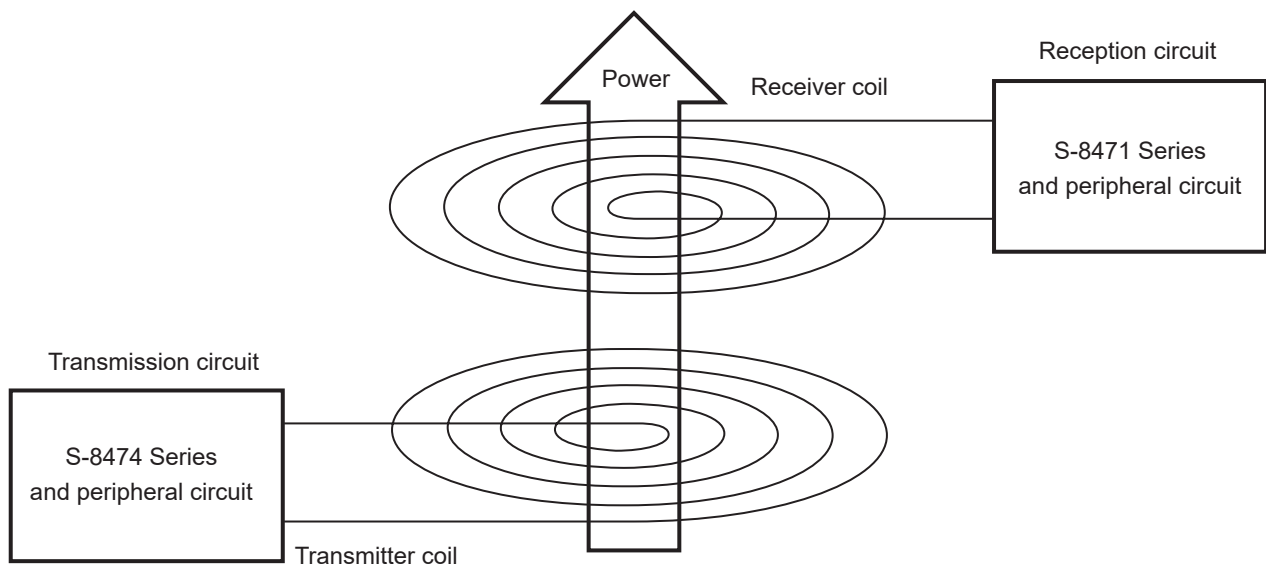


Figure 1 Block Diagram of Transmitter and Receiver

1.2 Phase direction due to coil connection and orientation

The resonant voltage waveform generated by the transmitter coil when using the S-8471 Series and S-8474 Series for wireless power transfer is not a true sine wave. The resulting waveform more closely resembles half-wave rectification.

For this reason, the receiver coil voltage waveform varies depending on direction and coupling (Refer to **Figure 2** and **Figure 3**).

As shown in **Figure 2**, this application note recommends the connection method, in which the phases of the voltage waveform of the transmitter coil and the voltage waveform of the receiver coil are reversed. Make sure to always use an oscilloscope to check that the coil voltage waveform phase is reversed.

In the connection example in **Figure 3**, if the coil coupling is strengthened, there is a risk that the receiver VDD voltage may exceed rated voltage at no load. It may also become impossible to stably transfer power in the light load area.

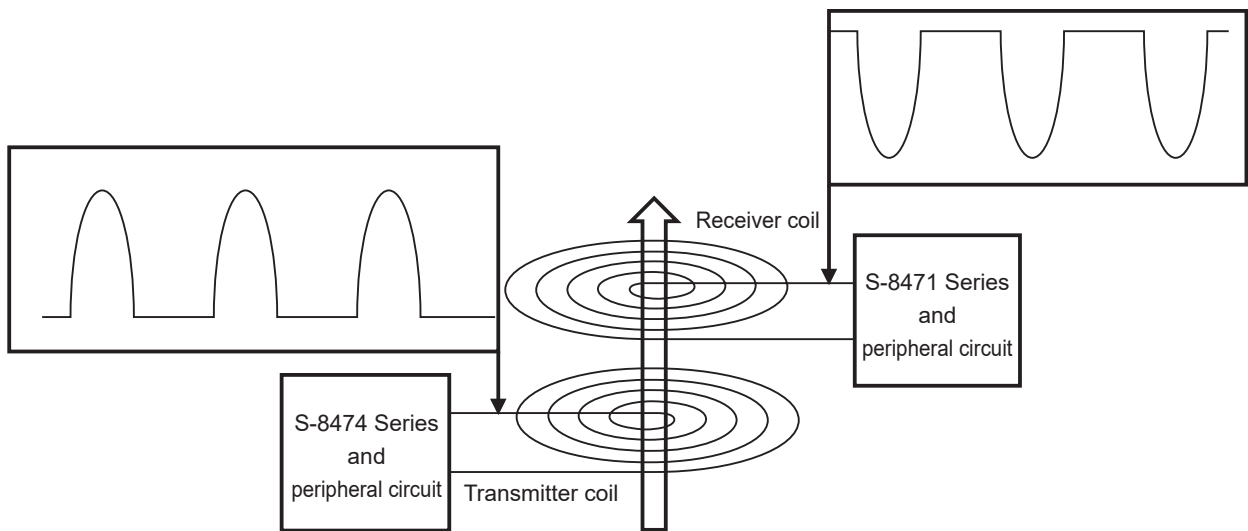


Figure 2 Reversed-phase Coil Voltage Waveform (Recommended Example)

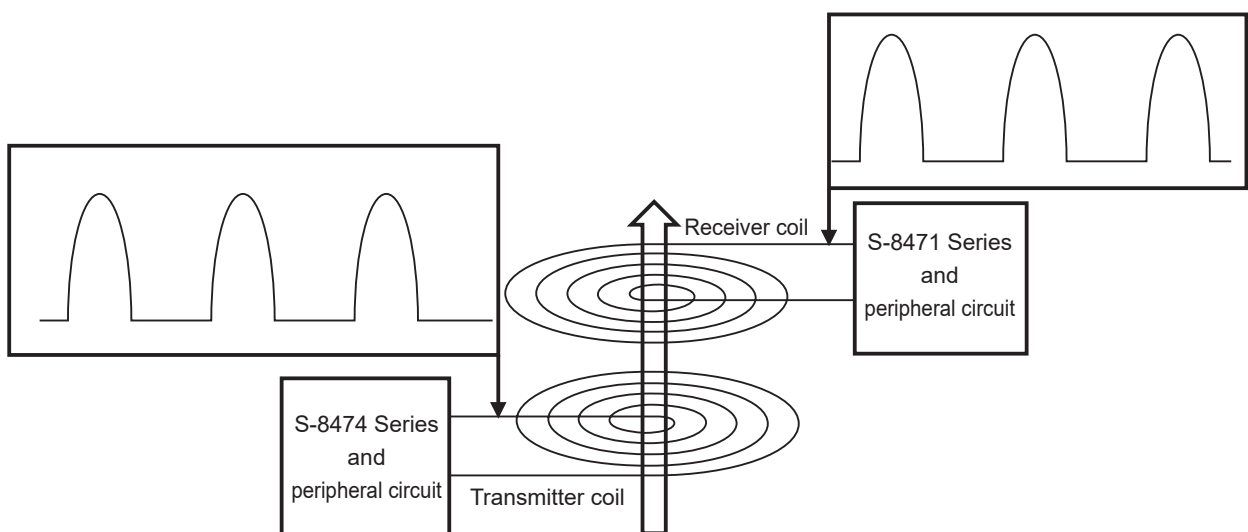


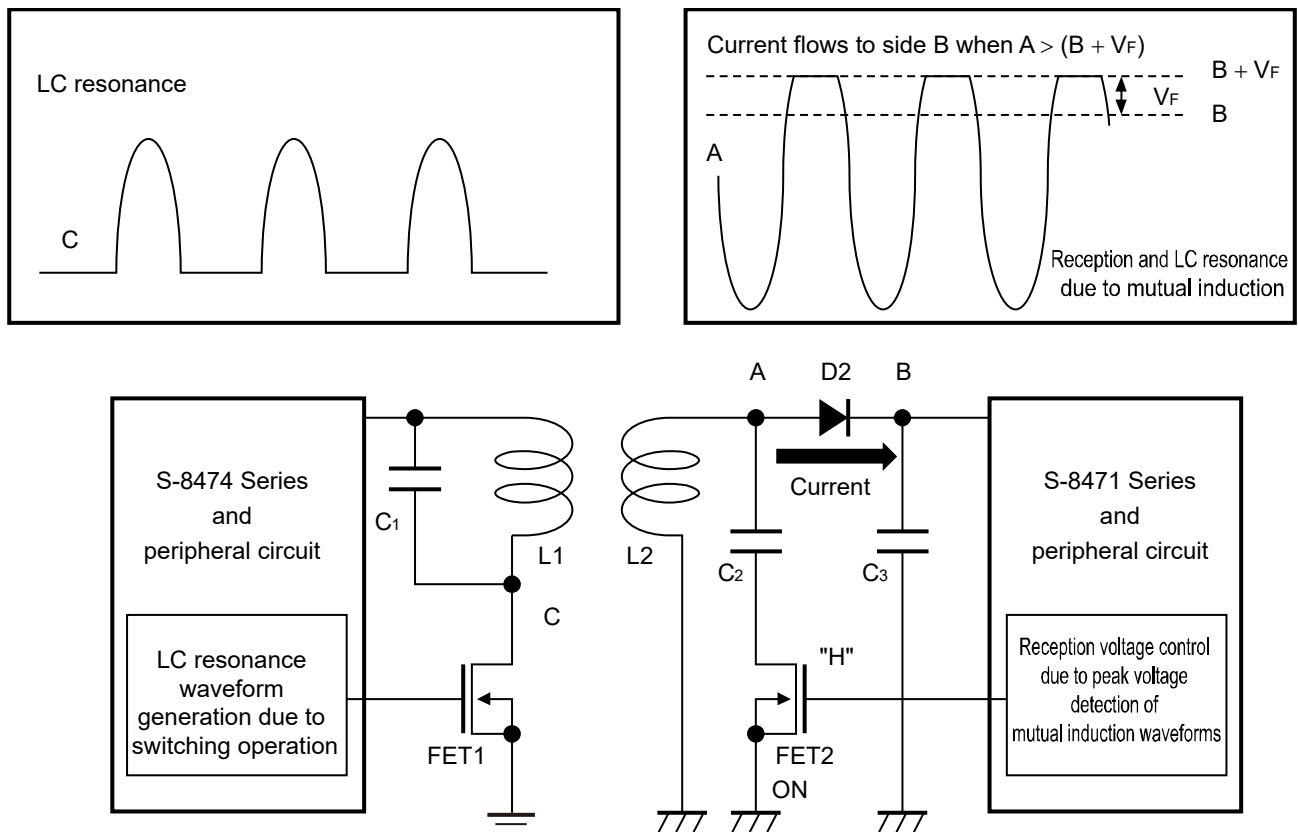
Figure 3 In-phase Coil Voltage Waveform (Non-recommended Example)

1.3 Operation when receiver FET2 is ON

Figure 4 shows a wireless power transfer circuit example and waveforms at particular points in the transmission and reception circuits (A, B and C).

The transmitter performs LC resonance, and detects either the presence of load or whether power has been received in order to perform mode control switching between an intermittent operation mode and a continuous operation mode.

Voltage difference occurs at both ends of the receiver coil L2 due to mutual induction. Receiver LC resonance begins in accordance with the transmitter waveform when receiver FET2 is ON. Rectification current flows and energy is stored by C₃ when the voltage difference between point A and B of the receiver reaches the forward voltage of the diode D2 (V_F).



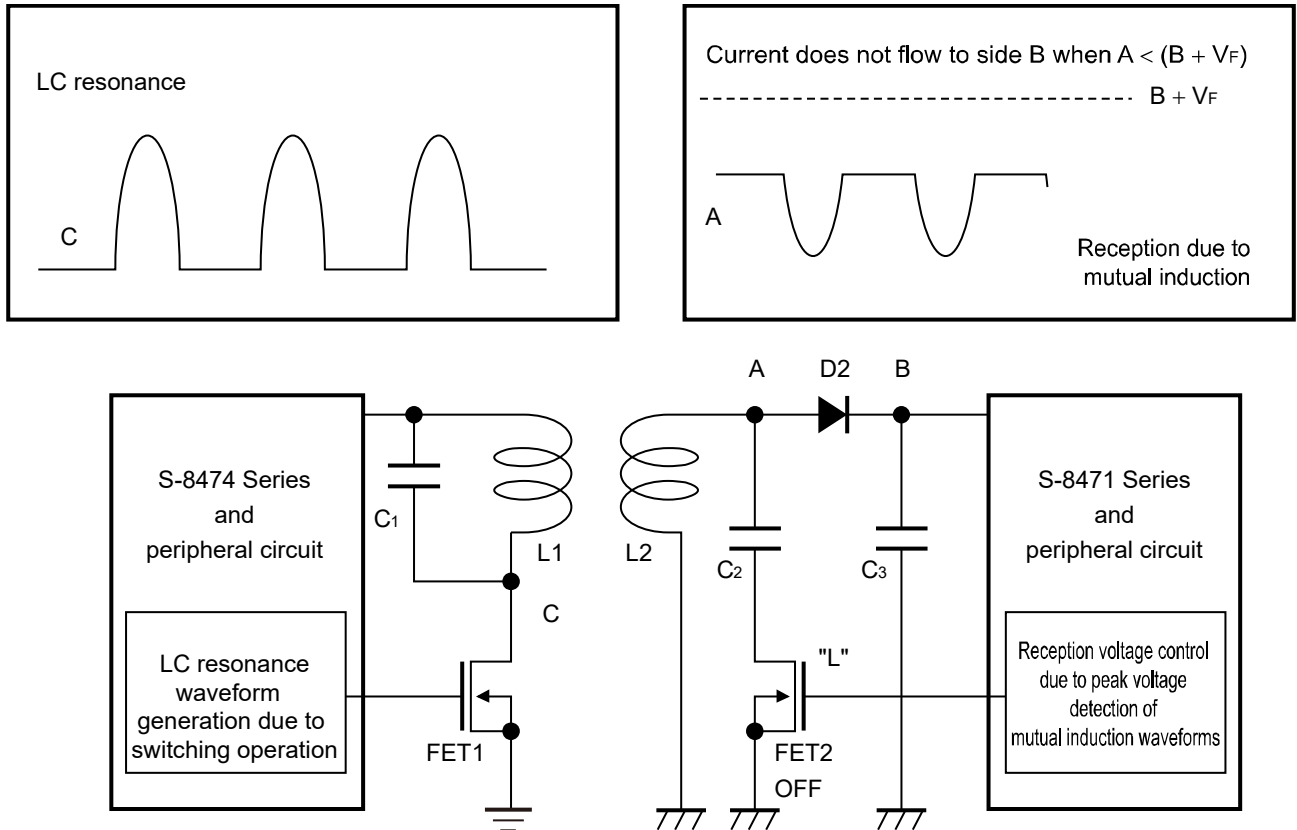
Remark V_F: Forward voltage of the diode D2

Figure 4 Waveforms and Circuit Diagrams of Transmitter and Receiver (FET2 is ON)

1.4 Operation when receiver FET2 is OFF

Figure 5 shows the waveforms when receiver FET2 is OFF. When receiver FET2 is turned OFF, the waveform amplitude at point A is reduced in comparison with that shown in **Figure 4**.

Even if receiver FET2 is turned OFF and a voltage difference occurs at both ends of the receiver coil L2 due to mutual induction in accordance with the transmitter waveform, LC resonance will not be performed. In this case, peak values are lower compared with those of LC resonance, and the voltage difference between point A and point B does not reach the forward voltage of the diode D2 (V_F). For this reason, rectification current does not flow.



Remark V_F : Forward voltage of the diode D2

Figure 5 Waveforms and Circuit Diagrams of Transmitter and Receiver (FET2 is OFF)

1.5 Relation between receiver FET2 control and receiver VDD voltage

Figure 6 shows a conceptual diagram of receiver FET2 control and VDD voltage waveforms. **Figure 7** shows the actual measured waveform. By repetitively turning receiver FET2 ON and OFF, the receiver VDD voltage (point B) transitions between the overvoltage detection voltage (V_{OVP}) and ($V_{OVP} - \text{hysteresis } (V_{HYS})$).

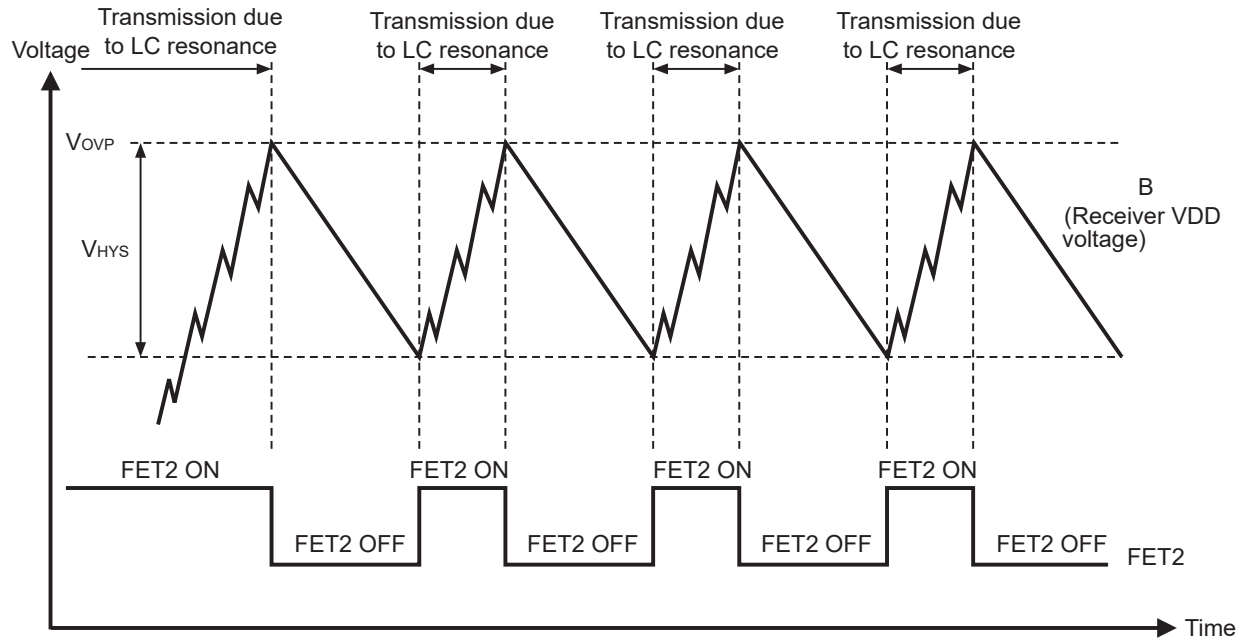
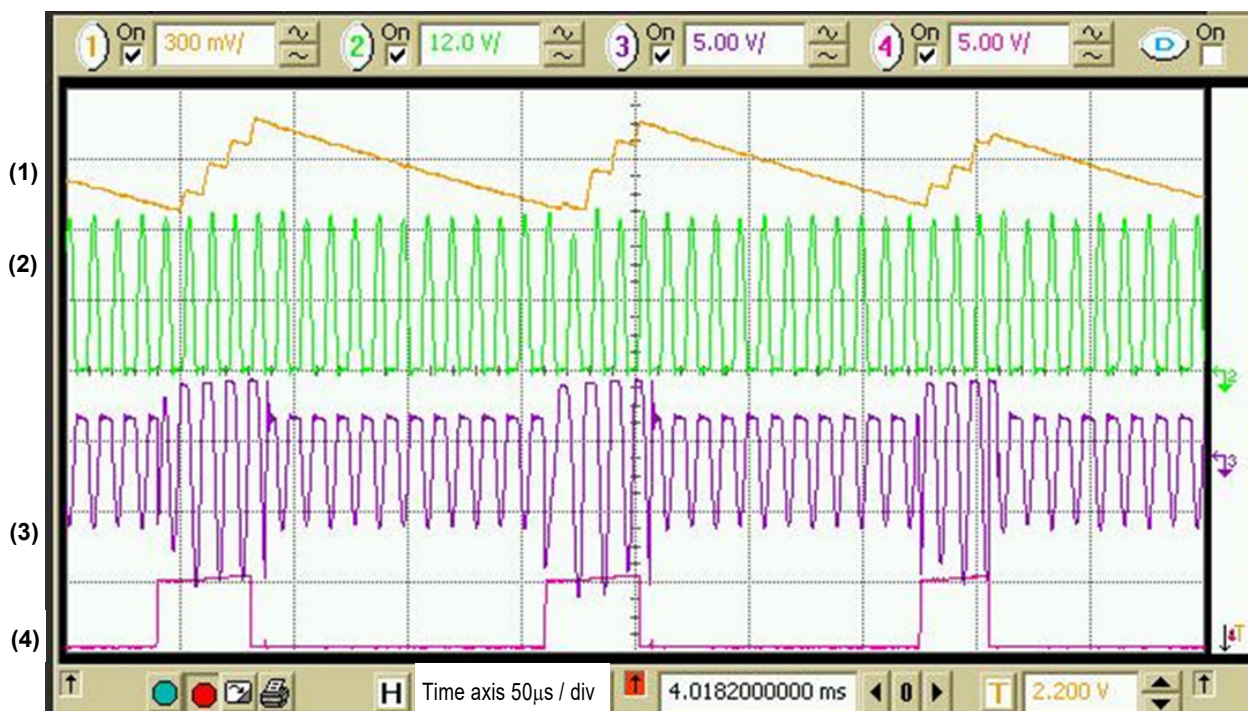


Figure 6 Relation between Receiver FET2 Control and Receiver VDD Voltage (Conceptual Diagram)



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

Figure 7 Relation between VDD, FET2 of Receiver and LC Waveform at Point C of Transmitter (Actual Measured Waveform)

6. Board Design Considerations

- When wiring a board, make a single GND as described in the S-8471 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 49**, 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 49**, do not use a power supply which might cause frequency component amplitude to prevent from malfunction.
- When designing the board in **Figure 49**, 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.

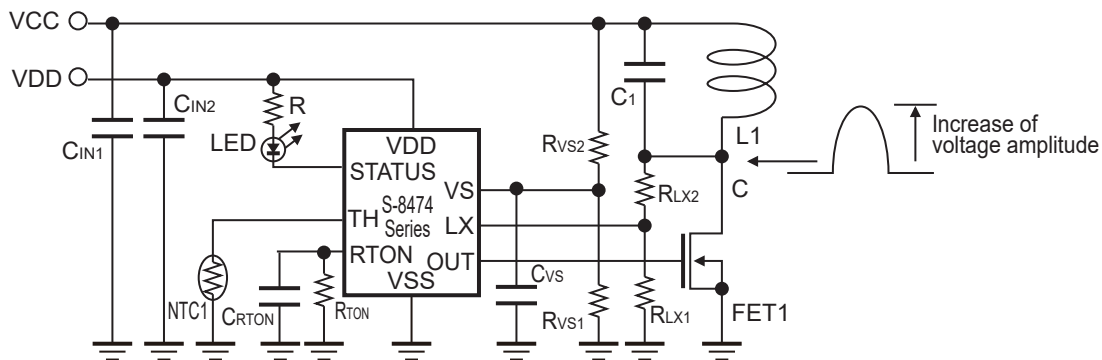


Figure 49

7. 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.

8. Related Sources

Refer to the following datasheets for details of the S-8471 Series and the S-8474 Series.

S-8471 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.