

ETI Evaluation Kit v2.2Tx

User Manual

Rev. 1.0, October 7, 2025

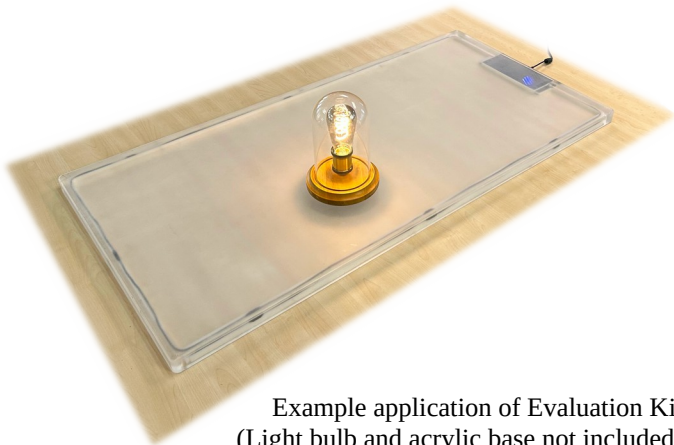


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Features

- Uses 6.78MHz ISM band
- 1 transmitter and 2 LED Field Probes included
- Constant RF current regulation in transmitter
- Autotuned transmitter allows flexible transmitter loop configurations
- Frequency locking for multiple-transmitter systems
- Built-in circuit protection in transmitter

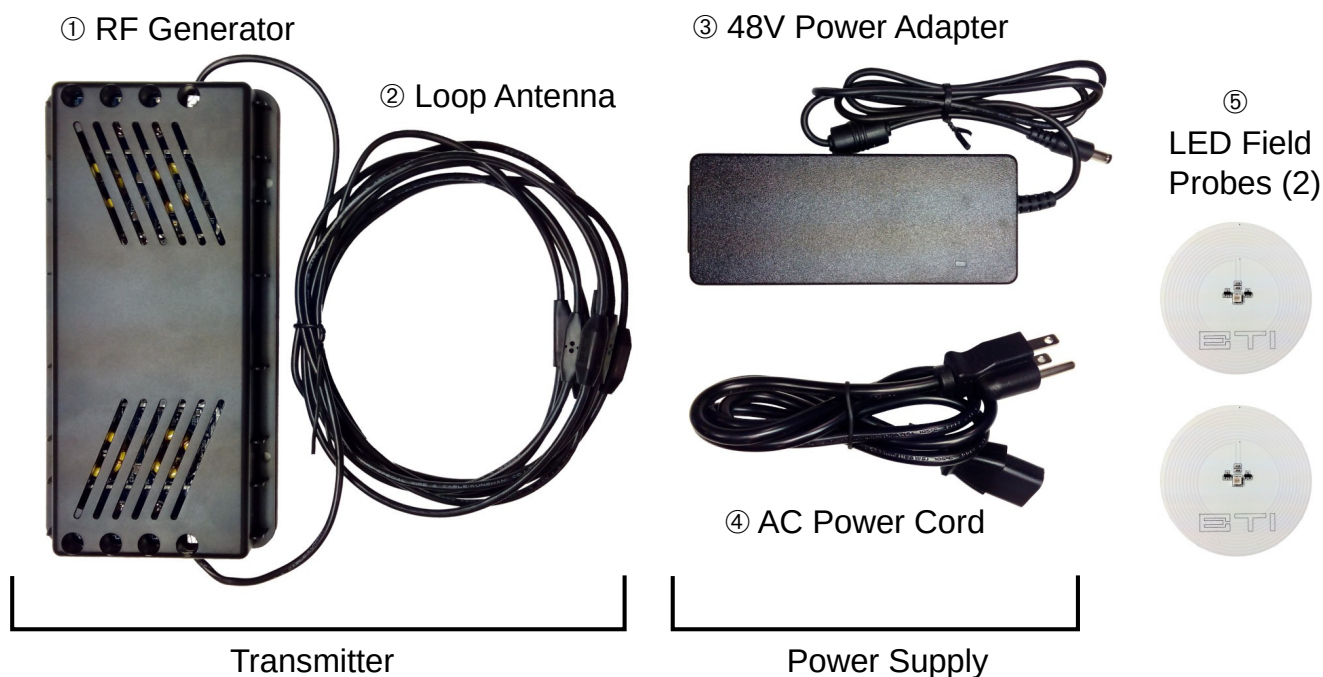


Example application of Evaluation Kit
(Light bulb and acrylic base not included)

Introduction

This Evaluation Kit is intended for quick prototyping using ETI’s Wire-free Power™ technology. It contains one transmitter and 2 LED Field Probes receivers. The transmitter consists of a constant-current RF generator and a magnetic loop antenna which defines the outer dimensions of the power zone. The LED Field Probe can freely move within the power zone while receiving power.

Evaluation Kit Contents

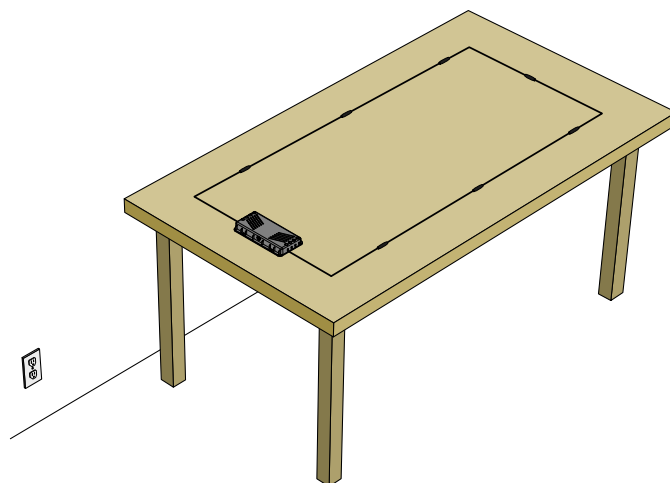


Item #	Item Name	Qty.	Description
1	RF Generator	1	48VDC input. 6.78MHz, 4.3A constant current RF output.
2	Loop Antenna	1	Resonant Magnetic Loop Antenna. 333cm total length.
3	48V power adapter	1	120/240VAC, 50/60Hz input. 48VDC, 2.2A output. 2.5mm barrel.
4	AC power cord	1	North American three prong AC power cord.
5	LED Field Probes	2	Wireless LED for testing system and probing power zone.

Getting Started

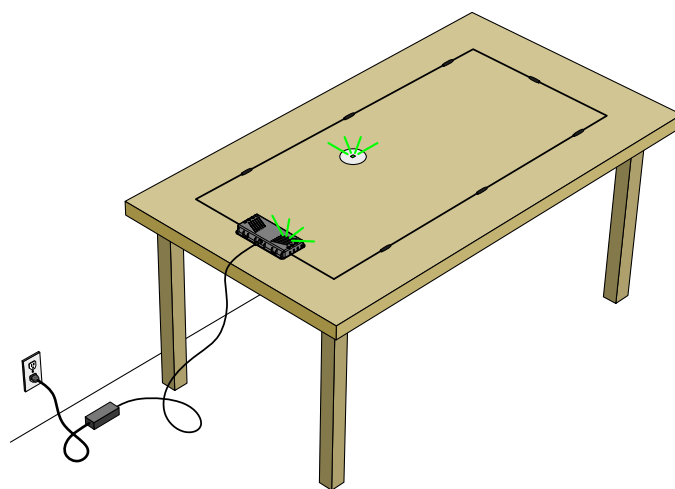
Step 1:

Place the transmitter on a non-metallic table. (Check under the table to ensure the table edge does not have a metal frame.) Arrange the wire loop neatly into a rectangular shape. Ensure the wire lies flat and is not tangled.



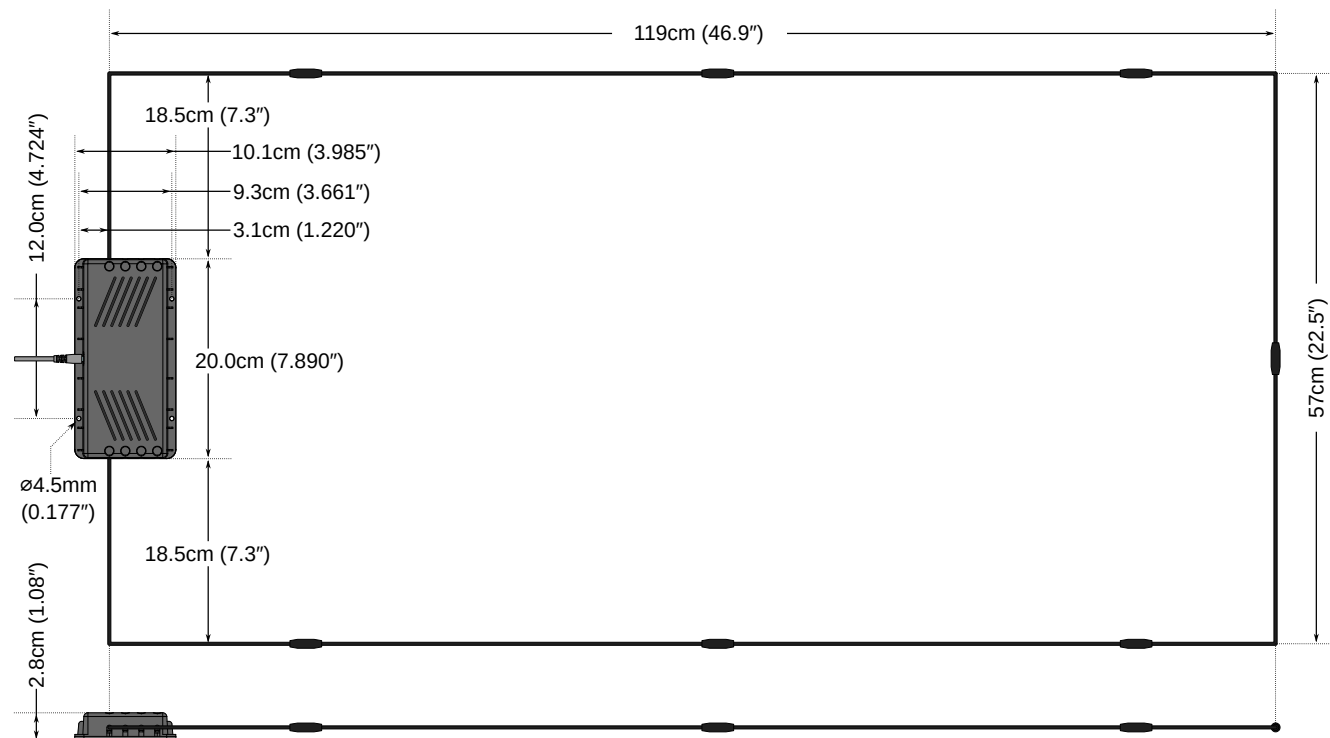
Step 2:

Plug the power supply into an AC outlet and connect the power cable to the transmitter. The Status Light inside the RF Generator should glow continuous green. (See pg. 12, Fig. 16.) If not, or if the Status Light glows red see Troubleshooting (pg. 12). Place a Field Probe on the table inside the Loop Antenna. The LED on the Field Probe should glow continuously. If the Field Probe LED doesn't light, or if it flashes, see Troubleshooting (pg. 12).



Transmitter Specifications

Dimensions



Electrical Parameters

Parameter	Values			Unit
	Min.	Typical	Max.	
Input DC Voltage ¹	10	48	53	V
Input DC Current ²	0.27	-	2.2	A
Input DC Power ²	13.2	-	105	W
Output RF Current	3.9	4.3	4.5	A
Output Frequency	6.765	6.780	6.795	MHz

- 1 The RF current and magnetic field strength are proportional to the input DC voltage (Fig. 13). The provided power supply outputs 48V.
- 2 The maximum and minimum DC current and power are defined at 48V DC input. See Figure 12 for upper and lower DC power limits at other supply voltages. The input power and current will vary depending on the loading condition. (See Fig. 7.) The RF Generator draws the minimum power when unloaded.

Description of Operation

The transmitter consists of an RF Generator and a Loop Antenna. The RF Generator drives a current at a frequency of 6.78MHz through the Loop Antenna, creating an oscillating magnetic field like that shown in Figure 1. Receivers can capture RF power from this oscillating field and convert it to DC power.

The magnetic field can be blocked by metallic surfaces. For optimal operation, minimize the presence and size of metallic surfaces near the Loop Antenna or between the Loop Antenna and the receivers. Do not operate the transmitter on a metallic surface. It will shut down until the metallic surface is removed. (See Troubleshooting, pg 12.)

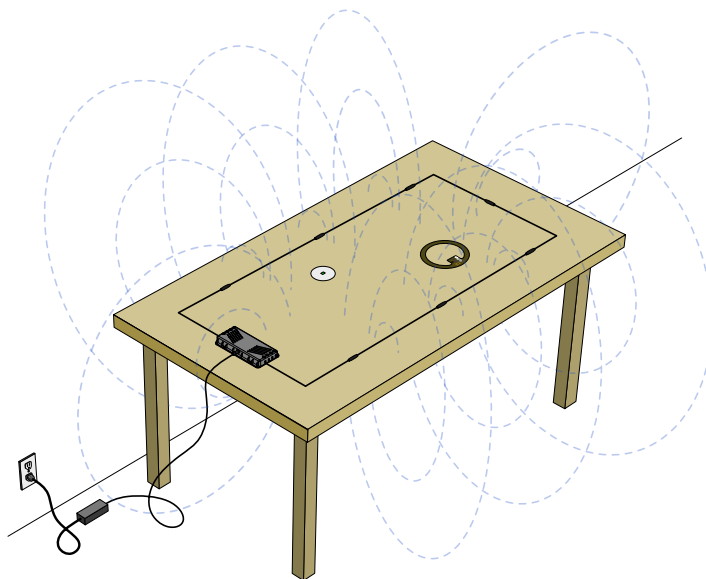


Figure 1: Magnetic field of the transmitter represented by dashed lines.

The RF Generator has multiple functions which maintain stable operation under varying operating conditions. Figure 2 shows a simplified schematic of the RF Generator and the Loop Antenna. The sections below provide detailed descriptions of the functions and behavior of the circuit.

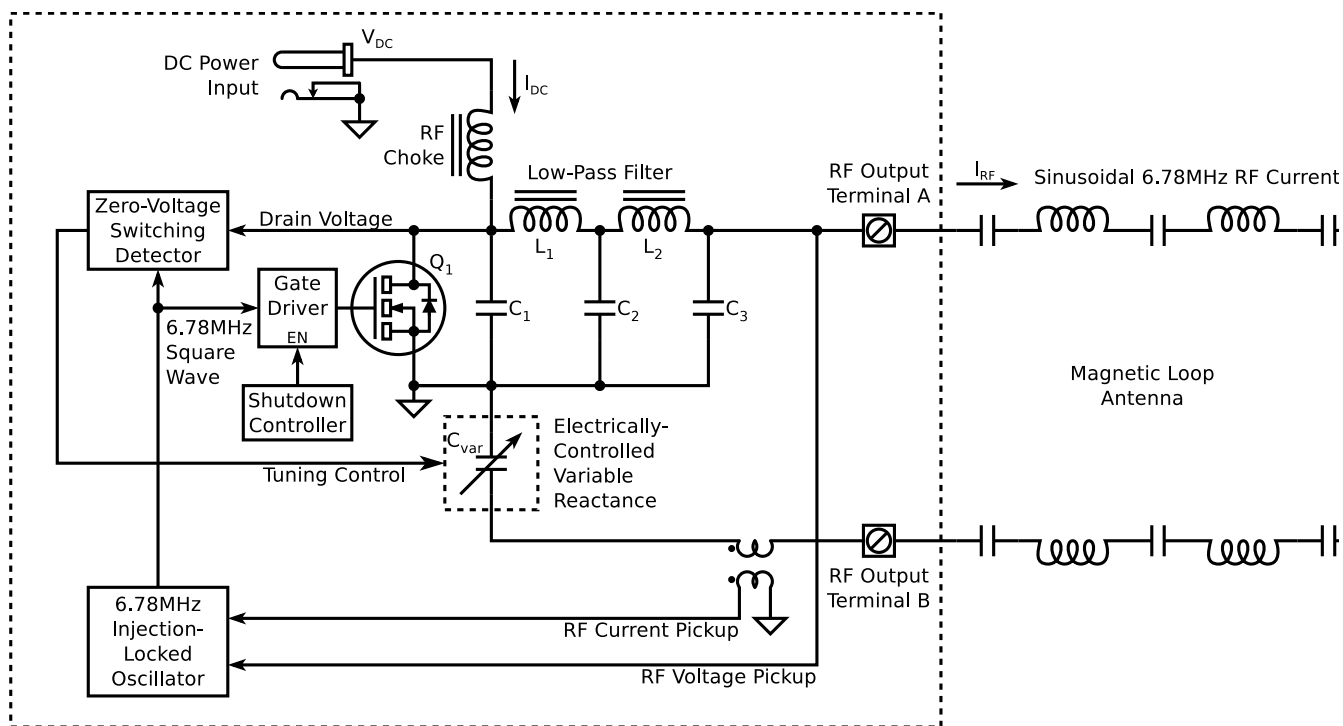


Figure 2: Simplified schematic of the transmitter.

Class-E Amplifier

RF power is generated by a Class-E amplifier, consisting of the Gate Driver, Q_1 , C_1 , and RF Choke. The input to the Class-E amplifier is a 6.78MHz square wave which drives the MOSFET Q_1 in switching mode. As a switching amplifier, the Class-E is very efficient at converting DC power to RF power. (See Fig. 9.) The input DC power draw is not constant, but varies depending on the load power. (See Fig. 7.) The DC power draw has a minimum of about 13.2W when the transmitter is unloaded. This minimum power is required for powering the control electronics and maintaining the magnetic field in the power zone. The minimum power draw may be larger if magnetic or conductive materials are placed within the power zone.

Constant RF Current Output

The output from Terminal A is a constant RF current (I_{RF}) of about 4.3A, which flows through the Magnetic Loop Antenna and returns to Terminal B. The constant-current functionality is achieved through the design of the low pass filter (L_1 , L_2 , C_2 , C_3).^[1] The current amplitude changes by less than 10% over the entire loading range. (See Fig. 11.)

Magnetic Loop Antenna

The Magnetic Loop Antenna generates the magnetic field that fills the power zone and transfers power to the receivers. (See Fig. 15.) The Magnetic Loop Antenna contains multiple series capacitors which cancel the inductive reactance of each segment of wire between the capacitors. This prevents high voltage from accumulating along the antenna and keeps it safe to handle.^[2] However, users should still refrain from touching any bare conductors carrying RF current. Keep the loop and RF terminals covered by insulation at all times when the system is in operation. If the system is to be operated for 30 minutes or longer it is also recommended to keep a minimum distance of 20 cm between the wire loop and the user's body to limit RF exposure. This minimum separation is best achieved by installing the loop within an insulating substrate, such as wood or acrylic.

Autotuning

The output current from Terminal A flows through the Magnetic Loop Antenna and into Terminal B. An electrically-controlled variable reactance is placed between Terminal B and RF ground.^[3] This reactance is automatically controlled by an internal feedback loop to correct for tuning errors in the Magnetic Loop Antenna caused by changes in its shape or by conductive or magnetic objects in its environment. The control signal is generated by a Zero-Voltage Switching (ZVS) Detector, which ensures that Q_1 operates in the efficient ZVS mode. This autotuning functionality makes the system adaptable to a range of different configurations and environments. Figure 14 shows the range of reactance of the Loop Antenna which the RF Generator can accommodate.³ The RF Generator will operate as long as the reactance of the Loop Antenna is between the lower and upper tuning limits. The tuning limits change with supply voltage due to nonlinear MOSFET capacitance. The Loop Antenna provided with the Evaluation Kit is designed to be close to the center of the tuning range when arranged according to the standard loop dimensions specified above.

³ This reactance includes the series inductance of the RF Generator PCB itself. The reactance was measured by shorting both Terminal A and Terminal B to ground, opening a small gap in the Magnetic Loop Antenna, and measuring the impedance across the gap.

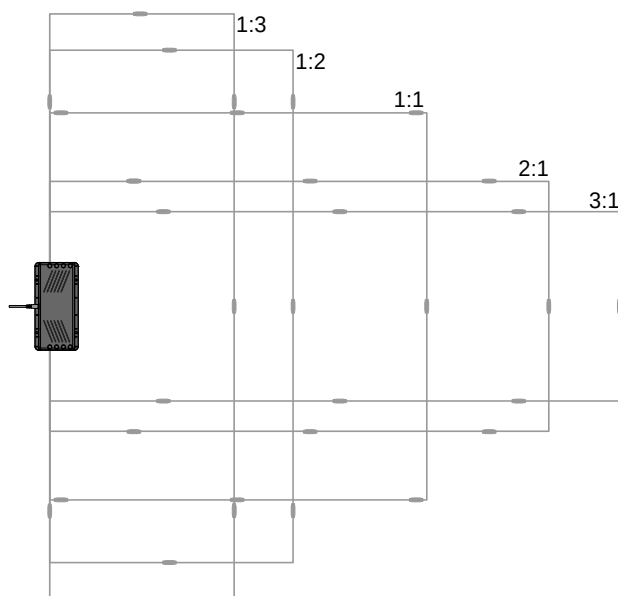


Figure 3: Range of rectangular aspect ratios of the Loop Antenna which may be accommodated by the autotuning function.

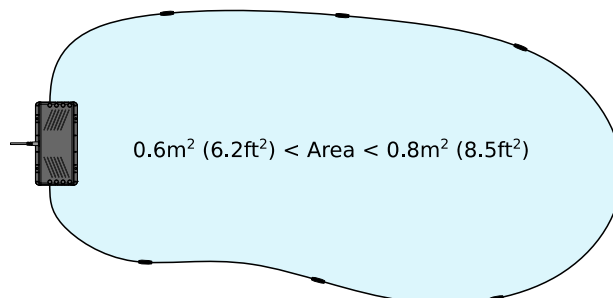


Figure 4: Range of enclosed areas for the Loop Antenna with arbitrary shape which may be accommodated by the autotuning function.

Figure 3 shows how the reactance range translates to a range of loop aspect ratios. When powered from the provided 48VDC power supply, the RF generator can operate with the provided Loop Antenna arranged in a rectangle with an aspect ratio ranging from approximately 1:1 to 3:1. As shown in Figure 4, the RF generator can also operate with the provided Loop Antenna arranged in an arbitrary shape as long as its enclosed area is between approximately 0.6m^2 (6.2ft^2) and 0.8m^2 (8.5ft^2). If the Magnetic Loop Antenna dimensions exceed the upper or lower limits of this range, or if the Magnetic Loop Antenna is perturbed by conducting or magnetic materials in its environment, the transmitter may shut down. If this occurs, adjust the loop area and/or remove the perturbing materials.

The autotuning circuit has blue and yellow indicator LEDs which show the level of the tuning control signal. (See Fig. 18.) Yellow indicates a high reactance of the loop, and blue indicates a low reactance.

Frequency-Locking

When multiple transmitters are placed in proximity to each other, they are able to lock frequencies and oscillate together without interference. This is achieved using an Injection-Locked Oscillator, which generates the gate-drive square wave for the Class-E amplifier.[4] The input signal to the Injection-Locked Oscillator comes from a combination of voltage and current pickup signals from the Magnetic Loop Antenna. These pickup signals allow the Injection-Locked Oscillator to sense the signal coming from a nearby transmitter. It will naturally lock to the same frequency as long the signal is strong enough.⁴

⁴ The frequency-locking function causes the frequency of the RF Generator to shift slightly in response to an RF load. See Figure 10 for a typical example of the relation between frequency and RF load power.

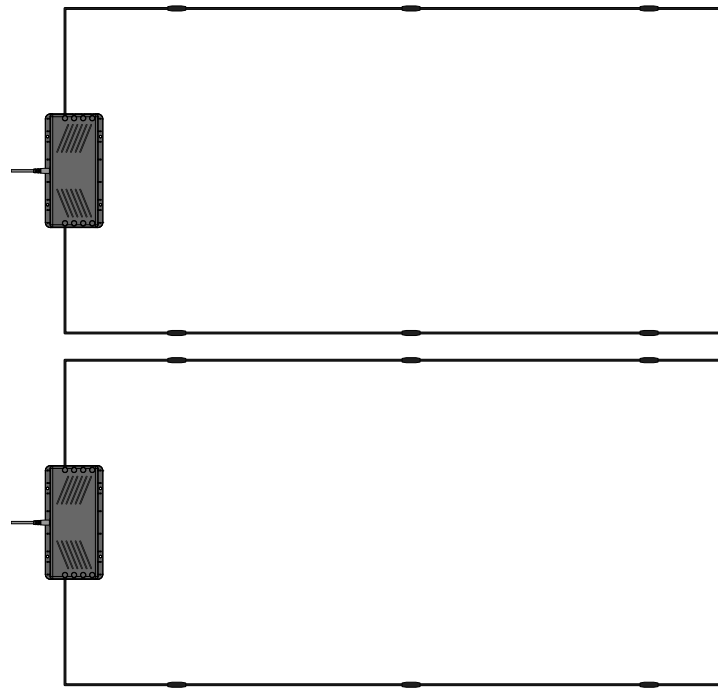


Figure 5: Two frequency-locked transmitters.

To frequency-lock two transmitters, place them adjacent to each other so that the wires on two sides of the Loop Antennas run parallel to each other, as shown in Figure 5. Keep at least 5cm (2") of separation between the wires and apply power to both transmitters. If one or both transmitters shut down, increase the separation.

Circuit Protection

The Shutdown Controller has multiple sensors which will shut down the RF Generator if a problem is detected in order to protect the RF Generator from potential damage. The sensors include an over-temperature sensor, an over-current sensor, an over-voltage sensor, and a tuning-limit sensor. The over-temperature sensor will shut down the RF Generator if the board temperature exceeds 75°C (167°F). The over-current sensor will shut down the RF Generator if the input DC current exceeds 2.2A. The over-voltage sensor will shut down the RF Generator if the input DC voltage exceeds 53V, or if the peak drain voltage of Q₁ exceeds 150V. The tuning-limit detector detects if the autotuning control loop has reached either the upper or the lower end of its range, and will shut down the RF Generator if the imaginary part of the Magnetic Loop Antenna impedance exceeds the limits shown in Figure 14.

When the RF Generator is shut down, a red indicator LED will illuminate, and the RF Generator will remain in the shut-down state for at least half a second, or as long as the problem condition persists. Once a half-second has elapsed or the problem condition has been removed, the RF Generator will attempt to re-start. If a problem condition is sensed, another shut down will be triggered. Otherwise, the RF Generator will resume normal operation. In normal operation, a green indicator LED will illuminate. (See Locations and Colors of LED Indicators on RF Generator, pg. 12 for photos of indicator LEDs.)

Air-cooling

The RF Generator will generate between 7W and 15W of heat in normal operation, depending on the loading condition. (See Fig. 8.) The RF Generator housing contains vents (see Fig. 6) which are designed for convective air cooling. Install the RF Generator in a location which permits free air flow and do not block the vents. When mounting the RF Generator in an enclosed space, an external fan may be required to prevent an over-temperature shutdown.

Do not allow liquid or debris to enter the air vents, as any stray material inside the case may cause electrical shorts on the internal circuit board.

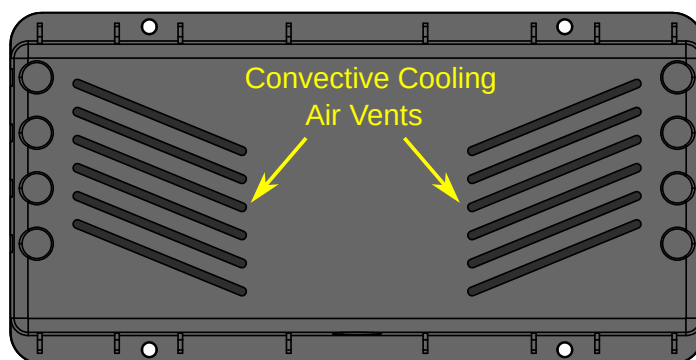


Figure 6: Top view of RF Generator case.

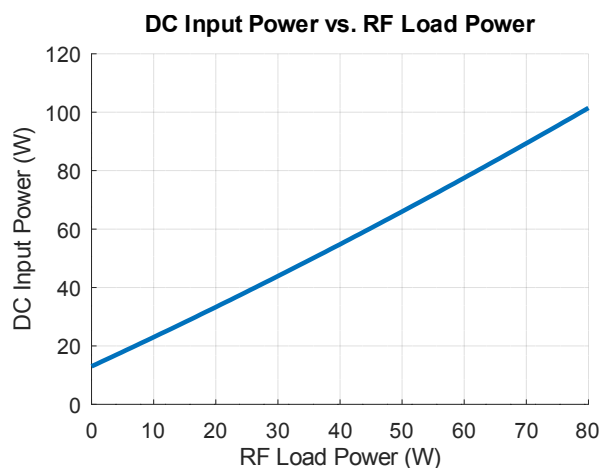


Figure 7: Test conditions: 48V, standard loop.

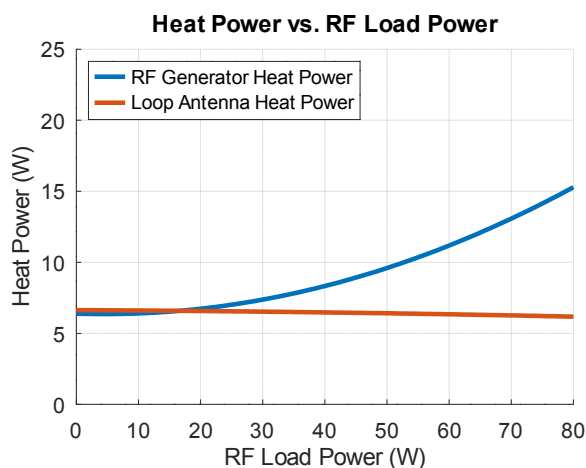


Figure 8: Test conditions: 48V, standard loop.

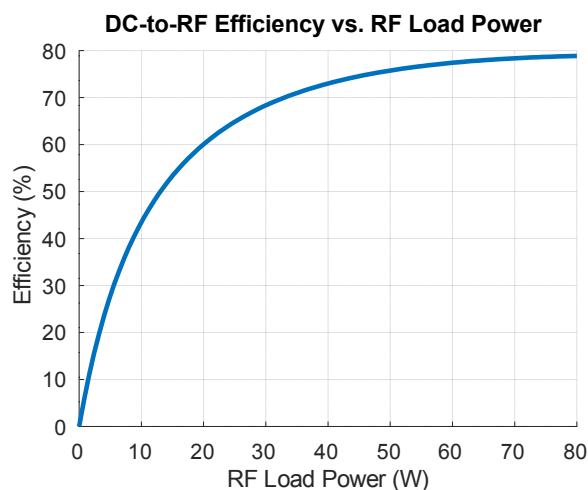


Figure 9: Test conditions: 48V, standard loop.

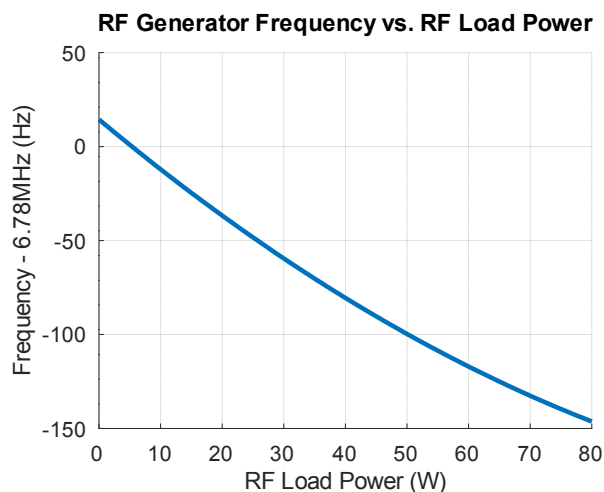


Figure 10: Test conditions: 48V, standard loop.

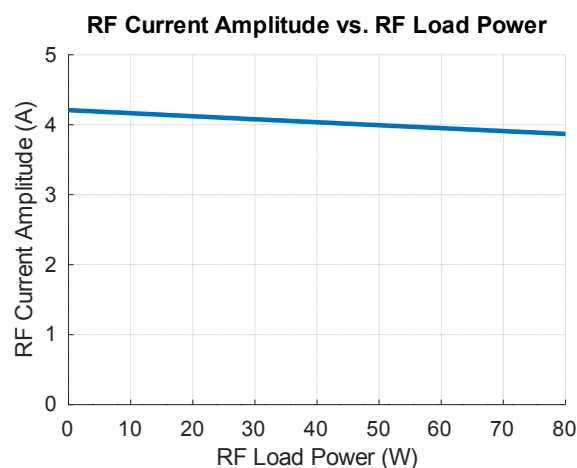


Figure 11: Test conditions: 48V, standard loop.

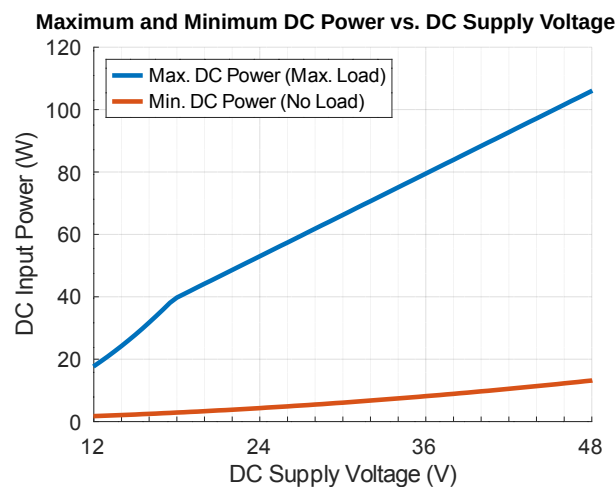


Figure 12: Test conditions: standard loop.

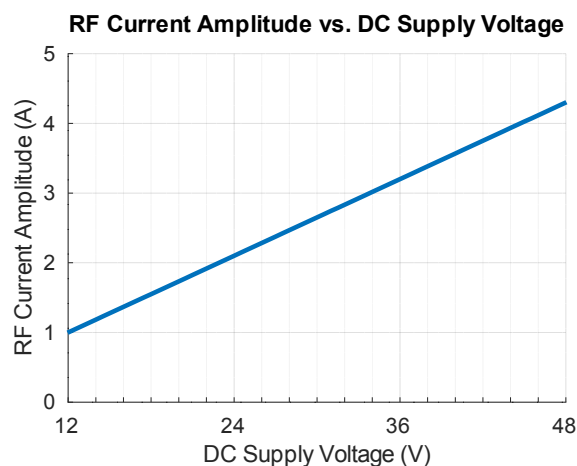


Figure 13: Test conditions: standard loop.

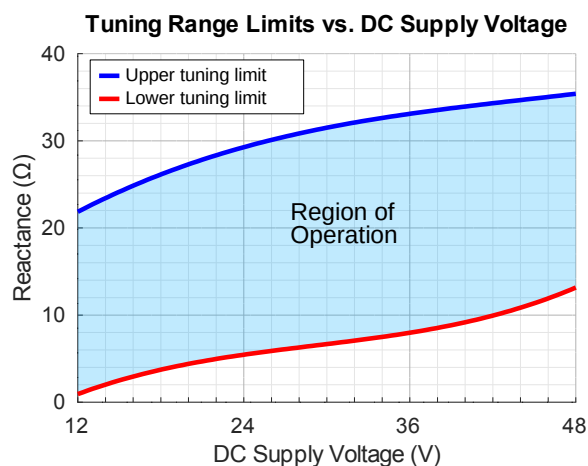


Figure 14: Test conditions: standard loop.³

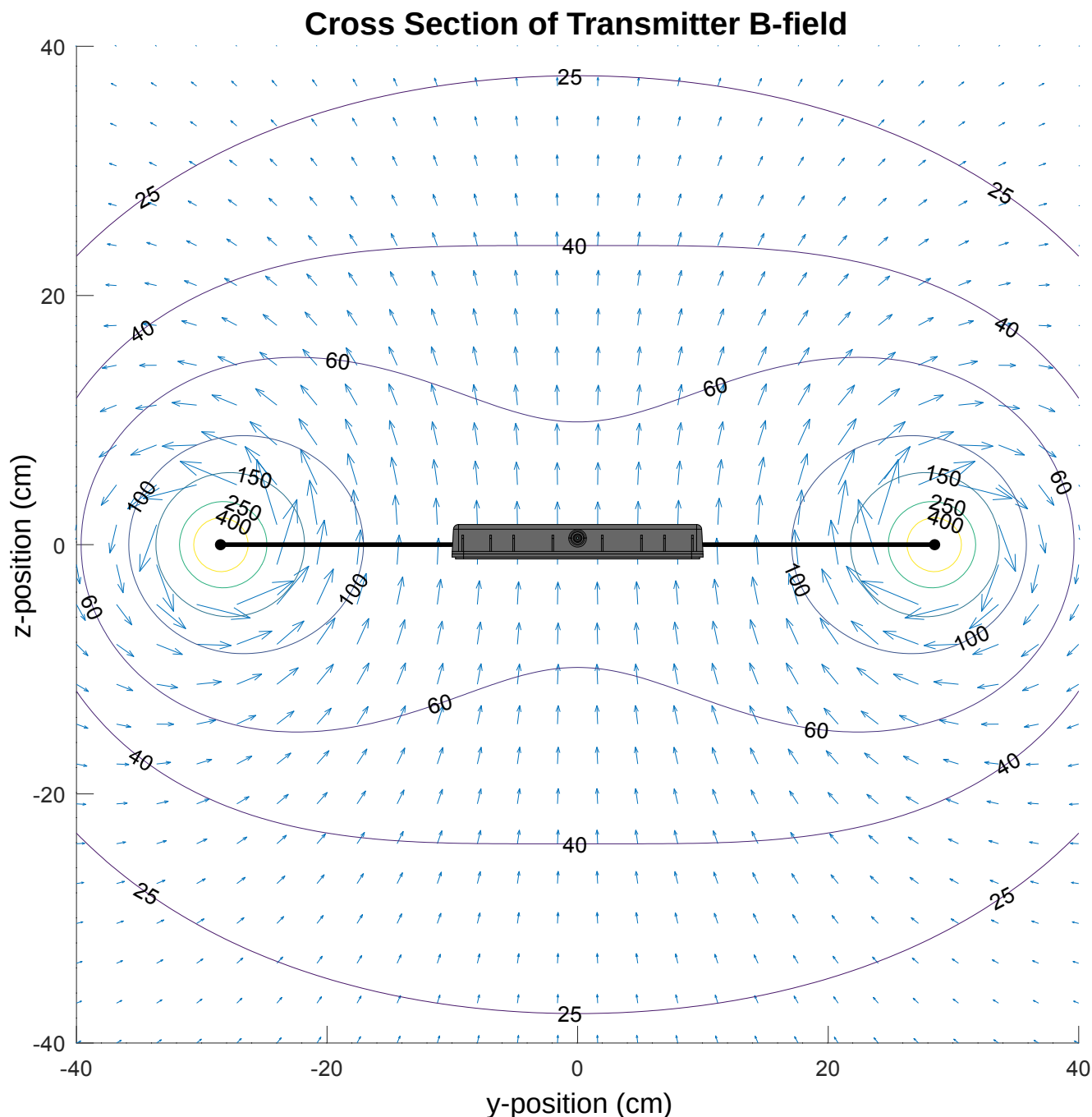


Figure 15: A vertical cross-section of the magnetic field of the transmitter in a plane passing through the center. The vector lengths indicate the magnitude of the B-field and their orientation indicates its direction at each point. The contours show the magnetic field strength in mGauss. The magnetic field is strongest in the near vicinity of the wire loop. If the system is to be operated for 30 minutes or longer it is recommended to keep a minimum distance of 15mm between the wire loop and the user's body to limit RF exposure.

Troubleshooting

Locations and Colors of LED Indicators on RF Generator



Figure 16: Green status indicator. An illuminated green LED indicates the RF Generator is operating properly and is outputting RF current.



Figure 17: Red status indicator. An illuminated red LED indicates a problem has been detected and the RF Generator has automatically shut down.



Figure 18: Yellow/Blue autotuning indicator. The color changes from yellow to blue as the tuning is changed. In shutdown mode, it glows yellow.

Problems and Solutions

Problem	Solution
Status lights not illuminated .	Check that the power supply is plugged in to a working AC outlet and the 2.5mm barrel connector is plugged in to the RF Generator.
Status light red or red with flashing green . No receivers in transmitter loop.	Verify that the transmitter is not placed on or near a metallic or conducting surface. Some tables may have an internal metal frame. Try moving the transmitter to a different surface. Make sure that the Loop Antenna lies flat and is fully extended.
Status light red or red with flashing green . Receivers present in transmitter loop.	The transmitter may be overloaded. Try removing receivers from the power zone. If the red LED is still illuminated after removing the receivers, verify that the transmitter is not placed on or near a metallic or conducting surface. Some tables may have an internal metal frame. Try moving the transmitter to a different surface. Make sure that the Loop Antenna lies flat and is fully extended.

Problem	Solution
Status light illuminated green . Receiver: no power output .	Try bringing the receiver closer to the transmitter, or changing its angle relative to the Loop Antenna. Check that no metallic objects or other receivers are in the proximity of the receiver. If there is still no power output from the receiver, check if the receiver is overloaded or shorted. Try removing the load and checking the receiver's output voltage.
Status light illuminated green . Receiver: low output voltage .	Try bringing the receiver closer to the transmitter, or changing its angle relative to the Loop Antenna. If voltage is still low, check if the receiver is overloaded. Try removing the load and checking voltage again.
Status light illuminated green . Receiver: full output voltage . Device: abnormal operation	If the device is receiving full voltage, but not operating properly, check the peak power draw of the device and ensure that the receiver can supply both the average power and the peak power requirements of the device. (Some devices draw short pulses of current.) If the device peak power draw is below the receiver output power limit and the device is still not operating properly, check that the device power supply requirements are compatible with the receiver output voltage ripple.

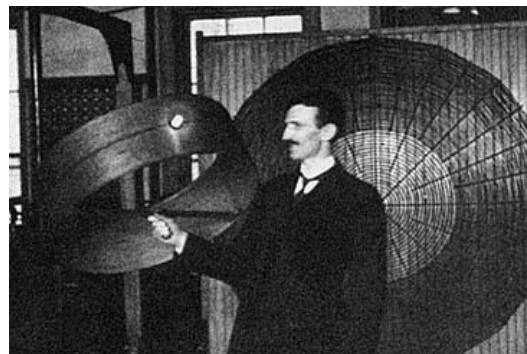
FCC STATEMENTS

This device complies with Part 18 of the FCC rules.

The ETI Evaluation Kit is not susceptible to interference. It may cause interference to nearby devices operating at ISM frequencies, such as 6.78MHz, 13.56MHz, or 433.92MHz, and it may also cause interference to capacitive touch sensors. If a nearby device experiences interference, (1) increase the distance between the device and the ETI Evaluation Kit, (2) ensure that the power cable for the ETI Evaluation Kit does not run close to the Magnetic Loop Antenna of the Evaluation Kit, (3) add an AC line filter or a clamp-on RF choke to the AC power line of the ETI Evaluation Kit, and/or (4) plug the ETI Evaluation Kit into an AC electrical circuit which is not shared by the device experiencing interference.

How Magnetic Resonance Works

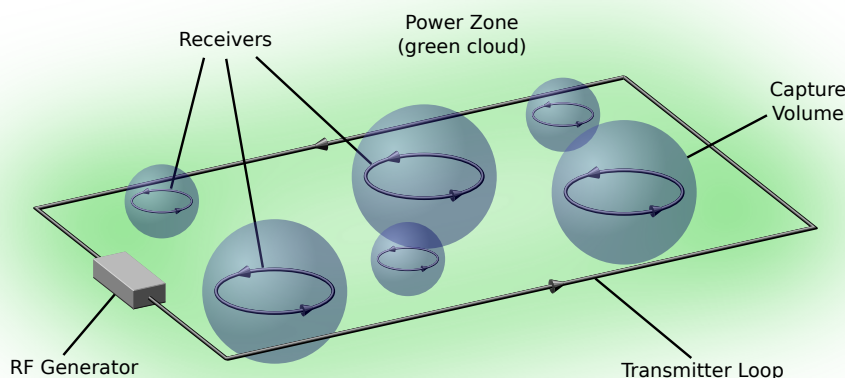
The history of wireless power dates back to the work of Nikola Tesla in the late 1800's. Tesla discovered that resonance (i.e. the tendency of a system to ring at a certain frequency when disturbed) allows power to be transferred efficiently between two coupled electrical systems, even if the coupling is weak. This is because resonance allows the energy in both systems to accumulate over many cycles, as long as both systems are tuned to, and driven at, the same frequency. As a result, the electrical amplitudes are much stronger than if the systems were non-resonant.



ETI Technology follows Tesla's approach by using resonant transmitters and receivers which are coupled through magnetic induction. Both electric and magnetic fields can be used to transfer power, but ETI Technology primarily uses magnetic fields due to their weak interaction with the human body.

ETI's magnetic resonance wireless power systems generate magnetic fields which oscillate at 6.78MHz. This frequency is low enough that most of the magnetic energy does not radiate away into space as waves, but rather stays localized in the vicinity of the transmitter in a region called the "power zone" (green cloud in diagram below). As the magnetic field expands and collapses, resonant receiver loops capture some of the magnetic energy contained within a volume of space surrounding each receiver. These capture volumes (gray spheres in diagram below) are proportional to the cube of each receiver resonator's diameter multiplied by its quality factor.[5]

Any magnetic energy that is not captured by receivers is returned to the transmitter when the magnetic field collapses. Some of this returned energy is lost as heat in the transmitter. The rest returns to the power zone as the field expands again. An RF generator continually replenishes the energy lost during each cycle. Its power draw depends on the sum of the energy lost to heat and the energy captured by the receivers. The system becomes more efficient as more receivers are added because more energy is captured and delivered to the loads relative to the constant energy lost per cycle in the transmitter.



Example Applications of ETI Technology



Figure 19: 4ft Ø loop with 91 LED receivers attached to bases of wineglasses.



Figure 20: [Airbrite](#)TM lighting display consisting of one active and two 24cm×48cm repeater resonator mats. Decorative glass objects are illuminated from the bottom by wireless LED receivers.

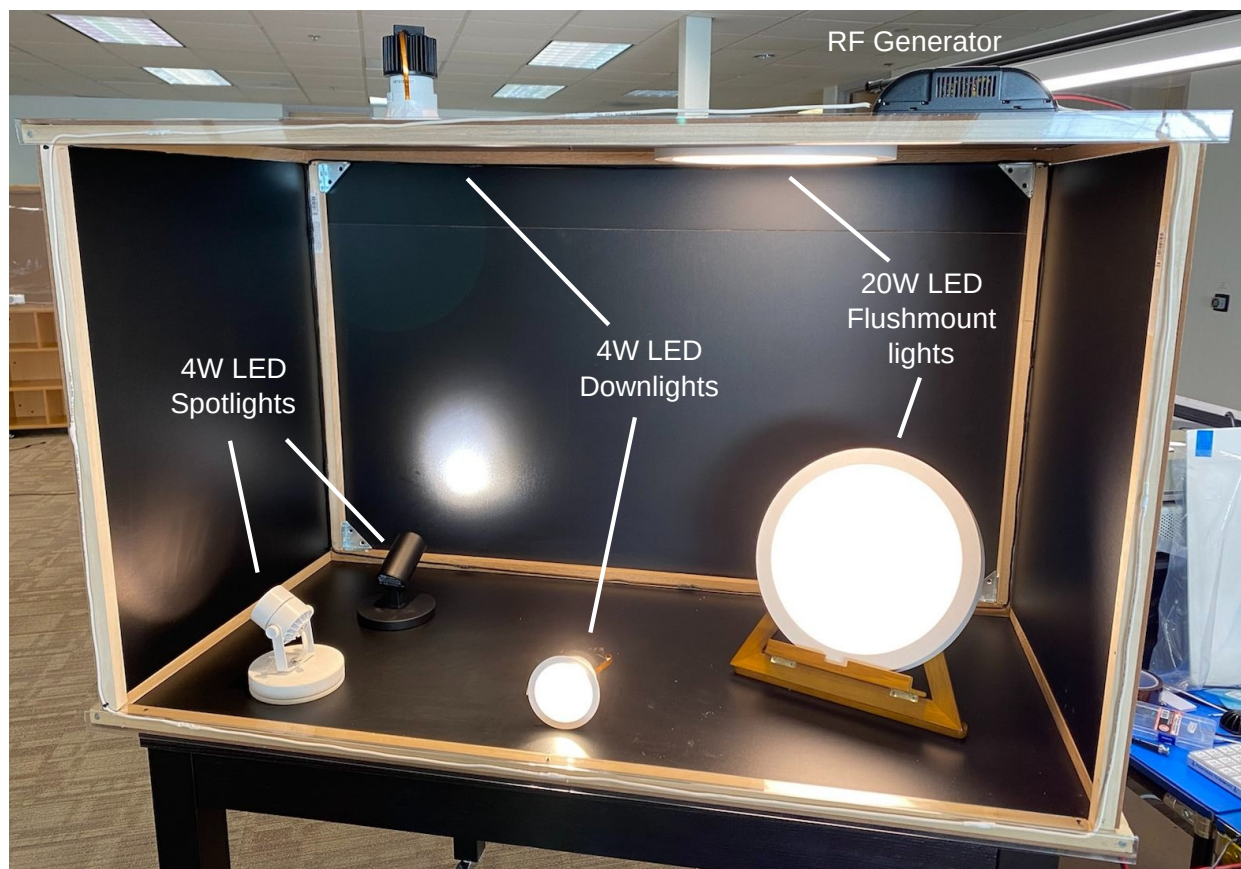


Figure 21: Wireless lighting powered by one active loop and one repeater loop (120cm×74cm).

Contact Information

Mailing Address

Etherdyne Technologies, Inc.
2933 Bunker Hill Lane
Suite 210
Santa Clara, CA 95054

E-mail

contact@etherdyne.net

Discord

<https://discord.gg/f2UGU4Vzkt>

LinkedIn

<https://www.linkedin.com/company/etherdyne>

YouTube

<https://www.youtube.com/@wirefree-power>

References

- 1: R. A. Moffatt and G. Popović, Load-Independent ZVS Class-E Inverters and Active Rectifiers Using Möbius Transform Filters, 2025 IEEE Wireless Power Technology Conference and Expo (WPTCE), 2025, doi: 10.1109/WPTCE62521.2025.11062138
- 2: R. A. Moffatt, T. Howarth, C. Gafner, J. J. Yen, F. -K. Chen and J. Yu, A Distributed, Phase-locked, Class-E, RF Generator with Automatic Zero-Voltage Switching, IEEE Wireless Power Transfer Conference (WPTC), 2019, doi: 10.1109/WPTC45513.2019.9055602
- 3: R. A. Moffatt, Continuously Variable Active Reactance, 2020 IEEE Wireless Power Transfer Conference (WPTC), 2020, doi: 10.1109/WPTC48563.2020.9295561
- 4: R. A. Moffatt and G. Popovic, A Modular Wireless Power Source Consisting of Injection-Locked RF Generators, 2023 IEEE Wireless Power Technology Conference and Expo (WPTCE), 2023, doi: 10.1109/WPTCE56855.2023.10216192
- 5: R. A. Moffatt, Geometric Quantities Characterizing Wireless Power Transfer Between a Resonator and Resonant Dipoles, IEEE Wireless Power Transfer Conference (WPTC), 2019, doi: 10.1109/WPTC45513.2019.9055581

Patents

For a list of ETI's patents, please visit: <https://www.etherdyne.net/patents>.