

NU1619EVM WPC Wireless Receiver Evaluation

Module Application Note

NU1619 wireless charging receiver solution is a high-efficiency, low-cost and easy-to-use wireless receiving solution. It provides 5V/1A, 10V/1A, 15V/1A output power; when used with the wireless charging transmitter module of NU1020+NU1513, it can provide a maximum output power of 19V/2.3A. At the same time, output voltage and maximum output current can be changed by I2C. Reverse charging can output 10W rated power. This solution meets the WPC Qi protocol requirements.

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1. Applications

NU1619 Evaluation Module (EVM for short) is a complete single chip solution of wireless charging receiver solution and reverse charging transmitter. EVM has advantages of high efficiency and low cost, which can not only reduce the difficulty of customer design, but also retain the differentiation of using. EVM meets the Baseline Power Profile (BPP) receiving standard in the latest WPC Qi protocol, and can output a rated power of 5W/5V/1A. It meets the Extended Power Profile (EPP) receiving standard in the latest WPC Qi protocol, and can output rated power of 15W/12V/1.3A and 40W/19V/2.3A. When used with the transmitter module NU1020+NU1513, the maximum output power is 40W/19V/2.3A. EVM meets the reverse charging transmitter standard in the latest WPC Qi protocol, and can output up to 10W of power.

The main features of EVM are as follows:

- Meets the BPP standard of WPC V1.2.4, and can output a rated power of 5W/5V/1A.
- Meet the EPP standard of WPC V1.2.4, and can output rated power of 15W/12V/1.3A and 40W/19V/2.3A.
- When matched with the transmitter module NU1020+NU1513, it can output a maximum power of 40W/19V/2.3A.
- Reverse charging meets the BPP standard of WPC V1.2.4 and can output a rated power of 10W.
- At 15W output, the full load efficiency is greater than 82%, and the peak efficiency is 82.4%. At 40W output, the full load efficiency is greater than 85.5%, and the peak efficiency is 86.5%. ①
- With ASK and FSK functions, two-way communication
- With digital demodulation (DDM)
- With accurate foreign object detection (FOD)
- Overvoltage protection of rectified voltage, overcurrent protection of output current
- The output voltage and current can be adjusted through I2C
- The output voltage of external DC/DC can be controlled by the built-in PWM signal

Note ① : 1: The wireless charging transmitter of NU1020+NU1513 is used for testing the receiving efficiency.

2: NU1619 is used as the wireless charging receiver, when testing reverse charging efficiency.

2. Schematic and BOM

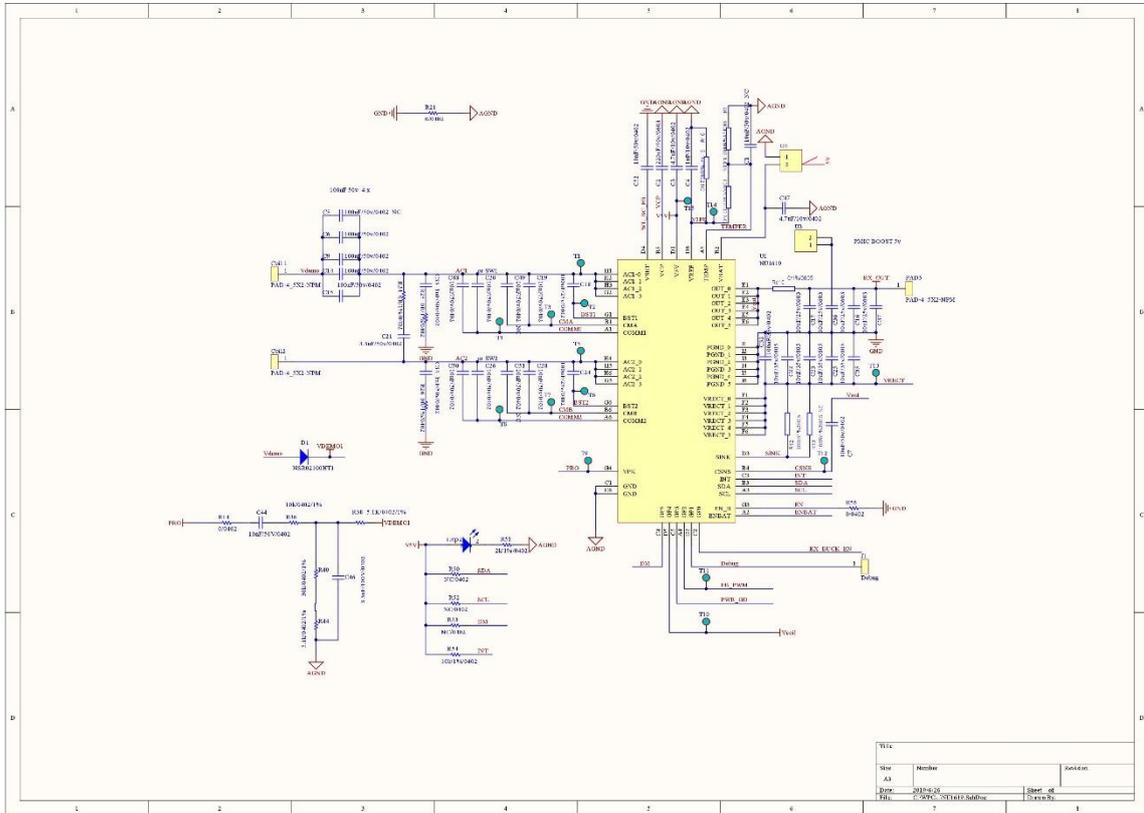


Figure 1: Schematic of 1619 EVM

Table 1: BOM

Description	Designator	Quantity
10nF/50v/0402 NC	Capacitor C1, C48	0
220nF/50v/0603	Capacitor C2	1
4.7uF/10v/0402	Capacitor C3, C47	2
1uF/10v/0402	Capacitor C4	1
100nF/50v/0402 NC	Capacitor C5	0
100nF/50v/0402	Capacitor C6, C9, C14	3
10nF/50v/0402	Capacitor C7, C19, C20, C26, C28, C44, C49, C51, C52	9
NC	Capacitor C8	0
C/10uF/25v/0603 NC	Capacitor C10, C11, C12, C38, C39	0
100nF/25v/0402 NC	Capacitor C13, C30, C31	0
100nF/50v/0402	Capacitor C15	1
10uF/25v/0603	Capacitor C16, C17, C36, C37	4
100nF/25v/0402	Capacitor C18, C24	2

3.3nF/50v/0402	Capacitor	C21	1
10uF/35v/0805	Capacitor	C22, C23, C25, C35	4
1uF/10v/0402 NC	Capacitor	C27	0
10uF/25v/0603 NC	Capacitor	C29	0
100nF/35v/0402	Capacitor	C32	1
1nF/50v/0402	Capacitor	C33, C34	2
100nF/35v/0402 NC	Capacitor	C40	0
47nF/50V/0402 NC	Capacitor	C41	0
1nF/50V/0402 NC	Capacitor	C42	0
47nF/50V/0402 NC	Capacitor	C43	0
6.8nF/100V/0402 NC	Capacitor	C45	0
3.3nF/100V/0402	Capacitor	C46	1
10nF/50v/0402 NC	Capacitor	C50	0
NSR02100HT1	Diode	D1	1
Inductor	Inductor	L1	0
Red LED	Typical RED, GREEN, YELLOW, AMBER GaAs LED	LED1 NC, LED2	1
100K/1%/0402 NC	[NoValue], Resistor, Resistor, [NoValue]	R1, R22, R33, Rc8	0
470K/0.5%/0402 NC		R3	0
240K/1%/0402 NC		R4	0
3.3K/1%/0603 NC		R5	0
510k/1%/0402 NC		R6	0
20K/1%/0402 NC		R7	0
120K/0.5%/0402 NC		R8	0
30K/1%/0402 NC		R9	0
51K/1%/0402 NC		R10	0
43K/1%/0402 NC		R11	0
600R/1%/0805		R12	1
100R/1%/0805 NC		R13	0
0/0402	Resistor	R14, R21, R56	3
5.1K/1%/0402 NC		R15	0
0/0402 NC	Resistor	R16, R17	0
470/1%/0402 NC	Resistor	R18	0
120K/1%/0402 NC		R19	0
4.99k/1%/0402 NC	Resistor	R23	0
0R/1%/0402	Resistor	R24, R25, R26	3
10k/0402/1%	Resistor	R36	1
0/0402/1%	Resistor	R37	1
5.1K/0402/1%	Resistor	R38, R44	2
30k/0402/1%	Resistor	R40	1

100k/1%/0402 NC	Resistor, [NoValue]	R41, RT1	0
NC/0/0402/1%	Resistor	R43	0
NC/0402	Resistor	R50, R52, R53	0
2k/1%/0402	Resistor	R51	1
10k/1%/0402	Resistor	R54	1
22/1%/0402 NC		Rc2	0
NC		Rc4	0
10K/1%/0402 NC		Rc9	0
0/1%/0805		Rc10	1
NU1619		U1	1
mp2229	BUCK	U5	0

2.1 Layout Guidelines

The NU1619EVM PCB is a 4-layer design with an area of 65mm*65mm and a copper thickness of 1oz. The middle area places the NU1619 chip and its main external circuit components, and the surrounding area is test signal terminals, which is convenient for testing, configuring and evaluating system performance. There are four mechanical holes in the four corners in order to fix the PCB.

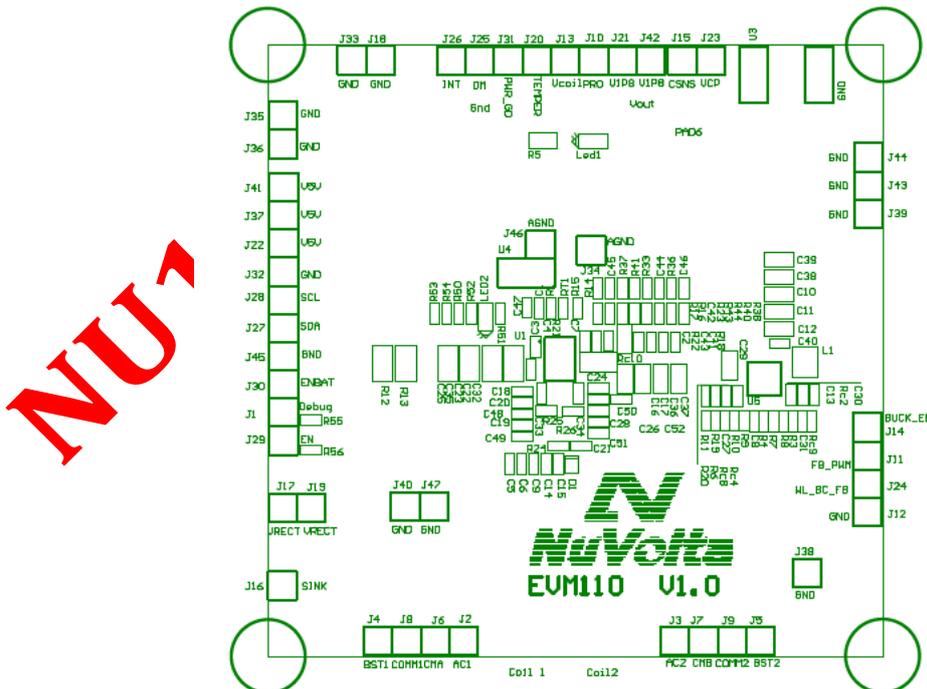


Figure 2: Top over lay of EVM1619

The first layer is the top layer, which places all electronic components for signal traces and wide power traces, and the second and third layers are the middle layers, mainly for signal traces, power traces and ground planes. The fourth layer is the bottom layer for the ground.

Usually the pads of the receiving coil (Coil1 and Coil2) are arranged on the side close to the chip power terminals (GND, AC1 and AC2) to minimize the length of the power wiring from the coil to the chip, and widen the wiring appropriately.

As shown in Figure 3 and Figure 4, AC1 and AC2 are connected to the pins from both sides of the chip. GND is connected to the pins of the chip with a wide copper for ground. Vrect and Vout are respectively connected to the chip pins from both sides. The decoupling capacitors of Vrect and Vout should be placed close to the chip, and the loop area should be as small as possible to reduce EMI noise and ripple.

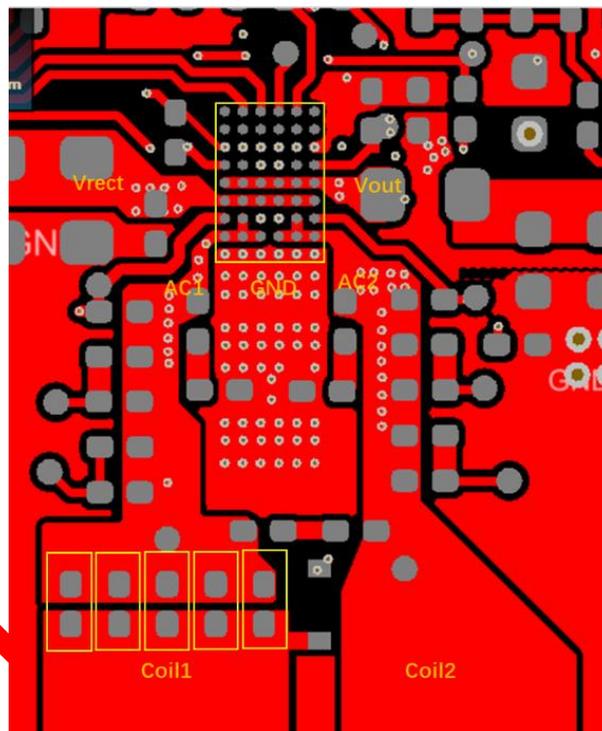


Figure 3: Top layer

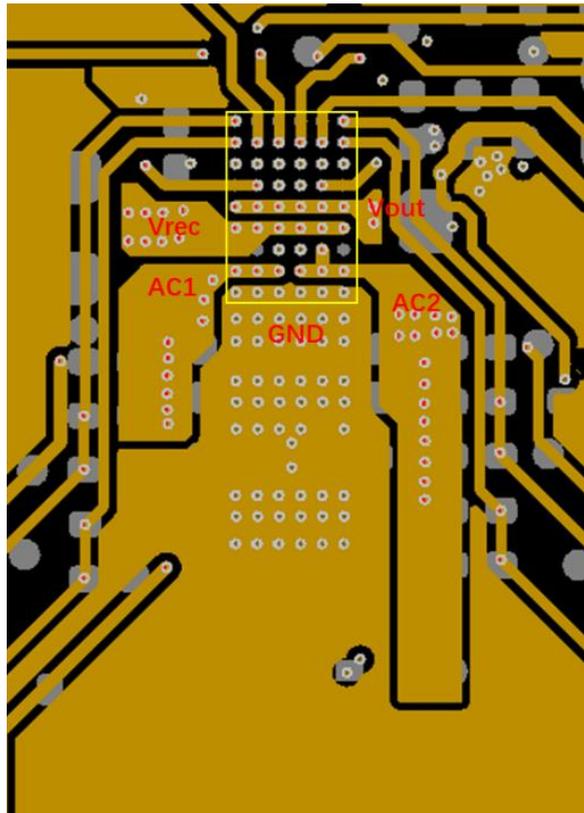


Figure 4: Layer L2

As shown in Figure 5 and Figure 6, the power pins AC1, AC2, Vrec and Vout are led out with 1-2 layers of blind via wiring, inside the green frame.

The signal pins close to the edge of the chip need to be led out through 1-2 layers of blind hole wiring, and the signal pins in the center of the chip are led out from the third layer wiring, inside the blue frame.

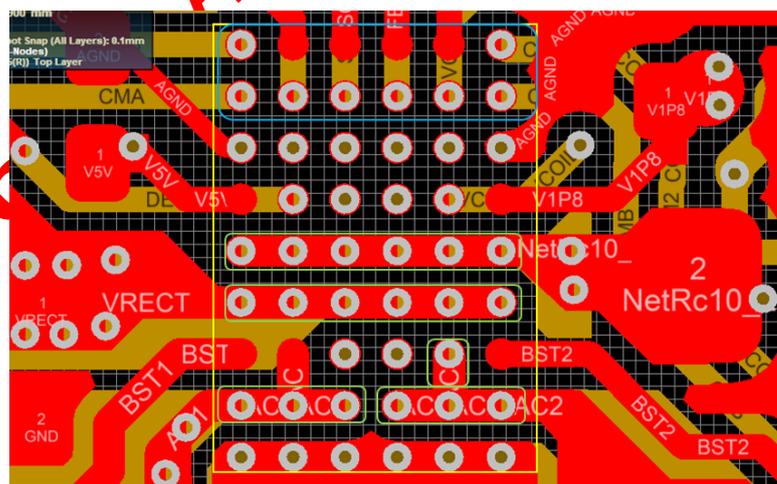


Figure 5: Chip vias and blind vias

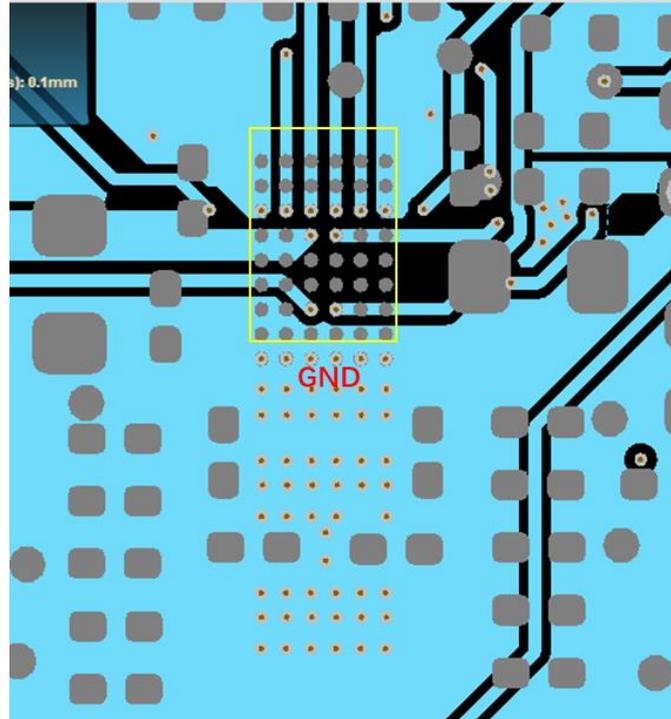


Figure 6: L3 layer

As shown in Figure 7, the bottom of the PCB is mainly arranged with a ground plane. The ground plane is divided into a power bottom GND and a signal ground plane AGND. The two ground planes are connected through a 0 ohm resistor, and the connection point is as close as possible to the ground of the output capacitor.

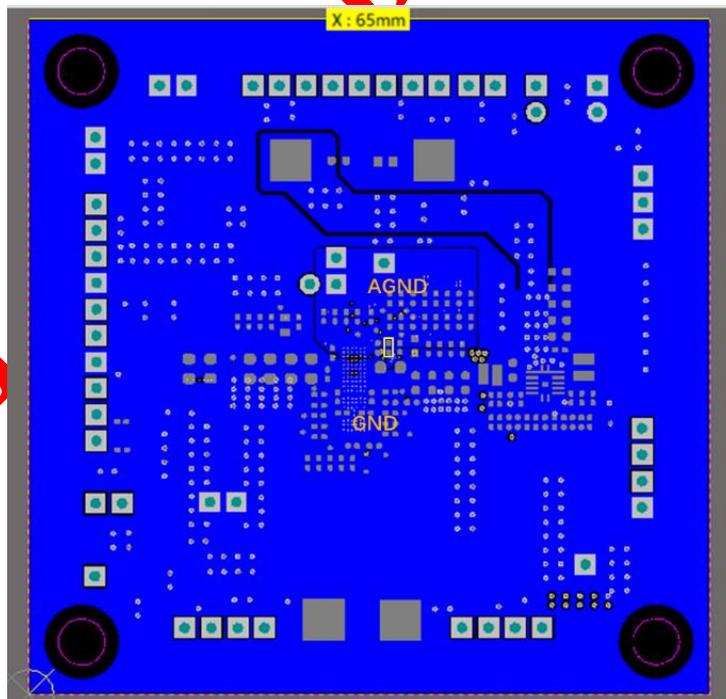


Figure 7: Bottom layer

Other wiring attention:

The resonant circuit is a jumping power circuit, and it needs to be placed as far away as possible from other signal lines

4. Interface description

On the EVM board, some interfaces are reserved for debugging performance and testing

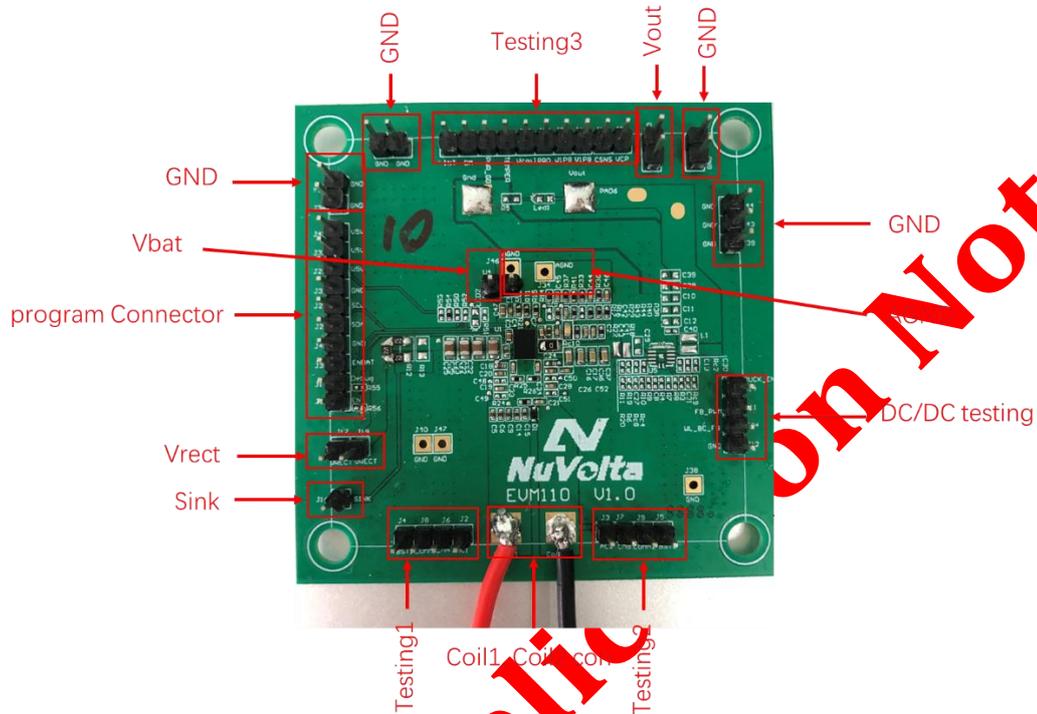


Figure 8 : Interface of EVM

Table 2: Interface description

Name	Description	Name	Description
Coil1, Coil2 Con	Pads of receiver coils	OUT	LDO output
DC/DC testing	Buck testing interface	VRECT	Rectified voltage
Testing1	RX testing interface 1	GND	Power ground
Testing2	RX testing interface 2	AGND	Analog ground
Testing3	RX testing interface 3	Vbat	Battery auxiliary power supply interface
Program connector	Interface for programming and debugging	Sink	Protection signal

5 Electrical Performance Specifications

Test condition:

- Environment temperature: 28°C
- Wireless power transmitter: NU1020+NU1513 EVM
- Distance between two coil :z=4.5mm

5.1 15W output specifications

Table 3: 15W output specifications

Parameter	Test condition	Min	Typ	Max	Unit
Output Characteristics					
Vout	Iout from 0A~1.3A		12		V
Iout			1.3		A
RX OCP			NA		A
Systems Characteristics					
Fac		110		205	kHz
η			80		%
η_{max}			82.2		%
FOD		NA			

5.2 40W output specifications

Table 4: 40W output specifications

Parameter	Test condition	Min	Typ	Max	Unit
Output Characteristics					
Vout	Iout from 0A~2.3A		19		V
Iout			2.3		A
RX OCP			NA		A
Systems Characteristics					
Fac		110		148	kHz
η			85		%
η_{max}			86.5		%
FOD		NA			

5.3 10W Reverse charging specifications

Table 5: 10W Reverse charging specifications

Parameter	Test condition	Min	Typ	Max	Unit
Output Characteristics					
Vout	Iout from 0A~1.3A		10		V
Iout			1		A
RX OCP			NA		A
Systems Characteristics					
Fac		110		205	kHz
η			75		%
η_{max}			80		%
FOD		NA			

6. EVM Evaluation

6.1 Test equipment

Table 5: Test equipment

Equipment	Description
Transmitter	NU1020+NU1513 EVM
Multimeter	Measure input and output voltage, current
Oscilloscope	Test waveform
Transmitter input	Adapter 65w that meets QC3.0/PD protocol
Electronic load	The electronic load must be able to provide load capacity of 12V/1.5A and 20V/2.5A.
TX coil	MPA2 (10Uh , ACR:55mOh)
RX coil	Customized (9Uh , ACR:250mOh)

6.2 15W/40W output test

6.2.1 Startup and shutdown test

- Use the transmitter of NU1020+NU1513, and place the coil of the receiver to the center of the transmitter coil. Detect the voltage waveform during Rx startup.

- Remove the coil of the receiver EVM from the surface of the transmitter coil. Detect the voltage waveform of the Rx shutdown process.

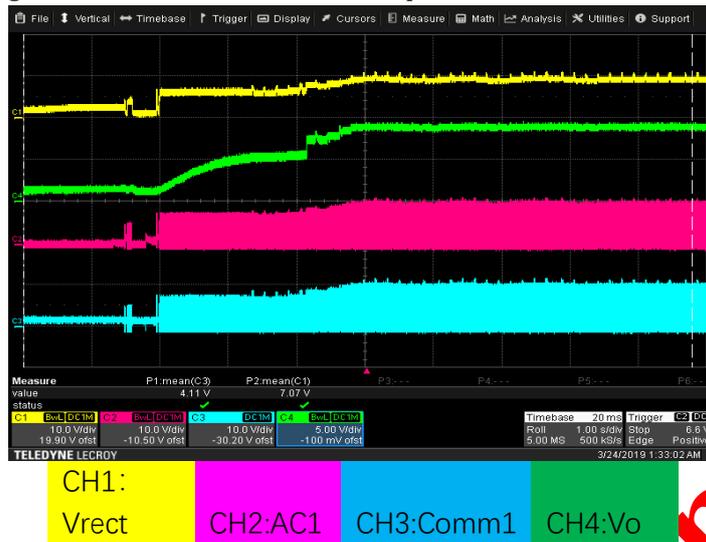


Figure 9: 9V output startup

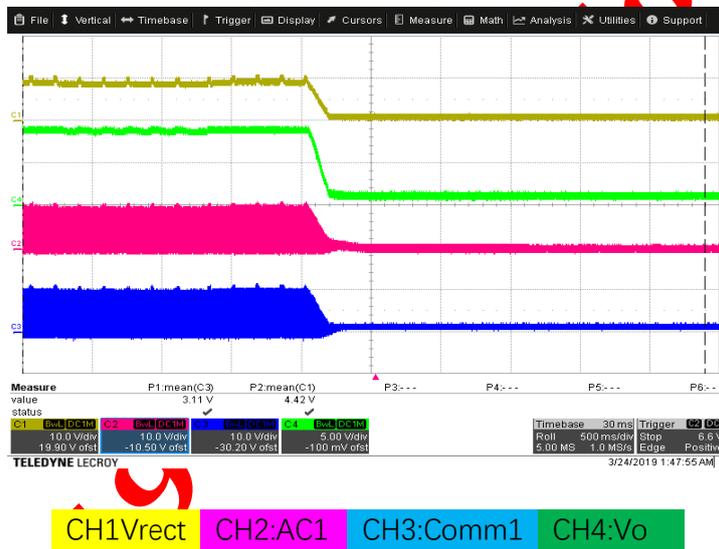


Figure 10: 9V output shutdown

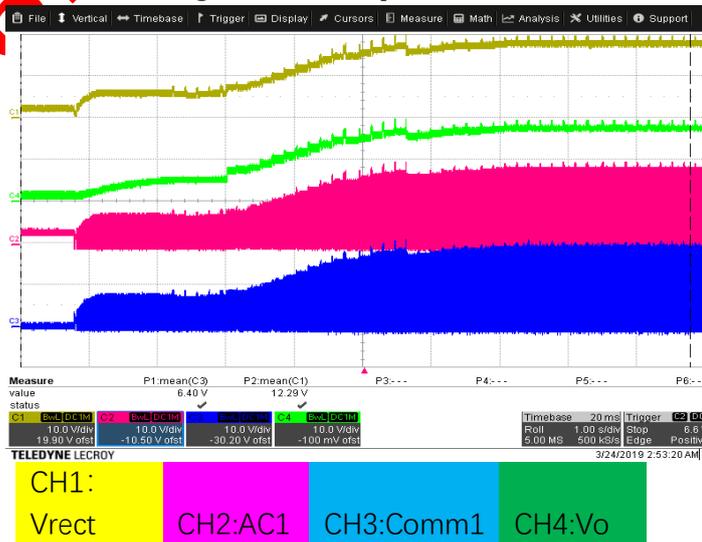


Figure 11: 18V output startup

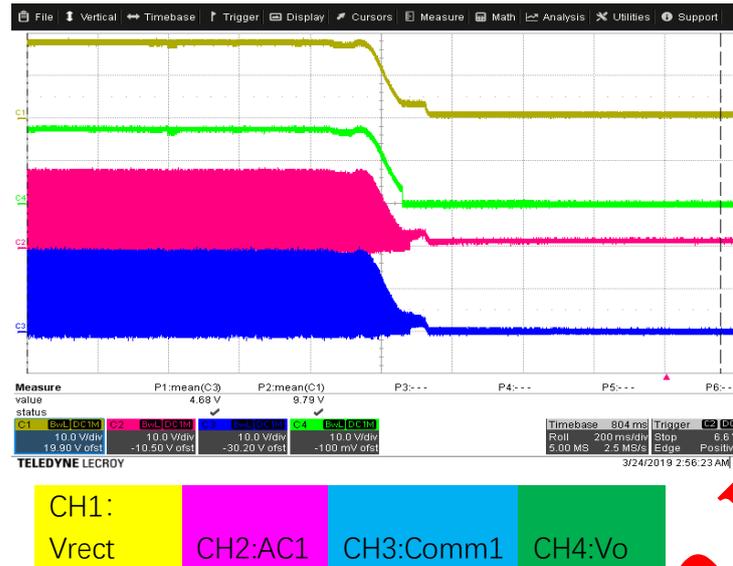


Figure 12: 18V output shutdown

6.2.2 15W output test

- The transmitter NU1020+NU1513 uses 12V QC3.0 power supply, and the coil center of the receiver EVM is aligned with the center of the transmitter coil
- Connect the EVM output to the electronic load, the output voltage is 12V, and the load is gradually increased from no load to 1.3A

Test result:

- The output voltage is around 10V, and the output voltage is around 12V when the load changes from no-load to 1.3A full load.
- During the power transfer phase, EVM works between 110kHz and 205kHz

6.2.3 40W output test

- The transmitter NU1020+NU1513 is supplied by a 20V PD adapter, and the coil center of the receiver EVM is aligned with the center of the transmitter coil
- Connect the EVM output to the electronic load, the output voltage is 19V, and the load is gradually increased from no load to 2.3A

Test result:

- The output voltage is around 18V, and when the load changes from no-load to full-load 2.3A, the output voltage is around 19V
- During the power transfer phase, EVM works between 110kHz and 148kHz

6.2.4 Output efficiency test

Gradually increase the load from no load to 1A full load, use a multimeter to measure

the output voltage (Vo) and output current (Io) of the receiving end, the input voltage (Vin) and input current (Iin) of the transmitter module, which can be used to calculate the overall system efficiency. The test points of the input voltage and output voltage must be as close as possible to the connection of the PCB to reduce the influence of the voltage drop on the wire and reduce efficiency.

The efficiency (η) of the module can be calculated by the following formula:

$$\eta = \frac{(V_o * I_o)}{(V_{in} * I_{in})}$$

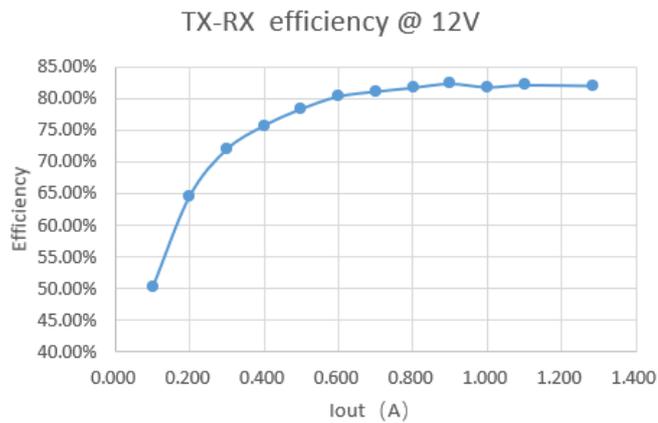


Figure 13: 12V output efficiency

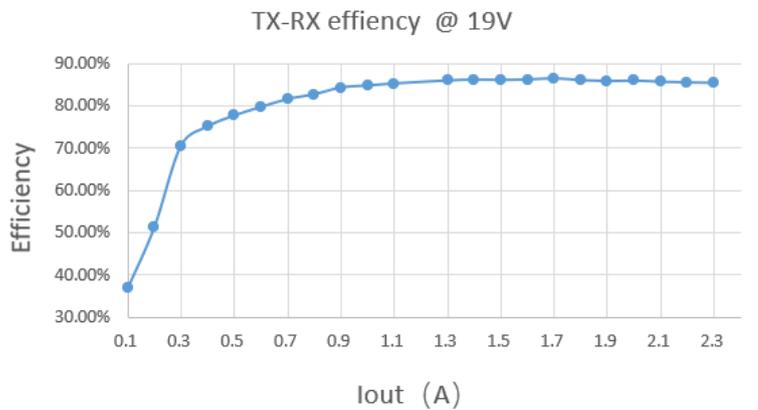


Figure 14: 19V output efficiency

6.2.5 Load switch test

Under the working condition of output 18V, switch the load from no-load to half-load, and then from half-load to no-load, and catch the working voltage waveform of Rx.

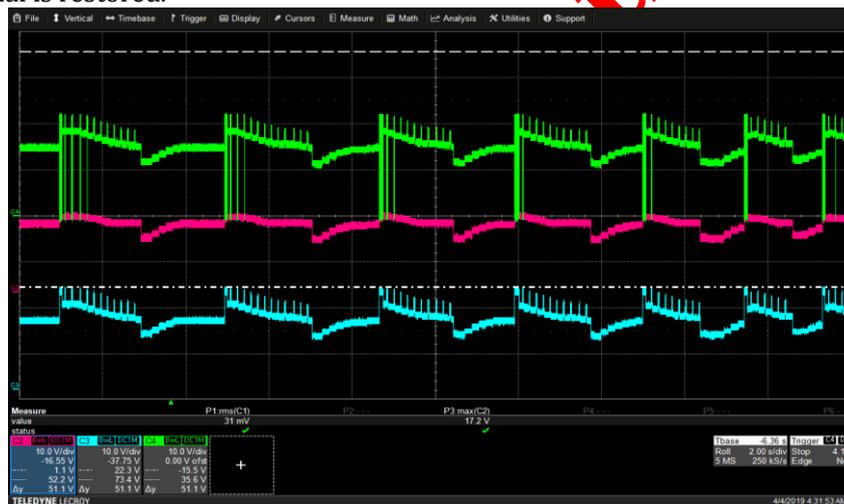


CH1: Vo Vrect CH4:sink

Figure 15: 18V output load switch

6.2.6 OVP protection test

Under the working condition of output 18V, the load switch causes Vrec increases to OVP voltage. When the Vrec voltage touches the OVP voltage, the sink signal is detected to be pulled down to clamp the Vrec. When the Vrec voltage drops, the sink signal is restored.



CH2:Vrect CH3:SINK CH4:I_coil

Figure 16: OVP TEST

6.2.7 Temperature rise test

Under the working condition of 19V output, the output power is 40W and the ambient temperature is 28°C. Use a thermal imager to detect and read the temperature, the highest temperature of the chip is 76.6°C, and the highest temperature of the coil is 65.8°C.

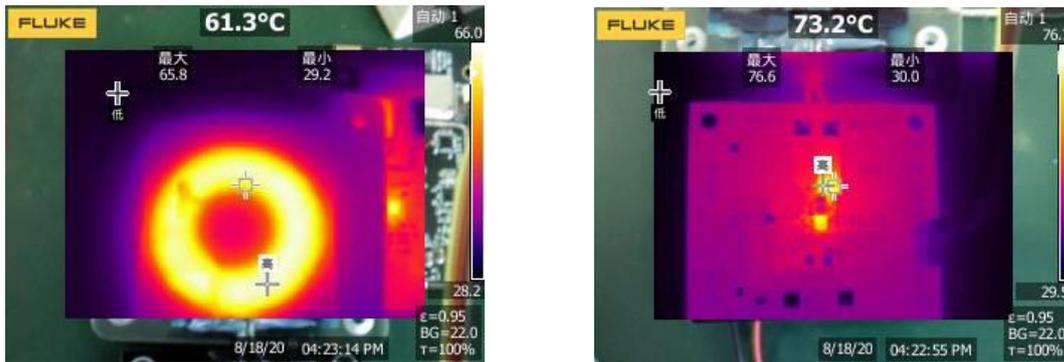


Figure 17: 40W temperature test

6.2.8 OCP Test

Align the coil center of the receiver EVM with the center of the transmitter coil. When the transmitter module enters the power transfer stage, set the load current of the receiver to 1A, and slowly increase it to 2.1A, and detect the Vrec and Vout voltages, and ASK. When the output current exceeds 2A, the receiver triggers protection and sends an EPT overcurrent signal.



CH1: commu1
 CH2:Vo
 CH3:SINK
 CH4:I o

Figure 18 : OCP Test

6.2.9 Foreign object detection (FOD)

EVM samples the output voltage, output current and operating frequency, uses a unique algorithm to calculate the power consumed by the entire receiver EVM. EVM encodes the corresponding power, and tells the transmitter through the modulation function to realize the foreign object detection function.

6.3 Reverse charge test

6.3.1 Startup of reverse charge

Using a DC source to supply the transmitter of the NU1619, and use another NU1619 as the receiver. Align the coil center of the EVM with the coil of the transmitter in center. Trigger the reverse charging function of the transmitter. Power output is detected at the receiver

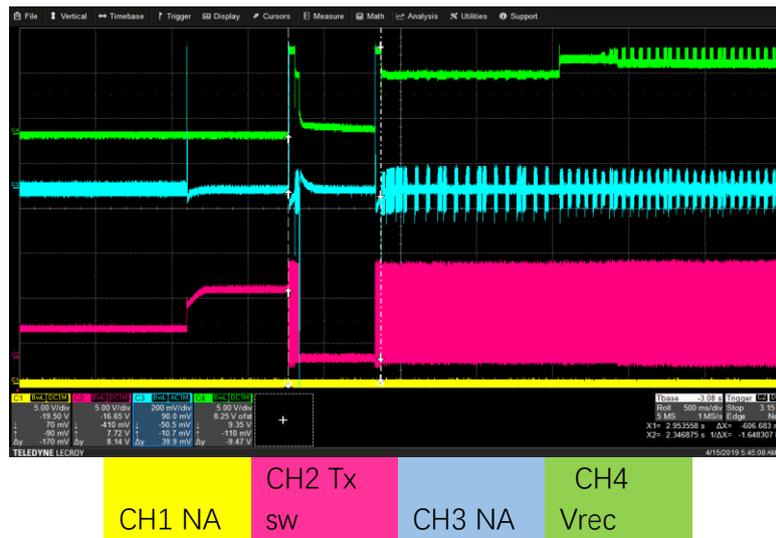


Figure19: Startup of reverse charge

6.3.2 Reverse charging output power

- Use a DC source to supply the transmitter of NU1619, and align the center of the EVM coil of the receiver with the center of the transmitter coil
- Connect the EVM output terminal to the electronic load, and gradually increase the load from no load to 1.1A

Test Results:

- The output voltage is around 10V, and the output voltage is always between 9.8V and 10.2V when the load changes from no load to 1.1A full load.
- In the power transmission stage, the operation frequency is between 110kHz and 205kHz

6.3.3 Reverse charging efficiency

The way of testing output efficiency is the same as the method in 6.2.4, and the test result is shown in the figure below.

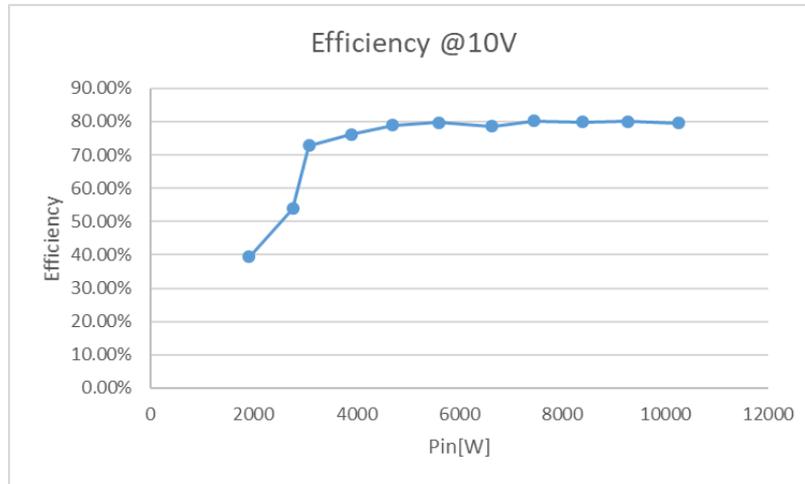


Figure 20: Efficiency of 10W output

6.3.4 Temperature rise test (10min)

Under the working condition of 10V input at the transmitter, the input power is 10W and the ambient temperature is 25°C. Use a thermal imager to detect and read the temperature, and the maximum temperature of the chip is 32.7°C.



Figure 21: Temperature test

6.3.5 OCP

Keep the output voltage of the mobile phone charger at 9V, align the coil center of the receiver with the center of the transmitter coil, when the transmitter module enters the power transfer stage, set the load current of the receiver to 1.1A, and slowly increase it. Test the output voltage with a multimeter. When the output

voltage is lower than 4V, record the output current value at this time, which is the output overcurrent protection of the receiver and the overcurrent protection point of the output is between 1.1A and 1.5A.

6.3.5 FOD

EVM samples the output voltage, output current and operating frequency, uses a unique algorithm to calculate the power consumed by the entire receiving end EVM, encodes the corresponding power, and tells the transmitter through the modulation function to realize the foreign object detection function.

7.Settings and GUI interface

NU1619EVM supports updating the internal program and setting register configuration of NU1619 through the I2C interface to configure the output voltage.

7.1 Configure via GUI interface

- First step: Connect the SDA, SCL, V5V and GND of the NU1619 to the corresponding pins of the I2C device and connect to a computer equipped with specific software. You can update the internal program of the NU1619 and modify the output voltage and other registers through the software GUI interface.
- Step 2: After connecting the I2C reader, click "connect" in the upper right corner to set the I2C device and the chip to connect successfully.
- Update the internal program of NU1619: Click "open file" in the MTP Program module, open the firmware to be burned, and then click "Program".

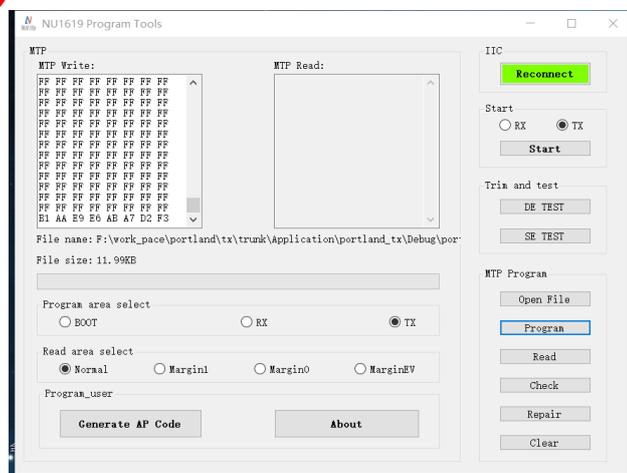


Figure 22 : GUI interface

Modify the output voltage and other registers through the software GUI interface, and click the right "SE Test" button.

- The Output regulation module sets the output voltage and VDrop. The output voltage can be set between 5V and 20V. If the voltage is set to 9V, you need to write "9000" in the column, and then click the "SET" button.
- The Vrec voltage, Vout voltage, and Isense current can be detected through the Output regulation module.
- The Rx control interface module can send specified commands to Rx through the upper computer.
- Read Infos module, you can read the commands sent by Rx through the host computer.

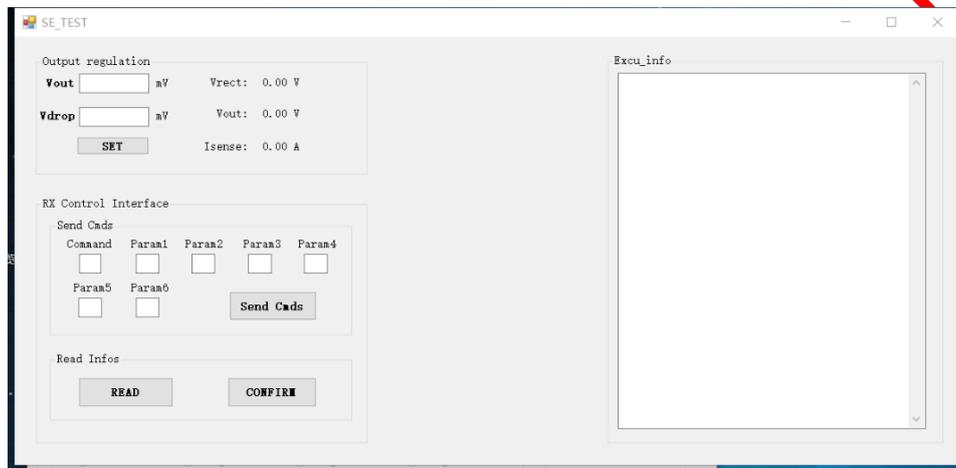


Figure23 . SE Test Interface