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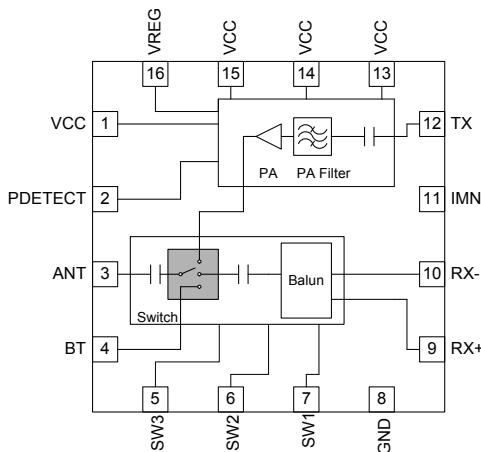
Features

- Single Supply Voltage 3.1V to 4.5V
- Integrated 2.4GHz to 2.5GHz b/g Amplifier, RX Balun and TX/RX Switch
- $P_{OUT} = 16\,dBm$, 11g, OFDM at 3.0% EVM and $P_{OUT} = 19\,dBm$, Meeting 11b Mask
- Low Height Package, Suited for SiP and CoB Designs

Applications

- Cellular handsets
- Mobile devices
- Tablets
- Consumer electronics
- Gaming
- Netbooks/Notebooks
- TV/monitors/video
- SmartEnergy

Functional Block Diagram

Product Description

The RF5225 FEM is a single-chip integrated front-end module (FEM) for high-performance WiFi applications in the 2.4GHz to 2.5GHz ISM band. The FEM addresses the need for aggressive size reduction for a typical 802.11b/g front-end design and greatly reduces the number of components outside of the core chipset. The FEM has integrated b/g power amplifier, power detector, RX balun, and some TX filtering. It is also capable of switching between WiFi RX, WiFi TX and BTH RX/TX operations. The device is provided in a 3mm x 3mm x 0.45mm, 16-pin package. This module meets or exceeds the RF front-end needs of 802.11b/g WiFi RF systems.

Ordering Information

RF5225	Standard 25 piece bag
RF5225SR	Standard 100 piece reel
RF5225TR7	Standard 2500 piece reel
RF5225PCK-410	Fully assembled evaluation board tuned for 2.4GHz to 2.5GHz and 5 piece loose samples

Optimum Technology Matching® Applied

☐ GaAs HBT	☐ SiGe BiCMOS	☑ GaAs pHEMT	☐ GaN HEMT
☐ GaAs MESFET	☐ Si BiCMOS	☐ Si CMOS	
☑ InGaP HBT	☐ SiGe HBT	☐ Si BJT	

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Absolute Maximum Ratings

Parameter	Rating	Unit
DC Supply Voltage	5.4	V_{DC}
DC Supply Current	400	mA
Full Specification Temp Range (Full Spec. Compliant)	-15 to +65	°C
Extreme Operating Temperature Range (Reduced Performance)	+65 to +85 -40 to -15	°C
Storage Temperature	-40 to +85	°C
Antenna Port Nominal Impedance	50	Ω
Maximum TX Input Power for 11b (No Damage)	+5	dBm
Maximum TX Input Power for 11g (No Damage)	+5	dBm
Moisture Sensitivity	JEDEC Level 3	

Caution! ESD sensitive device.

Exceeding any one or a combination of the Absolute Maximum Rating conditions may cause permanent damage to the device. Extended application of Absolute Maximum Rating conditions to the device may reduce device reliability. Specified typical performance or functional operation of the device under Absolute Maximum Rating conditions is not implied.

RoHS status based on EU Directive 2002/95/EC (at time of this document revision).

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Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
2.4 GHz Transmit Parameters					
Compliance					IEEE 802.11b, IEEE 802.11g, FCC CFG 15.247, .205, .209
Nominal Conditions					V_{CC}=3.7V, V_{REG}=2.8V pulsed at 1% to 100% duty cycle, Temp=+25°C, Freq=2.4GHz to 2.5GHz, unless otherwise noted
Frequency	2.4		2.5	GHz	
Output Power					
11g		16.0		dBm	54 Mbps, OFDM, 64 QAM meeting EVM requirement
11b		19.0		dBm	Measured at 1 Mbps meeting ACP1/ACP2 requirements
EVM*		3.0		%	RMS, mean, $P_{OUT(g)}$=16 dBm
Adjacent Channel Power					
ACP1		-38	-34	dBc	P_{OUT}=19 dBm, IEEE 802.11b, 1 Mbps CCK modulation
ACP2		-56	-53	dBc	P_{OUT}=19 dBm, IEEE 802.11b, 1 Mbps CCK modulation
Gain	26.5	30		dB	
Gain Variation					
V_{CC}			0.7	dB/V	
Frequency	-0.5		+0.5	dB	2.4 GHz to 2.5 GHz

*The EVM specification is obtained with a signal generator that has an EVM level <0.7%.

Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
2.4 GHz Transmit Parameters, cont'd					
Power Detect					
Voltage Detect	0.1		1.6	V	
P_{OUT} = 16 dBm		1.0		V	IEEE802.11g, 54 Mbps 64QAM modulation
P_{OUT} = 19 dBm		1.2		V	IEEE802.11b, 11 Mbps CCK modulation
Input Resistance		10		kΩ	
Input Capacitance			5	pF	
Bandwidth	800	1000		kHz	
Sensitivity					
> 10 dBm	25			mV/dB	
0 < P_{OUT} < 10 dBm	8			mV/dB	
Current Consumption					
IEEE802.11g I_{CC}		160		mA	RFP$_{OUT}$ = 16 dBm, 54 Mbps IEEE802.11g
IEEE802.11b I_{CC}		190		mA	RFP$_{OUT}$ = 19 dBm, 11 Mbps IEEE802.11b
Idle		140		mA	V_{CC} = 3.7 V, V_{REG} = 2.8 V, and RF = OFF
I_{REG}		3	10	mA	V_{REG} < 0.2 V
Leakage		5	10	μA	
Power Supply	3.15	3.7	4.5	V	
V_{REG} Voltage ON	2.7	2.8	2.88	V	
Input/Output Impedance		50		Ω	
Ruggedness					No damage
Output VSWR	10:1				Maximum: operating voltage, input power, temperature
Stability					
Output VSWR	4:1				
Out of Band Performance					
S21 (DC to 960 MHz)			25	dB	
S21 (1570 MHz to 1580 MHz)			14	dB	
S21 (1805 MHz to 1990 MHz)			20	dB	
S21 (2110 MHz to 2170 MHz)			15	dB	All other ports terminated in their nominal impedances
Harmonics					RBW = 1 MHz. Measured at 1 Mbps.
Second			-18	dBm	4.80 GHz to 5.00 GHz
Third			-18	dBm	7.20 GHz to 7.50 GHz
Turn-On/Off Time		0.5	2.0	μS	Output stable to within 90% of final gain
Antenna Port Impedance					
Input		50		Ω	Receive
Output		50		Ω	Transmit
Switch Control Voltage					
Low		0	0.2	V	
High	2.7	3.6	5.4	V	
Switch Control Current			10	μA	Per control line
Switch Control Speed			100	nsec	

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Parameter	Specification			Unit	Condition
	Min.	Typ.	Max.		
2.4 GHz Transmit Parameters, cont'd					
ESD					
Human Body Model	500			V	EIA/JESD22-114A
Machine Model	75			V	EIA/JESD22-115A
2.4 GHz Receive Parameters					
Frequency	2.4		2.5	GHz	
Insertion Loss		1.8	2.0	dB	
Noise Figure		1.8	2.0	dB	
Passband Ripple	-1		+1	dB	
Output Return Loss			-9.6	dB	
Output Impedance		100		Ω	No external matching
Balun					
Amplitude Balance			1	dB	
Phase Balance			10	°	Relative to 180°
Current Consumption			10	µA	
Bluetooth Parameters					
Frequency	2.4		2.5	GHz	
Insertion Loss		1.2	1.6	dB	SP3T switch, all unused ports terminated into their nominal impedance
Passband Ripple	-0.2		+0.2	dB	
Input/Output Power			8	dBm	
Output Return Loss			-10	dB	
Output Impedance		50		Ω	No external matching
Current Consumption			10	µA	Switch leakage current

*The EVM specification is obtained with a signal generator that has an EVM level <0.7%.

Isolation Table

Parameter	Min.	Typ.	Max.	Unit
WiFi RX to BT RX/TX		25		dB
WiFi TX to BT RX/TX		20		dB
WiFi RX to WiFi TX		20		dB

Switch Control Logic

SW1	SW2	SW3	Mode
L	L	H	Bluetooth
L	H	L	WiFi TX
H	L	L	WiFi RX

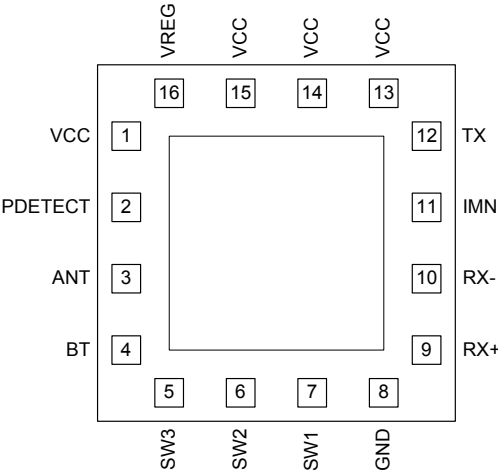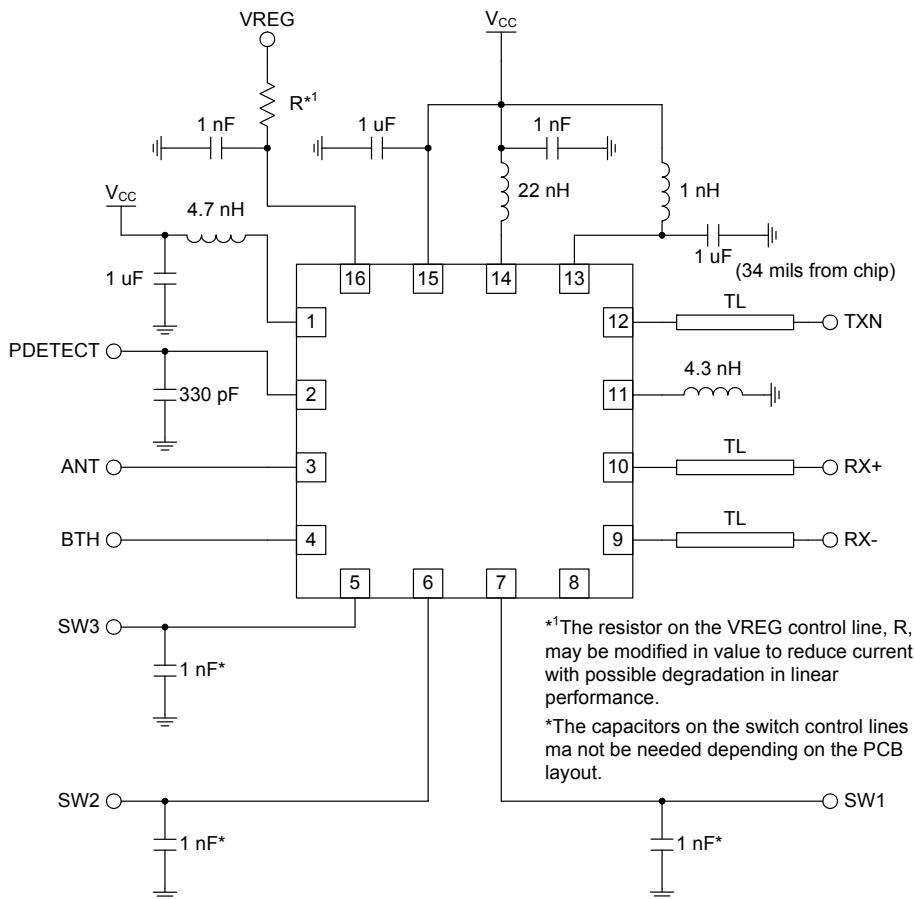| Pin	Function	Description
1	VCC	Supply voltage for the 802.11b/g PA. Add an external 1uF capacitor for low frequency decoupling.
2	PDETECT	Power detector voltage for TX section. PDET voltage varies with output power. May need external decoupling capacitor for module stability. May need external circuitry to bring output voltage to desired level.
3	ANT	FEM connection to filter and antenna. Port is matched to 50Ω and DC block is provided.
4	BT	RF bidirectional port for Bluetooth. Input is matched to 50Ω and DC block is provided.
5	SW3	Switch control port. See switch truth table for proper level.
6	SW2	Switch control port. See switch truth table for proper level.
7	SW1	Switch control port. See switch truth table for proper level.
8	GND	Ground.
9	RX+	Receive port for 802.11b/g band. Internally matched to 100Ω differential. DC block provided.
10	RX-	Receive port for 802.11b/g band. Internally matched to 100Ω differential. DC block provided.
11	IMN	Input matching network.
12	TX	RF input for the 802.11b/g PA. Input is matched to 50Ω and DC block is provided.
13	VCC	Supply voltage for the 802.11b/g PA. Add an external 1uF capacitor for low frequency decoupling.
14	VCC	Supply voltage for the 802.11b/g PA. Add an external 1nF capacitor for low frequency decoupling.
15	VCC	Supply voltage for the 802.11b/g PA bias circuit. Add an external 10nF capacitor for low frequency decoupling.
16	V$_{REG}$	Bias control voltage for the first, second, and third stage PA.
Pkg Base	GND	The center metal base of the QFN package provides DC and RF ground as well as heat sink for the front-end module.

Package Drawing

NOTES:

1 ▷ DIMENSION APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25mm AND 0.30mm FROM TERMINAL TIP.

2 ▷ DIMENSION REPRESENTS TERMINAL PULL BACK FROM PACKAGE EDGE UP TO 0.1mm IS ACCEPTABLE.

3 ▷ COPLANARITY APPLIES TO THE EXPOSED HEAT SLUG AS WELL AS THE TERMINAL.
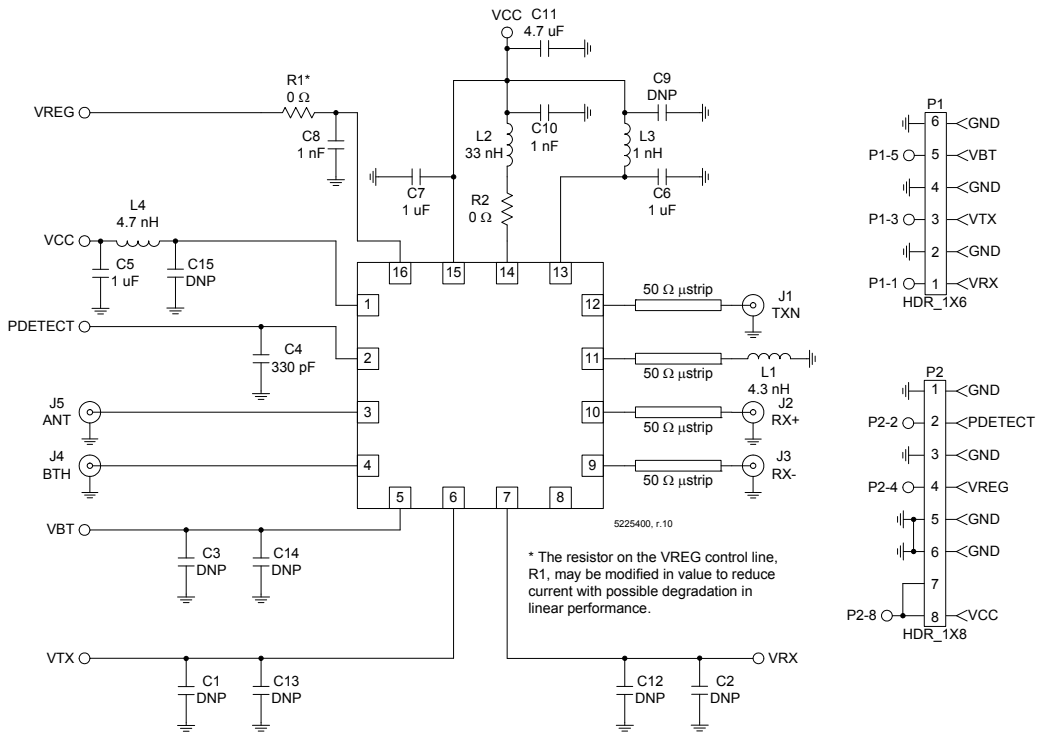
4   RADIUS ON TERMINALS IS OPTIONAL.

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Pin Out

```
              VREG   VCC    VCC    VCC
               16     15     14     13

VCC      1                                   12   TX

PDETECT  2                                   11   IMN

ANT      3                                   10   RX-

BT       4                                    9   RX+

                5      6      7      8
              SW3    SW2    SW1    GND
```

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Application Schematic

*1The resistor on the VREG control line, R, may be modified in value to reduce current with possible degradation in linear performance.

*The capacitors on the switch control lines ma not be needed depending on the PCB layout.

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Evaluation Board Schematic

5225400, r.10

* The resistor on the VREG control line, R1, may be modified in value to reduce current with possible degradation in linear performance.

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Theory of Operation

The RF5225 FEM is a single-chip integrated front-end module (FEM) for high performance WiFi applications in the 2.4 GHz to 2.5 GHz ISM band. The FEM addresses the need for aggressive size reduction for a typical 802.11b/g RF front-end design and greatly reduces the number of components outside of the core chipset therefore minimizing the footprint and assembly cost of the overall 802.11b/g solution. The FEM has integrated b/g power amplifier, power detector, RX balun and TX filtering. Also it is capable of switching between WiFi RX, WiFi TX, and BTH RX/TX operations. It has low insertion loss at the 2.4 GHz to 2.5 GHz WiFi and BTH paths. The device is manufactured in a QFN leadframe package and GaAs HBT processes. The device is provided in a 3 mm x 3 mm x 0.45 mm, 16-pin package. This module meets or exceeds the RF front-end needs of 802.11b/g WiFi RF systems.

For best results, the PA circuit layout from the evaluation board should be copied as closely as possible, particularly the ground layout and ground vias. Other configurations may also work, but the design process is much easier and quicker if the layout is copied from the RF5225 evaluation board. There is an indicator pin labeled P1 ID that should be left as a no-connect on the PCB. This pin is directly connected to the ground pad of the IC. For the best performance, it is recommended that voltage and RF lines do not cross under this pin. Gerber files of RFMD PCBA designs can be provided on request. The supply voltage lines should present an RF short to the FEM by using bypass capacitors on the V_{CC} traces. The RF5225 is a very easy part to implement, but care in circuit layout and component selection is always advisable when designing circuits to operate at 2.5 GHz. Please contact RFMD Sales or Application Engineering for additional data and guidance.

The RF5225 is designed primarily for IEEE802.11 b/g WiFi applications where the available supply voltage and current are limited. The RF5225 requires a single positive supply voltage (V_{CC}), positive current control bias (V_{REG}) supply, and a positive supply for switch control to simplify bias requirements. The RF5225 FEM also has built in power detection. All inputs and outputs are internally matched to 50Ω except the WiFi receive path it is deferential with nominal impedance of 100 ohm on each pin.
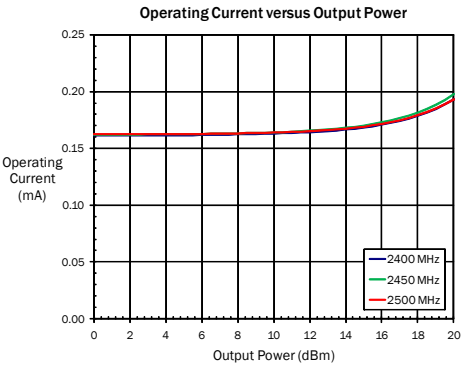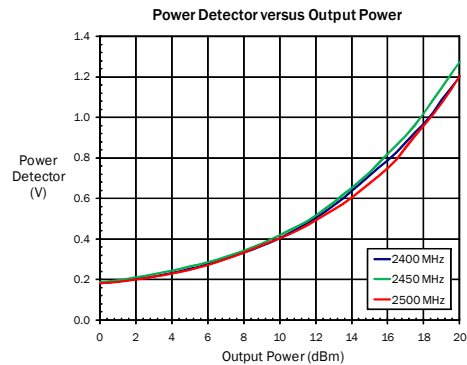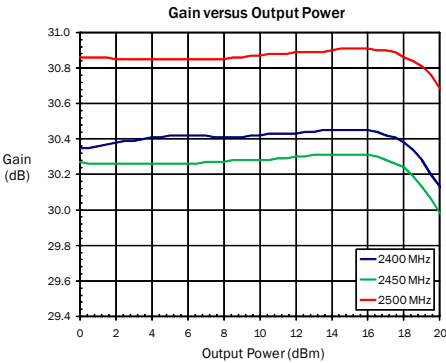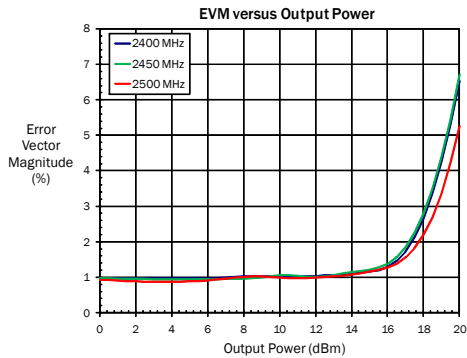
802.11b/g Transmit Path

The RF5225 has a typical gain of 30 dB from 2.4 GHz to 2.5 GHz, and delivers 16 dBm typical output power under 54 Mbps OFDM modulation and 19 dBm under 1 Mbps 11b modulation. The RF5225 requires a single positive supply of 3.1 V to 4.5 V to operate at full specifications. Current control optimization for the 802.11b/g band is provided through one bias control input pin (V_{REG}). The V_{REG} pin requires a regulated supply to maintain nominal bias current, a series resistor may be used to drop the voltage to a desired level. In general, higher V_{REG} voltage produce higher linear output power, higher operating current, and higher gain.

Out of Band Rejection

The RF5225 contains basic filtering components to produce bandpass responses for the transmit and receive paths. Due to space constraints inside the module, filtering is limited to a few resonant poles per RF path. The IMN inductor, L1 on the evaluation board schematic, optimized the input matching network. On the PCB, the value of this inductor can be modified to optimize the filtering. Additional filters may need to be added outside the module depending upon the end-user's application.

802.11b/g Receive Path

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The 802.11b/g path has a 100 Ω differential impedance with a nominal insertion loss of 1.6 dB. The RX port return loss is 10 db minimum. Depending on the application, if filtering is required beyond what the RF5225 can achieve then additional external filters will need to be added outside of the RF5225.

EVM versus Output Power

Gain versus Output Power

Power Detector versus Output Power

Operating Current versus Output Power

RF5225 Biasing Instructions:

- 802.11b/g Transmit (V_{CC} compliance=5.4V, 400mA, V_{REG} compliance=3V, 10mA)
  - Connect the FEM to a signal generator at the input and a spectrum analyzer at the output.
  - Bias V_{CC} to 3.7V first with V_{REG}=0.0V
  - Refer to switch operational truth table to set the control lines at the proper levels for WiFi TX.
- Turn on V_{REG} to 2.8V (typ.). V_{REG} controls the current drawn by the 802.11b/g power amplifier and the current should quickly rise to 145mA±20mA for a typical part but it varies based on the output power desired. Be extremely careful not to exceed 3.0V on the V_{REG} pin or the part may exceed device current limits.

- 802.11 b/g Receive
  - To Receive WiFi set the switch control lines per the truth table below.

- Bluetooth Receive
  - To Receive Bluetooth set the switch control lines per the truth table below.

Switch Control Logic

SW1	SW2	SW3	Mode
L	L	H	Bluetooth
L	H	L	WiFi TX
H	L	L	WiFi RX

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