

Electronics Online Challenge 2018

Linksys WRT54G 2.4GHz Wireless Broadband Router

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Final Summary Report

After a power surge in a team member's house, his internet (and his air conditioner) stopped working. He determined the power surge fried his router. Curiously, the team decided to disassemble the no-longer-functional Linksys WRT54G 2.4GHz Wireless Broadband Router for the project. A broadband router provides high-speed access, wireless or wired, to the Internet for multiple computers or other devices, such as security cameras and servers. Our mentor approved of our project. We chose a router because in an age of the Internet of Things, where everything is connected wirelessly, we wanted to understand in detail how wireless routers work.

For safety, we wore glasses during disassembly and our mentors made sure there were no dangerous electronic components. We removed the antennas, screws on the bottom, pulled apart the box, and unscrewed the motherboard from the case. It took more time to pull the box apart and figure out how to remove the motherboard from the backboard than we expected. We spent a significant amount of time identifying the components on the motherboard and learning about the function of each integrated circuit. A few chips had logos or company names written on the parts, but the majority just had letters and numbers. For example, the two chips verified to be TI parts by a TI customer service representative only had letters and numbers, so these chips may be multi-sourced, with TI as one of the manufacturers. We researched part markings and numbers, and then tracked down their corresponding datasheets, product briefs, and overviews, which we linked to each part at the end of this report. We easily identified that Broadcom manufactured the main processor, switch, and radio chip. Intel and SK Hynix made the memory chips. We needed help identifying a few of the other chips, so we called and emailed Linksys, the router's manufacturer, but they didn't respond. We also inquired from our mentors that had

semiconductor experience. This router was used 24/7 for over 12 years straight, and it was difficult to find the chip information for a discontinued router.

Our team learned a new perspective on electronics, especially by identifying all components. We were surprised it contained over 300 parts! We learned the project would have been immensely easier if we had a schematic, but we could not find one. None of the components showed visible damage; however, we knew a few parts were damaged by the power surge. We learned about its construction – the bulk of the parts was attached via surface mount technology and were so tiny that we used a phone's magnifier to photograph each part. The board had special Faraday shielding on the RF Output transceiver. We concluded that, since wireless signals are everywhere today, the shielding prevented external signals from interfering with the wireless transmission and reception. Finally, we learned the internet can be an extraordinary aid in researching. Internet forums and YouTube videos discussing routers aided our understanding of how routers work and what each part did.

Final Summary Word Count: 496 Words

Figure 1.0: The External Anatomy



Figure 1.1 Front View



Figure 1.2 Bottom View and Back View



Figure 1.3 Identified Version 3 from Label, Serial No. Starts with CDF8

A Division of Model No	Cisco Systems, Inc. WRT54G v.3	Wireless-G Broadband Rout With 4-Port Switch	er allu allu	
S/N		CDF80E4K9	712	
MAC	001310907AFB			
Made in Chin	a			
Own	ership ID	472	TESKN	
Di	evice ID	G90		

Deconstruct Process (All Images are Original from Team 986A)

Figure 2.1 Removed antenna caps and unscrewed antennas



Figure 2.2 Pulled out rubber feet and removed screws with screwdriver



Figure 2.3 Squeezed the back case inward and pulled off the front case



Figure 2.4 Removed screws on motherboard and separated bottom case





Figure 2.5 Router disassembled and tools used for deconstruct



Figure 2.6 Removed metal Faraday shield



Figure 2.7 Completed deconstruct



Research Process

Figure 3.1 Used phone as a digital magnifying glass to view components and as a camera



Figure 3.2 Researched forums, blogs, datasheets, overviews, product briefs, and inquired from engineers and mentors



Figure 3.3 Layout of all identified chips





Graph 1.0: Internal Electrical Components Count

Graph 2.0: Identified Chip Count by Manufacturer



Table 1.0: External Anatomy – Images of Actual Components

External Components	Description	Function/Comments
AC Power Supply	120V 60Hz Input 23 Watts	Supplies power to the main board when plugged into the power outlet
Antennas RP-TNC	Two removable antennas connected through Reverse Polarity Threaded Neill–Concelman connectors	Transmits and receives wireless internet
Antenna Caps	2 black plastic caps	Secures antenna in place
Back Case	Dark gray durable cases	Covers the back of the router and protects internal parts
Box Housing	Width 7.3 inches Height 1.9 inches Depth 6.1 inches Weight 1.1 pounds	Protects electrical components from wear and tear

Feet	Four removable rubber feed/stands Cisco Systems Logo	Provides stability, helps isolate device from dirt and spills, and allows air circulation for cooling Shows parent company of Linksys in 2003,LED indicators, product description	
Power Light Emitting Diode Indicator	Power light	flickers when in self-diagnosis mode during every boot up	
DMZ LED Indicator DMZ	DMZ light	Stays green when the DMZ function is enabled	
WLAN LED Indicator	WLAN light	Stays green whenever there is a wireless connection and flickers when router is sending/receiving data over the network	
Ethernet Ports LED Indicator	1-4 lights	Stays green if connection is successful through that wired port, and flickers when there is activity	

Internet LED Indicator	Internet Light	Stays green when a connection is made through the internet port	
Label	Serial Number Model Number MAC Address Label	Unique serial number for ID Model of router, media access control address identify	
Label Warranty	Warranty Void Tamper Label	Shows if router has been tampered with and voids warranty if broken (this unit was WAY past warranty)	
Example of the state of th	FCC Declaration of Conformity certification mark	Identifies product as approved by Federal Communications Commission	
Screws	Three silver flathead screws	Hold main board to the case	

Table 2.0: Other Internal Components - Images of Actual Components

Component/Image	Quantity	Function
Antenna Ports	2	Connects external antenna
Coaxial Cable 6 inches	1	Transmits signals from the antenna to the motherboard
Setup Button	1	Found behind the Cisco logo and used for setting up Wireless security
Metal Shielding	1	Faraday cage to enclose devices that produce radio-frequency interference

Power Port	1	Connects power to the motherboard by connecting the power supply
Printed Circuit Board	1	Insulated board with mounts for components, and with conductive lines and pads to electrically connect components to each other
Reset Button	1	Clears jammed connections when pressed
RJ45 Ports	5	RJ45 stands for "Registered Jack 45" and devices are connected using an Ethernet cable

Table 3.0: Printed Circuit Board Components - Images of Actual Components

Component/Image	Quantity	Function
Ceramic Capacitor	1	Used in DC power supply circuits due to their large capacitance's and small size

Electrolytic Capacitor	4	Frequently used to reduce the ripple voltage or for coupling and decoupling applications
Surface Mount Capacitors	170	Perform various functions that require small capacitance values
Surface Mount CrystalsImage: Crystals <t< th=""><th>3</th><th>Provide clocks (frequency of events) to a system for radio transmission/reception or for microprocessor timing</th></t<>	3	Provide clocks (frequency of events) to a system for radio transmission/reception or for microprocessor timing
Light Emitting Diodes (LED)	8	Diodes that convert electrical energy into light

Surface Mount LEDs	2	Smaller than leaded LED, convert electrical energy into light
Zener Diodes	3	Allows current to flow in one direction only and also allows the reversal of direction of flow when exposed to enough voltage
Surface Mount Zener Diodes	3	Like a regular Zener diode, but different package type
Ferrite Bead Inductors	2	Filter the amount of high frequency electromagnetic interference noise found in electronic circuits
Surface Mount Inductors	12	Passive devices that resist changes in electric current passing through it

Toroid Inductors	3	An insulated coil that is wire wound around a ring of traditionally powdered iron; used mainly on low frequencies
Surface Mount Resistors	114	Passive electrical components that provide electrical resistance
10/100 Base-T Dual Port Transformer For Modules by Mingtek	2	Increases or decreases the voltage of electricity flowing in the circuit
10/100 Base-T Single Port Transformer by Mingtek	1	Increases or decreases the voltage of electricity flowing in the circuit

Table 4.0: Integrated Circuit Information – Images of Actual Components

Manufacturer (Headquarters Country) Part Number Image	Quantity	Function	Information/ Comments	Integrated Circuit Package Types
Broadcom Limited (USA) BCM4712LKFB BCM4712LKFB BCM4712LKFB BCM4712LKFB BCM4712LKFB BCM4712LKFB BCM4712LKFB BCM4712LKFB BCM4712LKFB	1	Fully integrated Wi-Fi access point processor	<u>Overview</u>	HFC-BGA High Flip Chip Ball Grid Array
Broadcom Limited (USA) BCM5325EKQM	1	6 Port Managed 10/100 Robo Switch	Product Brief	128pin MQFP Metric Quad Flat Pack
Broadcom Limited (USA) BCM2050KML	1	2.4 GHz Radio Single Chip found under metal shielding	Reference Sheet	MQFP Metric Quad Flat Pack

Diodes Incorporated (USA) AP1605	1	Step-down switching regulator with Pulse Width Modulation/ Pulse Frequency Modulation dual mode control	<u>Datasheet</u>	SOP-8 Small Outline Package
Diodes Incorporated (USA) 1509-33	1	Step-down DC/DC converter • -33 marking denotes device has a 3.3V output voltage	<u>Datasheet</u>	SOP-8 Small Outline Package
Diodes Incorporated (USA) 1509-50	1	Step-down DC/DC converter • -50 marking denotes device has a 5.0V output voltage	<u>Datasheet</u>	SOP-8 Small Outline Package
SK Hynix (South Korea) HY5DU281622ET-J	1	Double Data Rate Synchronous Dynamic Random Access Memory	<u>Datasheet</u>	66TSOP-II Thin Small Outline Package

Intel (USA) TE28F320	1	Flash Read Only Memory maintains stored data without any external power source	Datasheet	48TSOP Thin Small Outline Package
Richtek Technology Corporation (Taiwan) RT9167A	1	300mA/500mA low dropout and low noise micro power regulator	<u>Datasheet</u>	SOP-8 Small Outline Package
SiGe Semiconductors (now Skyworks) (USA) 2528L	1	RF Front End 2.4 GHz Power Amplifier with Power Detector Found under metal shielding	Datasheet	16QFP
Skyworks (USA) S79 = AS179-92	2	20 MHz to 4.0 GHz Gallium Arsenide Single Pole Double Throw Switch	<u>Datasheet</u>	SOT-323 Small Outline Transistor

Texas Instruments (USA) LVC14A	1	Hex Schmitt-trigger inverter	Datasheet Part Marking Lookup TI Confirmed TI part by CSR 1(512)434-1560 Lisa Barrett	SOIC-14 Small Outline Integrated Circuit
Texas Instruments (USA) LAYA	1	Micropower 150mA Low-Noise Low-Dropout Regulator	Technical Documents Part Marking Lookup TI	SOT-23 5 Small Outline Transistor
Unidentified IC	2	Marking VF, VG Researched device marking codes but we can't confirm	No data found	SOT-23
Unidentified IC	2	Researched forums, blogs, internet, YouTube, inquired from mentors and engineers and no firm answer	No data found	Unknown

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