

LOW COST WIRELESS NETWORK HOW-TO

Table of Contents

- [Appendix A](#)
 - Symphony IC pictures, descriptions and a high power modification
- [Appendix B](#)
 - One Watt power amplifier modification for the Symphony
- [Appendix C](#)
 - High gain, low noise receive pre-amplifier modification for the Symphony
- [Appendix D](#)
 - Bi-directional 2.4 GHz one Watt amplifier with receive pre-amp modification for the Symphony
- [Appendix E](#)
 - Information, amplifier and antenna designs for the 915 MHz WaveLAN
- [Appendix G](#)
 - Information on 802.11 based wireless network cards

Proxim Symphony Image Map

Select IC or part for description and picture.



High resolution scans of the ISA Symphony [front](#) and [back](#).

High resolution scans of the PCI Symphony [overview](#), [RF section](#) and [controller section](#).

High resolution scans of a modified Symphony [under the main RF shield](#).

[High power \(400 mW\) modification](#) for the Proxim Symphony wireless Ethernet bridge.

Additional Notes

This card is labeled "REV19"

There appear to be test points on the card marked:

DIR - *direction control* ??

AEN - *address enable* ??

IORD - *I/O read* ??

IOWR - *I/O write* ??

The RF power amplifier IC, a 6-pin IC marked with "83A", is an [Agilent Technologies MGA-83563](#) running at 3 volts DC, dropped from 5 volts with a few resistors. It's possible to change out those resistors and run the IC at 3.6 - 3.9 volts to get more RF power output. The maximum DC voltage for this IC is 4 volts and the maximum RF power output is around +23 dBm (200 mW).

The best way to do this would be with another parallel resistor. Adding a 22 Ohm resistor in parallel with the four 39 Ohm resistors would bring the total resistance to around 6.8 Ohms. This should give you 3.6 VDC on the power pin. WTF?? Show your math...

V_d = Dropping resistor

V_1 = Voltage on the power line

V_2 = Voltage you want V_1 dropped to.

I = Current draw

$$V_d = (V_1 - V_2) / I$$

Substituting the Symphony values:

$$9.75 = (5 - 3) / I$$

$$I = 2 / 9.75$$

$$I = .205 \text{ amps}$$

Calculate the new value V_d :

$$V_d = (5 - 3.6) / .205$$

$$V_d = 6.8 \text{ Ohms}$$

Which is the value of four 39 Ohm resistors and one 22 Ohm in parallel.

This can also be adapted to other wireless network cards.

You should also remove the Pi-style attenuator pad in the RF input. This also increases the RF power output a little. Just remove the two 270 Ohm SMT resistors going to ground and replace the series 18 Ohm resistor with a 0 Ohm jumper.

The PIN diode switch is an [Agilent Technologies HSMP-3894](#).

The intermediate frequency (IF) receiver is based on the [National LMX2240](#). Visit that site for datasheets and application notes.

Tap Points For Transmit/Receive

It's be possible to tap the PIN diode bias line to control an external amplifier. When viewing the pictures, locate the PIN diode switch, near the antenna output and labeled with "G4A", and tap before the small SMT bias resistor. This is a TTL (+5 - 0 volts) indicator of transmit/receive and can be extended to control an external power amplifier. Measuring RSSI output voltage is also possible by following the output of pin 2 on the LMX2240 and measuring the voltage on the little solder pad. Refer to the LMX2240 data sheet for more info.

- [Partial schematic of RF amplifier section](#) (30k PNG)
- [RF IC layout](#) (14k PNG)

- [Symphony modification](#) Shows the 22 Ohm parallel resistor and the 0 Ohm jumper (77k JPEG)
- [Symphony modification](#) Taping the RSSI on the LMX2240 (70k JPEG)
- [My funky transmit LED](#) (41k JPEG)
- [Pictures of oscilloscope traces on the RSSI and PIN diode bias lines](#)

Thank you for the message. However, I am unable to provide you the information you seek. Proxim is required to remain within FCC guidelines for emissions on our products, and amplifying the output would violate this. I understand that you have a radio license, however, we are not able to provide the information which goes outside the specifications that we are certified under. In the same vein, our board designs are proprietary and therefore we can not disclose the design details you seek.

We apologize for the inconvenience this may cause you. Proxim certainly wants to support its user base, however, we must remain in conformation with regulatory guidelines and reasonable business practices.

Sure..

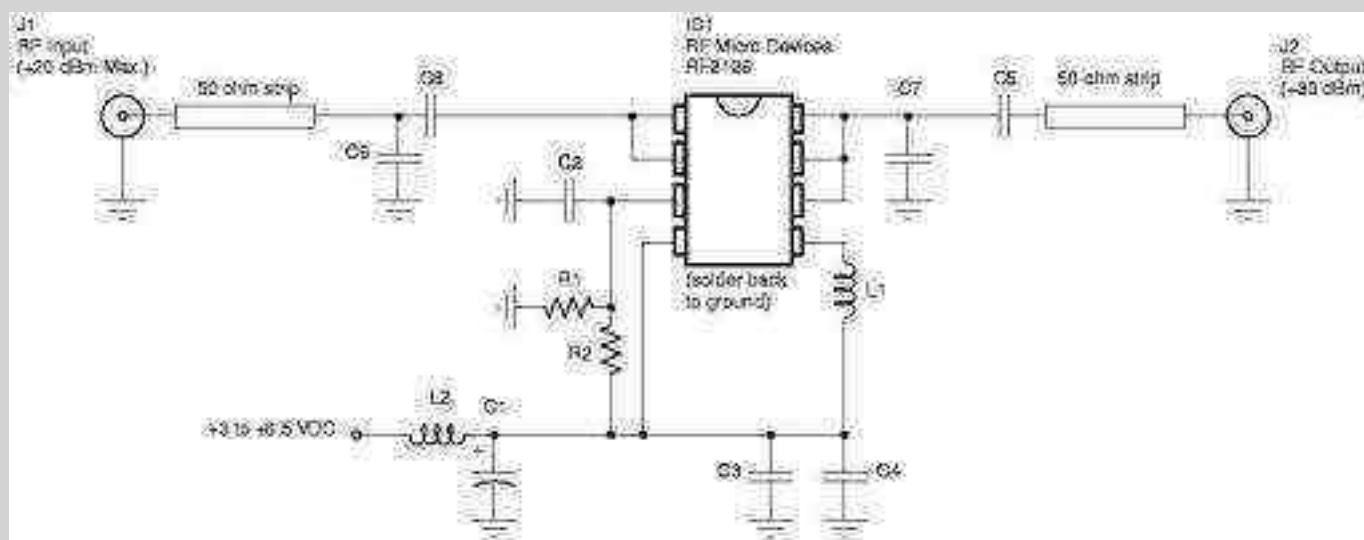
[Return to Main](#)

Modifying The Symphony For One Watt RF Power Output

This will show you how to add a RF power amplifier to your Proxim Symphony for under \$50. The cost is reduced by using the existing components on the Symphony, such as the PIN diode switch, and just inserting a higher power final amplifier.

Adaptation to wireless network cards other than the Symphony should be trivial.

Schematic



[Power](#)

[amplifier schematic](#)

Construction Notes

Start by reading the [data sheet](#) for the [RF Micro Devices](#) RF2126, you'll find out quickly that it's a tiny little 8-pin PSOP 2.4 GHz amplifier IC. If you are up to working with this device, call RFMD up at 336-664-1233 and order a few (around \$7 each), or ask if they will send you some free engineering samples.

You'll want to pick up some quality 1/32 inch, double-sided, one ounce copper clad FR-4 circuit board. The [Injectorall](#) circuit board from [Digi-Key](#) is perfect. Its part number is PC44-ND for 3 x 4.5 inches and costs \$3.23. You should also pick up the Toner Transfer System design paper by [DynaArt](#), part number TTS-5-ND for a 5-sheet pack. This will allow you to print the [circuit board pattern](#), ([PostScript](#) version), out on a laser printer and then iron it onto the copper clad board. This is probably the best, and cheapest, way to create your own printed circuit boards.

The next step is to make the circuit board for the amplifier. ***You should use the board pattern RF Micro Devices provides!*** This is because the delicate 50 ohm strip lines that are needed are a real pain to recreate on your own. Here are some links to help with the

fabrication of your own printed circuit board:

- [Making Excellent Printed Circuit Boards](#)
- [PC Board Tips from Mark Weiss](#)
- [Making PCBs at home](#)
- [PCB Designers Den by George Patrick](#)
- [Printed Circuit Prototyping](#)

You will need to modify the supplied circuit board pattern to allow for the two voltage divider resistors. Just cut into the trace leading to pin 3 of the RF2126 with a razor blade.

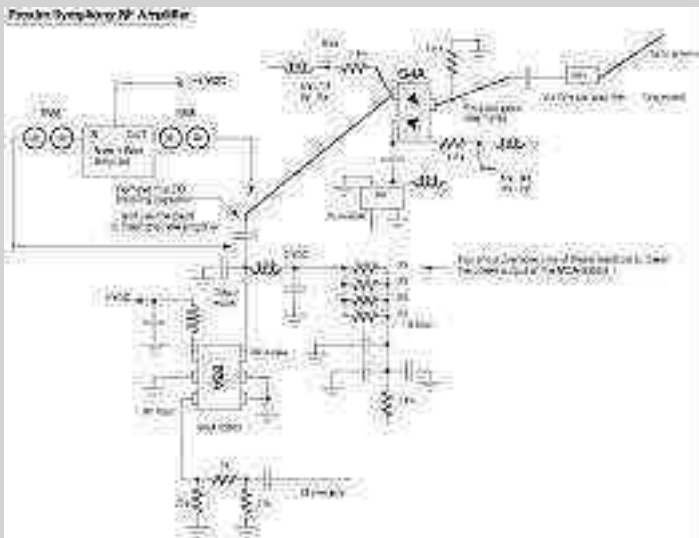
After your circuit board is etched, you should drill and solder all the ground vias. Those are what connects the top copper plane to the bottom plane on two sided copper clad boards. Do this by drilling a small hole where the marks are in the circuit pattern picture (the white dots in the above JPEG), then solder a piece of wire in the holes to connect the top and bottom planes. Cut off any excess length of wire flush to the copper plane. You can then start to solder in all the discrete components. Start with the small surface mount capacitors and inductors, then move to the larger components. The very last thing to solder in will be the RF2126 IC. This is done to protect the IC from any extended handling. You should then install PC board mount SMA jacks to quickly allow you to connect the amplifier up. Note that this is all easier said than done :)

If you are a wuss, RF Micro Devices sells completed evaluation boards for the RF2126 for around \$150 each. All the parts are already installed and it even includes SMA jacks.

Pre-made PC boards are now available for this project through [FAR Circuits](#).

Insertion

You'll need to unsolder the large RF shield to get access to the insertion points.



[Where to insert the new amplifier](#)

[module](#) (17k [PostScript](#))



[A picture](#)

Operation Notes

So now that you have about one watt RF power output into a high gain directional antenna, does this mean you can establish a wireless link fifty qazillion kilometers? Nope. Microwaves are line-of-sight, no matter what the power is. The higher power *will* overcome smaller obstructions, like trees and leaves, but it still won't cut through that hill in the middle of your link path.

So why bother?

Chicks dig RF burns.

<PROFESSOR_MODE>

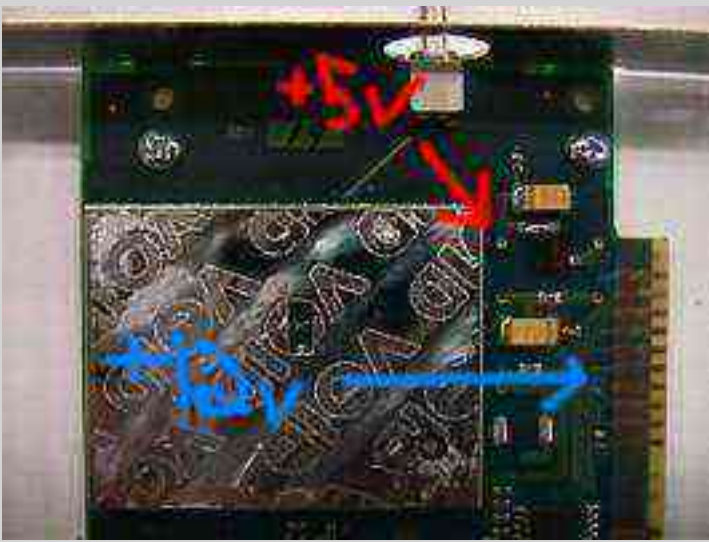
Technically, the fact that frequency hopping systems don't spread their signal results in no [processing gain](#). Processing gain comes from the increase in power density when the received signal is despread. This helps to improve the received signal's signal-to-noise ratio. In other words, frequency hopping systems will need to put out more power in order to have the same signal-to-noise ratio as a direct sequence system.

</PROFESSOR_MODE>

Pictures

View some of the [construction pictures](#).

+5 & +12 VDC Tap Points



[Open solder pads for +5 & +12 VDC](#)

Cautions

- This hack is ***not*** compatible with the higher power modification shown in [Appendix A](#). Use this only with an unmodified Symphony.
- You ***will*** need to completely shield the amplifier circuit when it's finished. Scrap copper clad PC board is perfect for this.
- ***Do not*** remove the antenna while your Symphony is powered on using the new power amplifier. Power it down by issuing the commands 'ifdown eth?' and 'rmmod rlmod'.
- One watt into a 24 dB directional antenna has an effective radiated power of over 250 watts.
- Don't point the antenna at your sisters.

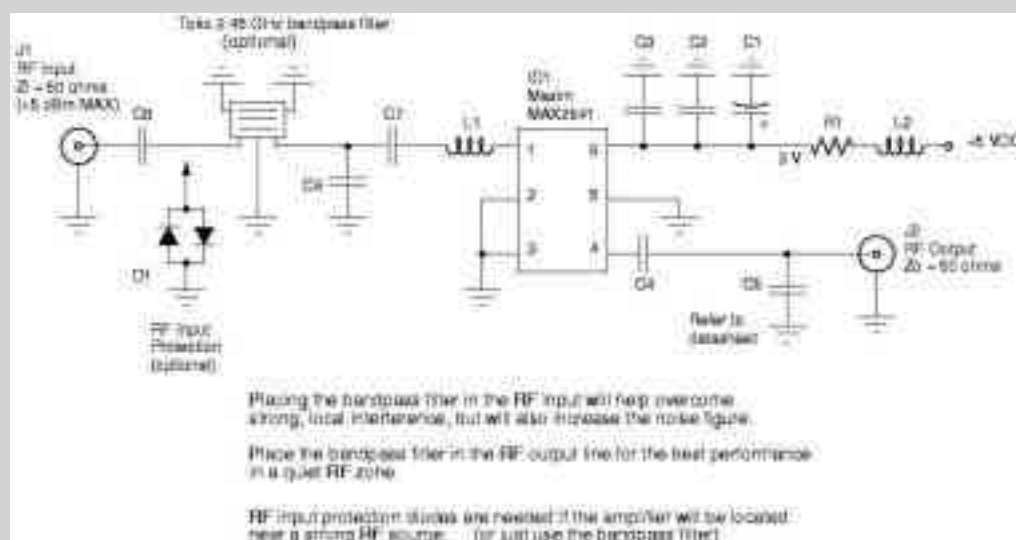
Return to the [Low Cost Wireless Network How-To](#)

High Gain, Low Noise 2.4 GHz Receive Pre-Amplifier Modification

This will show you how to add a high gain (13 dB), low noise figure (1.3 dB) receive pre-amplifier to your Proxim Symphony for under \$50. The cost is reduced by using the existing components on the Symphony, such as the PIN diode switch, and just inserting the receive pre-amplifier.

Adaptation to wireless network cards other than the Symphony should be trivial.

Schematic



[2.4 GHz Receive](#)

[pre-amplifier schematic](#)

Construction Notes

Start by reading the [data sheet](#) and [evaluation kit notes](#) for the [Maxim](#) MAX2641, you'll find out quickly that it's a tiny little 6-pin SOT23-6, 2.4 GHz ultra low noise amplifier IC. If you are up to working with this device, go to Maxim's website and order a few [free engineering samples](#).

You'll want to pick up some quality 1/32 inch, double-sided, 1 ounce copper clad FR-4 circuit board. The [Injectorall](#) circuit board from [Digi-Key](#) is perfect. Its part number is PC44-ND for 3 x 4.5 inches and costs \$3.23. You should also pick up the Toner Transfer System design paper by [DynaArt](#), part number TTS-5-ND for a 5-sheet pack. This will allow you to print the [circuit board pattern](#), ([PostScript](#) version), out on a laser printer and then iron it onto the copper clad board. This is probably the best, and cheapest, way to create your own printed circuit boards.

The next step is to make the circuit board for the amplifier. ***You must use the board pattern Maxim provides!*** This is because the delicate 50 ohm strip lines that are needed are a real

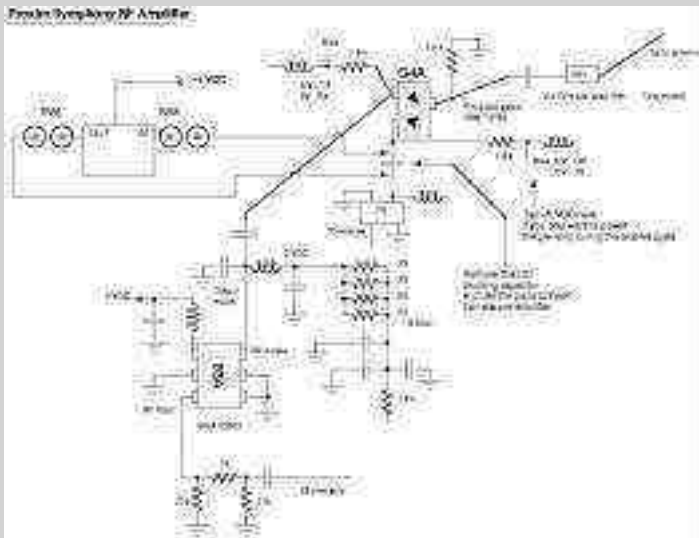
pain to recreate on your own. Here are some links to help with the fabrication of your own printed circuit board:

- [Making Excellent Printed Circuit Boards](#)
- [Tips from Mark Weiss](#)
- [Making PCBs at home](#)
- [PCB Designers Den by George Patrick](#)
- [Printed Circuit Prototyping](#)

After your circuit board is etched, you should drill and solder all the ground vias. Those are what connects the top copper plane to the bottom plane on two sided copper clad boards. Do this by drilling a small hole where the marks are in the circuit pattern picture (the black dots in the above JPEG), then solder a piece of wire in the holes to connect the top and bottom planes. Cut off any excess length of wire flush to the copper plane. You can then start to solder in all the discrete components. Install the small surface mount capacitors, then move to the larger components. The very last thing to solder in will be the MAX2641 IC. This is done to protect the IC from any extended handling.

Insertion

You'll need to unsolder the large RF shield to get access to the insertion points.



[Where to insert the new pre-amplifier](#)

[module](#) (18k [PostScript](#))



[A picture](#)

Operation Notes

The receive pre-amplifier will amplify *all* the signals it hears, so it's best if you insert a 2.45 GHz bandpass filter in the RF input line. You can order bandpass filters from [Digi-Key](#) for about \$20 each. The 2-pole model is part number TKS2610CT-ND and the 3-pole model is TKS2618CT-ND. The 3-pole model is the better of the two. These particular filters ([Toko](#)) ***can not be used with DC voltages on their terminals!*** This is because they are DC grounded. You'll need to add a DC blocking capacitor in front of the bandpass filter to block the PIN diode bias voltage. A 0603 style 22 pF capacitor will work fine.

If you need to power the pre-amplifier only during the receive cycle (not continuously on), view the following pictures to get the location to tap point this control voltage.

Pictures

View some of the [construction pictures](#).

+5 VDC Tap Point

You can tap the 5 volts here:



[Open solder pad for +5 VDC](#)

Return to the [Low Cost Wireless Network How-To](#)

Bi-Directional 2.4 GHz One Watt Amplifier With Receive Pre-Amp

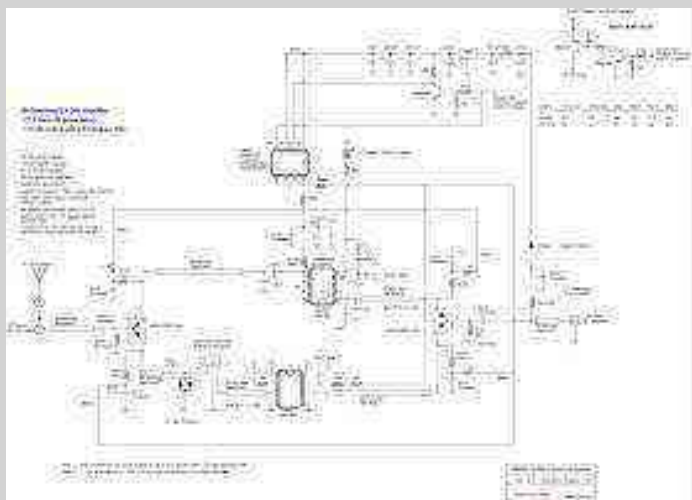
Some designs are for research only. Advanced microwave and RF design skills will be required to build these circuits.

This will show you how to add a bi-directional, 2.4 GHz amplifier to your Proxim Symphony for under \$100. Bi-directional means you can mount the amplifier *at the antenna* to help overcome any cable loss, and the amplifier will automatically switch between receive and transmit modes. The cost is reduced by using readily available materials and components. Also, instead of a complicated RF sensing transmit/receive switch, a logic level indication of transmit is sent to the amplifier through a length of low cost coaxial cable. The final RF power output of this amplifier will be around +31 dBm (1.3 watts) and the receive gain is around 16 dB (with a 2 dB noise figure).

Receive amplification is tricky subject. When done right, it works wonders. When done wrong, your stuck listening to shortwave broadcast stations in Yugoslavia. If you don't need to have the receiver amplifier (due to excess local noise/intermodulation or loss coax loss), just replace it with a stripline jumper. If you're too stupid to figure that out, then please don't build these.

Adaptation to wireless network cards other than the Symphony should be trivial.

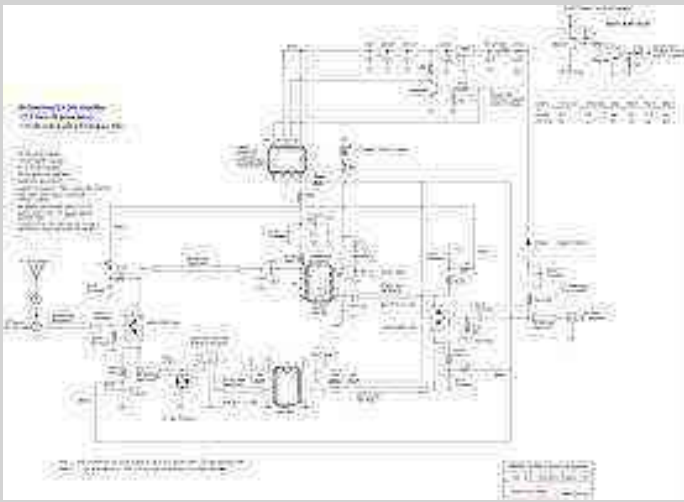
Schematics



Block Diagram

[2.4 GHz Bi-Directional GHz](#)

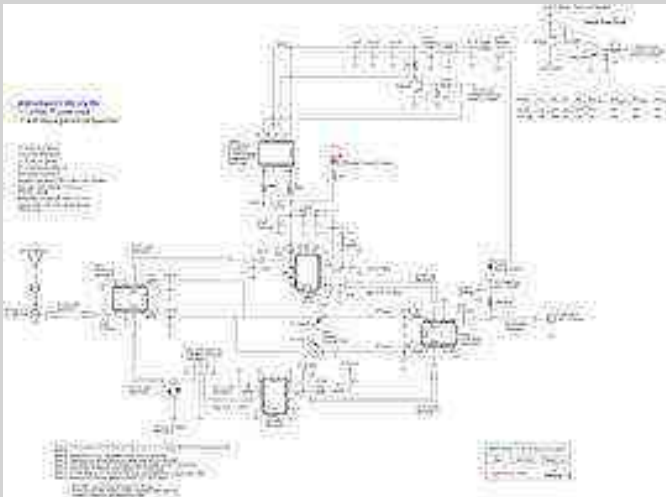
[Amplifier Block Diagram](#)



Number 1

[Bi-Directional 2.4 GHz Amplifier](#)

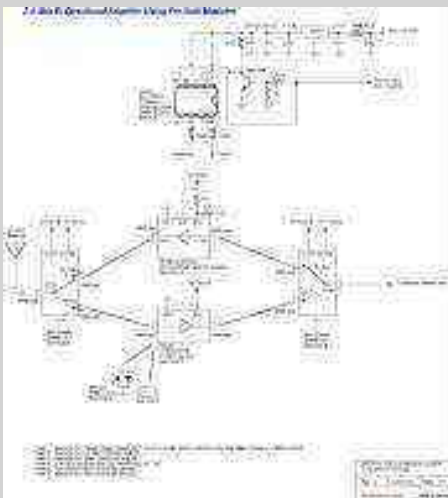
[Schematic](#) First original design - reference only, don't build



Number 2

[Bi-Directional 2.4 GHz Amplifier](#)

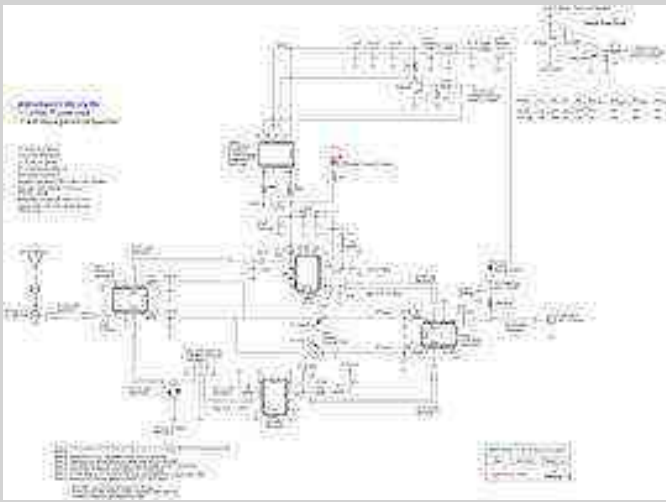
[Schematic](#) Second original design - reference only, don't build



Number 3

[Bi-Directional 2.4 GHz Amplifier Using Pre-Built](#)

[Modules and Evaluation Boards](#) Untested - reference only



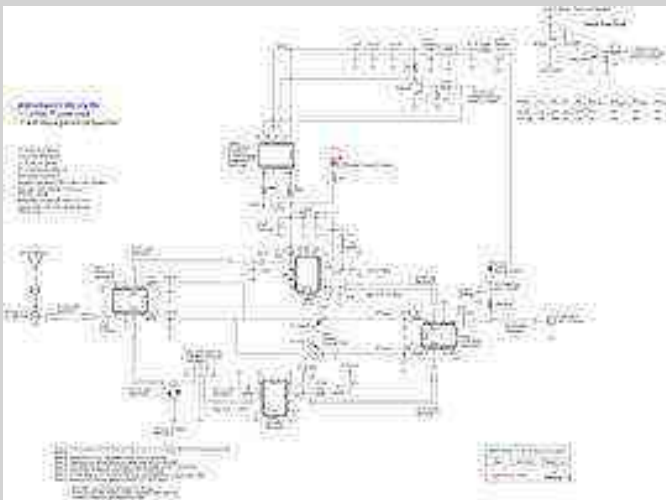
Number 4

[Newest Bi-Directional 2.4 GHz](#)

[Amplifier Design](#)

Includes an *experimental* idea for remote RF sense. Newest design - reference only, work in progress

Experimental [PCB design](#) for the above amplifier. DON'T USE! It's undocumented/ideas only right now, prints settings are: 3.75 inches long, 2 inches wide. 1/32", 1 oz FR-4 material. Pattern is for the old style antenna switch.



Number 5

[Power Amplifier Only for PRISM2](#)

[Based Access Points](#) Currently untested - reference only

Tap points for a [SOHOware PRISM2 access point](#) and a picture of the included [antenna jack](#). Transmit antenna is the one on the right, looking down on the unit with the ethernet/power jack facing away from you.

FCC Records of Commercial Amplifiers

- [Hyperlink - Pic 1](#)
- [Hyperlink - Pic 2](#)
- [Hyperlink PCB layout](#) (20k PDF)
- [Hyperlink amplifier block diagram](#) (34k PDF)
- [Breezecom 2.4 GHz amplifier FCC info](#) Includes parts list!
- [YDI - Pic 1](#)
- [YDI - Pic 2](#)

- [YDI - Pic 3](#)
- [YDI - Pic 4](#)

RF Sense Switch Ideas

This is the only real thing I'm having trouble with. If you have any better ideas, or close-up pictures of a commercial amplifier unit, please let me know.

- [RF sense switch ideas](#) Probably don't work too well (44k PNG)

Construction Notes

Start by reading the [data sheet](#) for the [RF Micro Devices](#) RF2126 1 watt 8-pin PSOP 2.4 GHz amplifier IC. If you are up to working with this device, call RFMD up at 336-664-1233 and order a few (around \$7 each), or ask if they will send you some free engineering samples.

Next, read the [data sheet](#) for the [Intersil](#) HFA3424 2.4 GHz - 2.5 GHz low noise amplifier. It's also a 8-pin PSOP device. You can order these for around \$8 each from [Arrow Electronics](#) or [Allied Electronics](#).

Next, read the [data sheet](#) for the [Intersil](#) HSMP-3894 SOT-23 PIN diode. You can order these for around \$1 each from [Down East Microwave](#) or [Allied Electronics](#).

Next, read the [data sheet](#) for the [Intersil](#) RF1K49093 8-pin PSOP power MOSFET. You can order these for around \$2 each from [Newark Electronics](#) or [Allied Electronics](#).

You'll want to pick up some quality 1/32 inch, double-sided, one ounce oz copper clad FR-4 circuit board. The [Injectorall](#) circuit board from [Digi-Key](#) is perfect. Its part number is PC44-ND for 3 x 4.5 inches and costs \$3.23. Teflon circuit board has better characteristics at microwave frequencies so use that instead if you can find it. [Down East Microwave](#) and [Rogers](#) sell Teflon board. Note that you will need to change the widths of all the 50 ohm striplines in the schematic due to the lower dielectric constant of Teflon board material.

Now, make the circuit board for the amplifier. You'll have to do this by hand until *someone* makes me a PCB pattern. Heh. You can use those rub on thingys from Radio Shack (#276-1490) to layout the pattern. The 1 mm wide traces are almost perfect for 50 ohm striplines on 4.34 er, 1/32 inch FR-4 board material (actual width required is 1.4 mm) and the 2 mm traces are perfect 50 ohm for striplines on 2.55 er, 1/32" Teflon board material. Leave large pads for the components that require grounding, and try to remove all the copper around the paths where actual RF energy will flow. Consult the various microwave design books from the [ARRL](#) for more information on designing microwave circuits.

Here is a cool [strip line calculator](#) CGI to help in the design and analysis of strip line circuits.

Here are some links to help with the fabrication of your own printed circuit board:

- [Making Excellent Printed Circuit Boards](#)
- [Tips from Mark Weiss](#)
- [Making PCBs at home](#)
- [PCB Designers Den by George Patrick](#)
- [Printed Circuit Prototyping](#)

After your circuit board is etched, you should drill and solder all the ground vias. Those are what connects the top copper plane to the bottom plane on two sided copper clad boards. Do this by drilling small holes where proper grounding is required, then solder a piece of wire in the holes to connect the top and bottom planes. Cut off any excess length of wire flush to the copper plane. You can then start to solder in all the discrete components. Start with the small surface mount capacitors, resistors, and inductors, then move to the larger components. The very last thing to solder in will be the ICs. This is done to protect the ICs from any extended handling. Note that this is all easier said than done :)

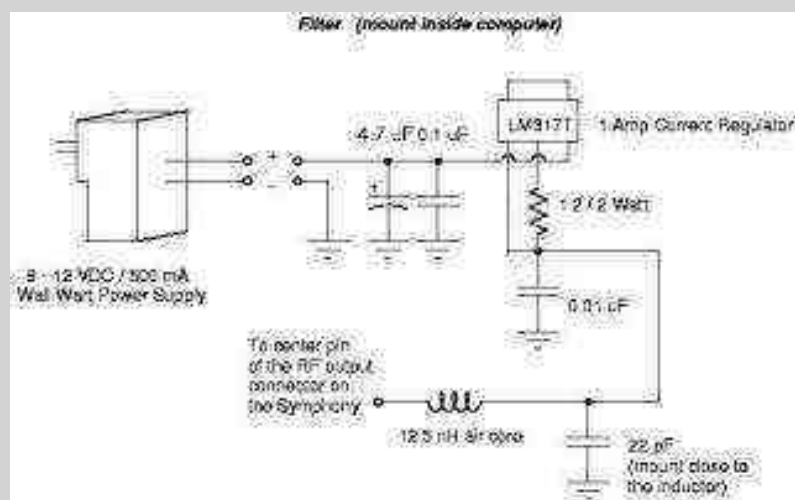
It's also possible to make a receive only pre-amplifier by just replacing the power amplifier section with a 50 ohm stripline, or you can make a power amplifier only by replacing the receive section with a 50 ohm stripline.

Datasheets & Notes

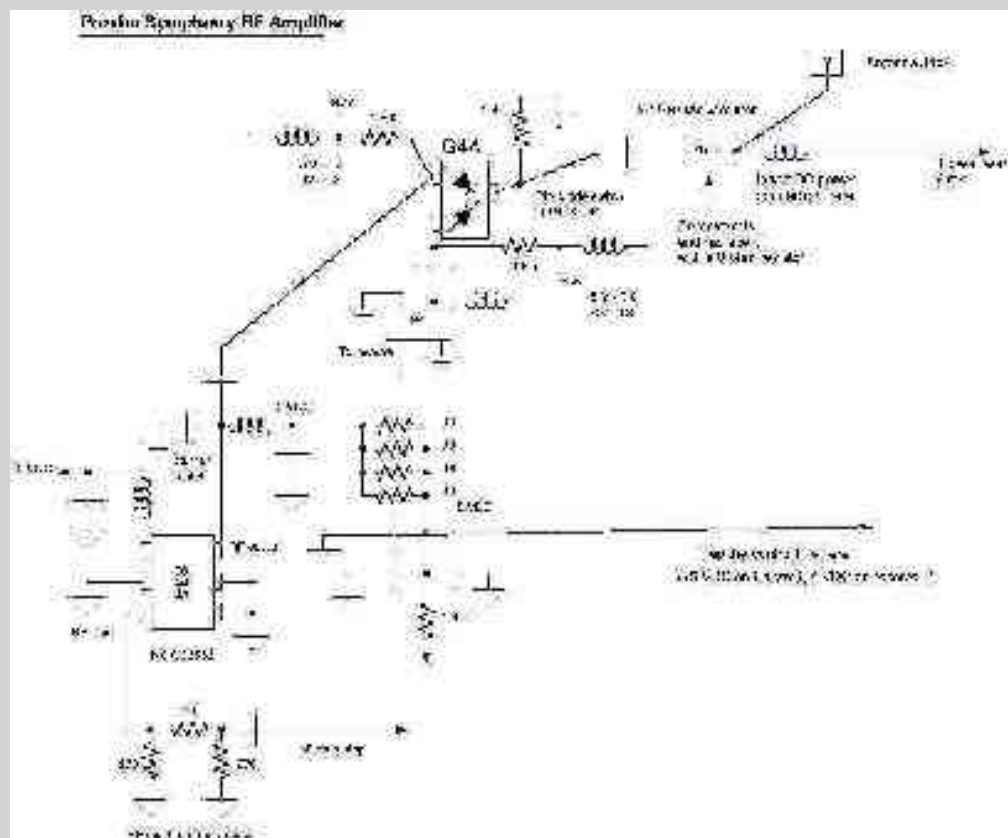
- [Intersil HFA3925](#) This is where I got the TX/RX switching idea from.
- [Johanson C-series chip capacitors](#) High quality microwave capacitors.
- [PRISM1KIT-EVAL DSSS evaluation kit parts list](#) Lists the actual manufacture part numbers in PRISM systems.
- [UPG152TA NEC L-band SPDT GaAs MMIC switch](#) High power switch that is easy to obtain.
- [MMST2222A NPN transistor datasheet](#)
- [Application of PIN diodes](#) From HP
- [Fast switching PIN diodes](#) From HP
- [Applications for the HSMP-3890 surface mount switching PIN diode](#) From HP

Insertion, DC Power Input & Control

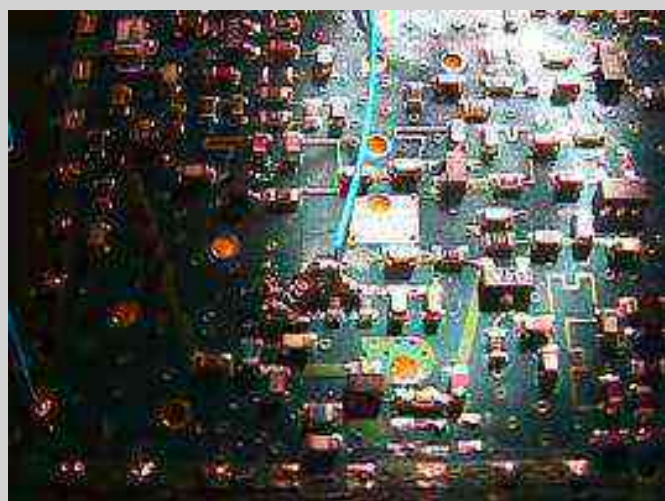
Stick the entire amplifier board inside a *well designed* waterproof case ([Hammond](#) boxes are perfect) and mount it right next to your antenna installation or on the antenna mast. You should run LMR-400 coax for the RF input feed line. The DC power for the amplifier is also inserted in this line, so you'll have to modify your Symphony to allow that. Run RG-6 quad-shield coax (Radio Shack #278-1317) for the amplifier's control line. Run this along side the RF input feed line and try to keep this line as short as possible. You can use normal F connectors on the control line if you desire.



[Wall wart power supply filter](#) (11k)



Symphony (17k PostScript)



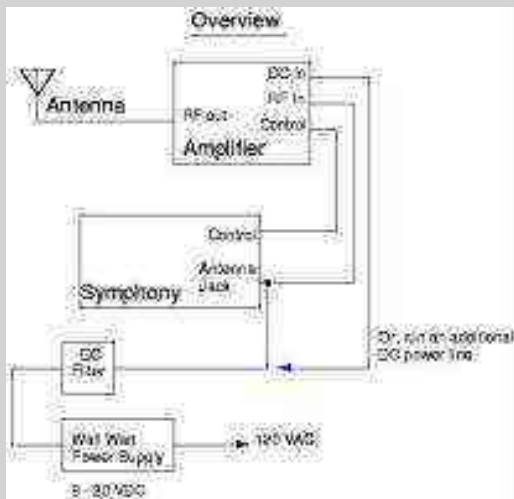
Symphony (blue wire)

<http://www.qsl.net/n9zia/wireless/appendixD.html> (6 of 9) [3/19/2002 11:40:14 AM]



[Amplifier's DC Power insertion point inside the Symphony](#)

It's also possible to provide the amplifier's DC power through an additional power line. You can do this if you don't want to modify your Symphony for DC power insertion on the RF output. Run the power in another run of RG-6 quad-shield, just like the control line.



[Overview of the power / control lines for the amplifier](#)

Operation Notes

This bi-directional amplifier uses an external control line to switch between transmit and receive modes. This eliminates the complexity of a homebrew RF sense circuit. The components and design are such that anyone with some experience in microwave circuit construction should be able to build this amplifier. You can then mount this amplifier directly at the antenna or, for a much easier setup, just a few feet away from the Symphony card.

Pictures

View some of the [construction pictures](#). *Note that this covers a prototype amplifier.*

Case Labels

- [Big label](#) ([PostScript](#))
- [Little label](#) ([PostScript](#))

Cautions & Notes

- You *will* need to completely shield the amplifier circuit when it's finished. Scrap copper clad

PC board is perfect for this.

- Don't remove the control line while the Symphony is in operation or you'll end up transmitting into your receive pre-amp.
- Don't take candy from strangers.

[Code of Federal Regulations]
[Title 47, Volume 1, Parts 0 to 19]
[Revised as of October 1, 2000]
[CITE: 47CFR15.23]

TITLE 47--TELECOMMUNICATION

CHAPTER I--FEDERAL COMMUNICATIONS COMMISSION

PART 15--RADIO FREQUENCY DEVICES--Table of Contents

Subpart A--General

Sec. 15.23 Home-built devices.

(a) Equipment authorization is not required for devices that are not marketed, are not constructed from a kit, and are built in quantities of five or less for personal use.

(b) It is recognized that the individual builder of home-built equipment may not possess the means to perform the measurements for determining compliance with the regulations. In this case, the builder is expected to employ good engineering practices to meet the specified technical standards to the greatest extent practicable. The provisions of Sec. 15.5 apply to this equipment.



ANSI RF radiation dosage meter.

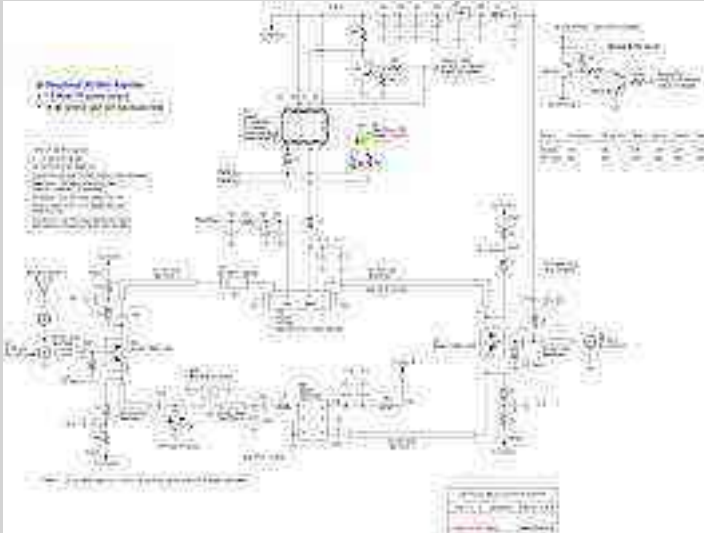


Return to the [Low Cost Wireless Network How-To](#)

Hacking The Original 915 MHz WaveLAN

NCR 915 MHz WaveLAN (2 Mbps DSSS) [pictures and IC descriptions](#).

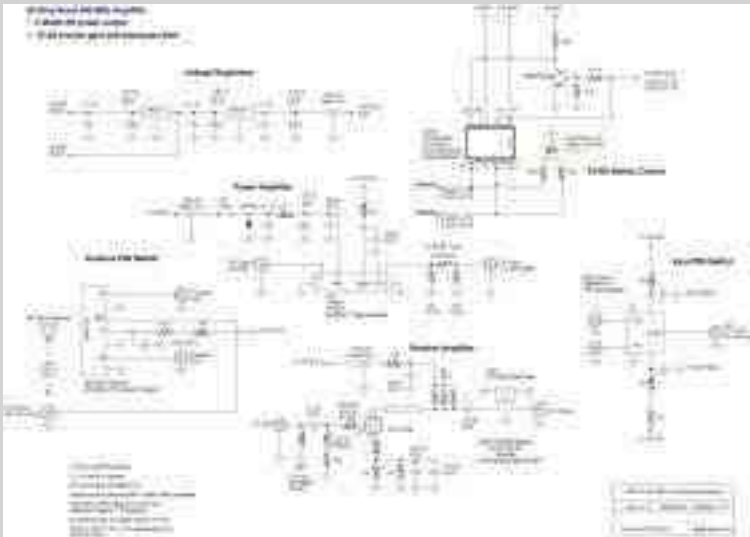
Schematics



Number 1

[Bi-Directional 915 MHz](#)

[Amplifier Schematic](#) Original design - reference only, don't build



Number 2

[New Bi-Directional 915](#)

[MHz Amplifier Schematic](#) Newest design - confirmed to work

[Pictures](#) of the above amplifier. Each of the sections was built as an individual module. This makes trouble shooting much simpler.

Datasheets & Notes

- [Hitachi PF0031 MOSFET power amplifier module datasheet](#) (68k PDF)
- [Hitachi PF0030 MOSFET power amplifier module installed in a Nokia cellular phone](#)

- [Inside a PF0030 module](#) Picture 1
- [Inside a PF0030 module](#) Picture 2
- [NEC UPG152TA GaAs MMIC SPDT RF switch datasheet](#) (26k PDF)
- [Microsemi UM9601 PIN diode datasheet](#) (470k PDF)
- [Mitsubishi MD003 PIN diode module data](#)
- [ATF10136 Low Noise GaAsFET datasheet](#) (50k PDF)

Links

- [Wireless Internet access in Latvia](#) Using 915 MHz WaveLANs. (dead link?)
- [Handoffs in Cellular Wireless Networks: The Daedalus Implementation and Experience](#)
- [Setting the base address on the NCR WaveLAN](#)
- [Context: Measured performance of a wireless LAN](#)

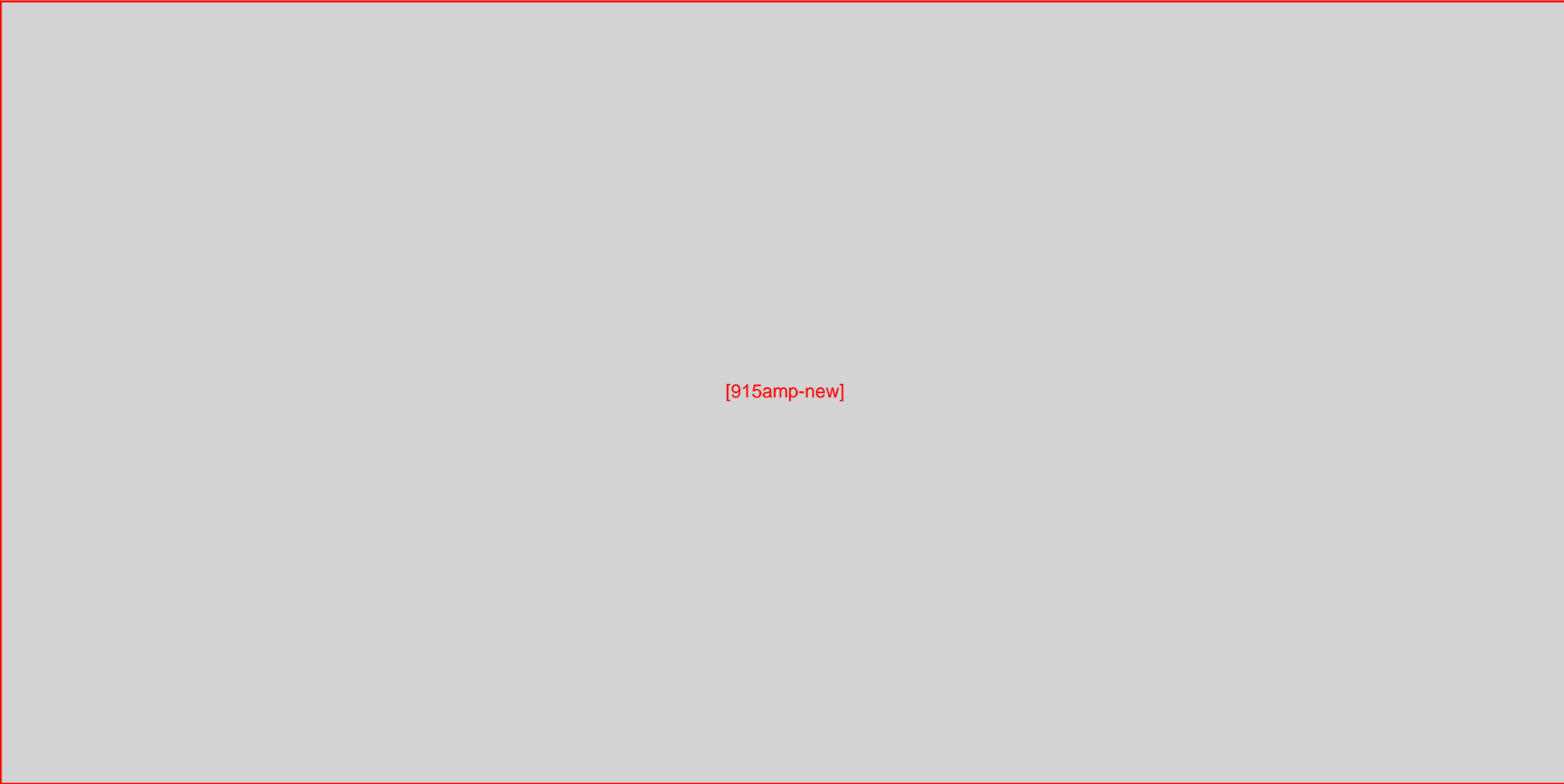
900 MHz Antenna Ideas / Designs / Schematics / Suppliers

- [Instructions](#) for a homebrew 10-element 900 MHz quagi.
- [Picture](#) of a homebrew 8-element 900 MHz quagi driven element.
- [Overall view](#) of a homebrew 8-element 900 MHz quagi.
- [Instructions](#) for a homebrew 6 dBd 915 MHz colinear antenna
- [Original 438 MHz](#) colinear design.
- [Instructions](#) for a homebrew 6 dBd 915 MHz J-pole antenna
- [J-pole antenna design notes](#)
- [Picture](#) of a homebrew 915 MHz J-pole using bronze brazing rod.
- [Homebrew Yagi](#) antennas for \$5.
- Two pictures ([one](#) and [two](#)) of our homebrew 900 MHz Yagi.
- [Homebrew high gain colinear](#) antennas for repeater use.
- [Homebrew high gain coaxial colinear](#) antenna for 432 MHz. Very easy to make.
- [Build A 9 dB, 70cm, Colinear Antenna From Coax](#) By N1HFX
- [Astron Antennas](#)
- [Down East Microwave](#)
- [Directive Systems](#)
- [M Squared](#) The best deal.

Yagi antenna gain can be approximated by counting the number of elements and then using this formula: $10 \log (\text{number of elements})$. Example, a 8-element Yagi has an approximate gain of 9 dBd.

Return to the [Low Cost Wireless Network How-To](#)

Bi-Directional 900 MHz Six Watt Amplifier With Receive Pre-Amp



[PostScript](#) version.

Capacitors

Schematic Reference	Value	Description	Package	Supplier	Supplier Part Number
---------------------	-------	-------------	---------	----------	----------------------

Inductors

Schematic Reference	Value	Description	Package	Supplier	Supplier Part Number
---------------------	-------	-------------	---------	----------	----------------------

Resistors

Schematic Reference	Value	Description	Package	Supplier	Supplier Part Number
---------------------	-------	-------------	---------	----------	----------------------

Diodes

Schematic Reference	Value	Description	Package	Supplier	Supplier Part Number
---------------------	-------	-------------	---------	----------	----------------------

Integrated Circuits / Transistors

Schematic Reference	Value	Description	Package	Supplier	Supplier Part Number
---------------------	-------	-------------	---------	----------	----------------------

Other

Schematic Reference	Value	Description	Package	Supplier	Supplier Part Number
---------------------	-------	-------------	---------	----------	----------------------

Notes

Part numbers are for reference only. Alternate components may be substituted.

[1] The Hitachi PF0031 is available from [RF Parts](#) for \$30.

[2] You'll need to order the 33 cm LNA kit from Down East Microwave. It's \$40, with SMA connectors.

[3] The MD003H PIN diode module is available from [RF Parts](#) for \$20.

[4] The Mini-Circuits ZMSW-1211 PIN diode module is available from [Fair Radio](#) for \$20.

You are better off buying the SMT resistors from Mouser in groups of 100 each. They only cost \$1.90 and they usually throw in a few extra.

Suppliers

- [Down East Microwave](#)
- [Mouser](#)
- [Digi-Key](#)
- [Richardson Electronics](#)
- [Allied Electronics](#)
- [Newark Electronics](#)
- [Arrow Electronics](#)
- [Radio Shack](#)
- [Coilcraft](#) Free sample inductors
- [RF Micro Devices](#)
- [Intersil](#)
- [Toko](#)

802.11 Wireless LAN Cards

Here are some internal pictures of a [Nokia C021 wireless LAN card](#). This 802.11 card is based on the [Intersil PRISM](#) chipset. Refer to their documentation for a more in-depth analysis.

- [Linux and Prism 2 based wireless cards](#)
- [PRISM I schematic, sheet 1](#)
- [PRISM I schematic, sheet 2](#)
- [PRISM I schematic, sheet 3](#)
- [PRISM I schematic, sheet 4](#)
- [PRISM I schematic, sheet 5](#)
- [Parts listing and descriptions for the above schematics](#) (144k PDF)
- [Another PRISM1 based wireless network device schematic](#) (129k PDF)
- [Samsung wireless card schematics](#)
- [D-Link/Gemtek 11 Mbps WLAN USB adapter, schematic 1](#) (7k PDF)
- [D-Link/Gemtek 11 Mbps WLAN USB adapter, schematic 2](#) (27k PDF)
- [D-Link/Gemtek 11 Mbps WLAN USB adapter, schematic 3](#) (15k PDF)
- [D-Link/Gemtek 11 Mbps WLAN USB adapter, schematic 4](#) (26k PDF)
- [D-Link/Gemtek 11 Mbps WLAN USB adapter, schematic 5](#) (35k PDF)
- [D-Link/Gemtek 11 Mbps WLAN USB adapter, schematic 6](#) (11k PDF)
- [NDC/SOHOware NetBlaster II PCI, schematic 1](#) (34k PDF)
- [NDC/SOHOware NetBlaster II PCI, schematic 2](#) (15k PDF)
- [NDC/SOHOware NetBlaster II PCI, schematic 3](#) (21k PDF)
- [NDC/SOHOware NetBlaster II PCI, schematic 4](#) (27k PDF)
- [NDC/SOHOware NetBlaster II access point, schematic 1](#) No RF section (135k PDF)
- [Another NDC access point schemtic](#) Includes RF section (432k PDF)

Inside a Nokia C021

Select a picture for larger image.



SMA antenna jack and the Toko TDF2A-2450-T bandpass filter. Also shown are the transmit/receive LEDs. The right section is the RF power amplifiers and receive pre-amplifier sections.



Alternate view. The 6-pin IC sorta in the middle is a [NEC UPG152 GaAs MMIC switch](http://www.qsl.net/n9zia/wireless/appendixG.html). You can tap it's control lines to control an external amplifier.



A little better view.



Shown are the HFA3726 400 MHz quadrature IF modulator/demodulator and the HFA3824 direct sequence spread spectrum baseband processor (small IC upper right) and their support components.



Alternate view.



Shown are the HFA3524 dual frequency synthesizer and the associated oscillators and VCOs. Off to the right is the AM79C930 PCnet mobile wireless LAN MAC controller, the 128k flash RAM and the 32k SRAM.



A picture.



Another picture.



And another.



Wow! Another.

Inside a SOHOware NCP130



Antenna connector. Reverse polarity SMA connector. Diversity antenna switching is done by applying the DC control voltage via the coax to the included external diversity antenna.



UPG152TA TX/RX switch and the bandpass filter.



RF power amplifier, standard PRISM2 based hardware.

Return to the [Low Cost Wireless Network How-To](#)

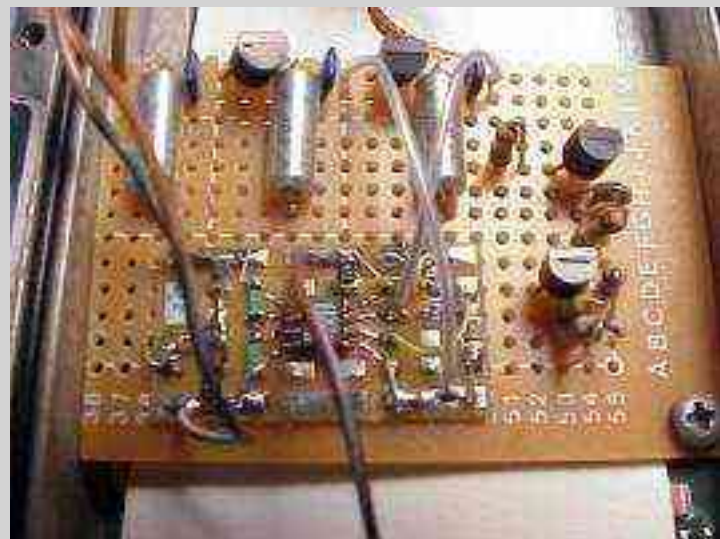
Bi-Directional 900 MHz Amplifier Pictures

Continued from the Low Cost Wireless Network How-To, [Appendix E](#)

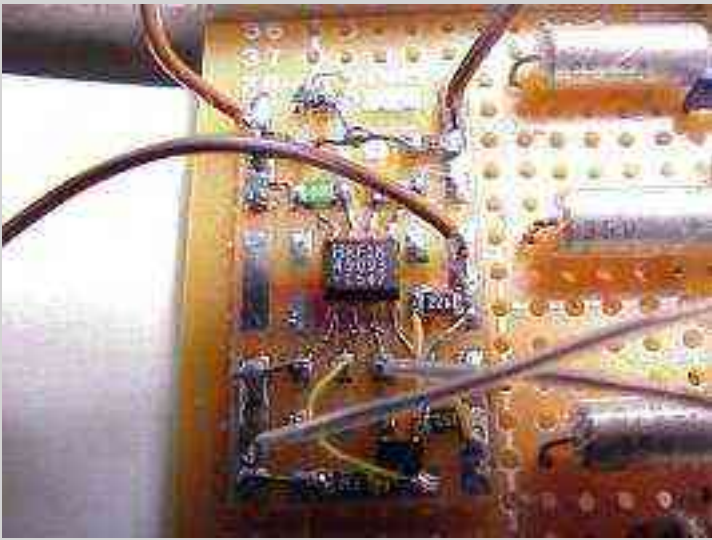
Select a picture for larger image.



Picture of the transmit/receive control logic boards and the voltage regulators. Once again, housed in an old California Amplifier MMDS downconverter case. +15 VDC comes in through the top via a 1000 pF feed-through capacitor. The transmit/receive control logic from the WaveLAN card enters via one of the F connectors on the right side. The +5 VDC on transmit and +9 VDC on receive signals leave the case through standard feed-throughs (non-capacitor).



The 78L05 is shown in the top left, 78L09 is top right. The HRF49093 MOSFET is mounted on a surface mount carrier called a Surfboard. I used surface mount parts in the transistor switching logic for simplicity. *Ignore those two transistors on the right hand side.*



Closeup of the transistor switching logic, the HRF49093 and its outputs.

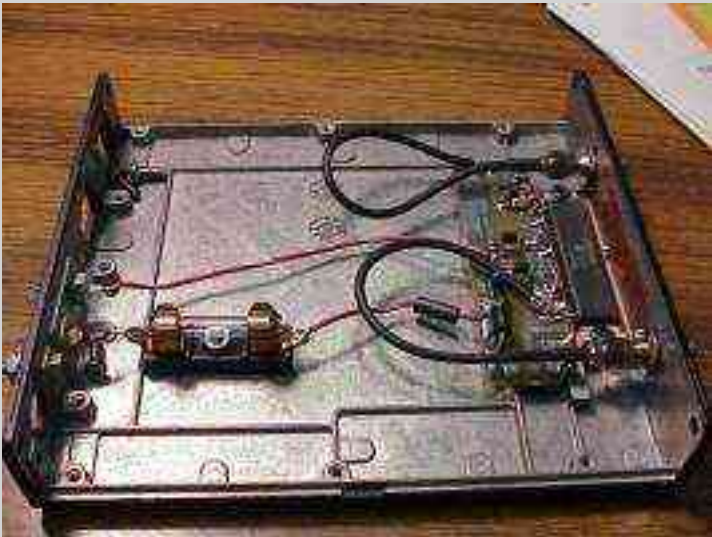


WaveLAN side PIN diode switch module. This is a Mini-Circuits ZMWS-1211, and was purchased from [Fair Radio](http://www.fairradio.com) for \$20. The RF connectors are SMA, and the switch logic is +5 VDC @ 2 mA. They are good up to 2.5 GHz.



Control line #1 (RF port #1 control) shown.. Along with the 100 pF mica bypass capacitor,

a type 43 ferrite bead, and a 2 k resistor used to drop the +9 VDC signal down to the +5 VDC used by the switch. *Math lesson!* $R = (9V - 5V) / 2 \text{ mA} = 2000 \text{ ohms}$



The beast. The [PF0031](#) based power amplifier. I say it's only 6 watts, but in reality, it'll do 10 watts easy. Note, however, in the following pictures you'll need to perform some serious RF engineering skillz, otherwise the amplifier *will oscillate*, probably destructively (AKA, blow up). I salvaged the heatsink and copper heat spreader from an [old Nokia cellular phone](#). I suggest you try to do the same. The PC board the amplifier is mounted to was bought surplus from [Down East Microwave](#), #CL11. This isn't the right PC board, so it will need some modifications to fit the module. The PF0031 module is available from [RF Parts](#).



Closeup of the PF0031 module and its support components. RF input is on the left side, through a SMA bulkhead and a 20 dB resistive pi attenuator using carbon composition resistors. The V_{apc} line is next (going left to right) and is air supported on a 56 pF ATC porcelain capacitor. The V_{dd} line is next, and is also air supported on a 56 pF ATC porcelain capacitor. Finally, on the right side is the RF output, also going through a SMA bulkhead. You can sorta see the copper heat spreader under the PF0031 module. **DO NOT** use heatsink grease on this module because the module's case is the *ground*. Heatsink grease would isolate the module from ground, and it will freak out and crash airplanes and stuff.



Closeup of the RF input side and the 20 dB attenuator. Should probably use surface mount resistors in the attenuator pad, but they won't handle the fairly high RF input power. You can also see how the circuit board was cut to isolate the V_{apc} line.



Closeup of the RF output side and the V_{dd} line. You can see the decoupling capacitors and the idiot diode.



Alternate view to show how the Vapc and Vdd lines are supported in the air by the 56 pF ATC capacitors and the little jumper wires to connect them back to the rest of the circuit.



To reduce power amplifier intermodulation distortion and to protect the amplifier in case of high SWR, you should use an isolator. This is a surplus cellular phone isolator from [Down East Microwave](#), #SE031. The magnet helps to "move it up" to the 900 MHz band. You'll need to sweep it with a signal generator and a diode detector, while moving the magnet around, to tune it. Glue the magnet in place when you're done. The 5 watt, 50 ohm load is also available from [Down East Microwave](#), #SC170. You'll need a N lesbian (N female to N female connector) to connect it to the isolator.



Receive pre-amplifier. Don't even bother with homebrew here, order the 33 cm LNA kit from [Down East Microwave](#), #33LNAK (\$40). It include all the parts, including the case (Hammond 1590A), PC board and SMA connectors. It will need to be modified slightly for use in this project. Most notable is the fact that it is feed directly with +9 VDC instead of going through a voltage regulator, and some of the bypass capacitors are removed. Also added, was a 915 MHz, +/- 15 MHz, bandpass filter (Down East Microwave #SC167, \$5) in the pre-amplifier's output stage. There is also a small, 0.6 inch, #22 hairpin inductor, shunt to ground, on the pre-amplifier's input. This acts as a highpass filter, filtering out anything below about 400 MHz. This should help reduce intermodulation problems from the mixing

with VHF pagers, FM broadcast, etc. Ohh, I forgot, you'll need to remove 2 turns from the series gate inductor if you add the hairpin inductor.



Closeup of the receive pre-amplifier's RF input, showing the shunt inductor and the modified series gate inductor.



Closeup of the receive pre-amplifier's RF output, showing the big 'ole bandpass filter. You'll need to cut the output trace (after the series capacitor) in order to insert the bandpass filter. I used tiny RG-178 coax jumpers to insert the filter. The bandpass filter was added after the pre-amplifier in order to preserve the amplifier's low noise figure (<0.7 dB).



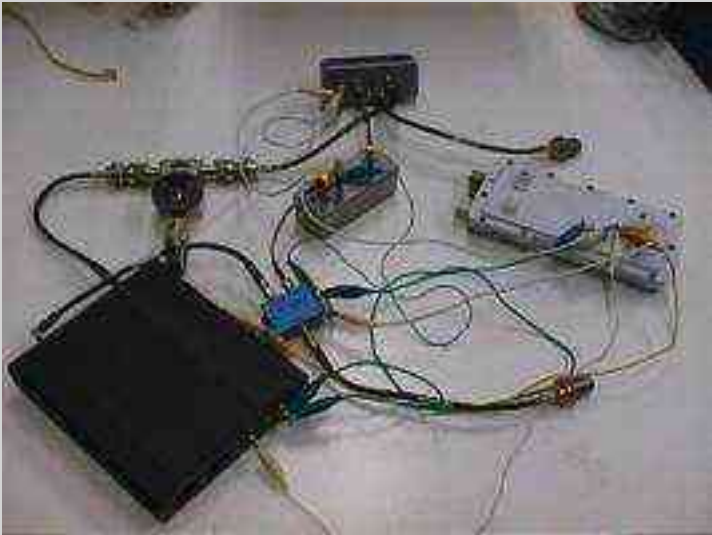
I lined the insides of *all* the cases with that anti-static foam you can buy at Radio Shack, part number 276-2400. Theoretically, this will absorb stray RF inside the case and help improve the circuit's input/output isolation. Or maybe I just smoke \$2 crack....



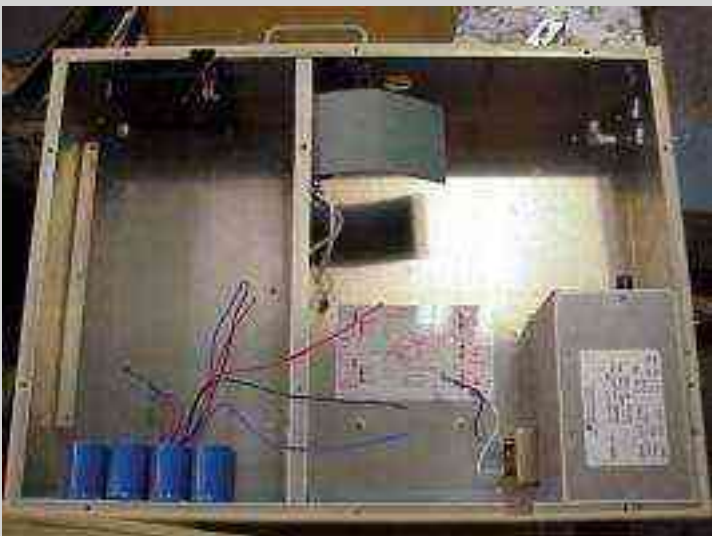
Here is the antenna side RF PIN diode module. This is where I had the original difficulty in designing high power amplifiers. How do you switch a high powered 900 MHz signal back and forth in microseconds? You get ideas from someone else, that's how! A million thanks to [Glenn Elmore, N6GN](#) for this section of the amplifier. The RF PIN diode module is a [Mitsubishi MD003](#). 0 VDC on the bias line connects the antenna line to the receive line, a +5 VDC @ 50 mA bias connects it to the transmit line. Mounted on a homebrewed PC board inside a Hammond 1590A case. Be sure **all** the ground pins on the module are connected to a low inductance ground. Also be sure to use high quality RF bypass capacitors, 56 pF ATC porcelain, in this case.



Closeup of the PIN diode module. You can see the bias resistor and ferrite bead floating in the air. The bias line passes through a regular feed-through (non-capacitor). RF connectors are SMA, with the teflon covered pin (ala the 33LNACK), the connectors are also available from [Down East Microwave](#).



All the modules sorta put together. Please don't use alligator clips, I'm a professional. The male SMA jumper cables are from [Down East Microwave](#).



This is BACO. Big Ass Case n' Organizer. Everything is gonna fit inside here.



Inside case shot.



Input PIN diode switch and the RF output N jack.



Alternate view, showing the power supply.

There you go, a 10 Watt, 2 Mbps DSSS 915 MHz WaveLAN. I was told twice it couldn't be done. Silly amateurs.

Under RF Shield - 2

Select a picture for larger image.

[sym_pic-12]

Under the smaller RF shield. IC to the right has *87AB X5080* and a National logo. IC to the left is a Texas Instruments [2272](#) op-amp.