Using Part 15 Wireless Ethernet Devices For Amateur Radio

Background:

In 1989 Al Broscius, N3FCT suggested the use of Part 15 Spread Spectrum wireless ethernet devices that were becoming available for amateur packet radio use.

> Implications for the Radio Amateur- an excerpt from "License-Free Spread Spectrum Packet Radio" by N3FCT in 1989

There are numerous manufactures of these devices. They operate on the shared 900 MHz, 2.4 and 5.7 GHz bands with speeds between 1.5 and 11 Mbps.

> Wireless LAN product/feature comparison- by Barry McLarnon, VE3JF (slightly dated) (a local mirror)
> Amateur Band Allocations- for the 900 MHz, 2.4 & 5.7 GHz bands

In early 1997 TAPR began development of a 1 watt, 128 Kbps 900 MHz FHSS radio, suggesting this is the future for amateur packet radio.

In late 1999 the FCC relaxed Amateur Spread Spectrum rules. Allowing any commercially available Part 15 SS device to be reclassified under Part 97. (Prior only certain spreading codes where allowed)

> Part 97.311- current Amateur spread spectrum rules

Today:

We know it is possible as unlicensed Part 15 devices to obtain omnidirectional ranges up to about 5 miles and directional ranges up to about 17 miles using high gain antennas.

We should also realize that greater communication ranges are possible (if necessary) by reclassifing these devices under Part 97. We are then allowed to modify them using pre-amps, RF amplifiers and high gain antennas. Then by placing a central routing node in the middle of town on top a tall building/tower or hill they can serve as a inexpensive high speed alternative to existing packet radio systems.

> Part 97 vs Part 15 Permissible Power Comparison - and clarification
> Price comparison- between a conventional packet setup and a Symphony setup
> Misc. Part 97 clarifications- pertaining to this application

True some urban areas may be very infested with Part 15 devices already. But you have 3 bands to choose from, and you shouldn't have any problems if you use FHSS, with one watt amplifiers before your antenna polarized the opposite of everyone else.

My Experiences:

I have experimented with Proxim's Symphony 1.6 Mbps Frequency Hopping Spread Spectrum 2.4 GHz network card. It was only $130 and as a Part 15 device coupled with an old 24 dB MMDS 2.5 GHz partial screen parabolic antenna (previously used for receiving rural wireless cable) you could easily obtain ranges up to 6 miles line of sight.

Low Cost Wireless Network How-To- our abundance of documented, experiences, work and research (which includes homebrew bi-directional amplifier designs and path-loss calculators)

Other Peoples Experiences:

During my Proxim Symphony experimentation I sought out reports from other hams who had attempted long distance communications paths:

Symphony based links: KE6WED, VE3JF, K5OKC, and 4Z4ZQ

Other hams exploring and using this technology using different hardware: KO6YQ, N3WFI, KG6DFV

Re-classifying:

All commercially available Spread Spectrum Wireless Ethernet Devices are suitable for Amateur Use. However there are 3 things you may need to pay attention to when re-classifying.

1. *You need to identify your station every 10 minutes by transmitting your callsign in ASCII or by some other method that is publicly documented.*
   I suggest having a script send out a ping every 10 minutes with your callsign embedded in it. (here is how)
2. *You will need to keep your operations within the 2400-2450 MHz amateur overlap if you plan to re-classify under Part 97.* (this is only an issue on the 2.4 GHz band with FHSS, all other bands have full overlap & DSSS systems can be set by user for center freq below 2.45)
   Order your Symphony directly from Proxim and send a copy of your license and they will program your cards country code to that of Australia, shifting operation in the 2400-2445 section. (more info)
3. *If you need to amplify your signal over 1 watt PEP you will need to incorporate automatic transmitter power control.*
   You may need to buy a expensive commercial amplifier (such as Teletronics Bi-directional SmartAmp) to accomplish this. (more info)

If your like me and are seeking a simple way to build a high speed, affordable, RF network, where you mimic the internet and have webpages, conferencing, FTP and so on, I encourage you to look into this technology and use it. If you use this technology and would like to share your experiences, or if you have questions, you may contact me. Also feel free to link to this document and or reprint any portion of it.

Steve, KB9MWR

Excerpt from;

License-Free Spread Spectrum Packet Radio

By: Albert G. Broscius, N3FCT 1989

Implications for the Radio Amateur

While it may be disheartening that commercial systems have become available before their amateur counterparts, it should be mentioned that these license-free systems may be used to augment or supplement our communications abilities even though they are not regulated under Part 97 of the Rules. It is also possible that a system which qualifies under 15.126 could be modified to be pursuant to Part 97 spread spectrum rules and thus allowed to operate at the higher power limit, one hundred watts, available for amateur spread spectrum as long as the control operator satisfied all appropriate requirements of the Rules. And of course, placing a 15.126 unit on a Microsat-class vehicle could pave the way for license-free space operation although there may be other restrictions which come into play in that situation.

The design of a power-limited spread spectrum network with realistic inter-node distances would require substantial antenna engineering skills which could be provided by amateur operators familiar with propagation conditions on these bands. However, the resulting network would be free of Part 97 restrictions in the spirit of the pre-Commission Ham activities. Realistically, a Wild West scenario of competing BBS networks and CB-style chaos could make this non-Ham would an unpleasant environment. Unfortunately, unless a pro-active position on this technology is taken, we may see a digital CB world forming around our shared allocations.

Neglecting intentional interference to amateur transmissions and power-limit abuses, there is still the issue of a high noise floor on the weak signal portions of the shared bands. Although these bands now suffer from their shared status, some fell that an influx of consumer electronics items which may each transmit up to one watt will cause unacceptable degradation on the "quite regions" of the band plan. Considering the possible density to be tens of radiators per city block, the argument of RF pollution seems credible.

Recommendations

To responsibly address this technology, we fell amateur operators should experiment with the commercial systems now available in establishing long distance communications paths using high-gain antenna systems coupled with the maximum legal power of one watt, determining interference levels seen by week signal receivers attributable to spread spectrum transmissions, and carefully introducing this technology to computer bulletin board operators who could financially support development of an unlicensed computer internet.

915 MHz | 2.4 GHz | 5.8 GHz | Reviews | Articles

Vendors | Links

Compiled by Barry McLarnon, VE3JF. Please send comments, corrections and additions to bm@hydra.carleton.ca.

Introduction

This is a survey of currently available wireless RF modem products suitable for wireless LAN and MAN applications. At the moment, this survey includes only those products which are suitable for unlicenced operation in the ISM bands: 900 MHz (902-928 MHz), 2.4 GHz (2400-2483.5 MHz) and 5.8 GHz (5725-5850 MHz). Some of these products are intended for very short range wireless applications, while others are designed to be used as longer-haul point-to-point wireless bridges, and some can be used in either role. No attempt has been made to differentiate between these usages in this survey. Also, I don't necessarily list every product in each vendor's wireless product line. Some product lines have many different variants, and the tables would get too unwieldy if I tried to list them all, but I try to include some representative products from each manufacturer. I tend to omit the "access point" products, and products in which the WLAN modem is integrated into something else, such as a portable computer. The vast majority of the products listed use spread spectrum modulation techniques, since that is where my main interest lies.

Most of the information presented here was taken from manufacturers' literature, so the figures concerning data rates and ranges are subject to specmanship. Caveat emptor! Accurate pricing information is also hard to come by, and subject to inaccuracies, so don't take what you see here as gospel. It's possible that some of the products listed are actually "vaporhardware". If you have any information along these lines, please let me know.

This survey covers only complete wireless modem products (i.e., plug-in cards or standalone units). It does not cover chip sets, amplifiers, etc. Many of these other products can be found in Lee Fry's Spread Spectrum Device Compendium.

Infrared wireless technology is a viable alternative for some WLAN applications. This is beyond the scope of this survey, but here are a few (very few at the moment!) links to IR WLAN vendors which may be helpful.

New! Due to a number of requests, I have started a page listing sources of antennas for WLAN/MAN applications. As with the modem listings, I cover only the manufacturers, not resellers. Most of the WLAN manufacturers can supply a variety of antennas, of course, but this list will provide some alternate (and quite possibly less expensive) sources. The antenna listing contains only a brief overview of WLAN-related product lines, not details on individual products.

New! I've added a new page for links to WLAN-related resources which don't fall into the other categories in this directory.

Lastly, I try to respond to all of the email I get, but please note that I also have a fulltime day job, and I maintain this stuff in my "spare" time. I may provide some advice, but if you expect me to provide free consulting engineering, you are likely to get what you paid for. :-)

Last Updated: 28 Nov 99

Product Listings: 915 MHz

Key to modem type:
DS: Direct Sequence Spread Spectrum
FH: Frequency Hopping Spread Spectrum
NB: Narrowband (non-spread FSK, MSK, PSK, etc.)

915 MHz Wireless LAN/MAN Modem Products									
Vendor	**Product**	**Type**	**Data Rate**	**Power**	**Maximum Range Indoor/Outdoor**		**Configuration**	**Price ($US)**	**Miscellaneous**
Aerotron	NLR-900T	DS	19.2 Kbps	725 mW	450 m	2.4 km	standalone (RS232)	995	Other versions available
Aironet	IC1200	DS	Up to 860 Kbps	450 mW	300 m	600 m	ISA card (1/2 size)	-	-
Aironet	PC1200	DS	Up to 860 Kbps	250 mW	300 m	600 m	ISA card PCMCIA Type II	-	-
Aironet	BR1000-E	DS	Up to 860 Kbps	450 mW	-	10 km	Standalone (ethernet)	-	12 channels. Several antenna options.
Apex Wireless	SS-200	FH	166 Kbps*	50 mW, 1 W	150-450 m	>3 km	Serial (RS-232)	-	*Channel bit rate. Serial port is 115.2 Kbps half-duplex or 57.6 Kbps simulated full-duplex. Has repeater & multipoint capability.
C-SPEC	WaveLAN PC-AT Wireless Adapter	DS	2 Mbps	250 mW	240 m	-	ISA card	695	-
C-SPEC	WaveLAN PCMCIA Wireless Adapter	DS	2 Mbps	250 mW	240 m	-	PCMCIA Type II	695	-
C-SPEC	OverLAN Wireless Bridge/Router	DS	2 Mbps	250 mW	240 m	16 km	standalone (ethernet)	3995	WaveLAN compatible, with roaming. Includes high gain antenna.
Cylink	AirLink 19MPE	DS	1.2 - 19.2 Kbps	800 mW	-	-	standalone (RS232/422, V.35)	2795	BPSK, 1.5 MHz bandwidth.
Cylink	AirLink 64MP	DS	1.2 - 64 Kbps	800 mW	-	48 km	standalone (RS232/422, V.35)	2995	BPSK, 5.1 MHz bandwidth.
Cylink	AirLink 128	DS	128 Kbps	800 mW	-	-	standalone (RS232/422, V.35)	3295	BPSK, 10.2 MHz bandwidth.
DATA-LINC	SRM6000	FH	Up to 115.2 Kbps	0.1-1 W	450 m	30-48 km	standalone (RS232/422/485)	1775	Several antenna options available. Has repeater capability.

DEC	Roamabout 915 DS/ISA	DS	2 Mbps	250 mW	240 m	-	PCMCIA Type II	695	-
Digital Wireless	WIT915	-	38.4 Kbps	1 W	-	-	OEM module (RS232)	-	Range up to "several miles"
FreeWave	DGR-115	FH	2.4 - 115.2 Kbps	1 W	-	32 km	standalone (RS232)	1250	3" whip antenna, SMA connector for external antenna.
GRE	GINA 6000NVK	DS	64 Kbps	725 mW	240 m	19 km	standalone (RS232/449, V.35)	1679	Other versions available.
Inficom	Infilink T1	-	1.544 Mbps	100 mW	-	16 km	standalone (V.35)	2995	E1 (2.048 Mbps) version also available ($3995).
Inficom	Infilink ATM	-	25.6 Mbps	100 mW	-	16 km	standalone (ATM)	9995	-
KarlNet	WaveLAN PC-AT Wireless Adapter	DS	2 Mbps	250 mW	240 m	-	ISA card	695	-
KarlNet	WaveLAN PCMCIA Wireless Adapter	DS	2 Mbps	250 mW	240 m	-	PCMCIA Type II	695	-
KarlNet	Wireless KarlBridge	DS	2 Mbps	250 mW	-	16 km	standalone (ethernet)	2895	WaveLAN compatible - bridging, multipoint and roaming.
KarlNet	Wireless KarlBridge/Router	DS	2 Mbps	250 mW	-	16 km	standalone (ethernet)	3295	WaveLAN compatible - bridging, multipoint, IP routing and roaming.
Lucent	WaveLAN PC-AT Wireless Adapter	DS	2 Mbps	250 mW	240 m	-	ISA card	545	-
Lucent	WaveLAN PCMCIA Wireless Adapter	DS	2 Mbps	250 mW	240 m	-	PCMCIA Type II	495	-
Metricom	Ricochet Wireless Modem	FH	100 Kbps*	-	-	500 m	standalone (RS232)	599	Modem $299 with 1 year network service. *Raw data rate - typ. user rate "9.8-28.8 kbps"
Microhard	MRX-900	FH	2.4-115.2 Kbps	1 W	-	>30 km	standalone (RS232)	995	20 user selectable hop patterns. OEM version (MHX-915) available for $495
Norand	RB4020 Wireless Network Radio Base	DS	192 Kbps	1 W	-	-	standalone (RS485)	-	LAN interface 460 kbps. Also has sync/async host ports up to 64 kbps.
Norand	RCB4000 Wireless Network Integrated Controller/Base	DS	192 Kbps*	1 W	-	-	standalone (RS232)	-	*User throughput 38.4 kbps
O'Neill	LawnII-232	DS	38.4 Kbps	40 mW	90 m	915 m	standalone (RS232)	275	Other versions available, e.g., LawnII-BAT battery-powered version ($395)

OTC Telecom	AirEZY 900	DS	1 Mbps	100 mW	150 m	240 m	standalone (ethernet: BNC or RJ-45)	-	-
Pinnacle	PinnacleLink	DS	2 Mbps	4 W ERP	-	26 km*	standalone (ethernet)	2195	*With optional amplifiers. Point-to-point and multipoint capability.
Solectek	AIRLAN Bridge Plus	DS	2 Mbps	up to 4 W ERP	-	5 km	standalone	2495	-
Solectek	AIRLAN/Bridge 203	DS	2 Mbps	-	-	5 km	standalone	2495	-
UNICOM	RF 915	DS	Up to 38.4 Kbps	1 mW - 1 W	-	5 km	standalone (sync/async serial)	-	Half or Full-duplex. 21 channels, 1 MHz bandwidth.
Utilicom	LongRanger 2020/ISM900-4TS256	DS	Up to 256 Kbps	0.25 - 4 W ERP	-	50 km*	standalone (RS232/RS422/EIA530/V.35)	2550*	*Depends on version. Directional antennas extra. Full-duplex.
Wave Wireless	SPEEDLAN Plus	DS	2 Mbps	0.25 W	-	16 km	standalone (ethernet)	3900	Bridge/router, includes antenna & cable
Webgear	Aviator Wireless	NB	150 Kbps	0.7 mW	25 m	-	standalone (parallel port)	129	Approx. transfer rate 75 Kbps
Wi-LAN	Hopper DS Wireless Modem	DS	19.2 Kbps	0.5 W	-	10 km	standalone (RS232)	1100	2.5 Mchips/s, 3 MHz bandwidth
Wi-LAN	Hopper FD Wireless Modem	DS/FH	19.2 Kbps*	0.5 W	-	9.5 km	standalone (RS232)	1495	*Full duplex (38.4 kbps max in half duplex)
Wi-LAN	Hopper Plus Wireless Ethernet Bridge	DS	1.45 Mbps	0.5 W	-	9.5 km	standalone (ethernet)	2895	8 Mchips/s
Xetron	Hummingbird 902	FH	19.2 Kbps	1 W	240 m	32 km	OEM card (RS232/485 or CMOS)	-	440 channels. Lower-power versions available.
Young Design	RM910-INT	DS	78.4 Kbps	20 mW	100 m	200 m	standalone(RS232)	535	Internal antenna version, 38.4 Kbps. Pt-to-pt or pt-to-multipoint.
Young Design	RM910-EXT	DS	78.4 Kbps	20 mW	200 m	1 Km (with Yagi Ant.)	standalone(RS232)	610	Same as above except connector for external antenna.

Product Listings: 2.4 GHz

Key to modem type:
DS: Direct Sequence Spread Spectrum
FH: Frequency Hopping Spread Spectrum
NB: Narrowband (non-spread FSK, MSK, PSK, etc.)

2.4 GHz Wireless LAN/MAN Modem Products

Vendor	Product	Type	Data Rate	Power	Maximum Range Indoor/Outdoor		Configuration	Price ($US)	Miscellaneous
Aerotron	NLR-2.4T	DS	19.2 Kbps	500 mW	450 m	2.4 km	standalone (RS232)	1695	Other versions available
ACT Networks	SkyWave Wireless Modem	FH	64 Kbps - 2.048 Mbps*	50 mW	-	32 km	standalone (RS422/530/V.35)	-	*Half-duplex. Full-duplex up to 1.024 Mbps. Adaptive Equalization.
ADTRAN	Tracer	DS	2xT1 or 1xE1	100 mW	-	48 km	standalone - DS1/DSX-1 (T1), G.703 (E1)	-	Separate RF deck, mast mountable
Aironet	IC2200	DS	Up to 2 Mbps	50/100 mW	150 m	300 m	ISA card (1/2 size)	-	5 channels
Aironet	PC2200	DS	Up to 2 Mbps	50/100 mW	150 m	300 m	PCMCIA Type II	-	5 channels
Aironet	UC2200-E UC2200-S	DS	Up to 2 Mbps	100 mW	150 m	300 m	Standalone: ethernet (-E) or RS-232 (-S)	-	5 channels
Aironet	PC3500	FH	Up to 2 Mbps	100 mW	150 m	600 m	PCMCIA Type II	-	IEEE 802.11 compliant
Aironet	UC3500-E UC3500-S	FH	Up to 2 Mbps	50/100/200 mW	150 m	300 m	Standalone: ethernet (-E) or RS-232 (-S)	-	
Aironet	PC4500	DS	1 or 2 Mbps	50/100 mW	75 m (2 Mbps) 100 m (1 Mbps)	300 m (2 Mbps) 500 m (1 Mbps)	PCMCIA Type II	-	IEEE 802.11 compliant
Aironet	BR2000	DS	1 or 2 Mbps	100 mW	-	19 km (2 Mbps) 40 km (1 Mbps)	Standalone (ethernet)	-	Various antenna options
Aironet	BR2040	DS	1,2 or 4 Mbps	100 mW	-	13 km (4 Mbps) 40 km (1 Mbps)	Standalone (ethernet)	-	Various antenna options

Aironet	PC4800	DS	1-11 Mbps	50 mW (US/Can: 100 mW)	30 m*	150 m*	PCMCIA Type II	-	*110 m / 550 m @ 1 Mbps. IEEE 802.11 @ 1/2 Mbps. Other products available (access point, ISA/PCI, etc)
Altvater	WIMANline	FH	625 Kbps*	100 mW (US: 1W)	-	5 km (US: 30 km)	standalone (RS232, X.21/V.11)	-	*User data rate up to 115.2 Kbps async, 128 Kbps sync.
Apex Wireless	SS-300	FH	166 Kbps*	50 mW, 1 W	150-450 m	>16 km	Serial (RS-232)	-	*Channel bit rate. Serial port is 115.2 Kbps half-duplex or 57.6 Kbps simulated full-duplex. Has repeater & multipoint capability.
Breezecom	AP-10 Access Point	FH	1-3 Mbps	10/100 mW	100 m	500 m	standalone (10BaseT)	1295	-
Breezecom	AP-10 PRO Access Point	FH	1-3 Mbps	10/100 mW	150 m	1 km	standalone (10BaseT)	1495	Up to 30% higher throughput than standard version.
Breezecom	SA-10 Station Adapter	FH	1-3 Mbps	10/100 mW	100 m	500 m	standalone (10BaseT)	695	-
Breezecom	SA-10 PRO Station Adapter	FH	1-3 Mbps	10/100 mW	150 m	1 km	standalone (10BaseT)	695	Up to 30% higher throughput than standard version.
Breezecom	SA-40 Station Adapter	FH	1-3 Mbps	10/100 mW	100 m	500 m	standalone (4X 10BaseT)	1195	Three antenna options
Breezecom	SA-40 PRO Station Adapter	FH	1-3 Mbps	10/100 mW	150 m	1 km	standalone (4X 10BaseT)	1195	Up to 30% higher throughput than standard version.
Breezecom	SA-PX PCMCIA Adapter	FH	1 Mbps	50 mW	70 m	300 m	PCMCIA	395	Licensed from Xircom.
Breezecom	SA-PC PRO PC Card	FH	1-3 Mbps	10/100 mW	-	600 m	PCMCIA	565	Up to 30% higher throughput than standard version.
Breezecom	WB-10 Wireless Bridge	FH	1-3 Mbps	0.1-4 W ERP	200 m	1-10 km	standalone (10BaseT)	1995	Full Duplex. Many antenna options.
Breezecom	BreezeLINK-121 Wireless E1/T1	FH	56 Kbps - 2.048 Mbps	50 mW	-	1-32 km	standalone (T1/E1, V.35, RS-530, X.21)	-	Range depends on data rate, model.
Clarion	M10	DS	10 Mbps	-	100 m	8 km*	standalone (ethernet AUI)	-	*With optional high gain antennas.
CRL	DS16-24/ISA	DS	1 Mbps	60 mW	50 m	1 km	ISA card*	-	*Radio/modem unit is external (RS485 interface).
C-SPEC	WaveLAN PC-AT Wireless Adapter	DS	2 Mbps	88 mW	240 m	-	ISA card	695	-
C-SPEC	WaveLAN PCMCIA Wireless Adapter	DS	2 Mbps	88 mW	240 m	-	PCMCIA Type II	-	-
C-SPEC	OverLAN Wireless Bridge/Router	DS	2 Mbps	88 mW	150 m	8 km	standalone (ethernet)	3995	WaveLAN compatible - IP routing, roaming. Includes high gain antenna.
C-SPEC	OverLAN RF-10 Wireless Bridge/Router	DS	10 Mbps	-	-	24 km*	standalone (ethernet)	9495	*With optional amplifiers. Standard range 5 km.

Cylink	AirLink 64SMP	DS	64 Kbps	650 mW	300 m	48 km	standalone (RS232/422, V.35)	3395	BPSK, 8 PN codes. 5.1 MHz bandwidth.
Cylink	AirLink 128S	DS	128 Kbps	650 mW	300 m	48 km	standalone (RS232/422, V.35)	3595	BPSK, 8 PN codes. 10.2 MHz bandwidth.
Cylink	AirLink 256S	DS	256 Kbps	650 mW	300 m	48 km	standalone (RS232/422, V.35)	3995	BPSK, 8 PN codes. 20.5 MHz bandwidth.
Cylink	AirLink 384S	DS	384 Kbps	650 mW	300 m	48 km	standalone (RS232/422, V.35)	4495	BPSK, 8 PN codes. 30.7 MHz bandwidth.
Cylink	AirLink 512S	DS	512 Kbps	650 mW	300 m	48 km	standalone (RS232/422, V.35)	4995	BPSK, 8 PN codes. 41 MHz bandwidth.
DATA-LINC	SRM6000H	FH	Up to 115.2 Kbps	-	450 m	30-50 km	standalone (RS232/422/485)	$1975	Several antenna options available. Has repeater capability.
DCT	VL128	DS	128 Kbps*	18 dBm	-	48 km	standalone (RS232/422/V.35)	-	*115.2 Kbps async. AT-command set. Full duplex..
DCT	VL256	DS	256 Kbps*	18 dBm	-	48 km	standalone (RS232/422/V.35)	-	*115.2 Kbps async. AT-command set. Full duplex..
DCT	VirtualNet PCMCIA Adapter	DS	1-4 Mbps	18 dBm	125 m	1.1 km	PCMCIA Type II	-	IEEE 802.11. Harris PRISM chip set..
DCT	VirtualNet ISA PC Adapter	DS	1-4 Mbps	18 dBm	125 m	1.1 km	ISA card	-	IEEE 802.11. Harris PRISM chip set..
DCT	VirtualNet Access Point	DS	1-4 Mbps	18 dBm	125 m	1.1 km	standalone (ethernet)	-	IEEE 802.11. Harris PRISM chip set..
DEC	Roamabout 2400 FH/ISA NIC	FH	1.6 Mbps	100 mW	150 m	300 m	ISA card	595	Same as Proxim RangeLAN2.
DEC	Roamabout 2400 FH/PC Card	FH	1.6 Mbps	100 mW	150 m	300 m	PCMCIA Type II	695	Same as Proxim RangeLAN2.
DEC	Roamabout 2400 DS/ISA NIC	DS	2 Mbps	88 mW	240 m	-	ISA card	695	Same as WaveLAN.
DEC	Roamabout 2400 DS/PC Card	DS	2 Mbps	88 mW	240 m	-	PCMCIA Type II	695	Same as WaveLAN.
Digital Wireless	WIT2400M	FH	115.2 Kbps	-	300 m	1 km	OEM module (RS232)	~400	Ranges are with unity gain dipole antenna.
Direct Network Services	FreePort	DS	5.7 Mbps	1 W ERP	80 m	-	standalone (ethernet)	-	Also uses 5.8 GHz. Trellis-coded 16PSK, 32 chips/baud
Direct Network Services	AirPort II	DS	5.7 Mbps	1 W ERP	-	2.9 km	standalone (ethernet)	-	Also uses 5.8 GHz. Trellis-coded 16PSK, 32 chips/baud
DTS	Skyplex I	DS	1.2 - 512 Kbps*	-	-	100 km*	standalone (RS232/RS422/EIA530/V.35)	-	*Depends on model. Appears to be based on the Cylink modems.
DTS	Skyplex II	DS	1.544 Mbps*	8 or 28 dBm	-	-	standalone (DSX-1)*	-	*E1 (2.048 Mbps) w/G.703 and fractional T1 w/V.35 also available.
EMTAC	A2422-2A/3A	DS	1 Mbps	20 dBm	-	180 m	PCMCIA Type II	-	2A has ext antenna, 3A has built-in bendable antenna. IEEE 802.11 compliant.

EMTAC	A2432-2A/4A	DS	1 Mbps	20 dBm	-	180 m	ISA card (PnP)	-	Two antenna options. IEEE 802.11 compliant.
Glenayre	Lynx cp2	DS	1.544 Mbps	Up to 1 W	-	48 km	standalone (DSX-1)	9950	Full duplex, 43 MHz separation. DSU/CSU option.
GRE	GINA 8000NVK	DS	64 Kbps	725 mW	240 m	19 km	standalone (RS232/449, V.35)	1979	Other versions available.
IBM	2480 Wireless LAN ISA	DS	2 Mbps	-	-	-	ISA card	-	PCMCIA cards, access points, bridges, etc, but few details on IBM website
KarlNet	WaveLAN PC-AT Wireless Adapter	DS	2 Mbps	88 mW	240 m	-	ISA card	695	-
KarlNet	WaveLAN PCMCIA Wireless Adapter	DS	2 Mbps	88 mW	240 m	-	PCMCIA Type II	-	-
KarlNet	Wireless KarlBridge	DS	2 Mbps	88 mW	150 m	8 km	standalone (ethernet)	2895	WaveLAN compatible - bridging, multipoint, roaming. Includes high gain antenna.
KarlNet	Wireless KarlBridge Bridge/Router	DS	2 Mbps	88 mW	150 m	8 km	standalone (ethernet)	3195	WaveLAN compatible - bridging, multipoint, IP routing, roaming. Includes high gain antenna.
Lucent	WaveLAN IEEE 802.11 ISA Card	DS	2 Mbps	15 dBm	90 m*	400 m*	ISA card	395	* 115/540 m @ 1 Mbps. IEEE 802.11.
Lucent	WaveLAN IEEE 802.11 PC Card	DS	2 Mbps	15 dBm	90 m*	400 m*	PCMCIA Type II	295	* 115/540 m @ 1 Mbps. IEEE 802.11.
Lucent	WaveLAN IEEE Turbo ISA Card	DS	1-11 Mbps	12 dBm	40 m*	120 m*	ISA card		*@11 Mbps - same as 802.11 product @1-2 Mbps
Lucent	WaveLAN IEEE Turbo PC Card	DS	1-11 Mbps	12 dBm	40 m*	120 m*	PCMCIA Type II Extended	495	*@11 Mbps - same as 802.11 product @1-2 Mbps
MaxTech	XWL-420 Wireless Ethernet LAN ISA NIC	DS	2 Mbps	50 mW		240 m	ISA card		
MaxTech	XWL-420 Wireless Ethernet LAN PC Card	DS	2 Mbps	50 mW		240 m	PCMCIA Type II		IEEE 802.11
MaxTech	XWL-420 Wireless Ethernet LAN Access Point	DS	2 Mbps	50 mW		240 m	standalone (ethernet)		IEEE 802.11. Range can be extended with optional antennas.
MikroTik	MicroTik Wireless Router Package	-	2 Mbps	100 mW	-	-	standalone (ethernet)	1499	PC-based, includes parabolic antenna & cable
Multicap	Serial~Wave	FH	1.6 Mbps*	100 mW	150 m	18 km	standalone (RS232)	1200	RangeLAN2 compatible. *User data rate up to 115 kbps. Includes TCP/IP stack.
Multipoint Networks	RAN64ss	DS	64 Kbps	18 dBm	-	-	standalone (RS232/EIA530/V.35)	-	Remote RF head eliminates 2.4 GHz feedline losses
Multipoint Networks	RAN128ss	DS	128 Kbps	18 dBm	-	-	standalone (RS232/EIA530/V.35)	-	Remote RF head eliminates 2.4 GHz feedline losses

Multipoint Networks	RAN2048ss	FH	2.048 Mbps	18 dBm	-	Up to 30 km	standalone (G.703)*	-	T1 (DSX-1) and multirate 64-2048 Kbps (RS530/V.35/X.21) versions available.
Netwave	AirSurfer Wireless PC Card	FH	1 Mbps	25 mW ERP	45 m	200 m	PCMCIA Type II	399	Former Xircom product.
Netwave	AirSurfer Access Point	FH	1 Mbps	25 mW ERP	45 m	200 m	standalone (10BaseT, 10Base2)	1499	-
Nokia	C020 C021	DS	2 Mbps	-	20-50 m	300 m	PCMCIA card	-	IEEE 802.11 compliant. Based on Harris PRISM™ chipset. C021 model has external antenna.
Nokia	A020 Access Point	DS	2 Mbps	-	20-50 m	300 m	standalone (ethernet)	-	IEEE 802.11 compliant. Based on Harris PRISM™ chipset.
Nomadic	Mercury RF-1	FH	1.6 Mbps*	100 mW	150 m	300 m	standalone (RS232)	1095	*User data rate 300 bps - 115 Kbps. RangeLAN2 compatible.
No Wires Needed	Swallow 550	DS	1,2,5.5 Mbps	18 dBm	-	-	PCMCIA Type II	-	Ext antenna optional. Complies with IEEE 802.11 air interface.
No Wires Needed	Parrot 550 Access Point	DS	1,2,5.5 Mbps	18 dBm	-	-	standalone (ethernet)	-	Dual diversity antenna. Complies with IEEE 802.11 air interface.
P-COM	Model 100-2	DS	56 Kbps - 2.048 Mbps	6 mw or 500 mW	-	75 km	standalone (V.35, DSX-1, G.703)	~6000	Modem and RF deck are separable.
Pinnacle	PinnacleLink	DS	2 Mbps	4 W ERP	-	26 km*	standalone (ethernet)	2195	*With optional amplifiers. Point-to-point and multipoint capability.
Pinnacle	PinnacleLink	DS	11 Mbps	4 W ERP	-	26 km*	standalone (ethernet)	2295	*With optional amplifiers. Point-to-point and multipoint capability. IEEE 802.11 compliant.
Proxim	RangeLAN2 7100 ISA	FH	1.6 Mbps	100 mW	150 m	300 m	ISA card	595	15 channels. OEM version available.
Proxim	RangeLAN2 7401/02 PC Card	FH	1.6 Mbps	100 mW	150 m	300 m	PCMCIA Type II	695	15 channels. One-piece modem. Several antenna options.
Proxim	RangeLAN2 7910/11 Serial Adapter	FH	1.6 Mbps	100 mW*	150 m	300 m	standalone (RS232)	-	*500 mW for 7911. Serial port baud rates up to 115.2 Kbps
Proxim	RangeLAN2 7920/21 Ethernet Adapter	FH	1.6 Mbps	100 mW*	150 m	300 m	standalone (ethernet)	-	*500 mW for 7921. Note that this is a modem that interfaces to an ethernet card or hub. It is not an access point, which is a different product.
Proxim	RangeLAN802 8401/02 PC Card	FH	2 Mbps	100 mW*	150 m	300 m	PCMCIA Type II	-	*400 mW version available. Two antenna options. IEEE 802.11 compliant

Proxim	RangeLAN802 8520/21 Access Point	FH	2 Mbps	100 mW*	150 m	300 m	standalone (ethernet)	-	*8521 is 400 mW. Several antenna options. IEEE 802.11 compliant
Proxim	RangeLink	FH	1.6 Mbps	100 mW	-	4.8 km	standalone (ethernet)	5950-7450	6 models, range/data rate depends on model.
Proxim	Symphony Cordless ISA Card	FH	1.6 Mbps	-	45 m	90 m	ISA card	149	
Proxim	Symphony Cordless PC Card	FH	1.6 Mbps	-	45 m	90 m	PCMCIA Type II card	199	
RadioConnect	Wireless Remote Office Link	DS	256 Kbps (or more)	-	-	32 km	standalone (10BaseT ethernet*)	-	Also has 6 telephone ports for voice/fax.
Solectek	AIRLAN/Bridge 200E	DS	2 Mbps	4 W ERP	-	40 km	standalone (ethernet)	3495	3 channels. High gain and sectoral/omni antenna options.
Solectek	AIRLAN/Router 200E	DS	2 Mbps	4 W ERP	-	40 km	standalone (ethernet)	5995	Includes Cisco router. Token ring version also available
Solectek	AIRLAN/Bridge 400E	DS	4 Mbps	4 W ERP	-	32 km	standalone (ethernet)	4495	-
Solectek	AIRLAN/Bridge 1000E	DS	10 Mbps	4 W ERP	-	40 km*	standalone (ethernet)	8895	*With optional high-gain antennas
Solectek	MP200-E	DS	2 Mbps	-	-	40 km	standalone (ethernet)	-	Multipoint capability. US/Canada only.
Solectek	MP550-E	DS	5.5 Mbps	-	-	32 km	standalone (ethernet)	-	Multipoint capability. US/Canada only.
Solectek	MP1100-E	DS	11 Mbps	-	-	40 km	standalone (ethernet)	-	Multipoint capability. US/Canada only.
Symbol	Spectrum24 LA 2400	FH	1 Mbps	100-500 mW	55-75 m	300 m	PCMCIA Type II	-	66 sequences, 10 hops/s
Raytheon	Raylink PC Card	FH	2 Mbps	100 mW	150 m	300 m	PCMCIA Type II	-	IEEE 802.11 compliant. Access point uses same card
RDC	PortLAN	FH	1 Mbps	-	150 m	830 m	PCMCIA Type II	695	-
RF-Link	2.4 GHz Wireless RS232	DS	Up to 192 Kbps	200 mW	150 m	2 km	standalone (RS232)	399	15 channels
Teletronics	Wireless LAN Card	DS	2 Mbps	50 mW*	350 m	50 km*	PCMCIA Type II	175	*With optional amplifier (500 mW out) and antenna. IEEE 802.11 compliant.
Teletronics	Access Point	DS	2/10 Mbps	50 mW*	350 m	50 km*	standalone (ethernet)	525	*With optional amplifier (500 mW out) and antenna. IEEE 802.11 compliant.
TTI Wireless	InterBuilding Link 200TSE	DS	2 Mbps	15 dBm	-	48 km	standalone (ethernet)	-	Repeater configurations available
TTI Wireless	InterBuilding Link 500TSE	DS	5 Mbps	15 dBm	-	48 km	standalone (ethernet)	-	Repeater configurations available
TTI Wireless	InterBuilding Link 1100TSE	DS	11 Mbps	15 dBm	-	48 km	standalone (ethernet)	-	Repeater configurations available

Utilicom	LongRanger 2020/ISM2.4-4TS256	DS	Up to 256 Kbps	0.25 - 4 W ERP	-	50 km*	standalone (RS232/RS422/EIA530/V.35)	2550*	*Depends on version. Directional antennas extra. Full-duplex.
WaveAccess	Jaguar DS132	FH	3.2 Mbps*	50 mW	-	1.5 km	standalone (10BaseT ethernet)	1395	*Max. throughput 2.5 Mbps. QPSK, 16QAM modulation.
WaveAccess	WaveLyNX BR132 Wireless Bridge	FH	3.2 Mbps	50 mW	-	32 km*	standalone (10BaseT ethernet)	2495	*With highest-gain antenna option. Range is greater at 1.6 Mbps fallback rate.
WaveAccess	Jaguar PC132	FH	3.2 Mbps*	50 mW	100 m	150 m	PCMCIA Type II	695	*Max. throughput 2.5 Mbps. QPSK, 16QAM modulation.
WaveAccess	Jaguar AP132	FH	3.2 Mbps*	50 mW	100 m	1.5 km	standalone (ethernet)	1495	*Max throughput 2.5 Mbps. Access point.
WaveRider	NCL135	FH	1.6 Mbps*	18 dBm	-	-	standalone (ethernet)	-	*User throughput up to 800 Kbps. Bridge/router.
Wave Wireless	SPEEDLAN Plus	DS	2 Mbps	0.25 W	-	16 km*	standalone (ethernet)	3900	*40 km w/optional amplifier. 6 selectable channels; includes antenna & cable.
Wave Wireless	SPEEDLAN XE-2	DS	2 Mbps	50 mW	-	40 km*	standalone (ethernet)	2900	*w/optional amplifier. Similar to above, but is single-port bridge.
Wave Wireless	SPEEDLAN 10 BRouter	DS	10 Mbps	4 W ERP	-	16 km	standalone (ethernet)	8900	Multipoint capability; includes antenna & cable
Wave Wireless	SPEEDLAN XE-10	DS	10 Mbps	50 mW	-	40 km*	standalone (ethernet)	4900	*w/optional amplifier. Similar to above, but is single-port bridge.
WebGear	Aviator2.4	FH	2 Mbps	-	150 m	300 m	PCMCIA*	-	*parallel port and USB products also available
Wi-LAN	Hopper Plus Wireless Ethernet Bridge	DS	1.9 Mbps	100 mW	-	9 km	standalone (ethernet)	3295	10 Mchips/s
Wi-LAN	Hopper Plus 30-24	DS	3.0 Mbps	22 dBm	-	-	standalone (ethernet)	-	-
Wi-LAN	Hopper Plus 45-24	DS	4.5 Mbps	-	-	-	standalone (ethernet)	3900	Available October 1998.
Wi-LAN	Hopper FD Wireless Modem	DS/FH	19.2 Kbps*	16 mW	-	-	standalone (RS232)	-	*Full duplex (38.4 kbps max in half duplex)
YDI	Model 2400	FH	115.2 Kbps	100 mW	-	16 km*	Standalone (RS232 sync or async)	1175	*80 km+ with amp. 250 Kbps over-the-air data rate
YDI	WL2400-PCM	DS	2 Mbps	50 mW	150 m	300 m	PCMCIA Type II	485	Used in the AP2400 and laptops. Built-in antenna. IEEE 802.11 compliant.
YDI	WL2400-PCM-J	DS	2 Mbps	50 mW	500 ft	8 km*	PCMCIA Type II	645	*50 km with optional amplifier. Used in the AP2400 and laptops. Ext antenna jack. IEEE 802.11,13 channels.

YDI	WL2400-ISA	DS	2 Mbps	50 mW	150 m	8 km*	ISA card	535	*50 km with optional amplifier. Used in PCs. IEEE 802.11, 13 channels.
YDI	AP-2E Access Point	DS	2 Mbps	50 mW	150 m	8 km*	Standalone (Ethernet 10BaseT or 10Base2)	1495	*50 km with optional amplifier. Requires a WL2400 WLAN card, ordered separately. IEEE 802.11, 13 channels
Z-COM	WL2420 LANEscape/ISA	DS	2 Mbps	50 mW	150 m	8 km	ISA card	420	IEEE 802.11.
Z-COM	WL2430 LANEscape/PCMCIA	DS	2 Mbps	50 mW	150 m	8 km	PCMCIA Type II	450	IEEE 802.11.
Z-COM	WL2410 LANEscape Access Point	DS	2 Mbps	50 mW	150 m	8 km	standalone (ethernet)	800	IEEE 802.11.
Zoom Telephonics	ZoomAir Model 4000	DS	2 Mbps	100 mW EIRP	90 m	300 m	PCMCIA Type II		IEEE 802.11
Zoom Telephonics	ZoomAir Model 4005	DS	2 Mbps	100 mW EIRP	90 m	300 m	ISA card		IEEE 802.11

Product Listings: 5.8 GHz

Key to modem type: **DS**: Direct Sequence Spread Spectrum **FH**: Frequency Hopping Spread Spectrum **NB**: Narrowband (non-spread FSK, MSK, PSK, etc.)
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5.8 GHz Wireless LAN/MAN Modem Products

Vendor	Product	Type	Data Rate	Power	Maximum Range Indoor/Outdoor		Configuration	Price ($US)	Miscellaneous
Cylink	AirPro T1	DS	1.544 Mbps	-	-	35 km	standalone (DSX-1)	-	E1 (2.048 Mbps) version also available
Glenayre	Lynx.sc Model 31000	DS	1.544 Mbps	23 dBm	-	80 km	standalone (DSX-1)	-	E1 (2.048 Mbps) version also available
Glenayre	Lynx.sc Model 31600	DS	2 X 1.544 Mbps	23 dBm	-	80 km	standalone (DSX-1)	-	E1 (2.048 Mbps) version also available
P-COM	Model 100-5	DS	56 Kbps to 2.048 Mbps	100 mW	-	50 km	standalone (V.35, DSX-1, G.703)	-	Modem and RF deck are separable.
RadioLAN	Model 101 Wireless ISA CardLINK	NB	10 Mbps	50 mW	36 m	91 m	ISA card	349	-
RadioLAN	Model P101 Wireless PC CardLINK	NB	10 Mbps	50 mW	36 m	91 m	PCMCIA card	449	-
RadioLAN	Model 10A Wireless NetworkLINK	NB	10 Mbps	50 mW	36 m	91 m	ISA card	799	-

RadioLAN	Model BL208 Wireless BackboneLINK	NB	10 Mbps	50 mW	36 m	91 m	standalone (ethernet)	999	-
Windata	FreePort	DS	5.7 Mbps	1 W ERP	80 m	-	standalone (ethernet)	9000	Also uses 2.4 GHz. Trellis-coded 16PSK, 32 chips/baud
Windata	AirPort II	DS	5.7 Mbps	1 W ERP	-	2.9 km	standalone (ethernet)	11000	Also uses 2.4 GHz. Trellis-coded 16PSK, 32 chips/baud

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WLAN Product Reviews

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David Newman and Kevin Tolly, "Wireless LANs: How Far? How Fast?", **Data Communications**, March 21, 1995, pp. 77-86. Covers PCMCIA adapters and access points from Aironet (ARLAN), Lucent, DEC, Solectek and Xircom.

Rex Baldazo, "Local Air Networks", **Byte Magazine**, June 1995, pp. 201-206. Covers the 900 MHz WaveLAN products from Lucent and DEC.

Dave Molta and Josh Linder, "The High Wireless Act", **Network Computing**, July 1, 1995, p. 82ff. Covers 900 MHz products from ATT&T, DEC and Solectek, plus Windata FreePort (2.4/5.8 GHz) and several infrared systems.

Padraic Boyle, "Wireless LANs: Free to Roam", **PC Magazine**,February 20, 1996, pp. 175-204. Covers PCMCIA adapters and access points from Aironet, AT&, BreezeCOM, DEC, IBM, Proxim, RDC, Solectek and Xircom.

Dave Molta, "The Bridges of Wireless County", **Network Computing**, October 15, 1995, pp. 76-87. Covers wireless bridge products from Aironet, C-SPEC, Cylink, Persoft, Solectek and Windata.

The Tolly Group, "Tolly Report on RDC Wireless LAN" (PDF format), September 1995. Compares the RDC PortLAN PCMCIA adapter with three competitive 2.4 GHz products from Lucent, Proxim and Xircom.

Peter Clegg, "Review: Digital Equipment Corp. RoamAbout", **LAN Times**, Feb. 27, 1995, p. 82. Reviews the 900 MHz PCMCIA unit.

Steven G. Clegg, "Wireless That Goes the Distance", **LAN Times**, Feb. 19, 1996, p. 96. Reviews the RDC PortLAN.

Steven G. Clegg, "Roam on the Network Range", **LAN Times**, Jan. 22, 1996, p. 80. Reviews the Xircom Netwave PCMCIA product.

"Wireless Radio LAN Technology Performance Test", Canterbury Christ Church College (UK). Compares FTP transfer rates between access points and PCMCIA-equipped laptops, for seven different 2.4 GHz WLAN products.

Joel Conover, "Sailing Along With BreezeNet Pro's Adapters", **Network Computing Online**, June 1997. Brief review of BreezeNet Pro products.

Joel Conover, "Bridging The Miles With 10-Mbps Spread Spectrum Wireless Networking ", **Network Computing**, October 24, 1997. Three 10 Mbps products from C-SPEC, Solectek and Wave Wireless reviewed.

Frank J. Derfler, Jr., "Skylinks: Wireless Bridges are an Inexpensive Way to Link LANs in Two Buildings. But How Well Do They Work?", **PC Magazine**, January 7, 1997. Brief review of bridge products from C-SPEC, Solectek, Persoft, Aironet and Clarion.

Intro | 915 MHz | 2.4 GHz | 5.8 GHz | Articles

Vendors | Links

Articles on WLAN Products and Applications

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"Wireless Field Test Project". Very interesting site which gives details on a project funded by the National Science Foundation to evaluate the use of wireless LAN hardware for the linking of schools. Also described is a wireless project in Mongolia.

Paul Schreier, "Spread Spectrum Challenges FM in Wireless Telemetry Systems", Personal Engineering & Instrumentation News, February 1996, pp. 29-38. Surveys a wide range of 900 MHz and 2.4 GHz SS modem products.

Paul Schreier, "Technology, Regs Dictate Multiple Decisions for Wireless Links", Personal Engineering & Instrumentation News , February 1997. Updated survey of a wide range of WLAN products.

Bruce Tuch, "Development of WaveLAN, an ISM Band Wireless LAN", **Lucent Technical Journal**, July/August 1993, pp. 27-37.

Guntis Barzdins and John Tully, "Wireless Internet Access in Latvia". An excellent practical article on wireless networking with the Aironet ARLAN (2.4 GHz) and Lucent WaveLAN (900 MHz) equipment, with emphasis on outdoor links.

Stuart Cheshire, "MosquitoNet". Describes mobile networking work of the Stanford Operating Systems and Networking Group, including the use of WaveLAN and Metricom WLAN equipment.

Randy H. Katz, "Bay Area Research Wireless Access Network (BARWAN)". Another project involving integration of different wireless components, including WLAN SS systems.

David Bantz and Frederic Bauchot, "Wireless LAN Design Alternatives", **IEEE Network**, March/April 1994, pp. 43-53.

Alex Hills and David B. Johnson, "A Wireless Data Network Infrastructure at Carnegie Mellon University", **IEEE Personal Communications**, February 1996, pp. 56-63.

Stephan Orr, "Wireless LAN Technology Struggles to be Useful and Cheap", **Computer Design**, March 1996, p. 94ff.

Willem Hollemans and Arie Verschoor, "Performance Study of WaveLAN and Altair Radio-LANs" **Proc. 5th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications**

(PIMRC '94), September 18-22, 1994, pp. 831-837.

A. Claessan, L. Monteban and H. Moelard, "The AT&T GIS WaveLAN Air Interface and Protocol Stack", **Proc. 5th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC '94)**, September 18-22, 1994, pp. 1442-1446.

Richard LaMaire et al, "Wireless LANs and Mobile Networking: Standards and Future Directions", **IEEE Communications Magazine**, August 1996, pp. 86-94.

Adriaan Kamerman, "Spread-Spectrum Techniques Drive WLAN Performance", **Microwaves & RF**, September 1996, p. 109ff.

Z.L. Shi, W. Tan, M. Fattouche and J. Sokoloski, "A Novel DS/FH Spread Spectrum Wireless Modem", **Wireless 96 (8th International Conference on Wireless Communications)**, 1996. Describes Wi-LAN "Hopper" product design.

Craig Mathias, "Wireless - Coming to a LAN Near You", **Mobile Computing**, October 1996. Several other WLAN articles at the same URL.

Dennis Klein, "Faster, less expensive Internet access", **Communications News**, August 1997. Survey of high-speed wireless bridge products.

Angela Champness, "Understanding IEEE 802.11", **Communications News**, August 1997. Overview of the IEEE 802.11 standard (1-2 Mbps, 2.4 GHz).

Bill Frezza, "Wireless LANs: The Search For Indoor Plumbing", **Network Computing**, December 15, 1995. Thoughts on the past, present and future of WLANs.

Ray Thompson, "FCC's Unidentified Wireless Object", **NetDayNews** (Date unknown). Discusses impact of the FCC U-NII allocation (5.2 GHz) on schools.

Ralph Cochrane, "Wireless LAN Review", **Land Mobile Magazine**, March 1997. Perspectives on WLANs from the UK.

Andy Seybold and Dave Hughes, "Experts Debate Free Wireless", **MicroTimes** (Date unknown). Debate about the practical problems of WLAN deployment.

Dewayne Hendricks, "Wireless In Ulaan Bataar", **MicroTimes**, June 23, 1997. Experiences in installing a wireless MAN system in Mongolia.

Mary Eisenhart, "Really Mobile Computing: Ricochet Untethers The Net", **MicroTimes**, May 27, 1996. On the Metricom Ricochet 915 MHz system.

Bill Frezza, "The Quest For Wireless Internet Access", Network Computing, August 26, 1996. The realities of high-speed wireless.

Lars Kongshem, "Colorado's 'cursor cowboy' helps schools go wireless and save money", **electronic shool online**, January 1997. More on the NSF project to test wireless linking of schools in Colorado.

"Idaho School District's Wireless WAN Opens Intranet, Internet Potential", **T.H.E. (Technology Horizons in Education) Online**, November 1997. Brief description of wireless linking of schools in Idaho using C-Spec's OverLAN product.

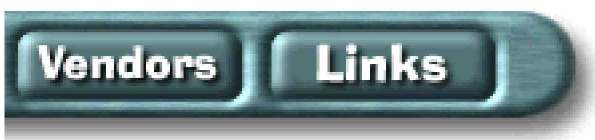
Barry McLarnon, "VHF/UHF/Microwave Radio Propagation: A Primer for Digital Experimenters" (based on a paper prepared for the 1997 ARRL/TAPR Digital Communications Conference).

Ad Kamerman and Nedim Erkocevic, "Microwave Oven Interference on Wireless LANs Operating in the 2.4 GHz ISM Band" **Proc. 8th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC '97)**, September 1-4, 1997, pp. 1221-1227.

Simson Garfinkel, "Communicating Without a Net", **WebServer OnLine**, Vol.3, No.1, January 1998. Interesting account about setting a wireless T1 (approx.) link, with emphasis on security issues. Mentions hardware from BreezeCom and C-Spec.

Ernest Worthman, "Wireless LANs - Techniques, Standards and Technologies", **RF Design**, December 1997, p.32. Survey of WLAN basics.

Kathleen Cholewka, "Web Connections Without the Wires", **Data Communications**, September 21, 1997, p.75. Comparison of wireless Internet access techniques.



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2400 Sand Lake Road
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Aironet Wireless Communications, Inc.
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Tel: 800-394-7353 or 330-665-7900
Fax: 330-665-7922
Email: sales@aironet.com
Another source of Aironet products is Telxon.

Altvater Gruppe Riemenstrasse 30 - D-74906 Bad Rappenau, Germany Tel: +49-7264/804-0 Fax: +49-7264/804-210 Email: info@altvater.com	USA: Airdata WIMAN Systems 2950 Tamiami Trail N. Suite 16 Naples, FL. 34103 Tel: 941-261-1633 Fax: 941-261-5325

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Tel: 206-882-2206 or 425-882-2206
Fax: 206-867-0865 or 425-867-0865
Email: info@data-linc.com

Digital Equipment Corp.
Maynard, MA
Tel: 508-493-5111

Digital Ocean
11206 Thompson Ave.
Lenexa, KS 66219-2303
This company has gone out of business.

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Calgary, AB, Canada T2E 7N6
Tel: 403-248-0028
Fax: 403-248-2762
Email: info@microhardcorp.com

SIA "Mikrotikls"
Aizkraukles iela 23
Riga, LV-1006
Latvia
Tel: +371 2 528 982, or +371 2 520 286
Fax: +371 7 542 530
Email: mt@mt.lv

Momentum MicroSystems, Inc.
2864 S. Circle Drive, Suite 401
Colorado Springs, CO 80906

Tel: 719-540-8338 or 800-894-5280
Fax: 719-540-8361
Email: support@mmicro.com

Multicap
Antwerpsesteenweg 124/19
B-2630 Aartselaar, Belgium
Tel: ++32 (0)3 877.44.80
Fax: ++32 (0)3 887.10.16
Email: multicap@eunet.be

Multipoint Networks Inc.
19 Davis Drive
Belmont, CA 94002
Tel: 650-595-3300
Fax: 650-595-2417
Email: sales@multipoint.com

Netwave Technologies, Inc. 6663 Owens Drive
Pleasanton, CA 94588
Tel: 510-737-1600 or 800-NETWAVE (sales)
Fax: 510-847-8744
Email: info@netwave-wireless.com

Nomadic Technologies
2133 Leghorn Street
Mountain View, CA 94043
Tel: 415-988-7200
Fax: 415-988-7201
Email: nomad@robots.com

Norand Corporation
550 2nd Street SE
Cedar Rapids, IA 52401
Tel: 319-369-3100 or 800-553-5971
Fax: 319-369-3453
Email: info@norand.com

Nu-Metrics
Box 518
University Drive
Uniontown, PA 15401
Tel: 412-438-8750 or 800-346-2025
Fax: 412-438-8769
Email: sales@nu-metrics.com

O'Neill Connectivities, Inc.

607 Horsham Road
Horsham, PA 19044
Tel: 800-624-5296 or 215-957-5408
Fax: 215-957-6633

[OTC Telecom]
2036 Bering Drive
San Jose, CA 95131
Tel: 800-770-6698 or 408-245-6888
Fax: 408-245-8886
Email: otcsales@ezylink.com

[P-COM Inc.]
3175 S. Winchester Blvd.
Campbell, CA 95008
Tel: 408-866-3666 or 1-800-646-PCOM (7266)
Fax: 408-866-3655

[Persoft, Inc.]
465 Science Dr
PO Box 44953
Madison, WI 53744-4953
Tel: 800-368-5283 or 608-273-4357

[Proxim, Inc.]
295 North Bernardo Ave.
Mountain View, CA 94043
Tel: 800-229-1630 or 415-960-1630
Fax: 415-960-1984
Email: sales@proxim.com

[RadioConnect Corporation]
6041 Bristol Parkway
Culver City, California 90230
Tel: 310-338-3388
Fax: 310-338-3399
Email: info@radioconnect.com

[RadioLAN]
455 DeGuigne Drive, Suite D
Sunnyvale, CA
Tel: 408-524-2600 or 888-2RadioLAN
Fax: 408-524-0600
Email: sales@radiolan.com

Raytheon Electronics
362 Lowell Street
Andover, MA 01810
Tel: 508-470-9011
Fax: 508-470-9452
Email: raylink@raytheon.com

RDC Communications Ltd. 1 Hamelacha Street Lod 71293, Israel Tel: +972-8-977-7000 Fax: +977-8-977-7050 Email: support@rdccom.com	RDC Networks Inc. 1160 Chess Drive, Suite #1 Foster City, CA 94404 Tel: 415-577-8075 Fax: 415-577-8077 Email: support@rdcnetworks.com

Solectek Corporation
6370 Nancy Ridge Drive, Suite 109
San Diego, CA 92121-3212
Tel: 800-437-1518 or 619-450-1220
Fax: 619/457-2681

Symbol Technologies, Inc.
116 Wilbur Place
Bohemia, NY 11716
Tel: 800-SCAN 234 or 516-563-2400
Fax: 516-563-2831

Telxon Corp.
3330 West Market Street
Akron, OH 44334-0582
Tel: 800-800-8008
Email: sales@telxon.com

UNICOM Inc.	
MATIX-MEDIA UNICOM America P.O. Box 3486 Winter Springs, FL, USA 32708 Tel: 888-696-5517 or 407-696-5517 Fax: 407-696-5526 Email: unicom-usa@unicompl.com	**UNICOM Pty. Ltd. Australia** P.O. Box 184 Mt. Waverley VIC 3149 Australia Tel: +61-3-9543-9400 Fax: +61-3-9543-9500 Email: UNICOMPL@msn.com

Utilicom Inc.
323 Love Place
Goleta, CA 93117
Tel: 805-964-5848
Fax: 805-964-5706

Wave Wireless Networking

1748 Independence Boulevard, C-5
Sarasota, FL 34234
Tel: 800-721-9283
Fax: 941-355-0219
Email: sales@the-wave-wireless.com

WaveAccess Wireless Communications
One Apple Hill, Ste. 203
Natick, MA 01760
Tel: 508-653-3646 or 508-653-3306
Email: ascott@waveaccess.com

Wi-LAN Inc.
#300-801 Manning Rd. N.E.
Calgary, AB, Canada T2E 8J5
Tel: 800-258-6876 or 403-273-9133
Fax: 403-273-5200
Email: wi-lan@wi-lan.com

Windata Corp.
543 Great Rd.
Littleton, MA 01460
Tel: 508-952-0170 or 800-553-8008
Fax: 508-952-0168 or -0169
Email: patc@wireless.windata.com
Note: The Windata products are also available from Cabletron

Wireless Scientific
1890 South 14th Street
Building 100, Suite 105
Amelia Island, FL 32034
Tel: 904-261-6977
Fax: 904-261-2129
Email: wsci@net-magic.net

Xetron Corporation
460 West Crescentville Rd.
Cincinnati, OH 45246
Tel: 513-881-3500
Fax: 513-881-3379
Email: sarab@xetron.com

Young Design, Inc
103 Rowell Court
Falls Church, VA 22046
Tel: 703-237-9090
Fax: 703-237-9092

Email: MFYoung@ydi.com

[Z-COM, Inc.](#)
7F-2, No. 9, Prosperity 1st Rd.
Science-Based Industrial Park
Hsinchu, Taiwan
Tel: +886-3-5777364
Fax: +886-3-5773359
Email: center@zcomwireless.com

[Zenith Data Systems](#)
2150 East Lake Cook Road
Buffalo Grove, IL 60089
Tel: 800-416-7591 or 708-808-5000
Fax: 708-808-4434
Email: ask.sales@zds.com

Intro | 915 MHz | 2.4 GHz | 5.8 GHz | Reviews
Articles | Links

Wireless LAN/MAN Resources

This page provides some links to organizations and other resources on the net related to wireless LANs and/or spread spectrum communications.

Amateur Radio Spread Spectrum Communications Page

FCC On-line Equipment Authorization Database

Future Computing Environments: Wireless Projects, Vendors, and Products

Spread Spectrum Scene

Telecom Information Resources

Wireless Books Online

Wireless Design Online

The Wireless LAN Alliance

Intro | 915 MHz | 2.4 GHz | 5.8 GHz | Articles

Reviews | Vendors

Some Vendors of Infrared Wireless Equipment

DTC Data Technology
FIRLAN
JOLT Ltd.
JVC
Silcom Technology
Spectrix Corp.

Back to main WLAN page

Antenna Sources for Wireless LAN/MAN Applications

Antenex, Inc. 2000-205 Bloomingdale Road Glendale Heights, IL 60139 USA Tel: 800-323-3757 or 630-351-9007 Fax: 630-351-9009 Email: sales@antenex.com	Directional yagi antennas for 915 MHz, omnidirectional collinear antennas for 915 MHz and 2.4 GHz.
California Amplifier 460 Calle San Pablo Camarillo, CA 93102 Tel: 805-987-9000 Fax: 805-987-8359 Email: sales@calamp.com	Grid parabolic reflector antennas for 2.4 GHz.
Conifer Corp. 1400 N. Roosevelt Avenue Burlington, Iowa 52601 USA Tel: 800-843-5419 or 319-752-3607 Fax: 319-753-5508 Email: conifer@conifercorp.com	Parabolic and panel directional antennas for 2.4 GHz, gains from 10 dBi to 23 dBi.
Cushcraft Corp. 48 Perimeter Road Manchester, NH 03103 USA Tel: 800-258-3860 or 603-627-7877 Fax: 800-258-3868 or 603-627-1764 Email: sales@cushcraft.com	Directional patch, panel and yagi antennas, and omnidirectional antennas, for 2.4 GHz and 5.8 GHz (also 5.2 GHz)
Gabriel Electronics Inc. P.O. Box 70 Scarborough, ME 04070 USA Tel: 207-883-5161 Fax: 207-883-4469 Email: info@gabrielnet.com	Solid and grid parabolic antennas for 2.4 GHz and 5.8 GHz
Larsen Electronics, Inc. 3611 N.E. 112th Avenue Vancouver, WA 98682 Tel: 360-944-7551 or 800-426-1656 Fax: 360-944-7556 Email: larsen@larsenet.com	Yagi, panel & omni antennas for 915 MHz; panel and omni antennas for 2.4 Ghz

Maxrad, Inc. 4350 Chandler Drive Hanover Park, IL 60103 Tel: 800-323-9122 Fax: 630-372-8077 Email: sales@maxrad.com	Yagi directional antennas for 915 MHz, omnidirectional whip antennas for 2.4 GHz.
Mobile Mark, Inc. 3900-B River Road Schiller Park, IL 60176 USA Tel: 800-648-2800 or 847-671-6690 Fax: 847-671-6715 Email: sales@mobilemark.com	Directional corner reflector antennas, and omnidirectional antennas, for 915 MHz and 2.4 GHz
Radioware PO Box 1478 Westford MA 01863, USA Tel: 800-950-9273 or 603-899-6959 Fax: 800-903-2987 or 508-251-0515 Email: radware@radio-ware.com	Yagi directional antennas for 915 MHz.
Radio Waves, Inc. 267 Boston Road Corporate Place Billerica, MA 01862 USA Tel: 508-663-5777 Fax: 508-663-6226 Email: info@radiowavesinc.com	Parabolic reflector, horn, sectoral and omnidirectional antennas for frequencies above 1.5 GHz.
Seavey Engineering Associates, Inc. 135 King Street Cohasset, MA 02025 USA Tel: 617-383-9722 Fax: 617-383-2089 Email: info@seaveyantenna.com	Flat plate and parabolic reflector directional antennas, various omnidirectional antennas (few details on web site)
Telewave, Inc. 1155 Terra Bella Ave Mountain View, CA 94043 USA Tel: 800-331-3396 or 650-968-4400 Fax: 650-968-1741 Email: sales@telewaveinc.com	Yagi directional and fibreglass collinear omnidirectional antennas for 915 MHz
Telex Communications Inc. Wireless Products Group 8601 E. Cornhusker Hwy. Lincoln, NE 68505 USA Tel: 800-898-6723 or 402-467-5321 Fax: 402-467-3279 Email: sales@telexwireless.com	Directional parabolic, patch, panel and yagi antennas, and omnidirectional antennas, for 2.4 GHz

Til-Tek Antennas Inc. 500 Van Buren St, P.O. Box 550 Kemptville, ON K0G 1J0 Canada Tel: 613-258-5928 Fax: 613-258-7418 Email: info@tiltek.com	Directional parabolic and omnidirectional collinear antennas for 2.4 GHz
Z-Communications Inc. 9939 Via Pasar San Diego, CA 92126 Tel: 619-621-2700 Fax: 619-621-2722 Email: sales@zcomm.com	8 dBi and 14 dBi gain patch antennas (indoor/outdoor) for 2.4 GHz

Intro 915 MHz 2.4 GHz 5.8 GHz Articles
Reviews Vendors

Part 15/ISM Bands are: 902 - 928 MHz, 2400 - 2483.5 MHz, 5725 - 5875 MHz

Amateur Band Allocations:

```
902 - 928 MHz       Secondary to industrial, scientific and medical
                    devices; location monitoring service, and
                    government stations.

2300 - 2305 MHz     Secondary - No primary
2305 - 2310 MHz     Secondary to fixed, mobile and radiolocation services
2390 - 2400 MHz     Primary
2400 - 2402 MHz     Secondary - No primary amateur service
2402 - 2417 MHz     Primary
2417 - 2450 MHz     Co-secondary with government radiolocation (industrial,
                    scientific and medical are primary)
2450 - 2483.5 MHz   No amateur - Industrial, scientific and medical ***

5650 - 5725 MHz     Co-secondary with space research (deep space) service
5725 - 5850 MHz     Secondary - No primary
5850 - 5925 MHz     Secondary to non-government fixed-satellite service
```

You may need to use directional antennas to avoid interfering with any primary occupants such as ISM (industrial, scientific and medical) As a secondary service you you may not cause harmful interference to primary service stations that may exist in your area, nor may you claim protection from harmful interference from primary stations.

*** 802.11b Direct sequence systems can be user set for frequencies centered below 2.45. (Channels 1-6) Some drivers for frequency hopping systems let you control how/where they hop. (Proxim will change the country code to that of Australia if you provide a copy of your ham license. That puts it in frequencies below 2.45.)

802.11b Direct Sequence Channel to Frequency Mapping

USA/FCC & Canada regions have 11 total channels allocated. All frequencies are in GHz. (Channels 1-6 land within the amateur overlap)

Channel	Center Freq.	High Freq.	Low Freq.
1	2.412	2.423	2.401
2	2.417	2.428	2.404
3	2.422	2.433	2.411
4	2.427	2.438	2.416
5	2.432	2.443	2.421
6	2.437	2.448	2.426
7	2.442	2.453	2.431
8	2.447	2.458	2.436
9	2.452	2.463	2.441
10	2.457	2.468	2.446
11	2.462	2.473	2.451

What is an ISM (industrial, scientific and medical) device (Part 18)?

Part 18 ISM devices utilize RF energy for non-communicative purposes. See the definition of ISM equipment in 47 CFR 18.107(c).

Shrink wrappers are a fine example of an ISM device. The plastic is heated and semiliquified by a very strong RF field only a few inches away. The sheet of plastic is then lowered onto the rest of the packaging, clings to the product and the cardboard, and resolidifies. Since telecommunications are precluded, and ISM signal will contain not data. The third character of the emission designator for a Part 18 device will always be N (N0N or P0N are most likely).

Wireless ethernet cards are Part 15 devices that just happen to be opperating on an ISM (part 18) band. Wireless ethernet cards are Not Part 18 devices.

The prime distinction between Part 18 and Part 15 devices is that Part 18 devices use RF to do something, and Part 15 devices use RF to communicate or send a command.

A recent publicized example titled: "FCC Queries Wireless 'Net Provider About Interference To Hams" Proves that Part 97 has priority over Part 15, and proves that that wireless ethernet gear is indeed Part 15 and not Part 18.

Part 97.311 Spread Spectrum FCC Rules for Ham bands:

```
97.311 SS emission types

(a) SS emission transmissions by an amateur station are authorized only
    for communications between points within areas where the amateur
    service is regulated by the FCC and between an area where the amateur
    service is regulated by the FCC and an amateur station in another
    country that permits such communications.  SS emission transmissions
    must not be used for the purpose of obscuring the meaning of any
    communication.
(b) A station transmitting SS emissions must not cause harmful
    interference to stations employing other authorized emissions, and
    must accept all interference caused by stations employing other
    authorized modes.
(c) When deemed necessary by a District Director to assure compliance with
    this Part, a station licensee must:
  (1) Cease SS emission transmissions;
  (2) Restrict SS emission transmissions to the extent instructed; and
  (3) Maintain a record, convertible to the original information (voice,
      test, image, etc.) of all spread spectrum communications transmitted.
(d) The transmitter power must not exceed 100 W under any circumstances.
    If more than 1 W is used, automatic transmitter control shall limit
    output power to that which is required for the communication.  This
    shall be determined by the use of the ratio, measured at the receiver,
    of the received energy per user data bit (Eb) to the sum of the
    received power spectral densities of noise (N0) and co-channel
    interference (I0).  Average transmitter power over 1 W shall be
    automatically adjusted to maintain an Eb/(N0+I0) ratio of no more
    than 23 dB at the intended receiver.
```

Part 97 vs Part 15 Permissible Power Comparison:
(calculations do not take coax losses into effect)

One of the main advantages to reclassifying your operations to Part 97 (besides the obvious theoretical interference protection from unlicensed operations) may be the amount of radiated power you are allowed.

As you may know Part 15 operation has a theoretical max of 100.23 Watts EIRP for directional antennas. And 4 Watt EIRP limit for links using omnidirectional antennas.

Amateur Radio has never had or has any type of ERP limits. The wording of Part 97.311 which regulates Amateur Spread Spectrum uses the words "transmitter power" which imply peak envelope power (PEP) or carrier power (CP) not effective radiated power (ERP). (If it said radiated power then ERP would be implied). Thus there are no ERP / EIRP limits for Part 97 operation.

Excerpt from Part 97.311:

```
(d) The transmitter power must not exceed 100 W under any circumstances.
    If more than 1 W is used, automatic transmitter control shall limit
    output power to that which is required for the communication.  This
    shall be determined by the use of the ratio, measured at the receiver,
    of the received energy per user data bit (Eb) to the sum of the
    received power spectral densities of noise (N0) and co-channel
    interference (I0).  Average transmitter power over 1 W shall be
    automatically adjusted to maintain an Eb/(N0+I0) ratio of no more
    than 23 dB at the intended receiver.
```

So some calculations show that the following are permissible under Part 97:

(Using the max of 1 Watt before having to incorporate automatic power control as per 97.311(d))

With 1 W (30 dBm) into a 24 dBi parabolic = 251.2 Watts EIRP

With 100 Watts PEP (the max allowed for SS using automatic power control) into a 24 dBi parabolic = 25,118 Watts EIRP

Excerpts from Part 15.257:

Omni-Directional Antennas:

```
(b) The maximum peak output power of the intentional radiator shall
    not exceed the following:

(1) For frequency hopping systems operating in the 2400-2483.5 MHz
    or 5725-5850 MHz band and for all direct sequence systems: 1 watt.
```

[The maximum gain of omni-directional antennas at this 1 Watt, is inferred to be 6 dBi from the paragraphs below, or 36 dBm maximum. 1 Watt is 30 dBm, plus the 6 dB gain, results in about 4 Watts Effective Isotropic Radiated Power (EIRP)]

Directional Antennas:

```
(i) Systems operating in the 2400-2483.5 MHz band that are used
```

```
exclusively for fixed, point-to-point operations may employ
transmitting antennas with directional gain greater than 6 dBi
provided the maximum peak output power of the intentional radiator is
reduced by 1 dB for every 3 dB that the directional gain of the
antenna exceeds 6 dBi.
```

So some calculations show that the following are permissible under Part 15 for directional antenna links:

Max Transmitter RF power (dBm)	Antenna Gain (dBi)	EIRP (W)
30	6	3.98
29	9	6.35
28	12	10.14
27	15	15.81
26	18	25.23
25	21	40.28
24	24	62.79
23	27	100.2

Excerpts from Part 15.247 - FCC Rules for ISM bands:

Unlicensed Part 15 operation is subject to the following two conditions; (1) The device may not cause harmful interference, and (2) The device must accept any interference received; including interference that may cause undesired operation.

- ISM Bands are: 902 - 928 MHz, 2400 - 2483.5 MHz, 5725 - 5875 MHz

```
Part 15.247

Omni-Directional Antennas

(b) The maximum peak output power of the intentional radiator shall
not exceed the following:

(1) For frequency hopping systems operating in the 2400-2483.5 MHz
or 5725-5850 MHz band and for all direct sequence systems: 1 watt.

[Note: The maximum gain of omni-directional antennas at this 1 Watt,
is inferred to be 6 dBi from the paragraphs below, or 36 dBm maximum.
1 Watt is 30 dBm, plus the 6 dB gain, results in about 4 Watts Effective
Isotropic Radiated Power (EIRP)]

Directional Antennas
[In addition to the above:]

(3) Except as shown in paragraphs (b)(3) (i), (ii) and (iii) of this
section, if transmitting antennas of directional gain greater than 6 dBi
are used the peak output power from the intentional radiator shall be
reduced below the stated values in paragraphs (b)(1) or (b)(2) of this
section, as appropriate, by the amount in dB that the directional gain
of the antenna exceeds 6 dBi.

(i) Systems operating in the 2400-2483.5 MHz band that are used
exclusively for fixed, point-to-point operations may employ transmitting
antennas with directional gain greater than 6 dBi provided the maximum
peak output power of the intentional radiator is reduced by 1 dB for
every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Example:
    Max Transmitter RF power (dBm)     Antenna Gain (dBi)     EIRP (W)
           30                             6                      3.98
           29                             9                      6.35
           28                             12                     10.14
           27                             15                     15.81
```

26	18	25.23
25	21	40.28
24	24	62.79
23	27	100.2

(ii) Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

(iii) Fixed, point-to-point operation, as used in paragraphs (b)(3)(i) and (b)(3)(ii) of this section, excludes the use of point-to-multipoint systems, omnidirectional applications, and multiple co-located intentional radiators transmitting the same information.

The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

```
-Typical 1200/9600 Ham setup-
 Paccomm Tiny 2  - $150
 MFJ data radio  - $120
 100ft RG-8/9913 - $ 55
 Decent Antenna  - $ 60
            TOTAL: $385


-Typical wireless ethernet setup-
 Symphony NIC/Linksys AP - $150
 100ft LMR-400           - $ 65
 24dB Parabolic          - $ 70
                    TOTAL: $285
```

Are we allowed to reclasify a part 15 device for amateur use?

Equipment that has been certified for use in another service may be used on amateur frequencies by a licensed amateur as long as it meets all appropriate standards. (97.315)

Since wireless ethernet cards use a tcp/ip variant digital protocol to communicate is this legal?

Any digital code may be used as long as the technical characteristics are publicly documented. To further this, if commercial products are available that facilitate the transmission and reception of the communications incorporating these codes they are considered to be "specified." Therefore wireless ethernet is legitimate. Even if it were not publicly documented such as a homebrew protocol it would be classified as an unspecified digital code which is also permitted under [97.309(a)]

If we re-classify these wireless ethernet cards under Part 97, how do we legally ID?

Careful review of 97.119(3) shows that identification for data emissions may be made by transmitting your callsign using a specified digital code [see 97.309 (3) & (4)] such as ASCII, or you may ID by some other method that is publicly documented. I suggest embedding your callsign in a ping packet to be sent out every 10 minutes. Another method to embed your callsign within the ethernet datagram is to configure your callsign as part of your network name. Your callsign will at least be encapsulated inside an ethernet frame. This is perfectly acceptable and reasonable since the technical characteristics of wireless ethernet are publicly documented. The rules no longer really specify how you must ID. Anyone with a sniffer on the link will be able to see your callsign.

Is streaming/ transferring MP3's or other types of music over a wireless amateur data link permitted?

The music prohibition concerns the playing of music itself on the air. So there is no problem here. Please refer to the famous 'trading of MIDI synthesizer commands over the air' example.

Are there any speed and or bandwidth constraints for data that we need to pay attention to?

Frequency Range	Speed Limit for Specified Codes	Maximum Bandwidth for Unspecified Codes
50.1 - 148 MHz	19.6 kilobauds	20 kHz
222 - 450 MHz	56 kilobauds	100 kHz
Above 902 MHz	No speed limit	No bandwidth limit

[97.307(f)(1)]

Wouldn't accessing a manufacturer's web site over an amateur data link violate 'no commercial' activity rules of ham radio?

I see no reason that this would violate Part 97. In fact, since the rules now allow you to conduct commercial transactions (as long as they are only for your own private use), presumably you could even buy radio equipment on line from a manufacturer's website, as long as you instigated the transaction, not the store. I can't think of why this is any different that the famous "buying a pizza with an autopatch" case that was specifically decided by the FCC a number of years ago.

Is there something about doing this via the Internet that would make it fundamentally different than doing it via an autopatch? John, W2FS

As an amateur (part 97) internet data link, only hams would be allowed to legally use it.

I see no reason why someone else in your family (a third party) couldn't view web info over an amateur data link. As long as the responsible licensed amateur is supervising the operation (locally or remotely).

How would you limit access (to this repeater) to just hams?

All DSSS and FHSS systems have some sort of user setable security ID, which restricts what equipment talks to what. Also you can implement common TCP/IP tricks (firewalling, or whatever) for further security.

As a Part 97 network we can't encrypt our network can we? What about eavesdroppers (people running sniffers) grabbing our passwords?

This probably isn't much of an issue for a private network, but I can see it being an issue when porting traffic over the internet. Keep in mind how the FCC rules are stated: "An amateur station shall not intentionally obscure the meaning ..." Encrypting just login & password strings doesn't obscure the meaning does it? Also using encryption can be classified as an "unspecified" digital code, which is permitted as long as you provide public documentation for it. Which can be fulfilled by posting your encryption key on your internet webpage, for example.

From: "R. Curry" <recurry@curry.org>
To: "Steve Lampereur"
Date: Thu, 23 Dec 1999 11:16:14 -0800
Subject: Re: symphonies w/ directional antennas

Steve, I have run two Symphony cards running over a full time link of about 5 miles using two 24 dbi gain dishes. I live in portion of town that is best described as not fully developed yet. I don't recall the brand of my dishes but they sound very similar to yours. Each has about 50' of Beldon 9913 coax as feedline. I found that you must have absolute line of sight. No trees, buildings or anything else in the way. This was absolutely critical. You need to be able to see the other antenna directly and you need to have the antenna pointed almost perfectly since these types of antenna have only a 8 degree beam width. Also, your antenna you have may not be tuned for the right frequency. The proxim devices use approx. 2.4 GHz to 2.48 GHz. Yours may be tuned higher and therefore losses will be high. There are similar antenna purpose made for these frequencies - that's what I'm using.

My link was great in dry conditions but when the fog or clouds or rain rolled in it became unusable. I just could not get 5 miles running reliably except in the dryest conditions with just two symphony cards since they are only 100mW. 2.4 GHz is highly attenuated by moisture so in the morning when it is damp the links would go down. With 500mW on one end and a short cable on the other it worked better. With 500mW on both ends they have been working flawlessly for over 6 months. Bottom line is you need clear line of sight and more power for a reliable link.

Regards,
Ron Curry, KE6WED

Table of Contents

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:

$9.75 = (5 - 3) / I$

$I = 2 / 9.75$

$I = .205$ amps

Calculate the new value V_d:

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

$V_d = 6.8$ 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..

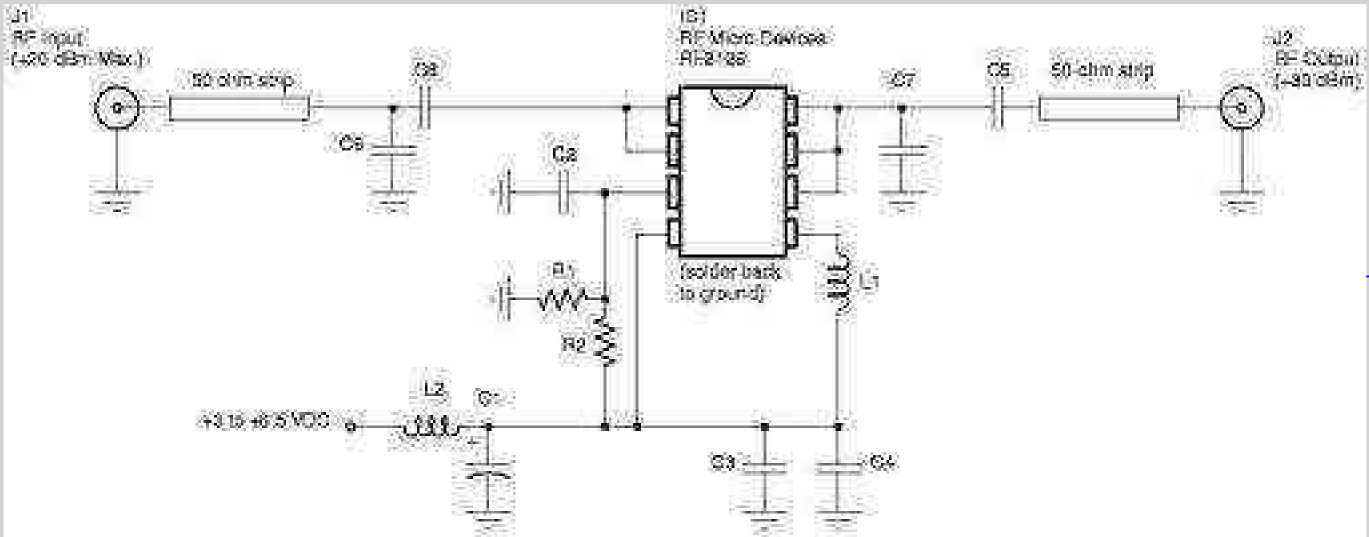
Return to Main

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.

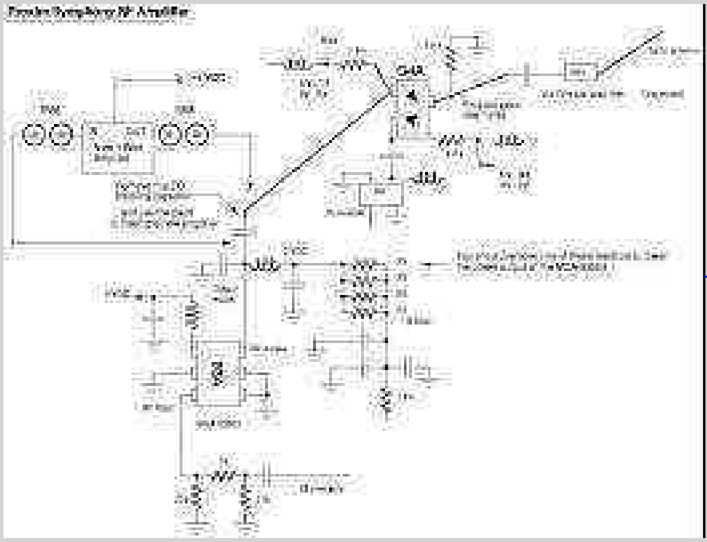
After your circuit board is etched, you should drill and solder all the ground vias. Those are what connects the top copper plane to the bottom plane on two sided copper clad boards. Do this by drilling a small hole where the marks are in the circuit pattern picture (the white dots in the above JPEG), 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 radio 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.

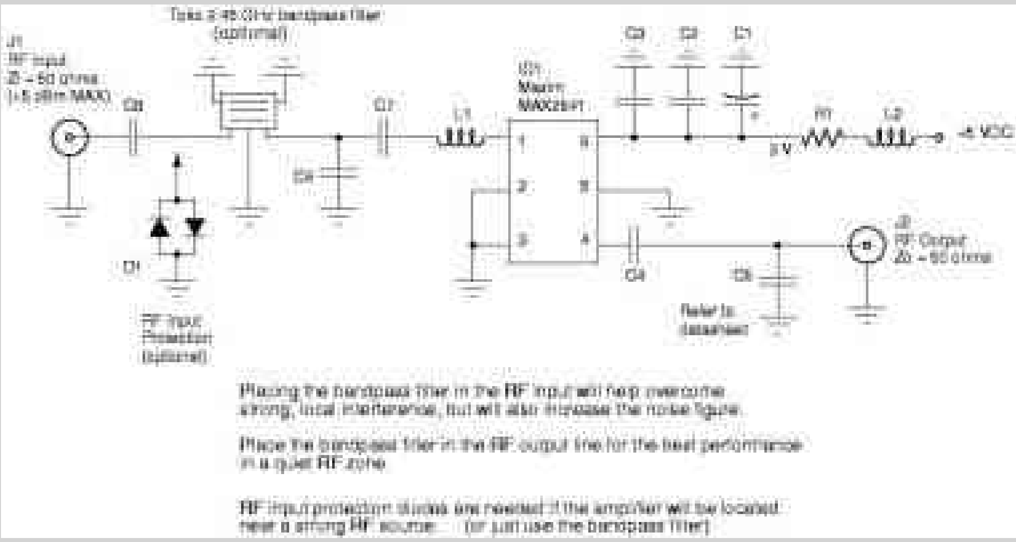
Return to the Low Cost Wireless Network How-To

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.

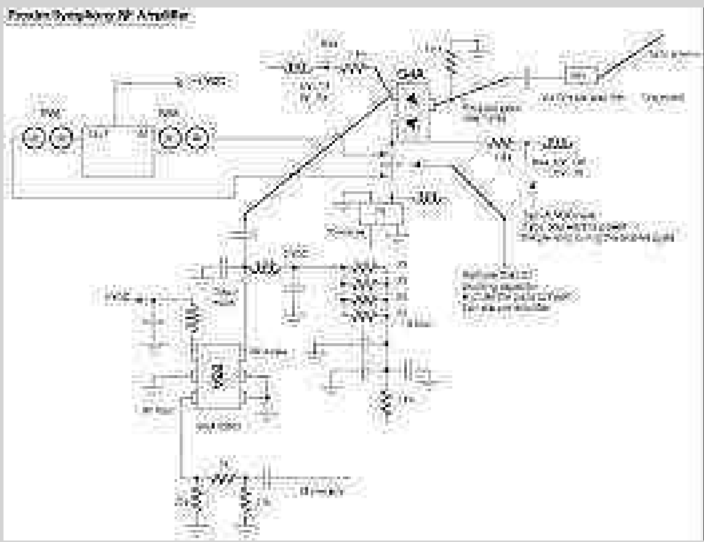
The next step is to make the circuit board for the amplifier. ***You must use the board pattern Maxim provides!*** This is because the delicate 50 ohm strip lines that are needed are a real pain to recreate on your own. Here are some links to help with the fabrication of your own printed circuit board:

- 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

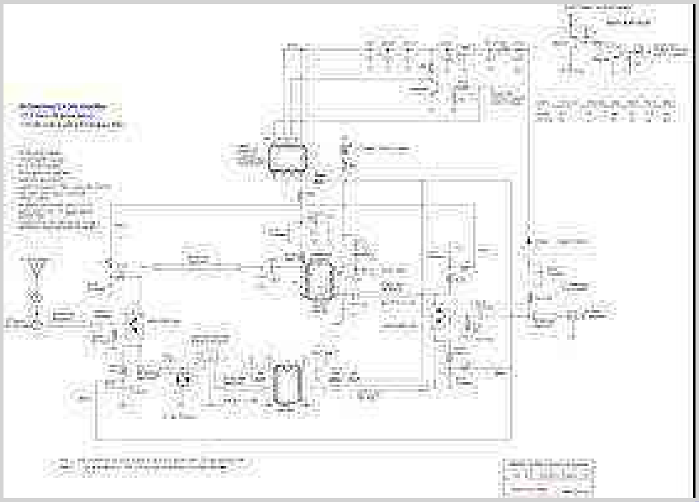
Some designs are for research only. Advanced microwave and RF design skills will be required to build these circuits.

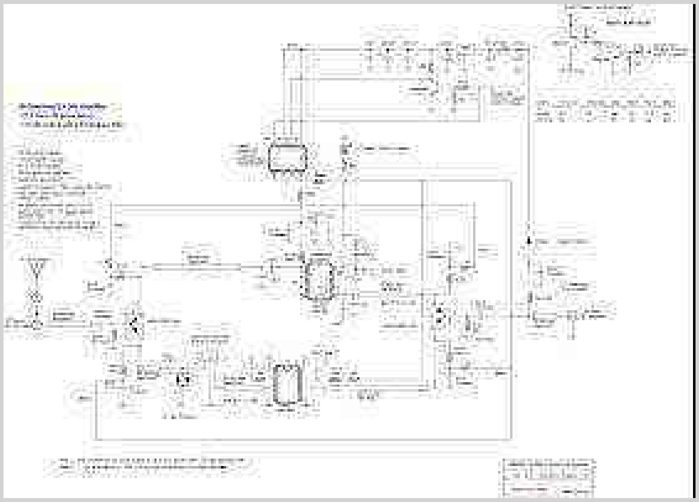
This will show you how to add a bi-directional, 2.4 GHz amplifier to your Proxim Symphony for under $100. Bi-directional means you can mount the amplifier *at the antenna* to help overcome any cable loss, and the amplifier will automatically switch between receive and transmit modes. The cost is reduced 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).

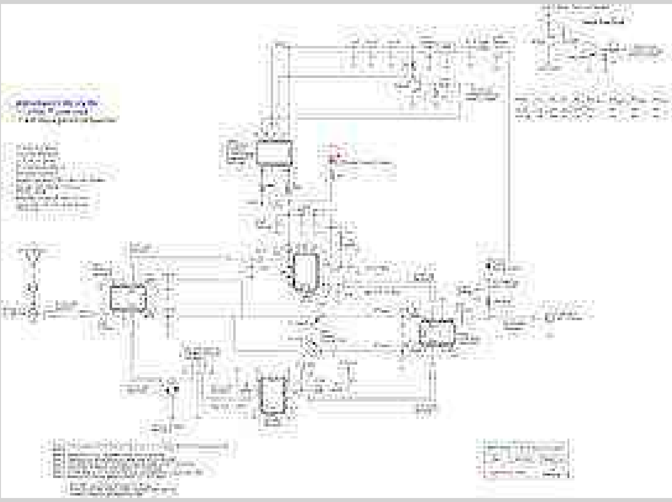
Receive amplification is tricky subject. When done right, it works wonders. When done wrong, your stuck listening to shortwave broadcast stations in Yugoslavia. If you don't need to have the receiver amplifier (due to excess local noise/intermodulation or loss coax loss), just replace it with a stripline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

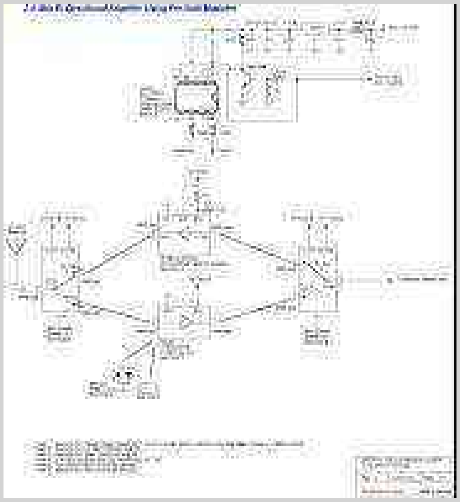
Adaptation to wireless network cards other than the Symphony should be trivial.

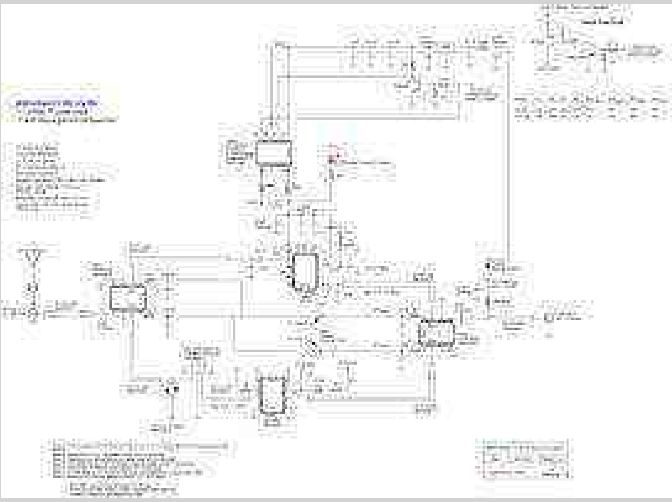
Schematics

Block Diagram  2.4 GHz Bi-Directional GHz Amplifier Block Diagram

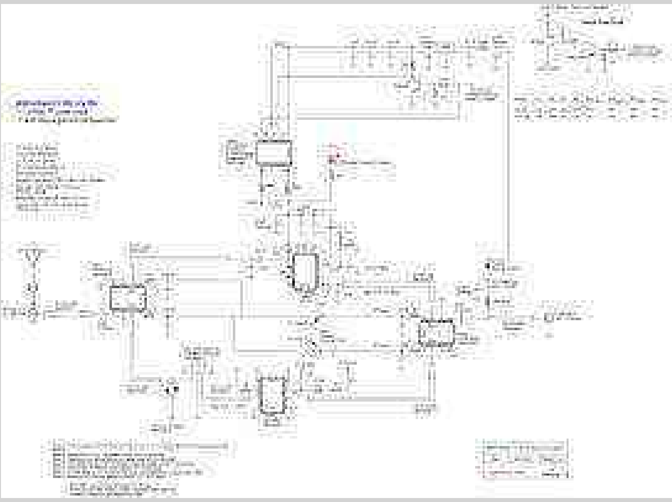
Number 1  Bi-Directional 2.4 GHz Amplifier Schematic First original design - reference only, don't build

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 :)

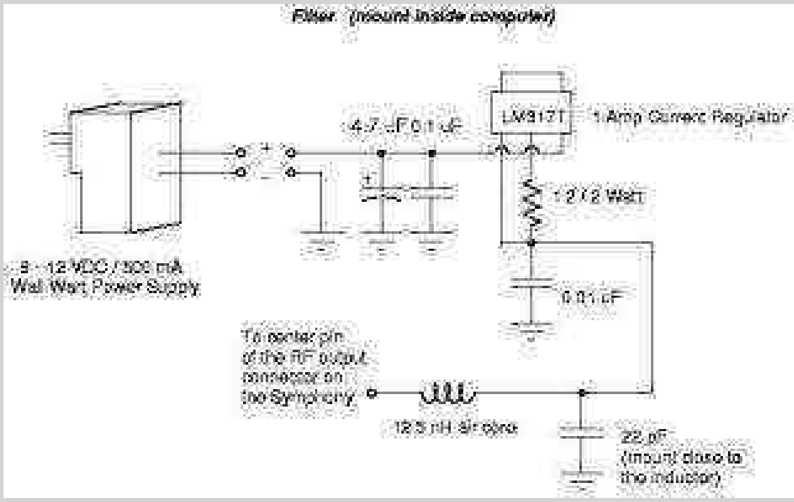
It's also possible to make a receive only pre-amplifier by just replacing the power amplifier section with a 50 ohm stripline, or you can make a power amplifier only by replacing the receive section with a 50 ohm stripline.

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

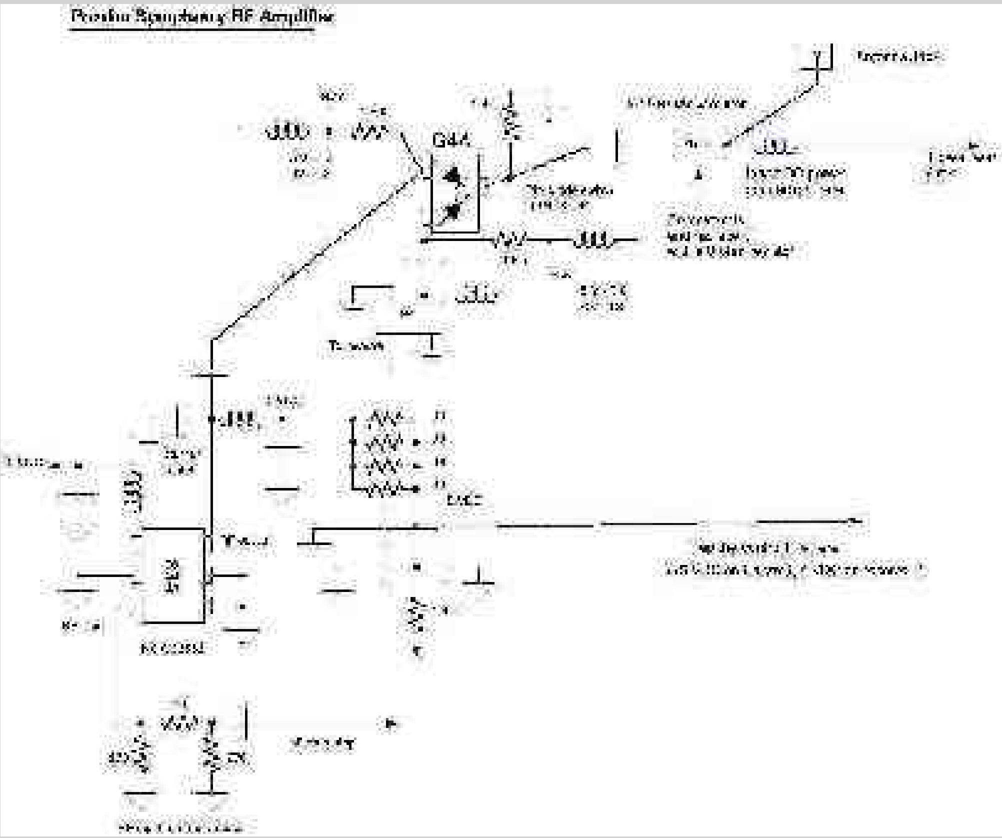
Insertion, DC Power Input & Control

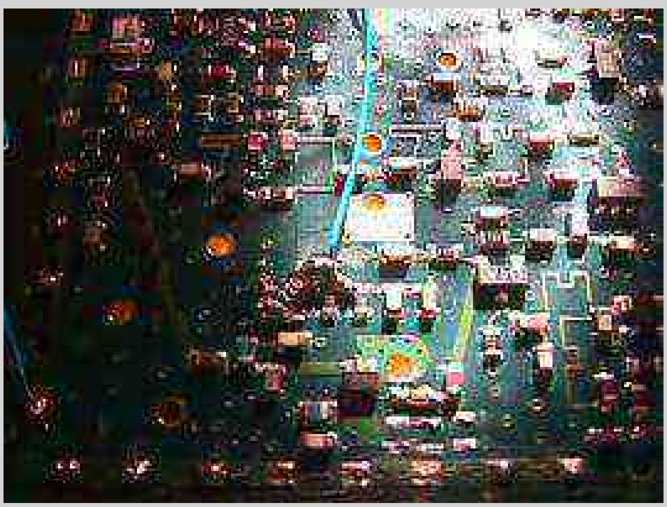
Stick the entire amplifier board inside a *well designed* waterproof case (Hammond boxes are perfect) and mount it right next to your antenna installation or on the antenna mast. You should run LMR-400 coax for the RF input feed line. The DC power for the amplifier is also inserted in this line, so you'll 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

PostScript)

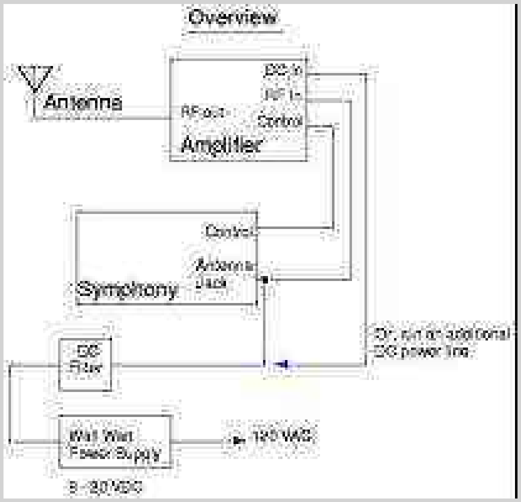
 DC power insertion on the Symphony (17k PostScript)

 Tap point for the amplifier control line inside the Symphony (blue wire)

The 22 ohm resistor is for the higher power modification and is not needed. Refer to the above diagram for more details.


[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.
```

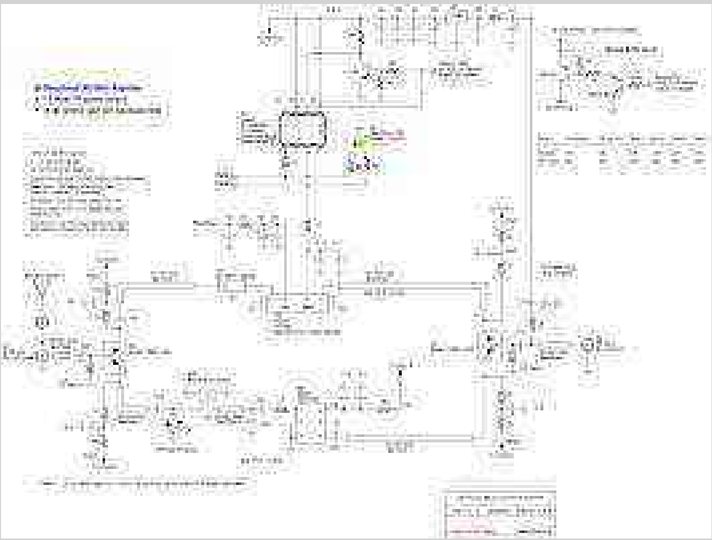
ANSI RF radiation dosage meter.

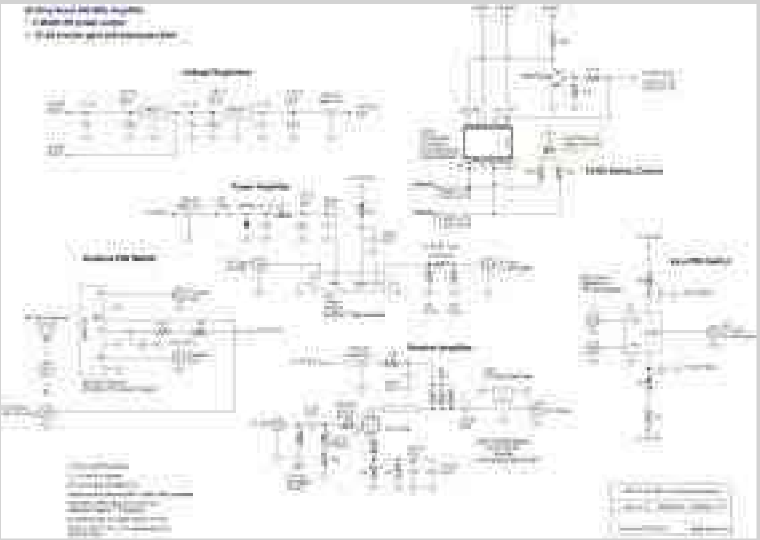
Return to the [Low Cost Wireless Network How-To]

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 (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

[915amp-new]

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

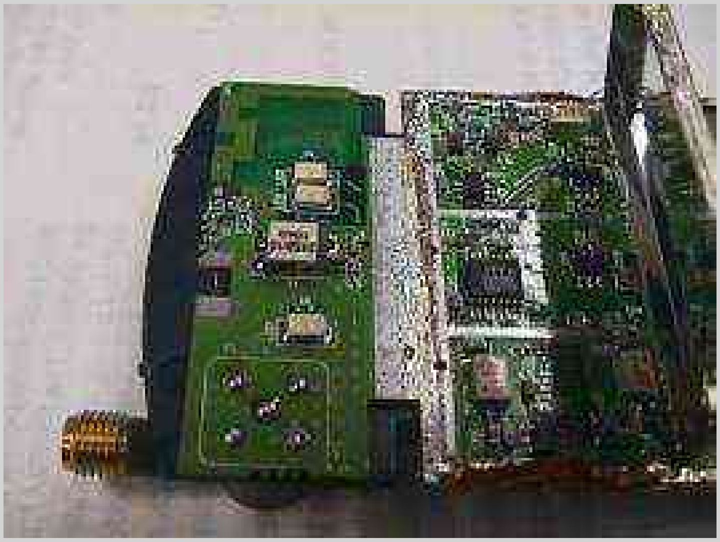
802.11 Wireless LAN Cards

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. You can tap it's control lines to control an external amplifier.

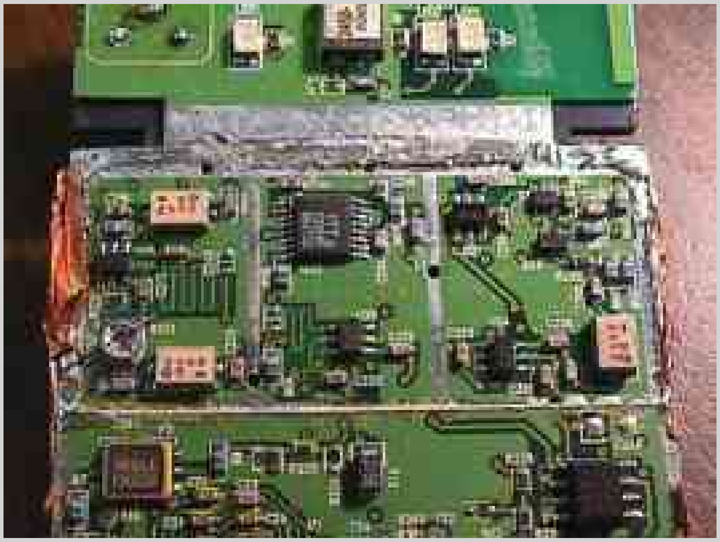
A little better view.

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 the to right is the AM79C930 PCnet mobile wireless LAN MAC controller, the 128k flash RAM and the 32k SRAM.

A picture.



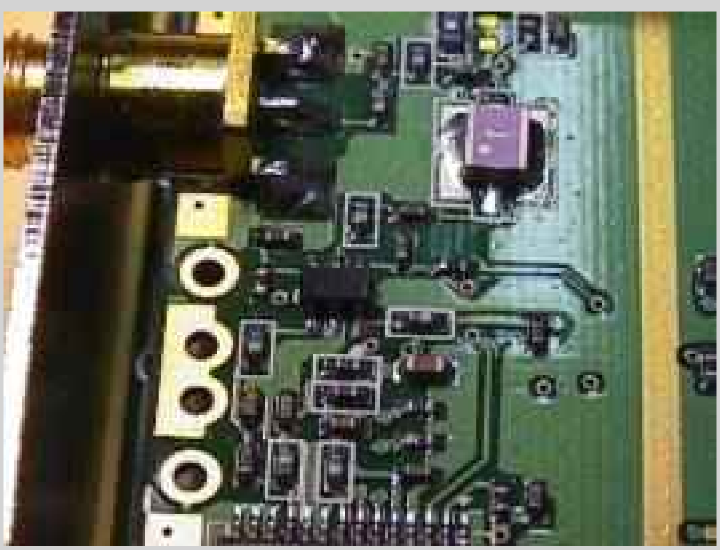
Another picture.

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.

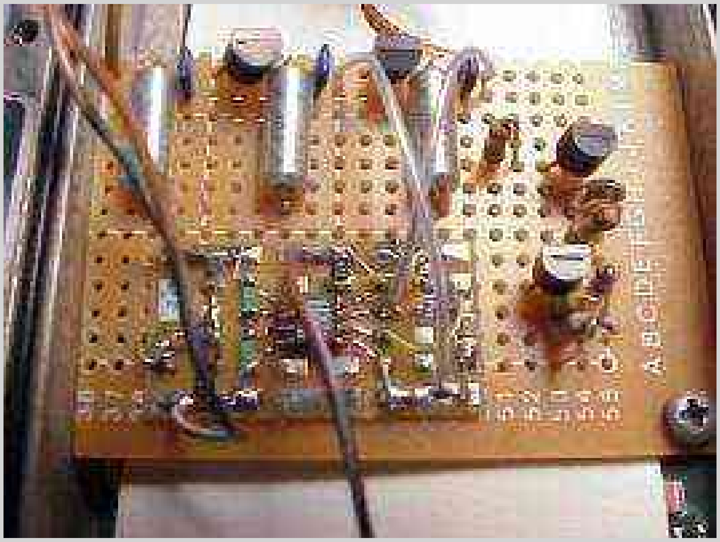
Return to the Low Cost Wireless Network How-To

Bi-Directional 900 MHz Amplifier Pictures

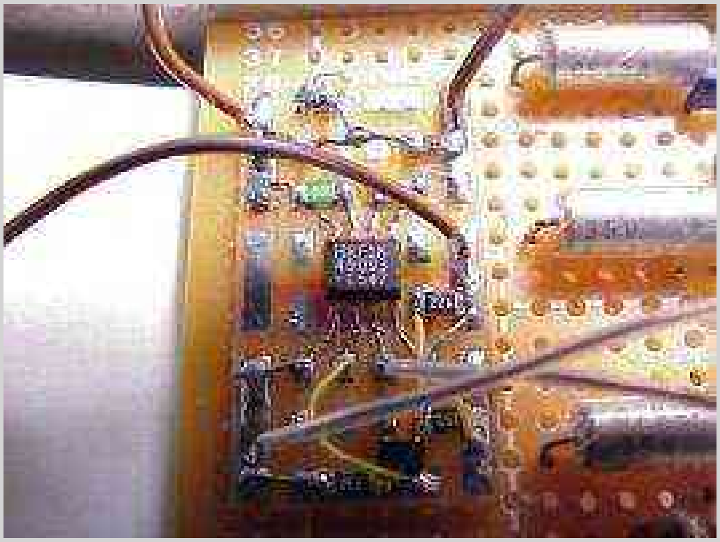
Continued from the Low Cost Wireless Network How-To, Appendix E

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).



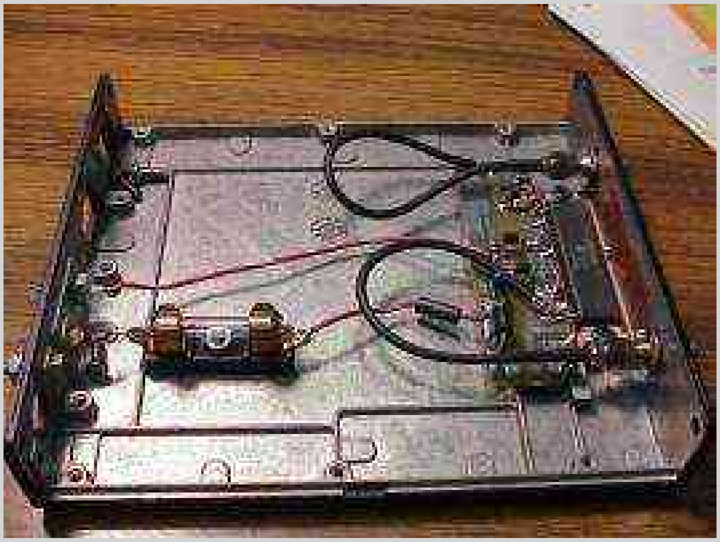
The 78L05 in shown in the top left, 78L09 is top right. The HRF49093 MOSFET is mounted on a surface mount carrier called a Surfboard. I used surface mount parts in the transitor switching logic for simplicity. *Ignore those two transistors on the right hand side.*



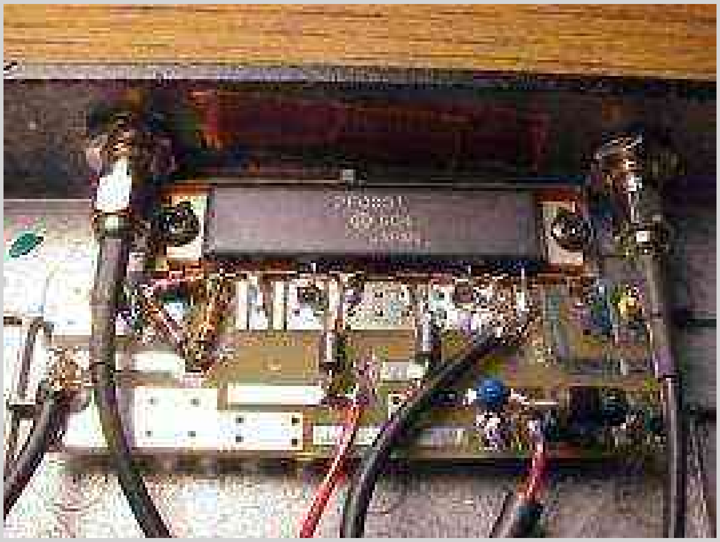
Closeup of the transistor switching logic, the HRF49093 and its outputs.

WaveLAN side PIN diode switch module. This is a Mini-Circuits ZMWS-1211, and was purchased from [Fair Radio](#) 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 mA) = 2000 ohms`

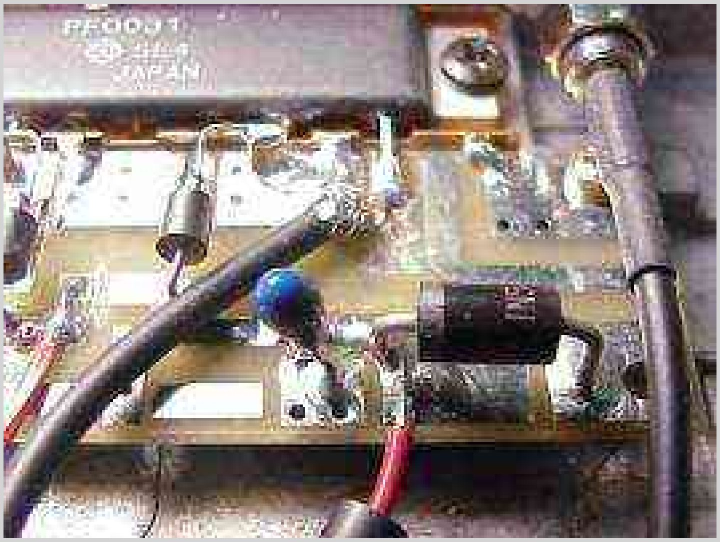


The beast. The [PF0031]() based power amplifier. I say it's only 6 watts, but in reality, it'll do 10 watts easy. Note, however, in the following pictures you'll need to perform some serious RF engineering skillz, otherwise the amplifier ***will oscillate***, probably destructively (AKA, blow up). I salvaged the heatsink and copper heat spreader from and [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]().

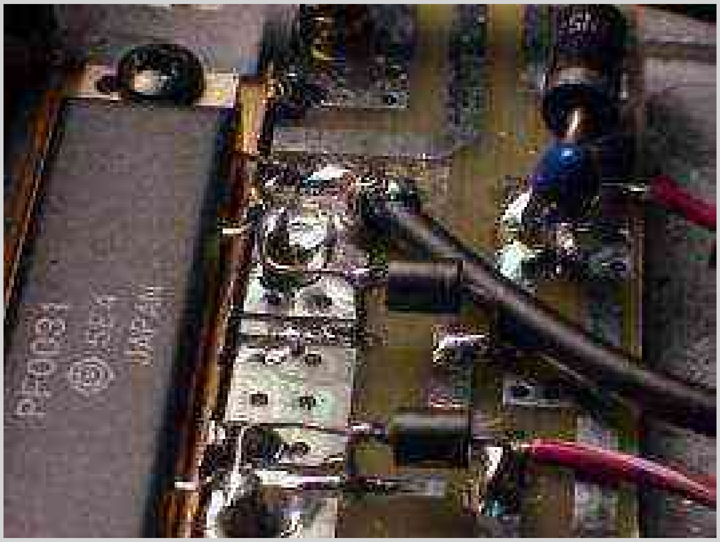


Closeup of the PF0031 module and its support componets. RF input is on the left side, through a SMA bulkhead and a 20 dB resistive pi attenuator using carbon composition resistors. The `Vapc` line is next (going left to right) and is air supported on a 56 pF ATC porcelain capacitor. The `Vdd` line is 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 `Vapc` line.



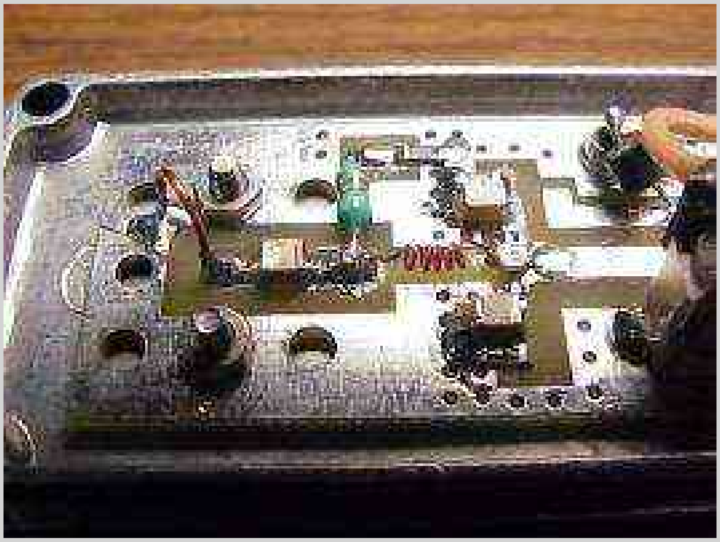
Closeup of the RF output side and the `Vdd` line. You can see the decoupling capacitors and the idiot diode.



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 avaiable 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.



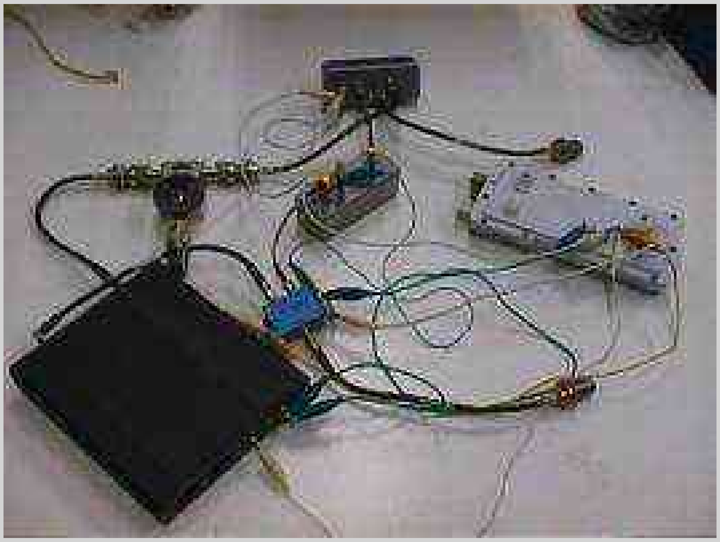
Closeup of the receive pre-amplifier's RF input, showing the shunt inductor and the modified series gate inductor.

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).

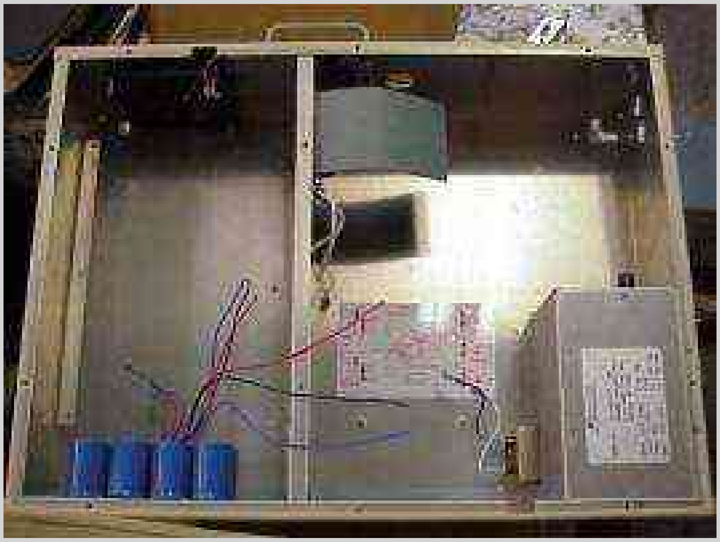
I lined the insides of *all* the cases with that anti-static foam you can buy at Radio Shack, part number 276-2400. Theoretically, this will absorb stray RF inside the case and help improve the circuit's input/output isolation. Or maybe I just smoke $2 crack....

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.

From: Barry McLarnon VE3JF <bm@lynx.ve3jf.ampr.org>
To: Steve Lampereur
Date: Fri, 18 Jun 1999 17:06:49 -0400 (EDT)
Subject: Re: wireless ethernet?

I have some Proxim RangeLAN2 cards (very similar to the Symphony's), I cut the supplied antenna coax and put on standard connectors so I could use higher gain antennas. I've used inexpensive 23 dBi gain grid parabolic antennas with good success on my 5 mile path.

The link margin (measured using attenuators) indicated that a range of 3-4 times that would be attainable, provided the path remained clear.

I have also a WaveLAN link on 2.4 GHz that spans an urban 10 mile LOS.

```
--
  Barry McLarnon  VE3JF/VA3TCP    |  bm@hydra.carleton.ca
  Ottawa Amateur Radio Club       |  bm@lynx.ve3jf.ampr.org
  Packet Working Group            |  http://hydra.carleton.ca
```

From: Steve Sampson <ssampson@usa-site.net>
To: Steve Lampereur
Date: Fri, 03 Dec 1999 18:09:16 -0600
Subject: Re: Symphony Info

I have a link running between Linux boxes from my house rooftop (about 20 feet) to a friends rooftop (also about 20 feet) and it crosses over the Oklahoma City GM Factory, that is 4.65 statute miles. (GPS measured) The link spans through a rural part of Oklahoma City.

I'm using the Proxim Symphony ISA cards with the supplied antenna cut off and BNC connector soldered on the RG-174 coax. Then I have a BNC to Type-N adapter which goes to the SmartAmp power injector. From there I have some Andrews 1/2" hardline from the back room to the roof where the (500mW w/ 14dB receive gain) Teletronics SmartAmp is mast mounted feeding the high quality, inexpensive Superpheonix 24 dB gain grid-parabolic antenna. ($65) It's feed is RG-8/U with a type-N connector. The antenna itself, is cast in an magnesium-aluminum alloy, and is very sturdy looking. (Which is good for the Oklahoma Winds and hail) They are are quoted as 7.5 degree beamwidth, I run them vertically polarized, as the other end had an antenna-vision nearby.

I used the amp first to make sure it will work, and to fine tune everything. My goal (and reason for hardline) is to run without an Amp. With an Amp I could probably have used RG-58, as the Amp works fine down to 2 mW in.

My web page is at: http://members.home.net/k5okc/

73,
Steve, K5OKC

From: Ronen Pinchook <ronen@netmanage.co.il>
To: Steve Lampereur
Subject: Re: The Haifa Group Wireless lan project
Date: Thu, 16 Mar 2000 09:09:08 -0000

Using two Symphonies each with 50 feet of 1/2 inch Heliax runs dropping about 2 dB, the maximum range I was able to acheive was 7.4 miles line of site. I don't use any power amplifiers. I use the cards themselves without any modification, connected to 24 dBi semi Grid Pack antennas. ($67 each)

Currently I have a reliable 5 mile Symphony link that has been going for several months.

I just recently tested a successfull 62 Mile link using BreezeCom Access Point units. The link was full quality stable with 3 leds showing. (This is a new record)

Here are some webpages served over wireless links;

http://wlan.iarc.org - is a wireless-lan web server this is a mirrored site that is currently under construction and is not always connected.

http://wlan.4z4zq.ampr.org - is my home computer, when it is on you may try to look at its web. Its connected with a proxim card and uses a Hill as a relay station

http://www.iarc.org/~ronen/wlan.html - is my wireless lan project page

Hope thats answer your questions
Ronen 4Z4ZQ

Name: Ronen Pinchook (4Z4ZQ) <ronen@ronen.org>
Israel Amateur Radio Club Digital Comm group Projects leader
http://www.ronen.org
http://www.ronen.ampr.org
http://www.iarc.org/~ronen
http://aldan.netvision.net.il/~ronen

From: Ian Kluft KO6YQ <ikluft@thunder.sbay.org>
To: Steve Lampereur
Date: Tue, 21 Dec 1999 10:06:10 -0800
Subject: SBAY Wireless Network

We have been using wireless ethernet over here in the South Bay/Silicon Valley metropolitan-area here in California for a while. Our equipment is all 2.4 GHz 802.11 DSSS techology. We have a couple wireless repeaters located in the hills. We have experimented with AX.25 over ethernet between the wireless repeater sites.

One repeater site is owned by Dave KE6MOW, in Montebello Ridge at an elevation of 1900 feet.

And one in Blackberry Hill (Los Gatos) that I maintain also at 1900 feet.

http://www.sbay.org/wvara-2000-08/repeater-list.html
http://www.sbay.org

From: Bruce MacDowell Maggs <bmm@cmu.edu>
To: Steve Lampereur
Date: Wed, 20 Dec 2000 12:08:19
Subject: Asymmetric Wireless Network

The high speed wireless network antennas here at Carnegie are mounted on a tower above Hammerschlag Hall. This tower is the highest point on the campus. The 900 MHz WaveLan DSSS equipment is in the W3VC Carnegie Tech Radio Club "shack" on the fourth floor of Hammerschlag Hall. To reduce signal attenuation, we used thick and inflexible "hardline" coaxial cables.

The link interconnects several student homes in Oakland (65 miles away) to the Carnegie computer network in Pittsburgh. It also links in; one site in Squirrel Hill (60 miles away), and also provides a link to my house a mile away in Shadyside.

Asymmetric wireless networking:
http://www.cs.cmu.edu/People/bmm/wireless.html

Bruce,
N3WFI

From: Steve Rubin <ser@tch.org>
To: Steve Lampereur
Date: Sat, 3 Feb 2001 16:16:49 -0800
Subject: Re: Ham Ethernet - Bay Area Wireless Users Group

I've got a 7 mile P-T-P link using BreezeCOM Access Point's (100mw I think) using UNI-24 antennas. A friend of mine is using Orinoco cards over about a 4 mile link, also using UNI-24's. Check out http://www.bawug.org for some other info.

--
Steve Rubin / KG6DFV

ID'ing Via Ping Packets

It's possible to transmit data in ICMP ECHO request and ICMP ECHO reply messages. (Commonly referred to as ICMP Tunneling) Embedding your callsign in a ping packet that is sent out every 10 minutes is a very easy and legal way to identify your reclassified Part 97 wireless network.

Reviewing the Unix ping on-line manual page shows us that the data may be set with: -p (pattern). You may send up to 16 characters (including spaces) per ping packet. This pattern must be specified as hexadecimal digits.

```
Example looped ID script:

#!/bin/sh
while true
  do
    /bin/ping -c 1 -s 21 -p 574952454C455353204E4F4445 44.92.20.35
    #                        WIRELESS NODE
    /bin/ping -c 1 -s 24 -p 46434320415253204341C4C5349474E 44.92.20.35
    #                        FCC ARS CALLSIGN
    /bin/ping -c 1 -s 22 -p 204B42394D575220464F52204944 44.92.20.35
    #                         KB9MWR FOR ID
    sleep 600
  done
```

Another method to embed your callsign within the ethernet datagram is to configure your callsign as part of your network name. (Notice how I utilize the 44.x.x.x amateur IP's and my hostname contains my callsign) If you do this, background DNS/ARP traffic will take care of the identification requirement.

Wireless ethernet communications are considered as using a specified digital code to communicate because commercial products are available that facilitate the transmission and reception of the communications and the technical characteristics of wireless ethernet are publicly documented.

The rules no longer really specify how you must ID. Using this method, your callsign will be encapsulated inside an ethernet frame. And this conforms with 97.119(b)(3) for specified data emission codes [see 97.309 (3) & (4)] This is a perfectly reasonable and acceptable method, anyone with a sniffer or running dump on the link will be able to see your callsign:

```
eth1: len 60 00:40:05:44:55:61->00:00:c0:40:0f:25 type = IP
IP: len 42 44.92.20.38->44.92.20.35 ihl 20 ttl 64 prot ICMP
ICMP: type echo request id 54377 seq 0
Öùù KB9MWR FOR ID
```

Keep in mind this is just one example of how to fulfill the identification requirement. You may use any other reasonable method you can come up with or any other method that is publicly documented. (which can be fulfilled by explaining your method on your internet webpage, as I have just done for example.)