

Radio Microphones

(Sub-titled "How Did I Get Stuck With This Job!")

One of my first gigs as a professional technician was doing radios for "Oliver!" the musical, back in 1983. I can tell you, things have changed a lot since then! We had a grand total of eight radios on the show, a big rig in those days. Three were Sony studio types at UHF 900Mhz, three were Microns at VHF 200Mhz and two were Beyers on HF 27Mhz. None had diversity receivers and it was quite an accomplishment to have a full complement working at any one time!

I remember being screamed at by a diva, who shall remain nameless because she's very much bigger than I am, after the fourth \$400 brand-new-out-of-a-box microphone capsule failed within thirty minutes of me fitting it to her. I nearly lost an arm down the cleavage of the same lady retrieving a wayward capsule (successfully) moments before she made a stage entrance.

Back then there were a total of sixteen "legal" frequencies available; four at 27Mhz, which suffered terribly from electrical and radio interference of all kinds, four at 200Mhz with frequencies that only allowed three to work together simultaneously. And then there were Sony's eight "Group A" UHF channels, but *nobody* could afford eight Sonys. In today's money a Sony diversity system cost around \$60,000 per channel. And acquiring them was like having children...it took at least nine months after you first wanted them before they finally arrived! And I'm sure we were just as excited about our first Sonys as most people are about their first child. (I know, we soundies are a sad lot!)

Today, the Spectrum Management Agency has decreed that radio microphones are "low interference potential devices". Transmitting about three thousandths of one watt, they are unlikely to interfere with a distant TV viewer watching their local TV station transmitting at fifty thousand watts. We are graciously allowed to use TV frequencies for radio microphones, provided they are not used in the broadcast region of a TV station with the same frequency (really!). Of course there is no protection from interference from other sources, and we must not cause interference, but it's the best deal we're going to get.

Each television channel has about 8Mhz of bandwidth available, into which fourteen or so radio channels can readily be accommodated. With dozens of unused TV channels around, there's almost no limit to the numbers of radio microphone channels that can be used, but for one big word, inter-modulation. (See separate item.)

Apart from the radio issues of getting radio microphones to work, the audio side of things is fairly trivial. You don't need to spend megabucks to get a good sounding system. Of course, the quality of the microphone capsule is important; you can't skimp on that.

Quality systems are no longer expensive, for example Shure's new UT series retails at less than \$1,600 per channel. For small systems of up to eight channels you'd be hard pressed to beat the performance/price ratio on these.

For very large high performance multi-channel systems, Sennheiser and Sony systems are still preferred due to their superior inter-modulation immunity and channel numbers



I learned a lot of tricks in those early years, and every one of them was essential to keep the radios going. Sometimes I think that today's diversity and noise reduction systems have made radios so easy to use that we rarely get the best performance out of them; we've become lazy about everything that counts. I could write a page on why each of these tips is important.

Ignore these at your peril!

Interference

Higher frequencies suffer less interference. UHF should be static free; HF (27Mhz) is a waste of time. Electrical interference is worse in lower frequency bands

Neon lighting can cause buzz. Make sure high voltage feed wires have *earthed* fully braided screens and use UHF frequencies.

Use wooden or plastic brackets to mount receiving antennas and wrap coax connectors with insulation tape to prevent electrical contact with metal objects, to prevent clicks, buzz, static and distortion.

Keep transmitter antenna away from metal including zips and metallised plastic braiding in costumes, and chains, eg fob watches, to prevent crackles and static. If possible get wardrobe to use plastic zips, not metal ones.

Receiving Antennas

If you have a diversity system, the signal should spend roughly equal amounts of time on both A and B receivers, and ideally a

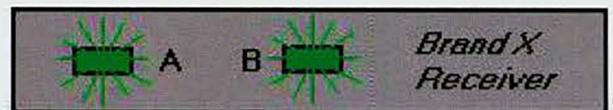


Figure 1: Diversity receiver indicators

available. This extra performance comes at a very high price, around \$10-15k + per channel. Despite the high prices of these top flight systems you'll still need to follow all of my tips for flawless performance!

buyers guide::

WIRELESS MICROPHONES

Prices INCLUDE sales tax and were correct on 15th February 1999. All care taken, no responsibility for errors. Four models only are shown in each category although these manufacturers have many more. Indicative only.

UHF MIC & SYSTEMS

AUDIO LTD

Audio Sound Centre (02) 9901 4455
RMS 2020 pocket diversity receiver with 16 channels, choice of pocket transmitter or HX2000 shotgun style transmitter with Schoeps capsules. \$9150.

RMS 2000 UHF pocket non diversity, two channel portable wireless system, suit ENG and mobile applications. \$6710.

AUDIO TECHNICA

Yamaha Music Australia (03) 9693 5111

AT 1900 SERIES UHF WIRELESS (NEW) True diversity system offers choice of handheld, or Body-pack transmitters suitable for guitar or headset microphone, balanced and unbalanced outputs, 100Hz-15kHz, rack mountable. \$T.B.A.

BEYERDYNAMIC

Syncrotech (02) 9879 0800

U400P bodypack with MCE50 lapel microphone. Receiver is 1RU, half width. All components feature multi-functional display 32 channels (798 - 822MHz). \$3770.

U400G guitar system with bodypack. 1RU receiver, half width, as above. \$3499.

U400HE handheld cardioid condenser, as above with digitally adjustable gain etc. \$3795.

U400HD handheld dynamic microphone with TGX60 hypercardioid pattern with digitally adjustable gain, 1RU, half width, 32 switchable channels, 798-822 MHz.

LECTROSONICS

Audio Sound Centre (02) 9901 4455

UCR 2006 compact receive suit camera mount, diversity 256 channel, available with belt pack transmitter, plug on transmitter or dedicated hand held transmitter. \$9150.

UDR 2006 half rack receiver with choice of transmitters, 256 channel with built in spectrum analyser via PC to assist channel selection between venues. \$12,480.

MIPRO

Audio Telex Communications (02) 9647 1411

MR801 Single channel, half rack, UHF true diversity receiver with choice of electret condenser hand held or belt pack transmitters. Features Pilotone and Noiselock Squelch system to prevent interference. Full range of accessories in-

cluding antenna dividers, boosters etc also available. \$1131.

MR588 30 Frequency, half rack, UHF true diversity receiver with choice of electret condenser hand held or belt pack transmitters. Receiver includes 30 selectable frequencies on transmitters and receiver. Features Pilotone and Noiselock Squelch system to prevent interference. Full range of accessories including antenna dividers, boosters etc also available. \$1567.

MR812 30 Frequency, full rack, UHF true diversity receiver with choice of electret condenser hand held or belt pack transmitters ensuring a fresh supply of batteries is a ways available (batteries supplied). Includes 30 selectable frequencies on transmitters and receiver. Features Pilotone and Noiselock Squelch system to prevent interference. Full range of accessories including antenna dividers, boosters etc also available. \$1859.

MR822 Dual Channel, 30 Frequency, full rack, UHF true diversity receiver with choice of electret condenser hand held or belt pack transmitters. Each channel has it's own 30 channel selectable receiver. Price includes two transmitters. Receiver is metal chassis with internal power supply and unique built-in transmitter battery charger. Will charge 2 transmitter batteries ensuring a fresh supply of batteries is always available (batteries supplied). Includes 30 selectable frequencies on transmitters and receiver. Features Pilotone and Noiselock Squelch system to prevent interference. Full range of accessories including antenna dividers, boosters etc also available. \$3331.86.

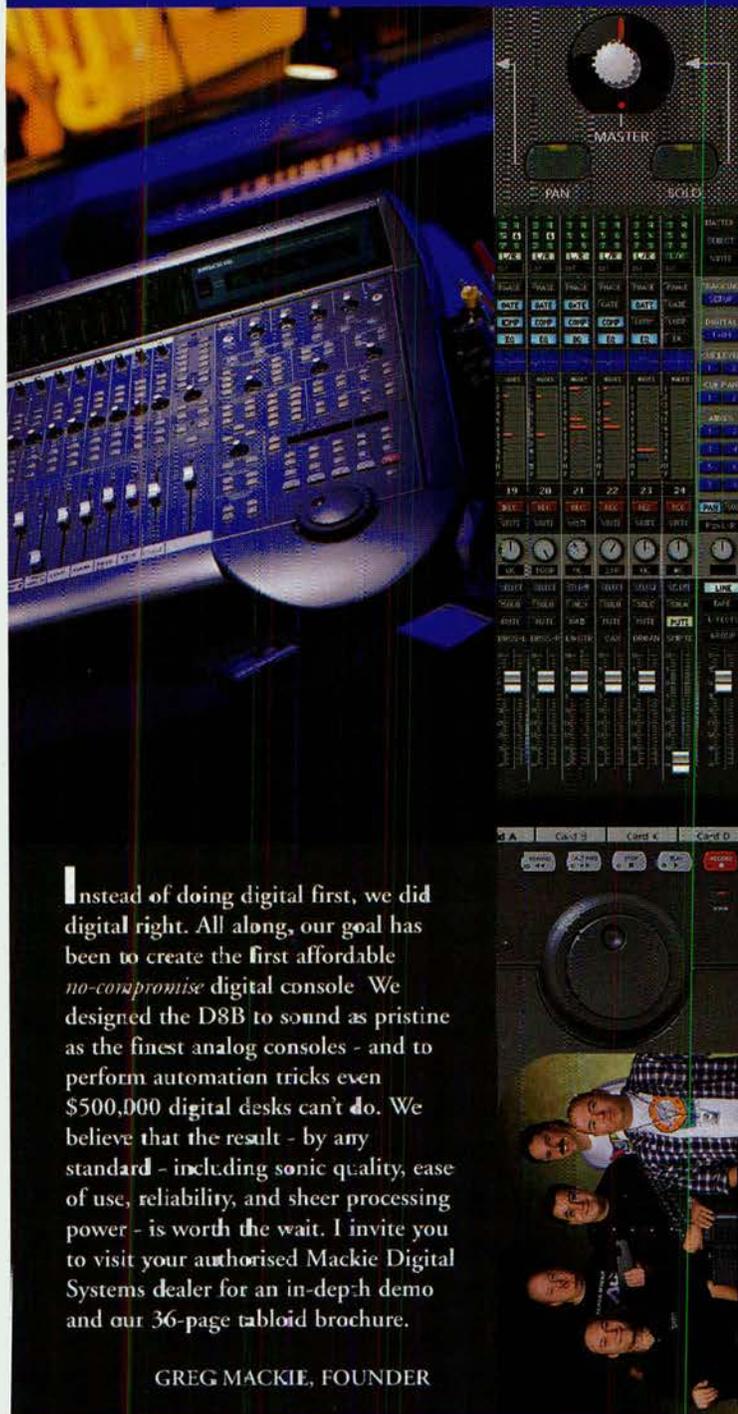
SAMSON

The Electric Factory (03) 9480 5988

UHF Series 1 systems True diversity, half RU systems. Receiver - 3 segment RF meter, AF peak LED, squelch control, rear panel XLR and 6.5mm outputs plus line/mic output level switch. Inserts include Shure, Samson, AT, Sony, EV. Beltpack/Lavalier, Headset, Handheld and Instrument systems available. From \$1,099.

>continued next page

TOTAL CONTROL. TOTAL CREATIVITY. THE MACKIE DIGITAL 8-BUS IS HERE



Instead of doing digital first, we did digital right. All along, our goal has been to create the first affordable *no-compromise* digital console. We designed the D8B to sound as pristine as the finest analog consoles - and to perform automation tricks even \$500,000 digital desks can't do. We believe that the result - by any standard - including sonic quality, ease of use, reliability, and sheer processing power - is worth the wait. I invite you to visit your authorised Mackie Digital Systems dealer for an in-depth demo and our 36-page tabloid brochure.

GREG MACKIE, FOUNDER

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lot of time on A and B together. If not, one or both of your receiving antennas are faulty or poorly sited.

Never assume that both receiver antennas in diversity systems are working properly. Disconnect each antenna in turn at the input to the receiver and "walk test" the transmitter through the whole performance area. If it doesn't work properly on each antenna separately, fix the problem or you're headed for trouble.

For a large performance area, site receiver antennas on opposite sides to ensure you always have one strong signal.

Try to position antennas with line-of-sight to transmitters. Particularly avoid having metal structures between units.

Tilting the receiving antenna off vertical will help prevent dropouts caused by standing waves.

TOP Tips

For maximum antenna signal, keep antennas clear of other metal objects by at least the length of the antenna's elements.

Low loss cable is essential for UHF antenna cable extensions, but not for VHF except for long runs, eg cross stage.

Use only crimp style connectors of the correct type for antenna leads for reliable operation.

And use 50 antenna cable, not 75 television coax, or you will lose signal at every cable junction because of impedance mismatch.

Antenna distribution systems work well, but make sure that the distributor has unity gain if using receivers designed for "on unit" ariels. Excessive gain will overload the input causing interference.

Testing

If possible, turn off noise reduction systems whilst "walk testing" transmitters. The noise reduction system masks dropout problems, which is what it is supposed to do, but it doesn't help you find the best locations for receiving antennas. If you can't turn it off, hum into the microphone. Listen for swishes and splats; if you've done your job properly, you won't get any.

Test every transmitter on stage before every performance. Don't turn them off after testing unless you plan to test them again.

Don't use kid gloves when testing transmitters – they have to stand up to the worst treatment during a performance. It is better they break before the performance, not during it. Yank all leads, wiggle all connectors, bang all cases and have all transmitters on together.

Tape or cover all controls to prevent "helpful" performers bugging things up!

Batteries

Use only brand name alkaline batteries.

Test battery voltage in situ with a digital voltmeter and with transmitter "on" before and after it has run for fifteen minutes. If the voltage has dropped by more than a small amount you have a dud battery or a dud transmitter.

Use rehearsals to test ultimate battery life. You may

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buyers guide::

WIRELESS MICROPHONES

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Samson, continued

UHF Synth Series Six Frequency agile, simultaneous operation of up to 96 channels, remote control of receivers via PC; options include active antennas and distribution amplifiers. Inserts include Shure, Sennheisser, Samson, Sony, EV, AT. Beltpack/Lavalier, Headset, Handheld and Instrument systems available. From \$5,199.

SHURE BROTHERS INC

Jands Electronics (02) 9582 0909

UT Series (SM58) Portable diversity receiver; Fixed frequency (choice of 8); Handheld - SM58 or BG3.1 capsule; Beltpack with choice of: Headworn (dynamic or condenser), Instrument WM98, Lapel (choice of 4) or Guitar cable. \$1595.

UC Series (Beta 58) 1/2 RU Receiver; Programmable - 10 groups of 16 frequencies; Handheld - Beta 87, Beta58 SM87 or SM58 capsule; Beltpack options same as UT series; Tone Key Squelch; Variable HF and LF; Low Battery indicator on Tx and Rx. \$3795.

U Series (Dual 2 x Beta 87) 1 RU 2 channel Receiver; Programmable - over 200 frequencies; Handheld - Beta 87, Beta58 SM87 or SM58 capsule; Beltpack options same as UT series; Tone Key Squelch; Low Battery indicator on Tx and Rx; Computer interface for remote monitoring and scanning. \$10,985 (dual system).

SONY

Sony Australia 9887 6666

Sony Australia Limited has two UHF ranges (operating on UHF Ch 66/67).

FREEDOM series is a cost-effective range for hand-held speech, lavalier and guitar applications. "FLASH" - available shortly a new FREEDOM series vocalist dynamic hand-held based on the F780 (wired vocalist). WRT-805A/66 - Body Pack Transmitter, optional Lavalier, Headset or Guitar cable \$607. WRT-800A/66 - Hand Held Transmitter \$656. WRR-800A/66 - Diversity Receiver Unit \$959. WRR-801A/66 - Diversity Base Receiver Unit inc, 1 x WRU801A/66 Tuner unit \$1,590.

BC series offers features used mainly by television broadcasters such as a slot-in receiver for Betacam SX and remote station battery indication. WRT-810A(66) - Uni-Dynamic, Hand Held \$1,648. WRT-820A(66) - Body Pack Trans-

mitter \$1,451. WRT-830A(66) - Uni-Electret, Handheld \$2,131. WRT-860A(66) - Body Pack Transmitter (Broadcast) \$2,680.

VEGA

EV1 Audio Australia (02) 9648 3455

U 2020 diversity frequency agile system with 100 frequencies available. Half rack receiver, balanced out on XLR, AF/RF/Div metering. Four channel antenna/power splitter available. Belt pack Tx available for headset/lapel/guitar operation. Hand held available with EV 557, 267, 767 and 967 capsules available. \$2529.

672 diversity frequency agile broadcast system. Frequency selection from PC programme. Miniature belt pack available plus hand held transmitters with N/D, RE, SM and Beta capsules. \$8909.

IN-EAR WIRELESS

SHURE BROTHERS INC

Jands Electronics (02) 9582 0909

PSM600 1/2 RU stereo transmitter; Dual frequency (choice of 10 pairs) available in 600 or 800MHz; Stereo, Mono or MixMode operation; Volume and Pan controls on the beltpack. Inbuilt limiter in the beltpack; optional antenna combiner. \$3495.

PSM600 with E1 Ear Drivers As above but with E1 Ear Drivers included. \$3995.

PSM700 1/2 RU stereo transmitter; Programmable (2 groups of 16 channels); Stereo, Mono or MixMode operation; Volume and Pan controls on the beltpack. Inbuilt limiter in the beltpack; optional antenna combiner. \$TBA.

PSM700 with E1 Ear Drivers As above but with E1 ear drivers included, also available with E5 two way ear drivers. \$TBA.

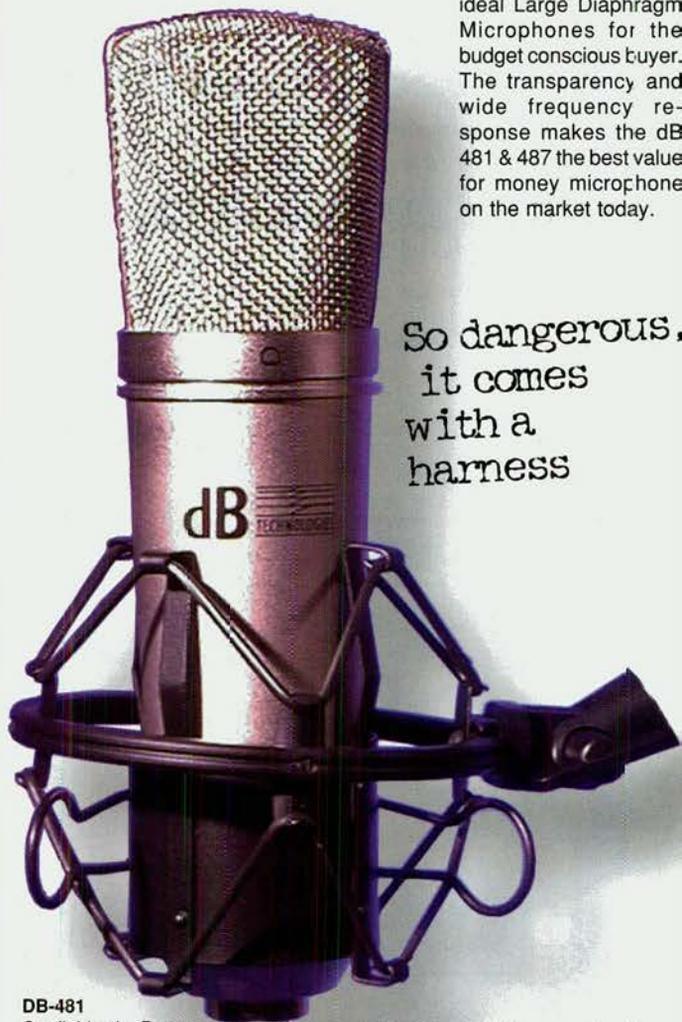
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SIGNAL PROCESSORS

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Nickel or Black finish

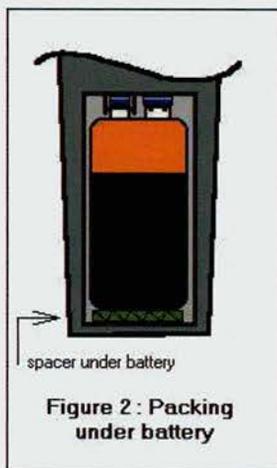
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have to change batteries at interval, after every performance or after every second or third performance depending on transmitter and battery type.

Some transmitters do not have power stabilising circuits and performance drops as batteries are used up; see note on batteries above.

Nine-volt batteries vary in length. Short ones may need a spacer to ensure good contact with the battery terminals and to prevent them rattling. Use a piece of cardboard.

Body-pack Transmitters

Vertical transmitter antennas work better than horizontal ones.

Run antenna cable straight down from the transmitter case. Do not fold back across transmitter. Use a longish rubber band attached to the end of the antenna and pinned to clothing to keep antenna extended without strain.

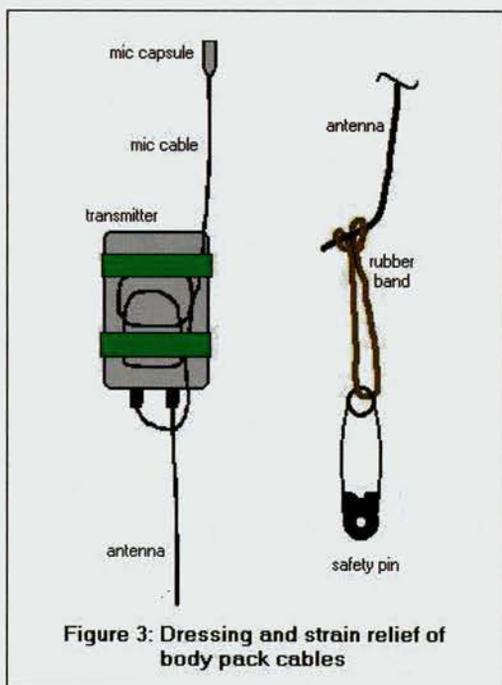


Figure 3: Dressing and strain relief of body pack cables

Sweaty skin reduces transmitted power at UHF. Keep antenna away from skin if possible, eg on outer layers of clothing.

Coil excess microphone cable and tape it to the transmitter case. (NB: Except where the microphone cable is also the antenna.) Run microphone cable away from transmitter in opposite direction to antenna.



Lapel Microphones

A drop of sweat can seal a capsule, blocking sound. Try to have front of capsule hanging downwards.

Watch out for strands of hair, which can penetrate the microphone mesh and cause crackling.

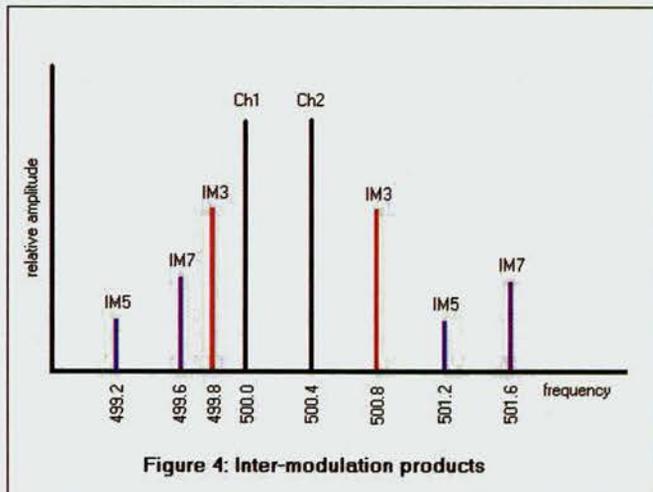


Figure 4: Inter-modulation products

Adjustments

Read the owner's manual before adjusting squelch levels and gain for optimum performance. Correct squelch adjustment is really important in multi-channel systems.

Inter-modulation Explained

Mixing two radio frequencies in a non-perfect amplifier causes the generation of distortion components called inter-modulation products. These new junk frequencies occur at the sum and difference of the two original frequencies. It happens at the output stage of transmitters, such as when one transmitter is in close proximity to another and radiates into its output stage, in the input stages of receivers, and in antenna booster amplifiers.

First order sum and difference products ($f_1 + f_2$, $f_1 - f_2$) will not cause a problem unless the difference happens to fall near to 10.7Mhz, which is used as an intermediate frequency in the modulation/demodulation process. For example, don't expect 500.0Mhz and 510.7Mhz to work happily together. Third ($2f_1 - f_2$, $2f_2 - f_1$), fifth ($3f_1 - 2f_2$, $3f_2 - 2f_1$) and seventh ($4f_1 - 3f_2$, $4f_2 - 3f_1$) order inter-mod difference products do cause problems. Higher order inter-mods can usually be ignored.

For example, if we have on transmitter at 500.0Mhz and one at 500.4Mhz, the following inter-mod frequencies will be generated: 499.2, 499.6, 499.8, 500.8, 501.2 and 501.6Mhz. None of these frequencies can be used for additional channels at the same time as 500.0 and 500.4 without risk of interference. So a two-channel system with a nominal 0.4Mhz spacing is already using up 2.4Mhz of bandwidth. In reality a clever frequency allocation will inter-leave additional channels between all these problem frequencies.

Because every combination of frequencies present will generate inter-modulation products, the number goes up exponentially as more channels are added, so that for a 13-channel installation there are already more than 1200 frequencies to be avoided.

There are two things that really differentiate a good radio microphone system from an average one: the quality of filtering in the output stage of the transmitter and the input stages of the receivers; and the linearity of all amplification stages in transmitters, boosters and receivers. Good electronics (usually = more expensive) means more channels can be crammed together with less risk of interference.

John Matheson designs electro-acoustic systems for Bassett Acoustics. Call him on +61 8 8363 1000.

SHURE®

Radio Frequency Guide

March 1999 edition ©

Handy pull-out
reference guide

Legal Frequency Bands For Australia

With the advent of DTTB, the VHF segment of the broadcast spectrum is being compromised in terms of wireless microphone usage. This guide will help you to identify clear frequencies in which to operate your wireless microphone equipment. This guide details the current situation as of March 1999 but further changes are expected this year. Refer www.jaids.com.au for latest information. EC & E



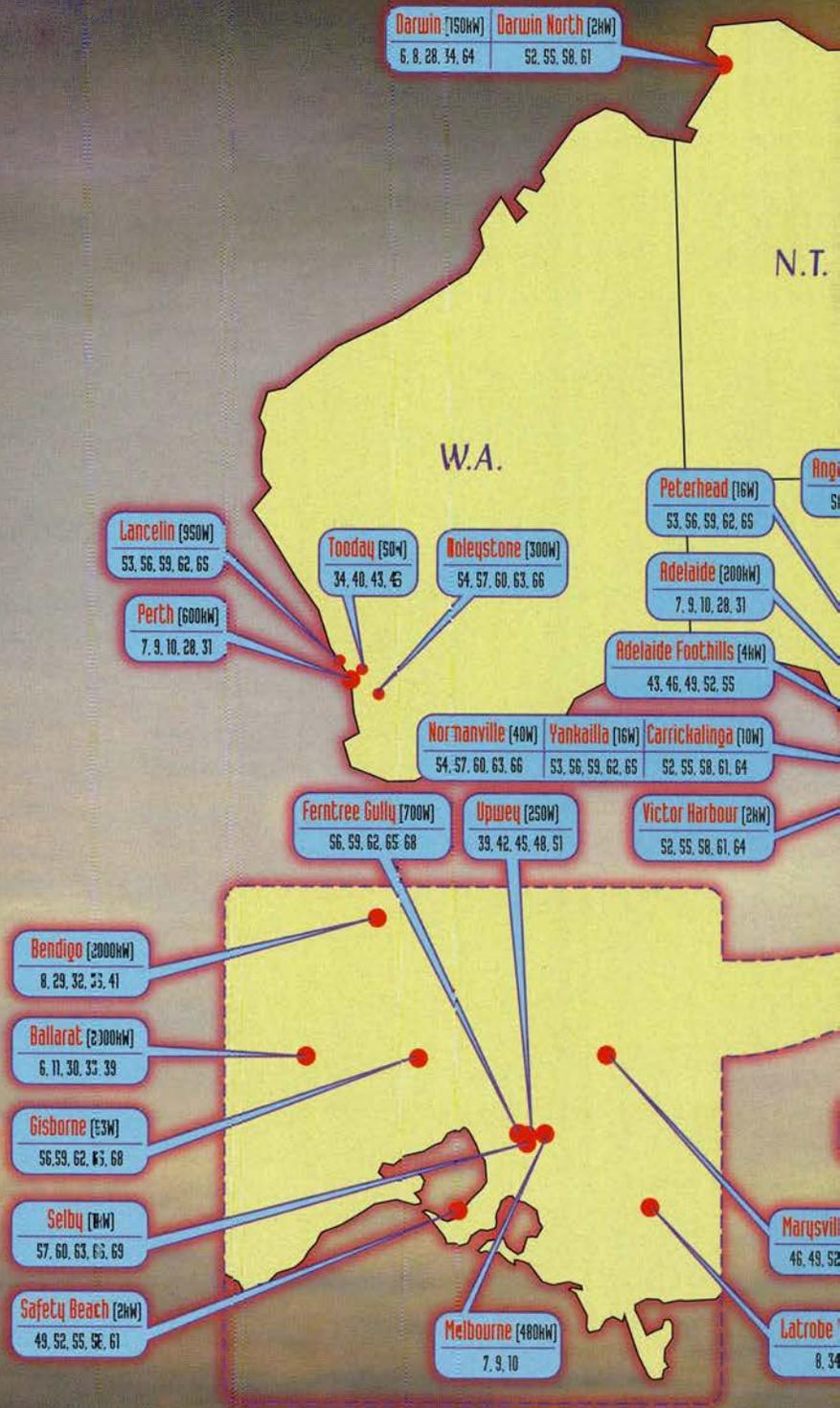
SHURE®

TV Channel	Frequency	TV Channel	Frequency		
VHF Band 3	6	174-181	45	645-652	
	7	181-188	46	652-659	
	8	188-195	47	659-666	
	9	195-202	48	666-673	
	9A	202-208	49	673-680	
	10	208-215	50	680-687	
	11	216-223	51	687-694	
	12	223-230	52	694-701	
	UHF Band 4	27	520-526	53	701-708
		28	526-533	54	708-715
		29	533-540	55	715-722
		30	540-547	56	722-729
31		547-554	57	729-736	
32		554-561	58	736-743	
33		561-568	59	743-750	
34		568-575	60	750-757	
35		575-582	61	757-764	
UHF Band 5		36	582-589	62	764-771
		37	589-596	63	771-778
		38	596-603	64	778-785
		39	603-610	65	785-792
		40	610-617	66	792-799
	41	617-624	67	799-806	
	42	624-631	68	806-813	
	43	631-638	69	813-820	
	44	638-645			

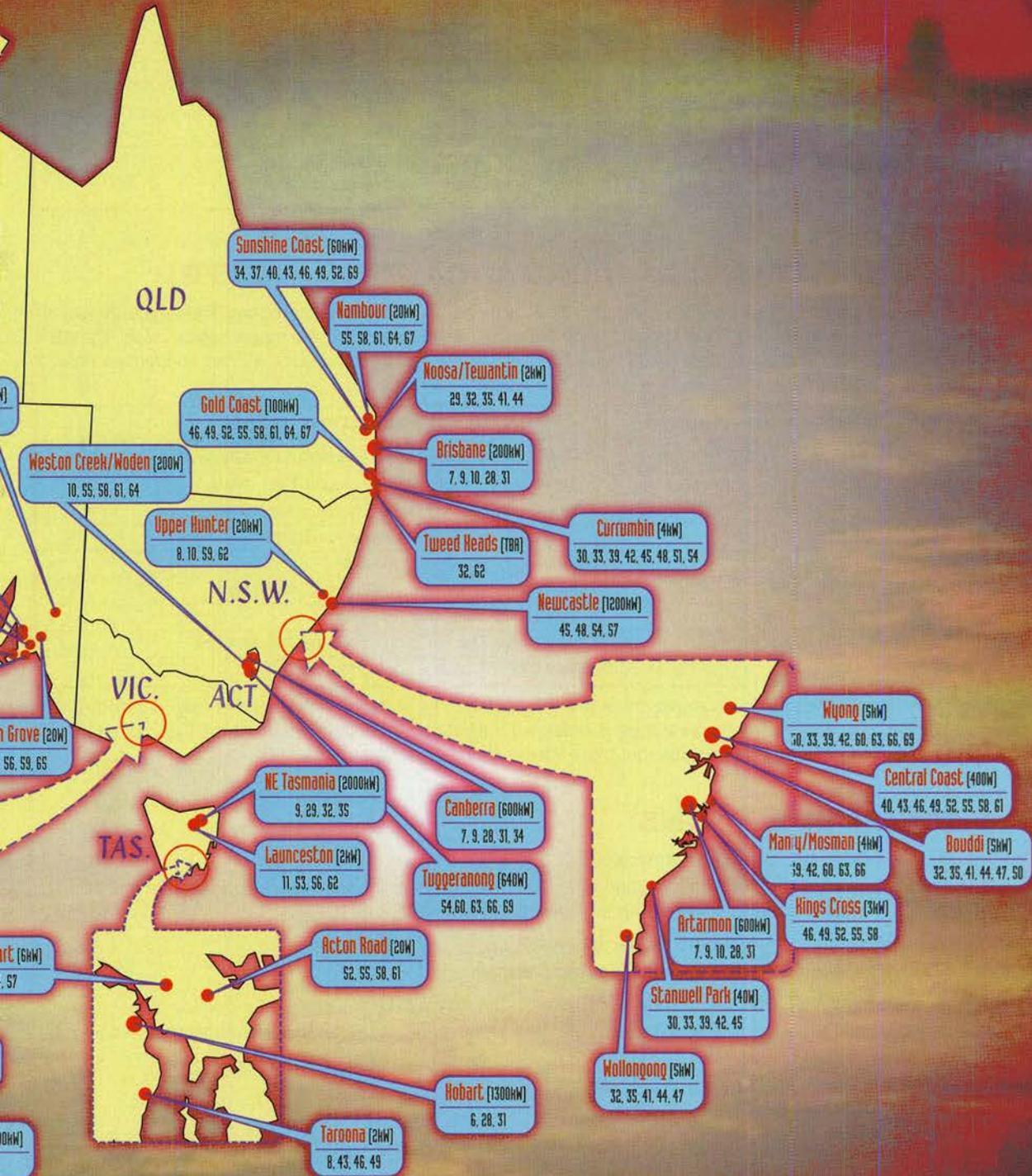
Note: Due to the large number of transmitters in existence many in rural areas have been omitted for clarity.

Legend:

Location(s) [Power]
TV Channels in use



Radio Frequency Guide



RELATIVE BENEFITS OF UHF VS VHF WIRELESS MICS

UHF	VHF
Greater spectrum available (520 - 820 MHz a total of 300 MHz of spectrum)	Less spectrum available (174 - 230 MHz a total of 54 MHz of spectrum)
Less competition for a clear frequency	More competition for a clear frequency
Shorter Wavelengths (300 - 500mm) therefore shorter antenna (approx. 75 - 125mm)	Longer Wavelengths (approx. 1.5m) therefore longer antenna (1/4 wave antenna approx. 400mm)
Propagation losses through air and walls are greater	Propagation losses through air and walls are less
Less RF background noise	Greater RF background noise
Higher cost to manufacture	Lower cost to manufacture
Greater risk of dropout from multipath - Diversity receivers essential	Less risk of dropouts from multipath - Diversity receivers desirable, but not essential

DIGITAL TERRESTRIAL TELEVISION BROADCASTING - (DTTB)

Digital TV is coming to all major capital cities of Australia from 1 January 2001 with testing to commence sooner. The spectrum allocation for DTTB has yet to be finalised. However, the following appears to be the most likely scenario for the major capital cities. The ABA has advised that it expects to publish the final channel plan by 30 June 1999. In rural areas transmissions will not commence until 1 January 2005.

TV CHANNEL	FREQUENCY RANGE (MHZ)	ALLOCATED USAGE
6	174 - 181	New Digital Transmission - Probably Seven Network
7	181 - 188	Seven Network's Existing Analogue Transmission
8	188 - 195	New Digital Transmission - Probably Nine Network
9	195 - 202	Nine Network's Existing Analogue Transmission
9A	202 - 209	New Digital Transmission - TBA
10 (Existing)	208 - 215	Ten Network's Existing Analogue Transmission
10 (Future)	209 - 216	New Digital Transmission - TBA
11	216 - 223	New Digital Transmission - Probably Ten Network
12	223 - 230	New Digital Transmission - Probably ABC

In UHF the situation is more confusing. In Sydney, for example, there are ten Analogue UHF translators - see the map. There may be additional UHF translators for Digital. However, where these will be is unknown until the channel plan is published. Typically, they will be on the adjacent channel to the existing analog transmission, but there will be major exceptions.

FREQUENTLY ASKED QUESTIONS:

Do I need a license to operate a wireless microphone in Australia?

Yes, you always need a license to operate any form of wireless transmitter. However, there is a class license in existence that permits you to operate many types of wireless microphones without making an individual license application.

Will there be compensation for VHF systems that can no longer be used?

No. The class license states that users are permitted to transmit in unused channels.

What will happen if I continue to use my VHF wireless microphone after 1 January 2001?

This has yet to be fully determined. Limited functionality may be possible over short range, however this would be contravening the class license.

Can I have my wireless microphones converted from VHF to UHF?

No. Circuit designs do not permit this.

There's something wrong with my wireless microphone, the RF LEDs on the receiver light-up even before I turn on the transmitter.

The probability is that you have a wireless microphone system that is on the same frequency as a TV station (this often occurs with systems purchased overseas). Switch the unit to a different frequency or if the unit is not switchable, take it back to the shop where you bought it and explain the situation to them. They may be able to change the system to one on a different frequency. For this reason you should always buy wireless microphones in the country of use. For example, Jands only distribute wireless microphones that can be successfully used in Australia.

ADDITIONAL READING:

Selection and Operation of Wireless Microphone Systems by Shure Brothers Inc - Available from Jands Electronics (02 9582 0909) or in .pdf form at <http://www.shure.com/booklets/techpubs.html>.

Radio and Television Broadcasting Stations 1998 is a listing of all existing analog Radio and Television Stations, including those in rural areas, their location and power. It is available from the Commonwealth Government Bookshop or in .pdf form at <http://www.aba.gov.au/what/broplan/plan/sbook98/index.html>.