

The Gradav Guide to Radio Microphone Operation



INTRODUCTION

Radio microphones are an important part of modern sound systems. As the equipment improves and the costs lower, the demand for greater numbers of channels operating together is increasing.

However, the greater the number of frequencies in use, the less stable the system becomes. Interaction between frequencies creates problems in the radio spectrum, which manifest themselves in ways only too clear to the audience!

We hope this guide will assist you to design and operate complete radio microphone systems with the minimum of problems and maximum performance.

System design and operation is something of a 'black art'. This guide should be viewed only as a starting point, for there will always be exceptions to the rule!

It is particularly valuable to understand what works in your venue, so that you can concentrate on operating the show; instead of chasing dropouts!

There is some jargon, as is inevitable in these matters, so please read the glossary before tackling the other sections.

INDEX

Glossary

Page 2	ADA	Aerial Distribution Amplifier
	AF	Audio Frequency
		Capsule
		Channel
		Diversity Operation
Page 3		Dropout
		Hot Packing
		Handheld
		Intermodulation Products
Page 4	JFMG	JFMG Ltd
		Pocket Pack - sometimes called body packs
	RF	Radio Frequency
	RFI	Radio Frequency Interference
		Squelch
	UHF	Ultra High Frequency
	VHF	Very High Frequency

Planning Your System

Page 5	Which frequencies should you use?
	System Layout
Page 6	Transmitters and Capsules

Testing and Rehearsal

Page 6	Testing and Rehearsal
Page 7	Fitting the transmitters
	Capsule placement

Showtime!

Page 8	Showtime!
	After the performance

Trouble Shooting

Page 9	Trouble Shooting Guide
Page 10	More ideas

Appendix

Page 11	JFMG details
	Licence information

GLOSSARY

Aerial Distribution Amplifier (ADA)

Where more than a few receivers are in use it can be awkward to arrange them so that they can use their own aerials. The use of an ADA will solve this particular problem.

The receive aerial is connected to the ADA. There are a number of outputs fed by this aerial, and these are connected in their turn to aerial inputs on the receivers.

This arrangement makes it easy to site the receiver aerials remotely and to best effect. These aerials are almost always more efficient than those supplied with the receivers. These 2 factors can give a significant improvement in reception

In ADAs it is common to provide unity gain (no change in signal level) or sometimes a small degree of positive gain. It is also possible to use simple splitter networks, but there are small losses in this arrangement.

Audio Frequencies (AF)

To distinguish signals in the audio band from those at radio frequencies we use the abbreviation AF.

Capsule

Strictly speaking, the capsule is the electro-mechanical device that converts the sound waves to an electrical signal. Or you could call it a microphone.

We will use capsule to signify the tie clip microphone, the attached cable and its connector, and avoid the use of the word microphone, which could easily be mistaken for the transmitter pack.

Channel

Channel is one of those words in the sound vocabulary that has several meanings, and you must rely on context to determine which meaning applies!

The number of ways in a mixer eg how many channels are you using?

It can also be used to denote a transmitter and matching receiver eg we were using 4 channels, meaning we were using a system comprising equipment operating on 4 different RF frequencies. We will use ways instead of channel in this context to improve clarity.

Channel, as in channel 69 (854 MHz - 862 MHz), can refer to the bandwidth allocated to a TV channel. Please see the appendix for details. We will show this type of channel as CH.

Diversity Operation

With 2 receiver aerials (instead of 1) and some smart electronics, you can reduce dropouts by 80%. At least, that is the result of research conducted by Sennheiser some years ago.

When the signal on the aerial in use (A) falls below a certain level, the receiver looks at the signal on the other aerial (B). Should the signal on B be greater than A, the receiver will switch to using B. This monitoring continues, with switching back to A should the need arise. I told you the electronics were smart!

If the aerials are sited close to each other you will reduce the benefit of diversity operation, as it is likely that both aerials will suffer low signal at the same time.

Diversity Operation (continued)

Rapid switching between aerials is often an indication that all is not well with the transmitter. Damage to the aerial, low RF output, and frequency drift, can all produce this symptom.

Dropout

A transmitter is said to drop out when the RF signal at the receiver falls below either the threshold level of the squelch control, or the prevailing RF background noise level.

Apart from losing the wanted audio signal, it is often the case that unwanted signals are received. This generally takes the form of hiss, crackles and pops, and other spurious noises that your audience will find disturbing.

Hot Packing

This phrase is used to describe the practice of moving the transmitter pack (not hand held) between wearers. Generally, each wearer will have their own capsule already fitted, and this is connected to the transmitter when the pack is worn.

It is not necessary to switch the transmitter off when removing or inserting capsule connectors. You do have to have the channel faded down at the desk though!

Handheld

Radio Microphones held in the hand or stand mounted.



Sennheiser SKM 3072

Intermodulation Products

Often shortened to intermod. These are the harmonic products generated by the interaction between radio transmissions. While we would normally only consider the transmitters in use, there are other sources of RF that can cause problems. Other users and RFI from computers and other electronic equipment, for example, can be responsible for intermodulation problems.

Frequencies we use have been chosen to give the maximum number of compatible ways in the radio spectrum available for our use. Because of the wide minimum spacing needed to give the audio quality we require – unlike walkie-talkies – and the need to minimise intermodulation products, you cannot rely on effective operation based solely on the fact that all the packs are operating on different frequencies.

This set of compatible frequencies is known as a Band Plan, and should be adhered to for the best results.

Mixing radio equipment from different sources without a proper Band Plan can lead to disastrous results. Even though each set of equipment may work well on its own, there is no guarantee that the combination will work satisfactorily.

The differing performances of radio microphone models will also have an effect on the number of ways that can be operated together. Generally, the more you pay, the more ways that will work together. For example it is unwise to operate more than 8 ways of Sennheiser Evolution G2 within CH69, while the 3000 series from the same manufacturer can operate up to 12. It is the performance of the inferior equipment that determines the number of ways you can use.

VHF and UHF frequencies will not create intermodulation problems between bands, for they are separated by a large frequency gap. Thus, you can operate a mixture of VHF and UHF packs to increase the total number of ways in operation without the need to purchase extra licences that operating large numbers in a Band may require.

The Gradav Guide to Radio Microphone Operation

JFMG

JFMG Ltd are the body responsible for issuing licences covering radio microphone operation. Full details are available in the appendix.

Pocket Packs - sometimes called Body Packs

Bodyworn transmitters that would normally be used with 'tie clip' microphone capsules.

Headworn microphones can be used instead of the 'tie clip' type.

It is possible to use other signal sources eg the output from electric guitars, by using suitable adaptor leads. We have used the term pocket pack, and have used 'pack' to indicate the transmitter alone.



Sennheiser SK50

Radio Frequencies (RF)

RF is the much used abbreviation for signals in the radio frequencies. It provides a ready discrimination between audio (AF) and radio. Used a lot when there's a problem!

Radio Frequency Interference

Any unwanted RF signals received by the system. Sources today can be all manner of electrical devices. Even the arcing from a faulty thermostat has been known to generate enough RFI to interfere with the operation of radio microphones.

Squelch

The squelch circuit operates on the RF signal. Only signals greater than the threshold setting will be passed to the receiver audio stages. Some equipment allows the operator to set the threshold level to suit the operating conditions in the venue. Other equipment has the squelch preset at the factory.

Where operating conditions are difficult it can be beneficial to adjust the squelch, if possible. Set the squelch control on the receiver to the minimum. Check that all the transmitters are on, except for the channel being set. Slowly increase the squelch setting until unwanted audio disappears.

This should ensure that in the case of dropout, silence and not noise, can be heard on the receiver output. Broken speech is less disturbing than the awful noises that can be heard otherwise. Should the wearer not be speaking at the time of the dropout; no-one will be aware, for one silence sounds much like another!

Very High Frequency (VHF)

Here we will use this designation to refer to equipment operating between 173 MHz and 220 MHz.

Ultra High Frequency (UHF)

Here we will use this designation to refer to equipment operating between 822 MHz and 870 MHz.

PLANNING YOUR SYSTEM

As with so many projects, the first stage has to be the planning. Care at this stage can save time and trouble later.

Which frequencies should you use?

If you are using a venue that has used radio microphones in the past, ask their advice. You can find that some frequencies just do not work in some venues. The technical staff will be able to give you the benefit of their experience.

If there is more than one user in a venue, a main house and a studio theatre for example, you may have your choice of frequencies restricted. Ask; life can get very complicated if you only discover frequency clashes at the last minute.

Remember that RF travels through walls, and from adjacent buildings as well. In North London there is a theatre next to a church. The church's change from VHF to UHF led to services with a difference at first!

VHF equipment is not well supported by manufacturers today. UHF is the band in which they seem to be concentrating their efforts. It is easier to make equipment that will switch through available UHF frequencies, than it is to switch through the VHF channels where the gaps between frequencies are much greater.

The shorter aerials used on UHF transmitters are much less prone to damage than their lengthier VHF counterparts. Short aerials are also easier to hide.

System Layout

For the purposes of this section we will assume that the receiver section of the system comprises receivers with an Aerial Distribution Amplifier (ADA) and a pair of receiver aerials.

If you are using several single receivers, you will still need to work to maximise performance. It may be much more difficult to re-site the receivers & aerials in the case of difficulty. Providing some separation between aerials will be helpful.

System performance is greatly affected by the location of the receiver aerials. Line-of-sight operation will always give the best signal path. Unless you use low-loss cable and connectors, losses in the aerial cable tend to mitigate the benefits of placing the receiver aerials close to the performance area when the receivers are at the rear of the house.

Some operators like to have the receivers and their aerials close to the performance area, whereby the long runs to the mixer are from the receiver outputs. The low impedance and signal level of these outputs will work well over the distances you are likely to encounter. The disadvantage with this arrangement is that unless you are using sophisticated equipment with computer monitoring, it will not be possible for the operator to monitor the indicators on the receivers.

However, this approach can be useful where reception is difficult and the need to improve overall reception outweighs the benefit of monitoring the receivers. If you are using someone on stage to change packs you can get them to monitor the receivers for the operator. Less than ideal, but better than nothing!

Aerial performance can be affected by the exact location. Even a small change of position can sometimes transform RF performance. Avoid large amounts of metal-work when installing aerials. Experiment to find the most effective position.

The Gradav Guide to Radio Microphone Operation

Place the aerials too close together, or too far apart, and there is a good chance that instead of the aerials receiving contrasting signals (one is up when the other is down), they will capture signals that follow similar patterns. Generally a separation of a few metres works well.

The aerials should be set vertically. This is important for the transmitter aerials should be polarised to match the transmitters, which should be worn with the aerials also set vertically. You will have less control over the positioning of aerials on Hand held transmitters, but they will tend towards the vertical in use.

Aerials have an up, and a down. With simple whip aerials it is not difficult, but when using di-pole receiver aerials for UHF it is not always obvious which is the 'earthy' side, which should be nearest the ground. Often there is an 'E' indication on the aerial to help you – if you look close enough!

Minimise the number of joins in the aerial cables. Every connector introduces a signal loss, which in turn can affect system performance.

Transmitters and Capsules

You will need to determine how many pocket packs and how many hand held transmitters are required.

Beware of the temptation to use a hand held and a pocket pack operating on the same frequency and sharing a receiver, when they are not intended to be used at the same time. If both transmitters are on simultaneously you will suffer interference as the receiver switches between the 2 signals. This noise is quite distinctive, resembles birdsong, and is known as 'birdies'.

The opposite problem is that neither transmitter is on, when one should be! This situation can easily result in intermodulation interference being heard when the mixer channel is faded in.

It is common practice to use extra capsules on cast members with small roles, where hot packing between them can reduce the number of radio microphones in use. This arrangement requires careful planning, the correct number of capsules, and someone on stage to supervise the changes.

While all manufacturers offer capsules in black, some can supply other colours. Pink can often be specified, but while it may be invisible against skin, it can be glaringly obvious when trailed through short dark hair.

TESTING and REHEARSAL

You've planned, and you've rigged. Now is the time to test. Do not rely on sorting out any problems during rehearsal. That way madness lies ...

Because of the intermodulation problems introduced in multi-channel operation, it is most important that you test the system with all transmitters switched on. If you have all of the transmitters close to each other, and near to a receiver aerial, you may experience intermodulation problems that will not appear under normal operating conditions. Separate the transmitters, or extend the distance between transmitters and aerial, and these symptoms will disappear.

To test tie clip microphones it is worthwhile holding the capsule against your chin. This will prevent 'popping' of the capsule. This technique also ensures that the capsule will always be the same distance from the mouth. Thus, for the same settings on the mixer, you can reliably compare both the output level and the timbre of each transmitter & microphone combination.

Fitting the transmitters

Hand held transmitters don't need a lot of fitting! However, it is worth taking the time to explain to their users that care is required in handling. They don't bounce, but they do roll off tables! Stress that these transmitters should only be left in designated places. It is only too easy for these transmitters to get lost if due care is not taken.

Pocket packs must always be used so that their aerials are vertical, so that their polarisation corresponds with the receiver aerials.

Pocket packs can be secured using the clips fitted to them. It can be useful to use pouches to hold the transmitters. They can be attached to the wearer or their clothing. While there is a need to hide the packs, they must be secure and placed to avoid damage. This is particularly true if the wearer is involved in dancing or other energetic moves eg a fight scene. Skimpy costumes may involve some ingenuity!

The small of the back is a good place to locate the pack. Comfortable, easy to camouflage, good access, and the waist makes it straightforward to secure the pack using its own clip or pouch & belt. It's also difficult to sit on!

Ingress of sweat will affect the pack performance, and may even cause damage. If you suspect that the pack placement may be prone to this problem you may adopt the cheap and easy remedy of slipping the pack inside a child's balloon.

NEVER use tape to secure aerials to the skin! Most of the RF will be absorbed by the body, when you need it to radiate towards the receiver aerials. You can experience the same problem where sweat conducts the RF from the aerial into the wearer. Move the pack!

Capsule placement

Capsules are supplied with 'tie clip' clips to secure the microphone head to the costume of the wearer. To prevent mechanical noises affecting the audio output it is worthwhile securing the cable by passing it under the clip.

Avoid 'costume scrape' by placing the capsule away from folds in the costume. Jewellery knocking on the capsule can also prove to be a noticeable problem.

If you wish to secure the capsule in the hairline it is important not to use hairspray once the capsule is in position. It will reduce the frequency response, and ultimately, can damage the capsule beyond repair. Make up can have the same effect.

Take care if securing the capsule around the face. Make up in the capsule is an ever present risk, but the visual impact should not be ignored. Capsule colours contrasting with the skin or hair colours can be quite distracting; as can lumps of tape to hold the capsule in place.



SHOWTIME!

Testing has failed to reveal any problems - or if it did, they have been dealt with, and now it's the real thing!

Switch on all packs and check that they are working into the receivers.

Check the battery strength indicator on the receiver, if available. Now is the time to swap a faulty or low battery – not mid show.

Hand out the transmitters and capsules to the wearers. Ensure that they know not to switch the pack off – ever. Switching packs off will prevent you monitoring what is happening. More importantly, they will, almost inevitably, forget to turn the pack on at the proper time.

The operator should check that all packs & capsules are working properly by checking the indicators on the receivers, and by listening at the sound desk. This step can reveal damage or badly sited capsules caused by careless fitting. It can also show you if packs have been supplied to the wrong wearers. It is probably easier to get the packs swapped than make changes on the desk and your plot.

Changes in conditions can affect the behaviour of your System. You are probably quite familiar with the changes to the audio that an audience makes. Absorption of AF frequencies by the mass of the audience, a rise in temperature and the affect of nerves on the wearers all have their part to play.

But are you aware that an audience also affects RF performance? Absorption of RF can influence performance, and sometimes an alteration to aerial placement may be required.

After the performance

Lets hope that all your hard work has paid off, and you have got to the end without incident or bloodshed.

Collect all packs & capsules as soon as possible. People walk off wearing them if you don't! Don't assume that handhelds will stay put forever, either.

Return to control. Switch off, and remove spent batteries. Ensure that new and spent batteries are not mixed. It happens!

Fit new batteries and test handhelds, packs and all capsules.

Testing and checking at this stage will give you the maximum time to identify problems and perhaps arrange repairs or substitutes. It is also the best time to find that you are short of batteries!

Only when you are sure that all are working properly, should you switch off the packs. Monitoring the receivers, switch off the packs one at a time. This procedure will ensure that all packs are switched off. On large systems it is too easy to miss a pack, and you don't want to start fault finding what turns out to be a flat battery in that busy period just before a performance.

Use this routine to check that all transmitters are still labelled correctly.

STORE TRANSMITTERS & CAPSULES IN A SECURE PLACE

TROUBLE SHOOTING

Having some problems? This section has some advice that should prove useful. With today's equipment it is very easy to swap packs, capsules and transmitter aerials. Substitution can be an easy way of isolating faulty equipment.

Distorts	<p>Input overload. Check the setting of the gain switch on the transmitter.</p> <p>Overload in the mixer input. Reduce output gain on receiver and/or reduce input gain on mixer.</p> <p>If headworn, check the position of the microphone capsule.</p>
No RF shown on receiver	<p>Check that the transmitter is on.</p> <p>Is the battery OK? Try another one.</p> <p>Has the rubber transit cover been removed from the battery?</p> <p>Has the battery been inserted correctly? Check polarity</p> <p>Check that the transmitter is set to the correct frequency</p>
Intermittant RF	<p>Check that the battery is properly installed.</p> <p>Inspect the transmitter aerial for damage and loose fitting.</p> <p>Check that the transmitter aerial is straight and as vertical as you can manage.</p> <p>Body absorbtion of RF. Check that the transmitter aerial is not stuck to the skin with tape. Avoid contact of aerial with skin if possible.</p>
Works, but hisses	<p>A faulty capsule. They can fail by giving low gain. Substitute a good microphone from another pack, or use the spare if only 1 pack is in use.</p> <p>A level mismatch, where a low signal is amplified by the next stage increasing background hiss to audible levels. Below are the most likely solutions to this.</p> <p>Reduce input gain on mixer, increase receiver output.</p> <p>Set attenuation setting to high on transmitter. If distortion results, return to original setting.</p>
Sweat in the pocket pack transmitter	<p>Some actors (and some locations!) produce a lot of sweating. Ingress of sweat can affect performance.</p> <p>Consider re-positioning the pack on the actor.</p> <p>Take a child's balloon and trim with scissors so that you can encase the whole transmitter (not aerial!) in a waterproof covering.</p>

The Gradav Guide to Radio Microphone Operation

Works only when close

Single unit:

check that frequency of transmitter and receiver match.

All channels in the system:

Aerial placement. Move each dipole aerial in turn checking the signal strengths on the RF displays for improvements.

Check transmitter aerial for looseness and damage.

Check receiver aerials are vertical and with the [E] element at the bottom.

Experiment with receiver aerial positions, while observing the RF displays on the receivers.

Microphone crackles

Screw-lock connectors need to have their locking ring tight. Check for looseness.

Snap fit connectors should be fully home.

Check the microphone connector for damage, and see that nothing is loose.

If you think you have found a faulty microphone, test your suspicions by substituting a working microphone from another unit. Then confirm by trying the suspect microphone on a pack that is known to work without crackling.

Scraping noises

Check that the capsule does not come into contact with costume or jewellery.

Cable scraping can cause spurious noises. Secure the microphone cable by passing it inside the crocodile jaws of the clip, creating a small semi-circular loop of cable just below the microphone capsule. Scraping noises travelling along the cable should be stopped where the cable is gripped.

APPENDIX

For licenses and information regarding any aspect of frequency management please contact JFMG Ltd. They are the body responsible for controlling the use of Radio Spectrum in the UK.

JFMG Ltd
33 - 34 Alfred Place
London
WC1E 7DP
Phone 020 7299 8660
FAX 020 7299 8661

website www.jfmfg.co.uk
email info@jfmfg.co.uk

VHF Licence information

There are 5 frequencies that may be used without a licence in the VHF Band. Equipment still needs to meet the performance standards as applied to all VHF radio microphones, as specified by Ofcom (formerly the Radio Agency).

173.80 MHz
174.10 MHz
174.50 MHz
174.80 MHz *
175.00 MHz

* This frequency often creates intermodulation problems when used with some of the other frequencies. We suggest you avoid this frequency if at all possible.

There are more VHF frequencies available for use with a suitable licence. If renting, your supplier will be able to advise. If purchasing, discuss with JFMG Ltd. There are frequencies available as shared or a co-ordinated. Shared frequencies can be used on a 'mobile' basis, while co-ordinated frequencies are issued to specified locations.

UHF Licence information

With the exception of CH69 and Ch70, all of this spectrum is used by terrestrial broadcasters. This does not mean that licenses for Radio microphones are not available, but you will need to discuss your Band Plan with JFMG early in your planning. The table below is only for guidance, and you should consult JFMG for the latest information.

822 MHz - 830 MHz	Ch 65	Co-ordinated only
830 MHz - 838 MHz	Ch 66	Co-ordinated only
838 MHz - 846 MHz	Ch 67	Co-ordinated only
846 MHz - 854 MHz	Ch 68	Co-ordinated only
854 MHz - 862 MHz	Ch 69	14 shared frequencies - UK wide
863 MHz - 865 MHz	Ch 70	Licence exempt. Prone to interference.



Unit C6, Hastingwood Trading Estate
35, Harbet Road, London N18 3HU
Phone 020 8803 7400 FAX 020 8803 5060
email: office@gradav.co.uk Web: www.gradav.co.uk