VHF FM BROADCASTING

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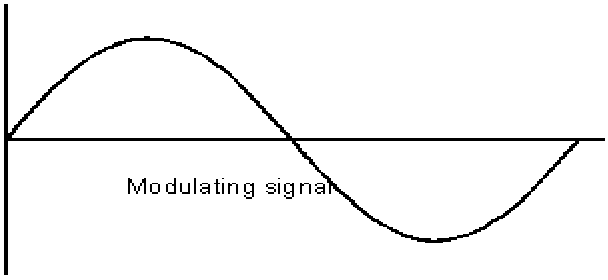
VHF broadcasting is established in most countries around the globe.
VHF broadcast technology provides excellent fidelity in terms of audio frequency response and background noise of all forms.
As a result of its advantages, VHF FM broadcasting has been widely accepted. Even though digital formats are being introduced, many see no need to migrate because the performance of the analogue FM transmissions is more than adequate.

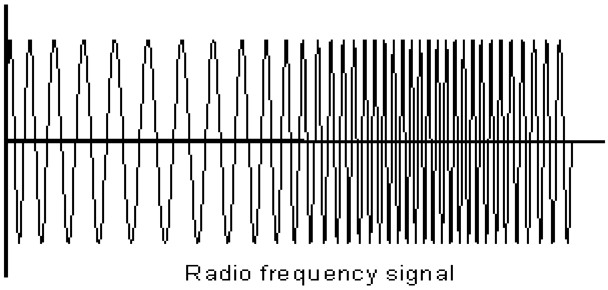
Beginnings of VHF FM broadcasting

When broadcasting first started in the 1920s amplitude modulation was the form of modulation used. It was the obvious and the easiest way to transmit sound.
However as radio technology developed its shortcomings became more obvious. The long and medium wave bands became more congested, giving rise to interference. Also the static and other background noise meant that high quality transmissions were not feasible.
It had been thought that the key to improving quality was to narrow the bandwidth of the transmission to reduce the amount of interference received. However this also reduced the audio bandwidth that could be transmitted and in addition to this, much noise was still present.
The quest for higher quality transmissions lead to the introduction of wideband frequency modulation. Although the first commercial stations were set up in the USA around 1939, it was not until the 1950s that FM started to become really accepted. It was in 1954 that the BBC announced their intention to start FM broadcasting. Now VHF FM is the accepted medium for high quality transmissions, and stations that use AM on the medium and long wave bands have to work hard to retain listeners who prefer the higher quality of VHF FM.

VHF FM basics

Amplitude modulation, which is the simplest and most obvious form of modulation varies the amplitude of the carrier so that it carries the sound information. Frequency modulation is slightly more subtle and as the name indicates it varies the frequency of the carrier in line with the variations in the modulating audio signal. This as the modulating waveform increases in voltage, so the carrier will swing in one direction and as it decreases it will move in the other direction.





Frequency modulation

One of the important factors of FM is the degree by which the carrier changes. This deviation is usually expressed in kilohertz variation either side of the centre (no modulation) frequency. Typically a signal may have a deviation of +/- 3kHz if it varies up and down by 3 kHz. There are two main categories on FM. The first is called narrow band FM, and this is where the deviation is relatively small, possibly 5 kHz. This type of transmission is used mainly by VHF / UHF point to point mobile communications. To appreciate the full benefits of FM, wideband FM is used having a greater level of deviation. The standard for broadcasting is +/- 75 kHz. To fully accommodate these transmissions a bandwidth of 200 kHz is used.

The advantage of FM is that as the modulation is carried solely as frequency variations, much noise, which appears mainly as amplitude variations can be discarded in the receiver. Accordingly it is possible to achieve much better noise performance using FM. The upper audio frequency limit is generally taken as 15 kHz for these transmissions. This is quite adequate for most high quality transmissions.

VHF FM broadcasting standards

In order to ensure that receivers can receive all the stations satisfactorily, that interference levels are reduced and that equipment can be standardised more, there are common standards used by the licencing authorities. Within the USA, the FCC sets the standards, whereas within Europe, ETSI, the European Telecommunications Standards Institute maintains standards that are generally used by the administrations within these regions, and often beyond.

These standards detail the main specifications which equipment should meet. The highlight specifications are detailed below. These are based mainly upon the ETSI figures.

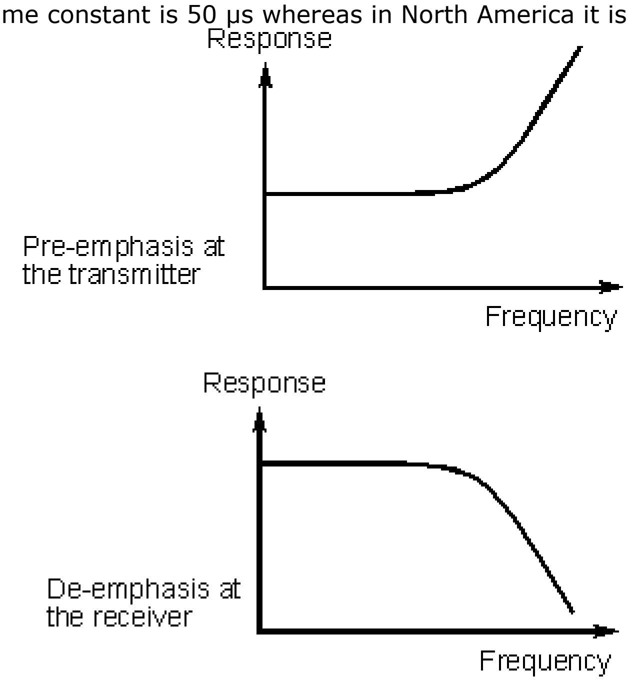
PARAMETER	FIGURES & DETAILS
Frequency band	87.5 - 108.0 MHz (USA uses 87.8 - 108.0 MHz)
Channel Width	200 kHz
Max deviation	Shall not exceed ±75 kHz
Preferred operating frequencies	Multiples of 100 kHz
Other channels	Shall be capable of carrying stereo, RDS, SCA, etc
Audio subcarrier	19 kHz

PARAMETER	FIGURES & DETAILS
frequency	
Stereo centre frequency	38 kHz, i.e. 2 x 19 kHz
RDS carrier frequency	57 kHz, i.e. 3 x 19 kHz

One of the problems with the high quality VHF FM transmissions is that the increased audio bandwidth means that background noise can often be perceived.
As VHF FM is intended to provide high quality audio transmissions, background noise needs to be reduced as far as possible.
One method of reducing he background noise is to use a scheme called pre-emphasis.

Pre-emphasis basics

The pre-emphasis and de-emphasis idea can be used on VHF FM because the background noise is more noticeable towards the treble end of the audio spectrum, where it can be heard as a background hiss.
To overcome this it is possible to increase the level of the treble frequencies at the transmitter. At the receiver they are correspondingly attenuated to restore the balance. This also has the effect of reducing the treble background hiss which is generated in the receiver.
The process of increasing the treble signals is called pre-emphasis, and reducing the in the receiver is called de-emphasis. The rate of pre-emphasis and de-emphasis is expressed as a time constant. It is the time constant of the capacitor-resistor network used to give the required level of change. In the UK, Europe and Australia the time constant is 50 μs whereas in North America it is 75 μs.



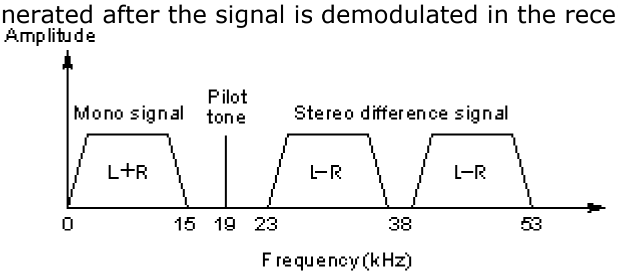
Pre-emphasis and de-emphasis of a signal

VHF FM receivers have the de-emphasis circuitry - consisting of a simple CR network built into the circuitry immediately after the FM demodulator. In this way it is not incorporated into an amplifier that may be used for other audio sources that would not require the de-emphasis applied to VHF FM transmissions.

In recent years stereo transmission has become an accepted part of VHF FM transmissions. The system that is used maintains compatibility with mono only receivers without any noticeable degradation in performance. The system that is used is quite straightforward.

A stereo signal consists of two channels that can be labelled L and R, (Left and Right), providing one channel for each of the two speakers that are needed. An ordinary mono signal consists of the summation of the two channels, i.e. L + R, and this can be transmitted in the normal way. If a signal containing the difference between the left and right channels, i.e. L - R is transmitted then it is possible to reconstitute the left only and right only signals. Adding the sum and difference signals, i.e. (L + R) + (L - R) gives 2L, i.e. the left signal, and subtracting the two signal, i.e. (L + R) - (L - R) gives 2R, i.e. the right signal. This can be achieved relatively simply by adding and subtracting the two signals electronically. It only remains to find a method of transmitting the stereo difference signal in a way that does not affect any mono receivers.

This is achieved by transmitting the difference signal above the audio range. It is amplitude modulated onto a 38 kHz subcarrier. Both the upper and lower sidebands are retained, but the 38 kHz subcarrier itself is suppressed to give a double sideband signal above the normal audio bandwidth as shown below. This whole of the baseband is used to frequency modulate the final radio frequency carrier. It is the baseband signal that is regenerated after the signal is demodulated in the receiver.

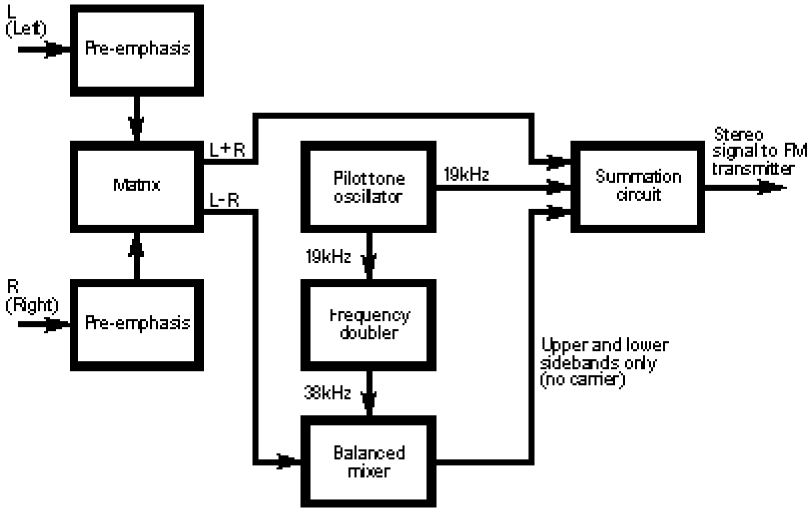


The modulating (baseband) signal for a stereo VHF FM transmission

To regenerate the 38 kHz subcarrier, a 19 kHz pilot tone is transmitted. The frequency of this is doubled in the receiver to give the required 38 kHz signal to demodulate the double sideband stereo difference signal.

The presence of the pilot tone is also used to detect whether a stereo signal is being transmitted. If it is not present the stereo reconstituting circuitry is turned off. However when it is present the stereo signal can be reconstituted.

To generate the stereo signal, a system similar to that shown in Fig. 8.5 is used. The left and right signals enter the encoder where they are passed through a circuit to add the required pre-emphasis. After this they are passed into a matrix circuit. This adds and subtracts the two signals to provide the L + R and L - R signals. The L + R signal is passed straight into the final summation circuit to be transmitted as the ordinary mono audio. The difference L - R signal is passed into a balanced modulator to give the double sideband suppressed carrier signal centred on 38 kHz. This is passed into the final summation circuit as the stereo difference signal. The other signal entering the balanced modulator is a 38 kHz signal which has been obtained by doubling the frequency of the 19 kHz pilot tone. The pilot tone itself is also passed into the final summation circuit. The final modulating signal consisting of the L + R mono signal, 19 kHz pilot tone, and the L - R difference signal based around 38 kHz is then used to frequency modulate the radio frequency carrier before being transmitted.

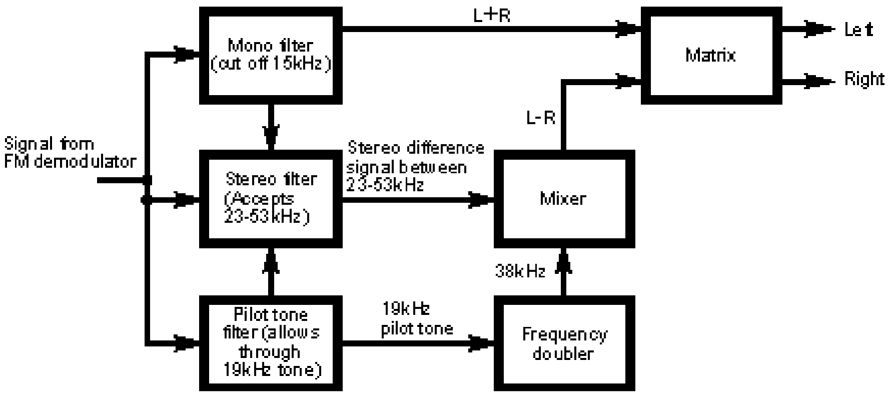


A simplified diagram of a VHF FM stereo encoder

Reception of a stereo signal is very much the reverse of the transmission. A mono radio receiving a stereo transmission will only respond to the L + R signal. The other components being above 15 kHz are above the audio range, and in any case they will be suppressed by the de-emphasis circuitry.

For stereo receivers the baseband signal consisting of the stereo sum signal (L+R) and the difference signal (L-R) centred around 38 kHz and the pilot 19kHz tone are obtained directly from the FM demodulator. The decoder then extracts the Left only and Right only signals.

The block diagram of one type of decoder is shown below. Although this is not the only method which can be used it shows the basic processes that are required. The signal is first separated into its three constituents. The L + R mono signal between 0 and 15 kHz, the pilot tone at 19 kHz, and the stereo difference signal situated between 23 and 53 kHz. First the pilot tone at 19 kHz is doubled in frequency to 38 kHz. It is then fed into a mixer with the stereo difference signal to give the L - R signal at audio frequencies. Once the L + R and L - R signals are available they enter a matrix where they are added and subtracted to regenerate the L and R signals. At this point both signals are amplified separately in the normal way in a stereo amplifier before being converted into sound by loudspeakers or headphones.



Block diagram of a stereo decoder

Today most stereo radios use an integrated circuit to perform the stereo decoding. Often the pilot tone is extracted and doubled using a phase locked loop. This provides a very easy and efficient method of performing this function without the need for sharp filters.

There are a number of VHF FM broadcast bands in use around the globe, and within these channels or frequencies are generally organised to provide the minimum of interference, while using the spectrum in an efficient manner.

Each country allocates the channels and frequencies in a slightly different manner, although within the overall ITU guidelines. As a result there is a large degree of conformity across the globe for the bands and channels used, although there are some local variations

Main VHF FM bands

There are a number of band allocations used around the globe:

- ***87.5 - 108.0 MHz:*** : This is the "standard" VHF FM band - the one that is most widely used around the globe.
- ***76.0 - 90 MHz:*** : This VHF FM band is used in Japan.
- ***65.8 - 74.0 MHz:*** : This VHF FM band is known as the OIRT band. It was used in Eastern Europe, although few countries (Russia, Ukraine, and some other still use. However there is a move to using the more standard 87.5 - 108 MHz band.

VHF FM broadcast band plan for UK

In the UK, the VHF FM broadcast band is split between the various forms of broadcasting supplied by the national broadcaster, the BBC, which is funded by a licence fee, and independent radio which is funded on a commercial basis, chiefly by advertising.

FREQUENCY BAND MHZ	APPLICATION
87.5 - 88.0	Restricted Service Licences
88.0 - 90.2	BBC Radio 2
90.2 - 92.4	BBC Radio 3
92.4 - 94.6	BBC Radio 4
94.6 - 96.1	BBC local radio
96.1 - 97.6	Independent local radio
97.6 - 99.8	BBC Radio 1
99.8 - 102.0	Independent national radio
102.0 - 103.5	Independent local radio
103.5 - 104.9	BBC local radio
104.9 - 108.0	Independent local radio

It can be seen that specific BBC national radio stations are allocated bands within the overall band-plan. The requirement for this amount of spectrum enables the whole country to be covered without undue levels of interference because stations are not sufficiently spaced in distance.

VHF FM broadcast channels & frequency plans for North America

In North America, the VHF FM band plans and frequencies are allocated in a slightly different way to other areas.

The VHF FM channels range from 87.8 to 108.0 MHz, proving an overall bandwidth of 20.2 MHz.

The stations are assumed to have a bandwidth of 200 kHz, and they are allocated centre frequencies (dial frequencies) with odd numbers for the figure after the decimal point, i.e. 87.9, 88.1 . . . etc.. This provides a total of 101 channels. These are given FCC designations of 200 for 87.9 through to 300 for a frequency of 107.9.

The upper 80 channels, VHF FM channels 221 to 300 on frequencies between 92 and 108 MHz are sued for commercial broadcasting. The lower 21 channels, i.e. those between channel numbers 200 and 221 are reserved for non-commercial educational broadcasts. Note that Canada and Mexico, countries that directly border onto the USA ?? not observe this reservation

Japanese VHF FM frequency band

The VHF FM band that is sued within Japanese extends from 76 to 90 MHz because the 90 to 108 MHz band is used for analogue VHF television - three channels each 6 MHz wide.

The Japanese VHF FM band is only 14 MHz wide and this limits the number of stations that can be accommodated, and as a result, many stations use AM.

Australian VHF FM band

Australia has taken on board the standard VHF FM band allocation of 87.5 - 108 MHz. Although VHF FM broadcasting opened in 1947, it did not gain sufficient market acceptance inth e early days and as a result the system was shut in 1961. It then re-opened in 1975 as VHF television closed.

Now much broadcasting takes place on VHF FM, with talk stations adopting he AM frequencies.

OIRT VHF FM band

The OIRT VHF FM band was used within much of the old Soviet block where they were members of the International Radio and television Organisation in Eastern Europe - OIRT. These countries included the USSR (now Russia) as well as most Eastern European countries, although not Eastern Germany and Yugoslavia as it was then.

The OIRT VHF FM band covers 65.8 - 74 MHz. It has advantages that the coverage area provided by the OIRT band is greater than that provided by the more widely used 87.5 - 108 MHz band.

As a result of the band being relatively small, and the lower requirement for high fidelity, the channels are only 10 kHz wide. The narrower bandwidth also helps with selective propagation issues that are more prevalent at these frequencies as well.

Most countries that used the OIRT band are now moving to the more standard 87.5 - 108 MHz allocation.