September 2008
Volume 9, Issue 3

ANODE

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Editor's Comments

September 2008
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Flee Market or Flea Market?

What was it about the Flea market that made all the committee members disappear so quickly on Saturday?

At the flea market

In conversation with Pine, I mentioned a suitable noise source for measuring the noise figure of a receiver. Then I couldn't find mine...

Calibrator Noise Source
http://astro.u-strasbg.fr/~koppen/RJove/calibrator.html

For those that like to congratulate themselves...
"SDR Transforms Amateur Radio"
http://electronicdesign.com/Articles/Index.cfm?AD=1&ArticleID=19439

ARRL proposes "fifth pillar" of amateur radio
http://technocrat.net/d/2008/5/16/41477
[Yeah right! When has the ARRL ever shown an aptitude for technology?]

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Antennas (Part 1)

by Gordon J. King
T.Eng(CEI), AMIERE, G4VFV

A radio signal is part of the electromagnetic wave family like light, infra-red, X-rays, etc. and can be regarded as a form of dynamic energy. It has the astonishingly high velocity of 300,000 km/s which means that it will travel 300m in 1 pico Second. Nothing can travel faster than an electromagnetic wave - nothing, that is, which we know of at the present? It is called an electromagnetic wave because it consists of two intrinsically linked component parts - an electric field and a magnetic field - which have the ability to exist in a vacuum without any conductive supporting medium. The velocity of wave travel just given, in fact, applies to space travel. The carrier wave is generated by a powerful oscillator and the energy is launched into space by the transmitting antenna. The electric and magnetic components are perpendicular to each other and to the direction of wave travel. This means that an electromagnetic wave is a transverse wave as distinct from the longitudinal type of wave, such as a sound wave whose supporting particles vibrate in the same direction as the wave travels.

In Fig. 1.1 (a) I have attempted to give an impression of an electromagnetic

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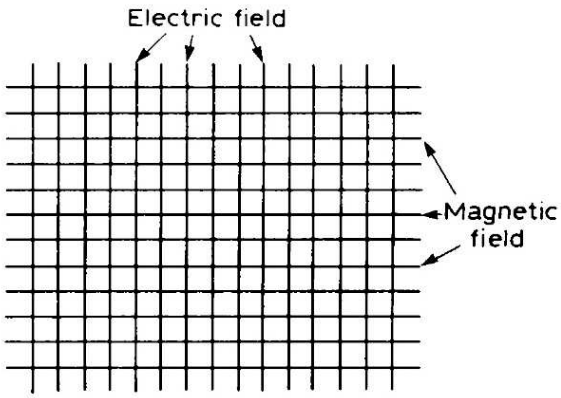
wave front advancing towards you out of the page, while Fig. 1.1 (b) gives a rough idea of how the electric and magnetic components effectively link together at right-angles on their trip through space. The two components, of course, are alternating in polarity at the carrier frequency of the radio signal. Let us consider the wave starting on an alternating electric field. This automatically creates an alternating magnetic field which then produces an alternating electric field, and so on, each one being at right-angles to the other as the wave spreads out into space.



(a)

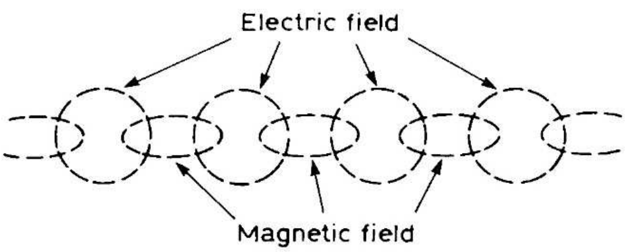


Fig. 1.1 (b)

Near the transmitting antenna the electric and magnetic fields alternate 90 degrees out of phase with each other, but as the wave spreads away from the antenna and the wave becomes what is known as a plane wave, so the two components get into step and remain that way. An electromagnetic wave can thus be looked upon as a sine wave. This, of course, applies to the carrier wave part of the radio signal. Unless a pure tone is being carried by the wave the audio information will be far removed from a simple sine wave. I will go into this modulation business later.

Frequency and Wavelength

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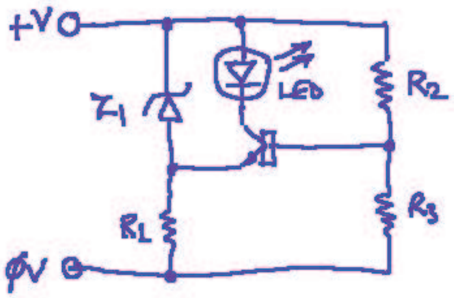
Circuits that do work



A few issues ago, I showed a circuit for a battery monitor that when analysed could not possibly work. The other day I came across a circuit I had drawn in the seventies. This circuit I can remember testing. Sorry I could not find the design details but it shouldn't be too difficult to work out. The zener (Z1) is there to turn on when the voltage applied is normal and above the turn-on voltage. This will reverse bias the transistor, turning off the led. When the voltage drops, the zener will stop conducting and the transistor will be biased correctly, conducting a suitable current that lights the led.

More on the Direct Conversion Receiver

As I showed the members at the last Ham-Comp and Electronic Enthusiasts meeting, the VFO needed a lot of work to get it easy to reproduce.

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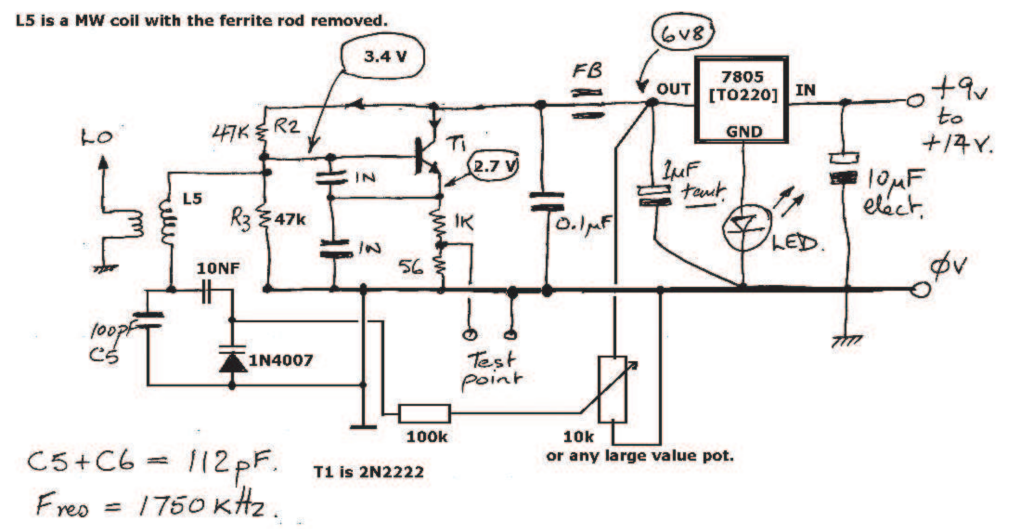
Here is the newest and latest circuit for the VFO for use in the receiver.



I shall be putting all the notes etc into an article on the receiver later. The test results also have been very promising with the stability and purity excellent. The secondary of the MW transformer provides adequate drive for the mixer diodes and a nice looking sine wave.

See you at the next Ham-Comp meeting.
[JB]

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Let us suppose that the radio signal falls in the very high frequency (v.h.f.) f.m. band (Band II) at say, 96 MHz. This means that the vibration rate or frequency of the carrier wave is 96 million times per second obviously, far too fast for human ears to detect and we can represent it by a sine wave as shown in Fig. 1.2. Now, the distance occupied in space by one cycle of this signal is equal to the velocity in space divided by the frequency. When the frequency is given in MHz, the formula merely resolves to:

Wavelength (l) = 300 / frequency (f) MHz in metres

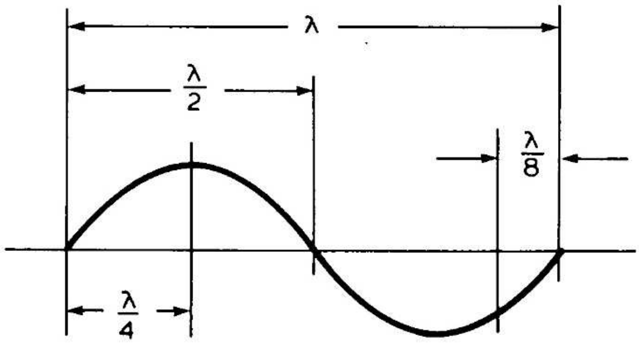

Fig. 1.2

You will see from this that the distance occupied in space by one cycle has now been called wavelength since wavelength is, in fact, equivalent to one complete cycle, as shown on Fig. 1.2. In radio antenna applications we often work in sub multiples of wavelength such as l/2 and l/4, where you will have noticed that the term wavelength is signified by the Greek letter lambda (l). Frequency is denoted by the lower case f while wavelength is given in metres (m) or sub-multiples thereof. Using the above formula, therefore, we find that our v.h.f. f.m. signal at 96MHz has a wavelength of 300/96, which works out to 3.125m. The l/2 is thus close to 1.56m and the l/4 close to 0.78m. It is very important to remember that these apply to the radio signal in space. When a radio signal travels through an antenna conductor or along a feeder then its velocity is reduced from the space value by factor v which is known as the velocity factor, more about which anon. Anyway, knowing either l or f we can easily find the other for example, f (MHz) = 300 / l (m)

Radio Wavebands

Table 1.1 lists the various radio wavebands with their frequencies and wavelengths. For "entertainment" radio we are mostly interested in the f.m. v.h.f. part of the spectrum which so far extends from about 88 to 108 MHz (3.4 to 2.7m). If we have a tuner with a.m. bands then we might also be interested in the long waveband (L.W.) from about 150 to 285 kHz (2000 to 1185m) and the medium waveband (c.w.) from about 535 to 1600 kHz (560 to 187m). Some tuners, especially those destined for overseas markets, are also equipped with an h.f. (high frequency) band or bands, the full scope of h.f. extending from 3 to 30 MHz (100 to 10m), as shown in Table 1.1, and sometimes called the short waveband. The range of a radio signal is influenced both by its frequency or wavelength and the nature of the lower and upper atmospheres above the earth's surface; but before we delve into this let's get some clearance on modulation.

Modulation

The part of the radio signal, which carries the audio information, is, as we have seen, the electromagnetic carrier wave. The audio signal can be applied to this in various ways, but the two ways in which we are most interested are by varying the amplitude of the wave and by varying its frequency slightly either side of the mean carrier frequency. The first is called amplitude modulation (a.m.) and the second frequency modulation (f.m.).

Amplitude modulation is used on the signal in the long, medium and short wavebands,

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though there are a.m. stations transmitting in the higher frequency bands. What happens is that after the carrier wave has been generated the audio information is super-imposed upon it in such a way that the amplitude of the wave is caused to alter in sympathy with the audio. Let's suppose that the audio is a pure tone represented by a sine wave, then the carrier plus the modulation gives rise to the nature of the signal shown in Fig. 1.3(a). When frequency modulated the amplitude of the carrier remains constant but this time the frequency of the carrier itself deviates slightly either side of its nominal value by an amount corresponding to the intensity of the sound being carried and at a rate corresponding to its frequency. The rate of deviation is thus greater for a modulating signal of 10 kHz than one of 1 kHz, while the extent of the deviation is greater for a loud signal than a soft one. The modulation index, as it is called, is equal to the frequency of deviation divided by the frequency of the modulation or:

Modulation index (M) = fd / fm

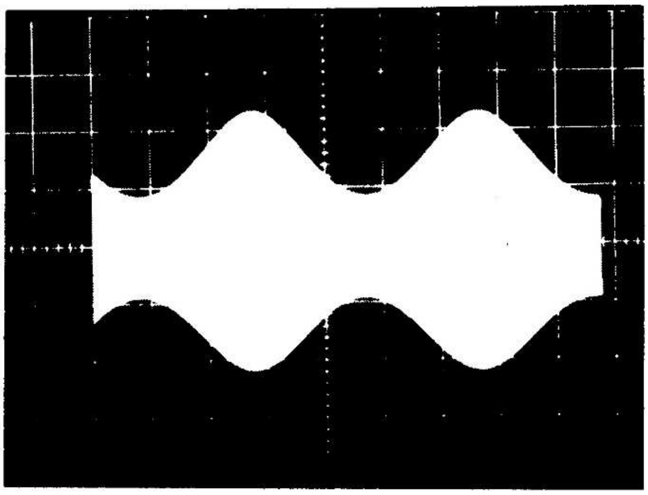
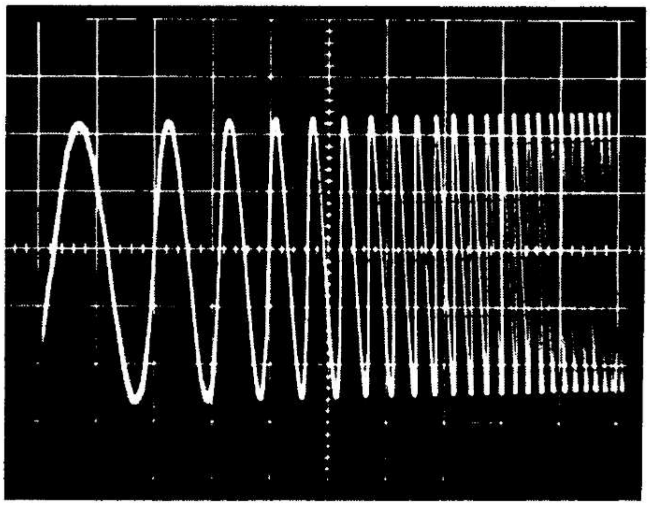


Fig. 1.3(a) ▲ ▼ Fig. 1.3(b)

The f.m. case is shown m Fig. 1.3(b) and it is the modulation index (M) which determines the sideband structure of the net signal in a somewhat complex mathematical manner. It is obviously outside the scope of this particular series of articles to delve deeply into the mathematics of modulation; but if we have a pure audio signal

Fig. 1.3(a) ▲ ▼ Fig. 1.3(b)



of say, 1 kHz amplitude modulating a carrier wave of frequency f then the net signal can be analysed to reveal the carrier at f and two sidebands, the lower at f - 1 kHz and the upper at f + 1 kHz. Sideband amplitude depends on the modulation depth, each being half the amplitude of the carrier when the modulation is 100 per cent (when the troughs of the top and bottom modulation envelopes meet) and non-distorting. The maximum modulation on Band II is fixed at +/-75 kHz deviation so that M would be around 5 assuming an upper frequency response at 15 kHz, though this can be modified by pre-emphasis the quality of the programme material and by the stereo sub-channel compo-

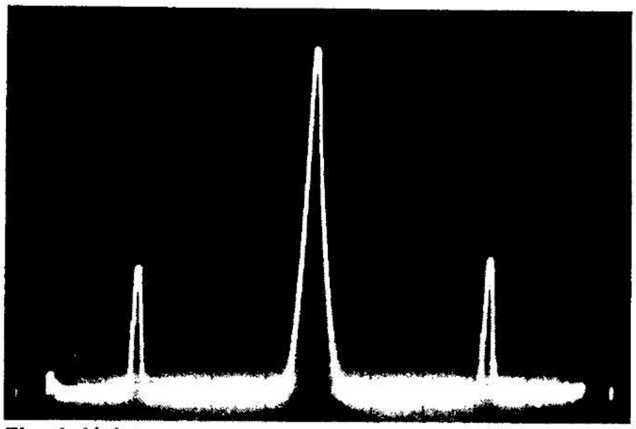


Fig. 1.4(a) ▲ ▼ Fig. 1.4(b)

nents. However, instead of the one pair of a.m. sidebands, our 1 kHz modulating frequency in

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the f.m. case produces multiple pairs of sidebands either side of f at +/- 1 kHz, f +/- 2 kHz, f +/- 3 kHz etc (all spaced from each other by 1 kHz, the modulating frequency). These spread quite a long way from f depending on the modulating signal itself (e.g. M), and their amplitudes are also influenced by M. Fig. 1.4(a) shows a pair of a.m. sidebands, while (b) shows a lab spectrogram of the multiple sidebands of an f.m. stereo signal. The bandwidth required by an a.m. signal is thus less than that required by an f.m. signal when both are modulated with the same audio. If we modulate to, say, 15 kHz on a.m. we can get away with a bandwidth of 2 x 15 kHz or 30 kHz, while on f. m. for the same modulating frequency we require a band width of 200 kHz or more at +/-75 kHz deviation, especially in stereo mode, and even then we may not be fully embracing all the upper-order pairs of sidebands, but fortunately we do not need to bother too much about the least significant side band pairs as they do not contribute much to the audio quality, anyway.

f.m. and only 9 kHz a.m. so now you can also understand why it is impossible to achieve hi-fi results on the l.w. and m.w. / a.m. system since 9 kHz bandwidth implies an upper frequency audio response around 4.5 kHz, which is hardly hi-fi! Frequency modulation also has other at tributes, including enhanced signal/noise ratio and hence dynamic range, capture effect where the tuner is "captured" by the stronger of two signals on or near the same frequency when the wanted one is only slightly stronger than the unwanted one (on a.m. this would cause an annoying whistle) and, of course, the prevailing capability of stereo reproduction though this is also possible on a.m.

It is useful to see where the "radio" bands reside in the overall electromagnetic wave spectrum and for this I have included the simplified diagram in Fig. 1.5. As a radio wave approaches the wavelength of light so it behaves more and more like light. That is, it is reflected, refracted, diffracted and has a tendency to cause shadows behind large objects not visible

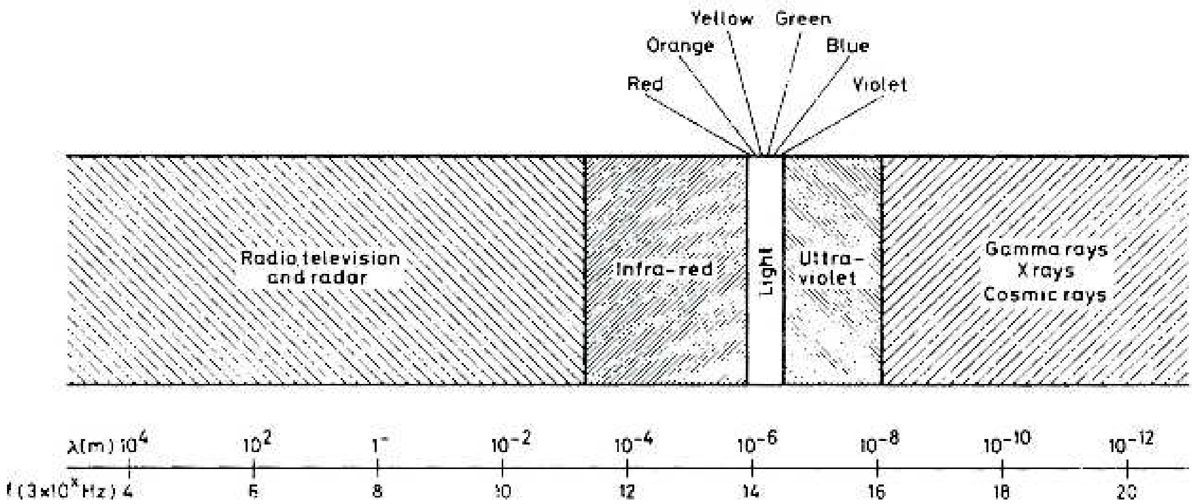

Fig. 1.5

You can appreciate now that it would be impossible to fit a viable number of f.m. stations into the l.w. and m.w. bands, which is the reason why v.h.f. is used for f.m. where there is much more elbow room. Channel spacing is 200 kHz

ones, of course, but radio shadows as they are called where radio reception is cut off. To some extent these characteristics are demonstrated at v.h.f. which we use for f.m., they are demon-

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strated more dramatically at u.h.f. the frequencies we use for TV, and even more so at s.h.f. and e.h.f. (standing for ultra high frequency, super high frequency and extremely high frequency).

Propagation

This, then, neatly brings us to the topic of propagation. This again is highly mathematical and somewhat abstract so I do hope the more knowledgeable readers will forgive my venture into simplification. A radio signal emanates from a transmitting antenna as an expanding sphere of electromagnetic energy, though the design of the antenna may be such to concentrate the energy more in one direction than others round the compass, perhaps to elevate it skywards or to concentrate it in a "beam" more or less horizontal to the ground.

Just how the signal is propagated depends on its frequency and hence wavelength, the conductivity of the terrain or water over which the signal is passing, the release of electrons by ionisation of the gases of the earth's outer atmosphere due to ultra-violet (u.v.) radiation from the sun and hence the conditions prevailing on the sun, time of day, time of year, and the earth's local atmosphere (troposphere) as dictated by the weather conditions.

Our planet is protected (fortunately!) by a gaseous atmosphere extending to a height of about 1000 km above its surface which has the highly desirable effect of filtering out excessive u.v. radiation. Sadly, so it is being inferred, we earth inhabitants are tending to destroy this filtration - by different kinds of pollution with the effect of a rise in u.v. emission at the surface of the earth, a change in the weather pattern and so I would forecast, a probable change in radio wave propagation which I can't help feeling I am beginning to detect already.

The ionosphere

The u.v. emission from the sun alters over an 11-year cycle which is denoted by the so-called sun-spot number (though is now seems that the cycle is longer than this). When the sun-spot number is at its peak the u.v. emission strengthens the ionisation, the electron density and hence the degree by which the ionosphere, as it is called, returns radio signals back to earth. Sunspot cycles have been recorded for many years and the average number works out to about 120.

Ionisation is negligible in the earth's lower atmosphere but reaches a value sufficient to affect radio waves at a height approaching 100 km. The ionisation is brought about by the solar radiation u.v. radiation and X-ray radiation stripping the electrons from the atoms of the rarefied gases. A relatively high value of ionisation is maintained up to about 300 to 500 km, the electron density then tapering off with increasing height. Rather than being held in a thick band, the ionisation separates into defined regions, called layers, at different heights. Each layer has a changing electron density whose most dense region is known as the peak of the layer. This maxima or peak may not be at the centre of the layer and neither does the ionisation vanish completely between the so-called layers.

The degree of the ionisation is almost wholly governed by the intensity of the u.v. radiation from the sun, and different wavelengths of radiation ionise different gases. The u.v. radiation is progressively absorbed owing to energy lost in the production of the ionisation as the radiation passes down through the atmosphere so by the time it reaches the earth's surface it is almost completely filtered out. Recombination of the ions and free electrons is relatively slow at the higher reaches of the atmosphere owing to the scarcity of gas molecules, but closer to the earth's surface gas molecules are more abundant so here recombination happens quickly the atoms soon being returned to neutrality.

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The layers are conventionally labelled D, E and F with increasing height. and during daylight hours the F region divides into two layers the lower called Fl and the higher F2. The D layer, whose height is around 50 km, is only present during daylight hours and this applies also essentially to the E layer, whose height falls around 100 to 150 km, though less active E layer ionisation is also detected at night at m.f.; but in essence, because of fairly speedy recombination, the E layer can only hold a high level of ionisation when in sunlight, its effect on radio propagation tailing off quite significantly when the sun sets on the layer which, at 100 km, is about 30 minutes after local sunset.

Intermittent ionisation also occurs in thin layers of about 2 km or less embedded in the E region. It is of an irregular and patchy makeup and can spread over a range to about 2000 km. Its level of ionisation is greater than that of the normal E layer and it has the characteristic of being opaque to the lower h.f. waves while partially reflecting the upper h.f. waves and sometimes v.h.f. waves as well. Because of its intermittent nature it is called sporadic E (Es or sp-E). Although it can support night-time h.f. signals it is mostly active during the daylight hours of summer. The F layer is the highest of all the layers and extends from around 150 km to 800 km or more. It is present both during daylight and night-time hours but, as already noted, splits into two distinct layers during the daylight hours. The Fl layer has a nominal peak around 200 km and holds fairly steady at this height summer and winter.

The Troposphere

The earth's lower atmosphere or troposphere as it is called also has an influence on the propagation of radio waves, especially at frequencies at upper h.f., v.h.f. and above. The temperature of the troposphere decreases with height at the rate of 6 degrees C/km down to about -55C. This is because the air near the earth is not heated by the sun but by convection currents from the heated earth. The drop in temperature results from the adiabatic expansion of the air as it moves into decreasing pressure with increasing height.

The troposphere where our weather conditions develop extends to a ceiling of about 10 km. Owing to the variation of temperature, pressure and moisture content with height upper h.f., v.h.f. and radio waves of higher frequency are refracted over a greater distance than explained by the geometric horizon distance between the transmitting and receiving aerials, which is equivalent to assuming that the earth's radius is increased by a factor k. The ionosphere itself becomes progressively more transparent to waves of these frequencies, which means that they pass through the layers into the outer space beyond so that propagation then becomes essentially tropospheric. Maximum possible distance (dm) for direct ray transmission can be expressed as:

dm = 3.565k (sqr(ht) + sqr(hr))

where dm is in km, ht and hr, the heights of the transmitting and receiving antennas respectively in m and k the factor expressing the apparent increase in the earth's radius. For a homogeneous atmosphere k is around 1.33, but it can increase above this value under certain weather conditions thereby propagating the direct-ray signal further. For example, when the barometric pressure starts to fall after a spell of steady anticyclonic pressure the k factor can rise dramatically and bring in relatively long-distance signals.

Irregularities

Moreover, the temperature, pressure and moisture content can vary from point to point and with time thereby producing irregularities in the refractive index, which, especially when elevated, can scatter signals over large distances.

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Another distance enhancing factor is a sudden discontinuity or, indeed, inversion in the normal temperature gradient. It is known that tropospheric stratification is more frequent than previously thought, and these sheets or layers of large vertical gradient can affect the propagation of signals quite substantially.

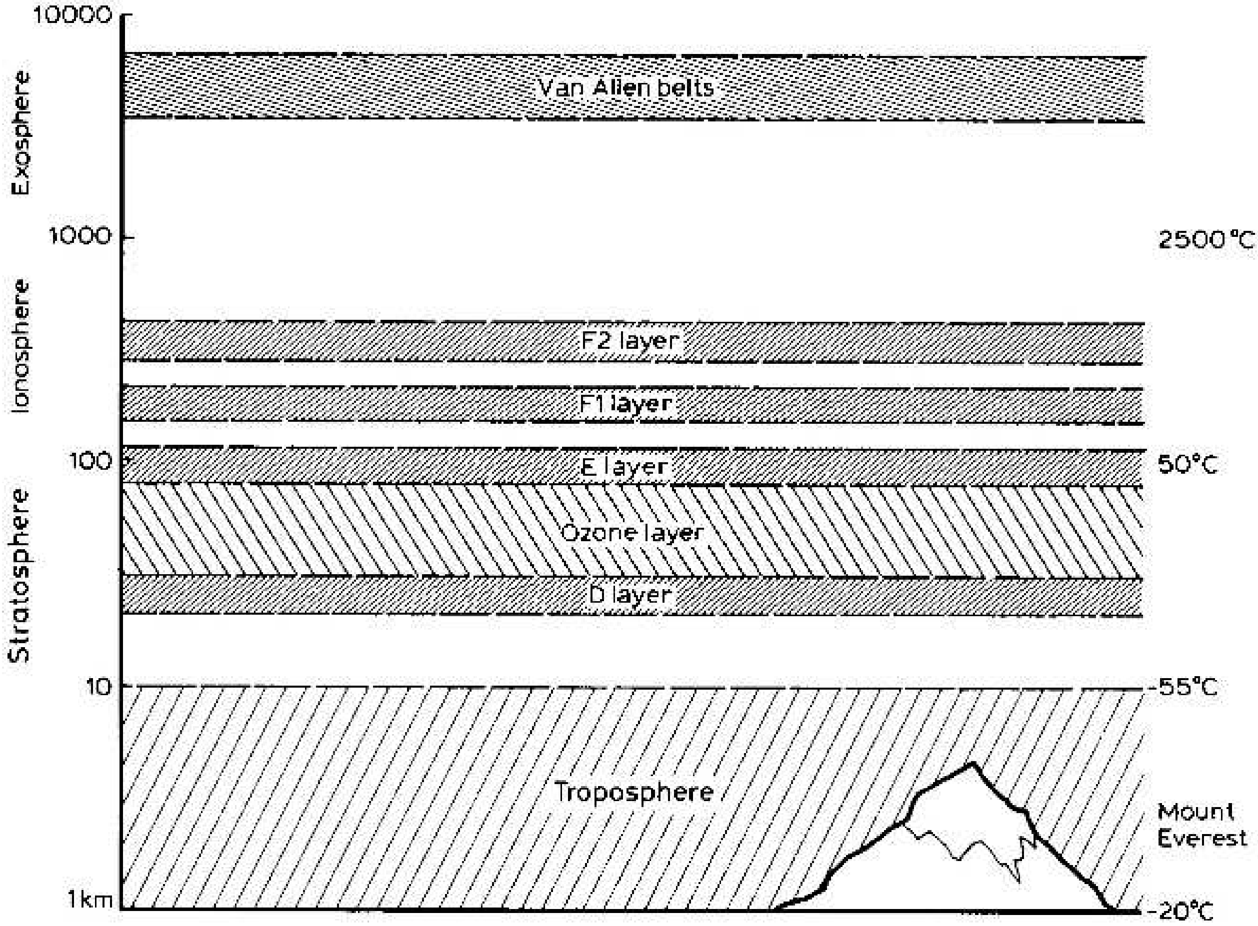

Fig. 1.6

other mechanisms involved. Some time ago G6DH noted the enhancement of signals as low as 3.5 MHz arriving along a sea path during weather conditions producing tropospheric ducting at v.h.f. while more recently *Radio Science* carried a convincing paper supporting super refraction ducting over sea paths from 20

Ducting

Tropospheric variations of these kinds normally influence v.h.f., u.h.f. and higher frequency waves more than the lower frequency ones; but propagation tests at 27 MHz have indicated that waves in this frequency range can also be distance-enhanced by tropospheric propagation (in addition to ionospheric propagation!). Strong refraction over water and ducting of the waves through the troposphere are MHz upwards. I have depicted in Fig. 1.6 the space immediately above the earth's surface, showing the troposphere and the ionised layers, which I have so far discussed.

Taken from: Practical Wireless August 1984
[This is part one of a series. Does anyone have the rest? Please let me know. I will be happy to scan it for you and return it. JB]

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Email: **zs6wr@gmail.com.**
Web page: www.jbcs.co.za/ham_radio

Bulletins (Sundays at …)
11h15 Start of call in of stations
11h30 Main bulletin start

Frequencies
439.000MHz 7.6MHz split
Input: 431.4MHz (West Rand Repeater)
145,625 MHz (West Rand Repeater)
10,135 MHz (HF Relay)

Radio Amateurs do it with more frequency!

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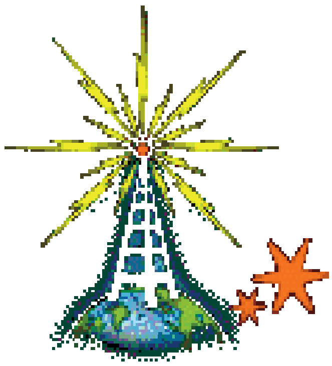
West Rand members - we need your input!

To make this the best ham radio magazine in South Africa we need your input. Please submit articles, comments, suggestions etc.

Please send plain text with no formatting to the email address below.

In July 2003, we re-published an Anode Compendium on CD. It has the issues from July 2000 until June 2005. This included the new Adobe reader. It has been updated, check with the chairman for details.



We need your input! Email us articles, comments and suggestions please. zs6wr@gmail.com