NEAR EAST UNIVERSITY

PROJECT OF ELECTRONICS
EE : 321

RADIO RECEIVER

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FREQUENCY MODULATION

Frequency modulation (FM) is a technique for coding a signal on a carrier wave and is a rival technique to amplitude modulation (AM). Both systems are used extensively in radio broadcasting, but in Television FM is used exclusively.

In AM, the signal modifies the amplitude of a constant frequency carrier wave(in a sound wave) amplitude is loudness and frequency is pitch) . The signal is transmitted in this modulated form and to recover the original signal at the receiver it must be amplitude demodulated (Demodulation is the reverse operation to modulation). In FM the carrier wave is of constant amplitude and the signal is coded in the preference fluctuations about a central (carrier) frequency. Again, to recover the original signal it must be demodulated- this time by frequency demodulation.

RADIO

Radiation of Electrical Energy

When a capacitor is changed, the energy represented by the change is stored in the electric medium of the capacitor; It is possible to utilize part of this energy for the purpose of radio communication. If a radio aerial or antenna (which, with the earth, forms a capacitor) is electrically charged, the stored energy will exist not only near the antenna but also out at a great distance. If an alternating voltage of high frequency is now applied between the antenna and the ground, this capacitor will be rapidly charge and discharged. If the frequency of reversal is sufficiently high, a second storage of energy in the field takes place before all the first energy stored at a great distance will have time to return to the antenna. Thus the antenna sends out successive energy impulses only a portion of which return to the system on each successive reversal; the unreturned energy impulses become electromagnetic waves the velocity of which is approximately that of light ($3X10^8$m per second in space or air) until intercepted or absorbed.

The wavelength λ is the distance, usually expressed in meters (or cm with microwaves), between successive wave crests. The frequency f of the radio wave propagation is the number of wave cycles per second and may be obtained from the equation.

$\lambda f = 3X10^8$m per second

PARTIAL TABLE OF FREQUENCY ALLOCATIONS

FREQUENCY (Mc)	UTILIZATION
0.535-1.605	Commercial broadcasting band
27.255	Citizens' personal radio
54-72	Television channels 2-4
76-88	Television channels 5-6
88-108	frequency-modulation broadcasting
174-216	Television channels 7-13
460-470	Citizens personal radio
470-890	Television channels 14-83

FREQUENCY BANDS

designation	FREQUENCY	Wavelength
VLF, very low frequency	3-30kc	100-10 Km.
Lf,Low frequency	30-300kc	10-1Km
MF, medium frequency	300-3000kc	1000-100 m
HF, high frequency	3-30mc	100-10 m
VHF, very high frequency	30-300mc	10-1 m
UHF, ultra high frequency	300-3,000mc	100-10 cm
SHF, super-high frequency	3,000-30,000	10-1 cm
EHF, extremely high frequency	30,000-300,000	10-1mm

For example, if the wavelength is 300m, the frequency $f=(3X10^{8})/(300X10^{3})=$ 1000 kilocycles(kc).(See tables 2 and 3 for allocations.)Continuos carrier waves used in broadcasting are produced by tube oscillators which ordinarily have an oscillating circuit, composed of inductance and capacitance in parallel, connects in the plate circuit. The oscillator is an example of a method which can be used for producing carrier waves.

MODULATION

The frequency of the carrier wave is far beyond the limits of audibility and is also far too high to operate such conversion devices as telephones or loud-speakers. In order to transmit and receive speech and music, the carrier wave must be modulated by the audiofrequency (a-f) waves produced by the voice and by music. There are at least three methods by which this may be accomplished: amplitude modulation (a-m), frequency modulation (f-m), and phase modulation (p-m).

In amplitude modulation, the amplitude of the carrier wave is varied in accordance with the amplitude of the a-f wave. The envelope of the carrier wave thus becomes the a-f wave. There are several methods of modulating the carrier wave by amplitude modulation.

A common methods is to introduce into the plate circuit of a tube, oscillating at the carrier frequency, and additional emf of audio frequency, the peak value of which is somewhat less than the steady plate voltage E^{b}. Figure2 shows a simple plate - modulation circuit. The carrier-frequency-tuned tank circuit L_pC_p and grid circuit are similar to those of oscillators. The secondary S of an a-f transformer b is introduced into the plate circuit. The primary current of this transformer comes from the microphone circuit consisting of a battery B and a microphone T. The capacitor C′ bypasses the carrier-frequency current around the secondary S of the a-f transformer b. Ordinarily there is not sufficient power in the microphone circuits, so that an amplifier is inserted between the microphone and the transformer b.

Frequency modulation is also being widely used. the amplitude of the carrier wave remains constant, but its frequency is varied in accordance with the frequency of the a-f or modulating, wave.

The amount by which the frequency varies from the average, often called the frequency deviation is proportional to the amplitude of the modulating frequency. For example if the frequency of the carrier wave is 500,000 cps, it could be modulated by a 500 cycle a-f wave by having its instantaneous frequency varied between 499,990 and 500,010 cps. With a 1,000 cycle a-f wave the same changes in modulation such as a, a would accrue 1,000 times per sec.

One method of frequency modulation is shown in figure....
At the left hand side is the usual oscillator L_p and C_p being the inductor and capacitor of the tuned tank circuit. A resistor R and a capacitor C are connected in series across the plate circuit of the modulator, the resistance of R being very high as compared with the reactance of C. Hence the emf e_g across the grid of the modulator tube is essentially 90 deg. out of pace with the plate voltage E_p. Thus the current in the modulator tube which is controlled by e_g will be 90 deg. out of phase with E_p.and will therefor behave like a reactor. This reactor tube is in parallel with the tank circuit accordingly the frequency of the tank circuit will be determind in part by the apparent reactance of the modulator tube. The current in the modulator tube and therefore the apparent reactance of the tube will change in accordance with the emf e_g of the audio signal impressed on its grid. The varying reactance of the modulator tube changes the frequency of the oscillatory tank circuit L_p and C_p in accordance with the frequency of the audio signal

Frequency modulation is advantageous in that the quality is improved and disturbances due to static are in a large measure eliminated.

DEMODULATION

It has already been pointed out that the ordinary sound-producing devices can not respond to the h-f modulated wave . And the frequency is far too high to be audible to the human ear. It is, therefor necessary to demodulate such waves in order that the receiving devices may be actuated by a-f currents similar to those used for modulation. This is called detection.

AMPLITUDE DEMODULATION

Amplitude modulation can be accomplished with any type of rectifying tube. however , if the tube operates near the lower part of 1-E curve, the sensitive is low. This is overcome in part by connecting a positive polarizing voltage $E_p$in series with the tube, . If an alternating emf wave e is impressed on the tube it is not perfectly rectified but produces an a-c wave i_p. Owing to the curvature of the characteristic, the current wave $i_{p.}$ is dissymetrical, the positive wave being larger than the negative wave. The average current is increased from I_p to I_p' and the existence of an audio emf is detected. The capacitor C shunts the h-f components of the rectified portions of the wave trains.around the telephones or loud speaker T.

The most common method of demodulating f-m waves is the use of a discriminator. The method is shown in figure 2 in the circuit diagram in (a), P and S are two coupled coils each tuned by capacitors C_1 and C_3 , respectively, so as to be resonant at the normal or unmodulated intermediate frequency. C_2, a blocking capacitor which has negligible impedance at radio frequencies is connected from the upper end of P to the center tap of S. T is a double-diode rectifier tube. Two single diodes can also be used. The two capacitors C_4 and C_5 are equal and their capacitance's are such that for radio frequencies, the two cathodes for the diode are essentially at ground potential. Also, C_2 and C are blocking capacitors which have negligible reactance at radio frequencies. Hence, for radio frequencies the primary

P and the r-f choke L are in parallel. Also the voltage a1 above ground Ea1 is the passor sum of E and E1 and the voltage of a2 above ground Ea2 is the passor sum of E and E2. That is, Ea. = E+E1;Ea2=E+E2. These relations are shown in Figure 35 (b,c,d).

Assume first that a current of normal radio frequency flows in P. The emfs E1 and E2 induced in S by this current with lag it by 90 deg.. Since the secondary circuit is tuned to this normal frequency the secondary circuit acts like a resistance and the secondary current I2 is either in phase or 180 deg out of phase with the secondary voltages E1 and E2 . Ea1 and Ea2 are found by the phaser addition of E and E1, and E and E2. Since by the method of connection these emfs are in opposition the net emf acting through the anode-cathode circuits of the double-diode T is zero, and the emf E2′ is zero, and no current goes to the phones or a loudspeaker connected across terminals AB.

If the frequency varies from the normal, the P and S circuits are no longer resonant and the current I2 in the secondary S either out of phase or departs from the 180 deg relation with the voltages E1 and E2. If the frequency increases, the current lags and the passor diagram will have the form shown in (c). Ea1 and Ea2 are no longer equal and the resultant rectified voltage develops across AB. Similarly, if the frequency decreases, the current leads and the passor diagram is shown in (d). Again Ea1 and Ea2 are unequal and rectified voltage, opposite that for the higher frequency develops across AB. Hence an a-f voltage which is proportional to the change of the frequency of a wide range develops across AB. This actuates the phones or loudspeaker which may be connects across AB , although an a-f amplifier is usually interposed.

Phase modulation and demodulation are not as yet used for general broadcasting. They are accomplished in much the same manner as frequency modulation except that in addition a special network is necessary.

Broadcasting

In modern broadcasting systems, a portion of the energy of the modulated r-f currents at the broadcast

ng station is convected by the antenna into electromagnetic waves which radiate out into space. These modulated waves are received by an antenna or a loop, are usually amplified, and then demodulated and converted into a-f waves by methods such as have just been described. The a-f waves usually are amplified before actuating the loudspeaker.

Superheterodyne reception.

In most modern receivers, Superheterodyne reception is used. The method is based on the principle that a h-f current of frequency a may be converted to a lower frequency by superposing on it. The second current of frequency a'. The frequency of the two, after passing through a detector tube, will result in an envelope frequency equal to a-a'. This envelope frequency is called the beat frequency and, in receivers, the intermediate frequency (i-f or I-F). The intermediate frequency is obtained by a local oscillator superposing its frequency on the incoming modulated signal. If the incoming modulated frequency is 1,000 kc and the superposing frequency is 1455 kc, the beat frequency is 1455-1000, or 455 kc . In tuning, the frequency of the local oscillator is adjusted to the incoming frequency so that *the beat or intermediate frequency* always remain the same. This simplifies the design of the amplifier and the circuits of the e-f stages since they can be adopted to fix frequencies and thus operate under optimum conditions.

RECEIVERS

Most receivers are designed to operate from an a-c supply of 110 to 120 volts, the usual domestic voltage. This a-c supply goes to the primary of a transformer in which one of the secondary wiring steps up the voltage for the plate supply (B voltage) , and low-voltage windings supply the heaters of the several tubes as well as the rectifier heaters. A full-wave rectifier and filter converts the a-c plate supply, which may be 300 volts or more to direct current. Frequently the electro magnet of the loudspeaker is used as the choke coil of the filter. The low hum resulting from the ripples in the 60 cycle rectified wave usually is not objectionable. The d-c plate supply of B voltage is arranged to supply all plate circuits. Screen grids are sometimes connected to a voltage devider connects across the d-c plate supply voltage such a devider may consist of a resistor and a capacitor in series , the grid being connected to the junction of the two.

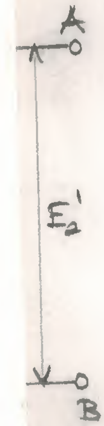
In the a-m system, the r-f energy of the signal from the antenna amplified by the r-f amplifier and is "mixed" with the frequency from the local oscillator to give the intermediate frequency. Two e-f amplifiers (first and second) amplify the energy of the signal and the diode detector converts the intermediate frequency into audio frequency. This is amplified by the combination of the phase inverter and push-pull amplifier, and the audio frequency then operates the loudspeaker.

The f-m system operates in much the same manner except that demodulation is accomplished by the discriminator. The limiter reduces the amplification when the volume exists a predetermined value. The rectifier and filter system for the

B voltage supplied and the amplification system for the loudspeaker are omitted.

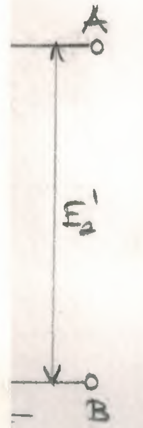
FM VERSUS AM

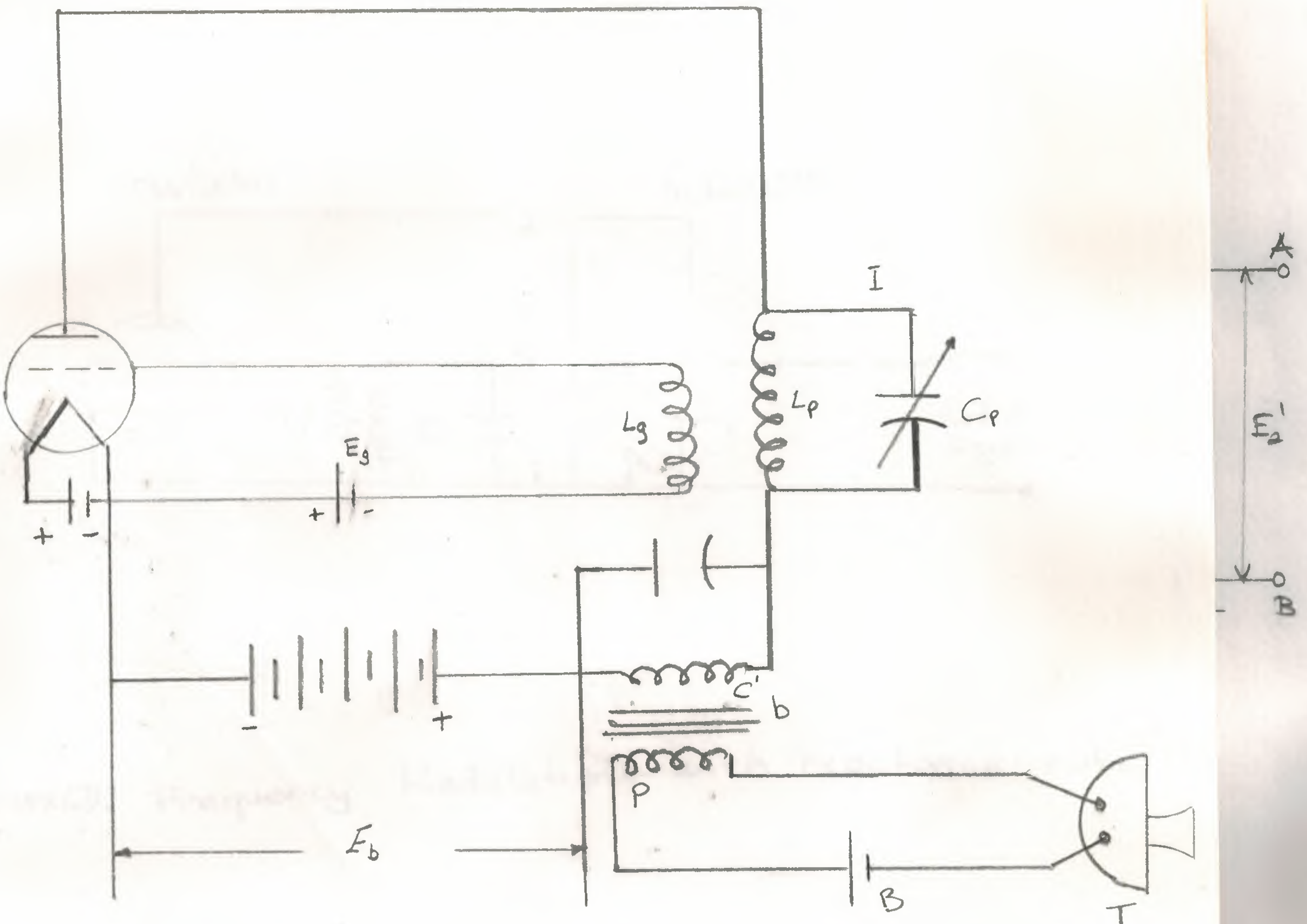
FM systems offer a far greater immunity to noise and general interference from other broadcasting channels than AM. This is however, only gained at the expense of a larger channel 'band width' , which is required if the signal is to be reconstruct faithfully at the receiver. Typically an FM channel for sound reproduction has a band-width of 200Khz., compared with 20khz. for AM. For television the band width is much higher.



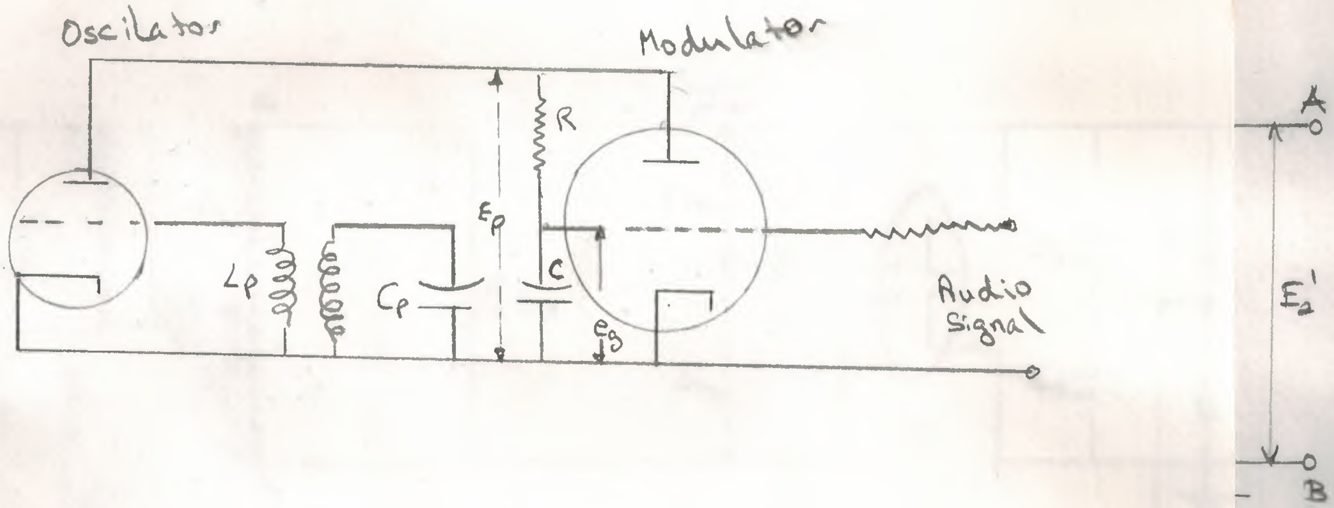
FM was first applied by E H Armstrong during the 1930 s. Its development was delayed by the necessary high frequency carrier wave required (as FM requires a channel band-width of 200 Khz, it can only be used extensively with carrier frequencies above 1 Mhz.). FM is mainly used in the VHF and UHF frequency bands, that is above 10 Mhz. By the 1930s AM had become so well entrenched in Britain that it took another 20 years before FM gained commercial acceptance.

APPENDIX

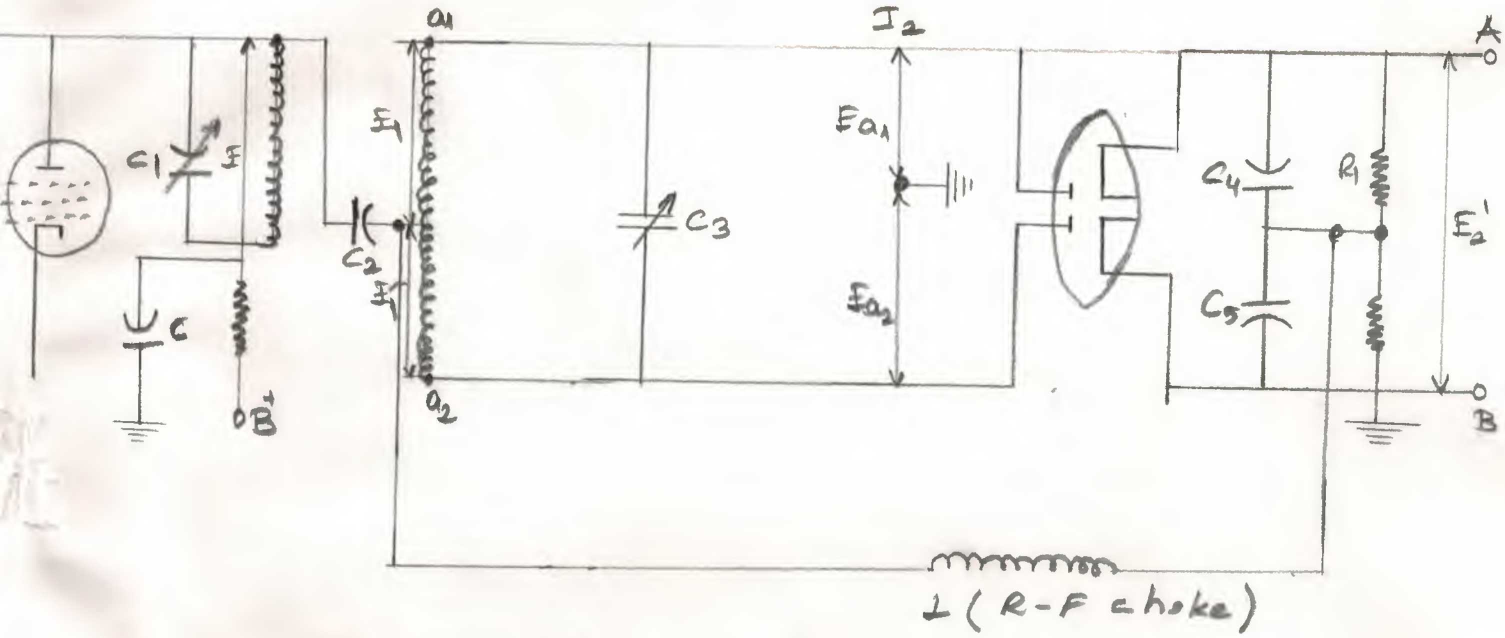




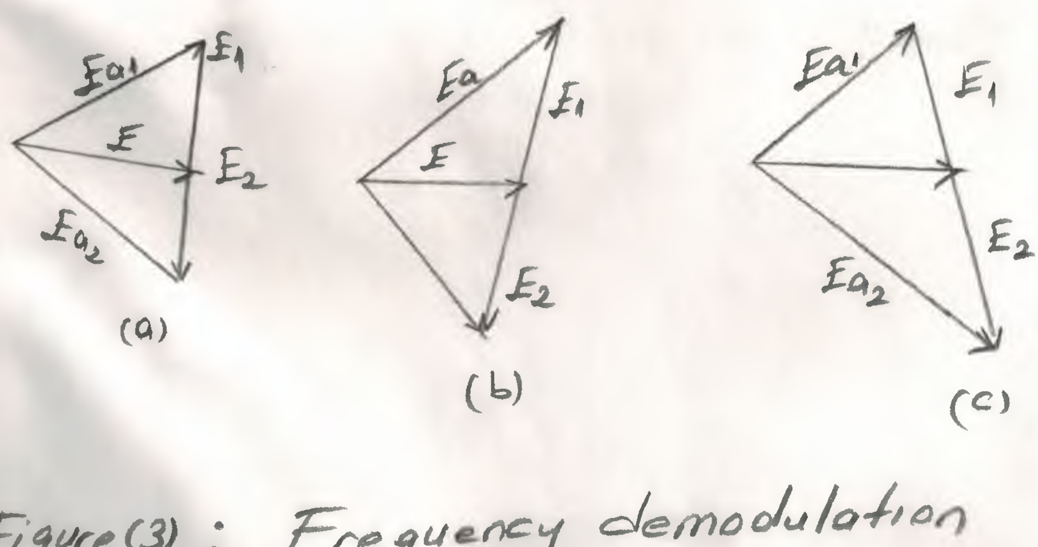
Figure(1): Plate Modulation



Figure(2): Frequency Modulation with reactance tube



F-M demoodulation Circuit



Figure(3) : Frequency demodulation