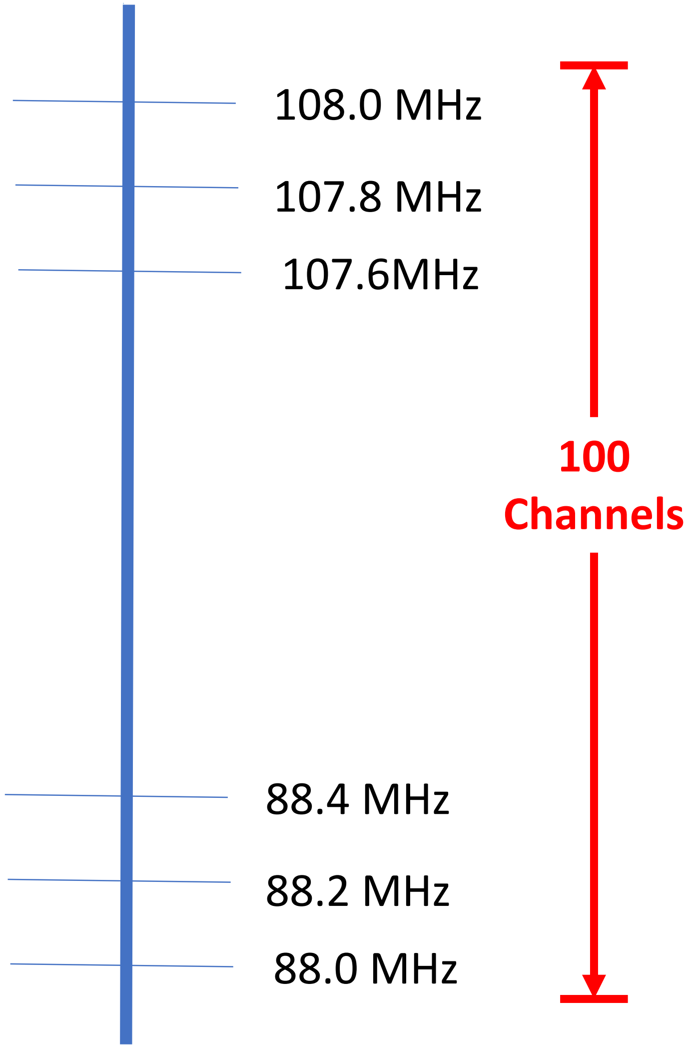
FREQUENCY MODULATION

ECE 328

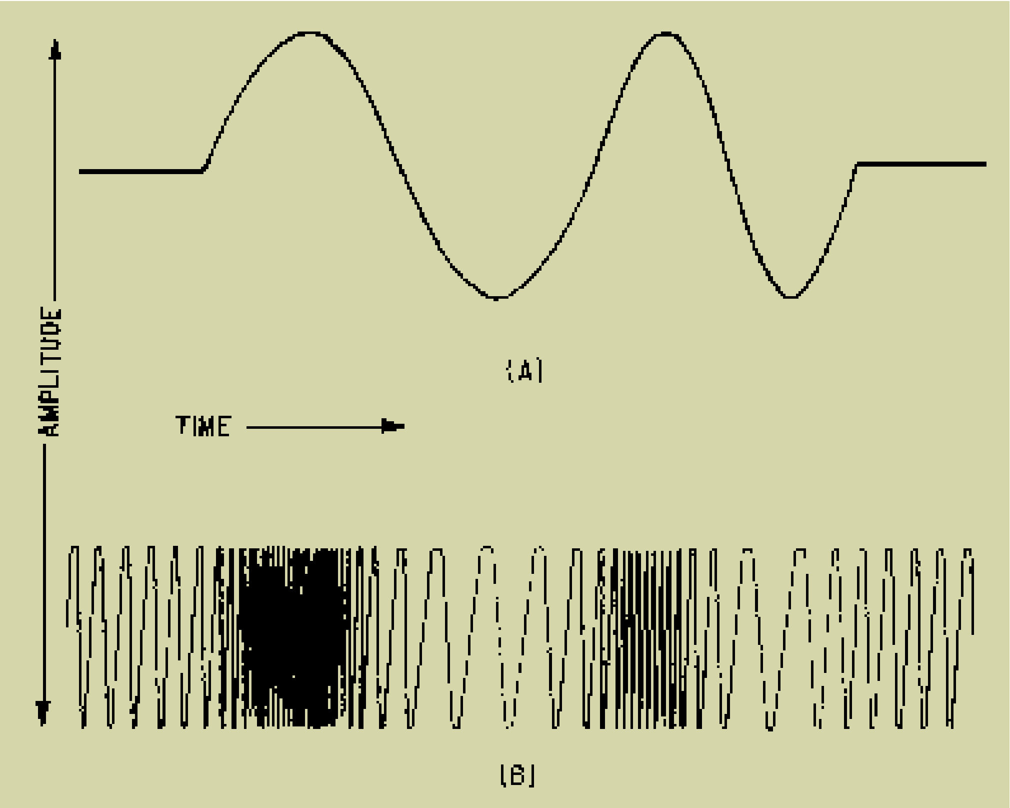
Friday, 09 June 2017

HISTORY OF FREQUENCY MODULATION

1. **Edwin H. Armstrong**, known as one of the founding fathers of radio technology, invented the superheterodyne radio receiver in 1918 and frequency modulation (FM) in 1933.
2. FM radio was first deployed in **monaural form in 1940**.
3. **FM stereo was introduced in 1960**.
4. **These two concepts**, along with his regenerative circuit technique developed in 1912, formed the basis of radio frequency electronics as we know it today.
5. In Kenya (ITU region 1) FM radio stations broadcast between radio frequencies of 87.5 MHz to 108 MHz with a channel bandwidth of 200 kHz.



BASIC RULES OF FREQUENCY MODULATION



1. Amount Of Frequency Shift is Proportional to the Amplitude of the Modulating Signal

(This Rule Simply Means That If A 10-Volt Signal Causes A Frequency Shift Of 20 Kilohertz, Then A 20-Volt Signal Will Cause A Frequency Shift Of 40 Kilohertz.)

2. Rate of Frequency Shift Is Proportional To The Frequency of The Modulating Signal

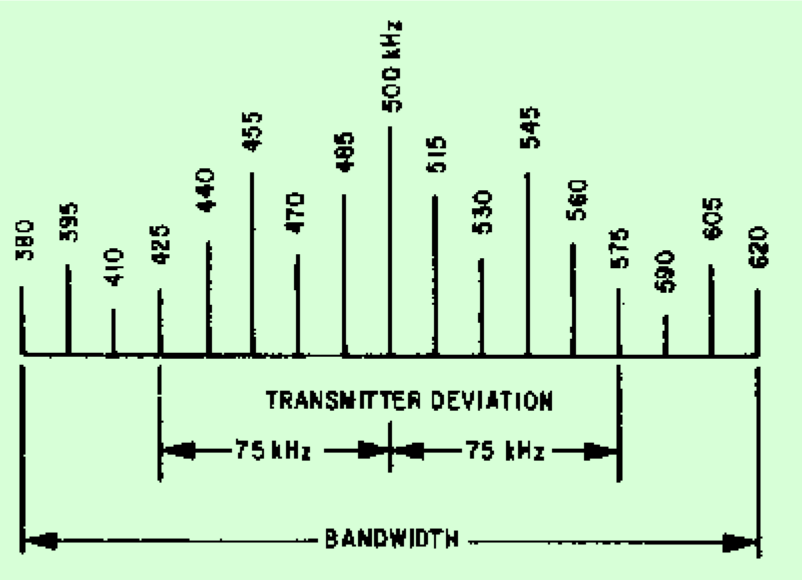
(This Rule Means That If The Carrier Is Modulated With A 1-Kilohertz Tone, Then The Carrier Is Changing Frequency 1,000 Times Each Second.)

FM MODULATION INDEX

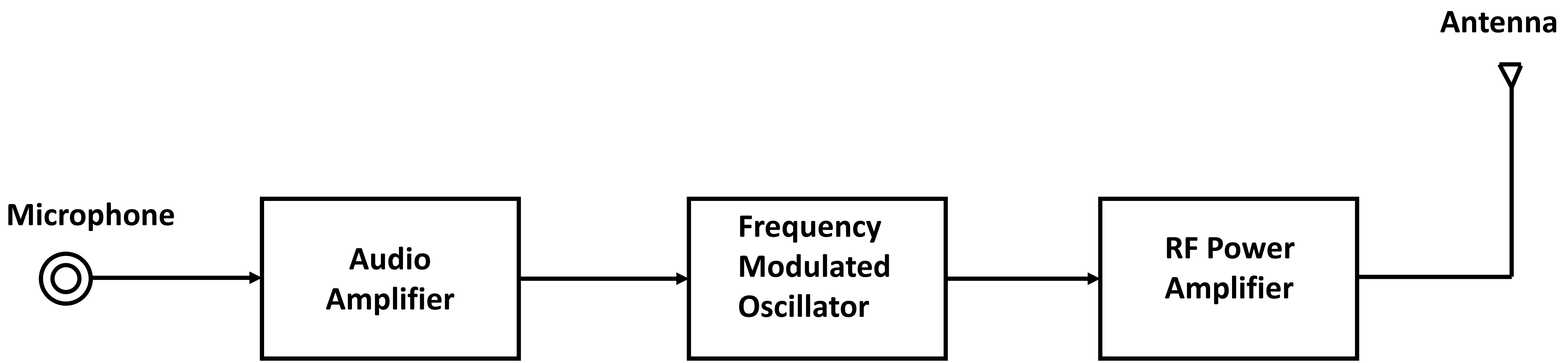
1. The modulation index is defined as:

$$\frac{\Delta f}{f_m}$$

3. The index determines the number and spacing of the side frequencies of the transmitted signal.



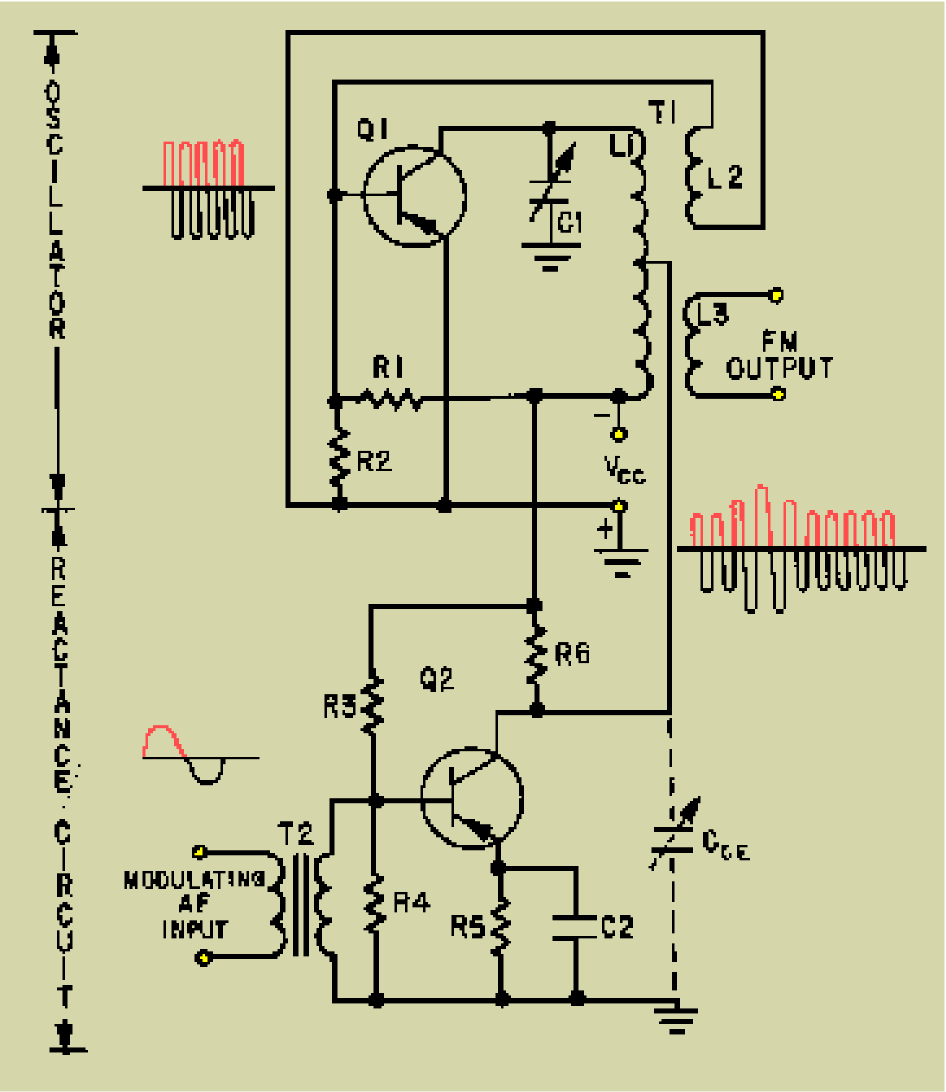
BLOCK DIAGRAM OF A FM TRANSMITTER



REACTANCE FM MODULATOR

1. The semiconductor-reactance modulator is used to frequency modulate low-power semiconductor transmitters.
2. Q1, along with its associated circuitry, is the oscillator.

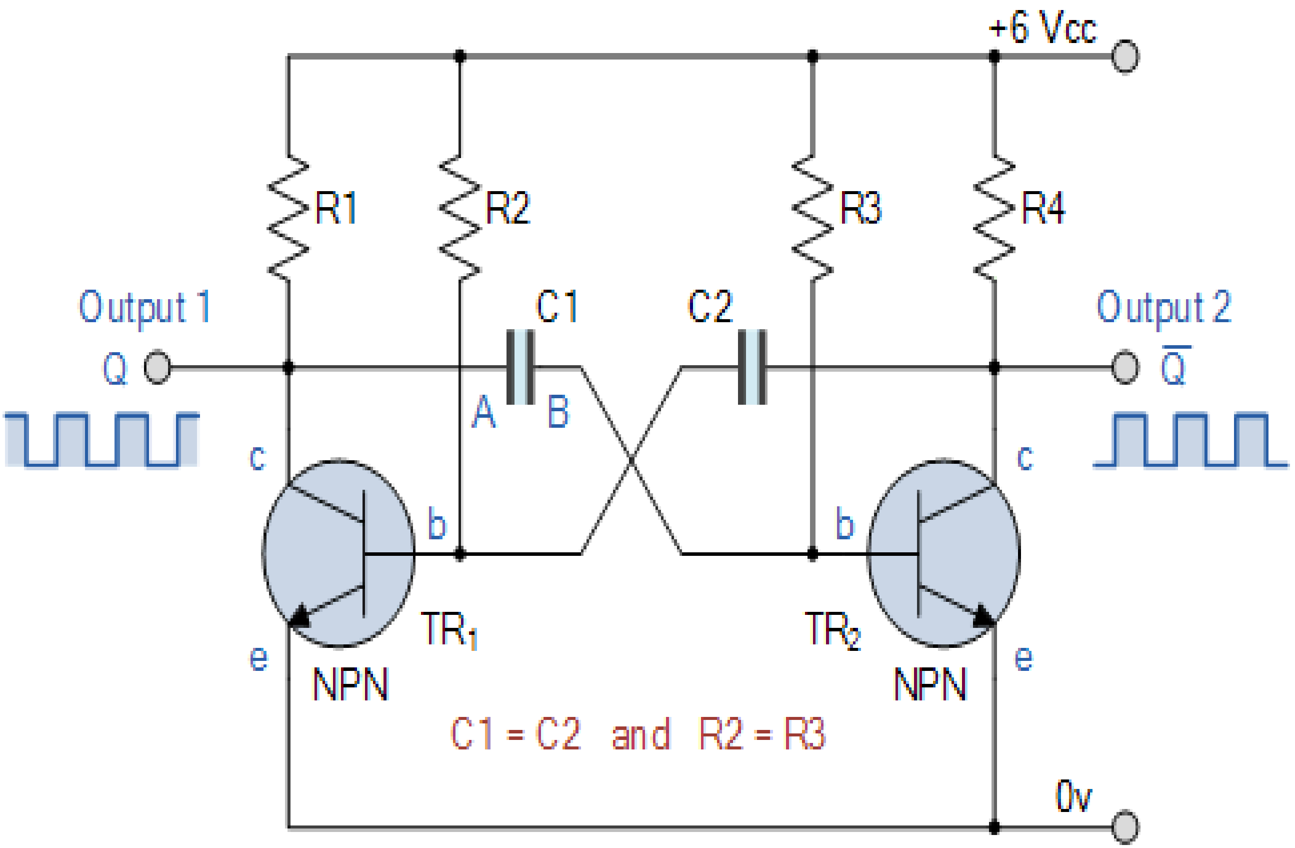
1. Q2 is the modulator and is connected to the circuit so that its collector-to-emitter capacitance (C_{CE}) is in parallel with a portion of the RF oscillator coil, L1.
2. As the modulator operates, the output capacitance of Q2 is varied.
3. Thus, the frequency of the oscillator is shifted in accordance with the modulating signal the same as if C1 were varied

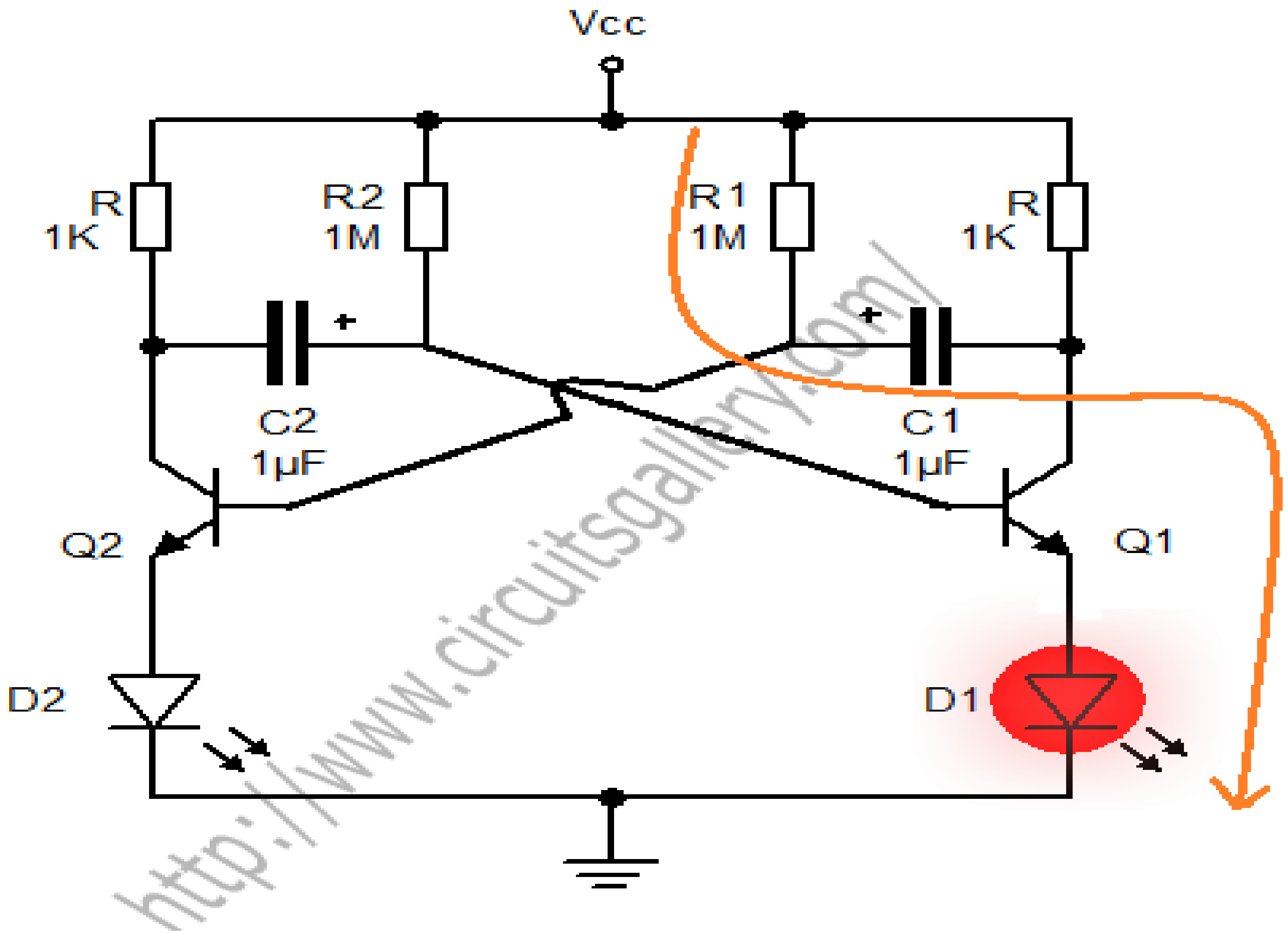


ASTABLE MULTIVIBRATOR

The basic transistor circuit for an **Astable Multivibrator** produces a square wave output from a pair of grounded emitter cross-coupled transistors.

The transistors either NPN or PNP, in the multivibrator are biased for linear operation and are operated as **<u>Common Emitter Amplifiers</u>** with 100% positive feedback.

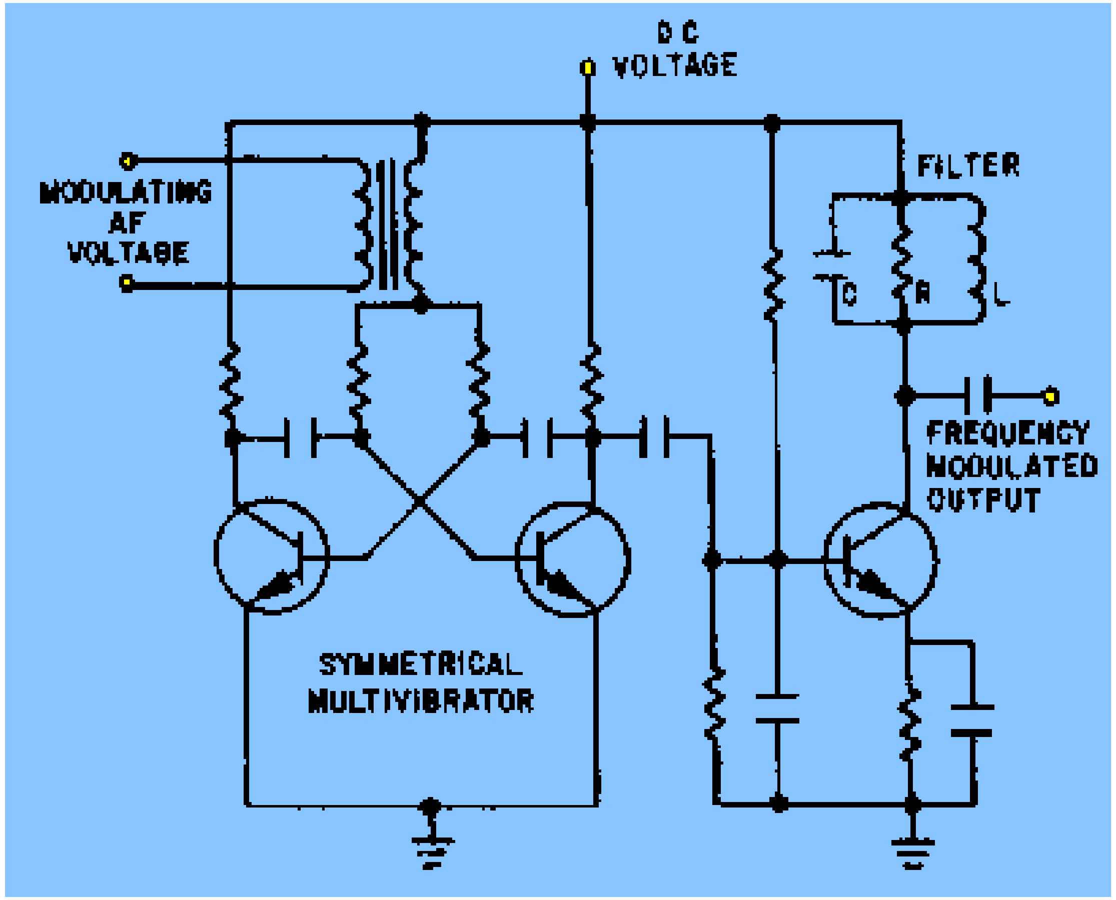




Vcc
R
1K
R2
1M
R1
1M
R
1K
C2
1μF
C1
1μF
Q2
Q1
D2
D1
http://www.circuitsgallery.com/

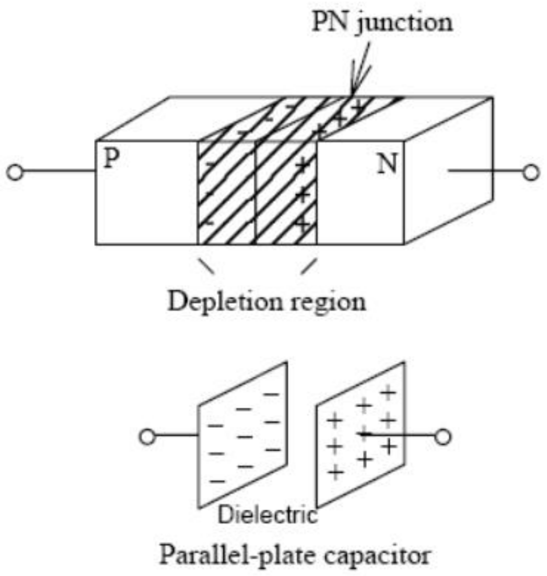
MULTIVIBRATOR FM MODULATOR

1. The Multivibrator FM Modulator is based on the astable multivibrator.
2. The modulating signal is connected in series with the base-return of the multivibrator transistors and causes the fundamental frequency of the multivibrator to vary.
3. The multivibrator output consists of the fundamental frequency and harmonics.
4. The desired fundamental frequency, or desired odd harmonics, can be amplified after all other odd harmonics are eliminated in the LCR filter section.
5. A single frequency-modulated carrier is then made available for further amplification and transmission.

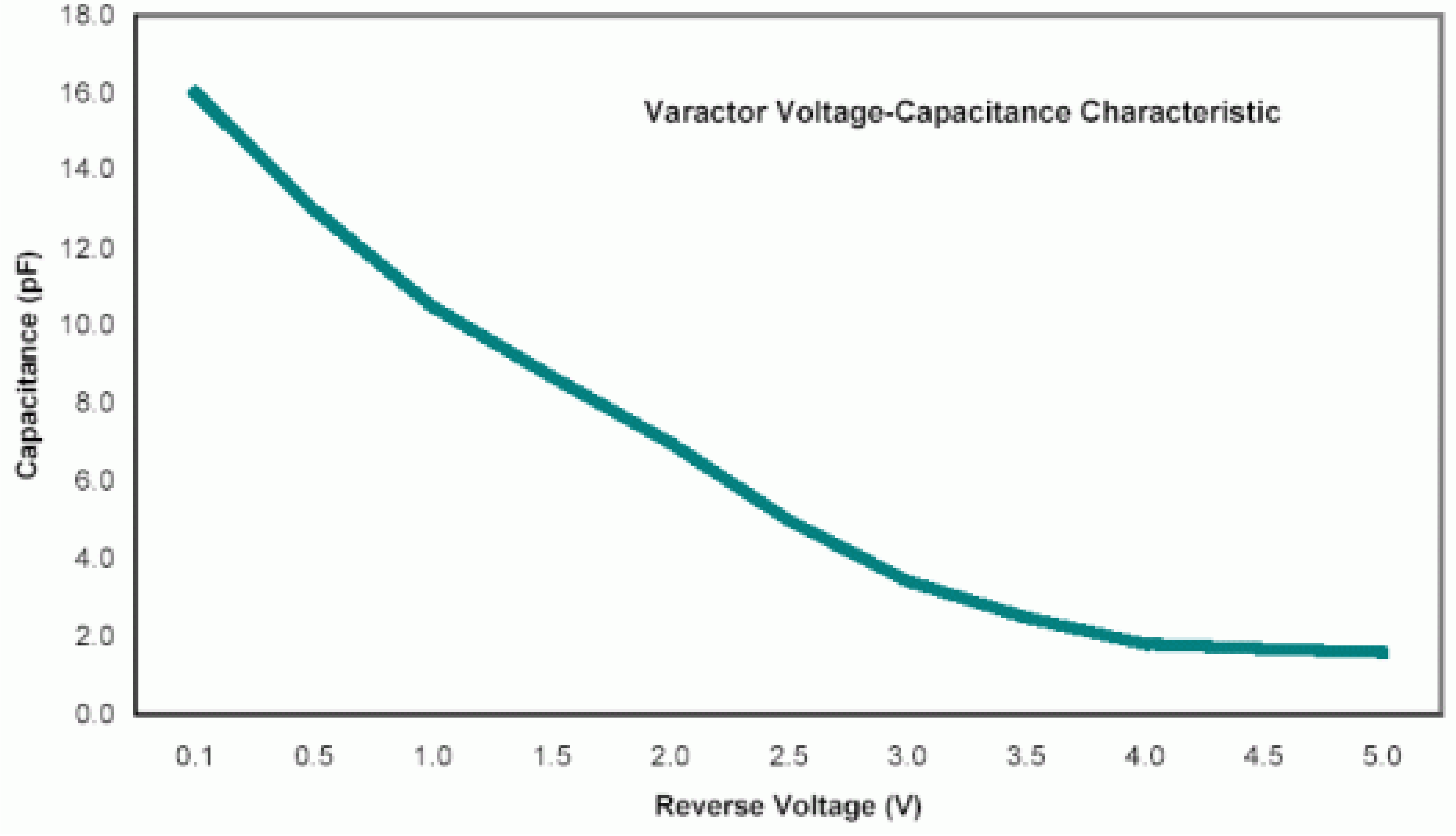


VARACTOR DIODE FM MODULATOR (1)

- A varactor diode , also known as varicap diode, is pn junction designed to have a certain amount of capacitance between junctions when reverse-biased.
- When reverse-biased, a small depletion region is formed because of the diffusion of minority carriers.
- The positive and negative charges occupy n and p sides of junction, respectively.

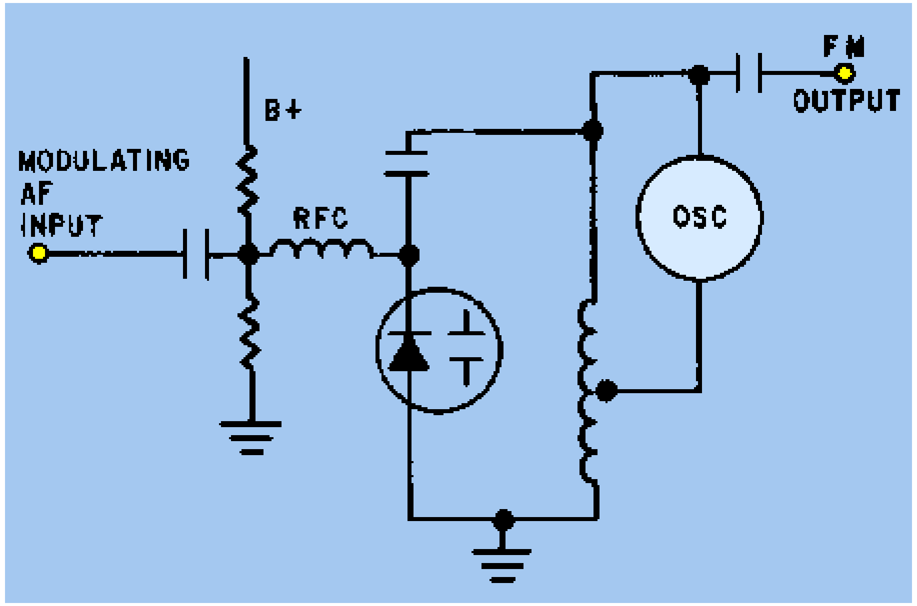


CHARACTERISTIC OF VARACTOR DIODE

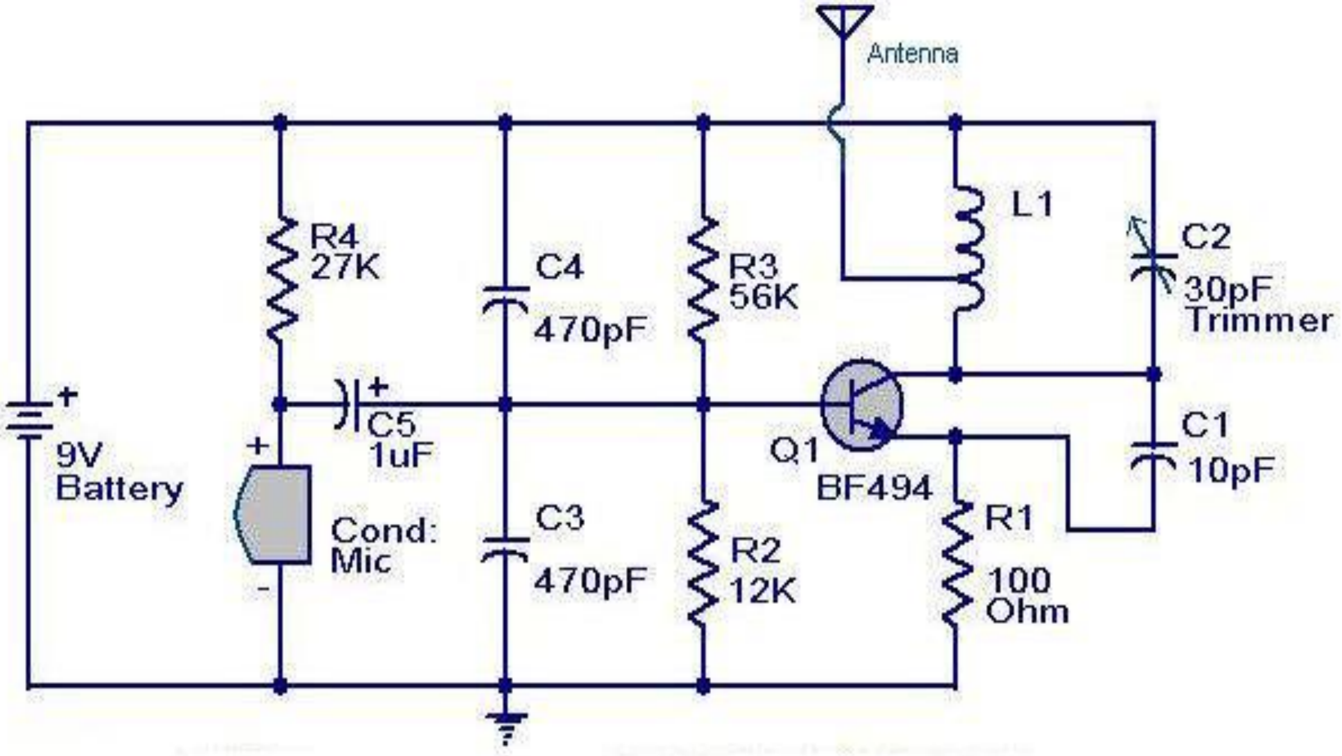


VARACTOR DIODE FM MODULATOR (2)

- The Modulating signal varies the capacitance of the varactor diode which is part of the LC circuit of an oscillator to provide an FM output.
- The output is then used to control the frequency of the oscillator



SIMPLE TRANSISTOR FM MODULATOR



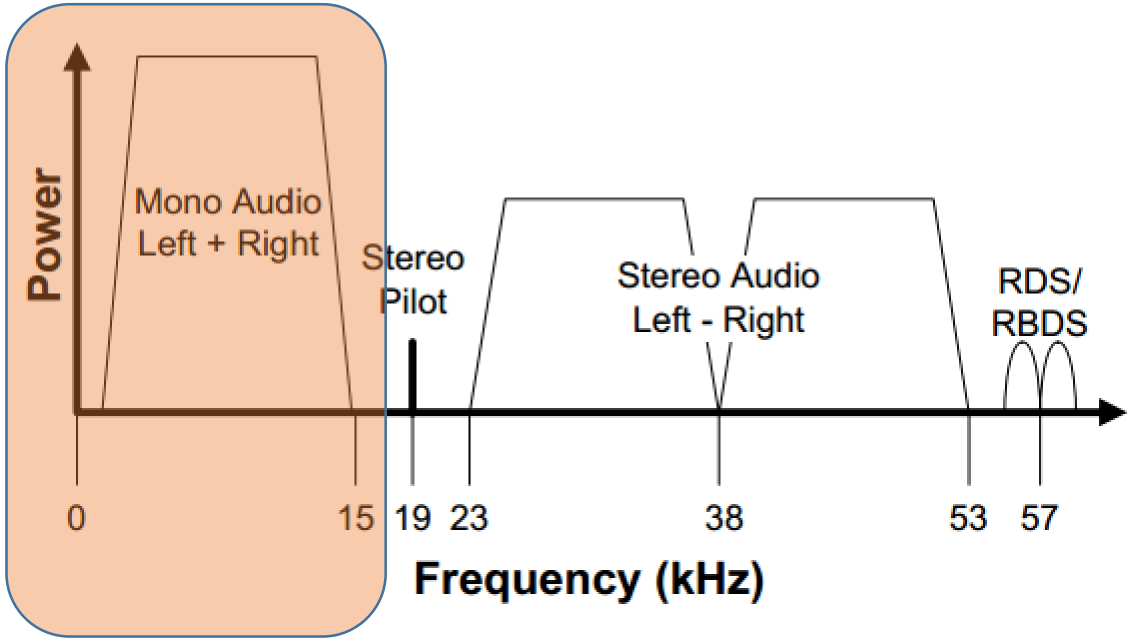
1. The condenser microphone serves as a transducer converting sound to electrical signal which is fed to the base of Q1.

2. Transistor Q1 performs the amplification as well as modulation.

3. The capacitor C2 and L1 determines the frequency of transmission.

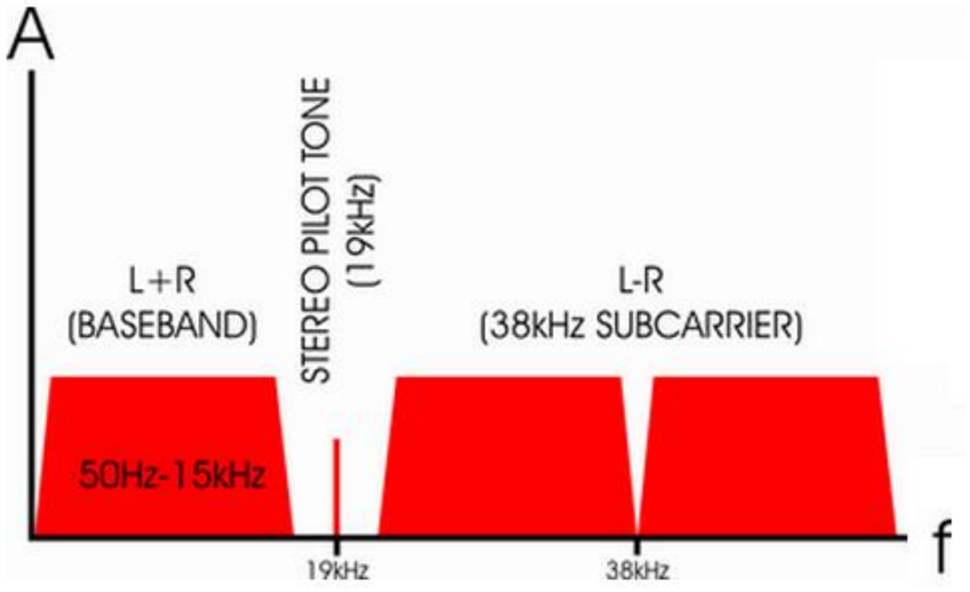
FM STEREO TRASMITTER (1)

- **Prior to 1961**, monaural broadcasting of audio signals was the standard for AM, FM and TV.
- **In 1961**, the Federal Communications Commission (FCC) approved the transmission of stereophonic sound, which extends the idea of multiplexing signals to generate stereo audio.
- One of the key requirements of the stereo multiplex signal was to be backwards compatible with the large existing base of FM monophonic receivers.
- To accomplish this goal, the 0 to 15 kHz baseband part of the multiplex (MPX) signal had to contain the left (L) and right (R) channel information (L+R) for monophonic reception.



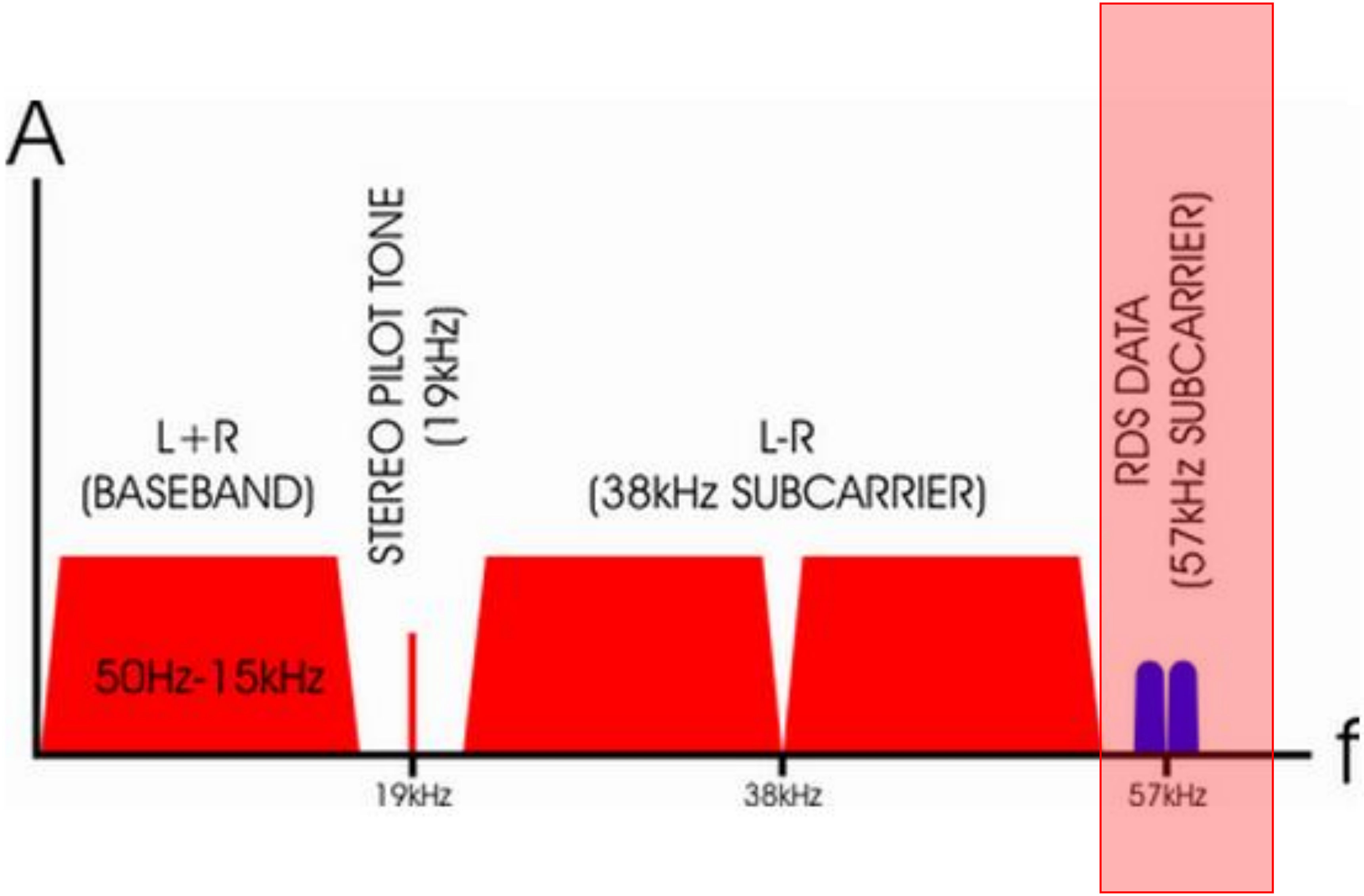
FM STEREO TRASMITTER (2)

1. Stereophonic sound is achieved by amplitude modulating the (L-R) information onto a suppressed 38 kHz subcarrier in the 23 to 53 kHz region of the baseband spectrum.
2. A 19 kHz pilot tone is added to the multiplex signal to enable FM stereo receivers to detect and decode the stereo left and right channels.
3. The composite baseband signal format meets the backwards compatibility needed for FM mono receivers while simultaneously providing enough information for FM stereo receivers to decode the left and right stereo channel outputs.



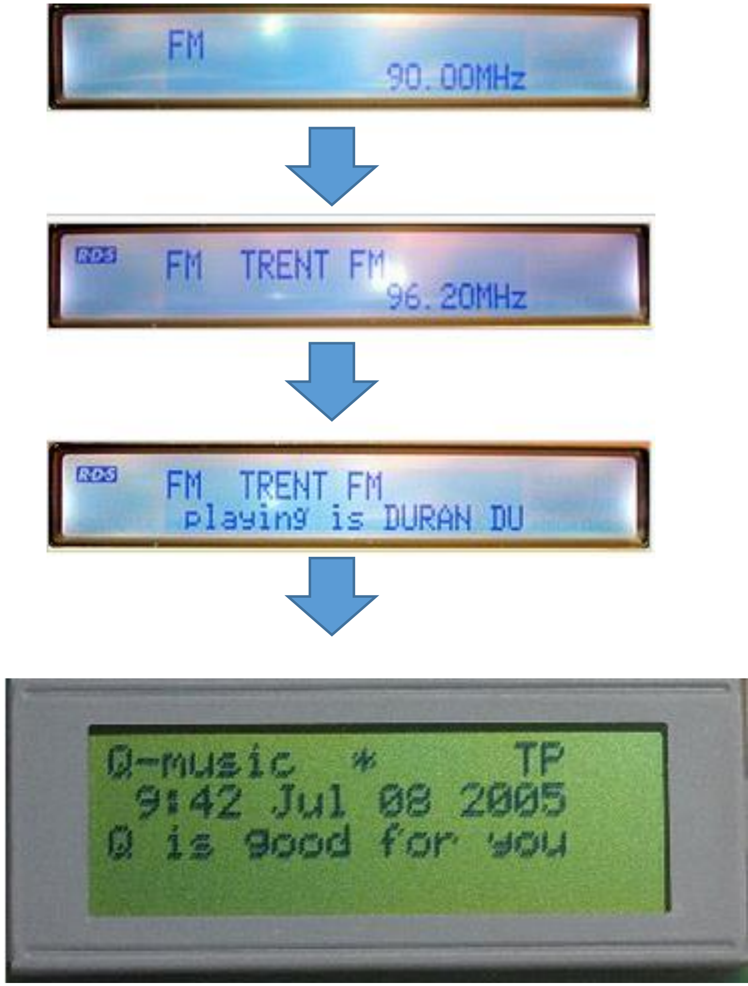
RADIO DATA SYSTEM (RDS)

1. Today's MPX signal includes a 57 kHz subcarrier that carries RDS (RBDS) signals.
2. **Radio Data System (RDS)** is a communications protocol standard for embedding small amounts of digital information in conventional FM radio broadcasts.
3. RDS standardizes several types of information transmitted, including time, station identification and programme information.
4. The standard began as a project of the European Broadcasting Union (EBU), but has since become an international standard of the International Electrotechnical Commission (IEC).
5. RDS carries data at 1,187.5 bits per second on a 57-kHz subcarrier, so there are exactly 48 cycles of subcarrier during every data bit.
6. The RBDS/RDS subcarrier was set to the third harmonic of the 19-kHz FM stereo pilot tone to minimize interference and intermodulation between the data signal, the stereo pilot and the 38-kHz DSB-SC stereo difference signal. (The stereo difference signal extends up to 38 kHz + 15 kHz = 53 kHz, leaving 4 kHz for the lower sideband of the RDS signal.)

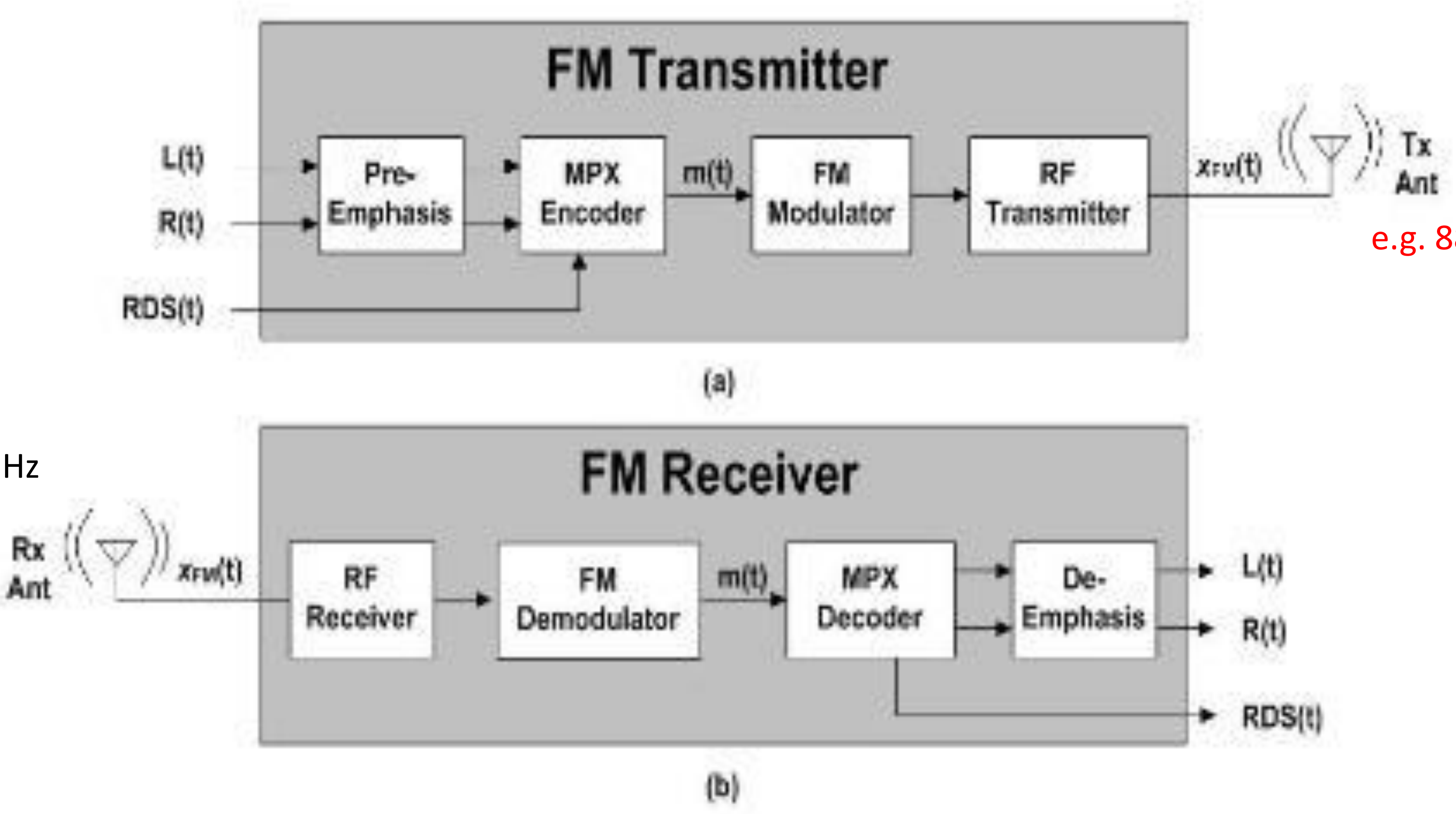

A
f
L+R
(BASEBAND)
50Hz-15kHz
STEREO PILOT TONE
(19kHz)
L-R
(38kHz SUBCARRIER)
RDS DATA
(57kHz SUBCARRIER)
19kHz
38kHz
57kHz

INFORMATION FIELDS IN RDS

AF (alternative frequencies)	**Allows a receiver to re-tune to a different frequency providing the same station when the first signal becomes too weak (e.g., when moving out of range).**
CT (clock time)	**Can synchronize a clock in the receiver or the main clock in a car. Due to transmission vagaries, CT can only be accurate to within 100 ms of UTC.**
EON (enhanced other networks)	**Allows the receiver to monitor other networks or stations for traffic programmes, and automatically temporarily tune into that station.**
PI (programme identification)	**This is the unique code that identifies the station. Every station has a specific code with a country prefix.**
PS (programme service)	**This is simply an eight-character static display that represents the call letters or station identity name.**
PTY (programme type)	**Codes up to 31 pre-defined programme types (e.g., in Europe: PTY1 News, PTY6 Drama, PTY11 Rock music) allows users to find similar programming by genre.**



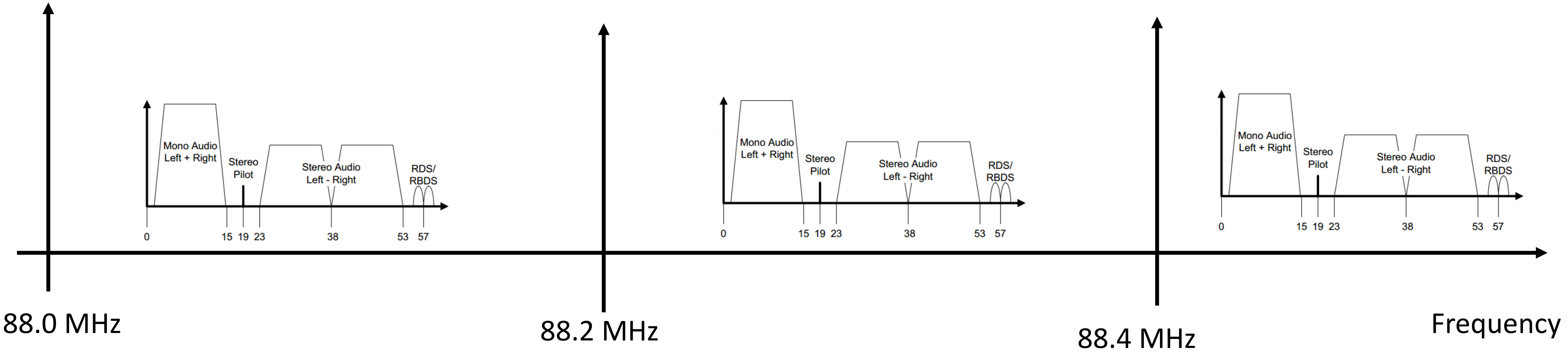
BLOCK DIAGRAM OF FM TRANSMITTER WITH RDS



e.g. 88.4 MHz

88.4 MHz

FREQUENCY PLANNING FOR FM TRANSMISSION



ONE CHIP FM TRANSMITTER

1. The MAX2606 is a compact, high-performance intermediate frequency VCO specially designed for wireless communication circuits.
2. It has on-chip varicap diode and feedback capacitances that avoid the need for external tuning components.
3. Only an external inductor is needed to set the oscillation frequency.
4. The nominal frequency is set to 100 Mhz by inductor L1, (390nH).
5. R1 can be used to select a channel of transmission between 88Mhz and 108Mhz