



Chelmsford Amateur Radio Society

Advanced Course

Transmitters

Part-2 - Mixers & Modulation



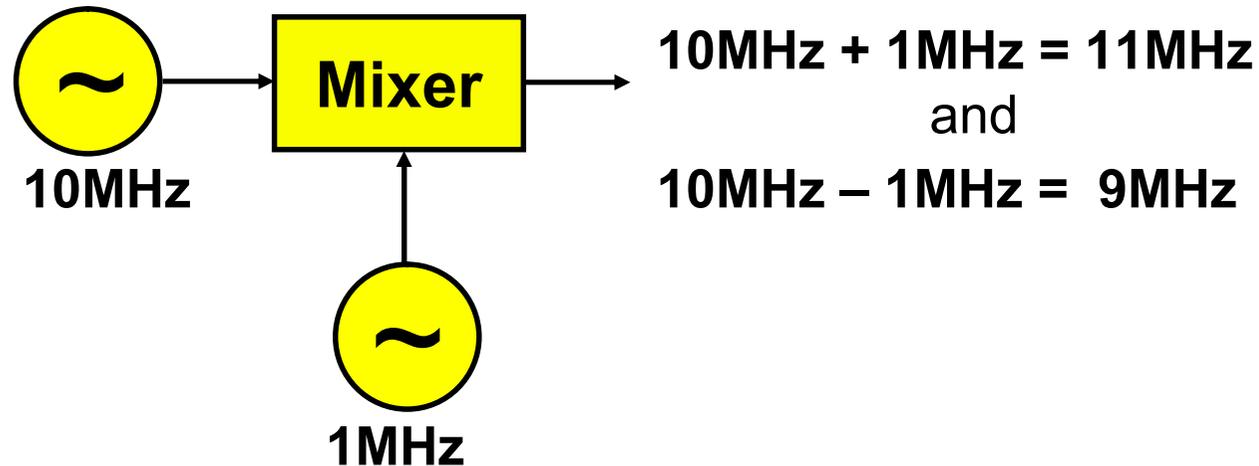
Mixers in Transmitters

- **Need to recall and expand Intermediate course on mixers and modulation in Transmitters.**
- **In general VFOs, Crystal Oscillators and Synthesisers do not directly generate the final RF Output frequency.**
- **Mixers are used to combine two or more frequency sources as part of the modulation and up-conversion scheme.**
- **Need to understand that spurious outputs can also occur, as well as deviation issues on FM.**



Mixers

- Two frequencies can be combined in a mixer circuit
- Result is the creation of sum and difference frequencies

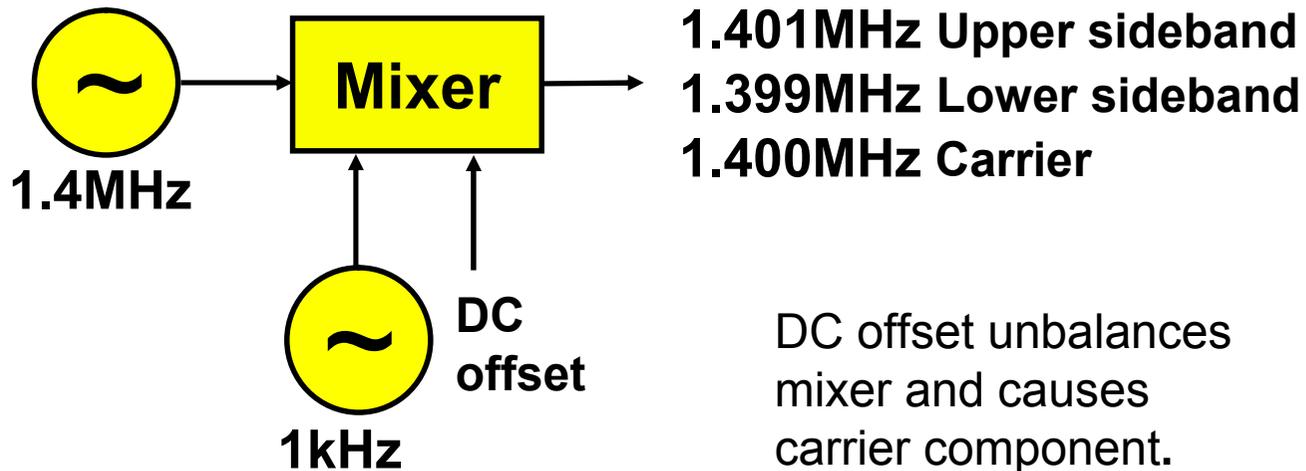


- **NOTE:** Overdriving a mixer, underdriving the LO port, or poor suppression of harmonics can result in other unwanted spurious mixer products. If PSU isolation is poor, mains hum sidebands can also be inadvertently added



Mixer as a Modulator

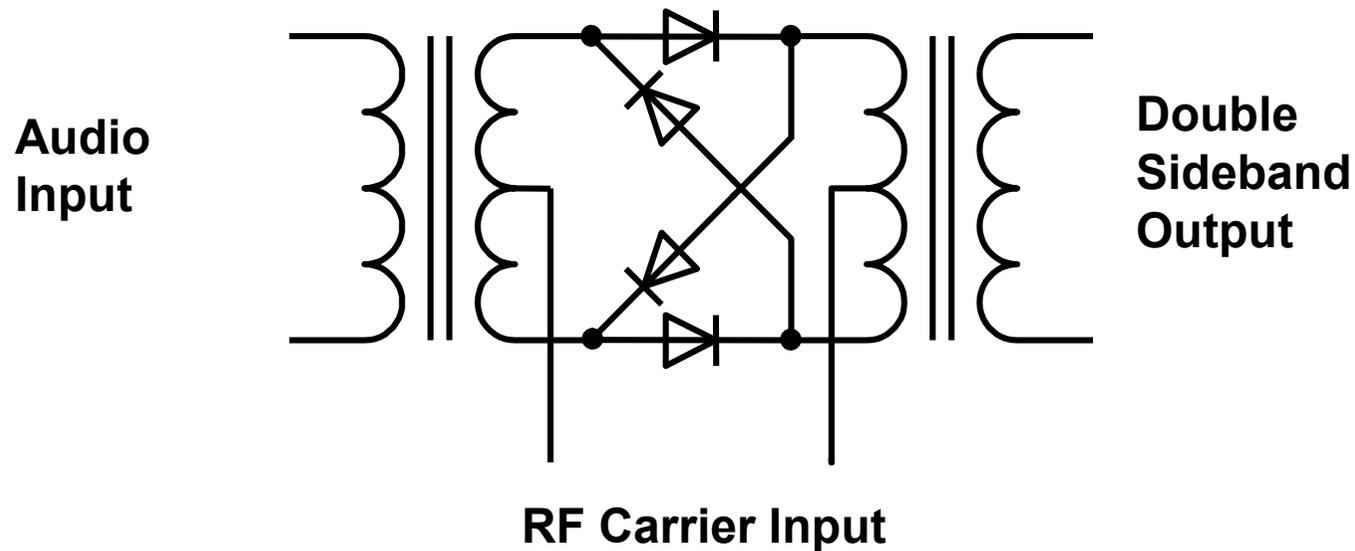
- **Mixer may be used as an AM modulator**
 - AM has carrier and two sidebands
 - Most power is in the carrier signal
- **Excessive audio causes over-modulation**





Balanced Mixers

- A **Balanced Mixer** is used to create **SSB** as it will nullify the carrier component to leave the two sidebands
- **RF** is applied to centre taps which results in null net carrier
- **AM** can be generated by deliberately unbalancing it

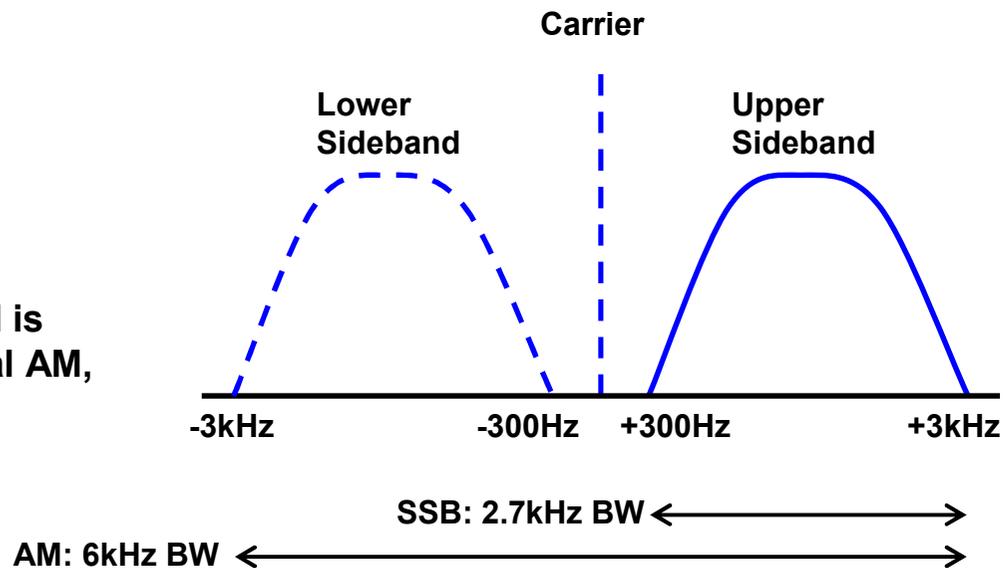




AM & SSB Bandwidth

- **SSB has a number of advantages**
 - No carrier, so power is not wasted
 - Half the bandwidth of AM
- **No RF power without modulating audio**
 - Smaller PSU
 - Less heat

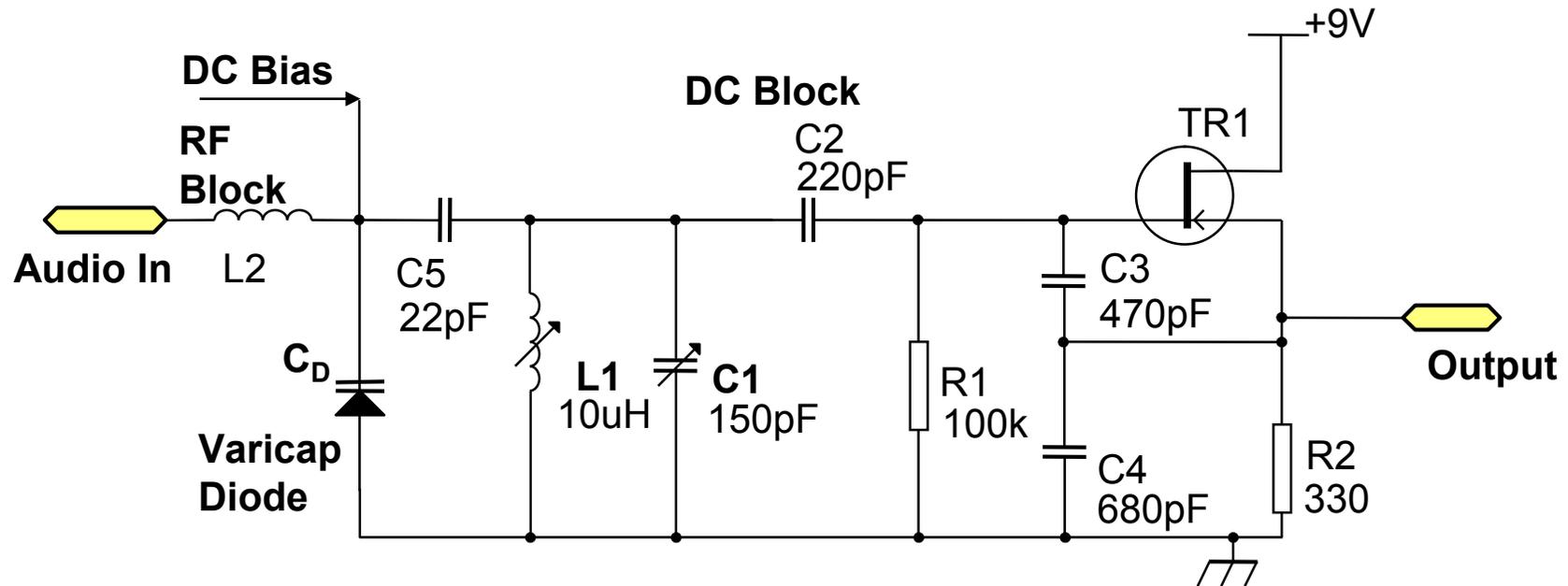
Carrier and Unwanted Sideband is suppressed compared to normal AM, reducing bandwidth





FM Modulator

- Colpitts Oscillator with Frequency Modulation by Varicap Diode
- L1 and C1 set nominal frequency, which is varied by C_D
- FM Bandwidth is more complex as sidebands extend wider than AM





Transmitter Up Conversion

- **SSB generation and other modulation is performed at low or intermediate frequencies to ease design, filtering etc**
- **This must be up-converted to final RF frequency by another mixer**
- **Example:**
 - SSB for 2m band may be generated at a 6MHz IF
 - It is then added to a 138MHz RF LO to produce a 144MHz output
- **Note that using a multiplier (especially for SSB) would destroy the frequency and bandwidth relationships**



Modulation Terms

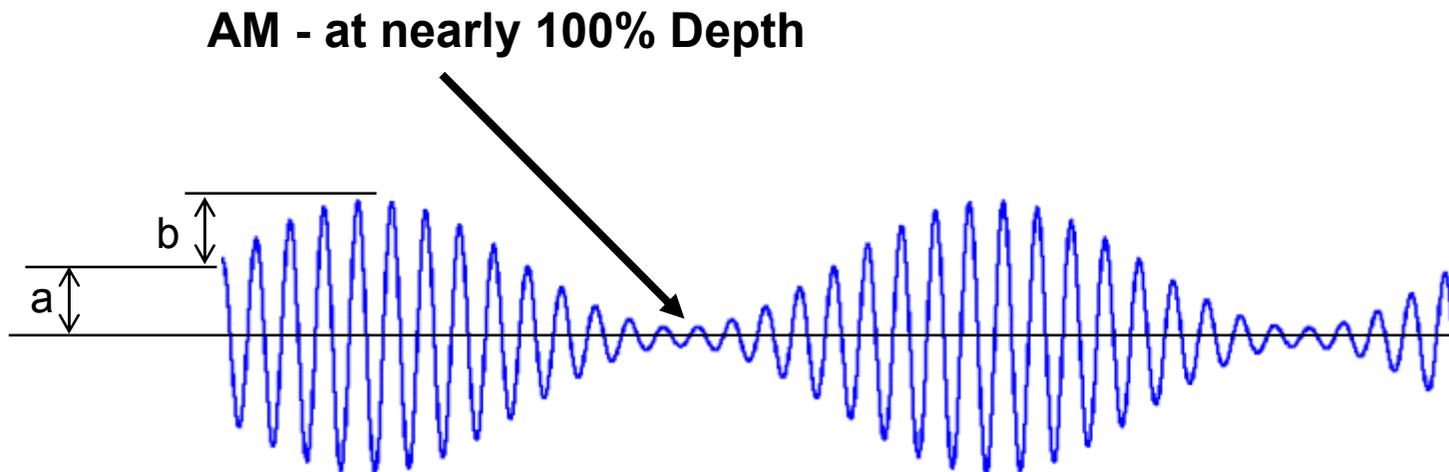
- **FM Deviation** refers to the max shift away from the nominal carrier
- **Narrow vs Wideband FM.** The FM section of 2m the band has been re-channelised to 12.5kHz spacing, vs 25kHz on most of 70cms
- **Peak Deviation** is 2.5kHz for 12.5kHz channel spacing and 4.8-5kHz for a 25kHz spacing.
- **Wide Tx deviation on narrowband receivers will interfere in adjacent channels.** It will also get clipped by IF filters/discriminators and result in choppy received audio - a common issue for older radios on 2m.



AM Depth

- **AM Depth** refers to the extent of AM modulation.
If 100% depth is exceeded, clipping/distortion occurs

AM Depth, $m = b/a$, and is often expressed as a percentage



a = level of unmodulated carrier, b = modulation peak level



FM Bandwidth

- Unlike AM, FM has a whole series of continuous sidebands which extend beyond the nominal deviation
- A good guide is Carsons Rule:-

FM Bandwidth = 2 x (Maximum Audio Freq + Peak Deviation)

or

$$\mathbf{BW = 2 (\Delta F_{\max} + \Delta f)}$$

- Examples:-
- For 70cms: $\mathbf{BW=2x (3kHz + 5kHz) = 16kHz}$ (need a 25kHz FM Channel)
- At 2m: $\mathbf{BW=2 x (2.8kHz+ 2.5kHz) = 10.6kHz}$ (for a 12.5kHz Channel)



Emission Codes

- **Be aware of emission codes.**
- **Sometime used for Logs, NoVs etc to describe transmitter modulation**
- **Common modulations use codes:**
 - A1A** - Hand Sent(?) On/Off keying of the carrier - Morse
 - A3E** - Amplitude Modulated Voice Telephony - AM
 - F3E** - Frequency Modulated Audio - FM
 - J3E** - Single Sideband
- **Data modulation**
 - F1B** - Direct Frequency shift keying
 - F2B** - FSK Audio on an FM Transmitter
 - J2B** - FSK Audio on an SSB Transmitter



Data Modulation

- **F1B** - Direct Frequency shift keying - FSK
Data directly modulated the rf carrier frequency
- **F2B** - FSK Audio on an FM Transmitter - also know as AFSK
Data uses a pair of Audio tones - the Audio is a subcarrier
- **J2B** - FSK Audio on an SSB Transmitter
Audio tones (eg 1275/1445Hz for RTTY) directly initiate carrier output