Generating FM.

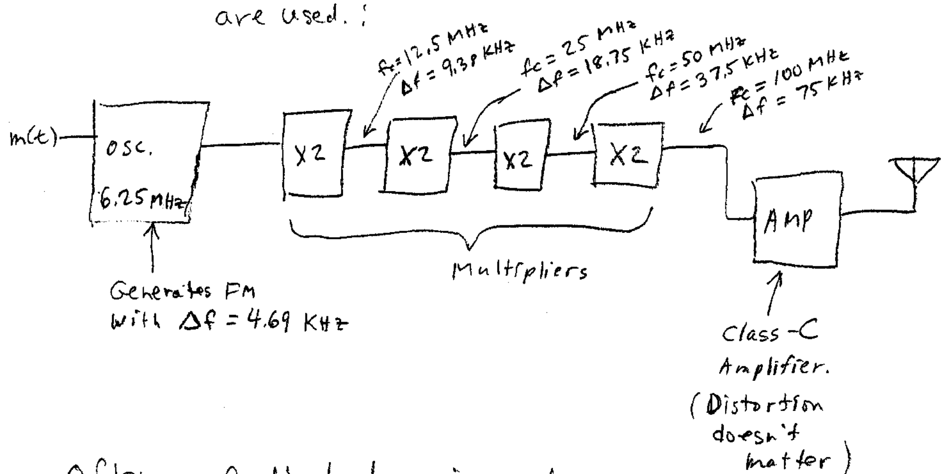
Direct method — "voltage controlled oscillator"

See 7A-2 for schematic.

Advantages: Capable of large modulation
May not be necessary to use multipliers.

Disadvantages: Poor carrier frequency stability.

To get larger frequency deviation, often multipliers are used.:



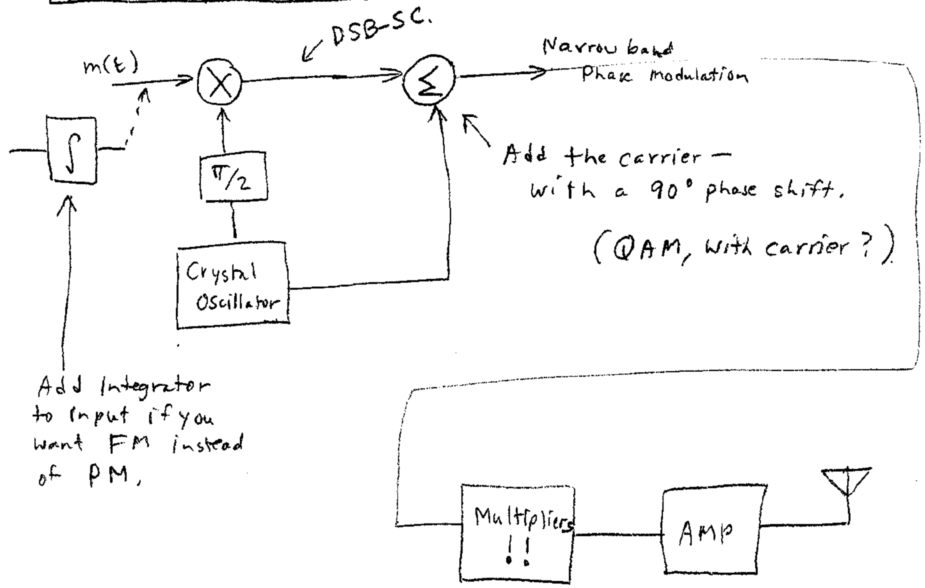
Often a feedback loop is used to stabilize the frequency.

Multiplier is either:

Ⓐ — Class C amplifier with output tuned to harmonic.

Ⓑ Full wave rectifier, and tuned circuit

Armstrong's method



Based on the assumption that higher order side bands can be ignored.--- Only the first is needed. — Very low modulation levels.

Distortion may be high ---

(3rd harmonic of m(t)) $\approx \frac{\beta^2}{4}$ (text p. 230)

β	$\frac{\beta^2}{4}$	
.5	.06 = 6%	
.1	.0025 = .25	communications grade only
.2	.01 = 1%	"mid-fi"
.05	.0006 = .06	decent quality.

Reason for high distortion ---
Truncation of power series.

More -- Armstrong's method ...

β is highest at lowest mod frequencies —

so (Example) -- Allow 1% distortion at 50 Hz

This means max $\beta = .2$ $\frac{\Delta f}{f_m}$

$$\Delta f = \beta f_m = (.2)(50) = 10 \text{ Hz}.$$

To get 75 KHz deviation —

need to multiply by 7500

This means the starting f_c (for 10 Hz deviation)

must be $\frac{100 \times 10^6}{7500} = 13 \text{ kHz}$

This is too low for $f_m = 15$ kHz. (mono)

MUCH too low for $f_m = 53$ KHz (stereo).

Solution (?)

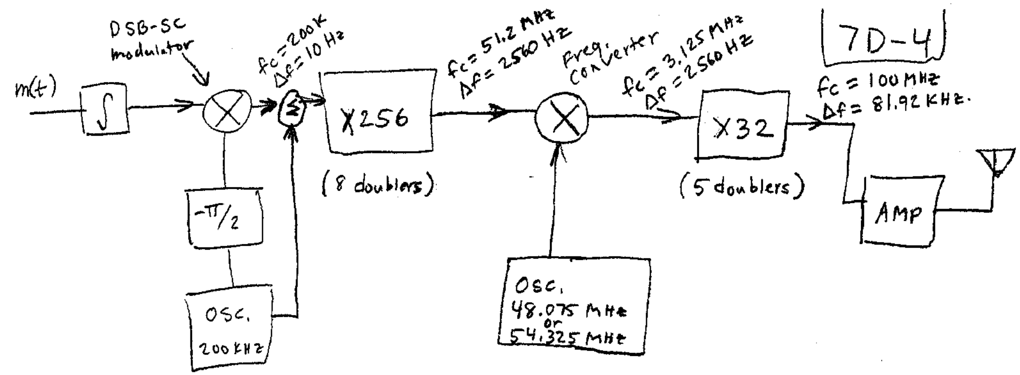
Use a heterodyne technique.

Start with a reasonable frequency -- (200 KHz)

Do some of the multiplication.

Convert it down (heterodyne -- or frequency shift)

Do more multiplication.



Actually use initial $\Delta f = \frac{75\,000}{8192} = 9.15$ Hz.

Advantages —
Very stable frequency (f_c) -- crystal oscillators.

Disadvantages —
Need many multiplier stages.
Possibly high distortion.

Notes —
Not often used in broadcast transmitters.
More common in communications transmitters.

Consider --- $f_c = 160$ MHz $\Delta f = 5$ KHz

$300 \text{ Hz} < f_m < 3000 \text{ Hz}$.

6% distortion is ok at 300 Hz.

Need $\beta = \frac{5000}{300} = 16.67$

Can do $\beta = .5$ — so need to multiply by $\frac{16.67}{.5} = 33.33 \approx 32$

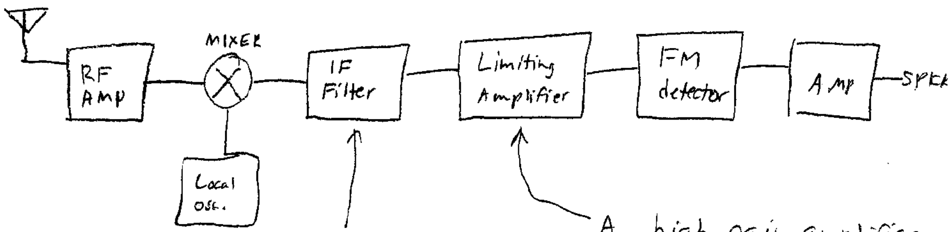
5 doublers.

Use initial $f_c = \frac{160 \text{ MHz}}{32} = 5$ MHz.

This is reasonable.

Demodulation

All FM receivers use "limiters" to remove the AM component.



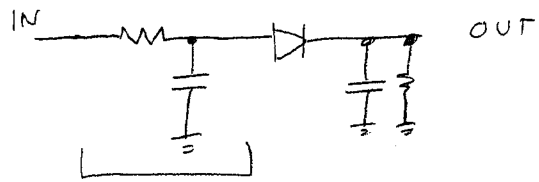
Usually 10.7 MHz

A high gain amplifier that limits ...

Driven to clipping – So the output is always the same amplitude.

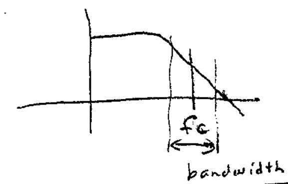
Slope detection

Use a filter – so the signal is on the slope. Then use an envelope detector.



Filter

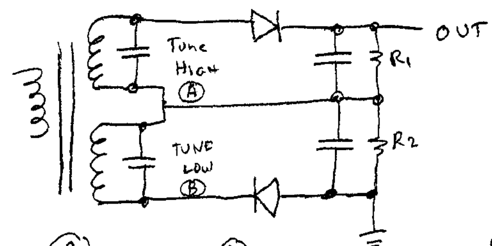
Often, an LC filter.

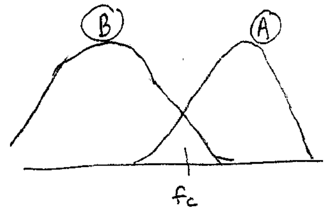


Filter creates AM signal from FM.

Double-tuned discriminator –

Use 2 slope detectors, one tuned on each side ..





Even order distortion cancels.

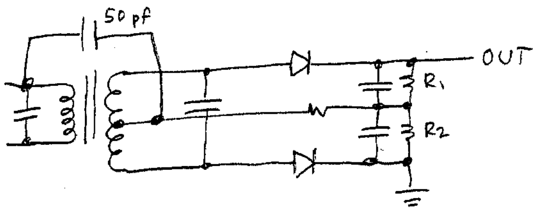
Outputs are combined (sum) in a differential rectifier

When $f = f_c$ .. $V_{R1} = -V_{R2}$

so the sum $= 0$

$f \neq f_c$ – the voltages are different, giving output.

Foster - Seeley discriminator



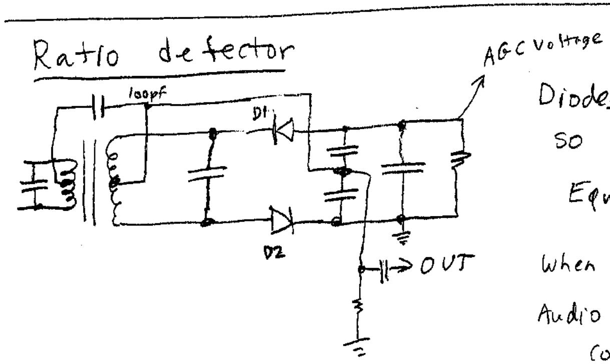
V_{out} = sum of Voltages on R1 + R2.

When $f = f_c$, secondary voltage is 90° out of phase with primary voltage.

$V_{R1} = V_{R2}$ - so they cancel.

$f \neq f_c$ - it is not 90°, so you get output.

Ratio detector



Diodes polarized so voltages add -

Equal when $f = f_c$

When $f \neq f_c$,

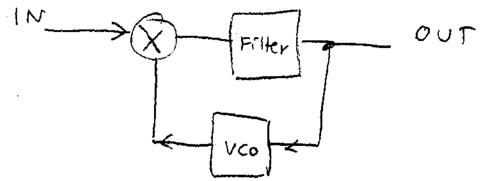
Audio output = ratio of contributions of D1 + D2.

Advantages: Rejects AM

Can get away without limiter.

(but still needs AGC, or something to control input amplitude)

Phase - Locked loop



VCO tracks input, maintaining 90° error.

"OUT" is the error voltage, used to tune VCO, is also the recovered modulation.

"Filter" holds the value of OUT.