2455 kHz − 2001 kHz = 454 kHz
2455 kHz − 2003 kHz = 452 kHz

Bfo = 455 kHz

IV 2nd mixer output to audio amplifier

Bfo − First mixer output

455 − 454 kHz = 1 kHz
455 − 452 kHz = 3 kHz

Frequency modulation - transmission

3 parameters of a sing-wave carrier signal → Amplitude frequency, phase.

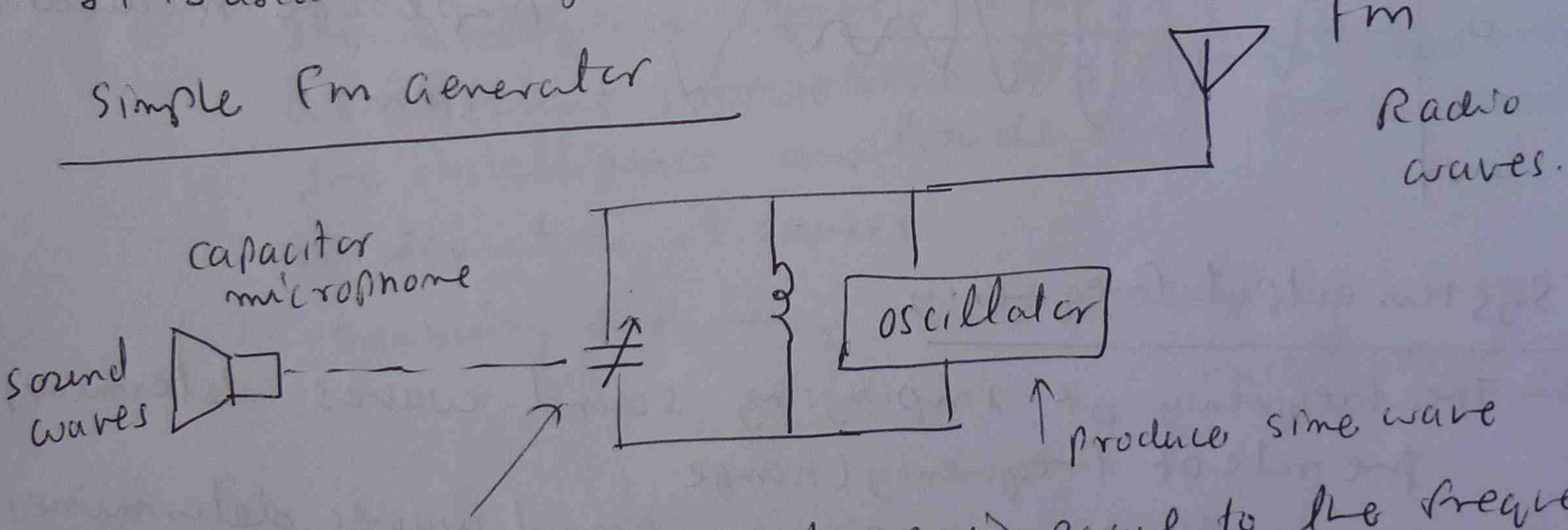
Angle modulation

The modulation in which the angle of a sine wave carrier is the characteristics varied from it's reference value

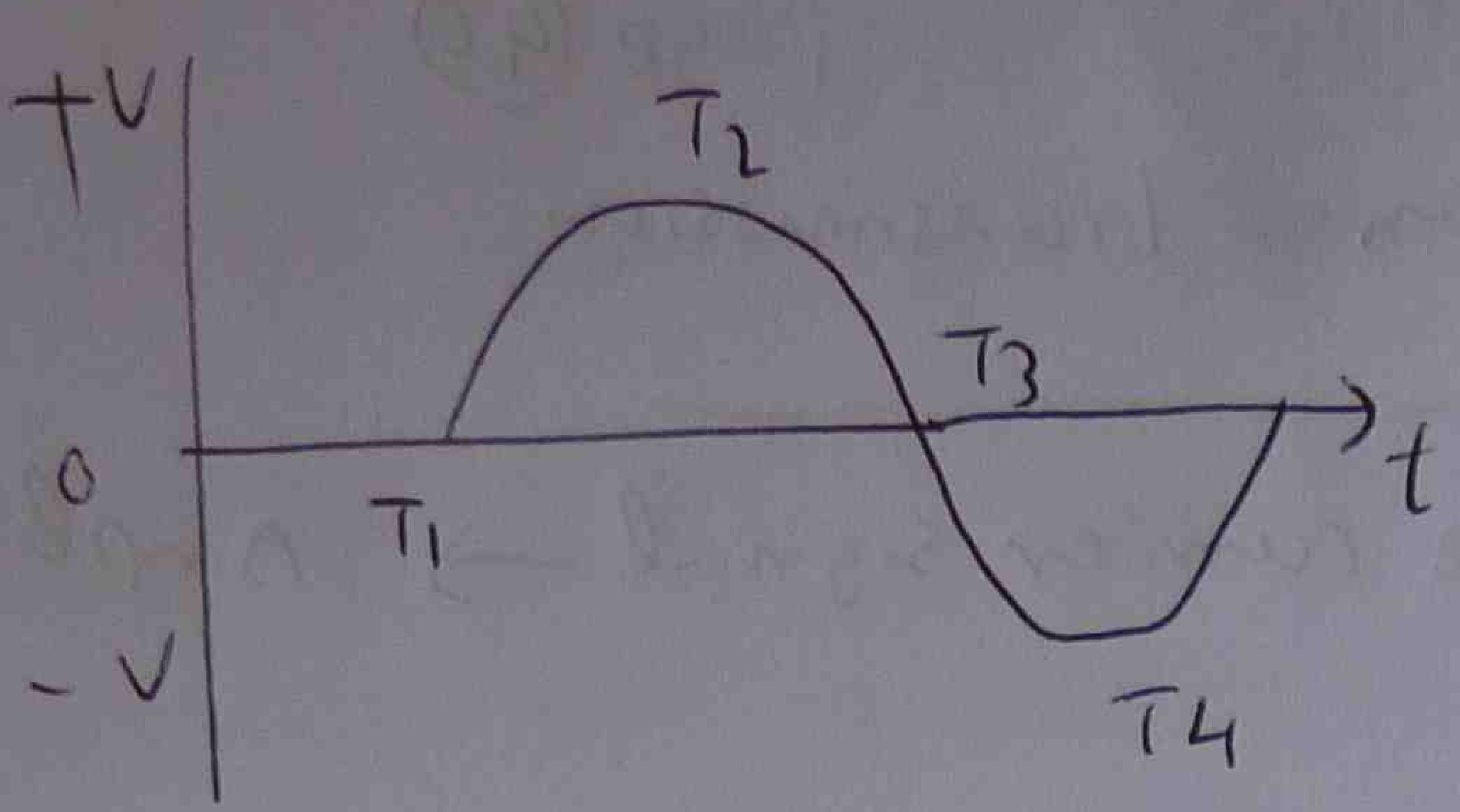
Angle modulation → Phase modulation (Pm) (Phase difference from ref.)
Angle modulation → Frequency modulation (Fm) (freq. difference from ref.)

Pm is not directly used as the transmitted signal It is used to help generate Fm.

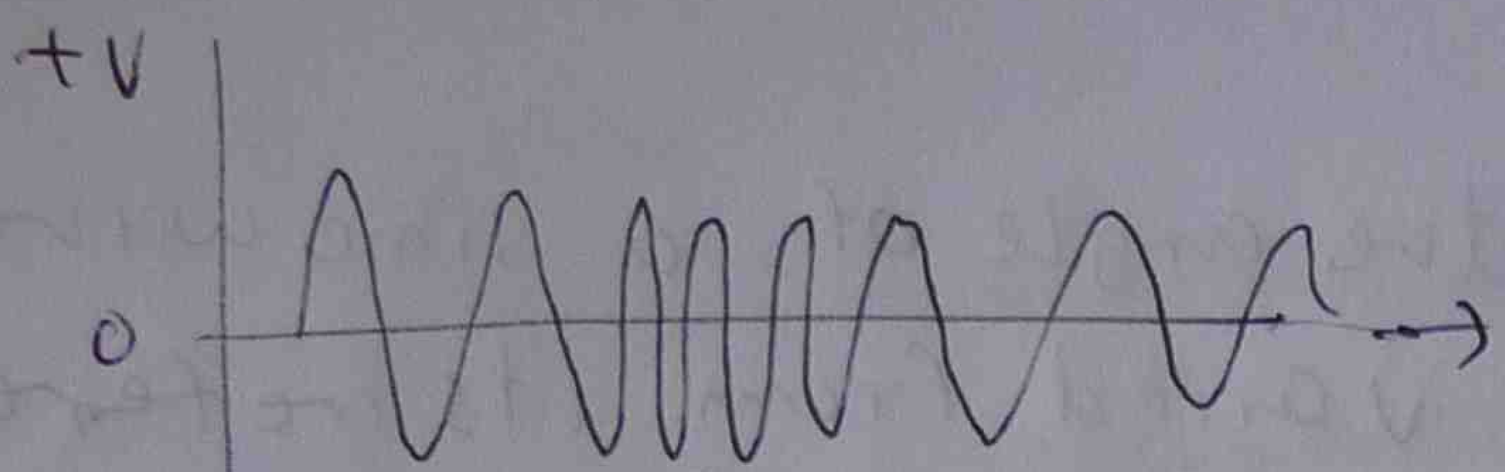
Simple Fm Generator



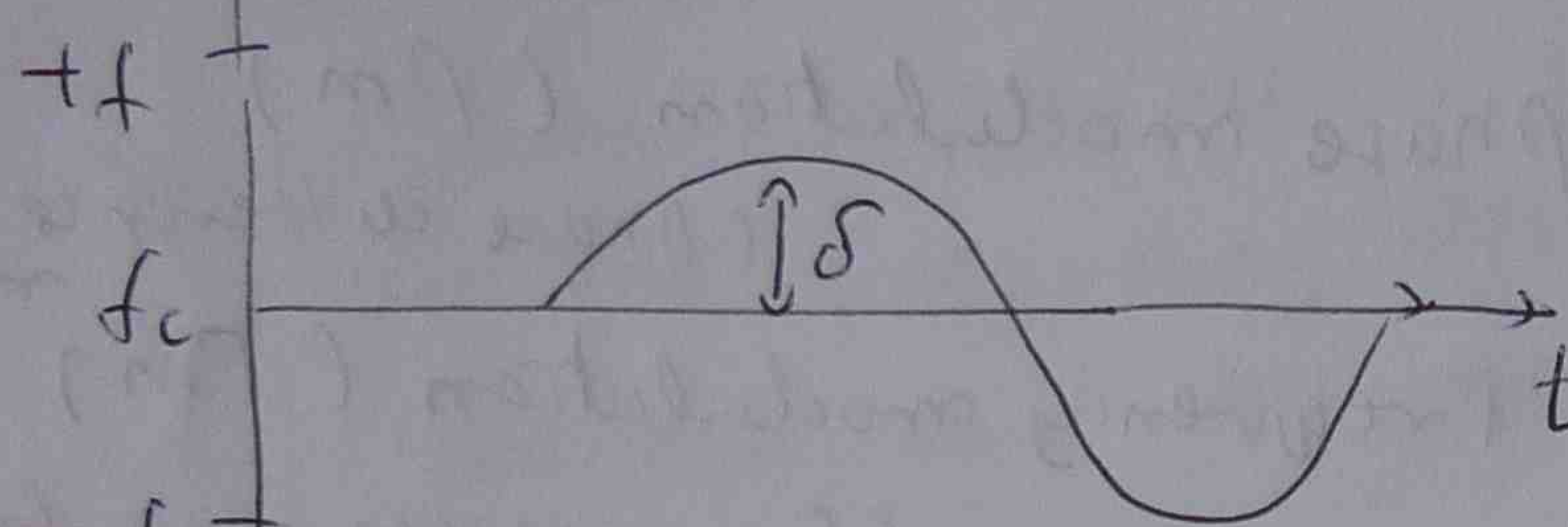
- The rate of this capacitance is equal to the frequency of the sound waves striking the mike and the amount of capacitance charge is proportional to the amplitude of the sound waves.
- This capacitance value has a direct effect on oscillator's frequency.



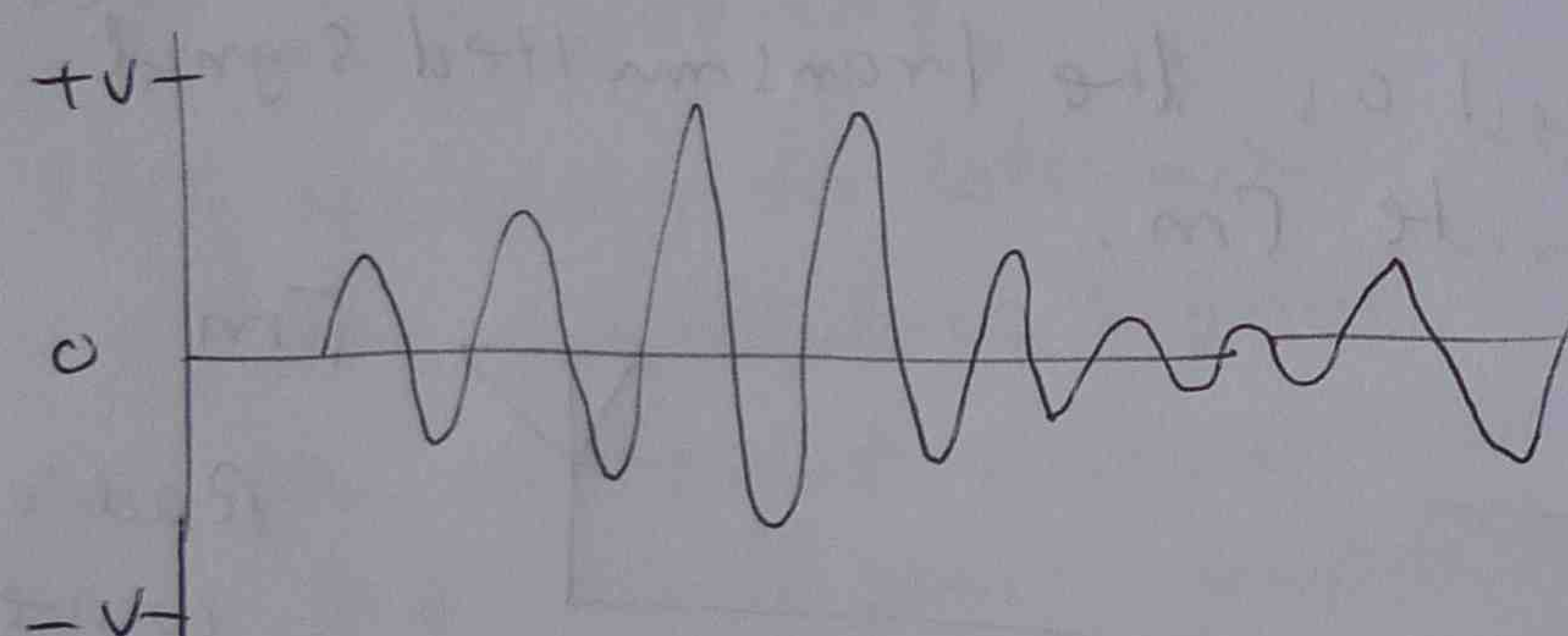
Sound wave (Intelligence signal)



Frequency modulation (Fm)



Frequency Versus Time in Fm



Amplitude modulation (Am)

System output frequency

- The frequency of impinging sound waves determines the rate of frequency change
- The amplitude of impinging sound waves determines the amount of frequency change.
- Frequency deviation (δ)

  The amount of oscillator frequency increase and decrease around f_c.

- The intelligence amplitude determines the amount of carrier frequency deviation
- The intelligence frequency (f_i) determines the

rate of carrier frequency deviation.

Pb An FM signal has a center frequency of 100 MHz but is swinging between 100,001 MHz and 99,999 MHz at a rate of 100 times per second.

Determine

(a) The Intelligence frequency f_i
(b) The intelligence amplitude
(c) What happened to the intelligence amplitude if the frequency deviation changed to between 100,002 and 99,998 MHz.

(a) $f_i = 100$ MHz

(b) No way to determine the actual amplitude of the intelligence signal. Every FM system has a different proportionality constant between the intelligence amplitude and the amount of deviation it causes.

(c) Doubling frequency deviation $\longrightarrow$ doubling intelligence amplitude.

FM Analysis

For phase modulation, the equation for instantaneous voltage

$$e = A \sin(\omega_c t + m_p \sin \omega_i t)$$

where e = instantaneous voltage
A = peak value of original carrier wave
ω_c = carrier angular velocity $2\pi f_c$
m_p = maximum phase shift caused by intelligence signal (rad)

ωi = modulating (intelligence) signal angular velocity $(2\pi f_i)$

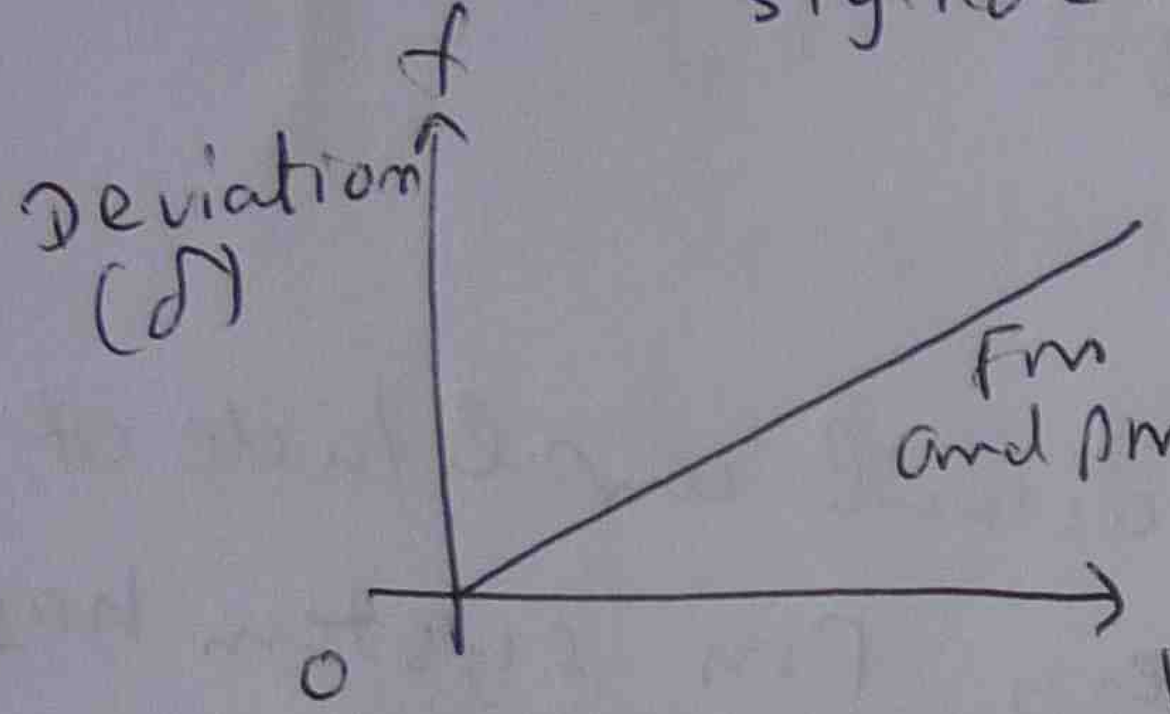
Fm

$$e = A \sin(\omega_c t = m_f \sin_{\omega i} t)$$

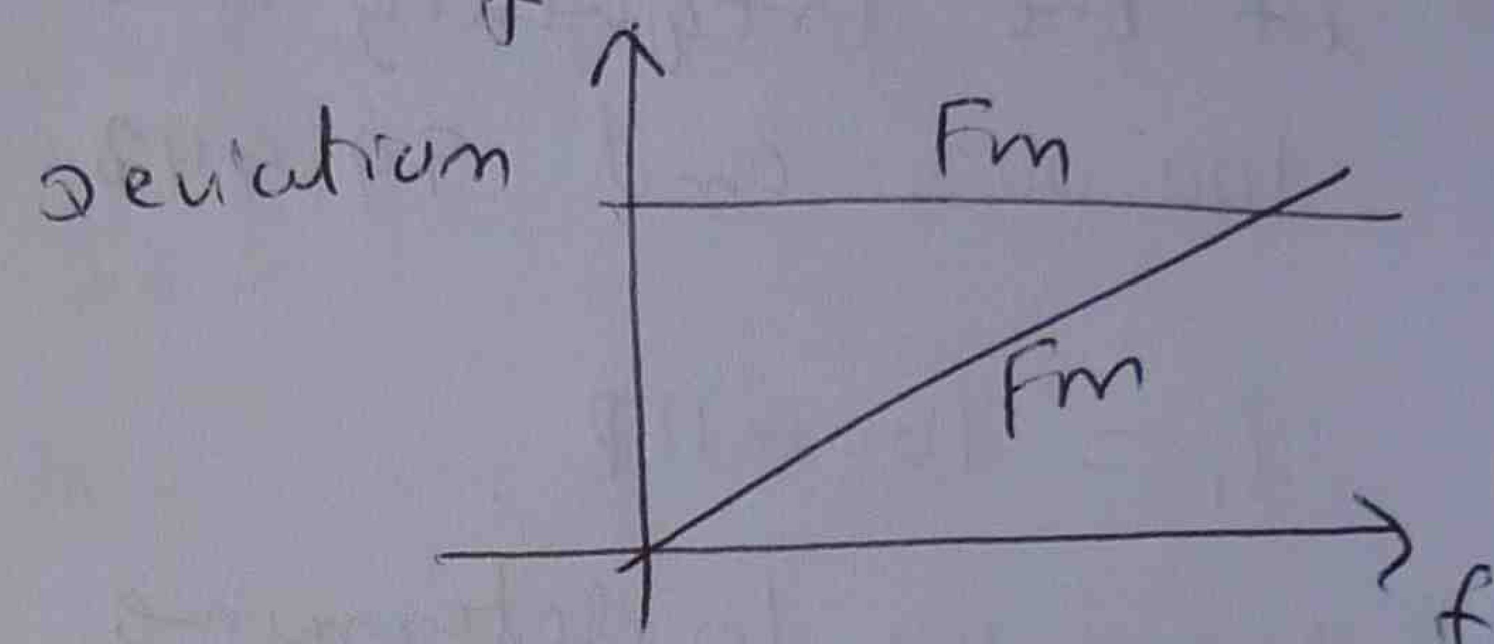
mf = Fm modulation index = $\frac{\delta}{f_i}$

δ = maximum frequency shift caused by the intelligence signal (deviation)

f_i = frequency of the intelligence (modulating) signal.



Intelligence amplitude



Intelligence frequency

Fm mathematical solution

The Bessel function solution to Fm equation

$$f_c(t) = J_0(mf)\cos\omega_c t - J_1(mf)[\cos(\omega_c - \omega i)t - \cos(\omega_c + \omega i)t] + J_2(mf)[\cos(\omega_c - 2\omega i)t + \cos(\omega_c + 2\omega i)t] - J_3(mf)[\cos(\omega_c - 3\omega i)t + \cos(\omega_c + 3\omega i)t] + - -$$

where $f_c(t)$ = fm Frequency component

$J_0(mf)\cos\omega_c t$ = Carrier component

$J_1(mf)\cos(\omega_c - \omega i)t + \cos(\omega_c + \omega i)t$ = component at $\pm f_i$ around carrier

$J_2(mf)\cos(w_c - 2w_i)t + \cos(w_c + 2w_i)t$
= component at $\pm$ 2 fi ~~around~~
around the carrier etc

To solve for the amplitude of any side-frequency component J_n, the following equation should be applied

$$J_N(mf) = \left(\frac{mf}{2}\right)^n \left[\frac{1}{n!} - \frac{(mf/2)^2}{1!(n+1)!} + \frac{(mf/4)^4}{2!(n+2)!} - \frac{(mf/2)^6}{3!(n+3)!} + - - \right]$$

Table 5.1 page 161 Bessel function table

Pb Determine a bandwidth required to transmit an FM signal with $f_i = 10$ KHZ and a maximum deviation $\delta = 20$ KHZ.

$$m_f = \frac{\delta}{f_i} = \frac{20\text{KHZ}}{10\text{KHZ}} = 2$$

Table 5.1

mf	J_0	J_1	J_2	J_3	J_4
2	✓	✓	✓	✓	✓

$f_i = J_1 = 10$ KHZ

Thus J_0, J_1, J_2, J_3, J_4 exist

$J_1 \to \pm 10$ KHZ, $J_2 \to \pm 20$ KHZ, $J_3 \to \pm 30$ KHZ, $J_4 \to \pm 40$ KHZ — Last ∴ total reqd bandwidth = 2 x Last

Total required band width = $2 \times 40 = 80\,KHz$

Pb — Repeat the above problem with f_i changed to 5 KHz.

$$m_f = \frac{\delta}{f_i} = \frac{20\,KHz}{5\,KHz} = 4$$

m_f	J_0	J_1	J_2	J_3	J_4	J_5	J_6	J_7
4	✓	✓	✓	✓	✓	✓	✓	✓

$J_1 = 5 \quad J_2 = 2\times5 = 10 \quad J_3 = 3\times5 = 15, \quad J_4 = 4\times5 = 20$

$J_5 = 5\times5 = 25, \quad J_6 = 6\times5 = 30, \quad J_7 = 7\times5 = 35\,KHz$

Total Band width = 2x Last J

$= 2\times J_7 = 2\times35 = 70\,KHz$

CARSON's RULE

Bandwidth necessary for an FM signal

$$BW = 2(\delta_{max} + f_{i\,max})$$

Pb — An FM signal $2000 \sin(2\pi\times10^8 t + 2\sin\pi\times10^4 t)$ is applied to a 50Ω antenna.

Determine

(a) the carrier frequency

(b) The transmitted power

(c) m_f

(d) f_i

(e) BW (by two methods)

(f) power in the largest and smallest side band,

(S2)

$$2000 \sin(\underbrace{2\pi \times 10^8}_{2\pi f_i} t + \underset{m_f}{2} \sin \underbrace{\pi \times 10^4}_{2\pi \times f_i} t)$$

(a) $\because 2\pi f_c = 2\pi \times 10^8 \longrightarrow f_c = \frac{2\pi \times 10^8}{2\pi} = 10^8 Hz = 100 MHz$

Carrier freq = f_c

(b) Peak voltage

$$P = \frac{(\text{Peak voltage}/\sqrt{2})^2}{\text{Antenna Resistance}} = \frac{(2000/\sqrt{2})^2}{50} = 40 kW$$

(c) $m_f = 2$

(d) $2\pi f_i = \pi \times 10^4$

$$f_i = \frac{\pi \times 10^4}{2\pi} = 5 kHz$$

(e) $BW = 2(\underset{m_f \times f_i}{\delta_{max}} + \underset{f_i}{f_{i max}})$

$$= 2(2 \times 5 kHz + 5 kHz) = 30 kHz$$

(f) $m_f = 2$

m_f	J_0	J_1	J_2	J_3	J_4
2	0.58	✓	✓	✓	0.03
		f_i	$2f_i$	$3f_i$	$4f_i$
		5			20 kHz

$J_1 = 0.58$, $J_4 = 0.03$

Largest

$$P = \frac{(0.58 \times 2000/\sqrt{2})^2}{50} = 13.5 kW$$

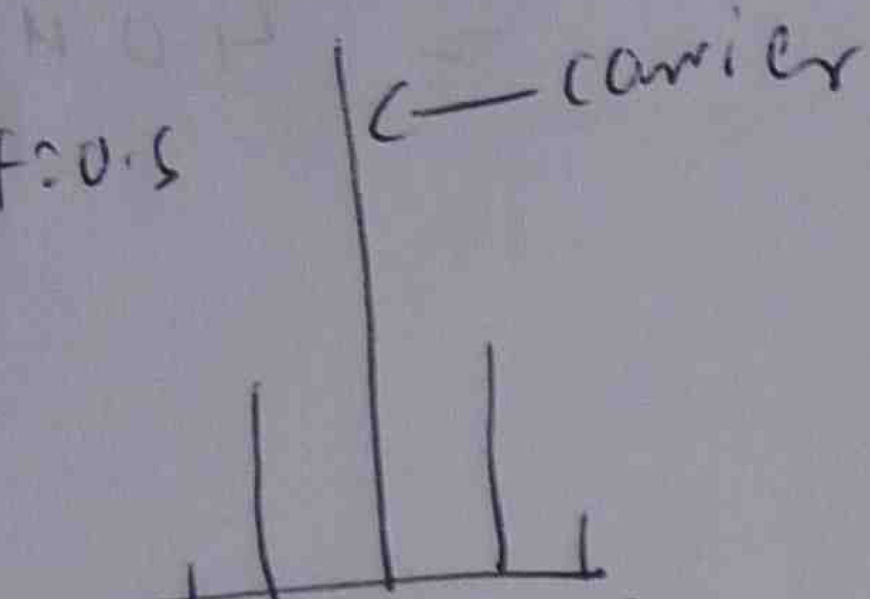
(or) $2 \times 13.5\,kw = 27\,kw$ for two side band,
at $\pm 5\,kHz$ from carrier

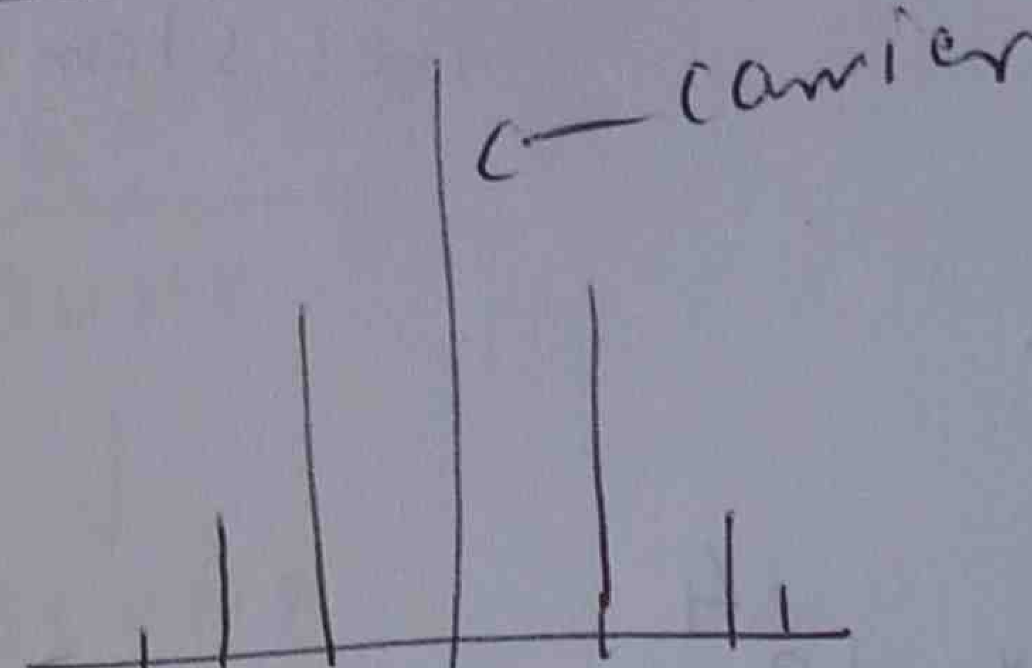
Smallest $P = \dfrac{(0.03 \times 2000/\sqrt{2})^2}{50\Omega} = 36\,W$

for two side bands $\rightarrow 36 \times 2 = 72\,W$
at $\pm 20\,kHz$ from carrier

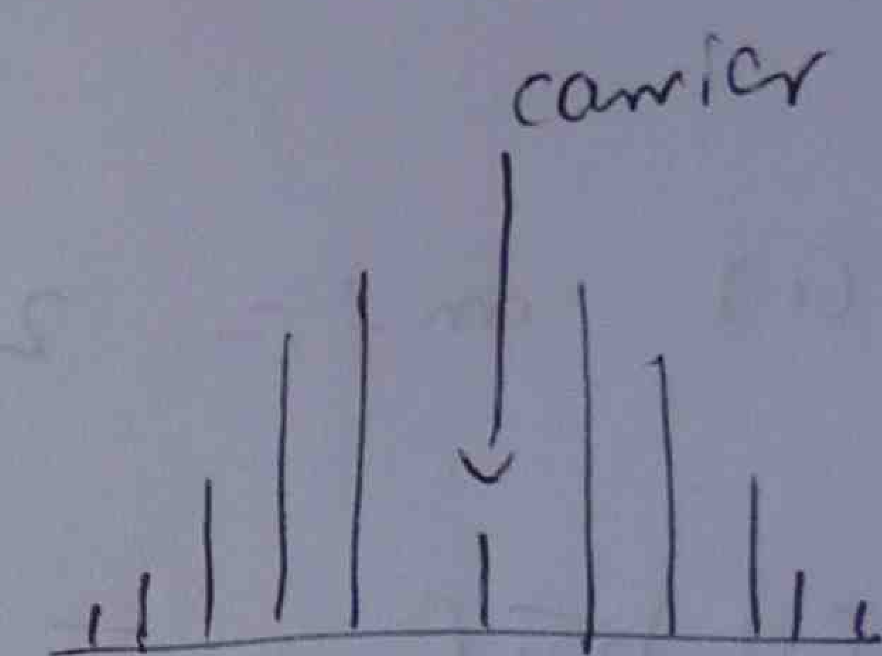
---

mf:0.5

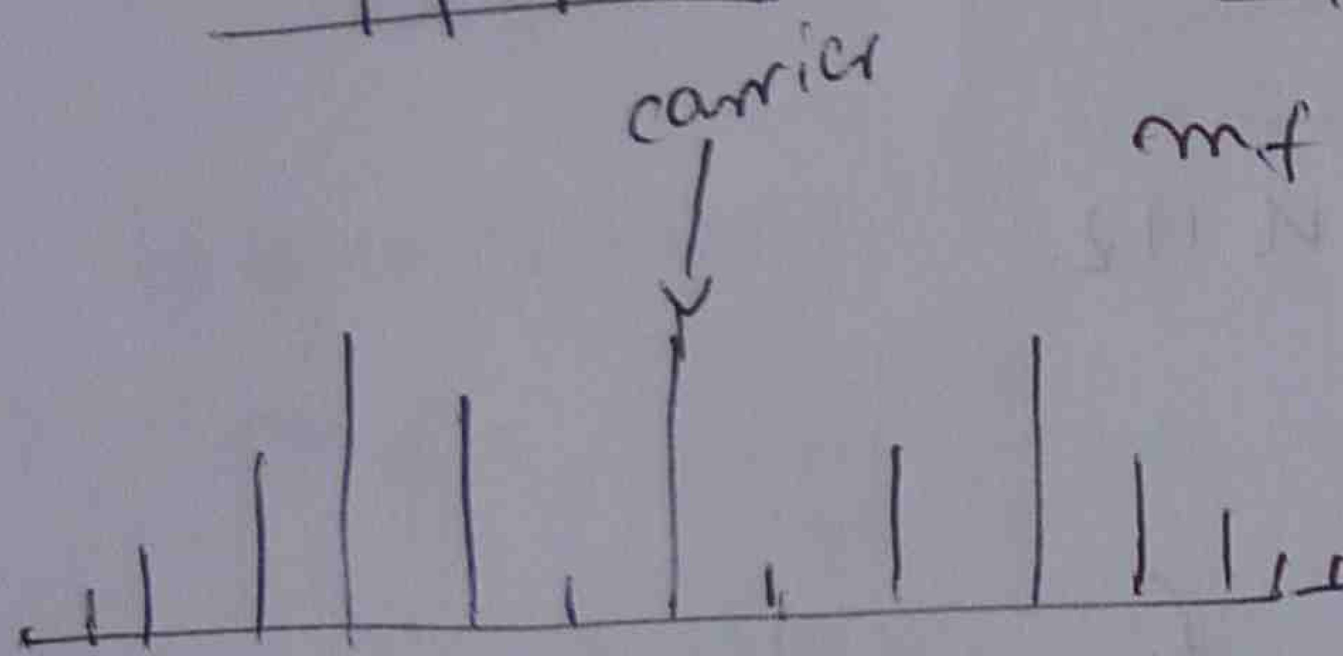




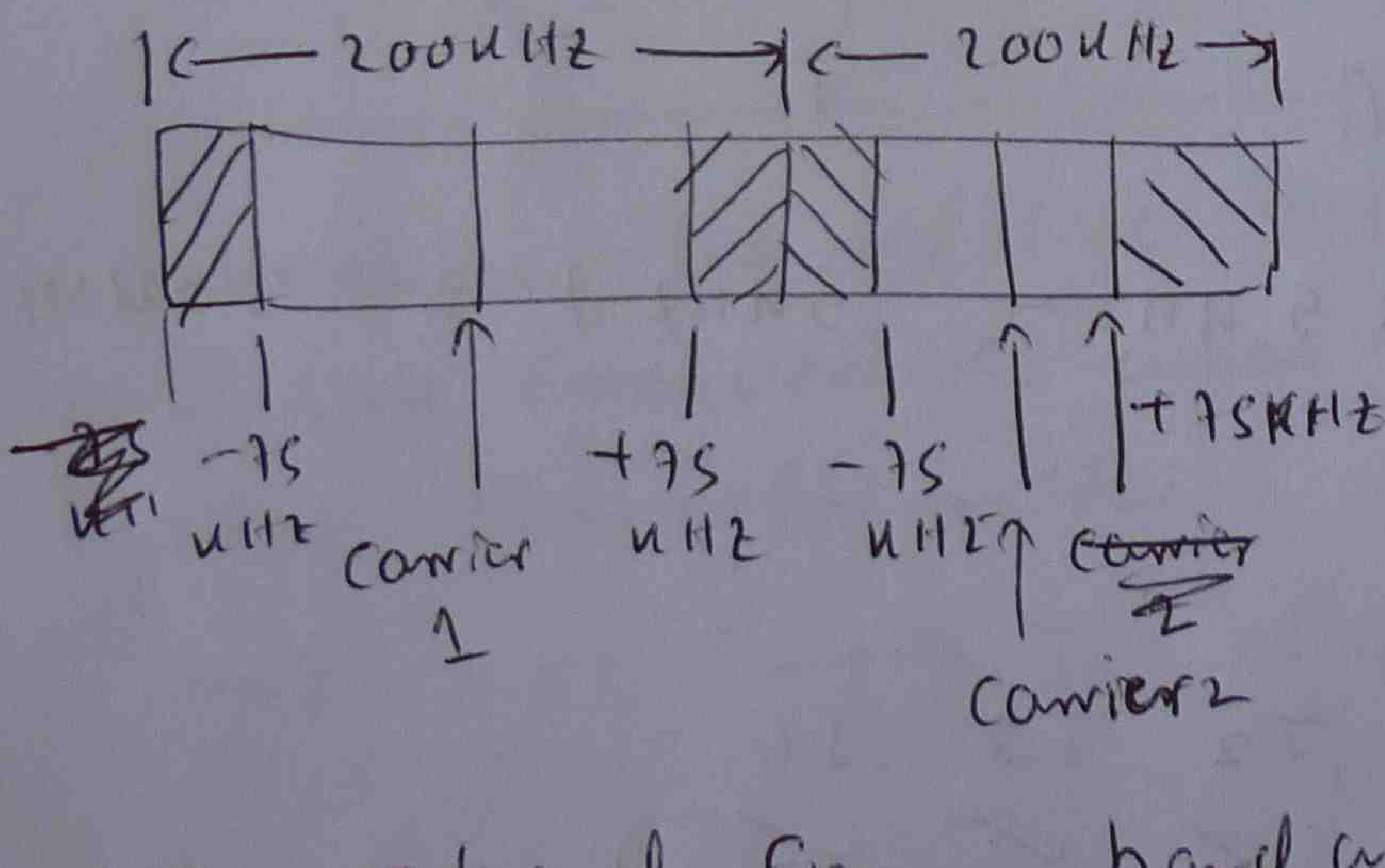
mf = 1.0



mf = 2.5



mf = 4



Narrow band fm bandwidth 10 → 30 kHz

Fm is used for police / air craft / taxicab
weather service / private industry network.

Pb (a) Determine the permissible range in maximum modulation index for commercial FM that has 30 Hz to 15 kHz modulating frequencies.

(b) Repeat for a narrow band system that allows a maximum deviation of 10 kHz and 100 Hz to 3 kHz modulating frequencies.

(a) The maximum deviation in broadcast FM is 75 kHz

$$m_f = \frac{\delta}{f_i} = \frac{75\ kHz}{30\ Hz} = 2500$$

$$\downarrow$$

$$\frac{75\ kHz}{15\ kHz} = 5$$

10 kHz & 100 Hz

(b) $m_f = \dfrac{10\ kHz}{100\ Hz} = 100$

100 Hz to 3 kHz

$$m_f = \frac{10\ kHz}{3\ kHz} = 3.33$$

Pb Determine the relative total power of carrier and side frequencies when $m_f = 0.25$ for a 10 kW FM transmitter.

$m_f = 0.25 \longrightarrow J_0 = 0.98$

$J_1 = 0.12$

Carrier power $= (J_0)^2 \times \text{Rating} = (0.98)^2 \times 10\ kW = 9.604\ kW$

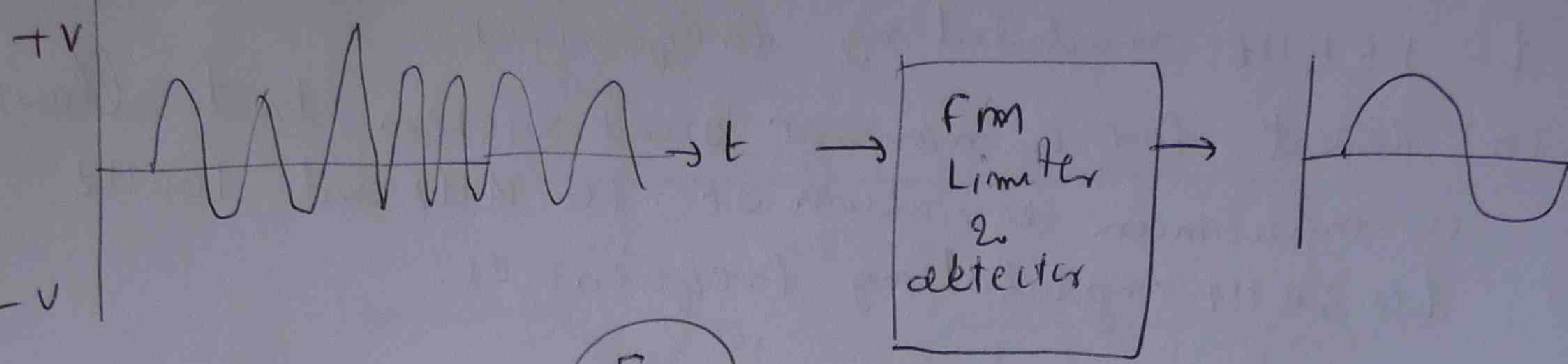
Side band $= (J_1)^2 \times \text{Rating} = (0.12)^2 \times 10\ kW = 144\ W$

Total power = carrier power + 2 side band power

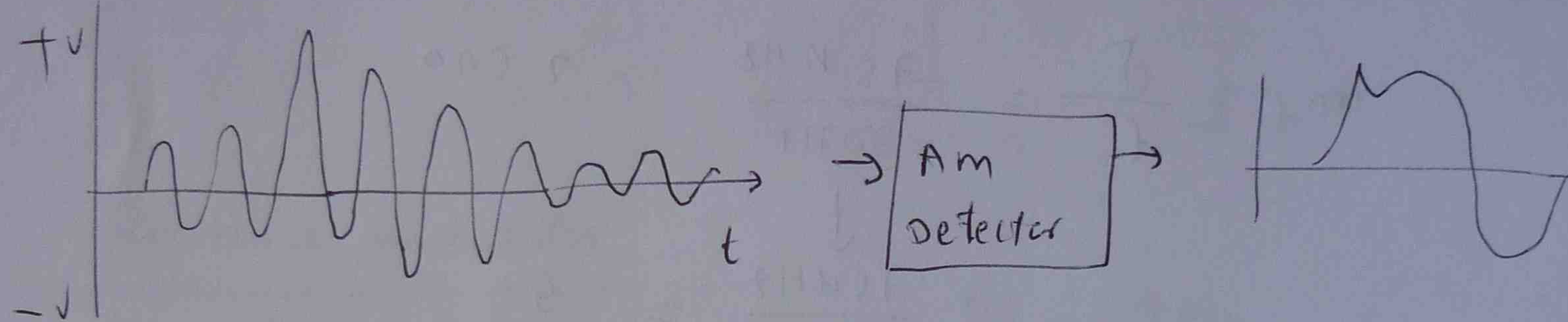
$= 9.604 + 2 \times 144 \times 10^{-3} = 10\ kW$

55

Noise suppression



Fm



The spikes of external noise picked up during transmission are clipped off by a limiter circuit.

The amount of frequency deviation (Fm) caused by pm is $= \delta = \phi f_i$

δ = frequency deviation, ϕ = Phase shift (radians)

f_i = frequency of intelligence signal

Pb determine the worst-case output S/N for a broad cast Fm program that has a maximum intelligence frequency of 5 kHz. The input S/N is 2.

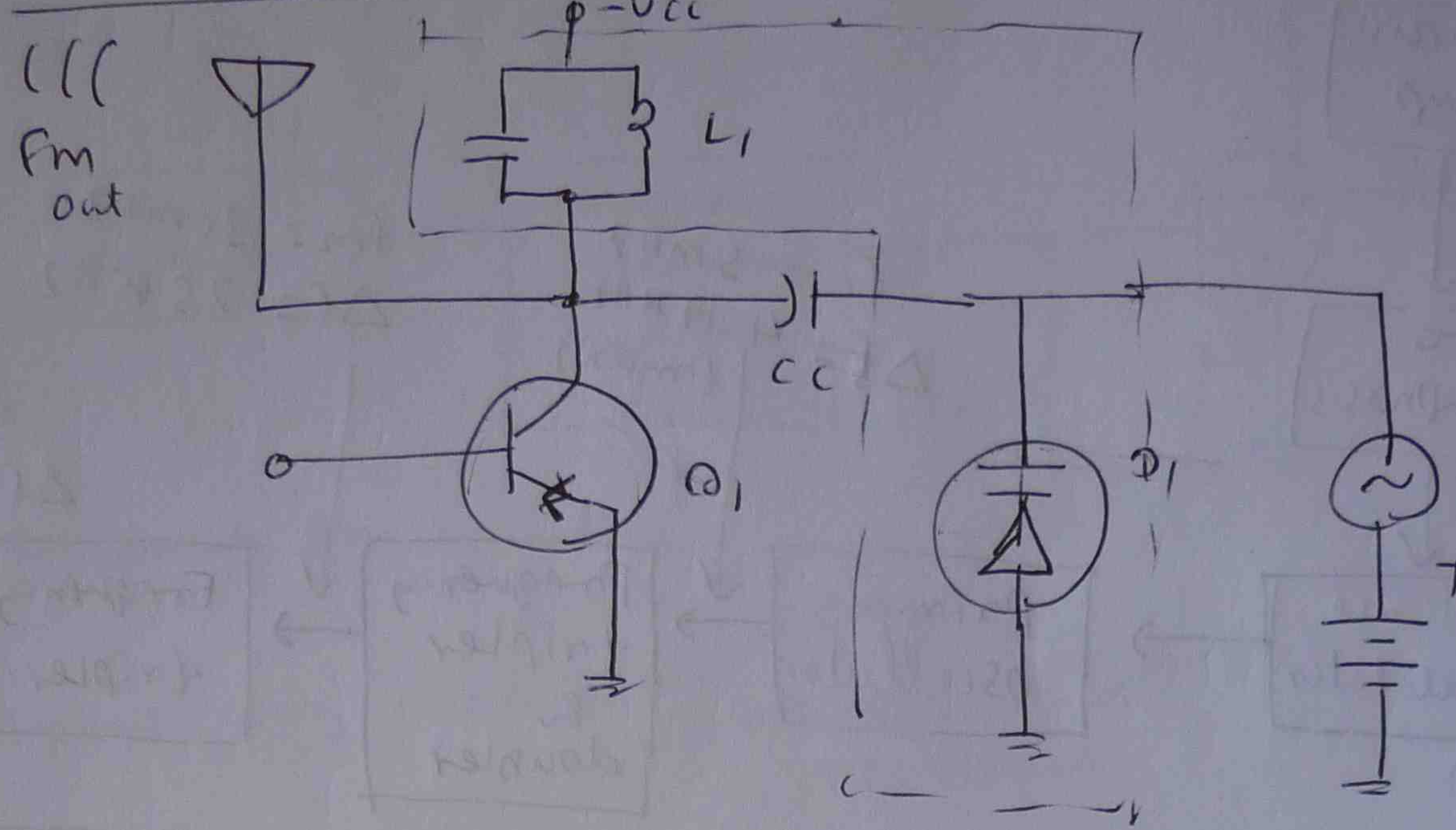
$$\frac{S}{N} = 2 \longrightarrow \phi = 0.5 \qquad f_i = 5\,kHz$$

$$\therefore \delta = \phi \times f_i = 0.5 \times 5\,kHz = 2.5\,kHz$$

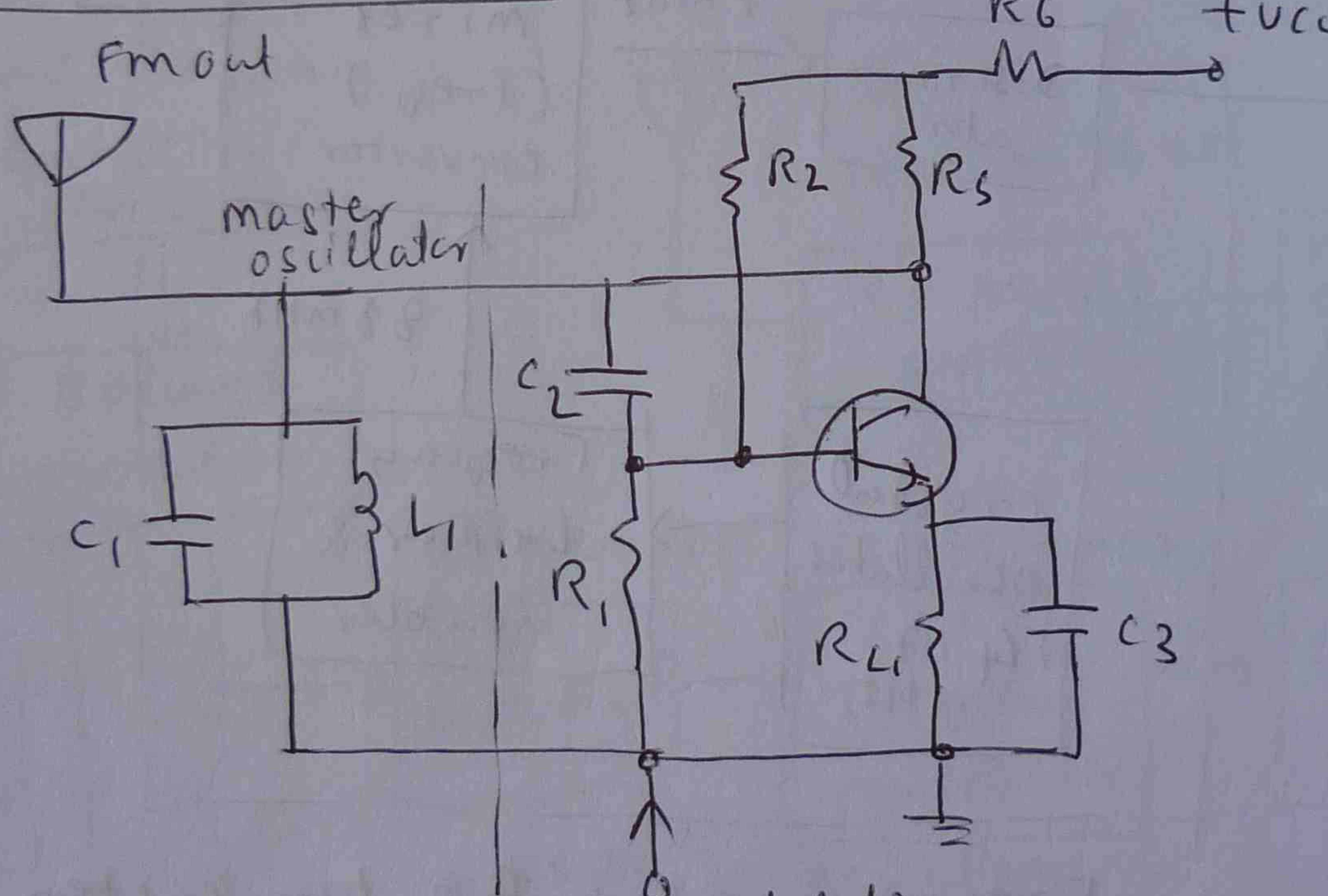
$$\text{worst case} = \frac{\text{max: deviation}}{\delta} = \frac{75\,kHz}{2.5\,kHz} = 30$$

(56)

Varactor diode modulator



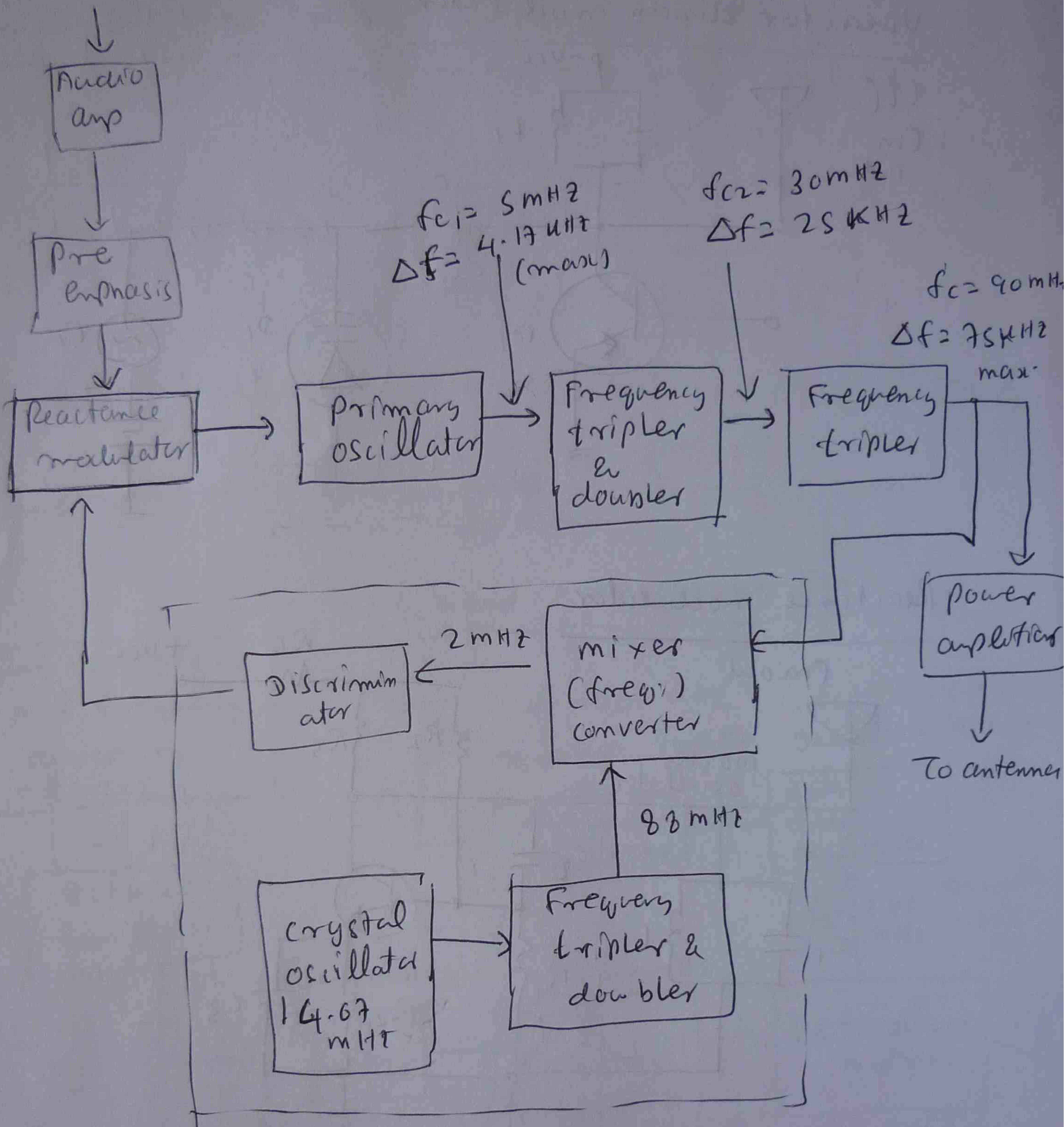
Reactance modulator



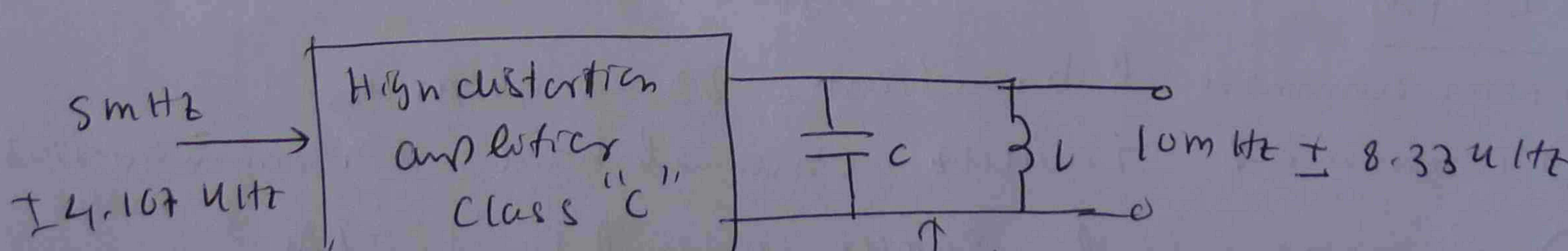
Use of Fm

1. Non commercial broadcast 88 → 90 MHz
2. commercial 200 kHz channel band width from 90 → 108 MHz
3. TV audio signal 50 kHz, Chanel bandwidth 54 → 88 MHz
4. narrow band public service channel 108 → 174 MHz in excess of 806 MHz
5. Narrow band amatur radio 29.6 MHz, 52 to 53 MHz 146 to 147.5 MHz, 440 → 450 MHz

Crosby direct fm transmitter

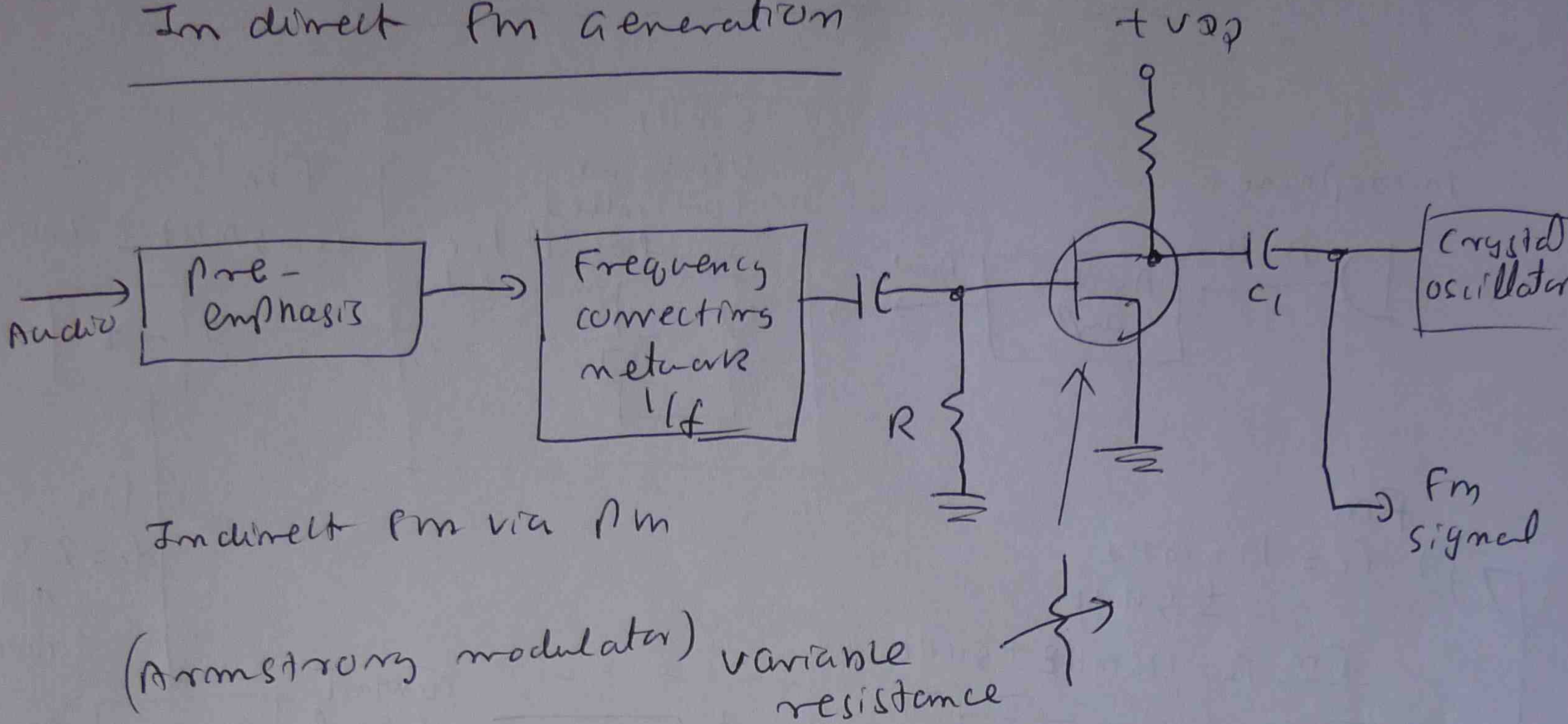


Frequency stabilization system



$$f_c = 10\ \text{mHz} = \frac{1}{2\pi\sqrt{LC}}$$

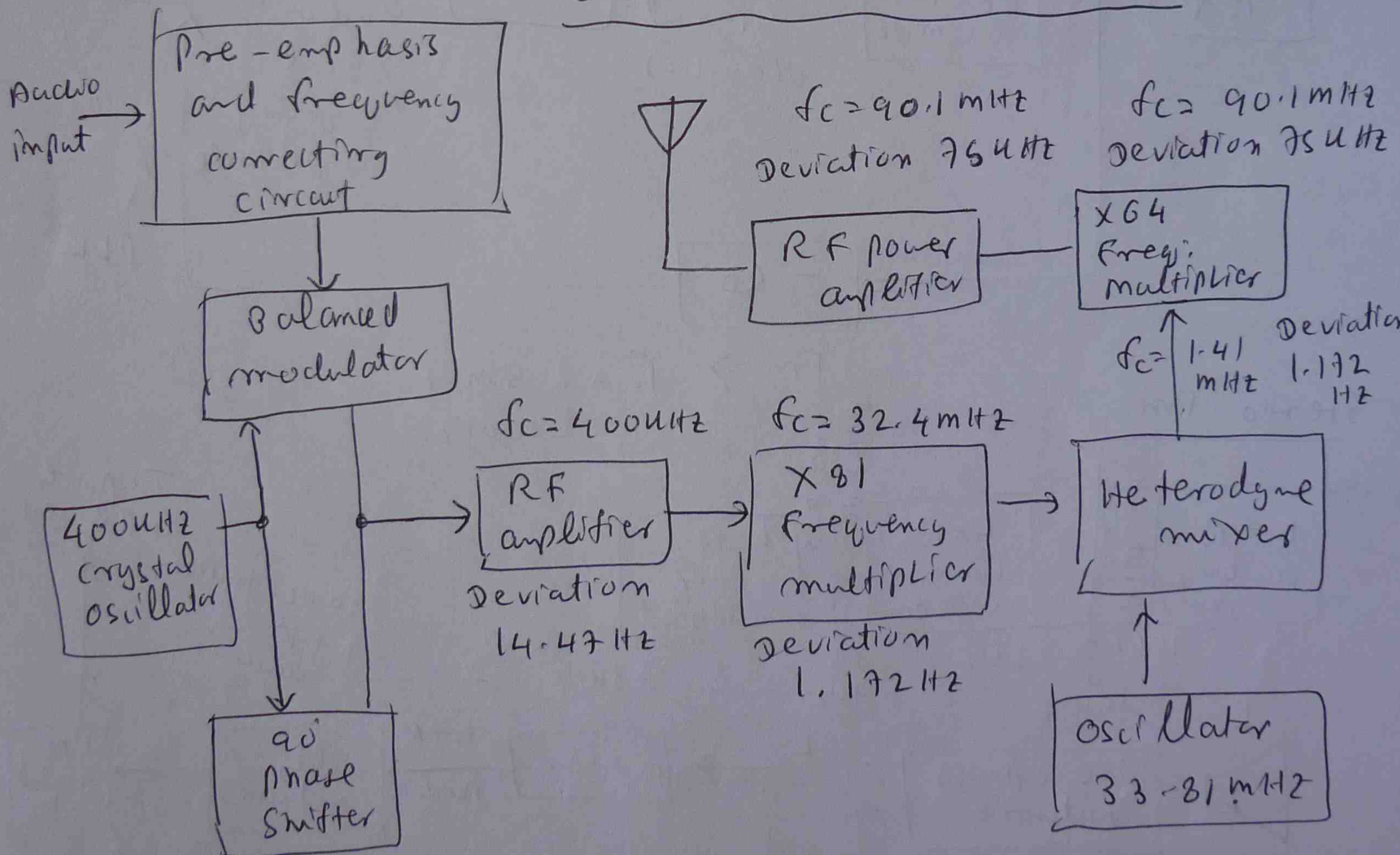
Indirect FM Generation



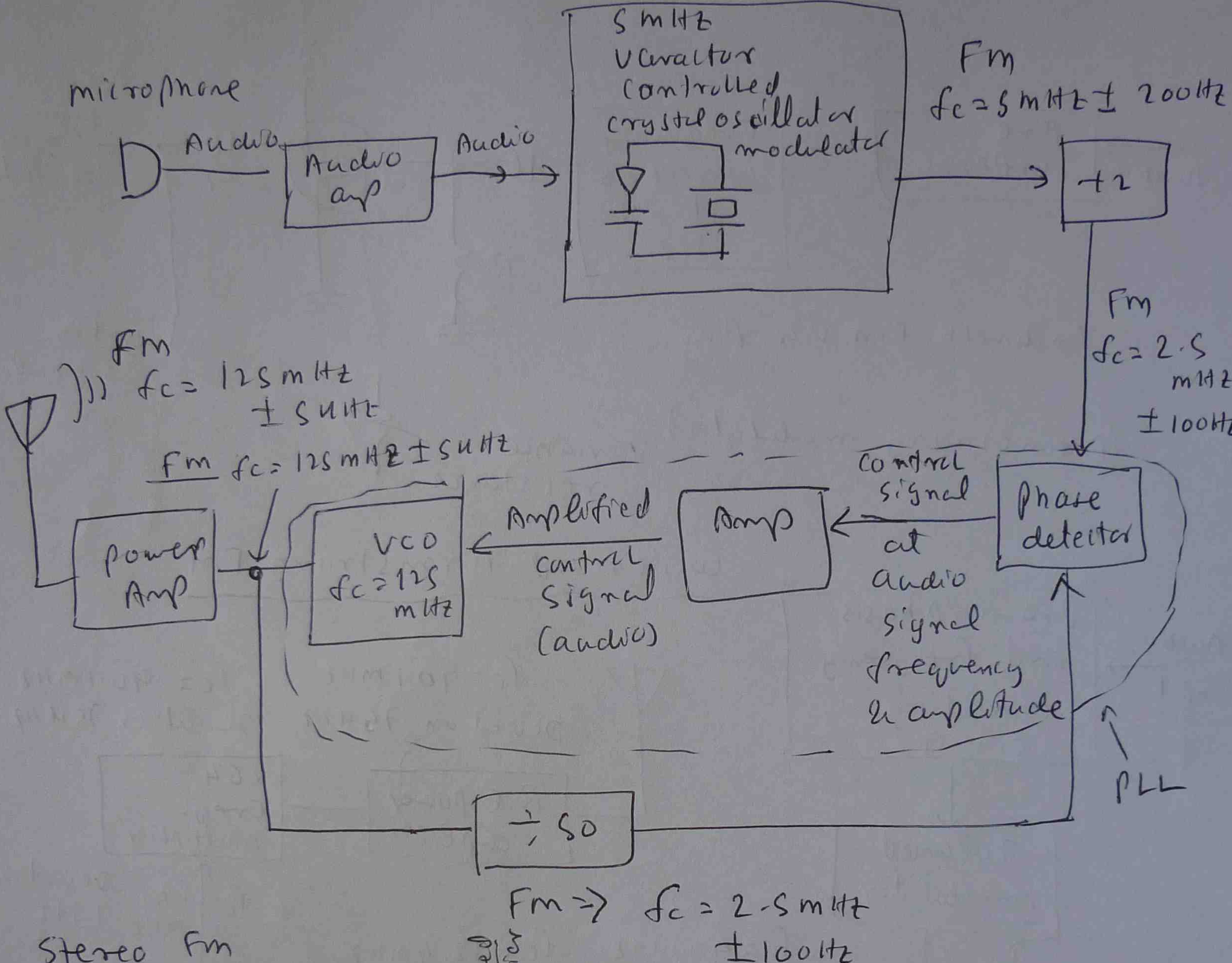
Indirect FM via PM

(Armstrong modulator)

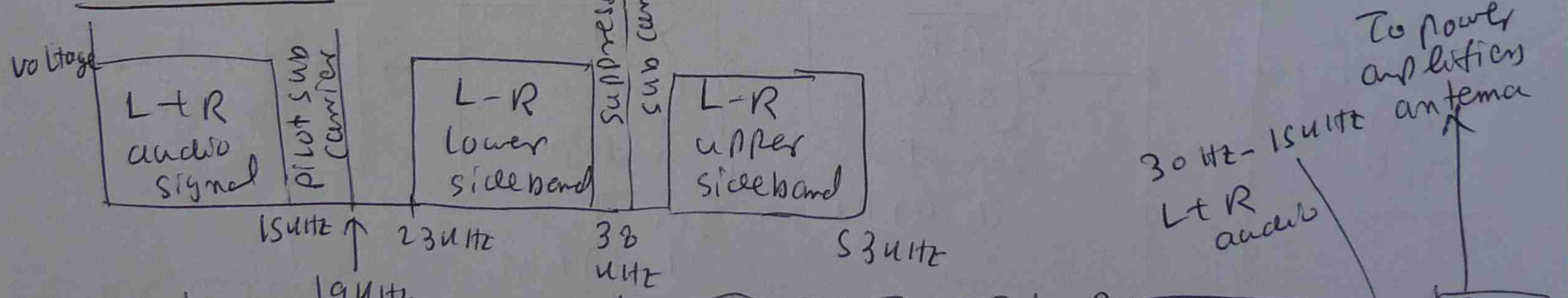
Wideband Armstrong FM

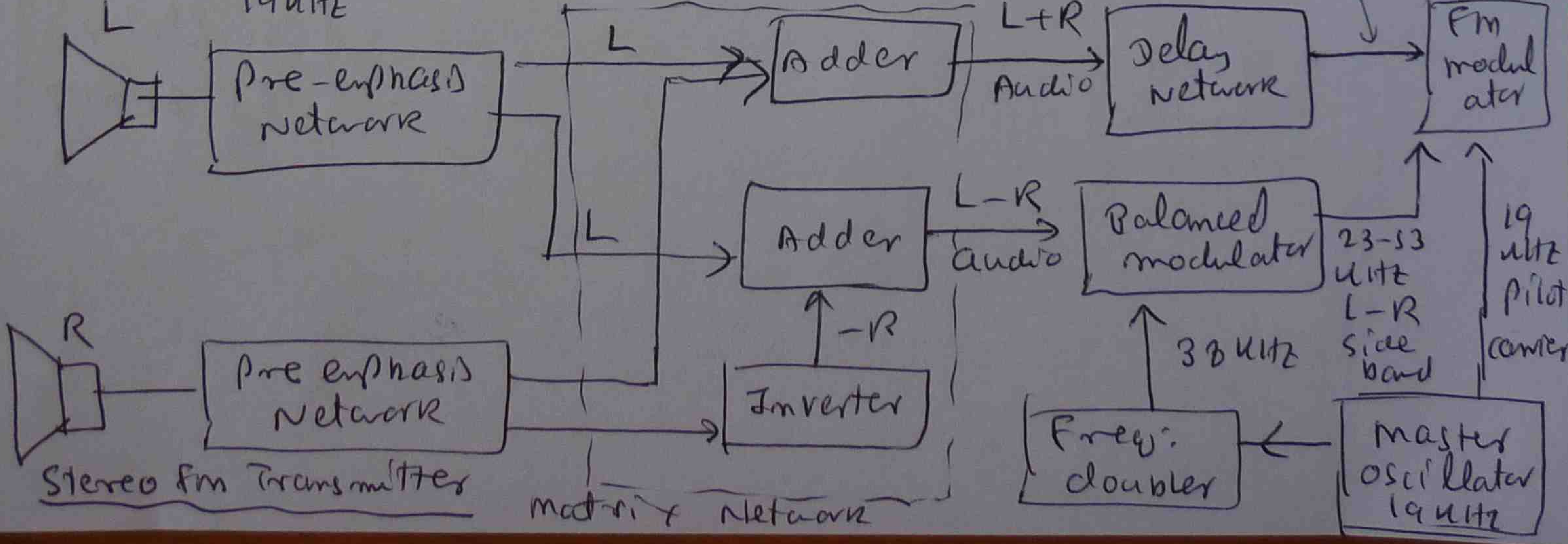


Phase locked loop Fm transmitter



Stereo Fm





Stereo fm Transmitter

Week (7)

Frequency modulation - reception

Discriminator (Detector)

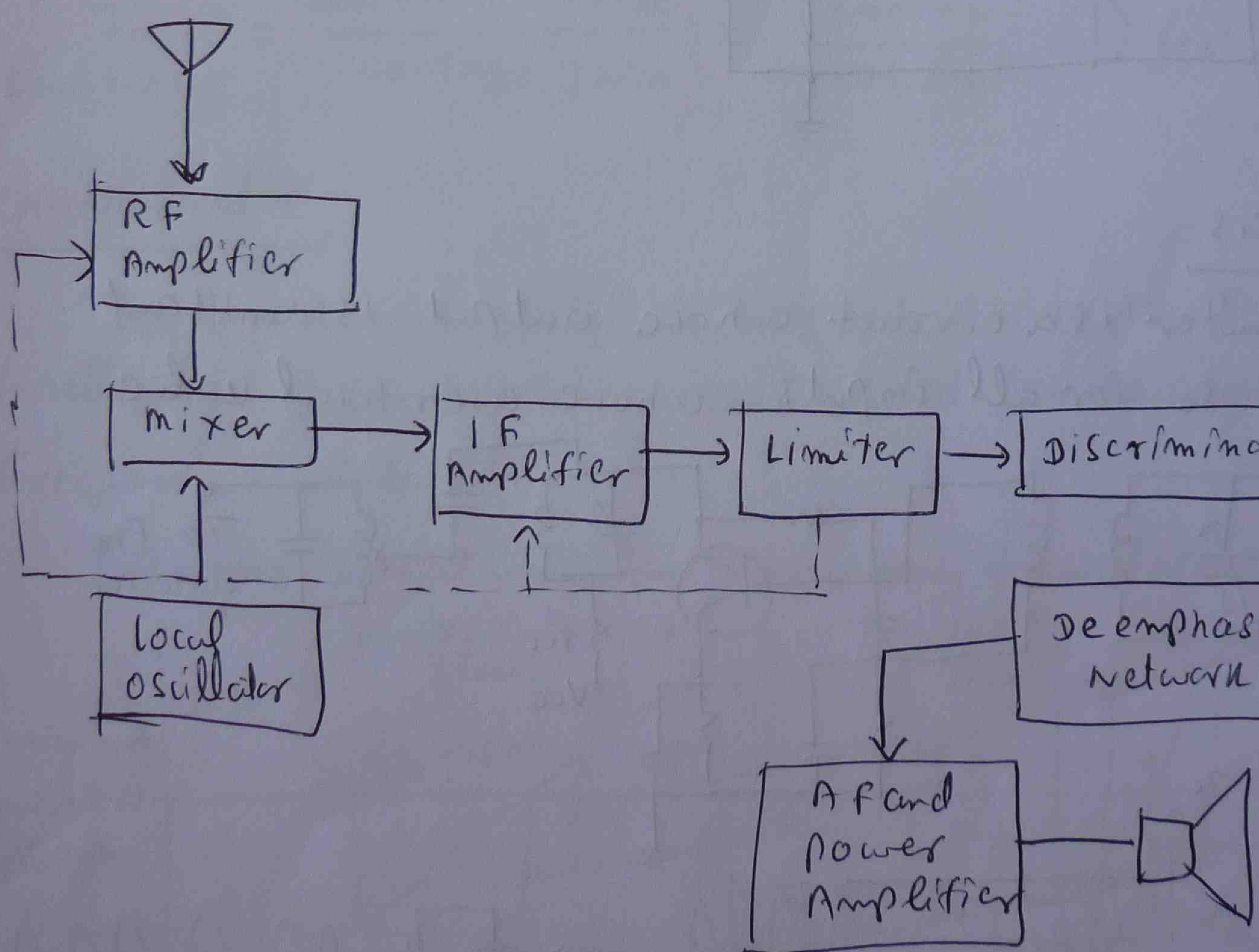
The discriminator extracts the intelligence from the high frequency carrier.

De-emphasis network

The deemphasis network following demodulation is required to bring the high frequency intelligence back to the proper amplitude relationship with the lower frequencies.

AFC - Automatic frequency control

This circuit provides a slight automatic control over local oscillator circuit.



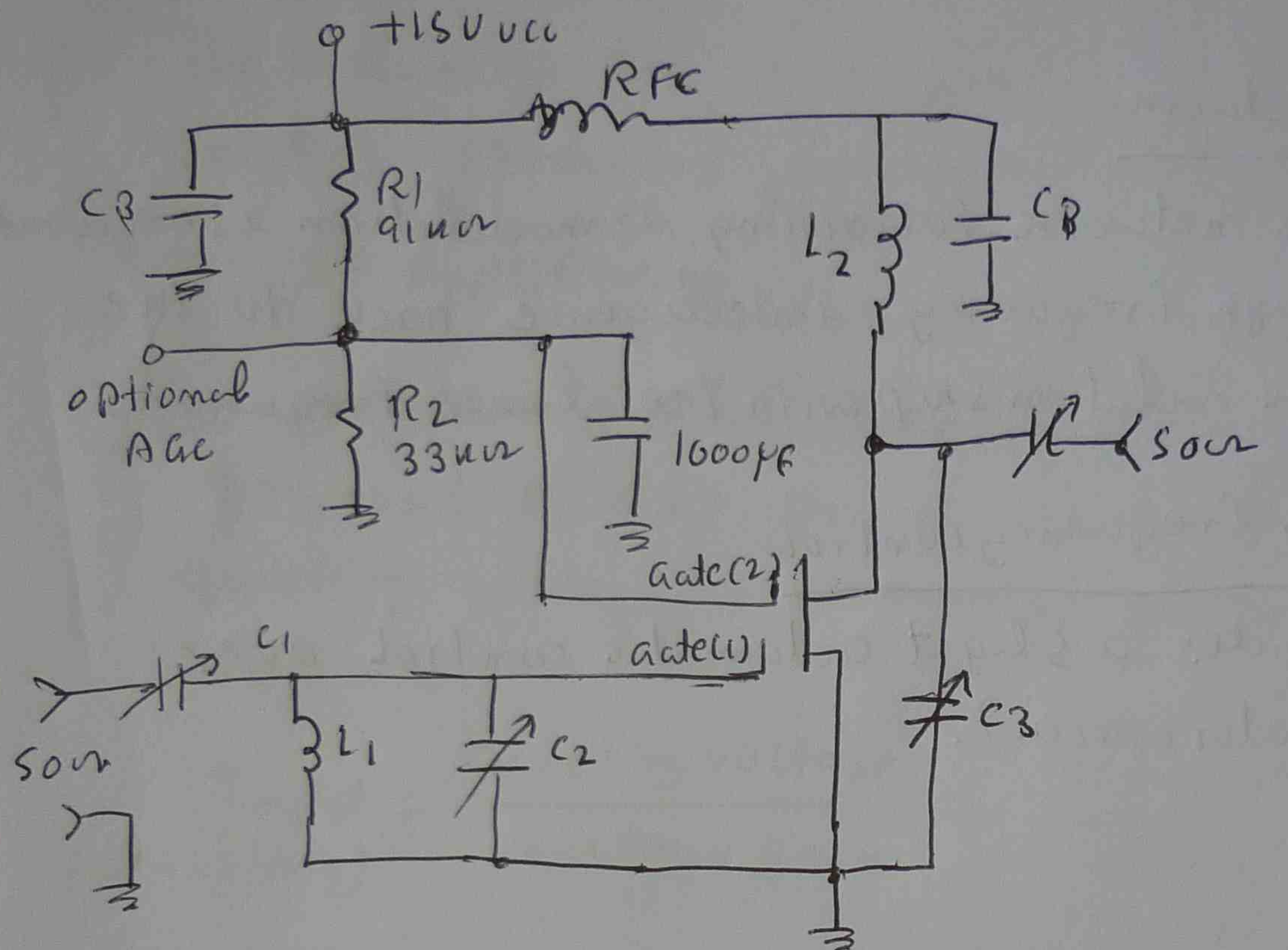
Standard IF frequency for FM = 10.7 MHz

RF Amplifier

RF amplifier reduces the image frequency problem.

Reduction in local oscillator reradiation effect.

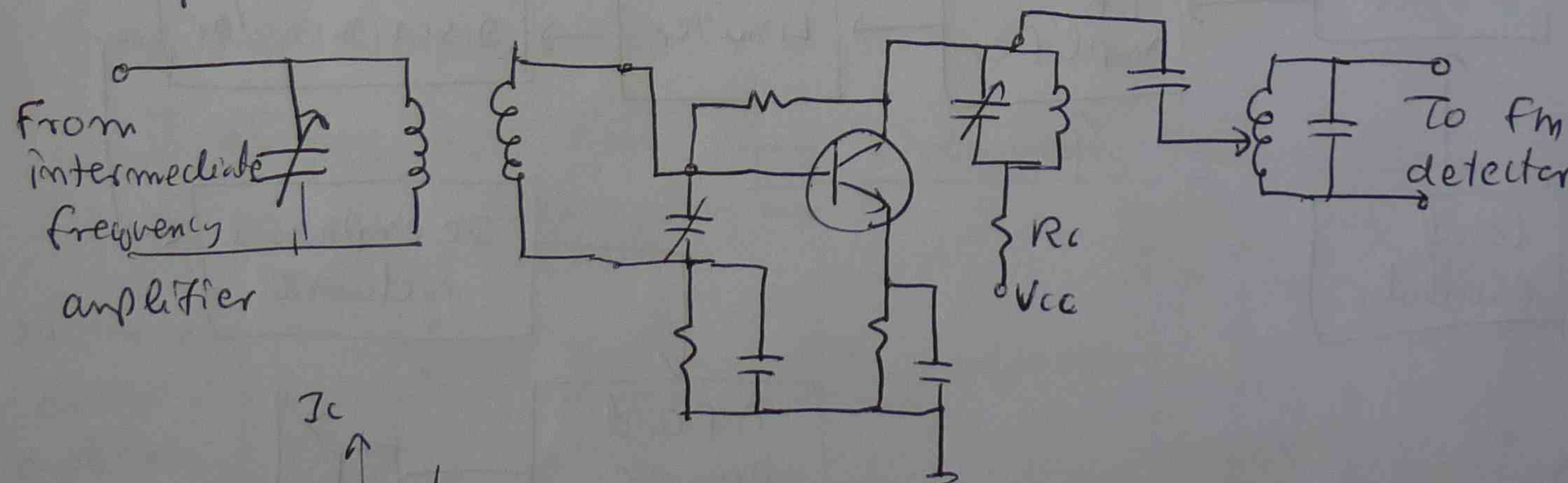
MOSFET RF Amplifier

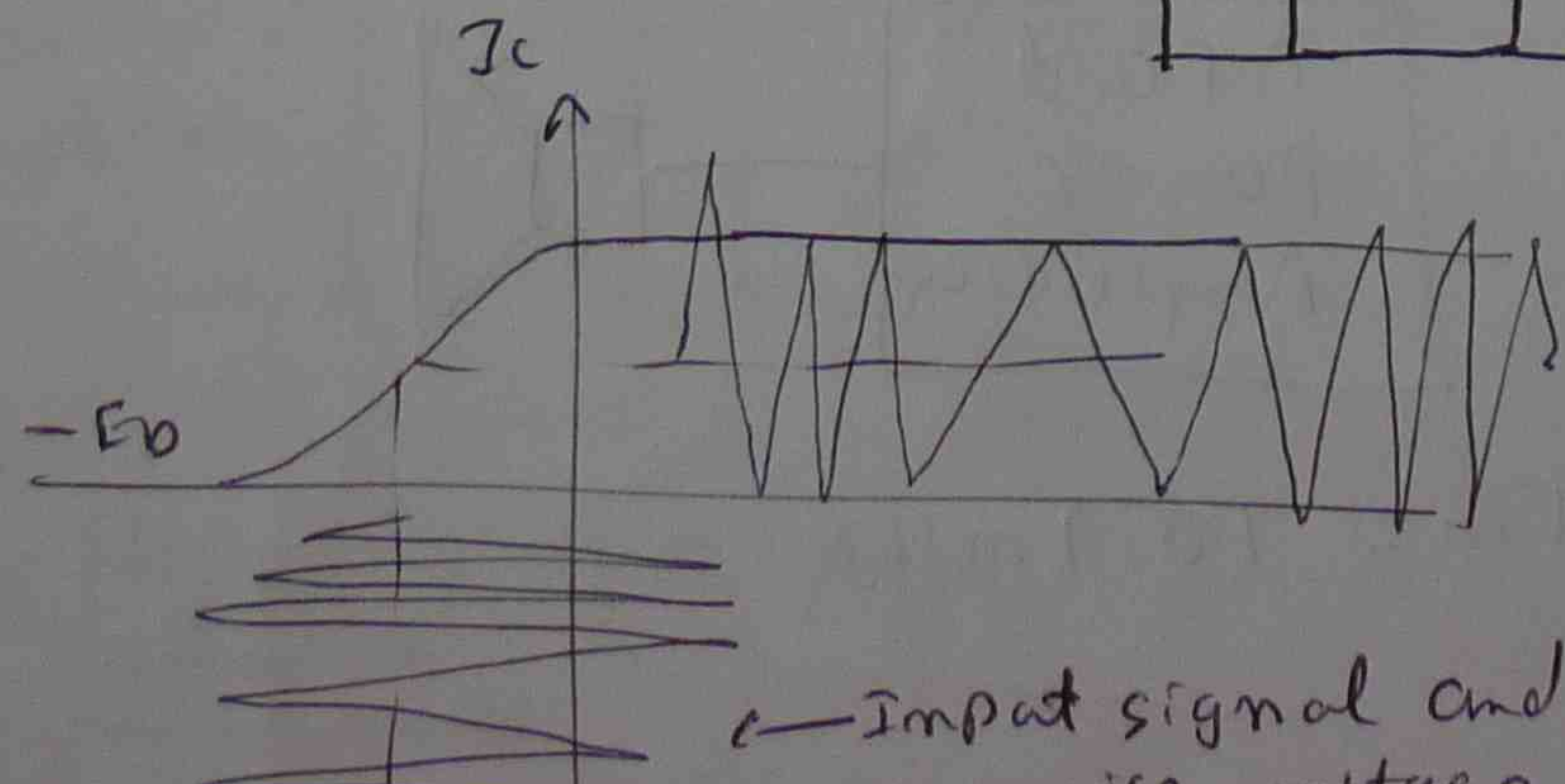


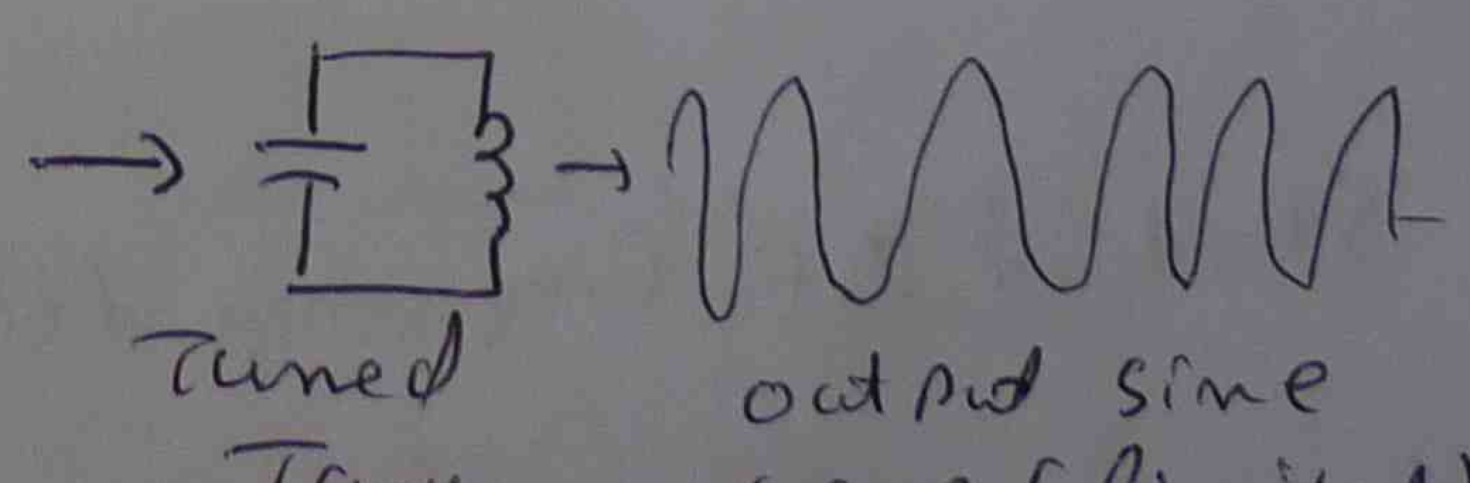
	100 MHz	400 MHz
C_1 =	8.4 pF	4.5 pF
C_2 =	2.5 pF	1.5 pF
C_3 =	1.9 pF	2.8 pF
C_4 =	4.2 pF	1.2 pF
L_1 =	150 mH	16 mH
L_2 =	280 mH	22 mH
C_B =	1000 pF	250 pF

Limiters

A limiter is a circuit whose output is constant amplitude for all inputs above a critical value







Sensitivity of FM Receiver

How much input signal into an FM receiver is required to produce a specific level of quieting normally 30dB.

The minimum required voltage for limiting is called quieting, threshold or limiting knee voltage.

IC IF Amplification

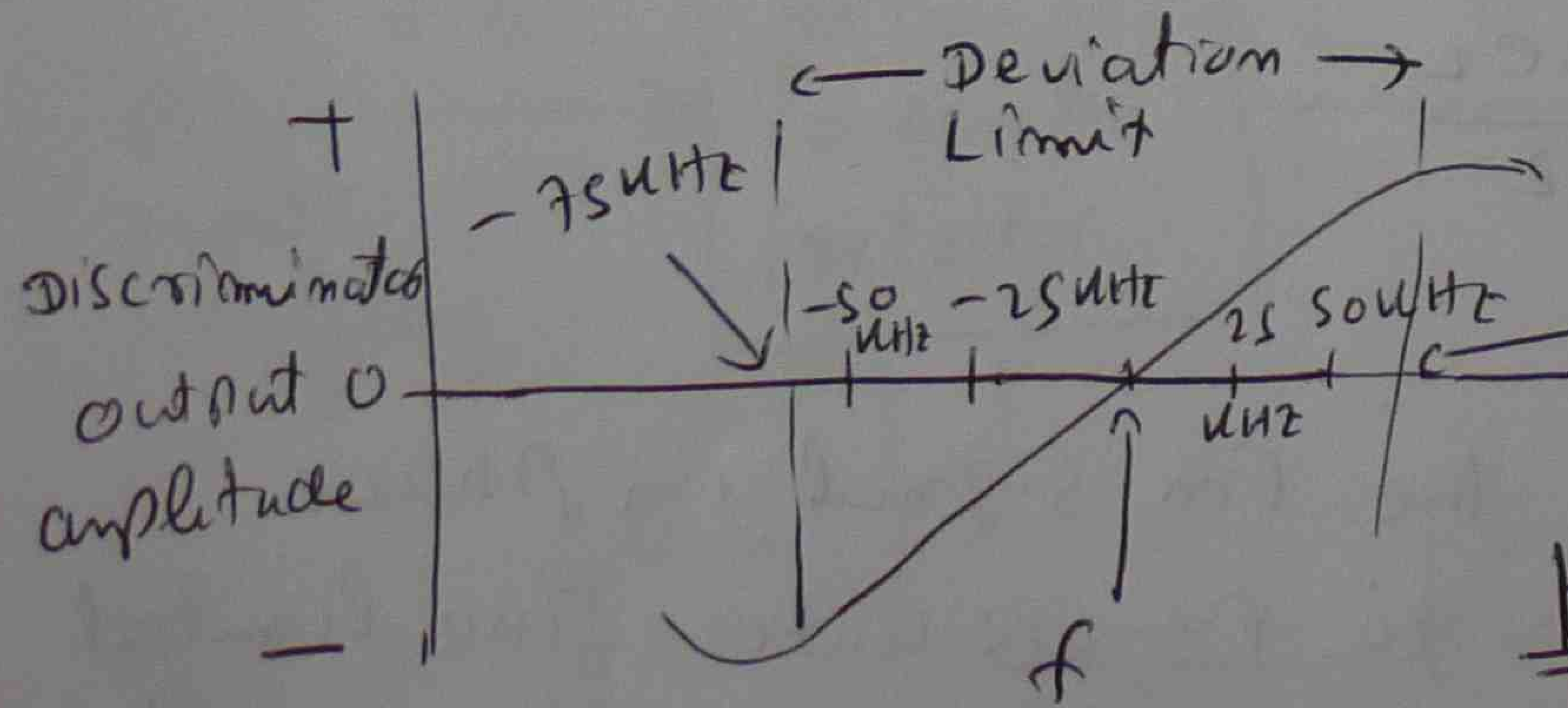
Pb A certain FM receiver provides a voltage gain of 200,000 (106 dB) prior to its limiter. The limiter's quieting voltage is 200 mV. Determine the receiver's sensitivity.

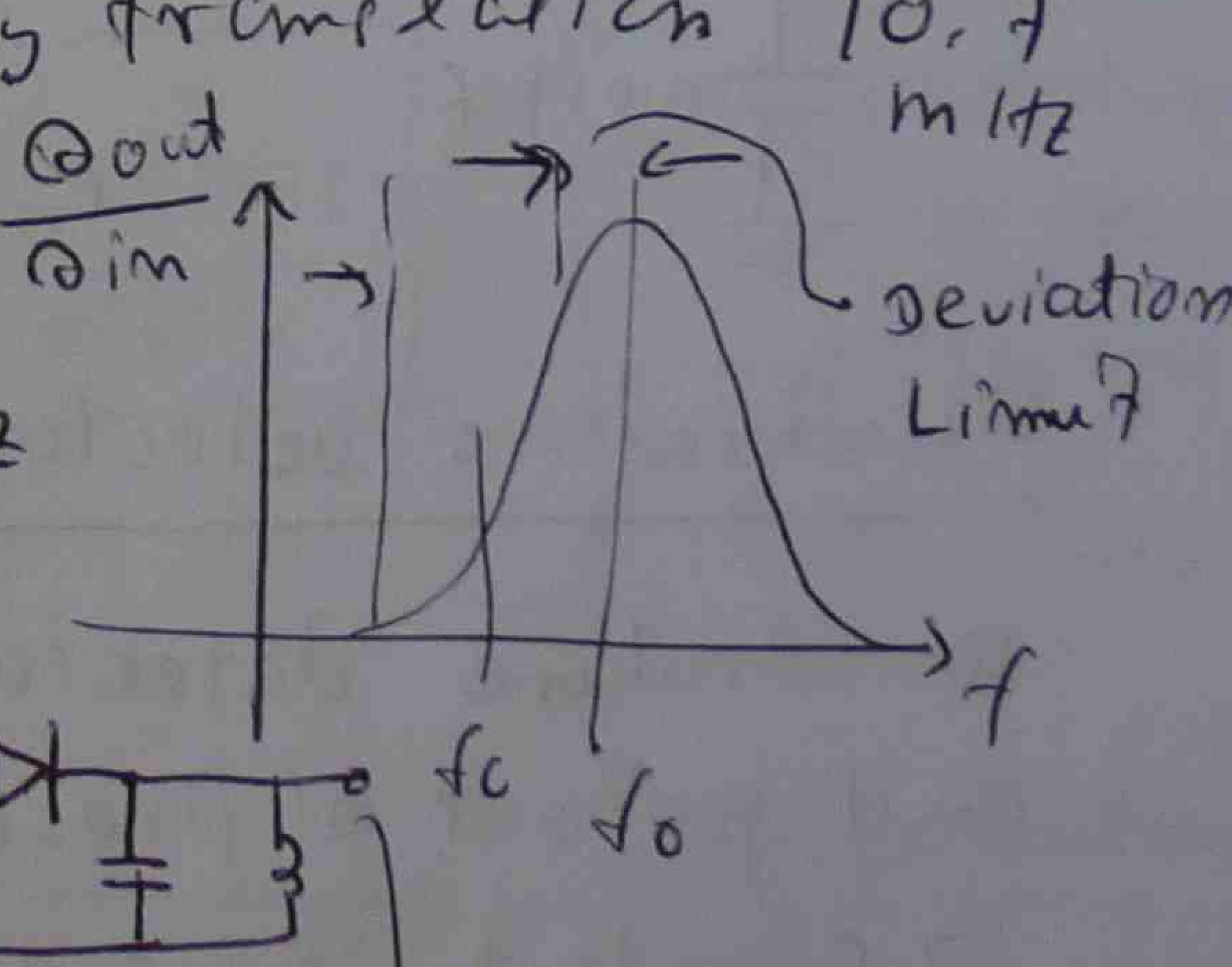
$$\text{Input (sensitivity)} = \frac{\text{quieting voltage}}{\text{voltage gain}} = \frac{200\,mV}{200{,}000} = 1\,\mu V$$

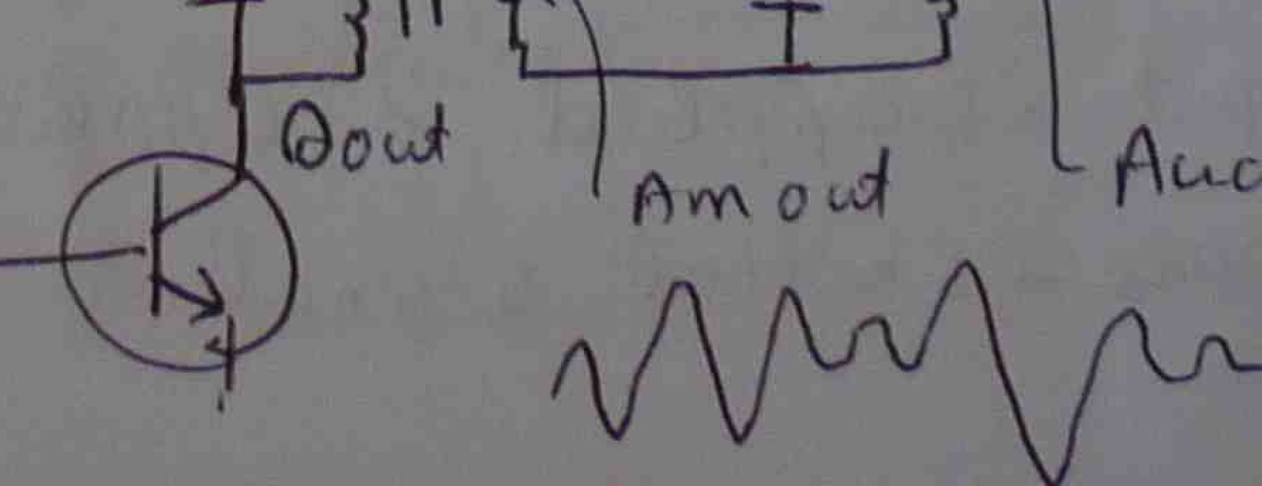
Discriminator

The FM discriminator (detector) extracts the intelligence that has been modulated onto carrier via frequency modulation.

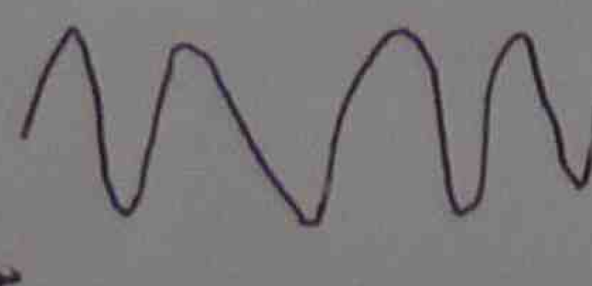
$\pm$ 75 kHz deviation $\longrightarrow$ frequency translation 10.7 MHz







Slope detection

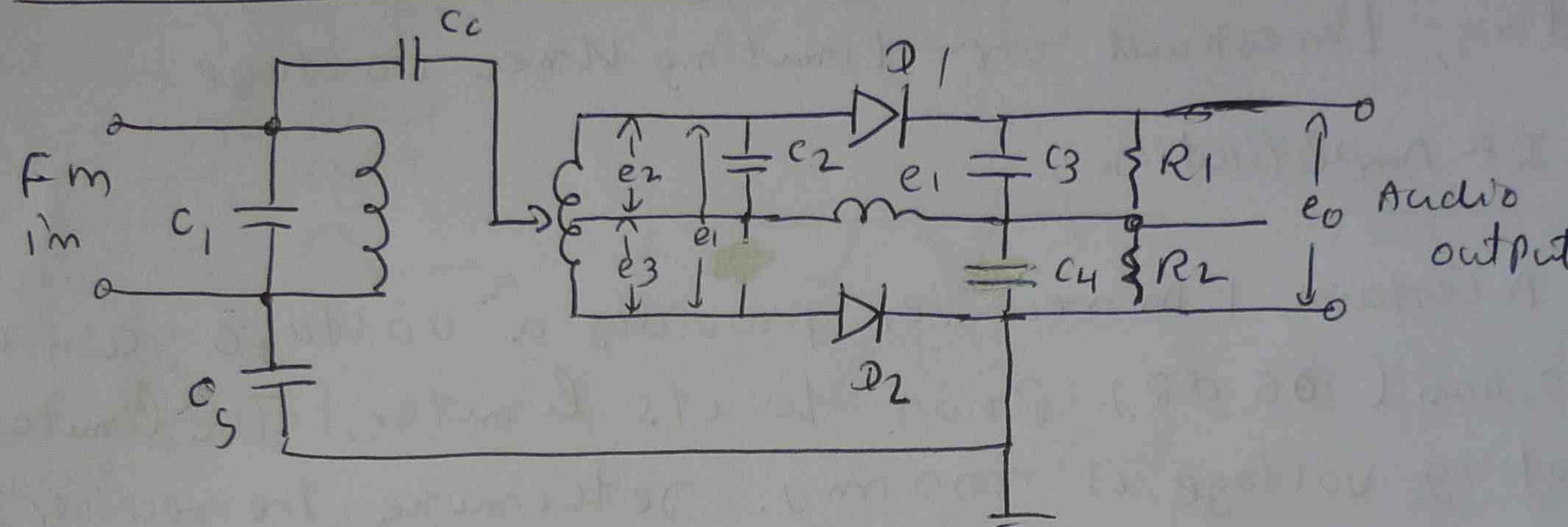


Slope detector

- Change fm in to Am.
- A simple diode detector recovers the ~~Am~~ intelligence contained in Am wave form 's envelope.

Foster - seely discriminator

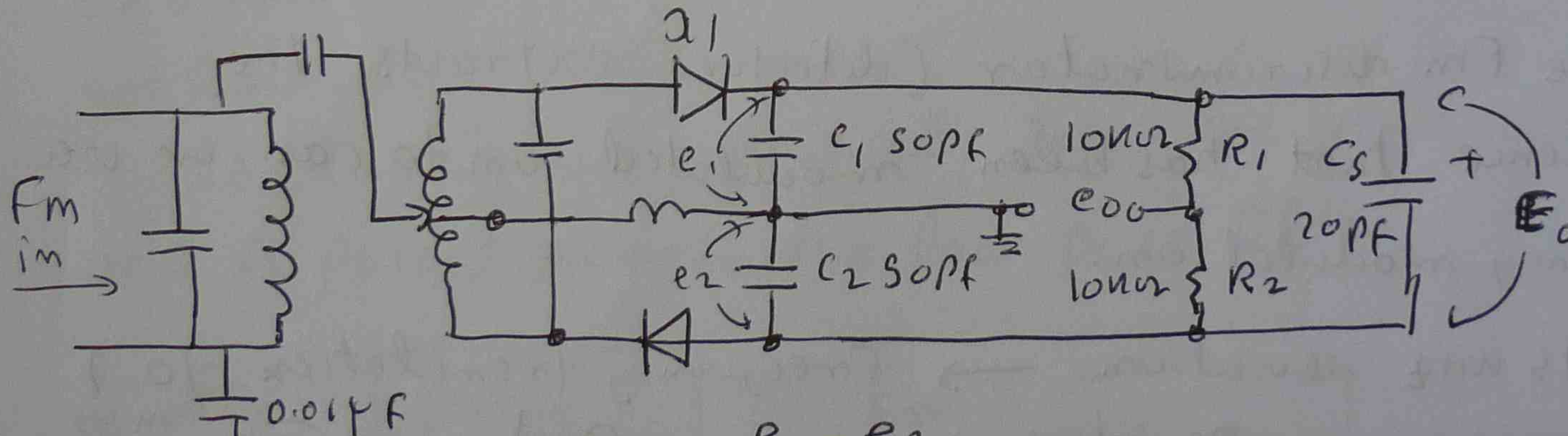
Fm detection



Ratio detector

excellent linear response to wide band Fm signals.

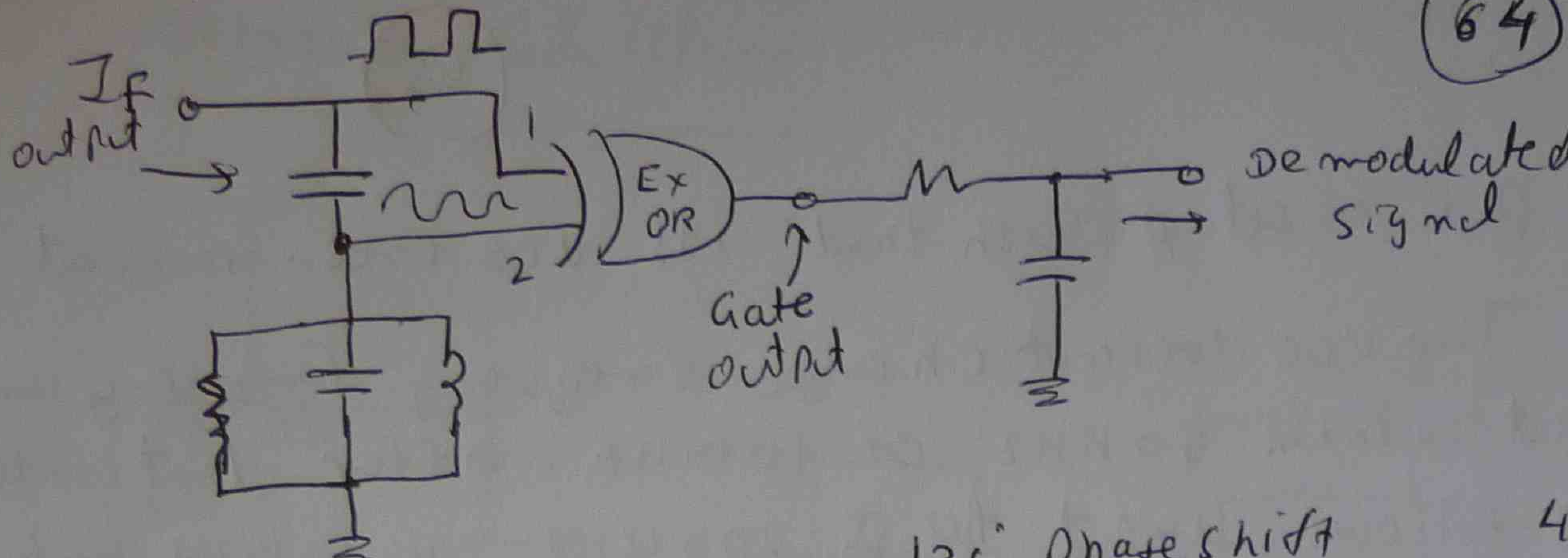
To respond only to frequency changes of input signal. Amplitude changes in the input have no effect upon the output.

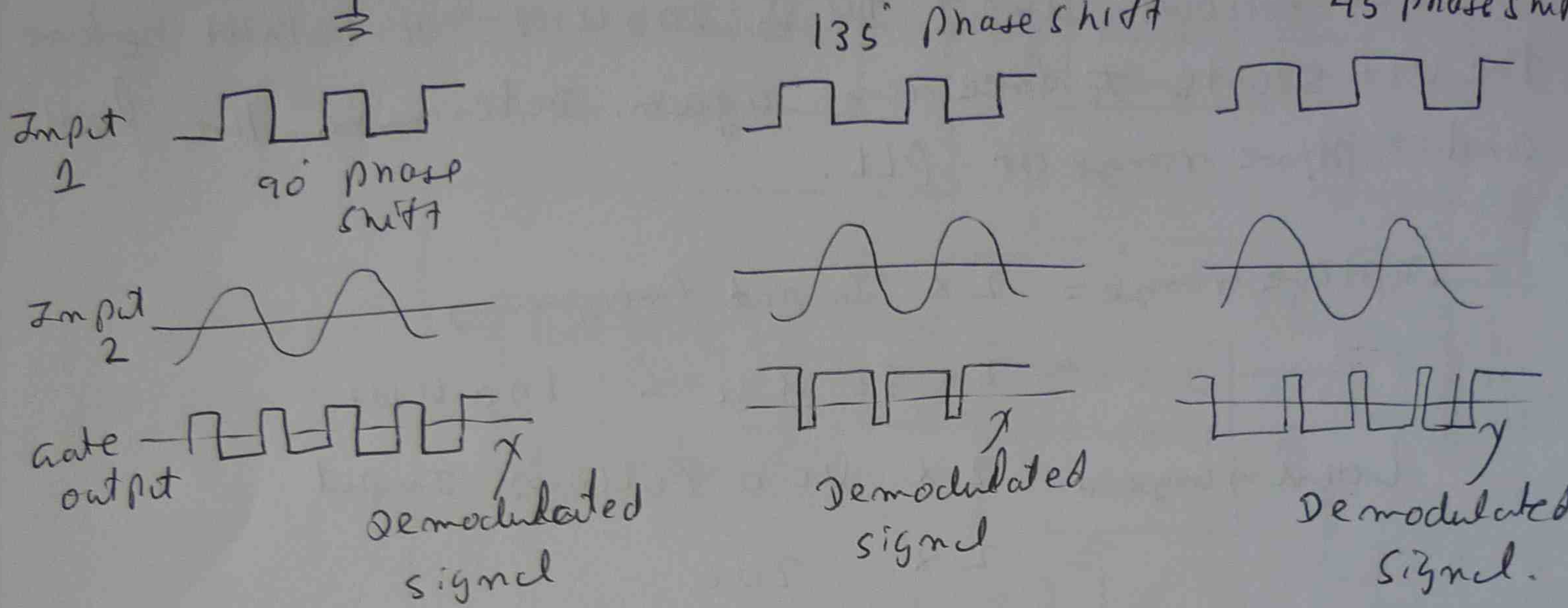


$$e_0 = \frac{e_1 - e_2}{2}$$

Quadrature Detector

Quadrature detector uses the fm signal in phase and 90° out of phase. Use 90 Ex-OR Gate. The limited IF output is applied is applied directly to one input and phase-shifted signal to other.

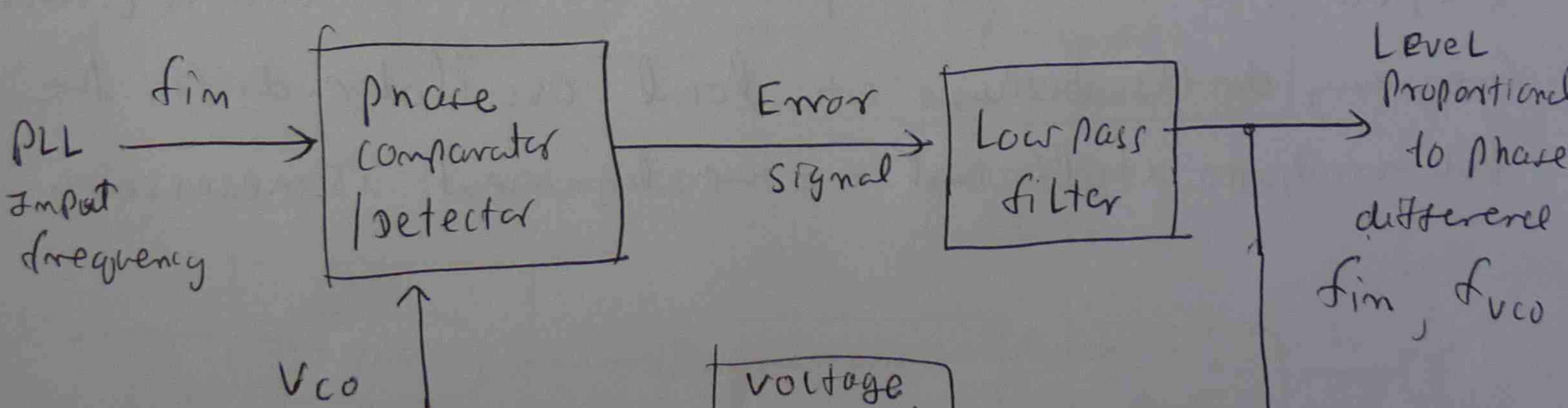




Phase locked loop (PLL)

The comparator compares the two signals and develop an output that is constant if the two input frequencies are identical.

If two are not identical, then the comparator's output is passed through the low pass filter.



PLL operation

Free running
capture
Lock / tracking

Pb

A PLL is setup such that its VCO free-runs at 10 MHz. The VCO does not change frequency frequency until the input within 50 kHz of 10 MHz. After that conditions the VCO follows input to ± 200 kHz of 10 MHz before the VCO starts to free run again. Determine the lock and capture range of PLL.

Capture range = 2 × Input frequency

= 2 × 50 kHz = 100 kHz

Lock range = 2 × VCO follows Input

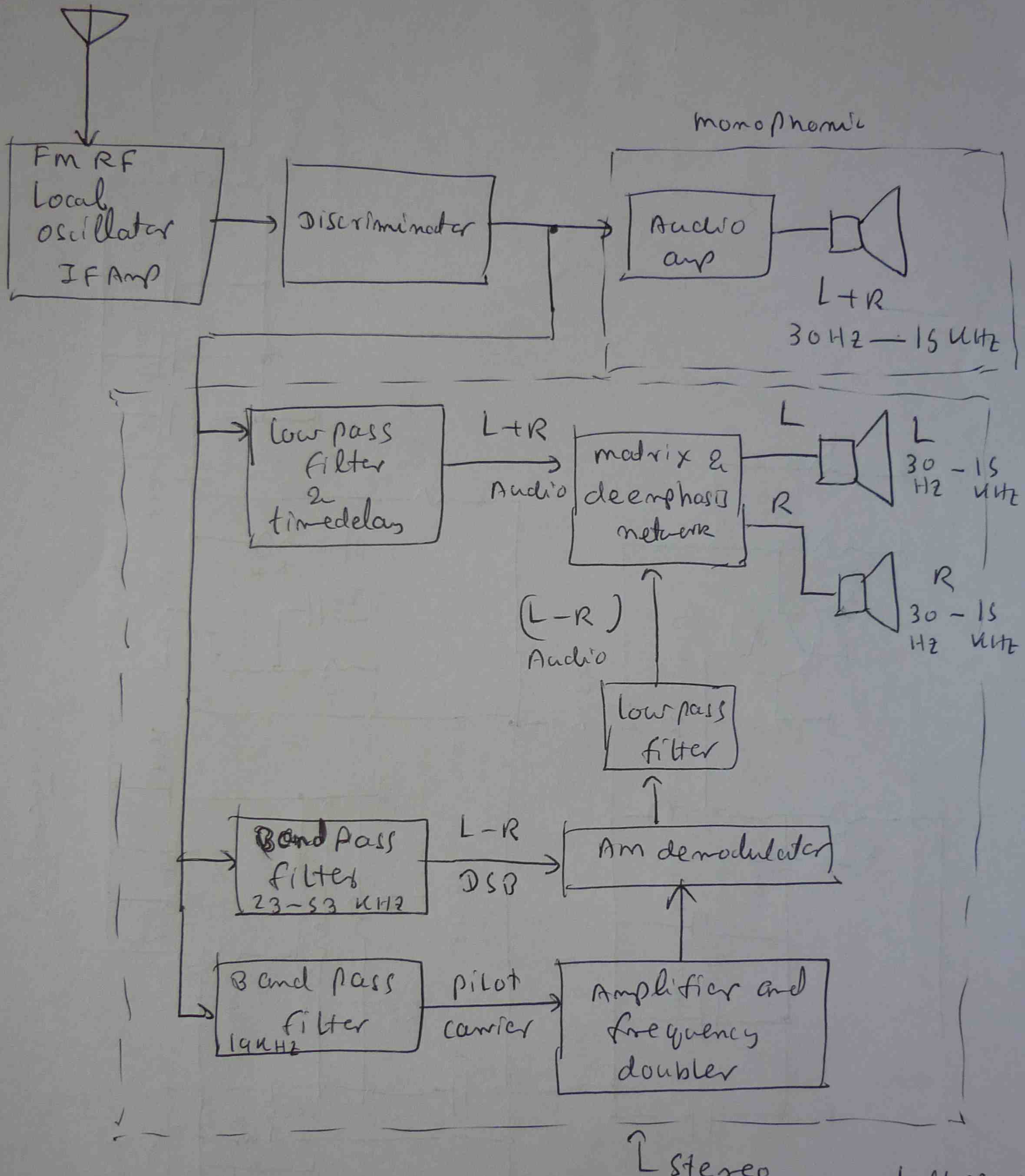
= 2 × 200

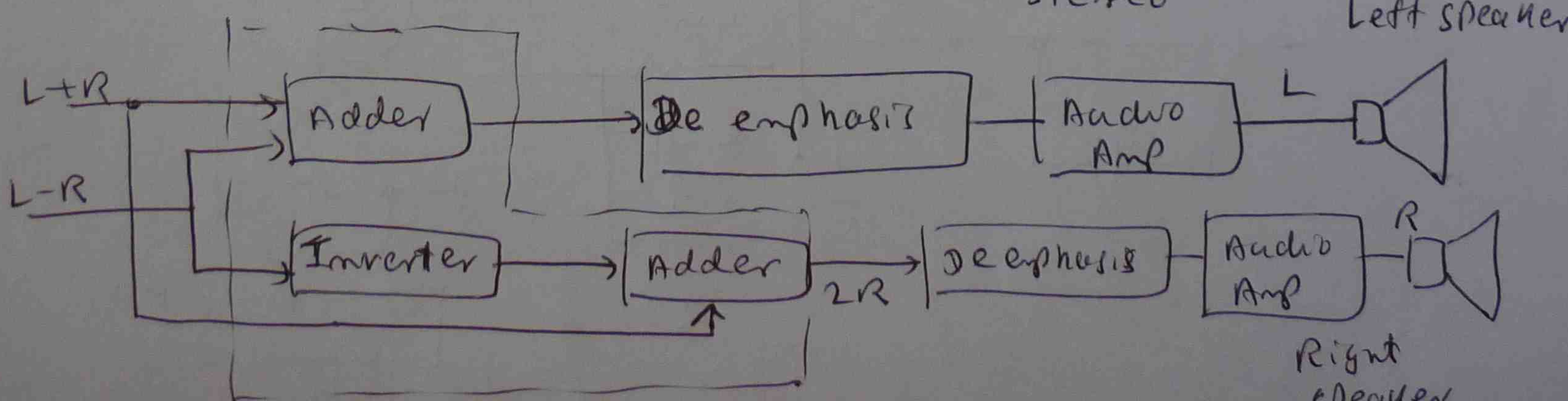
= 400 kHz

PLL FM Demodulator

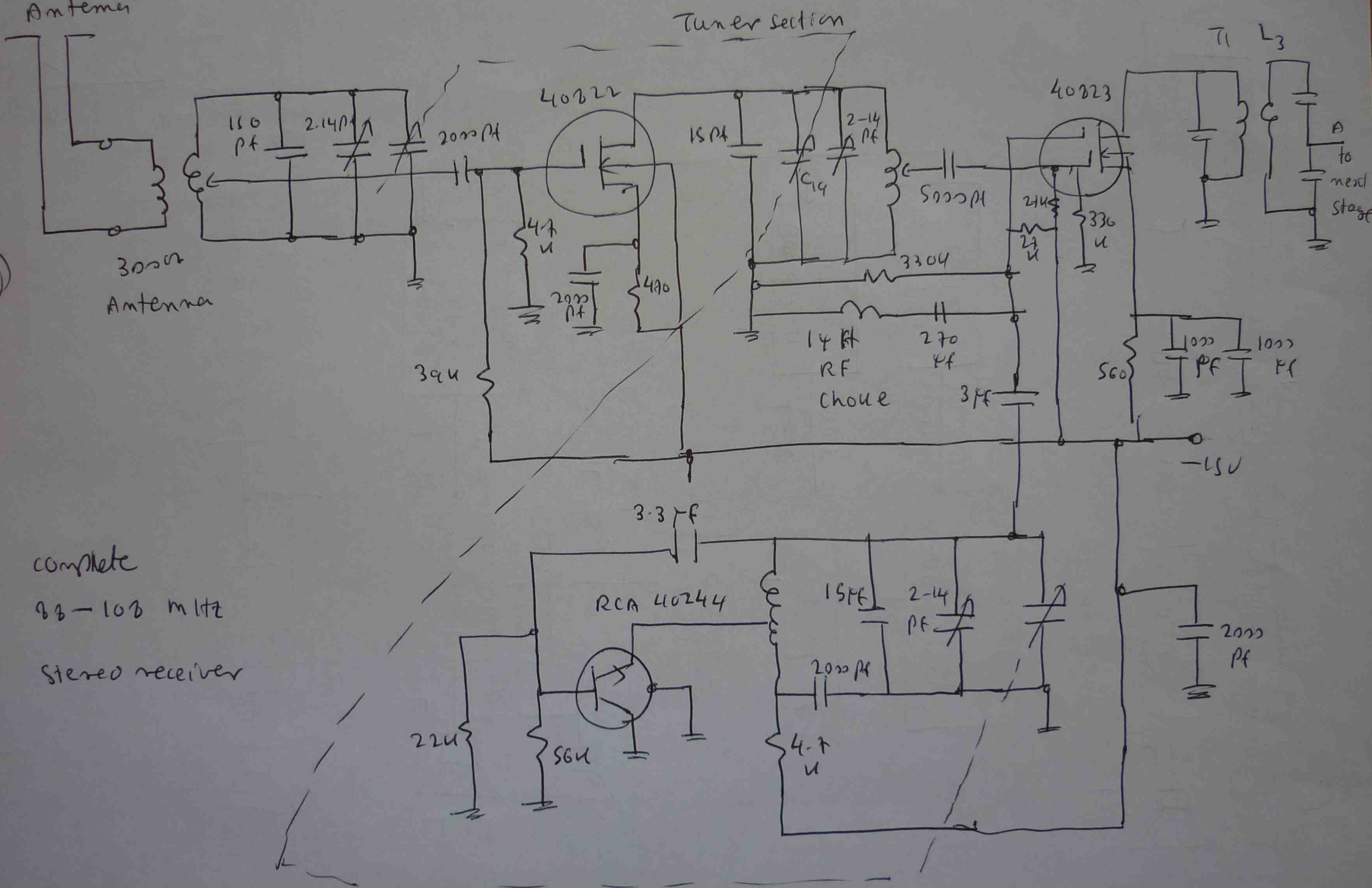
If the PLL Input is an FM signal, the low pass filter output (VCO Inputs) is the demodulated signal. The VCO input control signal (demodulated FM) causes the VCO output to match the FM signal applied to the PLL (comparator input). If the FM carrier (centers) frequency drifts because of local oscillator drift, the PLL readjusts itself and no realignment is necessary.

Stereo demodulation





FM Receiver



complete

88 — 108 MHz

stereo receiver

Communications techniques

Frequency conversion

Double conversion

The process of first stepping down the RF signal to a first, relatively high IF frequency and then mixing down again to a second, lower final IF frequency.

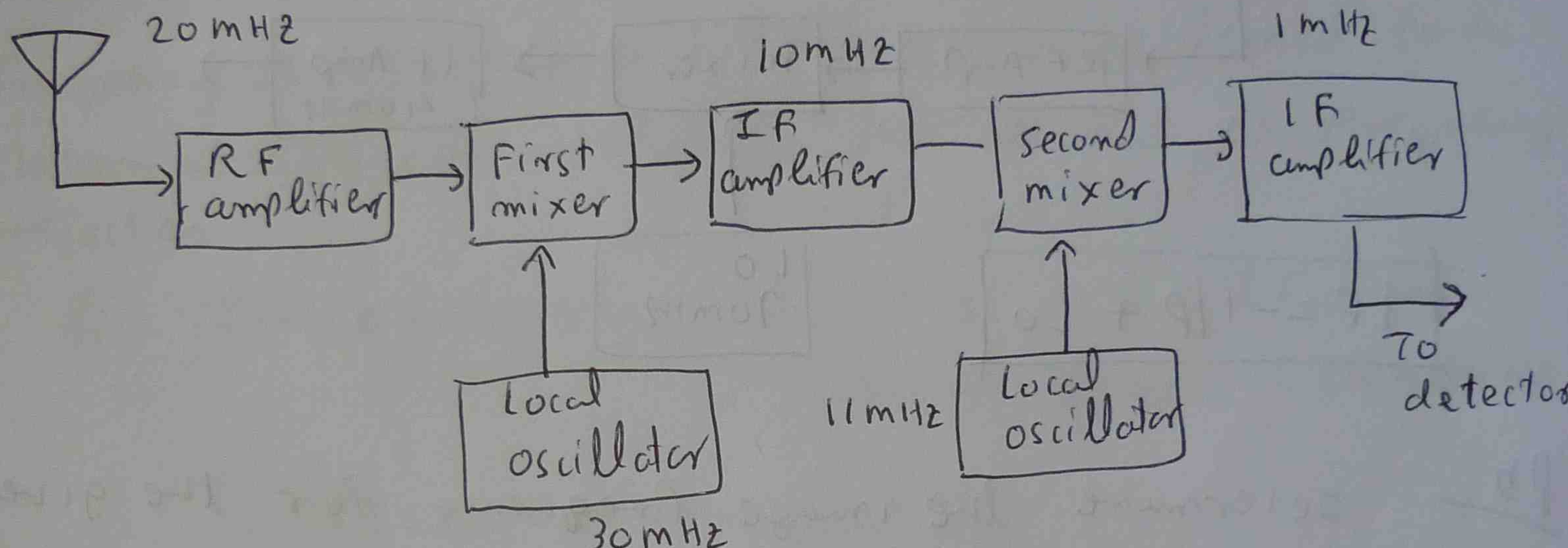


Image frequency = IF amplifier 10mHz + Local osillator 30mHZ = 40mHZ

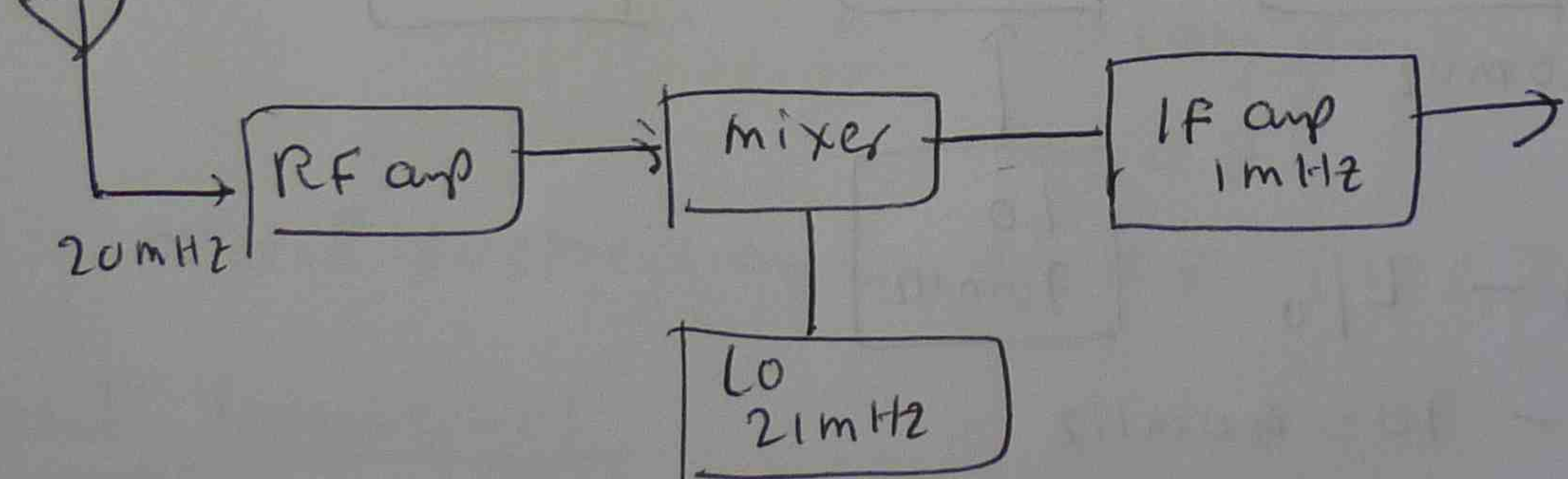


Image frequency = I~~f freq~~ + LO + IF amp

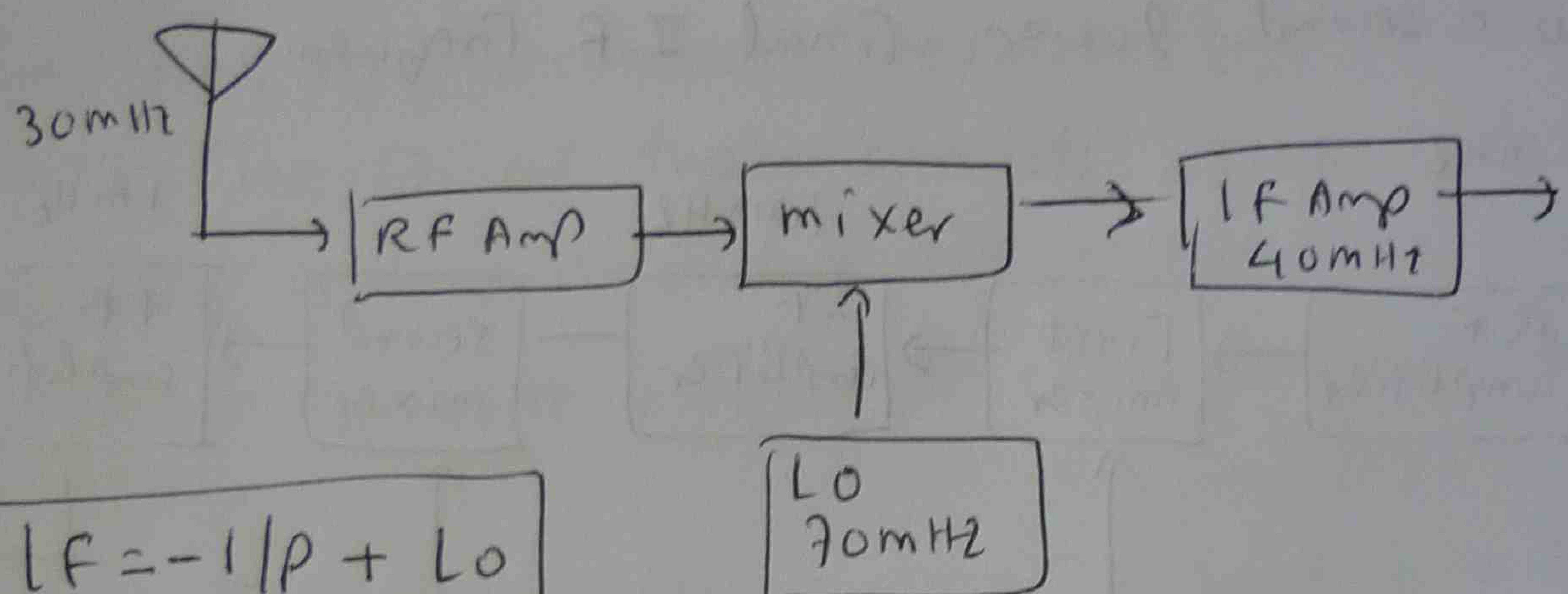
= ~~20~~ + 21 + 1

= 22 mHz

Image frequencies are not a major problem for low frequency carriers below 4mHz.

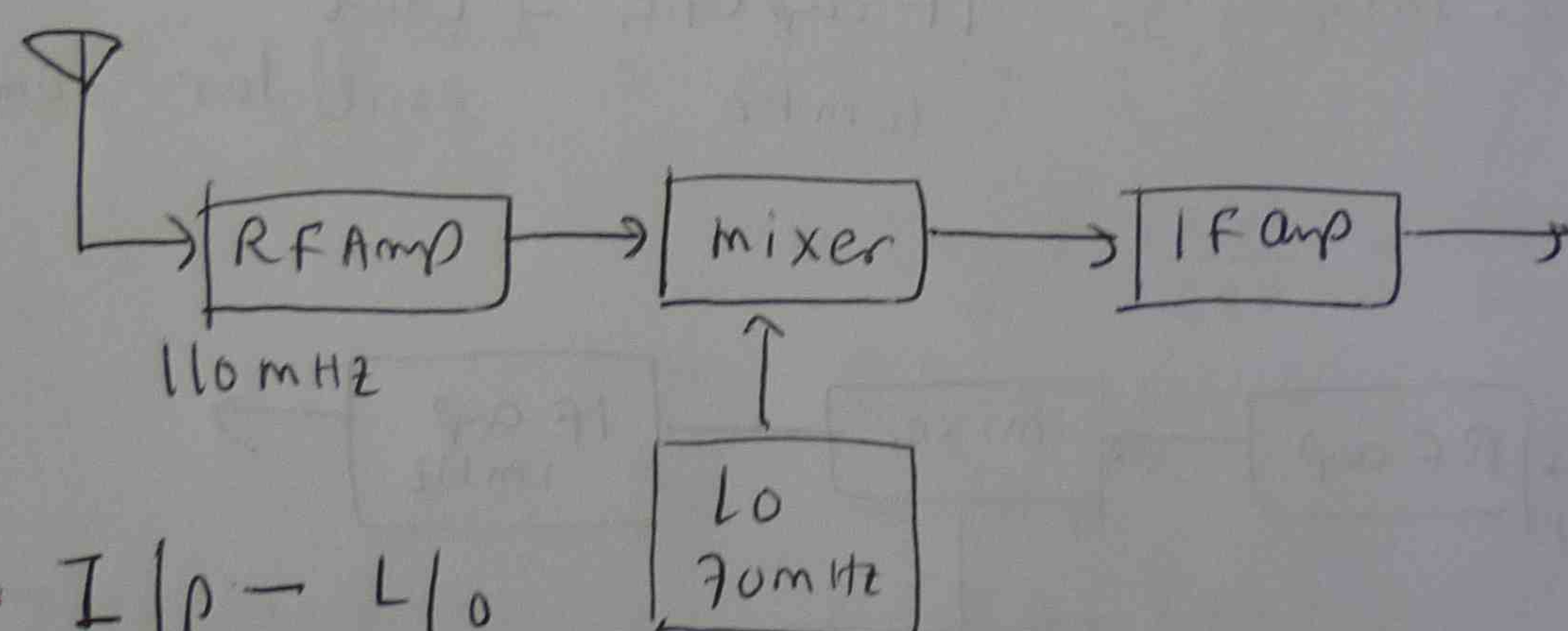
up conversion

The IF is a higher frequency than the received signal. The 70MHz local oscillator mixes with the 30MHz signal to produce the desired 40MHz IF. Sufficient selectivity at 40 MHz is possible with a crystal filter.



$$\boxed{IF = -I/P + LO}$$

Pb Determine the image frequency for the given system.



$$O/P = I/P - L/O$$
$$= 110 - 70 = 40 MHz$$

It needs a higher ~~Q~~ IF amplifier and better high frequency response IF transistor.

Tuned circuit prior to mixer

Preselector, responsible for frequency rejection

Image rejection dB = $20 \log \left[\frac{f_i}{f_s} - \frac{f_s}{f_i} \right] Q$

where f_i = Image frequency
f_s = desired signal frequency
Q = tuned circuit Q.

pb — An Am broadcast receiver has two identical tuned circuits. The Q of these circuits is 60 and the IF frequency is 455 KHz and the receiver is tuned to a station at 680 KHz. Calculate the amount of frequency rejection.

Desired signal (f_s)

f_i = Image frequency = tuned freq. + 2 × IF freq.
$= 680 + 2 \times 455 = 1590$ KHz

$f(s) = 680$ KHz

Image rejection (dB) $= 20 \log \left(\frac{f_i}{f_s} - \frac{f_s}{f_i} \right) Q$
$= 20 \log \left(\frac{1590}{680} - \frac{680}{1590} \right) 60$
$= 20 \log 114.6$
$= 41$ dB

Total suppression = 41 dB (or) 82 dB

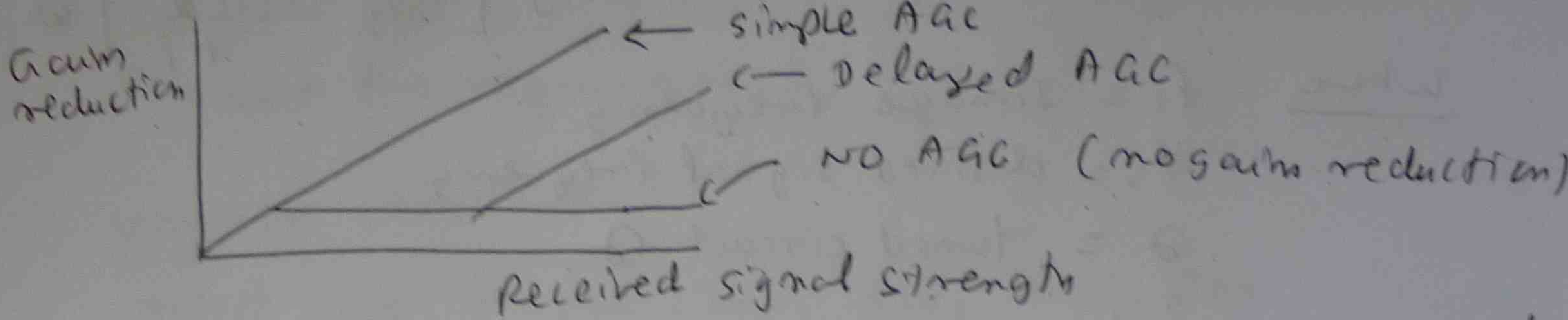
Special techniques

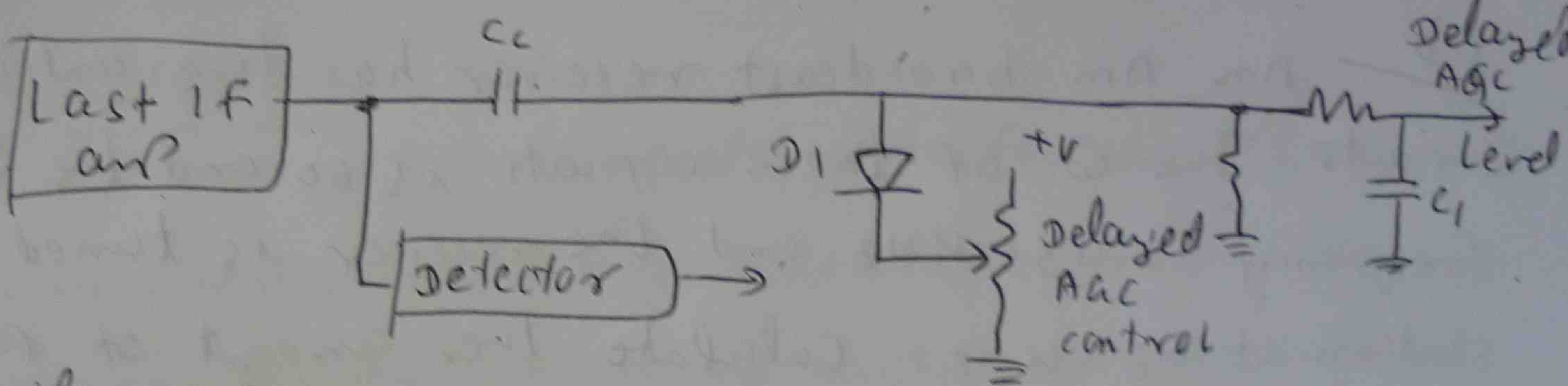
Delayed AGC -

Automatic Gain Control - As soon as even a weak received signal is tuned, simple AGC provides some gain reduction.

Delay AGC → The AGC does not provide any gain reduction until some arbitrary signal level is attained.

There fore no gain reduction for weak signals.

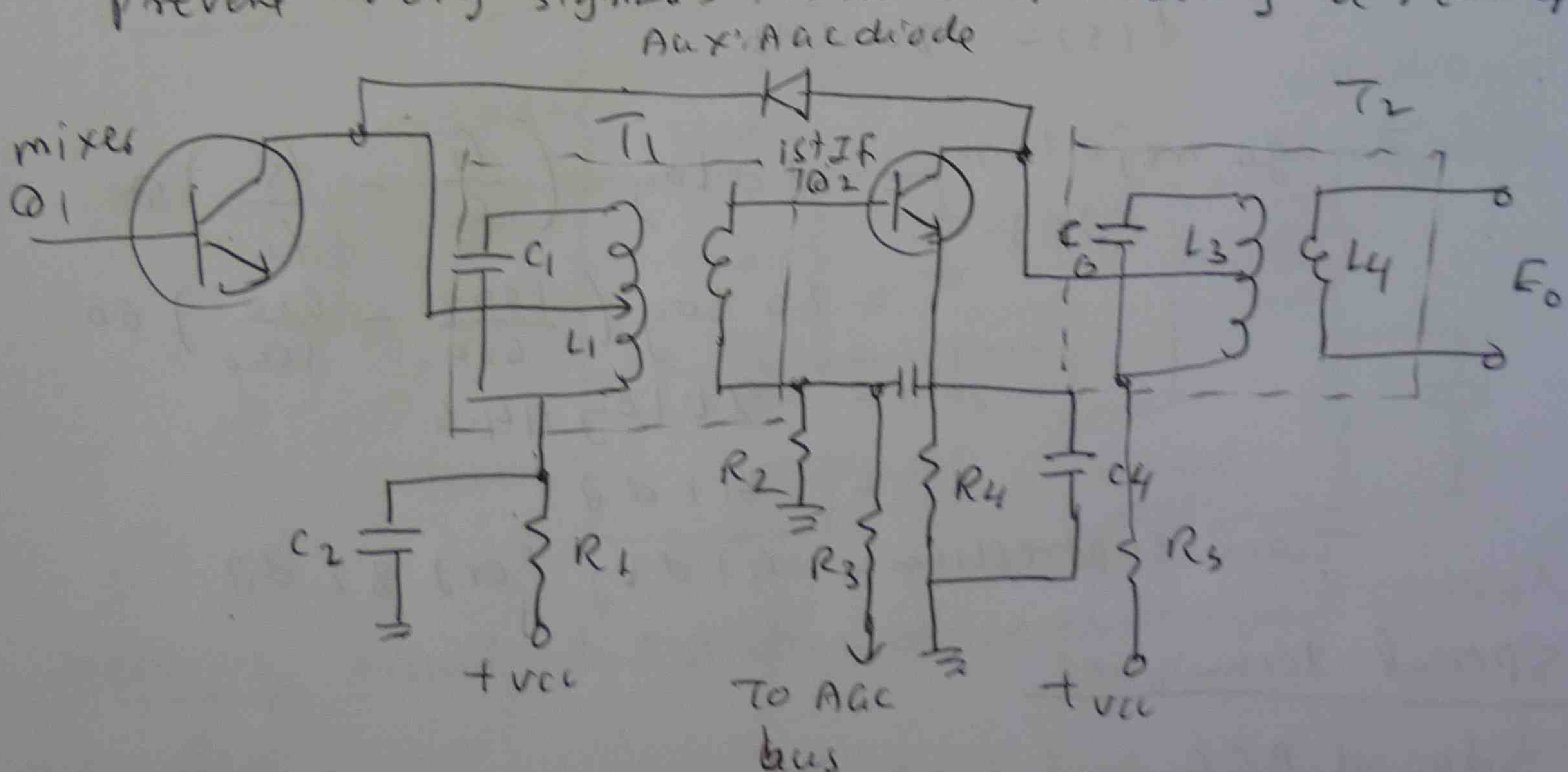




Auxiliary AGC

step reduction in receiver at some arbitrarily high value of received signal.

Prevent very signals from over loading a receiver.



Band spreading

Spreading of tuning indications over a wide scale range to ~~fa~~ facilitate tuning in a crowded band of frequencies.

Variable sensitivity

User control the receiver gain (and thus sensitivity) to suit the requirement.

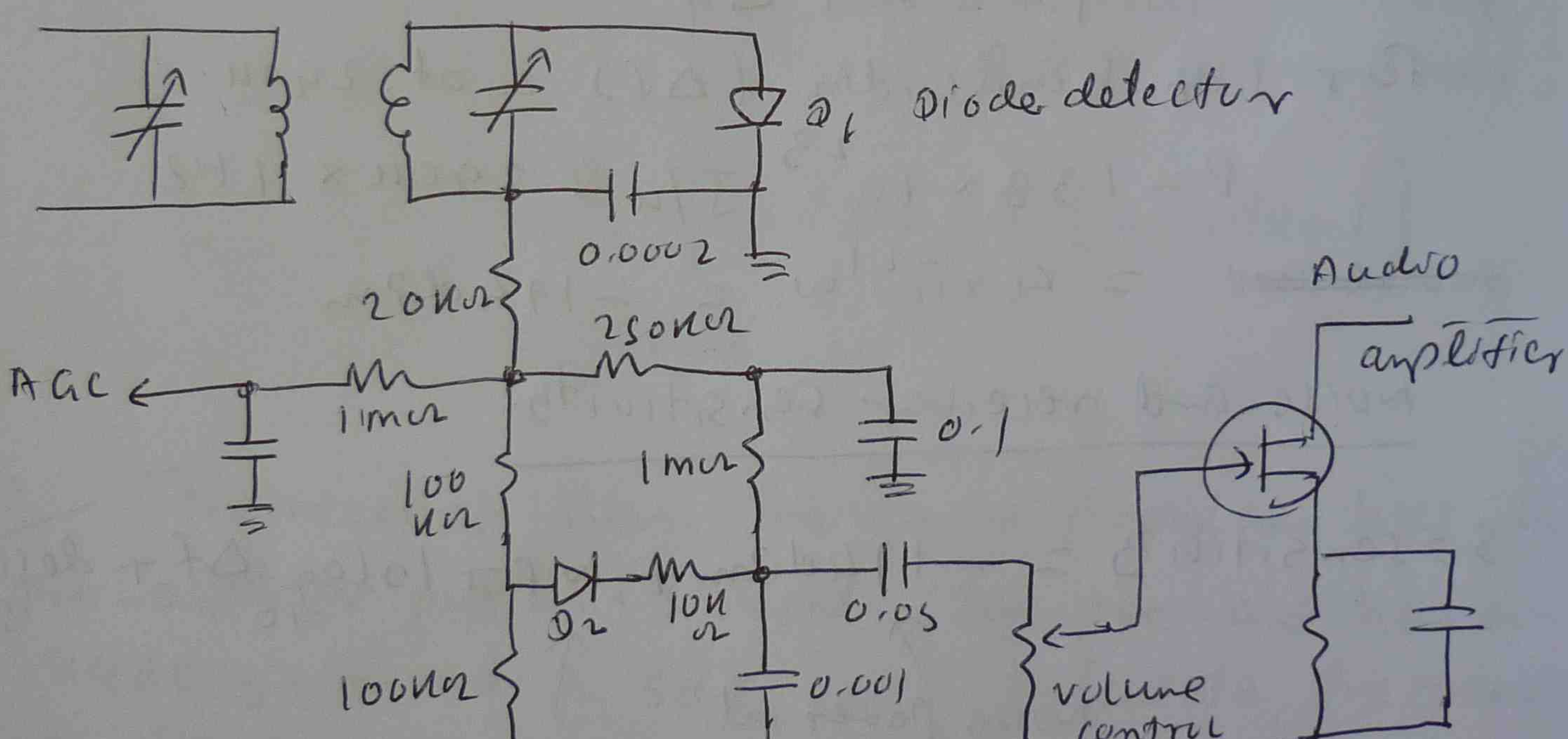
Variable selectivity

Detect code transmissions. SSB, AM, FM.

Noise Limiter

Reception of Electromagnetic interference (EMI) by a receiver creates undesired amplitude modulation.

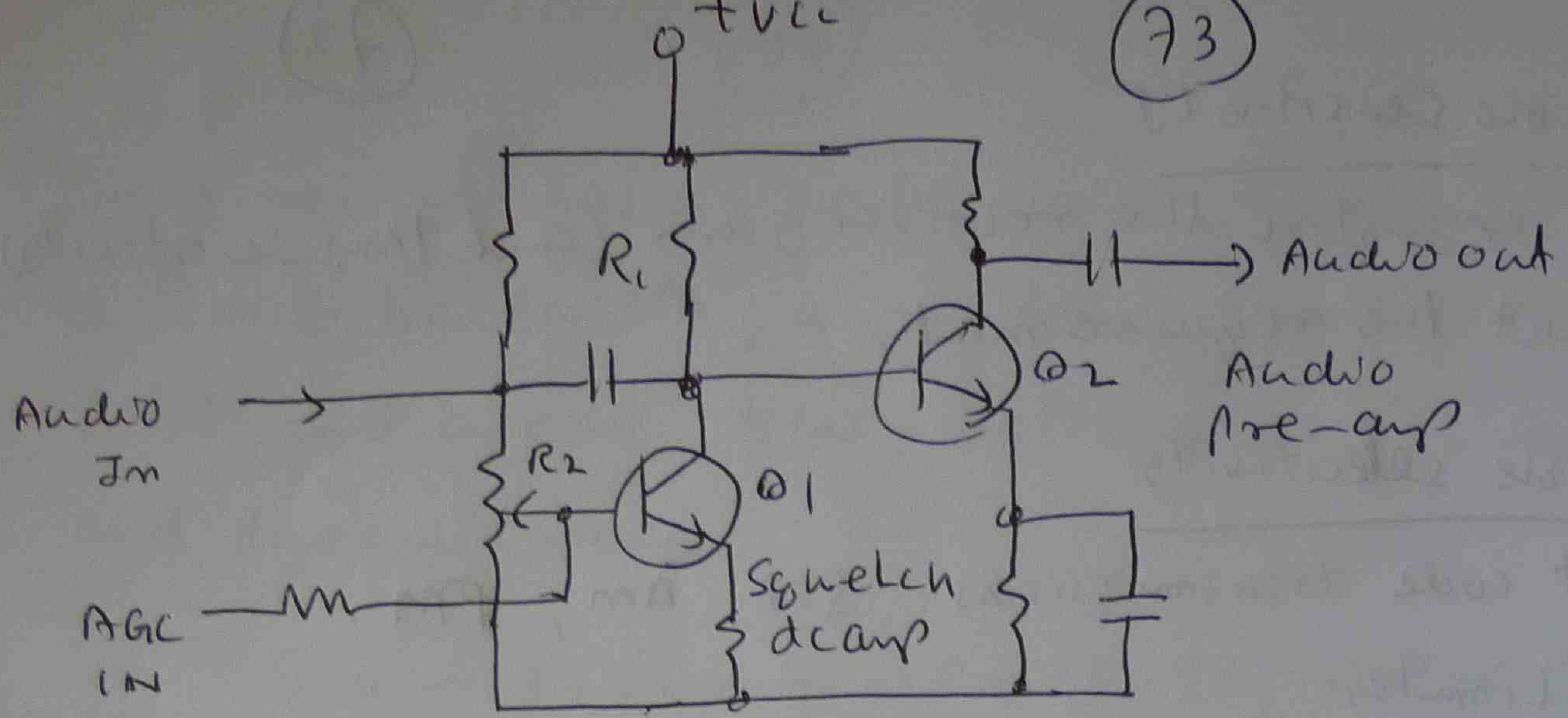
A noise limiter circuit is employed to silence the receiver for the duration of a noise pulse.



metering visual identification of received signal strength.

Squelch minimizing noise output that occurs when ~~tuning~~ tuning between stations.

Quieting / Q circuit / muting.



Receiver noise, sensitivity dynamic range relationships

Noise power

$$P_n = KT\Delta f$$

for 1 Hz bandwidth (Δf) & at 290K

$$P = 1.38 \times 10^{-23} \text{ J/K} \times 290\text{K} \times 1\text{ Hz}$$

~~Noise ...~~ $= 4 \times 10^{-21}\text{ W} = -174\text{ dBm}$

Noise and receiver sensitivity

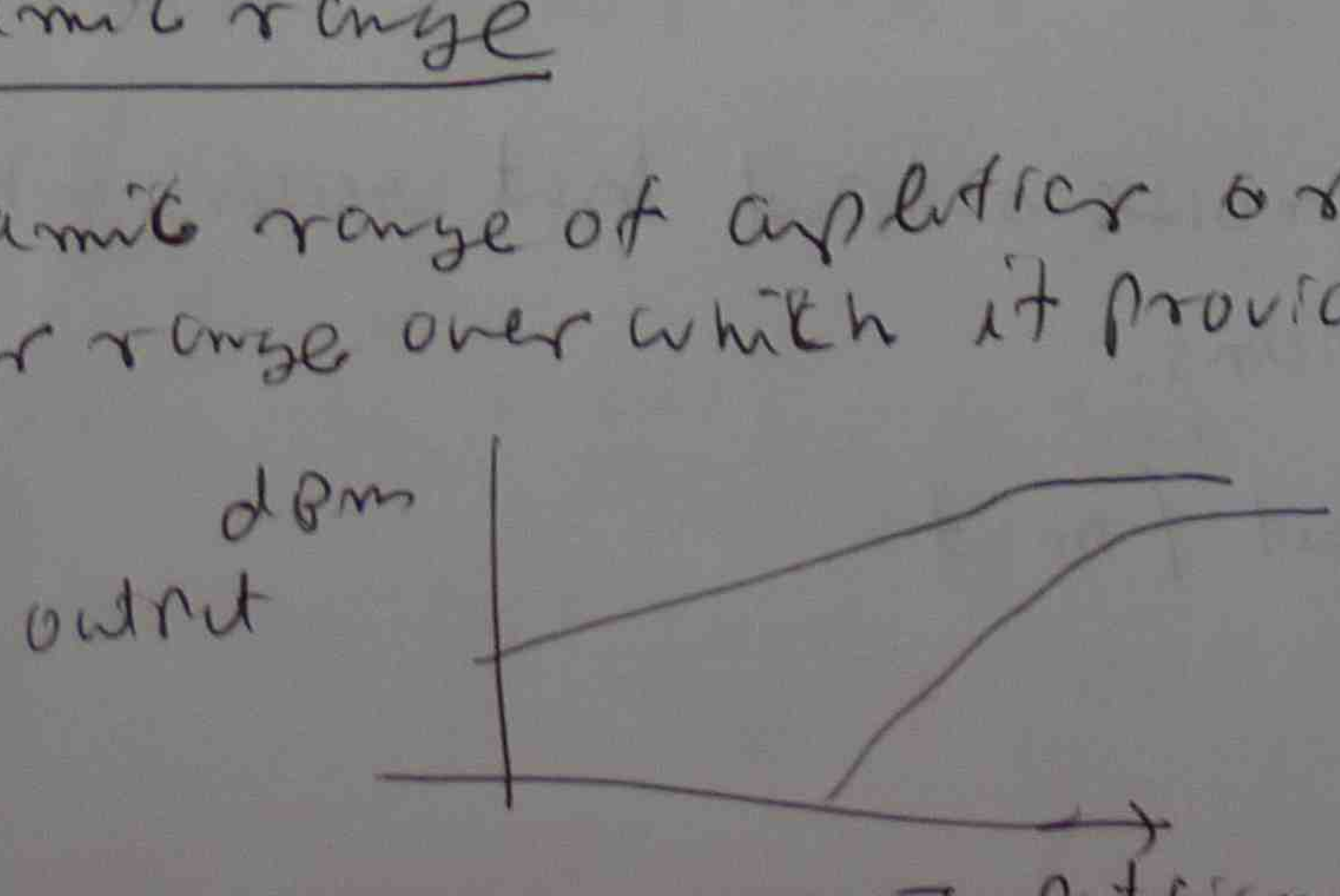
S = sensitivity = -174 dBm + NF + $10\log_{10}\Delta f$ + desired S/N

Noise power at room temperature

noise figure

Dynamic range

Dynamic range of amplifier or receiver is the input power range over which it provides a useful output.



Pb A receiver has a 20dB noise figure (NF), a 1MHz bandwidth, a +5dBm third order intercept point, and a 0dB S/N. Determine its sensitivity and dynamic range.

$$S = -174\,dBm + NF + 10\log_{10}\Delta f + \frac{S}{N}$$

$$= -174\,dBm + 20\,dB + 10\log_{10} 10^6 + 0$$

$$= -94\,dBm$$

Dynamic range $= \frac{2}{3}\left[3^{rd} \text{ order intercept point} - \text{noise floor} \right]$

$$= \frac{2}{3}\left[5\,dBm - (-94\,dBm) \right]$$

$$= 66\,dB$$

Pb The receiver from the above problem has a pre-amplifier put at its input. The pre-amp has a 24dB gain and a 5dB NF. Calculate the new sensitivity and dynamic range. desired S/N = 60 dB

upto NF = 20dB; $10\log_{10}\Delta f$

$$S = -174\,dBm + NF + S/N + 10\log_{10}\Delta f$$

$$NR = \log^{-1}\frac{NF}{10}$$

$$NR_1 = \log^{-1}\frac{5dB}{10} = 3.16$$

$$NR_2 = \log^{-1}\frac{20dB}{10} = 100$$

~~$PG_1 = NR_1 +$~~

$$PG_1 = \log^{-1}\frac{\text{gain}}{10}$$

$$= \log^{-1}\frac{24}{10} = 251$$

75

~~$NR = 10\log_{10}\left(NR_1 + \frac{NR_2 - 1}{PG_1}\right)$~~

$$NR = NR_1 + \frac{NR_2 - 1}{PG_1}$$

$$= 3.16 + \frac{100-1}{251} = 3.55$$

$$NF = 10\log_{10} NR = 10\log_{10} 3.55 = 5.5\,dB$$

total system NF

$$S = -174\,dBm + NF + \log_{10}\Delta f + \frac{S}{N}$$

Noise floor $= -174 + 5.5 + 60 = -108.5\,dBm$

Dynamic range (dB) $= \frac{2}{3}\left(\text{third order intercept point} - \text{noise floor}\right)$

$$= \frac{2}{3}\left[(NF - \text{gain}) - S\right]$$

$$= \frac{2}{3}\left[(5 - 24) - (-108.5)\right]$$

$$= 59.7\,dB$$

Pb The 24dB gain pre-amp in above Pb is replaced with a 10dB (PG_1) gain pre-amp with the same 5dB NF. What is the system's sensitivity and dynamic range?

$$NR = NR_1 + \frac{NR_2 - 1}{PG_1}$$

$$= 3.16 + \frac{100-1}{10} = 13.1$$

$$Nf = 10\log_{10} NR = 10\log_{10} 13.1 = 11.2\,dB$$

$$S = -174\,dBm + Nf + \log_{10}\Delta f + \frac{N}{R}$$

$$= -174 + 11.2 + 60 = -102.8\,dBm$$

$$\text{Dynamic range} = \frac{2}{3}\left(\text{Third order intercept point} - \text{Noise floor}\right)$$

$$= \frac{2}{3}\left((Nf - \text{gain}) - S\right)$$

$$= \frac{2}{3}\left((5 - 10) - (-102.8)\right)$$

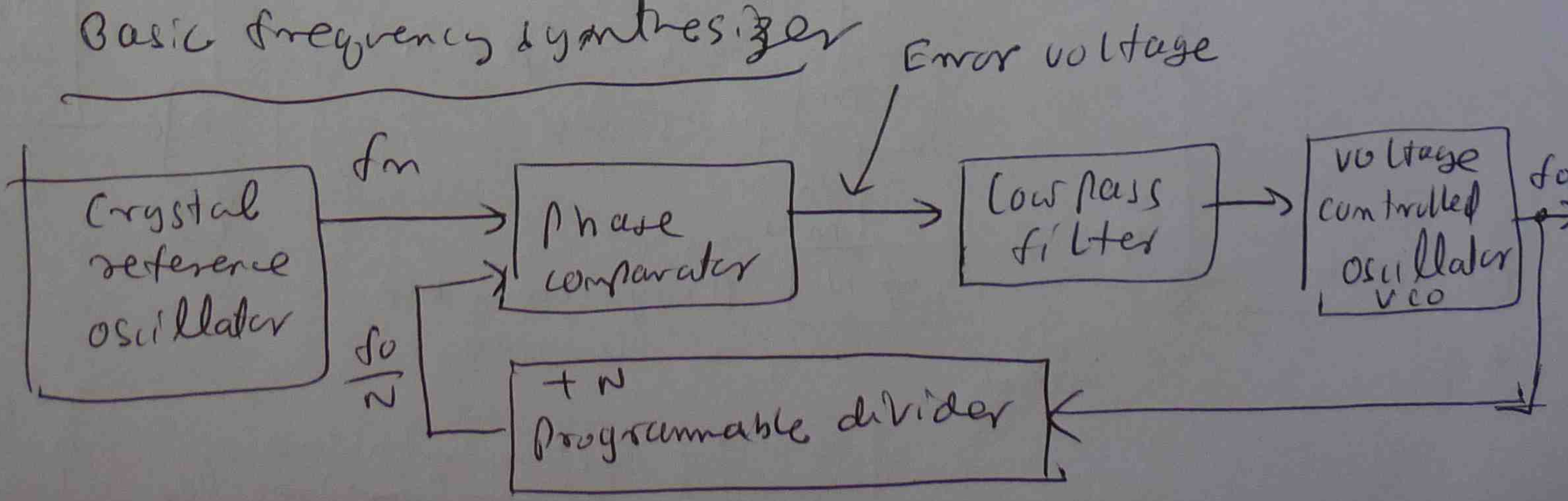
$$= \frac{2}{3}\left(-5 + 102.8\right) = \cancel{65.28}$$

$$= 65.2\,dB$$

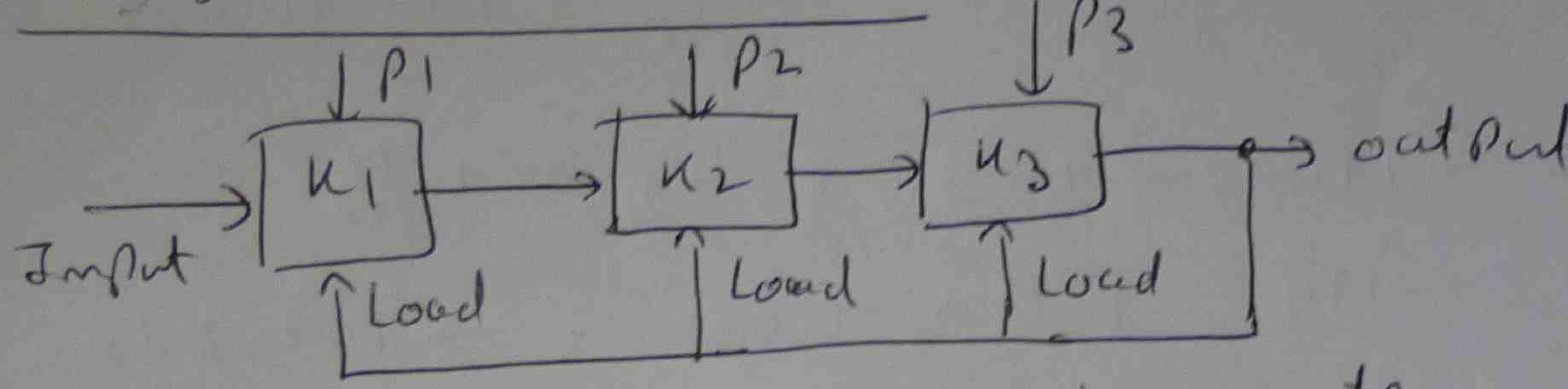
Frequency synthesis

most new transceiver designs use frequency synthesizers to generate the highly accurate frequencies used for the transmitter carrier and receiver local oscillator.

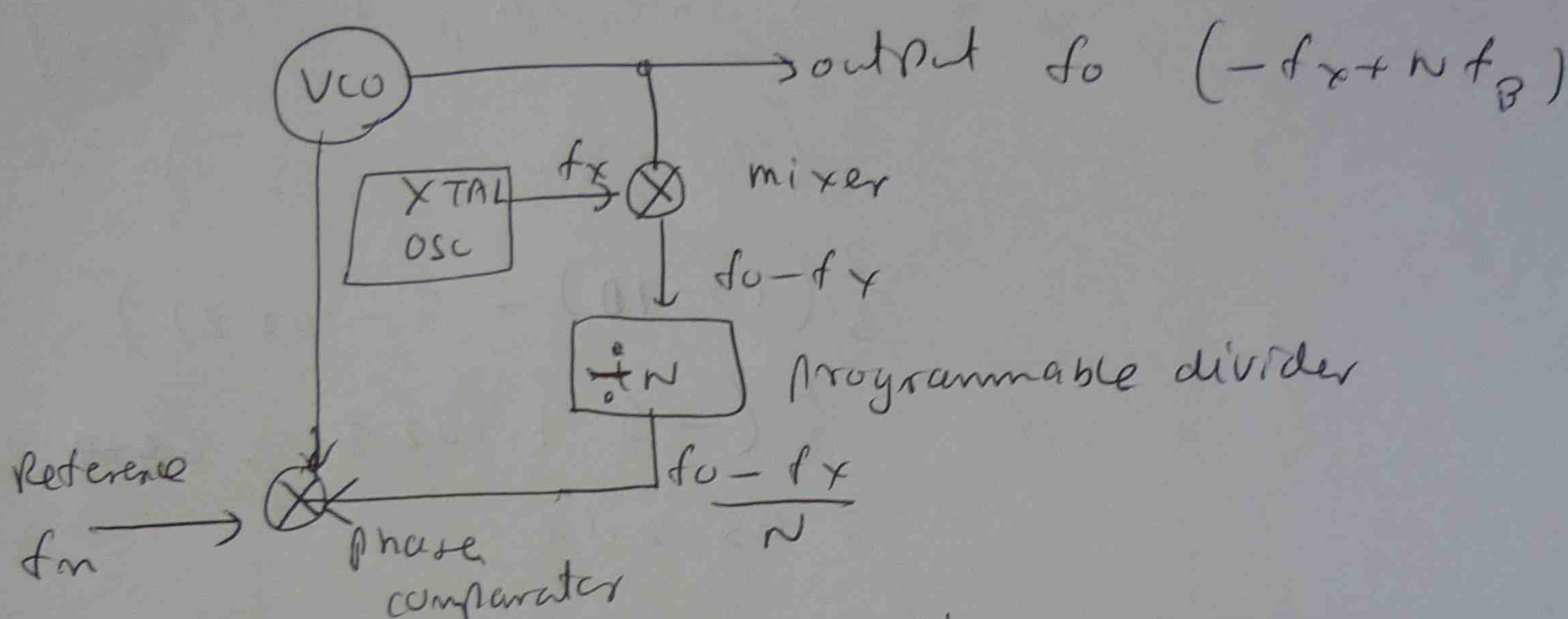
Basic frequency synthesizer

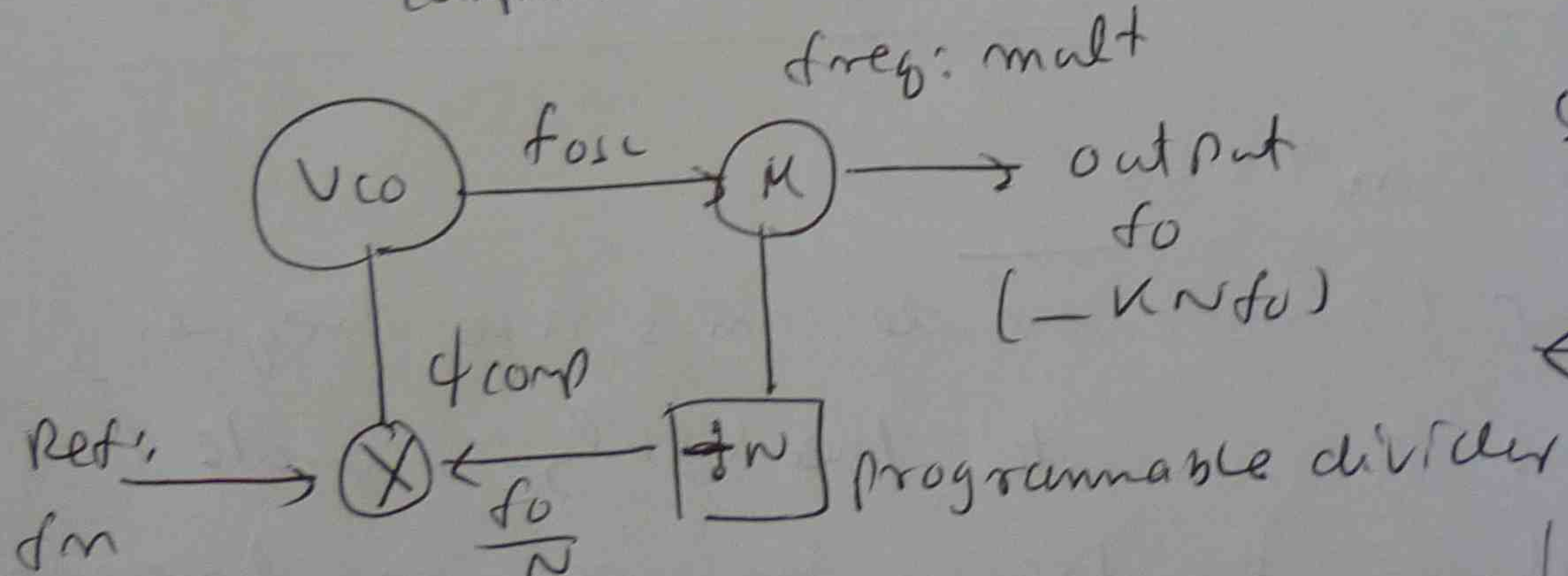


Programmable division

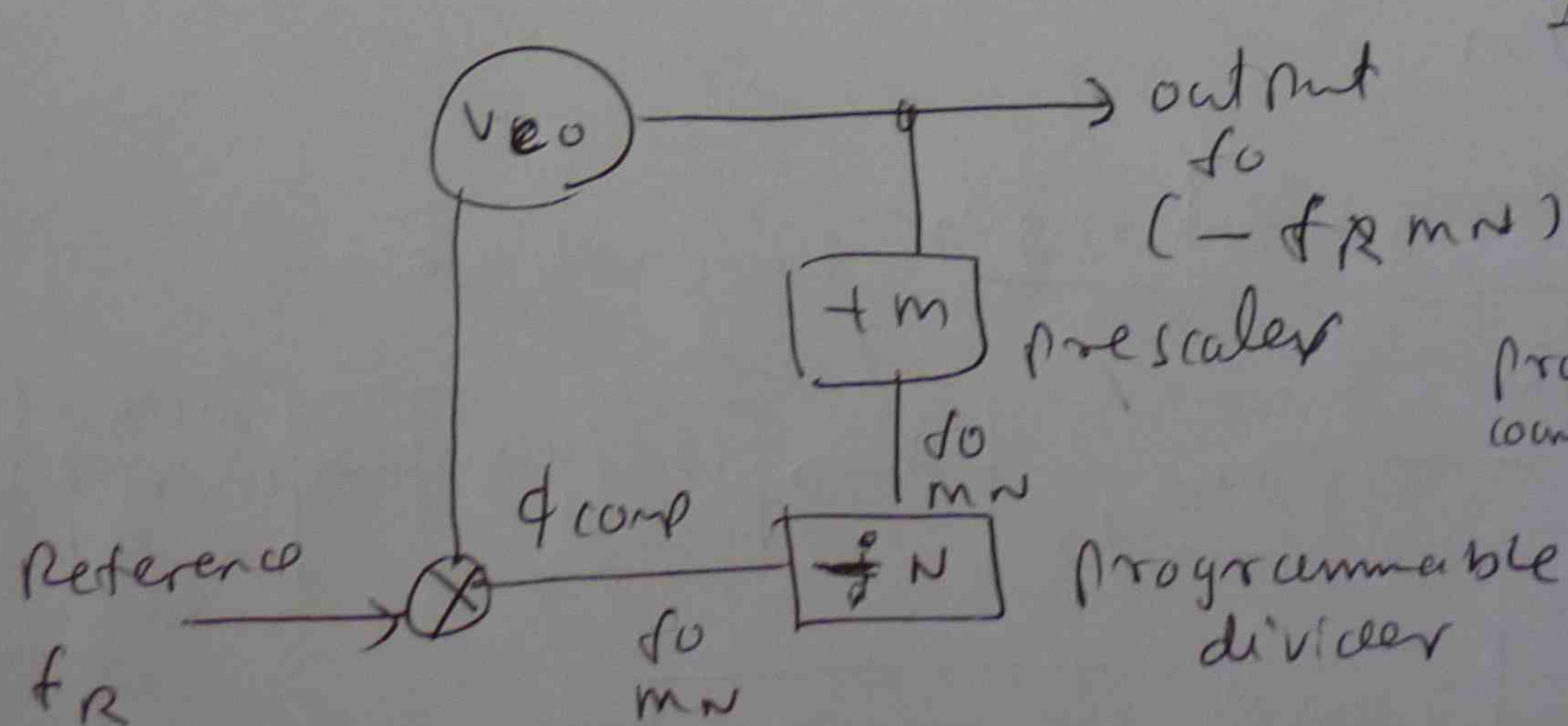


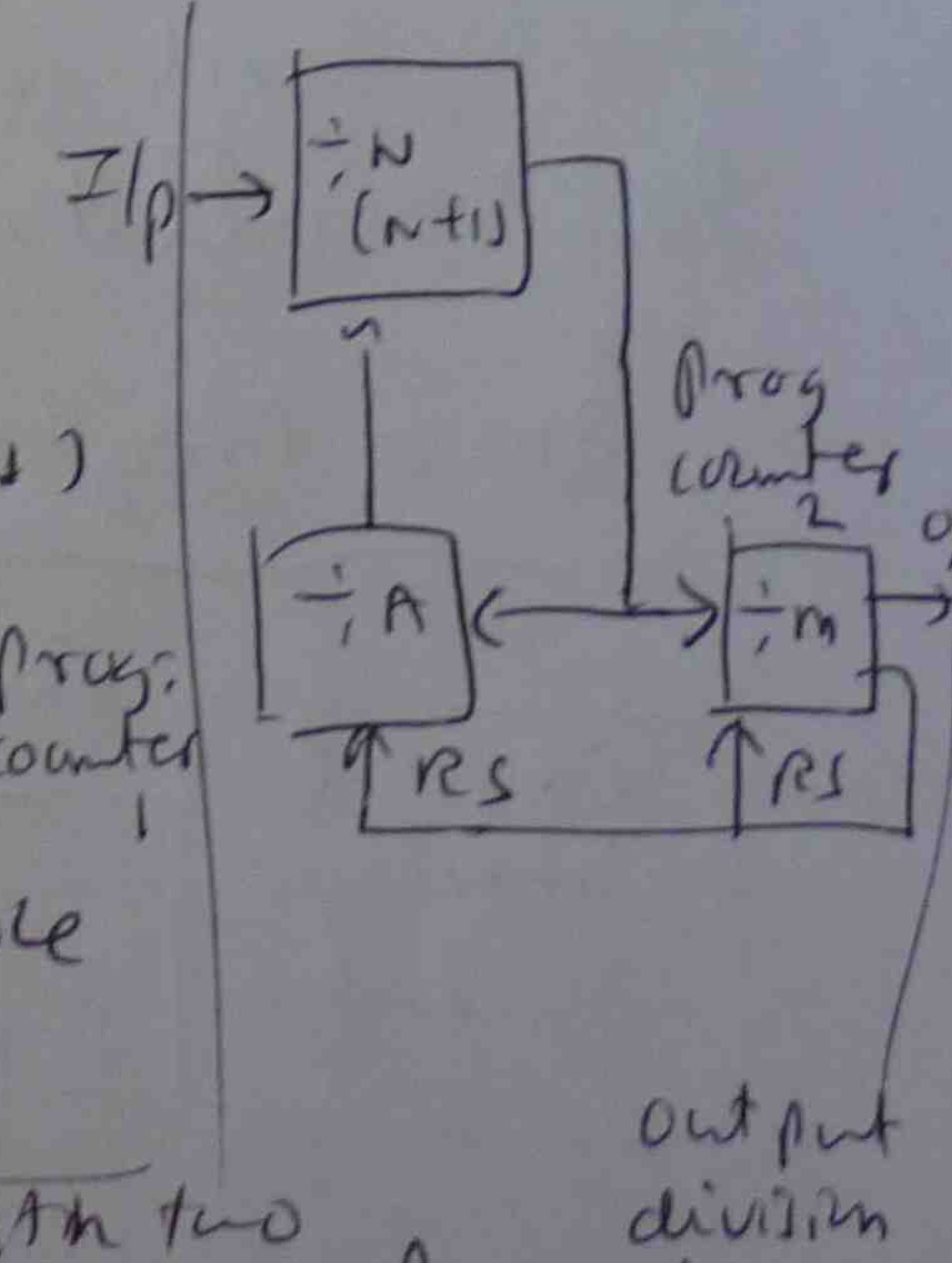
Decade (or) divide by 16 counter





Synthesizer alternatives





Divider system with two modulus ~~prescaler~~ prescaler

Week 9 78

COMMUNICATION TRANSCEIVERS

Standard phone line 3 kHz bandwidth

TV - 6 MHz bandwidth

FM communication transceivers

Two way communication - 150 → 174 MHz band via frequency modulation.

Business & industry - 450 to 470 MHz | 900 MHz

Spread spectrum techniques

Allow transmissions that can not be jammed.

Frequency Hopping

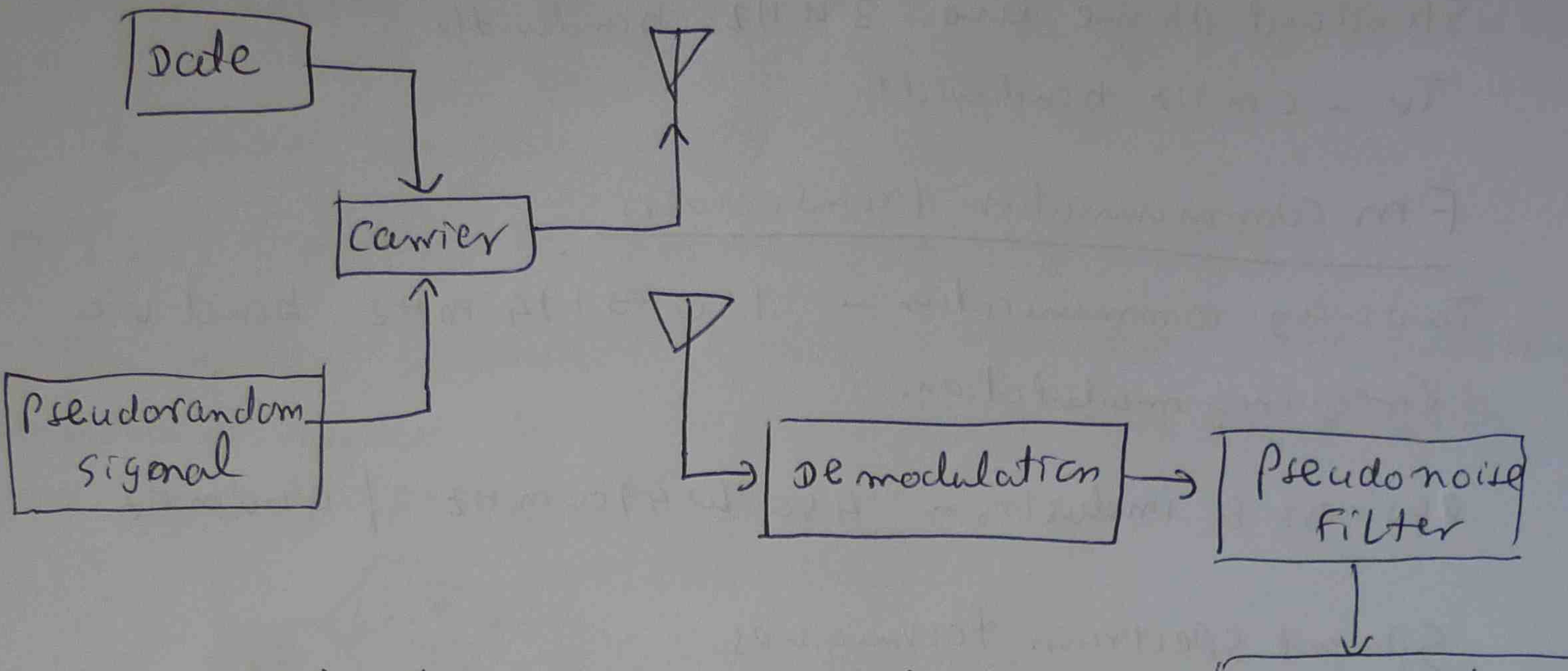
The transmitted signal is contained by a carrier that is switched in a pseudorandom fashion. Pseudorandom implies a sequence that canbe recreated.

Time Hopping

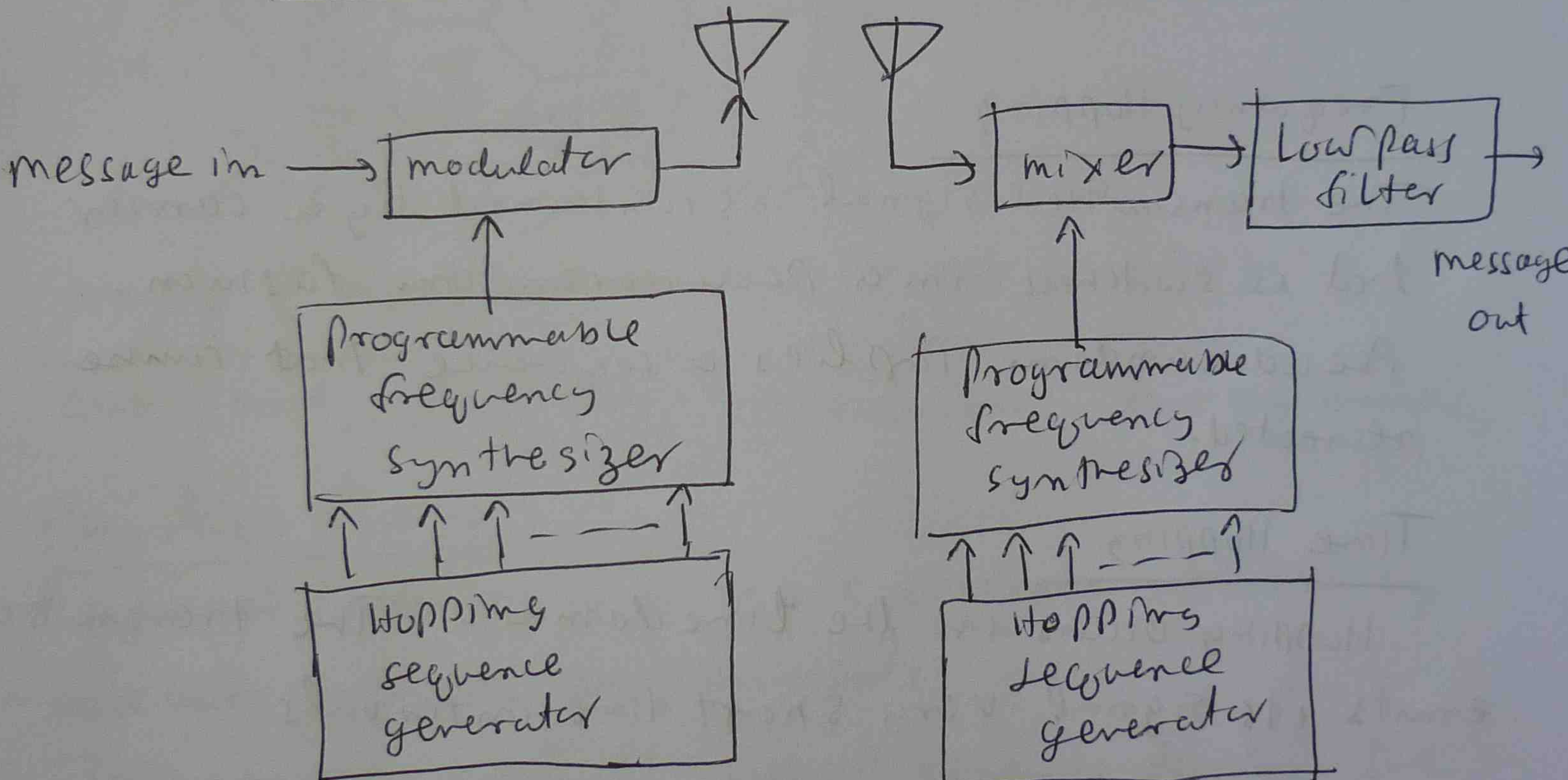
Hopping occurs in the time domain. The transmitter emits its signal very short time intervals.

Direct sequence

Its pseudorandom sequence uses pulses shorter than the message bits, called chips. The chips ~~success~~ successively modulate fractions of the bits typically phase shift the carrier. The receiver multiplies the incoming signal by the same chip signal to recover the original digital signal.



Direct sequence spread spectrum



Frequency hopping spread spectrum

Cellular telephone

800 → 900 MHz band away from UHF TV

Frequency reuse

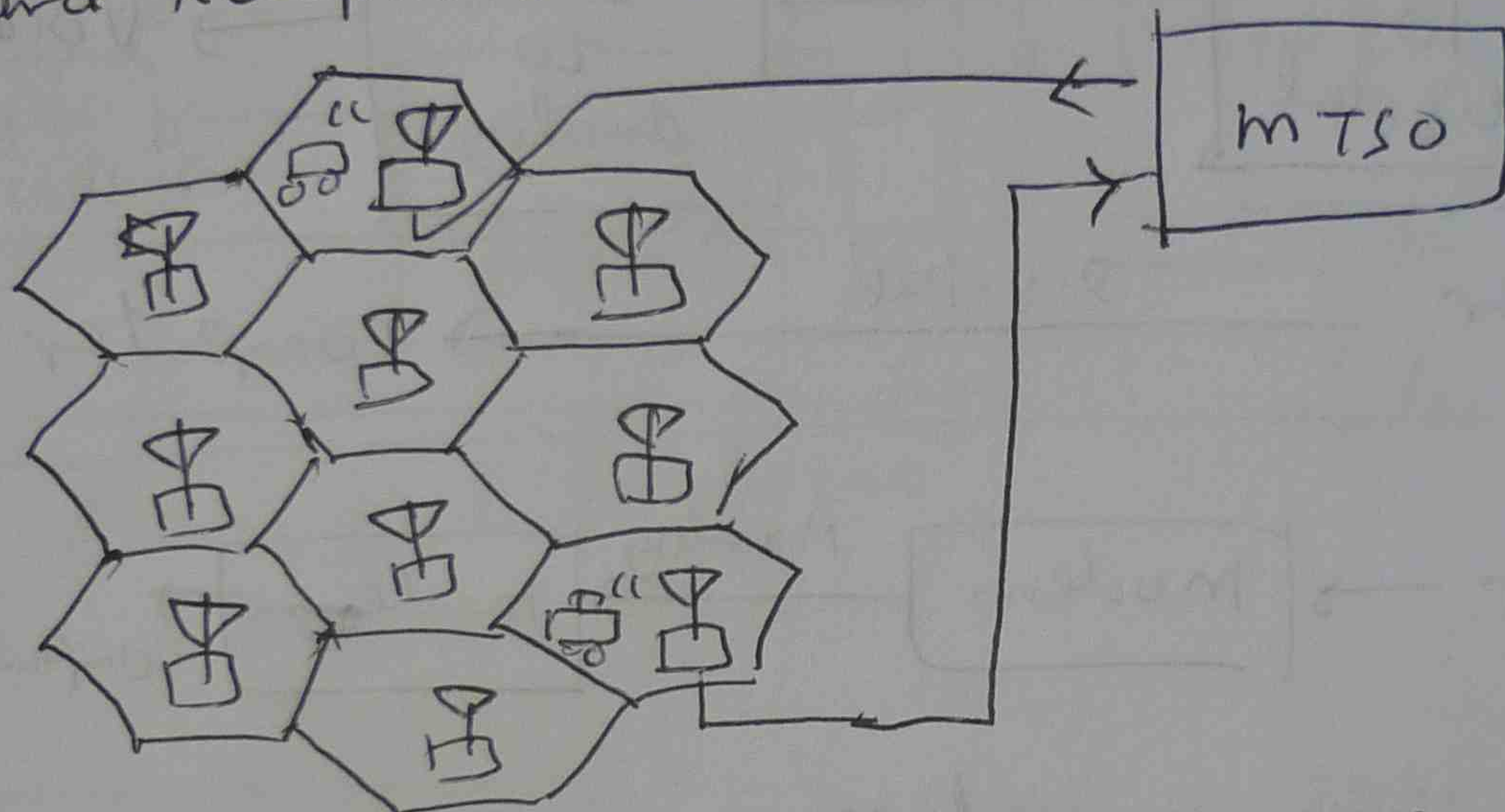
Using the same carrier frequency (channel) in different cells that are geographically separated.

Amp systen – peak deviation of 12 kHz & 30 kHz channel spacing.

40MHz specturm allocation.

MTSO (mobile Telephone Switching office)

The MTSO central processor controls the switching equipment needed to interconnect mobile users with the land telephone network.



Amps (Advanced mobile phone service)

Control unit, logic unit, transceiver, two antennas.

Rayleigh fading

A repid variation in signal strength received by mobile units in urban environments.

To maintain adequate signal strength during the fade, transmitter power must be increased by the fading margin of up to 20dB.

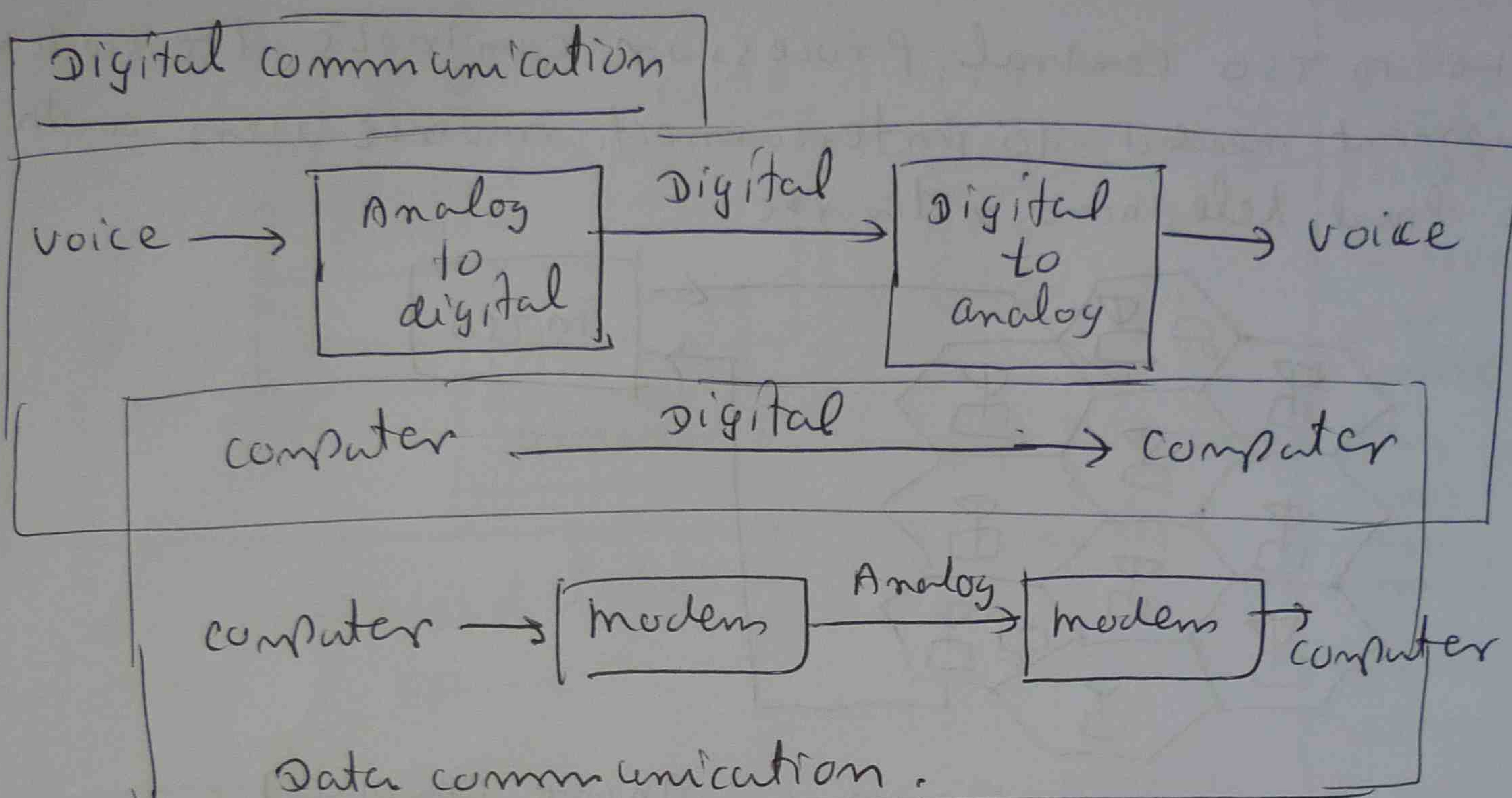
(21)

Digital Data communication

Transfer of information in digital form.

Telephony

Telephone, interconnection system, line characteristi



Telephone switching

- Strowger stepping switches.
- Crossbar switching
- Solid state switching

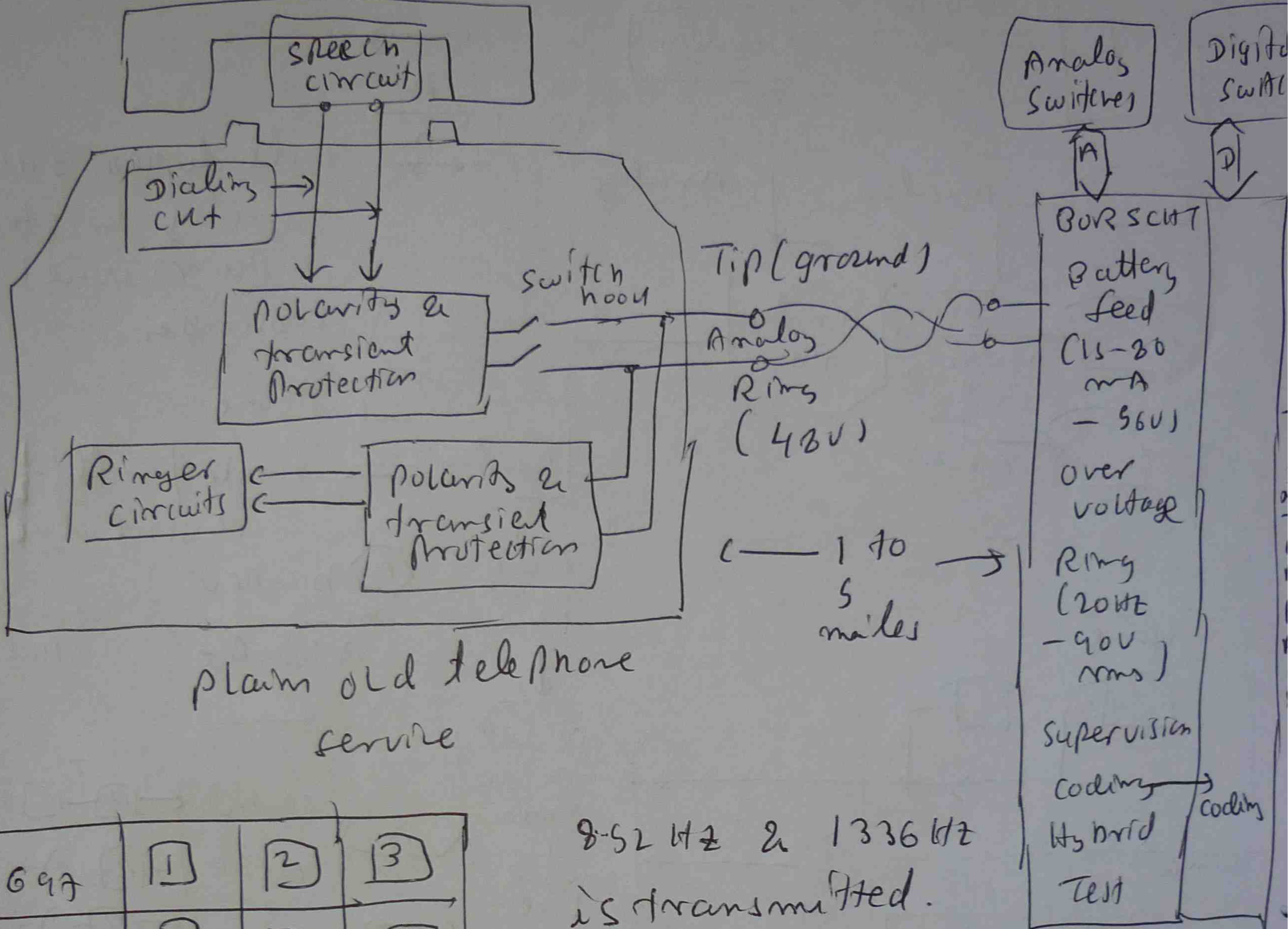
Subscriber's telephone line No.22 twisted pair wire that handles 300 Hz to 3 kHz audio voice signal.

Dial pulsing

The interruption of the circuit according to the number dialed.

When selecting the digital 8, a dual frequency tone of 852 Hz and 1336 Hz is transmitted.

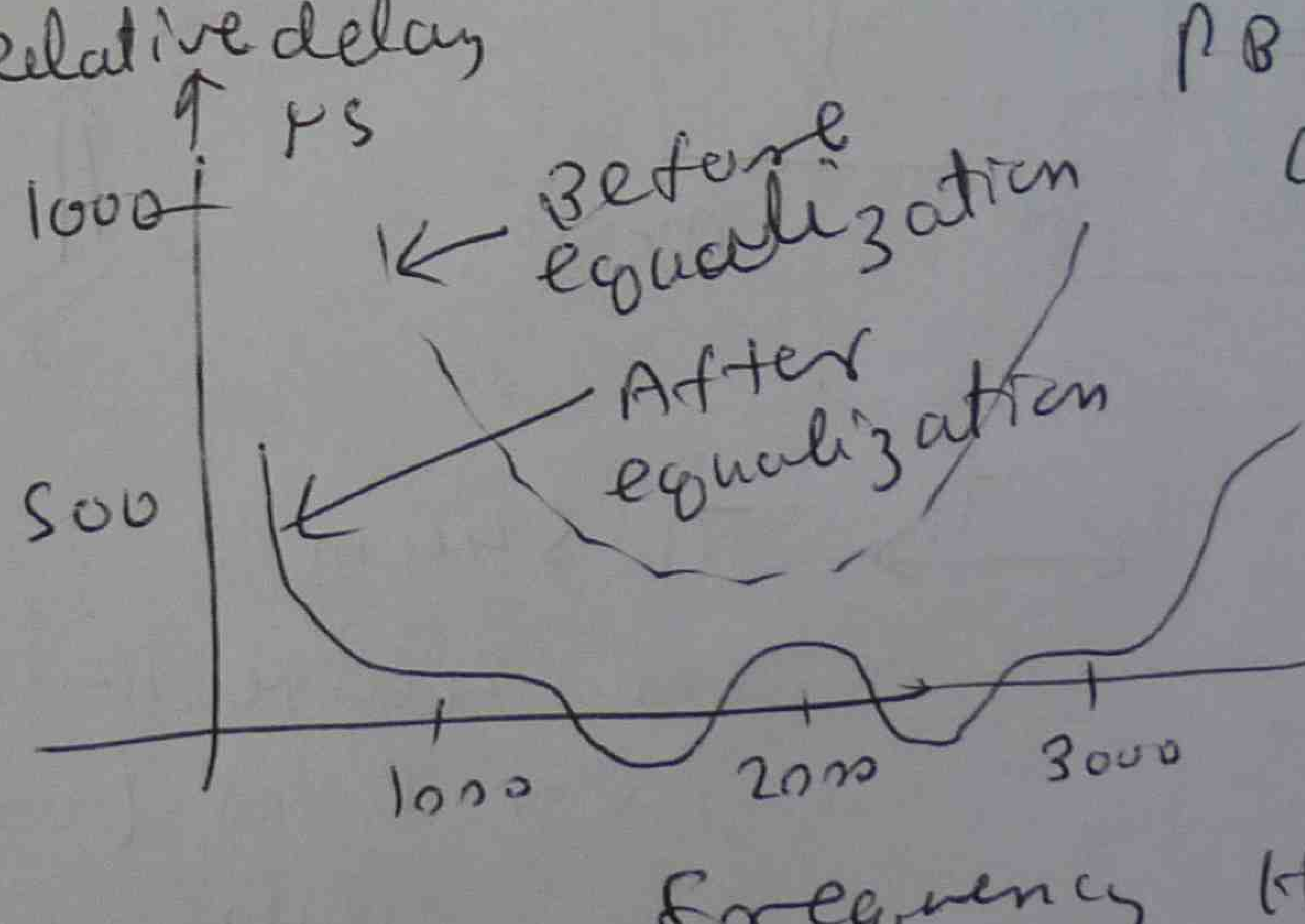
Band frequency 300 to 3000 Hz



plain old telephone service

697	1	2	3
770	4	5	6
852	7	8	9
941		0	
Freq (Hz)	1209	1336	1472

852 Hz & 1336 Hz is transmitted.



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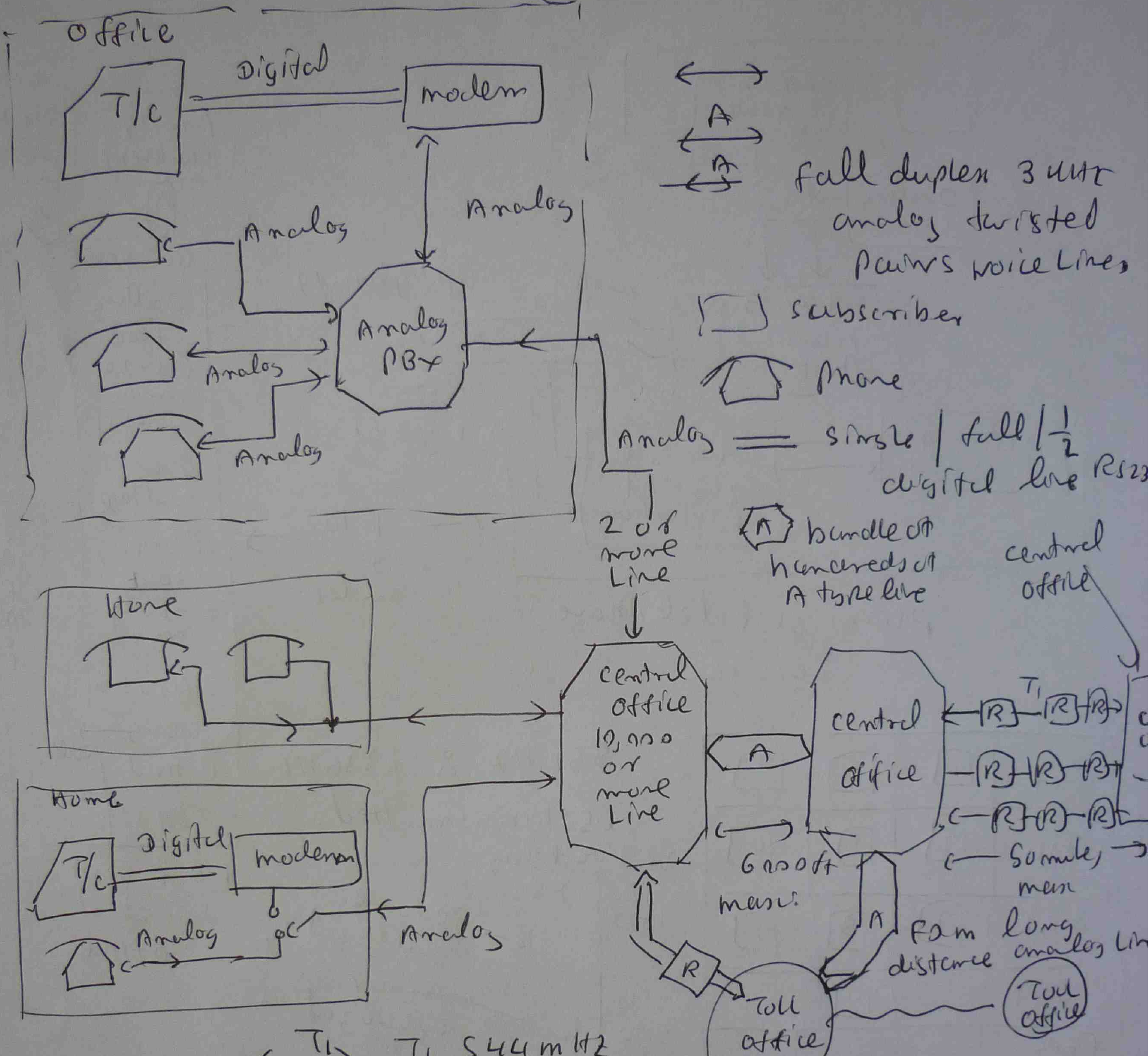

$\xleftrightarrow{T_1}$ T_1 544 mHz

Tam 4 wire twisted pair lines (or trunks, carrying 24-3) kHz voice channels full duplex

R T_1 repeater

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Week 10

Pulse modulation

Transmit only the samples and let the receiver reconstruct the total signal with a high degree of accuracy.

Am / Fm & pm

Some parameters of the modulated wave varies continu-ously with the message; whereas in pulse modulation, some parameter of a sample pulse is varied by each sample value of the message.

The pulses are usually of very short duration so that a pulse modulated wave is off most of the time.

Pm allows:-

1. Transmitters to operate on a very low duty cycle, as is desirable for certain microwave devices & lasers
2. The time intervals between pulses to be filled with samples of other messages.

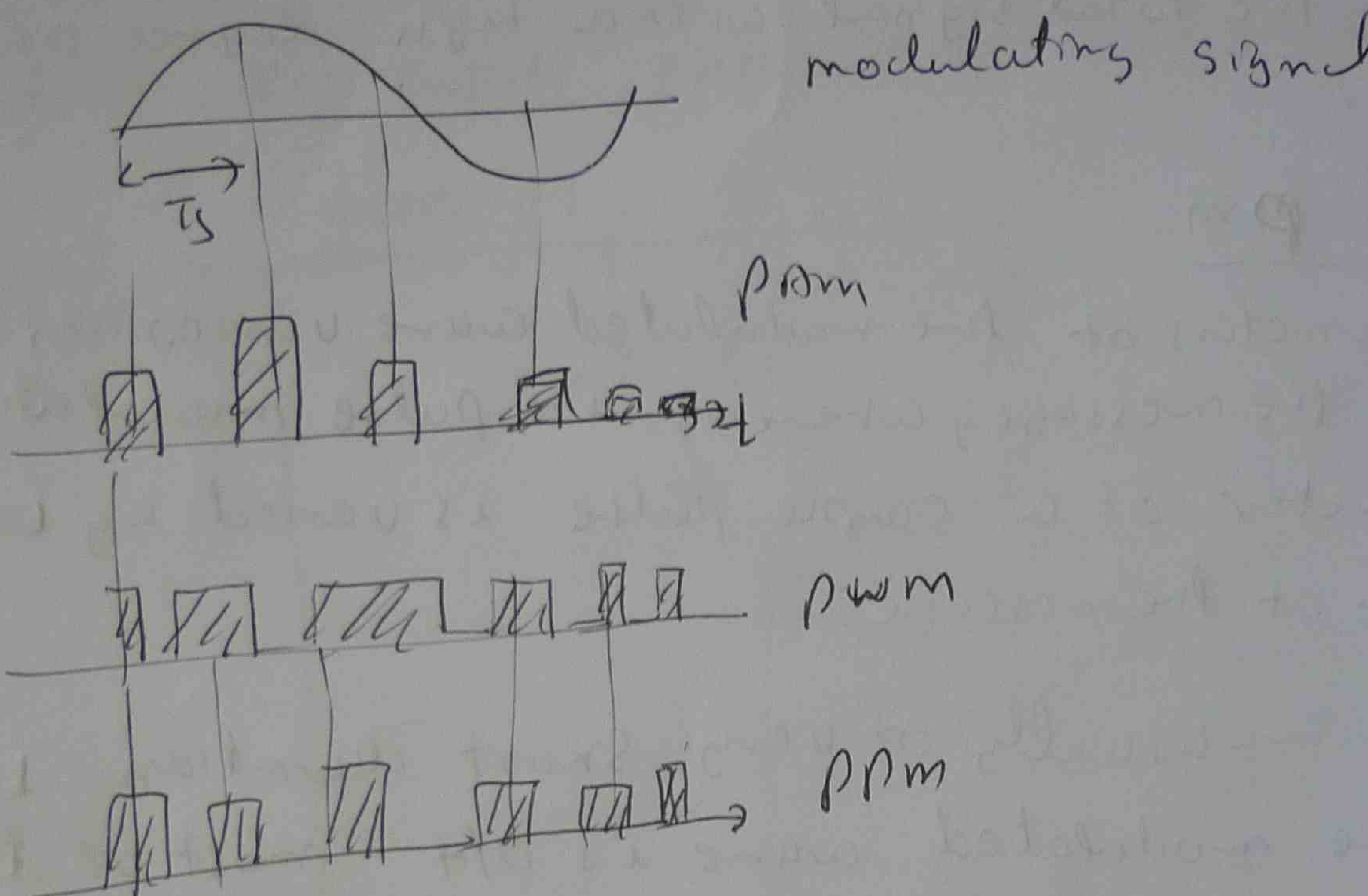
TDm - Time division multiplexing | Analog computer to sharing.

Greater channel bandwidth size for greater complexity.

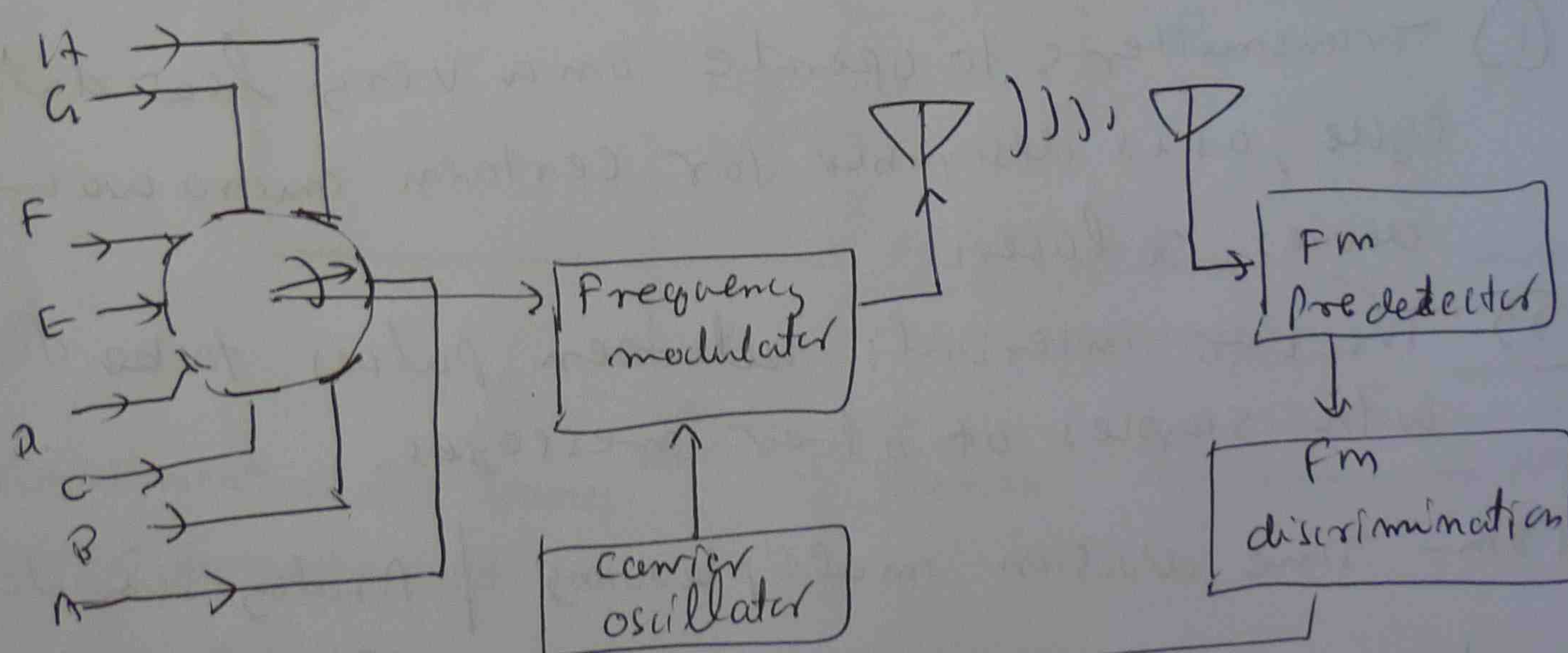
Pulse modulation
- (1) pulse amplitude modulation (PAm)
- (2) pulse width modulation (PWm)
- (3) pulse position modulation (PPm)

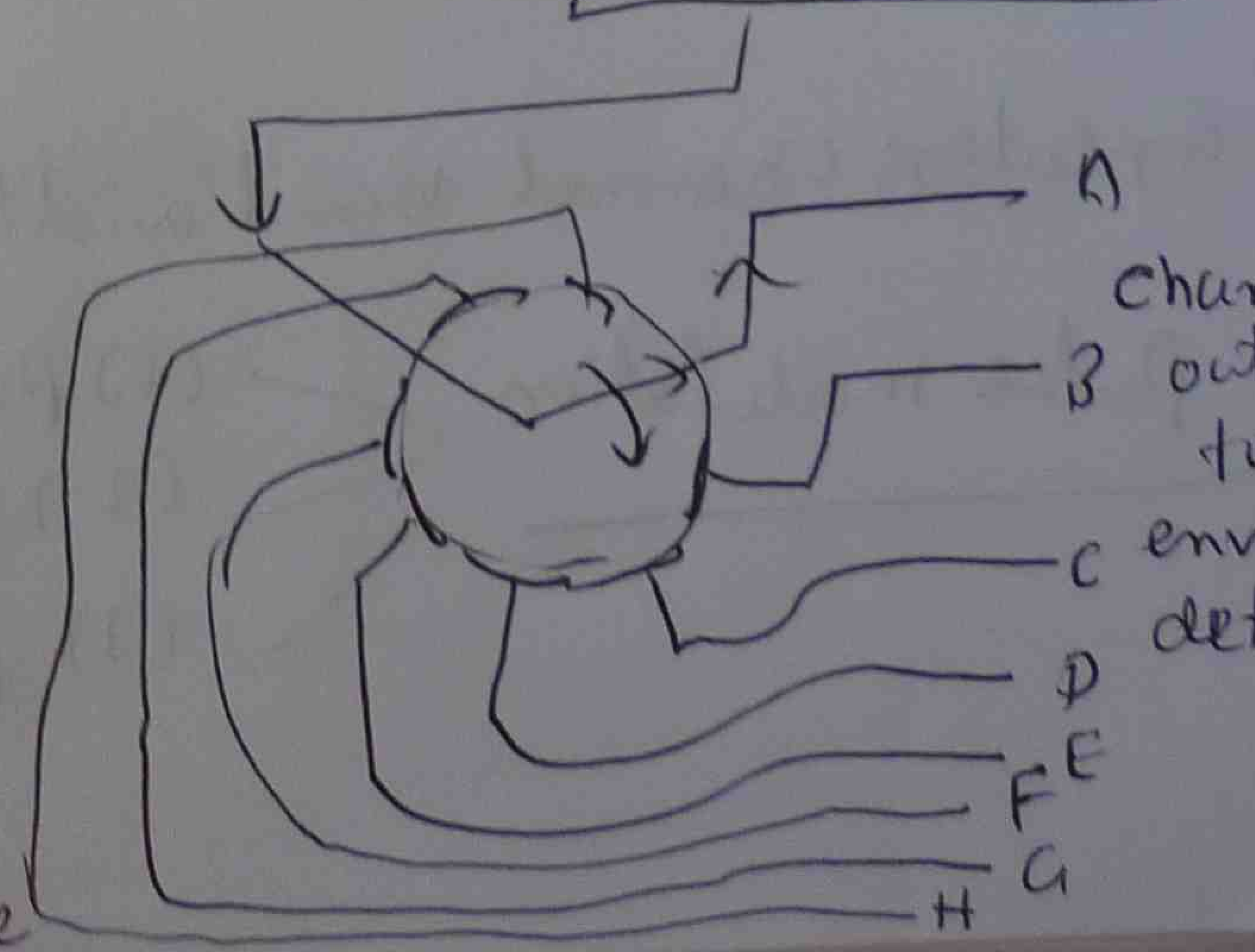
Pulse amplitude modulation (PAm)

The pulse amplitude is made proportional to the modulating signal's amplitude.



8 channel TDM PAM system





Transmitter

variable amplitude pulses are used to frequency modulated carrier

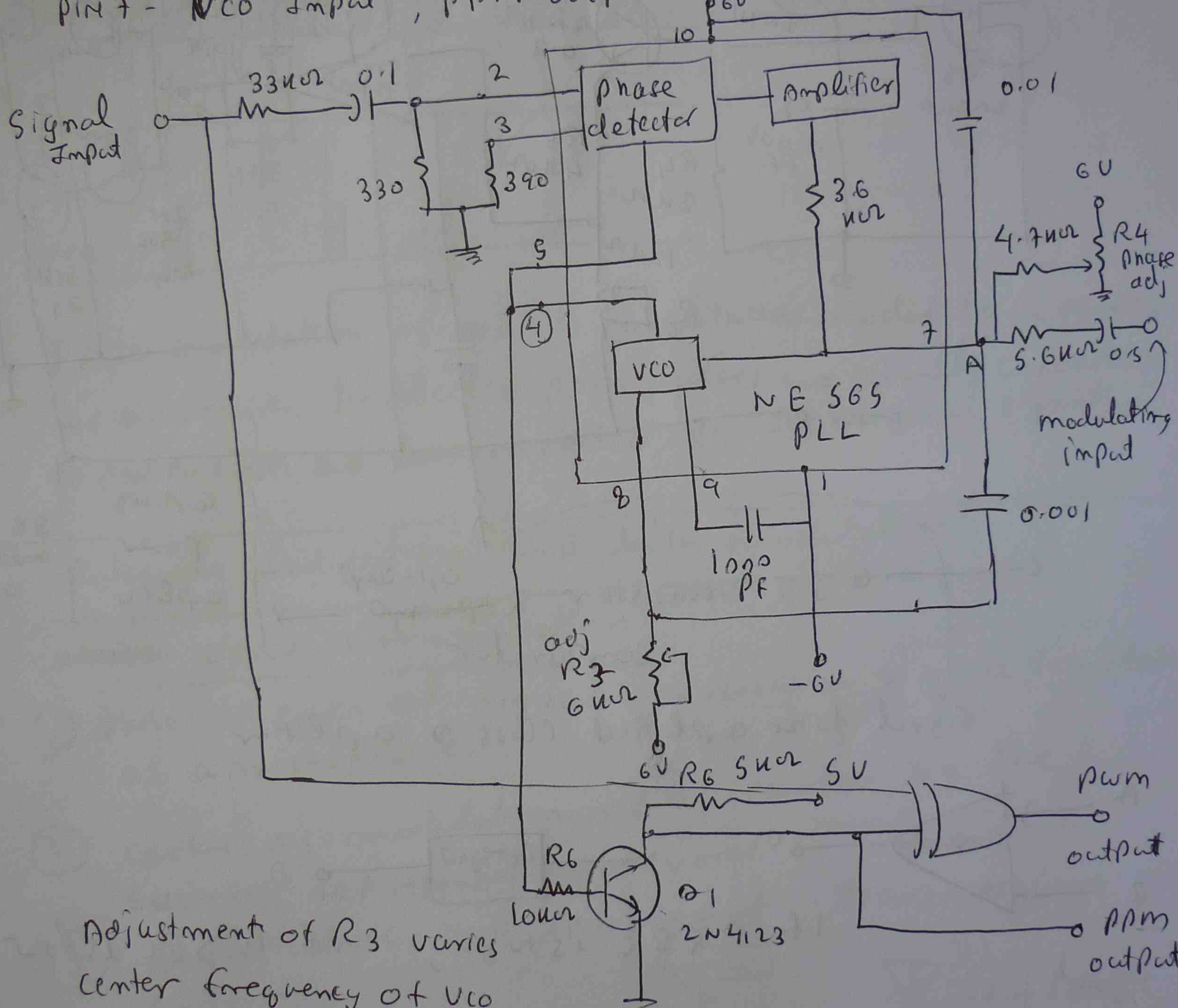
RC filter - Detection in Std Am receiver

PWM constant amplitude, superior noise performance

Pulse width modulation

PWM → Pulse duration modulation (PDM)
→ Pulse length modulation (PLM)

565 PLL – Phase lock loop, PIN 4 – VCO output
PIN 7 – VCO Input, PPM output is amplified by Q_1



Adjustment of R3 varies center frequency of VCO

The R4 potentiometer may be adjusted to set up the quiescent PWM duty cycle

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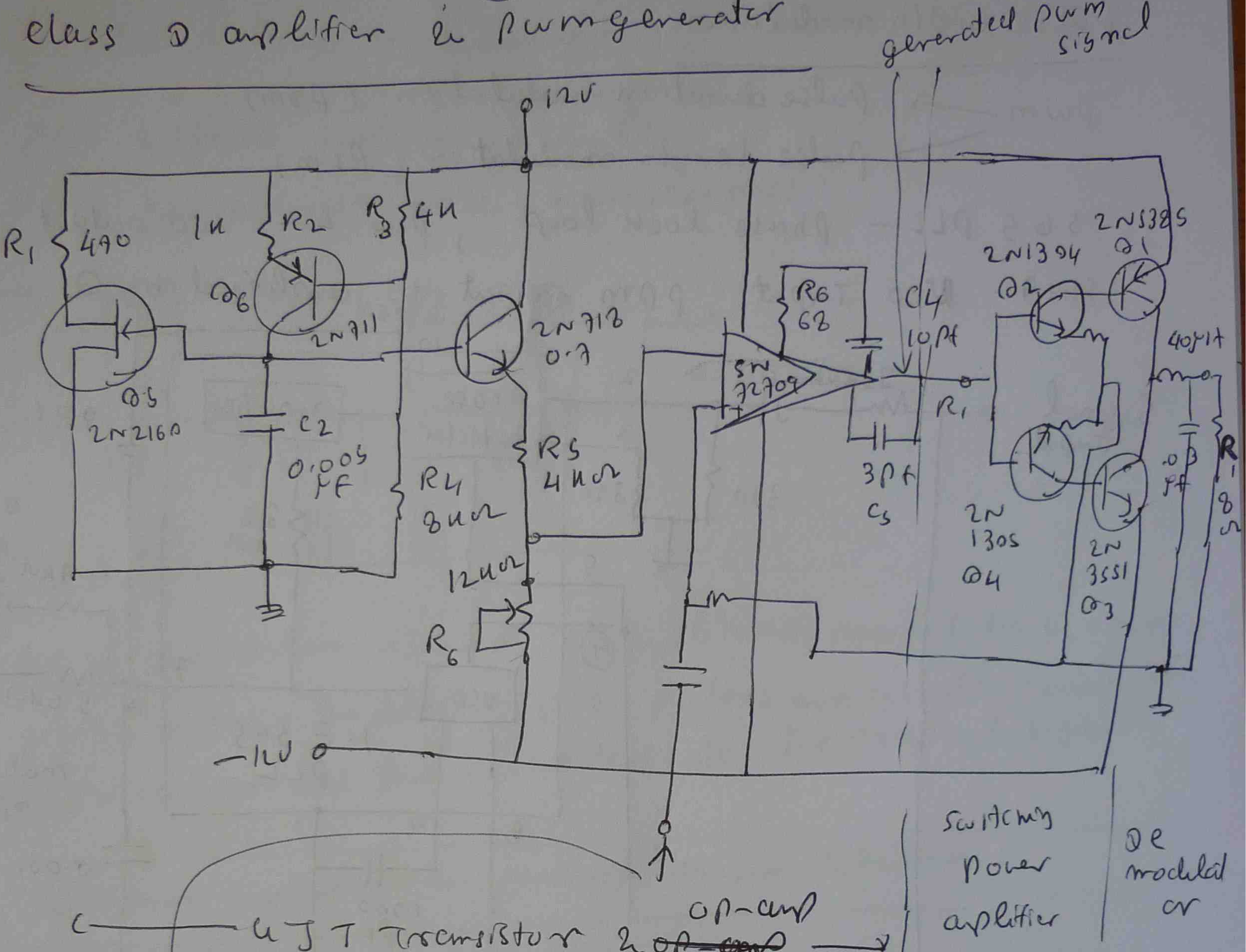
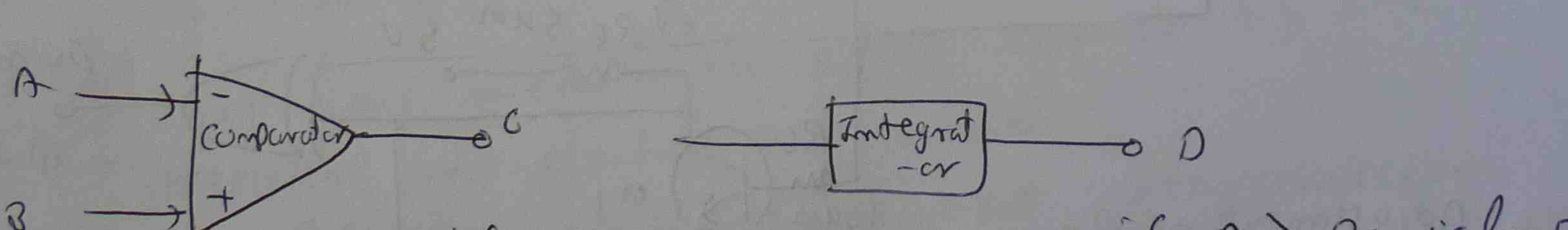
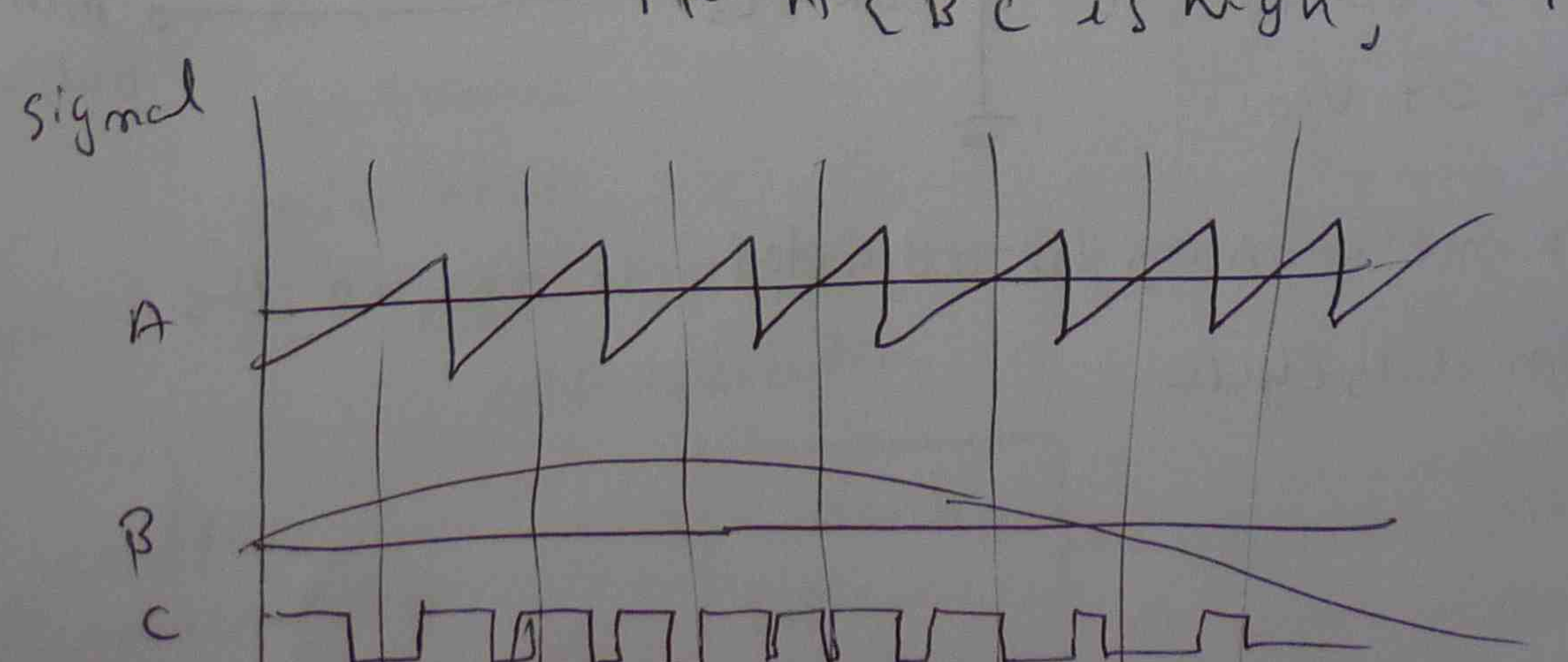
class D amplifier & pwm generator



Signal to be amplified class D amplifier



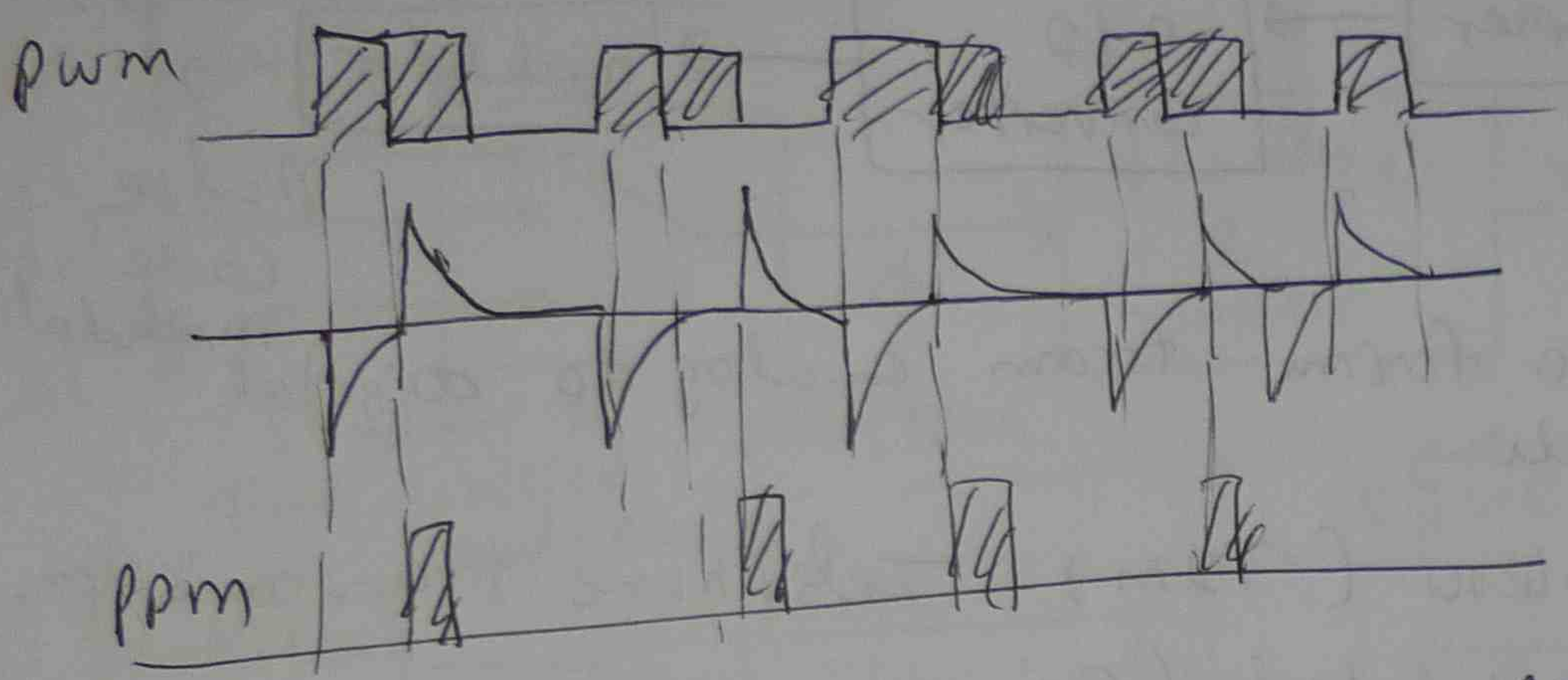
If A < B C is high, if A > B C is low



Pw generation waveform

Pulse position modulation

PPM & PWM are very similar
PPM has superior noise characteristics

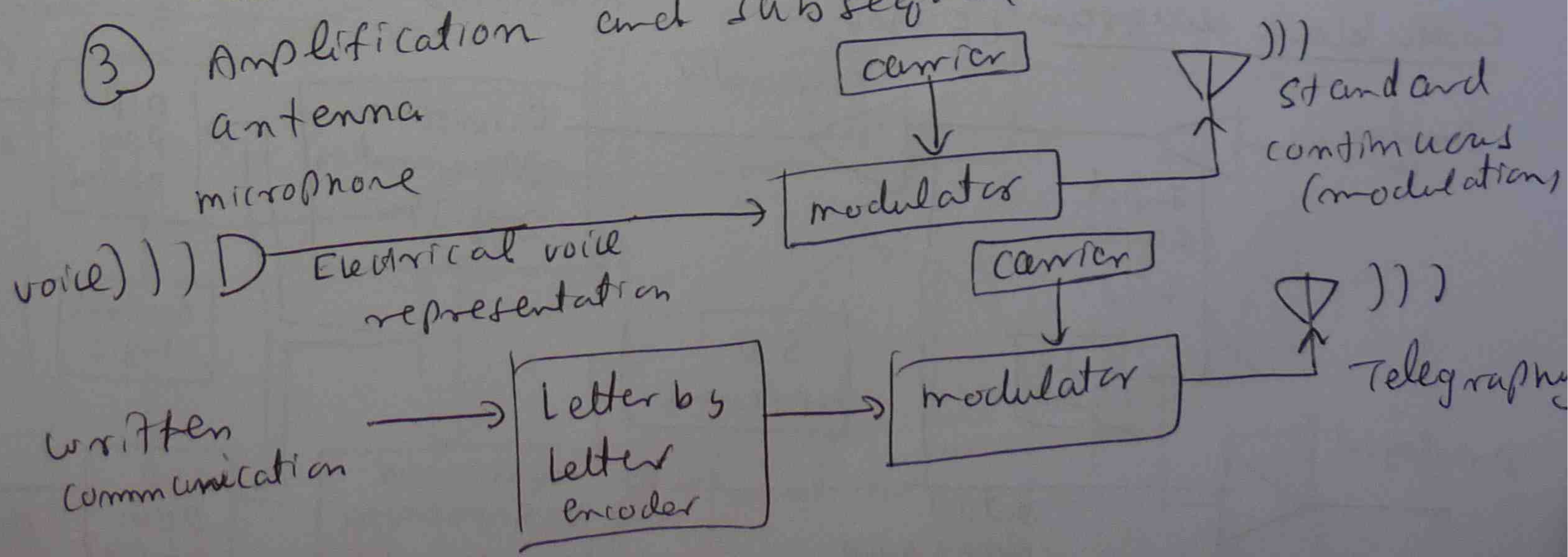


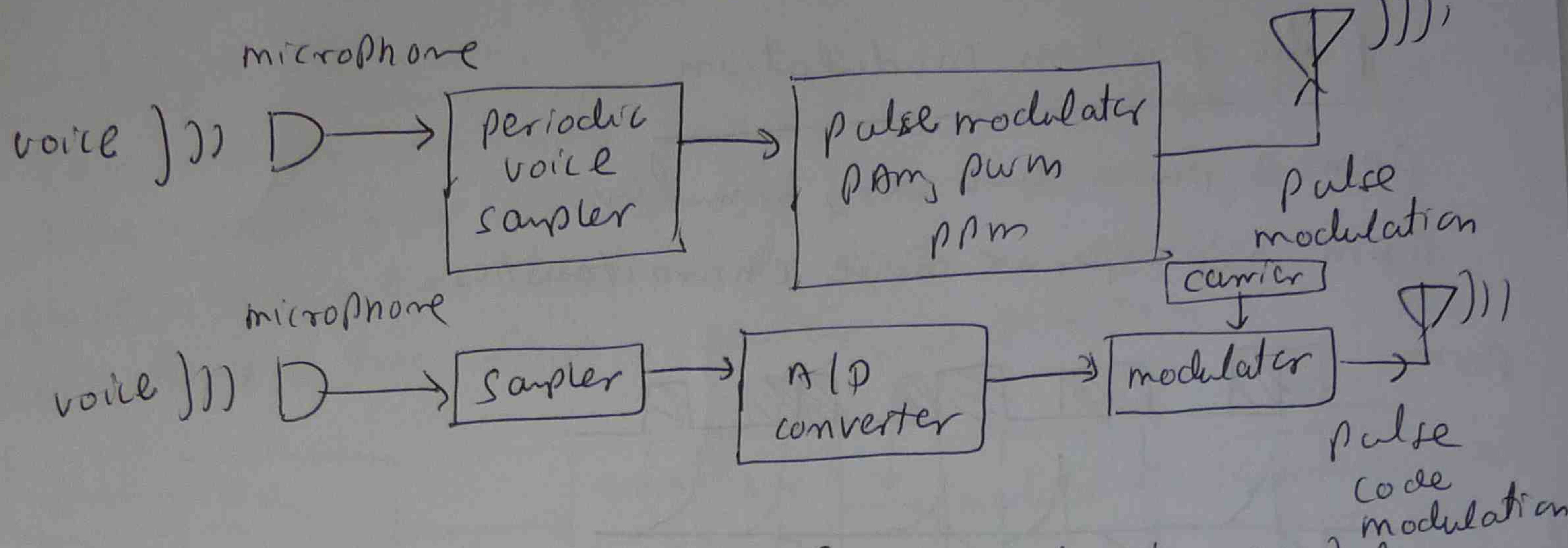
PPM modulation is used to amplitude modulate a carrier.
At the receiver, the detected PPM pulses are usually converted to PWM first and then converted to the original signal.

Pulsecode modulation and delta modulation

~~voice~~ voice communication

1. voice to electrical signal conversion via a transducer as a microphone.
2. Continuous modulation of a carrier by the electrical representation of voice
3. Amplification and subsequent transmission via antenna





conversion of a wave form from analog to digital form by means of coding

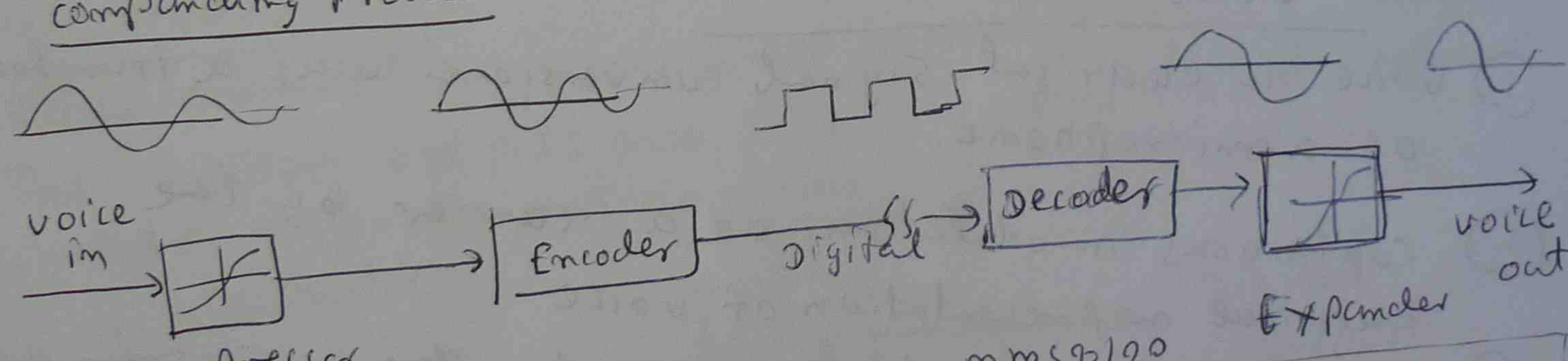
Time division multiplexer (TDM). Telephone transmission.

Frequency division modulated (FDM)

companding $V_{out} = \dfrac{V_{max} \times \ln\left(1 + \mu \frac{V_{in}}{V_{max}}\right)}{\ln(1+\mu)}$

companding is a process of volume compression before transmission and expansion after detection.

companding process



codec block diagram LF 3700