RADAR RECEIVERS – SALIENT FEATURES

1. IT SHOULD HAVE *LARGE DYNAMIC RANGE*
2. LARGE GAIN
3. IT SHOULD NOT INTRODUCE UNWANTED PHASE CHANGES THAT COULD DISTORT ECHO'S.
4. IT SHOULD BE PROTECTED FROM OVERLOAD, SATURATION & BURN OUT FROM UNWANTED SIGNALS.
5. TIMING & REF SIGNALS SHOULD BE PROPER FOR ACCURATE EXTRACTION OF TGT INFORMATION .

RADAR RECEIVERS – SALIENT FEATURES (CONTD)

6. IT SHOULD **MAXIMISE THE S/N RATIO** BY USING A MATCHED FILTER.
7. IT SHOULD GENERATE AS **LITTLE INTERNAL NOISE** AS POSSIBLE (ESPECIALLY IN THE I/p STAGES).
8. OVERALL **NOISE FIGURE** SHOULD BE AS **LOW** AS POSSIBLE.
9. IT SHOULD BE **SIMPLE, RUGGED** AND SHOULD BE HAVING **PROPER TUNING CAPABILITY**.
10. IT SHOULD BE **LESSER IN SIZE** AND SHOULD BE **DIGITAL** TO THE EXTENT POSSIBLE.

RECEIVER NOISE FIGURE

Fn= Nout (Practical Rx) =

Nout

N (Ideal Rx) k To Bn G

= Nout = Sin.Nout = Sin /N_{in}

(N_{in}) Sout $N_{in.}$Sout Sout / Nout

Sin

IT IS A MEASURE OF NOISE PRODUCED BY A PRACTICAL Rx COMPARED TO THE NOISE OF AN IDEAL Rx.

Fn= k To Bn G+ ΔN = 1 + ΔN

k To Bn G k To Bn G

Where ΔN = additional noise introduced by the practical (non - ideal) Rx / Network

Fn (decibels) = 10 Log Fn

RX NOISE FIGURE (CONTD)

DEFINITION : **NOISE FIGURE IS THE DEGRADATION OF S/N RATIO AS THE SIGNAL PASSES THROUGH THE NETWORK**

K= BOLTZMANN'S CONSTANT = 1.38×10^{-23} J/DEG.

To = STANDARD TEMP (290 K)-

G= $\frac{\text{Sout}}{\text{Sin}}$.

NOISE BAND – WIDTH = Bn

NOISE FIGURE OF NETWORKS IN CASCADE (Fo)

- O/P NOISE OF 2 NETWORKS IN CASCADE , NOUT

= NOISE FROM NETWORK 1 AT O/P OF NETWORK 2 + ΔN_2 (NOISE INTRODUCED BY NETWORK 2)

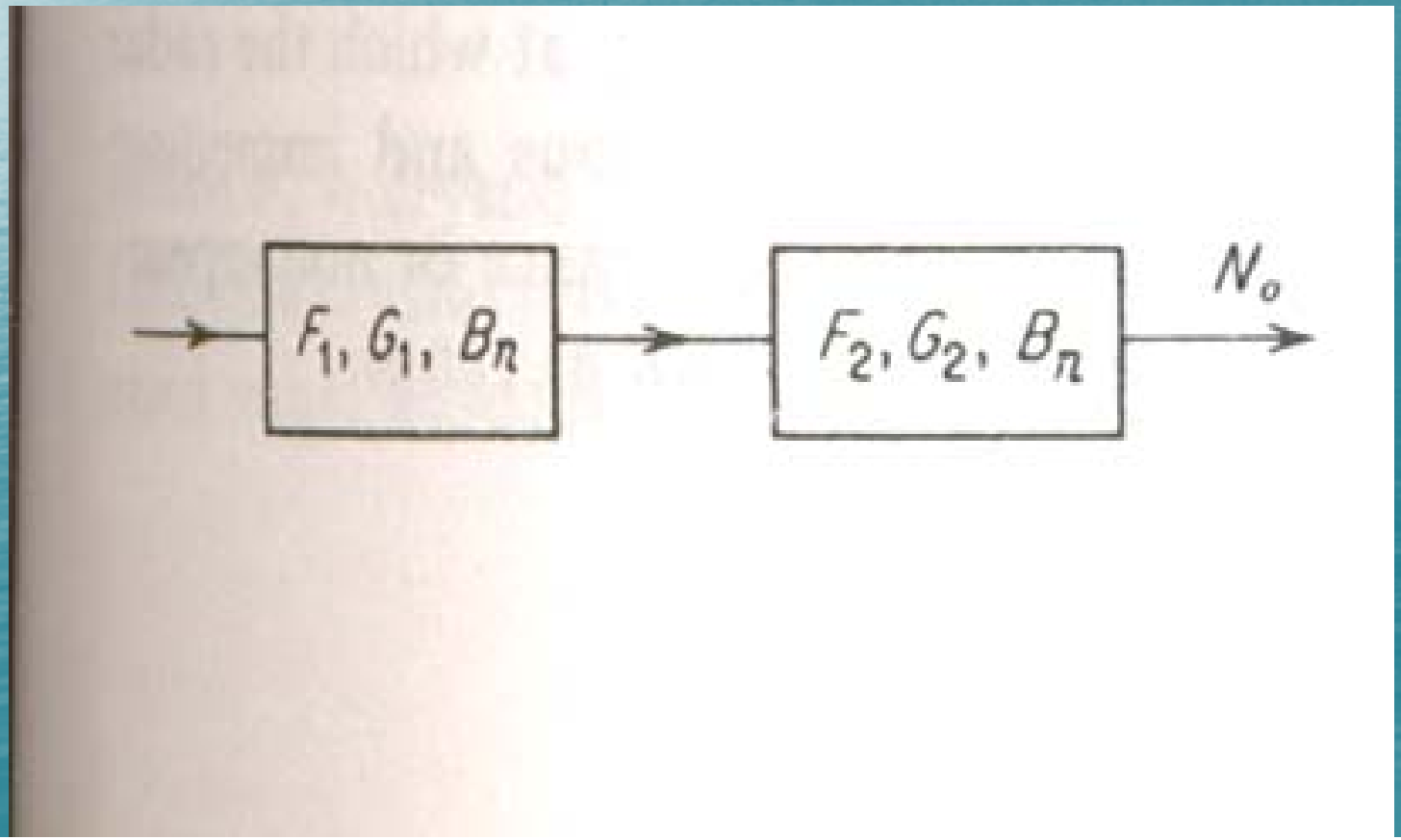
$$Fo\ k\ To\ Bn\ G_1\ G_2 = F_1 k\ To\ Bn\ G_1 G_2 + \Delta\ N_2 \quad (1)$$

$$F2 = 1 + \frac{\Delta N_2}{k\ To\ Bn\ G2}$$

$$\Delta N_2 = (F_2 - 1)\ k\ To\ Bn\ G_2$$

SUBSTITUTING IN 1 ABOVE

Two networks in cascade.



NOISE FIGURE OF NETWORKS IN CASCADE (Fo)

- Fo k To Bn G_1 G_2 = F_1k To Bn G_1G_2+ (F2-1)k To Bn G2

DIVIDE THE ENTIRE EQUATION BY K T_O Bn G_1G_2

NOISE FIG,

$$F_O = F1+\frac{F_2-1}{G_1}$$

N NETWORKS IN CASCADE

$$\text{NOISE FIG , } F_O = F_1+ \frac{F_2-1}{G_1} + \frac{F_3-1}{G_1G_2} +\text{--------} + \frac{F_{N-1}}{G_1G_2\text{----}G_{N-1}}$$

EFF. NOISE TEMP(T_e) OF A NETWORK/ RECEIVER

Te IS DEFINED AS THE FICTIONAL TEMP AT THE I/P OF THE NETWORK , THAT ACCOUNTS FOR THE ADDITIONAL NOISE ΔN AT THE OUTPUT .

$$\Delta N = K\, Te\, B_N\, G$$

$$Fn = 1 + \frac{\Delta N}{K\, T_O\, B_N\, G}$$

$$= 1 + \frac{K\, T_e\, B_N\, G}{KT_O\, B_N\, G} = 1 + \frac{T_e}{T_O}$$

$$Te = (Fn - 1)\, To$$

EFFECTIVE NOISE TEMPERATURE (T_E) OF A NETWORK/ RECEIVER (contd)

SYSTEM NOISE TEMP (T_S) – IT IS THE EFFECTIVE NOISE TEMP OF THR RX INCLUDING THE EFFECT OF ANTENNA TEMPERATURE (T_a)

WHERE F_S IS THE SYSTEM NOISE FIGURE .

NOTE : EFFECTIVE NOISE TEMP AND NOISE FIGURE BOTH DESCRIBE THE SAME CHARACTERISTICS OF S A NETWORK .

NOISE FIGURE TERM IS MORE COMMONLY USED IN RADAR R_X'S

MIXERS

- KEY ELEMENT OF RX WHICH CONVERTS RF TO IF .
- CONVERSION — SINGLE / DUAL
- DUAL CONVERSION SUPERHET RX'S ARE USED TO AVOID SOME SORT OF INTERFERENCE & ECM .

- A MIXER SHOULD HAVE LOW CONVERSION LOSS, INTRODUCE LITTLE ADDITIONAL NOISE OF ITS OWN, MINIMIZE SPURIOUS RESPONSES AND NOT BE SUSCEPTIBLE TO BURNOUT , ESPECIALLY WHEN IT IS USED AS FRONT END IN THE R_X .

NOISE FIGURE OF A MIXER (Fm)

$Fm = L_C T_R$

Lc = CONVERSION LOSS = $\frac{\text{AVAILABLE RF POWER}}{\text{AVAILABLE IF POWER}}$ = 3.5 TO 6 dB

T_R = NOISE TEMP RATIO = $\frac{\text{ACTUAL AVAILABLE IF NOISE POWER}}{\text{AVAILABLE NOISE POWER FROM AN EQVT RESISTANCE}}$

$= \frac{Fm\ K\ To\ B\ Gc}{K\ To\ B} = Fm\ Gc = \frac{Fm}{Lc}$

WHERE $Lc = \frac{I}{Gc}$

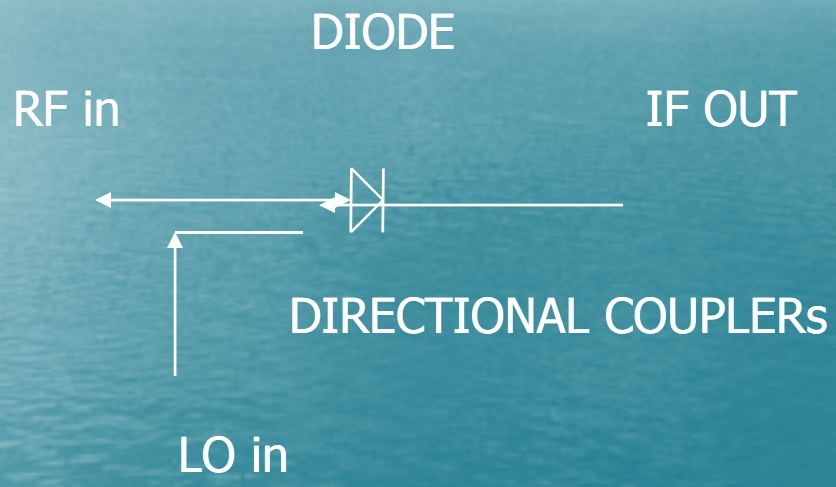
GENERALLY LOWER THE CONVERSION LOSS, LARGER IS THE NOISE TEMP RATIO.

RX NOISE FIGURE WITH A MIXER FRONT END

$F_{OS} = F_1 + \frac{F_2 - 1}{G} = L_C [T_R + F_{IF} - 1]$

TYPES OF MIXERS

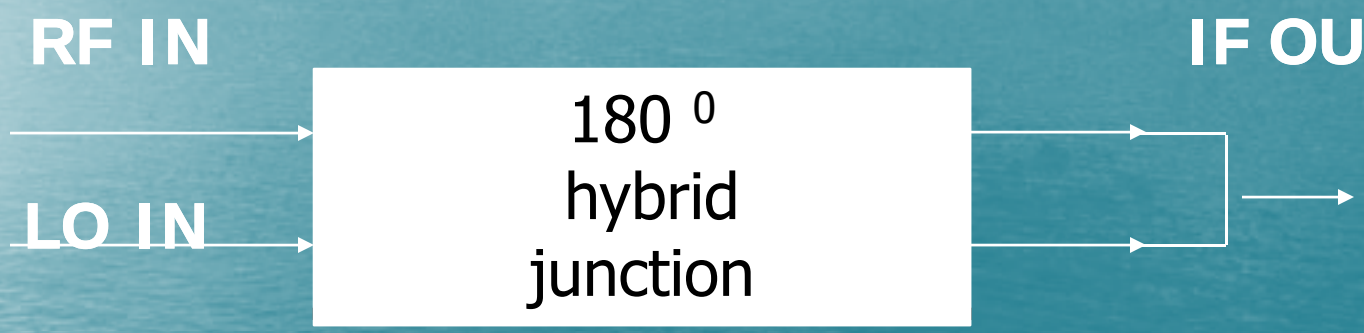
1. SINGLE ENDED MIXER



DIODE IS A NON- LINEAR DEVICE WHICH CAN PRODUCE SUPRIOUS RESPONSES . SINGLE CONVERSION RX'S PROVIDE BETTER SUPPRESSION OF SPURIOUS RESPONSES THAN DUAL CONVERSION RX

TYPES OF MIXERS (CONTD)

2. BALANCED MIXER



BALANCED MIXER IS EQUIVALENT TO 2 SINGLE ENDED MIXERS IN PARALLEL AND 180^0 OUT OF PHASE.

BALANCED MIXER(contd)

- THE IF SIGNAL IS OBTAINED BY SUBSTRACTING THE OUTPUT OF THE TWO DIODE MIXERS.
- LOCAL OSC AM NOISE AT THE TWO DIODE MIXERS WILL BE IN PHASE AND WILL BE CANCELLED OUT.
- ANY EVEN HARMONICS OF BOTH THE RF & LO SIGNALS ARE ALSO SUPPRESSED . THIS PROVIDES WIDE BAND WIDTH.
- THE TWO DIODE MIXERS SHOULD HAVE IDENTICAL CHARACTERISTICS AND BE WELL MATCHED.

IMAGE REJECTION MIXER

- RF SIGNAL IS SPLIT AND FED TO 2 MIXERS AND LO IS FED TO ONE PORT OF HYB.JN.
- HYB JN PROVIDES 90^0 PHASE SHIFT BETWEEN LO I/P TO TWO MIXERS.
- THE SECOND HYBRID JN PROVIDES ANTOHER 90^0 PHASE DIFFERENCE , SO AS TO SEPARATE IMAGE. FREQUENCY AND THE SIGNAL FREQUENCY.
- THE NOISE FIGURE OF THE IMAGE – REJECTION MIXER AS WELL AS THE BALANCED MIXER WILL BE HIGHER THAN THAT OF A SINGLE ENDED MIXER BECAUSE OF THE LOSS ASSOCIATED WITH THE HYBRID JN'S.
- PROVIDES 30 DB OF IMAGE REJECTION APPROX.

- Image-recovery mixer.

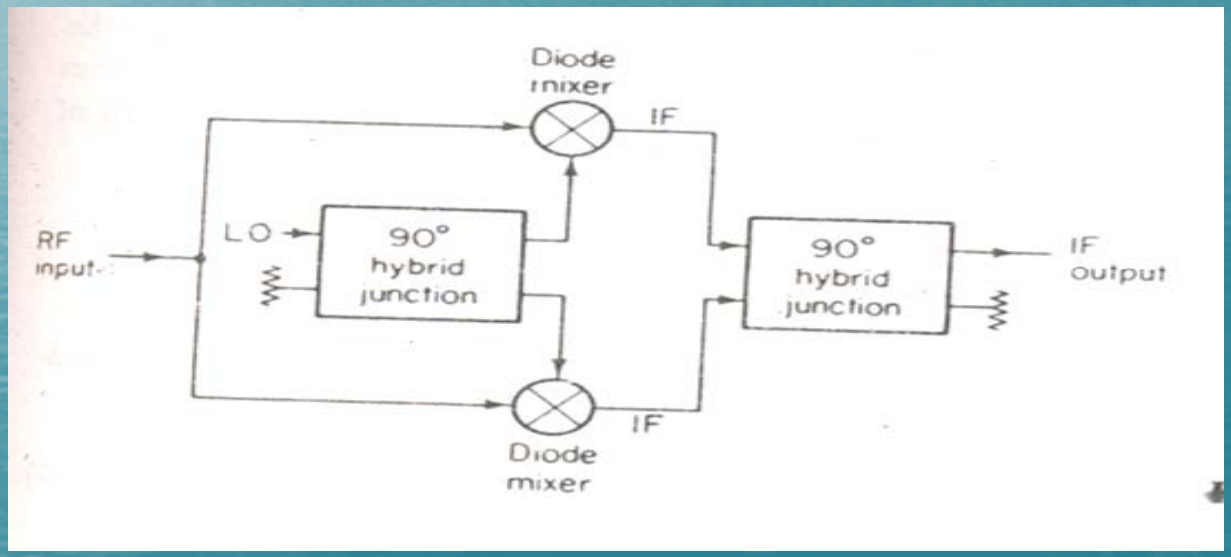


IMAGE RECOVERY MIXER

- IT IS AN IMAGE REJECTION MIXER DESIGNED TO REDUCE THE MIXER CONVERSION LOSS BY PROPERLY TERMINATING THE DIODE IN A REACTANCE AT IMAGE FREQUENCY.

- HOWEVER THIS (LOWER Lc) MAY BE OFFSET BY INCREASE IN NOISE TEMP, MISMATCH IN IF AND HIGHER INTERMODULATION.

LOW NOISE FRONT END (SUPER HET Rx)

- FIRST STAGE OF SUPER HET RX.
- SILICON BIPOLAR TRANSISTOR – LOWER FREQ. GALLIUM – ARSENIDE FET- HIGHER FREQ.
- A DIODE LIMITER CAN BE PUT BEFORE / AHEAD OF THE TRANSISTOR WHICH HELPS IN WITHSTANDING HIGHER POWER BEFORE BURN – OUT.
- BUT NOISE FIGURE INCREASES WHEN LIMITER IS USED. (O.5 DB AT X – BAND & 0.2 DB AT C BAND)
- THE LOWER THE FREQ, THE LOWER CAN BE THE TRANSISTOR NOISE FIGURE.
- IT IS BETTER TO TRY TO REDUCE THE SYSTEM'S LOSSES THAN TRY TO REDUCE THE NF OF LNA.

LOW NOISE FRONT END (contd)

- **OTHER LOW NOISE FRONT ENDS**

- PARAMETRIC AMP
- MASER
- THEY WERE EXPENSIVE , BULKY AND DID NOT HAVE SUFFICIENT DYNAMIC RANGE.
- MIXER AS THE FIRST STAGE (FRONT END) IS A VALID OPTION INSPITE OF ITS HIGHER NOISE FIGURE.

TYPES OF RADAR DISPLAYS (SCOPE = DISPLAY)

- **A-SCOPE** **DEFLECTION MODULATED** RECT DISPLAY (VERTICAL DEFLECTION IS PROPORTIONAL TO AMP OF RX O/P AND HORZ COORD IS PROPORTIONAL TO RANGE)

APPLICATION : MANUALLY TRACKING RADAR.

B – SCOPE : INTENSITY MODULATED RECT.
DISPLAY (RANGE VS β ON HORIZONTAL AXIS) .
APPLICATION : AIR BORNE MILITARY RADAR .

C- SCOPE : **INTENSITY MODULATED** RECT DISPLAY. (TWO ANGLES). Elevation vs β (horizontal)
APPLICATION : AIRBORNE INTERCEPT RADAR.

TYPES OF RADAR DISPLAYS (SCOPE = DISPLAY)

- **E- SCOPE : INTENSITY MODULATED** RECT.

DISPLAY (E VS RANGE ON HORIZONTAL)

APPLICATION : USED IN MILITARY AIR BORNE RADARS TO OBTAIN VERTICAL PROFILES OF TERRAIN AHEAD OF AIR CRAFT

PPI DISPLAY : INTENSITY MODULATED CIRCULAR DISPLAY WHERE ECHO SIGNALS ARE SHOWN IN PLAN VIEW WITH RANGE AND β ANGLE DISPLAYED IN POLAR COORDINATES IN MAP LIKE DISPLAY.

CENTRE OF DISPLAY IS THE LOCATION OF RADAR

TYPES OF RADAR DISPLAYS (contd)

- **APPLICATION OF PPI** : SECTOR SCAN PPI TO SCAN A LIMITED SECTOR IN AN AIRBONE RADAR FOR SURVEILLANCE.
- **OFF SET PPI** - PROVIDES A LARGER DISPLAY AREA FOR A SELECTED PORTION OF THE COVERAGE. LOCATION OF RADAR IS AT A LOCATION DIFF. THAN THE CENTRE OF DISPLAY.
- **RANGE – HEIGHT INDICATOR (RHI) DISPLAY**

  INTENSITY MODULATED RECTANGULAR DISPLAY.

  (TGT HEIGHT/ ALTITUDE VS RANGE HORIZONTAL) .

  APPLICATION : USED WITH METEOROLOGICAL RADARS TO OBSERVE VERTICAL PROFILE OF WEATHER ECHOES .

TYPES OF RADAR DISPLAYS (contd)

CRT DISPLAY

- WIDELY USED AS A RADAR DISPLAY
- TWO TYPES OF CRT DISPLAY

DEFLECTION – MODULATED CRT

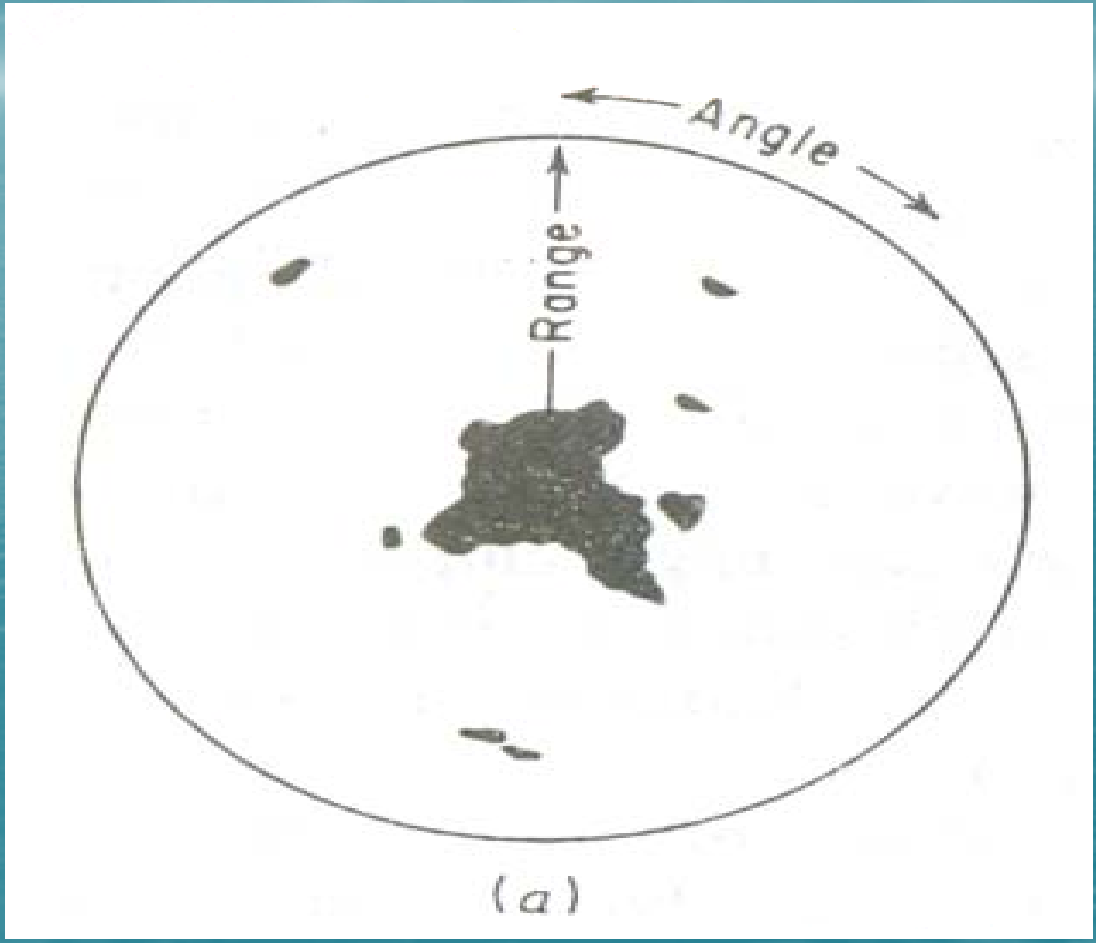
- TGT IS INDICATED BY THE DEFLECTION OF THE ELECTRON BEAM. (LIKE A - SCOPE).

- **INTENSITY – MODULATED CRT**

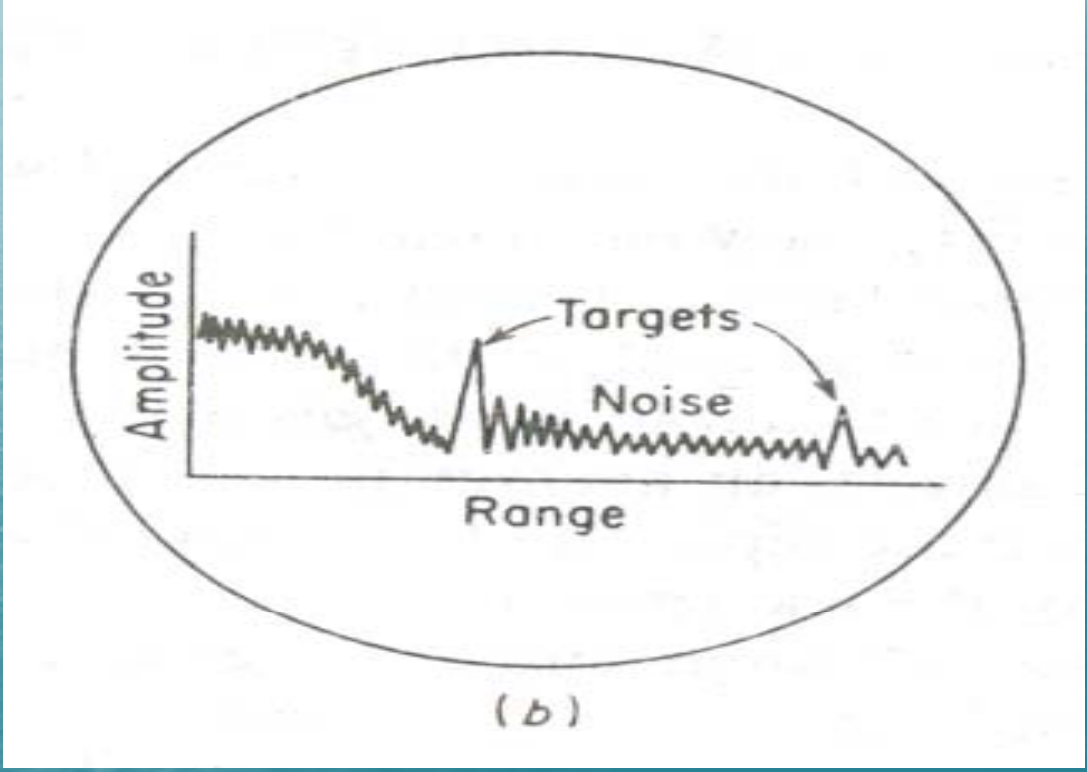
ECHO IS INDICATED BY INTENSIFYING THE ELECTRON BEAM AND PRESENTING A LUMINUOUS SPOT ON THE FACE OF THE CRT (LIKE PPI)

DEFLECTION MODULATED DISPLAY HAS SIMPLE CIRCUITS AND TGT CAN BE READILY IDENTIFIED IN THE PRESENCE OF NOISE CLUTTER OR INTERFERENCE .

PPI PRESENTATION



A-SCOPE PRESENTATION



TYPES OF RADAR DISPLAYS (contd)

- INTENSITY MODULATED DISPLAY HAS THE ADVANTAGE OF PRESENTING DATA IN A MORE CONVENIENT AND EASILY INTERPRETED FORM.
- CRT DISPLAY THOUGH WIDELY USED IN RADAR , TV AND COMPUTERS IS BY NO MEANS IDEAL.
- **DISADVANTAGES OF CRT**
- EMPLOYS A RELATIVELY LARGE VACUUM TUBE .
- THE AMOUNT OF INFORMATION THAT CAN BE PRESENTED IS LIMITED BY THE SPOT SIZE OF THE ELECTRON BEAM.
- IN INTENSITY MODULATED CRT DISPLAY , THE CONTRAST RATIO CAN CAUSE BLOOMING OF THE DISPLAY BY LARGE TGTS SO AS TO MASK THE BLIPS FROM NEARBY SMALLER TGTS.

DECAY CHARACTERSTICS OF CRT

- THE DECAY TIME OF THE VISUAL INFORMATION DISPLAYED SHOULD BE LONG ENOUGH TO ALLOW THE OPEARATOR TO DETECT THE ECHO , YET SHORT ENOUGH SO THAT INFORMATION OF ONE SCAN , DOES NOT INTERFERE WITH THE INFORMATION ENTERED FROM THE SUCCEEDING SCAN.
- EARLIER CRT'S HAD TO BE VIEWED IN A DARK ROOM BUT NOW THESE CAN BE VIEWED IN AMBIENT LIGHT.
- CRT HAS BEEN ABLE TO MAKE SIGNIFICANT IMPROVEMENTS AND IS A COMPETITIVE DISPLAY BECAUSE OF ITS.
- **RUGGEDNESS**
- **LOWER COST**
- **ABILITY TO OPERATE OVER WIDE TEMP RANGES.**
- **ABILITY TO CONVENIENTLY DISPLAY THE TYPE OF INFORMATION OBTAINED BY A RADAR.**

STROKE DISPLAY

- IN PPI , A ROTATING RADIAL LINE (STROBE) ROTATES IN SYNCHRONISM WITH THE SCANNING ANTENNA.
- WITH NO ECHO PRESENT THE TRACE OF STROBE IS DIM, AND IS BRIGHTENED TO INDICATE THE LOCATION OF SIGNAL ON DETECTION .
- THE BRIGHTENED BLIP FADES WITH TIME DEPENDING ON PERSISTENCE OF PHOSPHOR OR REFRESH CHARAC TERISTICS OF CKTS.
- THE OPERATOR FOCUSES ATTENTION ON RADIAL (ROTATING) STROBE LINE TO DETECT TGTS.

RASTER DISPLAY

IT HAS ADVANTAGES OVER STROKE DISPLAY

- A RASTER IS A SCAN PATTERN IN WHICH AN AREA IS SCANNED FROM SIDE TO SIDE IN LINES FROM TOP TO BOTTOM.
- A RASTER DISPLAY CAN BE MADE BRIGHTER THAN A STROKE DISPLAY.
- INFORMATION FROM OTHER SENSORS/RADARS LIKE (IFF) CAN ALL BE COMBINED ON ONE DISPLAY ,IN ADDITION TO PROCESSED RADAR VIDEO AND RAW VIDEO.

SCAN CONVERTER

THIS IS REQUIRED TO CHANGE THE FORMAT OF A STROKE DISPLAY TO THAT OF A RASTER TV – LIKE DISPLAY .

- IT CHANGES THE R,Θ (RANGE & AZIMUTH) COORDINATES OF A PPI INTO X,Y COORDINATES OF A RASTER (TV- LIKE) DISPLAY.
- THE RASTER DISPLAY CAN BE PRESENTED CONTINUOUSLY TO THE OPERATOR SINCE IT CAN BE REFRESHED AT A RAPID RATE .

RASTER DISPLAY (contd)

THE FORMAT OF A RASTER DISPLAY CAN BE THAT OF A TV DISPLAY OR THAT OF A COMPUTER MONITOR . THE ADVANTAGE OF A TV DISPLAY FORMAT IS THAT IT CAN BE RECORDED ON A TAPE THR' VCR VIEWED ON NORMAL TV MONITOR.

FLAT PANEL DISPLAYS (FPD)

TYPES OF FPD

LIQUID CRYSTAL DISPLAY (LCD) USED IN LAP TOP COMPUTERS, WATCHES , INSTRUMENTS AND CALCULATORS (WHERE LOW WEIGHT , VOLUME AND POWER CONSUMPTION ARE IMPORTANT).

- THESE ARE NON-RADAR APPLICATIONS

LCD DISPLAY (contd)

LCD DOES NOT EMIT LIGHT OF ITS OWN. LIGHT IS DIRECTED FROM BEHIND AND THE DISPLAY IS SAID TO BE BACKLIT DISPLAY

TWO TYPES OF LCD DISPLAY – ACTIVE MATRIX LCD AND PASSIVE MATRIX LCD

.

FPD (contd)

2) **PLASMA DISPLAY**

THIS CAN PRODUCE LARGE FLAT FULL COLOR DISPLAYS, LED'S

& ELECTROLUMINESCENT DISPLAYS

ADVANTAGES OF FPD'S OVER CRT DISPLAY

- THEY ARE SMALLER, LIGHTER , OCCUPY LESS VOLUME (REDUCED DEPTH) AND REQUIRE LESS POWER THAN CRT'S.
- THEY ARE MORE RELIABLE & HAVE LOWER LCC.
- FPD IS ESPECIALLY WELL SUITED FOR COCKPIT DISPLAYS IN MILITARY AIRBORNE APPLICATIONS TO HANDLE COMMAND AND CONTROL INFORMATION / EW SENSORS DATA NAVIGATION INFORMATION DATA ETC IN ADDITION TO PRESENTING RADAR INFORMATION.

COLOR IN RADAR DISPLAYS

- ATTENTION GETTER (TO ALERT THE OPERATOR)

STORM / RAINFALL	DISPLAY COLORS
	BLACK / GREEN / YELLOW/ RED

TYPES OF LCD'S (LIQUID CRYSTAL DISPLAYS)

- PASSIVE – MATRIX LCD
- ACTIVE – MATRIX LCD

PASSIVE MATRIX HAS MUCH WIDER NON – RADAR APPLICATIONS, BECAUSE OF ITS LOW COST.

THE ACTIVE MATRIX LCD (AMLCD) HAS MUCH HIGHER RESOLUTION, BETTER IMAGE QUALITY , CAN DISPLAY IN COLOR AND FASTER RESPONSE (GREATER VIDEO BANDWIDTH).

THUS THE AMLCD HAS MORE POTENTIAL FOR RADAR APPLICATIONS THAN THE PASSIVE MATRIX.

- **AN EXAMPLE OF DISPLAY COLORS USED FOR AN AIR BORNE WEATHER AVOIDANCE RADAR**

STORM INTENSITY	RAINFALL RATE	DISPLAY COLOR
DRIZZLE	0.25 mm/hr	BLACK
LIGHT	1.0 mm/hr	GREEN
MEDIUM	4.0 mm/hr	YELLOW
PILOT ALERT (Industry Standard)	11.5 mm/hr	RED

NOTE : ALTHOUGH A MONOCHRONE DISPLAY WITH VARIOUS SHADES OF GRAY CAN EXHIBIT THE ABOVE INFORMATION, A COLOR IS MORE PLEASING AND IS WIDELY ACCEPTED.

DUPLEXERS AND RX PROTECTORS
BRANCH TYPE DUPLEXER

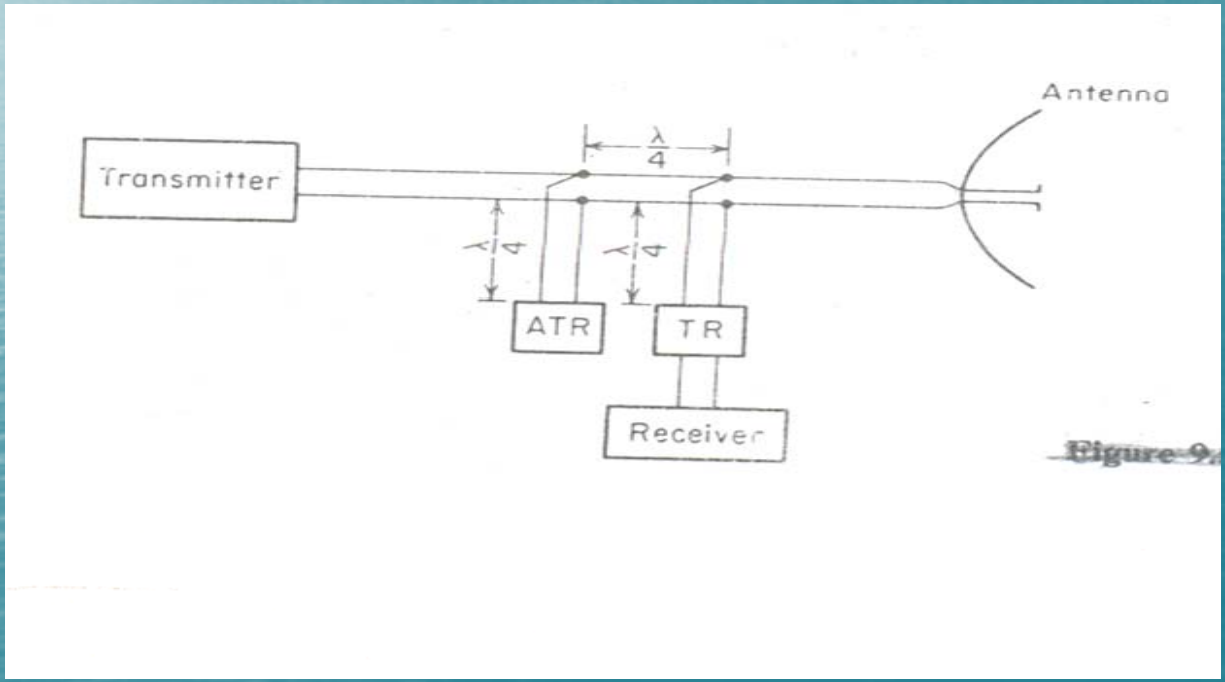
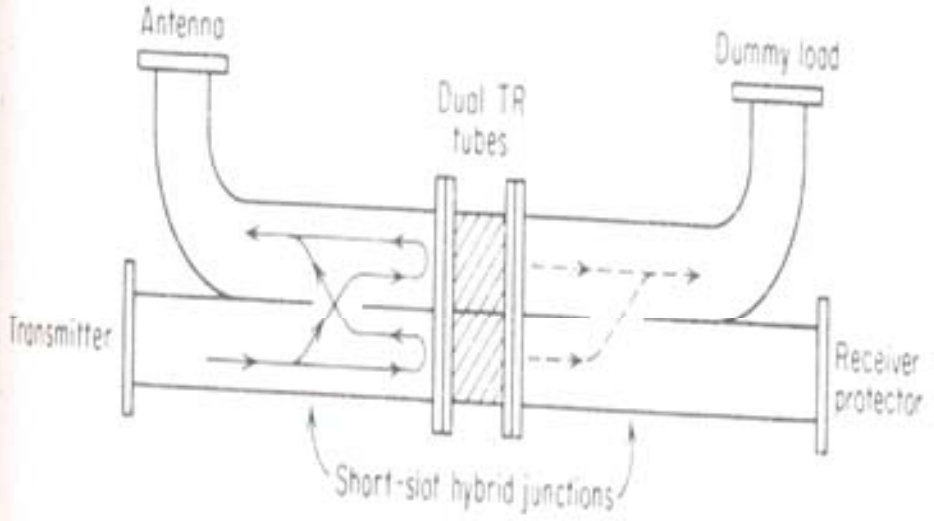


Figure 9.

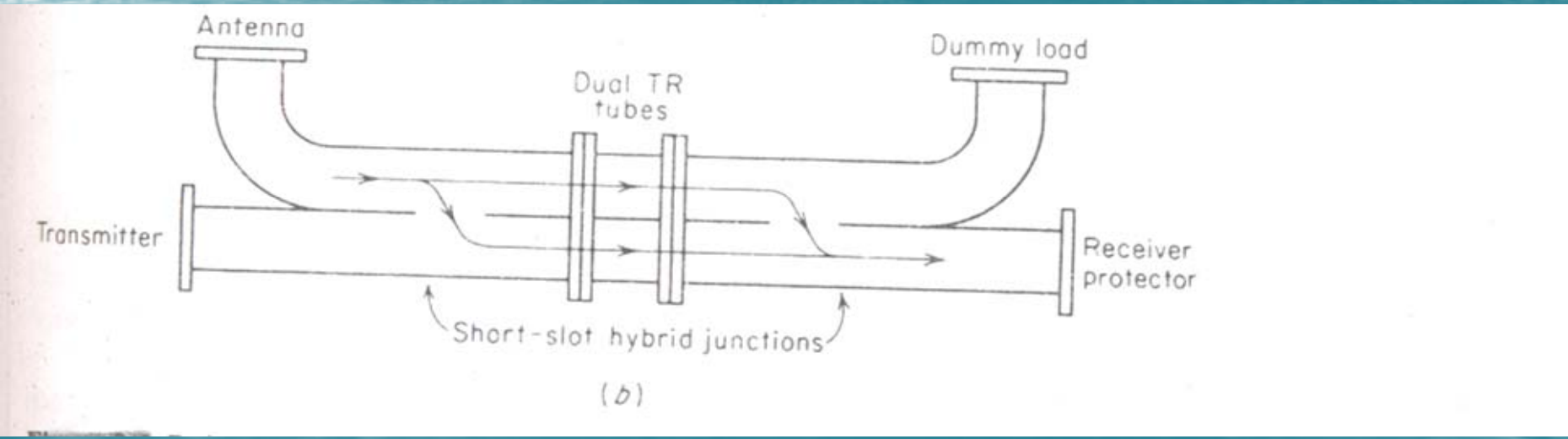
TRANSMIT CONDITION



(a)

RECEIVE CONDITION

- A RADAR DUPLEXER IS THE MW EQVT OF A FAST, LOW- LOSS, SINGLE POLE, DOUBLE THROW SWITCH.
- DUPLEXER SHOULD PROVIDE AN ISOLATION OF 60 TO 70 DB BETWEEN TX AND RX.



TR TUBE

- **IT IS A GAS DISCHARGE DEVICE** DESIGNED TO BREAK DOWN & IONIZE QUICKLY AT THE ONSET OF RF POWER AND THEN DEIONIZE QUICKLY ON REMOVAL OF POWER .
- GAS USED – ARGON (IT HAS LOW BREAKDOWN VOLTAGE)
- ARGON HAS LONGER DEIONISATION TIME, IS THUS NOT SUITABLE FOR SHORTER RANGES.
- ADDITION OF HALOGEN OR WATER VAPOR HELPS TO REDUCE THE DEIONISATION TIME.

TR TUBE (contd)

- **HASTENING THE BREAKDOWN OF TUBE** (a) AN AUX SOURCE OF ELECTRONS IS SUPPLIED TO THE TUBE TO INITIATE DISCHARGE ON APPLICATION OF RF POWER.

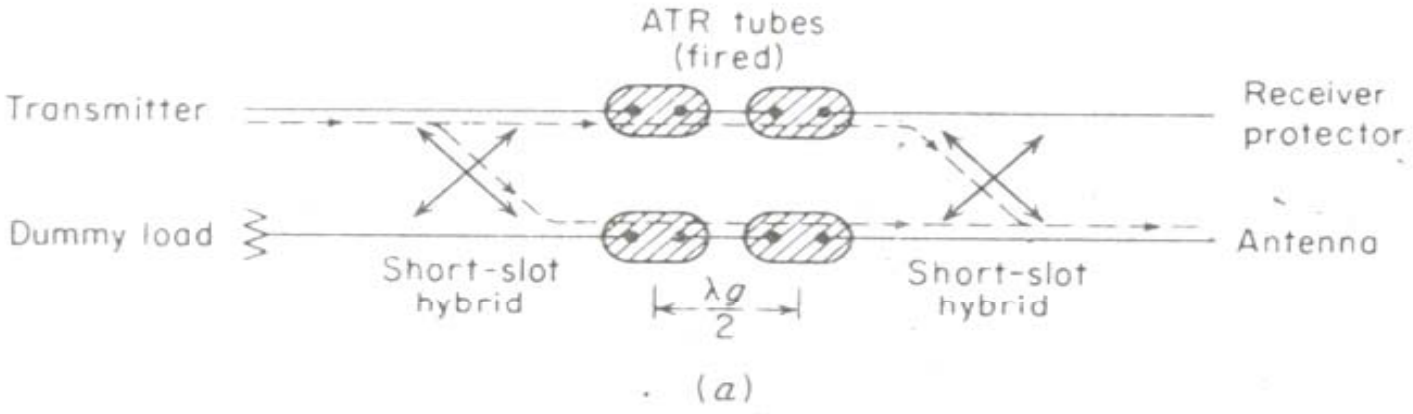
(b) AN ALTERNATIVE IS TO INCLUDE A SOURCE OF RADIOACTIVITY (TRITIUM) WHICH PRODUCES LOW ENERGY LEVEL β RAYS TO GENERATE SUPPLY OF ELECTRONS

.

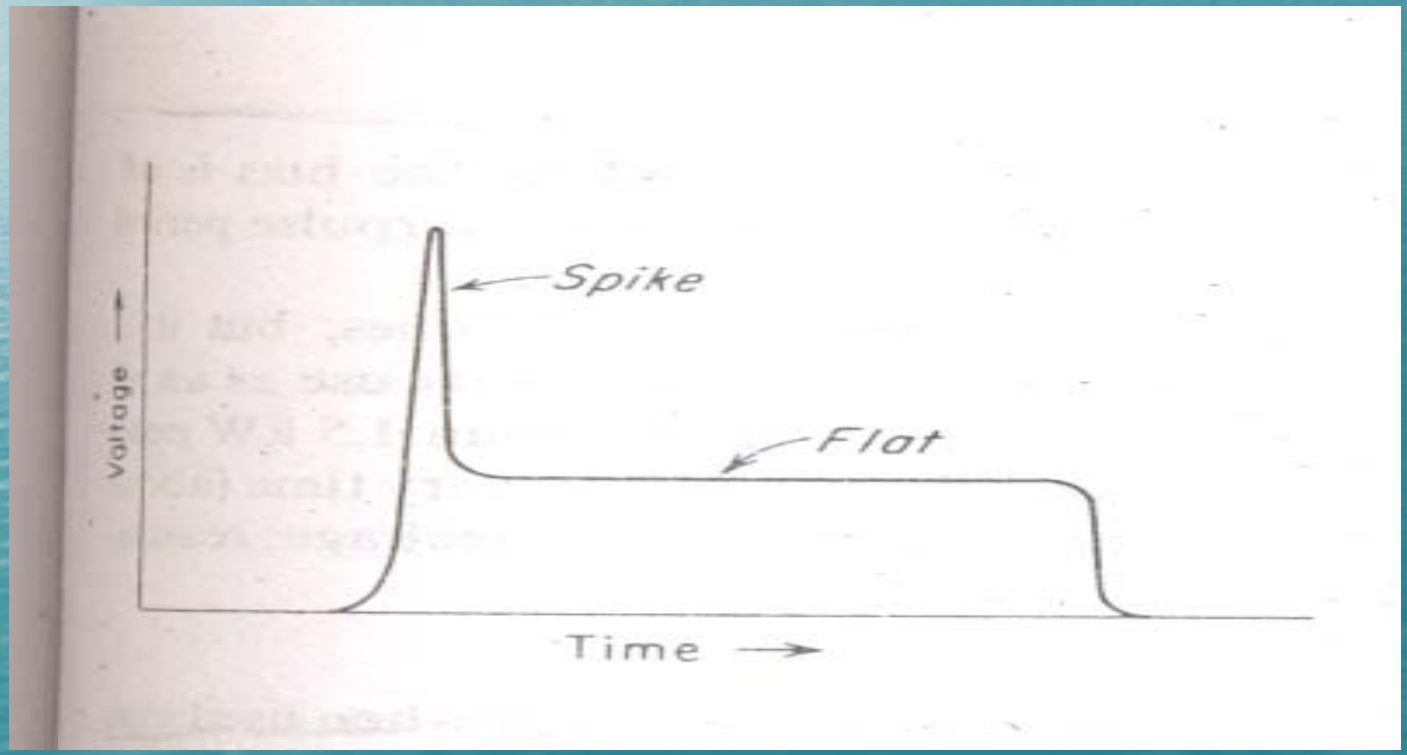
ARC LOSS (0.5 TO 1 DB) A FRACTION OF THE TX POWER INCIDENT ON THE TR TUBE IS ABSORBED BY THE DISCHARGE RESULTING IN ARC LOSS.

INSERTION LOSS (0.5 TO 1 DB) – ON RECEPTION

BALANCED DUPLEXER USING ATR TUBES.



LEAKAGE PULSE THROUGH TR TUBE



RX PROTECTOR

- A DUPLEXER CAN NOT ALWAYS DO THE ENTIRE JOB OF PROTECTING THE RECEIVER . IN ADDITION TO THE TR SWITCH A RX MIGHT REQUIRE DIODE OR FERRITE LIMITER TO LIMIT THE AMOUNT OF LEAKAGE THAT GETS BY THE TR SWITCH . THESE LIMITERS ARE CALLED RX PROTECTORS.

RX PROTECTOR(contd)

- IN ADDITION THERE COULD BE A MECHANICALLY ACTUATED SHUTTER TO SHORT – CIRCUIT AND PROTECT THE RX WHEN EVER THE RADAR IS NOT OPERATING.

PIN DIODE LIMITER PLACED IN FRONT OF RX HELPS REDUCE THE LEAKAGE AND ACT AS A RX PROTECTOR (MAINTAINS O/P POWER CONSTANT) ABOVE A THRESHOLD. DIODE LIMITER COULD BE PASSIVE OR ACTIVE.

PIN DIODE LIMITER (contd)

PASSIVE (SELF - ACTUATED) - IT IS UNBIASED OPERATION OF THE DIODE LIMITER WITHOUT THE USE OF EXTERNAL CURRENT SUPPLY.

ADVANTAGE : UNLIMITED OPERATING LIFE,FAST RECOVERY TIME,VERSATILITY TO PERFORM MULTIPLE ROLES AND NO RADIO – ACTIVE PRIMING.

DOIDE LIMITER(ACTIVE)

ACTIVE – BIASING OF THE DIODE DURING HIGH – POWER PULSE IS KNOWN AS ACTIVE

IT IS CAPABLE OF HANDLING A GREAT DEAL OF MORE POWER THAN WHEN OPERATED PASSIVELY.

DISADVANTAGE – IT DOES NOT PROTECT THE RECEIVER WHEN THE BIAS IS OFF . THIS RESULTS IN POOR PROTECTION WHEN RADAR IS SHUT DOWN OR FROM ASYNCHRONOUS TRANSMISSIONS DURING INTERPULSE PERIODS.

CIRCULATORS AS DUPLEXERS

FERRITE CIRCULATOR IS A 3 OR 4 PORT DEVICE

-OFFERS ISOLATION BETWEEN TX & RX IN 3 PORT DEVICE

- TX IS CONNECTED TO PORT 1
- ANT IS CONNECTED TO PORT 2
- RECD ECHO CONNECTED TO PORT 3
-

ISOLATION BETWEEN VARIOUS PORTS = 20 -30 db WHICH IS DETERMINED BY THE REFLECTION (DUE TO IMPEDANCE MISMATCH) OF THE TX SIGNAL RETURNED FROM ANT TO THE RX DIRECTLY.

- **CIRCULATORS (contd)**
- CIRCULATORS CAN BE MADE TO WITHSTAND HIGH PEAK POWER . HOWEVER ,SIZE & WT INCREASES ACCORDINGLY.
- SMALL SIZE CIRCULATORS ,USUALLY IN CONJUNCTION WITH A RECEIVER PROTECTOR OFTEN ARE USED AS THE DUPLEXER IN SOLID STATE TR MODULES.
- A LARGE CIRCULATOR (80 LBS) CAN HANDLE 50 KW AVERAGE POWER.
- A SMALL CIRCULATOR (1.5 OZ) IS RATED AT 50 W

SOLID STATE DUPLEXERS

- SOLID STATE DUPLEXERS HAVE POTENTIAL
- FOR LONG LIFE, FAST RECOVERY TIME.
- NO RADIO ACTIVE PRIMING
- VERSATILITY
- ACTIVE CKTS CAN HANDLE MORE POWER THAN PASSIVE OPERATION .
- PIN DIODES SWITCHED IN SYNCHRONISM WITH TX PULSES WILL HANDLE LARGE POWER, BUT WILL HAVE LONGER RECOVERY TIMES AND HIGH LEAKAGE POWER.

SOLID STATE DUPLEXERS

EXAMPLE: L BAND SELF SWITCHING DUPLEXER

(USING 4 PIN DIODES BIASED BY 4 VARACTOR DIODES)

PEAK POWER HANDLING CAPACITY : 100 KW

AVG POWER : 100 W

3 µSEC PULSE WIDTH

INSERTION LOSS : 0.5 dB

SPIKE LEVEL : 2.8 KW

FLAT LEAKAGE : 32 W

RECOVERY TIME : 15 µSEC

C BAND SOLID STATE DUPLEXER (16 PIN DIODES)

PEAK POWER = 1 MW

PULSE WIDTH = 14 **µSEC**

INSERTION LOSS : 0.6 DB

ISOLATION PROVIDED BY SOLID STATE DUPLEXER : 60 DB.

VARACTOR RX PROTECTOR

- SUCH A DEVICE IS FAST ACTING PN (VARACTOR) DIODE.
- LIMITS THE RISE TIME TO LESS THAN ONE NANOSECOND.
- LIMITS THE MULTI – KW RF PULSES TO 1-W SPIKE LEVELS.(X-BAND PASSIVE RX PROTECTOR0

FERRITE LIMITER

- HAS FAST RECOVERY TIME AND LONG LIFE
- CAN SUPPORT A PEAK POWER OF 100 KW.
- INSERTION LOSS IS HIGHER (1.5 DB)
- BULKY / HEAVIER AND MORE EXPENSIVE COMPARATIVELY
- AIR OR LIQUID COOLING MAY BE REQUIRED
- A DIODE LIMITER USUALLY FOLLOWS FERRITE LIMITER TO REDUCE THE LEAKAGE AT HIGH PEAK POWER.

PRE- TR LIMITER (GASEOUS TUBE) PLACED INFRONT OF SOLID STATE LIMITER.

- FUNCTION OF PRE- TR LIMITER IS TO REDUCE THE POWER THAT HAS TO BE HANDLED BY DIODE LIMITER .
- IT HAS HIGH POWER HANDLING CAPABILITY , CAN OPERATE WITH LONG PULSES , HAS FAST RECOVERY TIME AND CONTAINS A RADIO ACTIVE PRIMING SOURCE.

PRE- TR LIMITER

- IT HAS LIMITED OPERATING LIFE
- MAY REQUIRE LIQUID COOLING (WHILE HANDLING HIGH POWER)
- THE PRE – TR TUBE CAN BE A QUARTZ CYLINDER FILLED WITH CHLORINE OR MIXTURE OF CHLORINE AND AN INERT GAS.
- CHLORINE, A HALOGEN GAS, HAS VERY RAPID RECOVERY TIME (TYPICALLY A FRACTION OF A μSEC FOR PW ≤ 10 μS)

COMPARISON OF VARIOUS DUPLEXING DEVICES

DEVICE	RECOVERY TIME	PEAK POWER (HANDLING CAPACITY)
TR TUBE	< 1 µS TO 100 µS	1MW
PRE – TR	50 nS TO 1 µS	5MW
DIODE LIMITER	50 nS TO 10 µS	100 MW
FERRITE LIMITER	20 nS TO 120 nS	100 KW
MULTIPACTOR	1 nS TO 20 nS	80 KW

NOTE : THESE VALUES DEPEND ON FREQUENCY AND OTHER FACTORS. THUS THE VALUES ARE ONLY AN APPROXIMATE GUIDE (AND NOT ABSOLUTE)

- **MULTIPACTOR**
- FAST RECOVERY TIME IS IMPORTANT FOR HIGH PRF & HIGH DUTY CYCLE RADARS, SINCE IT IS A VACCUM TUBE.

MULTIPACTOR ALLOWS RECOVERY TIME TO BE REDUCED TO 5-10 nSEC.

- MULTIPACTOR IS A VACCUM TUBE HAVING SURFACES CAPABLE OF LARGE SECONDARY (ELECTRON) EMISSION, UPON IMPACT OF ELECTRONS.

MULTIPACTOR (contd)

- **THE ELECTRON CLOUD**
- GENERATED DUE TO SECONDARY EMISSION MOVES IN PHASE WITH THE OSCILLATIONS OF APPLIED RF ELECTRIC FIELD AND ABSORBS ENERGY FROM RF FIELD. THIS DISSIPATION OF RF POWER THERMALLY AT THE SECONDARY EMISSION SURFACE REQUIRES LIQUID COOLING TO REMOVE THE ABSORBSED POWER.
- THE FLAT LEAKAGE POWER PASSED BY MULTIPACTOR IS OFTEN HIGH ENOUGH TO REQUIRE A PASSIVE DIODE LIMITER TO FOLLOW IT.

DISADVANTAGES OF MULTIPACTOR

- OFFERS NO PROTECTION WHEN POWER IS TURNED 'OFF'
- COMPLEX, AS IT REQUIRES LIQUID COOLING, AND AN IGNITOR ELECTRODE FOR QUICK MULTIPACTING ACTION.
- REQUIRES AN OXYGEN SOURCE TO MAINTAIN MAGNESIUM OXIDE SURFACE TO PROVIDE SEC. EMISSION.
- REQUIRES A PUMP TO MAINTAIN GOOD VACCUM

SENSITIVITY TIME CONTROL (STC)

STC : IT IS THE PROGRAMMED CHANGE OF GAIN (OF RX) WITH TIME.

- AT SHORT RANGES THE RX GAIN IS LOWERED TO REDUCE LARGE NEARBY CLUTTER ECHOES.
- AS THE PULSE TRAVELS OUT IN RANGE THE GAIN IS INCREASED UNTIL THERE ARE NO MORE CLUTTER ECHOES.
- STC IS APPLIED IN RF PORTION OF THE RX BY BIASING THE DIODES OF RX PROTECTOR TO PROVIDE A TIME VARYING ATTENUATION.
- THE STC VARIATION DEPENDS UPON THE NATURE OF THE TERRAIN SEEN BY THE RADAR.

.

- STC CAN BE USED EVEN WHEN NO CLUTTER IS PRESENT TO COMPENSATE FOR THE LARGE CHANGE IN MAGNITUDE OF THE TGT ECHO SIGNAL AS A FUNCTION OF RANGE.
- HOWEVER, STC CAN'T BE USED WITH PD RADARS THAT USE HIGH PRF RESULTING IN RANGE AMBIGNTIES.

RADAR BEACONS

- IT IS A TRANSPONDER SYSTEM.
  (R^X,T^X AND ANT SYSTEM)
- BEACON ACTION IS INTIATED BY THE RECEPTION OF AN INTERROGATION PULSE FROM THE RADAR.
- THE REPLY CAN BE ON RADAR FREQ OR A DIFF FREQ.
- SINCE BEACON REPLIES WITH FULL POWER,LONG RANGES ARE POSSIBLE.
- MAGNITUDE OF REPLY SIGNAL DOES NOT FLUCTUATE AS IN THE CASE OF CONVENTIONAL RADAR SYSTEM.

INTERROGATION FRIEND / FOE (IFF)

- BEACONS CAN BE ARRANGED SO THAT THEY WILL OPERATE ,IF PULSE LENGTH IS OF A SPECIFIC VALUE OR PRF IS CHANGED TO SOME PARTICULAR VALUE (OTHER THAN NORMAL RADAR VALUES).
- BEACON RESPONDS ONLY TO CORRECT INTERROGATION AND DOES NOT TRANSMIT ALL THE TIME.
- BEACON INSTALLED ON AIRCRAFT CAN BE USED FOR SELF IDENTIFICATION AND AS WELL AS TO DETERMINE ITS POSITION.
- THE PRESENCE OF A BEACON ON A TARGET INCREASES ENORMOUSLY THE RANGE OVER WHICH A TARGET MAY BE TRACKED.