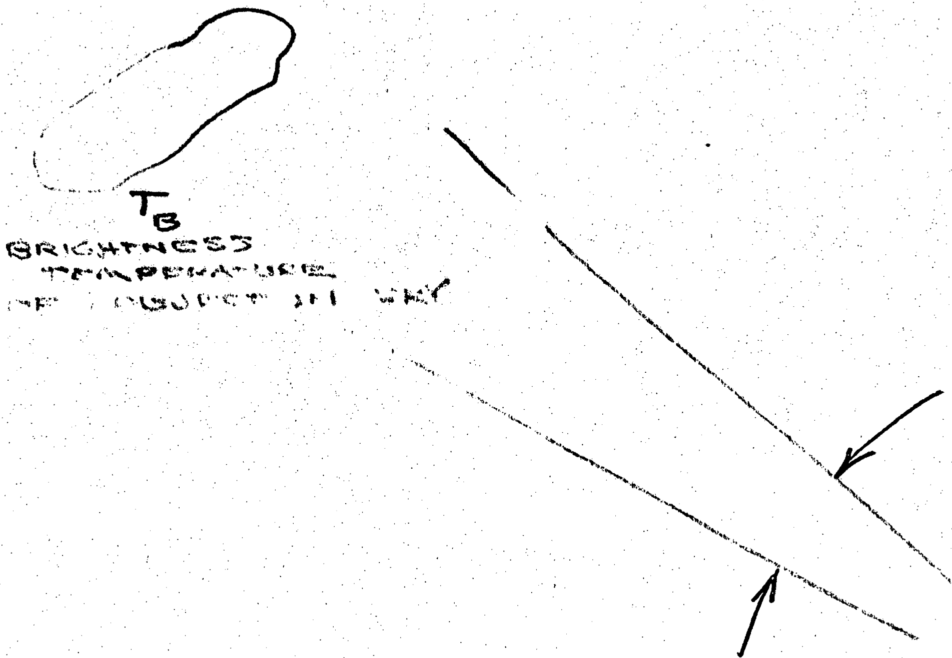
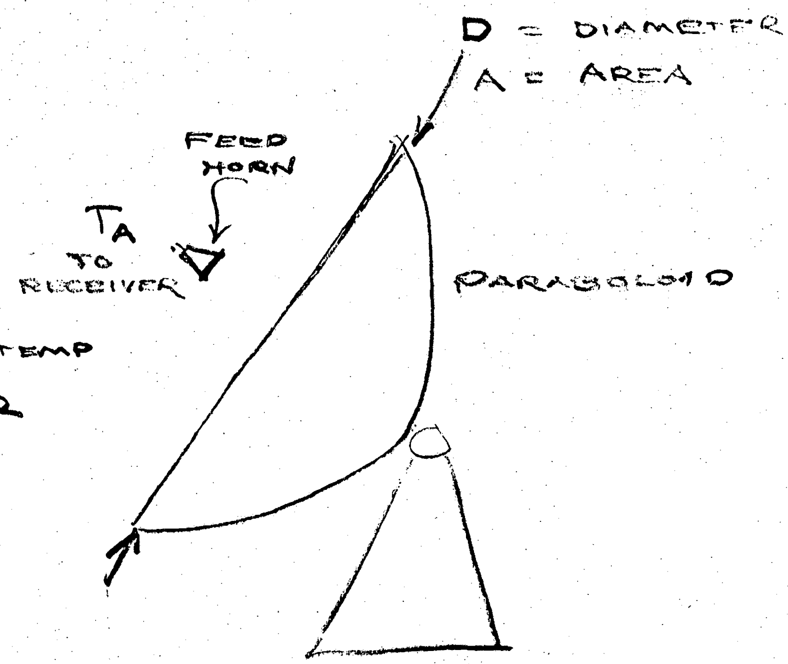
LECTURE NOTES
S. WEINREB
JUNE 17, 1978





ANTENNA NOISE TEMPERATURE; ANTENNA GAIN FUNCTION; SKY BRIGHTNESS TEMP

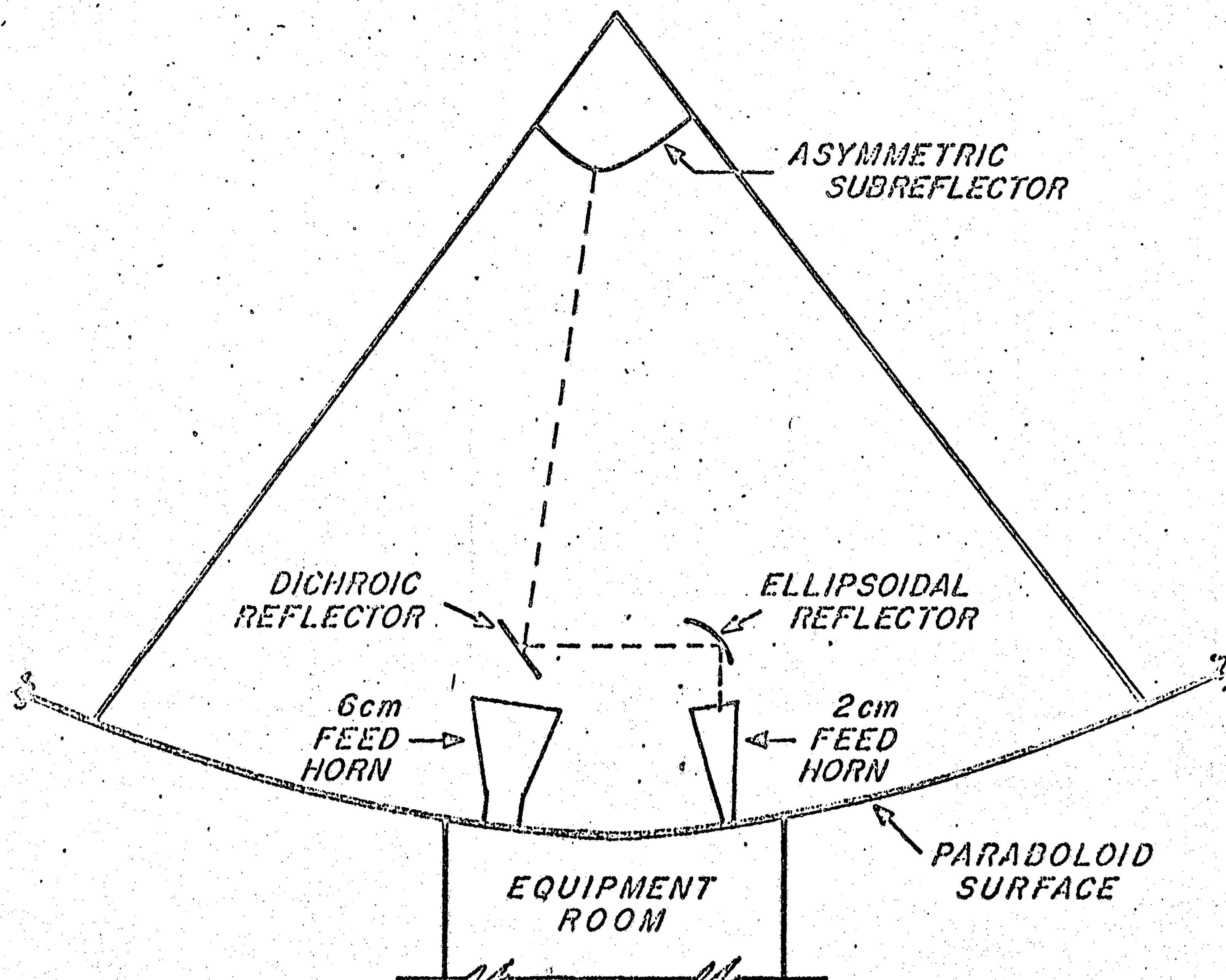
$$T_A = \frac{1}{4\pi} \int_{4\pi} G(\theta,\varphi)\, T_B(\theta,\varphi)\, d\Omega$$

$$G(0,0) = \frac{4\pi A}{\lambda^2}$$

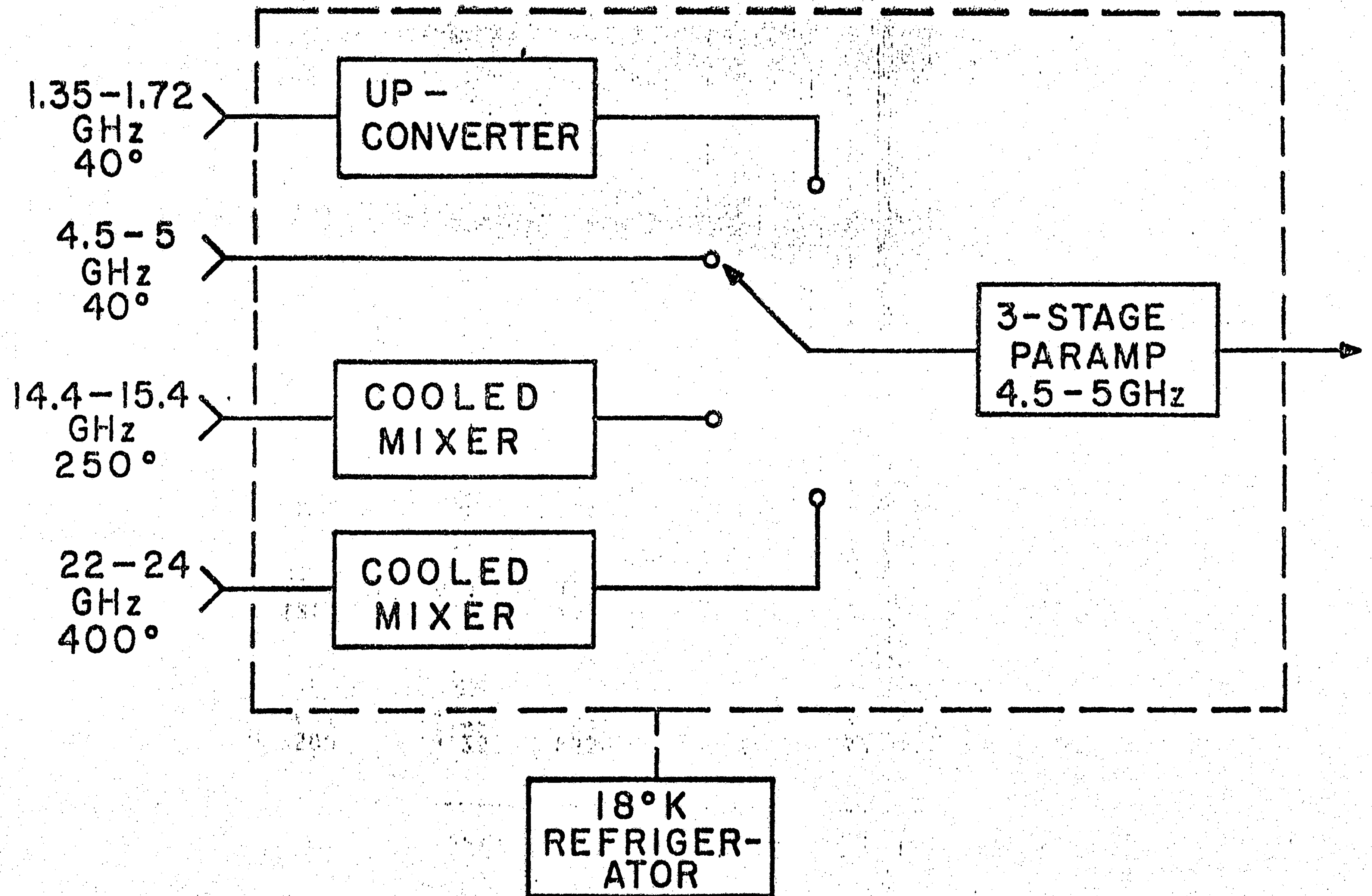
$$\frac{1}{4\pi} \int G(\theta,\varphi)\, d\Omega = 1$$

BASIC RADIO TELESCOPE

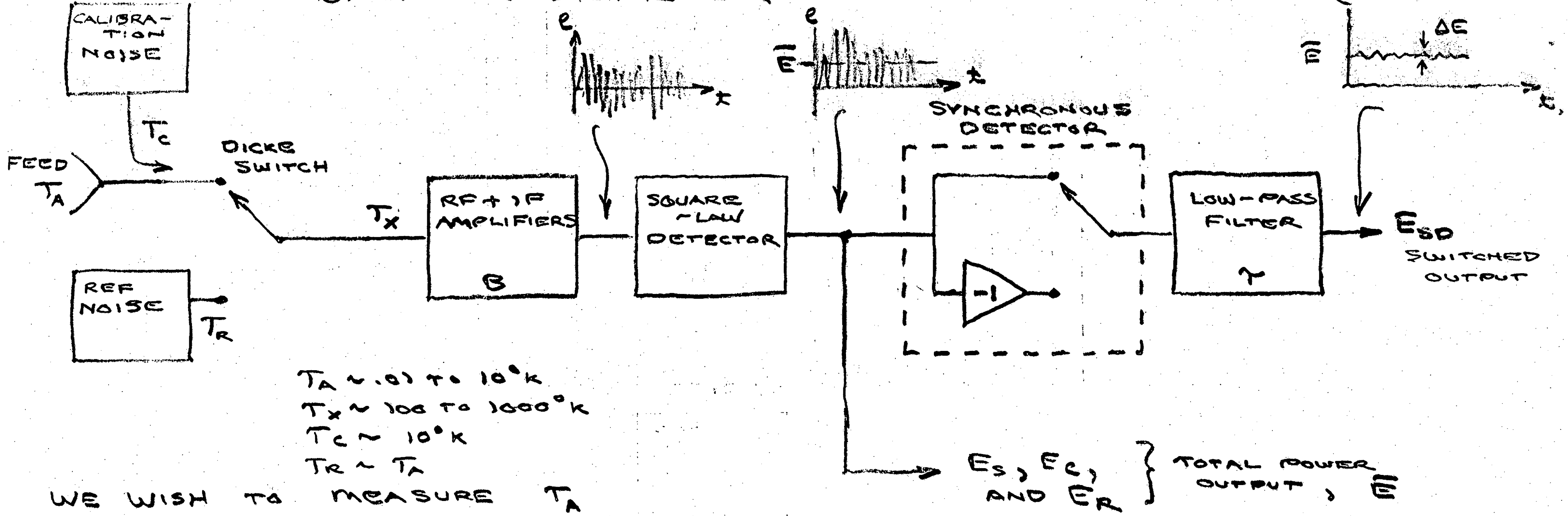
VLA FEED CONFIGURATION



VLA FRONT-END CONFIGURATION



BASIC RADIOMETER



$T_A \sim .01$ to $10°K$
$T_X \sim 100$ to $1000°K$
$T_C \sim 10°K$
$T_R \sim T_A$

WE WISH TO MEASURE T_A

BASIC INPUT-OUTPUT RELATION ⟶

$$\left(\text{AVERAGE DETECTOR OUTPUT VOLTAGE, } \bar{E}\right) = \Big(\underbrace{k\ B\ G'}_{=G}\Big) \times \left(\text{TOTAL INPUT NOISE TEMPERATURE}\right)$$

k: 1.38×10^{-23}; B: NOISE BANDWIDTH; G': TOTAL POWER GAIN

SWITCH UP, CAL OFF ⟶ $\bar{E}_S = G(T_X + T_A)$ SIGNAL VOLTAGE

SWITCH UP CAL ON ⟶ $\bar{E}_C = G(T_X + T_A + T_C)$ CALIBRATION VOLTAGE

SWITCH DOWN CAL OFF OR ON ⟶ $\bar{E}_R = G(T_X + T_R)$ REFERENCE VOLTAGE

3 EQUATIONS, 3 UNKNOWNS (T_A, G, T_X)

LECTURE NOTES
S. WEINREB
JUNE 20, 1974

SENSITIVITY LIMITATIONS

①

$$\frac{RMS}{MEAN} \equiv \frac{\Delta E}{\bar{E}} = \frac{\Delta T_A}{T_x + T_A} = \frac{1}{\sqrt{B\tau}}$$

LIMIT DUE TO STATISTICAL FLUCTUATIONS OF NOISE

(B: NOISE BANDWIDTH; τ: INTEGRATION TIME)

②

$$\frac{\Delta G}{G} \sim 1\%$$

LIMIT DUE TO RECEIVER GAIN STABILITY

MODIFICATIONS TO BASIC RECEIVER

① DICKE SWITCHING – SYNCHRONOUS DETECTION

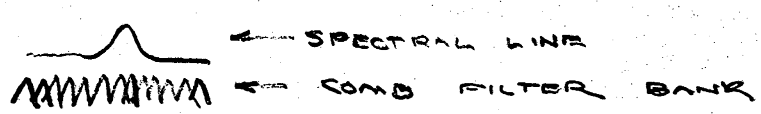
$$\bar{E}_{SD} = E_S - E_R = G(T_A - T_R)$$

② COMPUTER SYNCHRONOUS DETECTION

$$T_A = \frac{\bar{E}_S - \bar{E}_R}{\bar{E}_C - \bar{E}_S} \cdot T_C + T_R$$

③ MULTICHANNEL LINE RECEIVER

– COMB FILTERS AND MULTIPLE DETECTORS



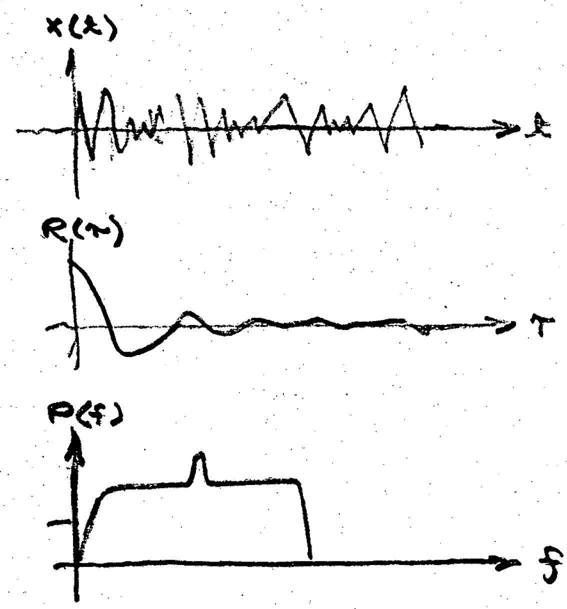
AUTOCORRELATION RECEIVERS

$$T(f) = \int_{-\infty}^{\infty} R(\tau) \cos 2\pi f \tau \, d\tau$$

{ TEMPERATURE SPECTRUM $T(f)$ AS FOURIER TRANSFORM OF AUTOCORRELATION FCN, $R(\tau)$

$$R(\tau) = \lim_{T \to \infty} \frac{1}{2T} \int_{-T}^{T} x(t)\, x(t+\tau)\, dt$$

{ DEFINITION OF $R(\tau)$ IN TERMS OF SIGNAL TIME FUNCTION, $x(t)$.



MODIFICATIONS TO THEORY

MODIFICATION	EFFECT
τ CANNOT $\to \infty$	FREQUENCY RESOLUTION $\Delta B \sim \frac{1}{\tau_{MAX}}$
T CANNOT $\to \infty$	STATISTICAL FLUCTUATION $\frac{\Delta T}{T} = \frac{1}{\sqrt{BT}} \sim \sqrt{\frac{\tau_{MAX}}{T}}$
$R(\tau)$ IS SAMPLED IN STEPS OF $\Delta\tau$	$f_{MAX} = \frac{1}{2\Delta\tau}$
$x(t)$ IS SAMPLED IN STEPS OF Δt	NO EFFECT IF $f_{MAX} = \frac{1}{2\Delta t}$
$x(t)$ IS QUANTIZED IN N BITS	$\frac{\Delta T}{T}$ SLIGHTLY INCREASED