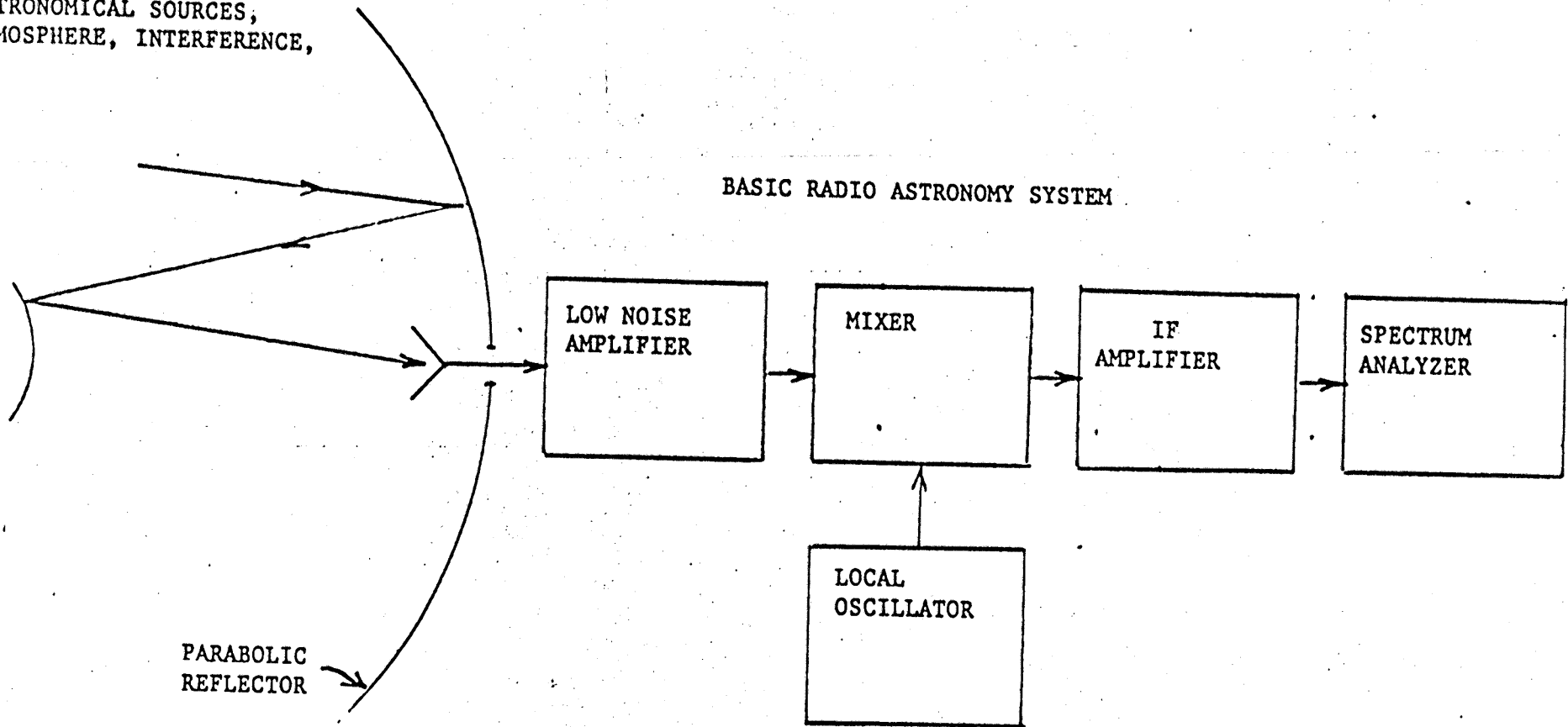


RADIO WAVES FROM:
ASTRONOMICAL SOURCES,
ATMOSPHERE, INTERFERENCE,

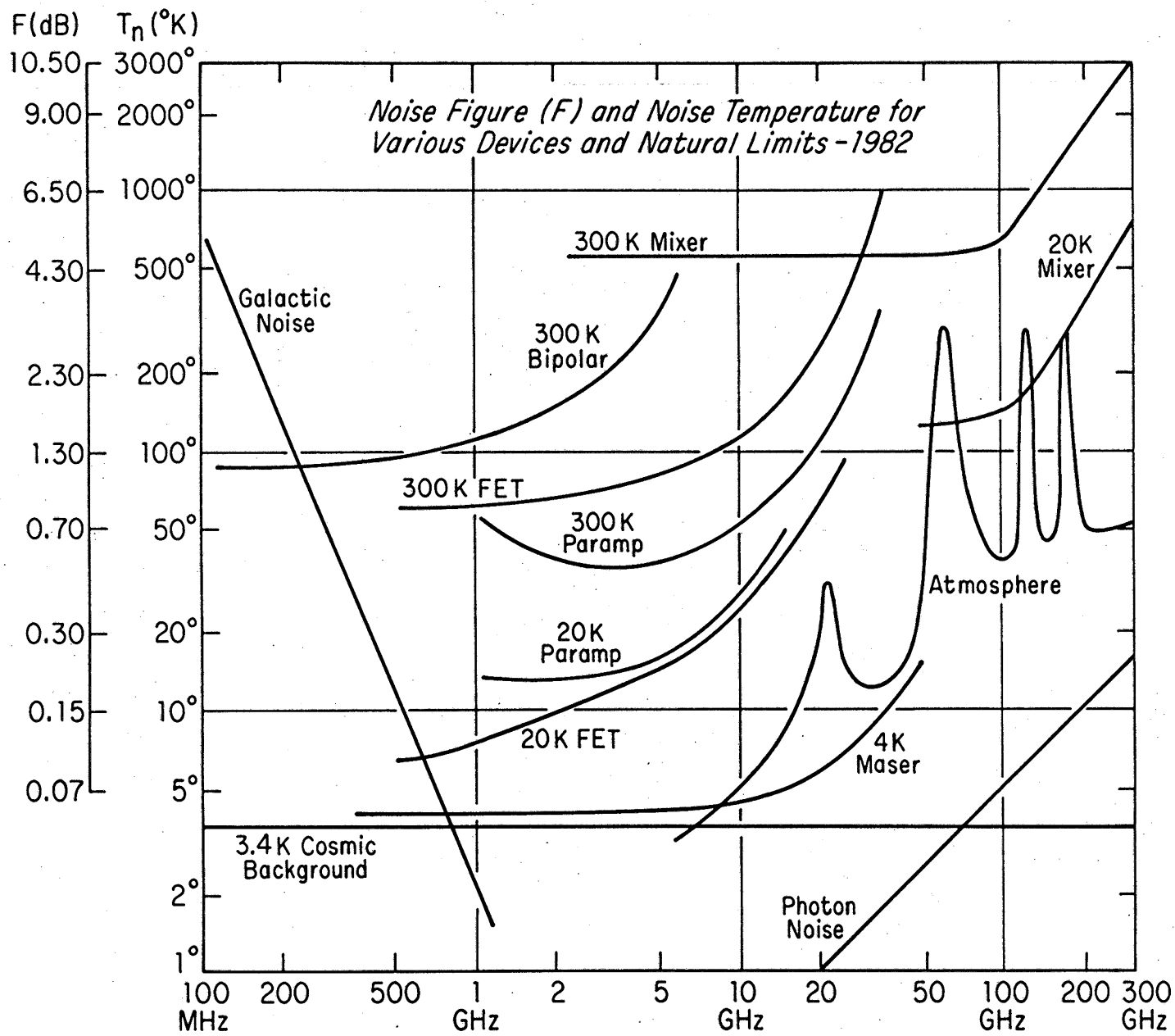
BASIC RADIO ASTRONOMY SYSTEM



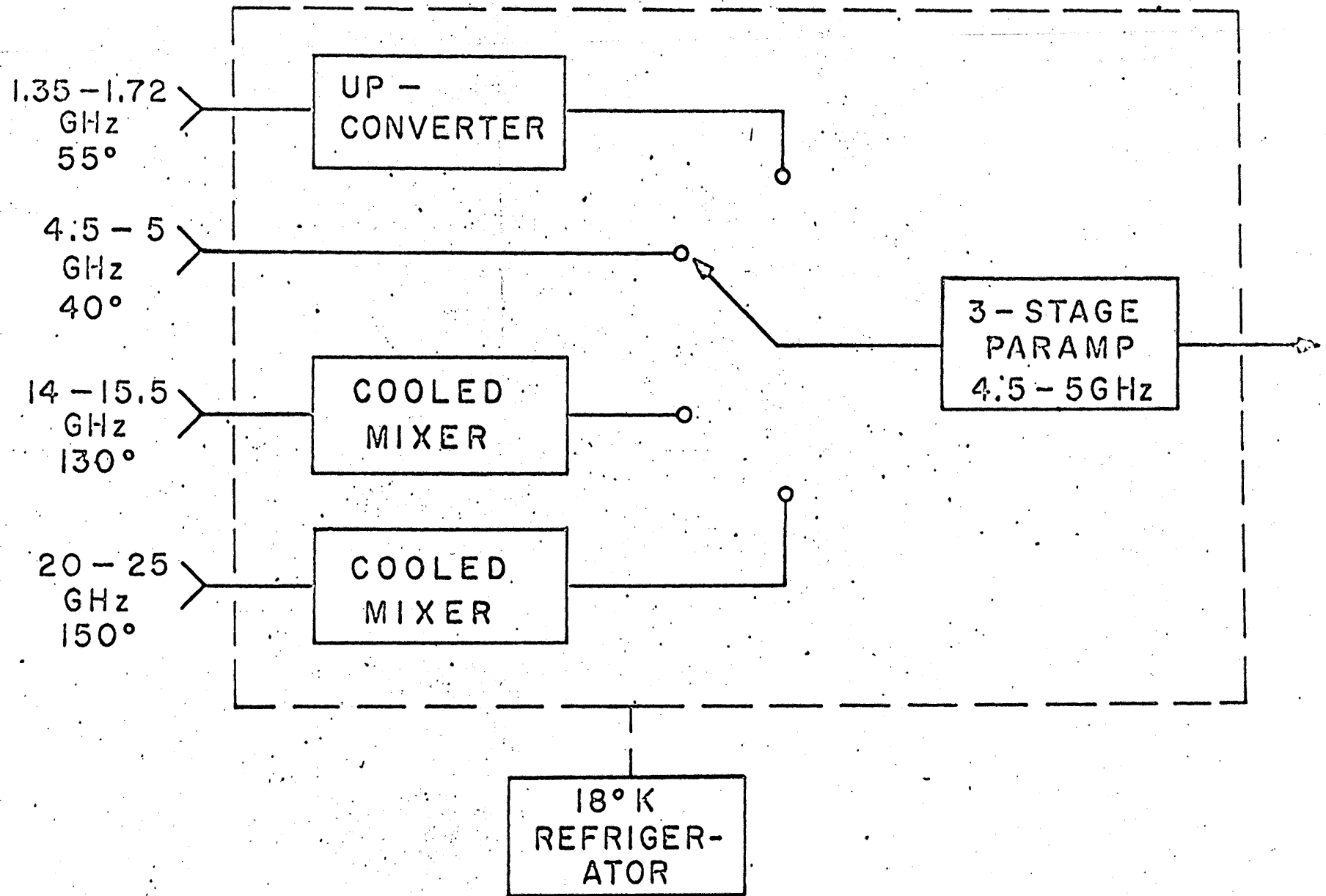
PROBLEM AREAS

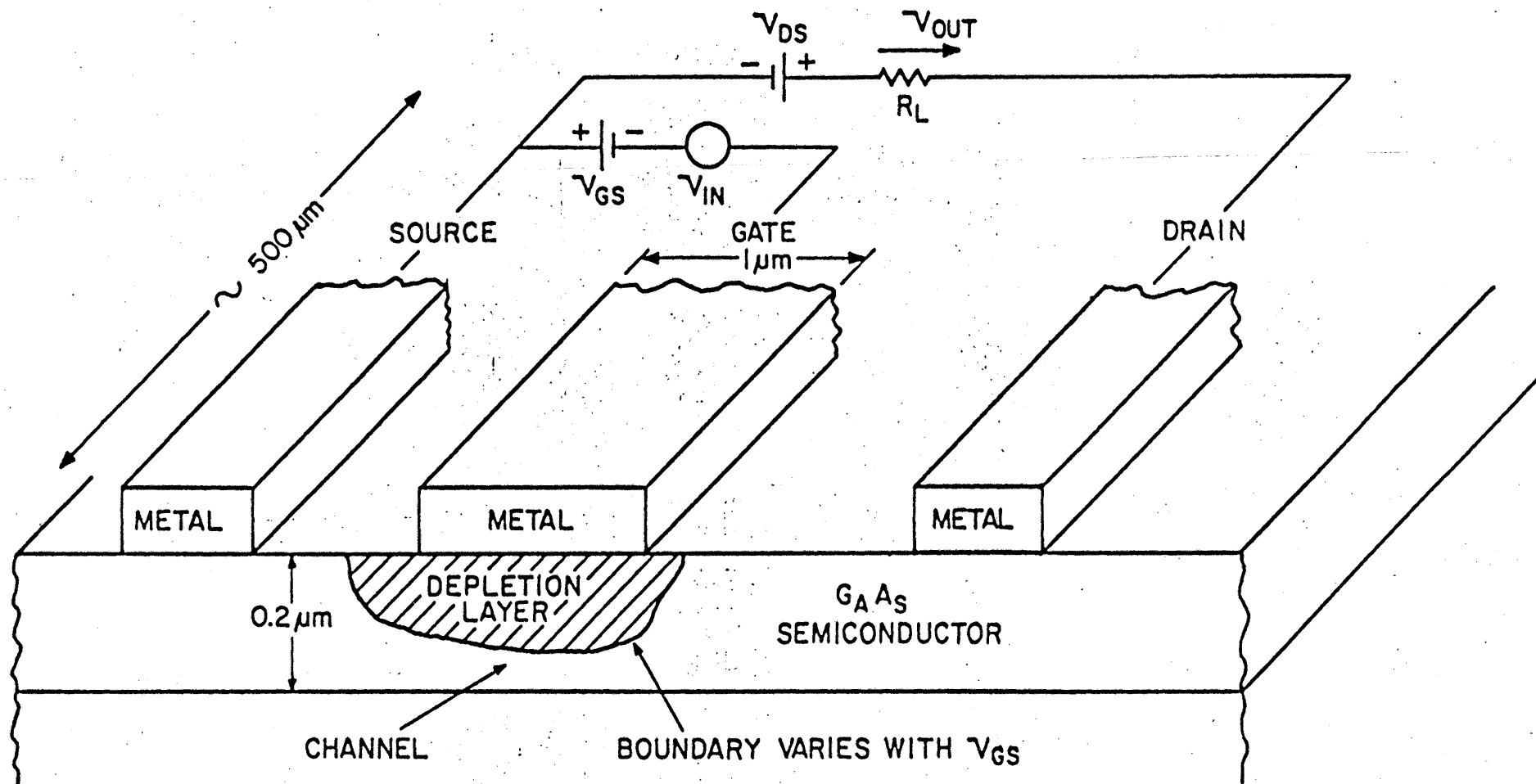
- 1) IN CM RANGE LOW-NOISE AMPLIFIERS LIMIT SENSITIVITY AND TEND TO BE UNRELIABLE.
- 2) IN MM- λ RANGE LOW-NOISE AMPLIFIERS DO NOT EXIST; EFFICIENT MIXERS MUST BE DEVELOPED.
- 3) MM- λ LOCAL OSCILLATORS ARE EXPENSIVE, UNRELIABLE AND DO NOT EXIST FOR SHORT MM- λ RANGES.
- 4) SPECTRUM ANALYZERS COVERING GHz BANDWIDTHS WITH $\sim 10^4$ CHANNELS ARE NEEDED.

LECTURE NOTES
S. WEINER
6/20/83

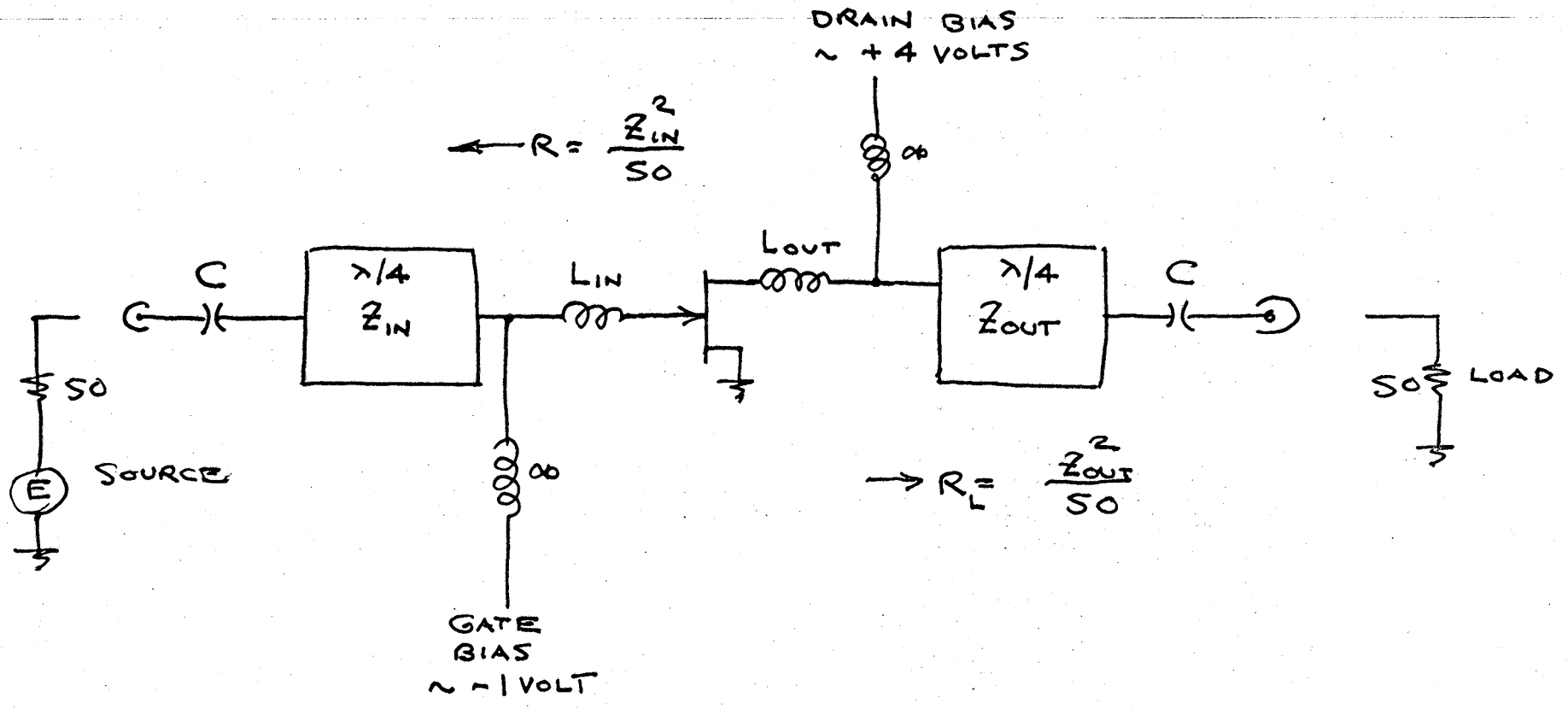


VLA FRONT-END CONFIGURATION





ISOMETRIC VIEW OF GASFET



ONE - STAGE FET AMPLIFIER

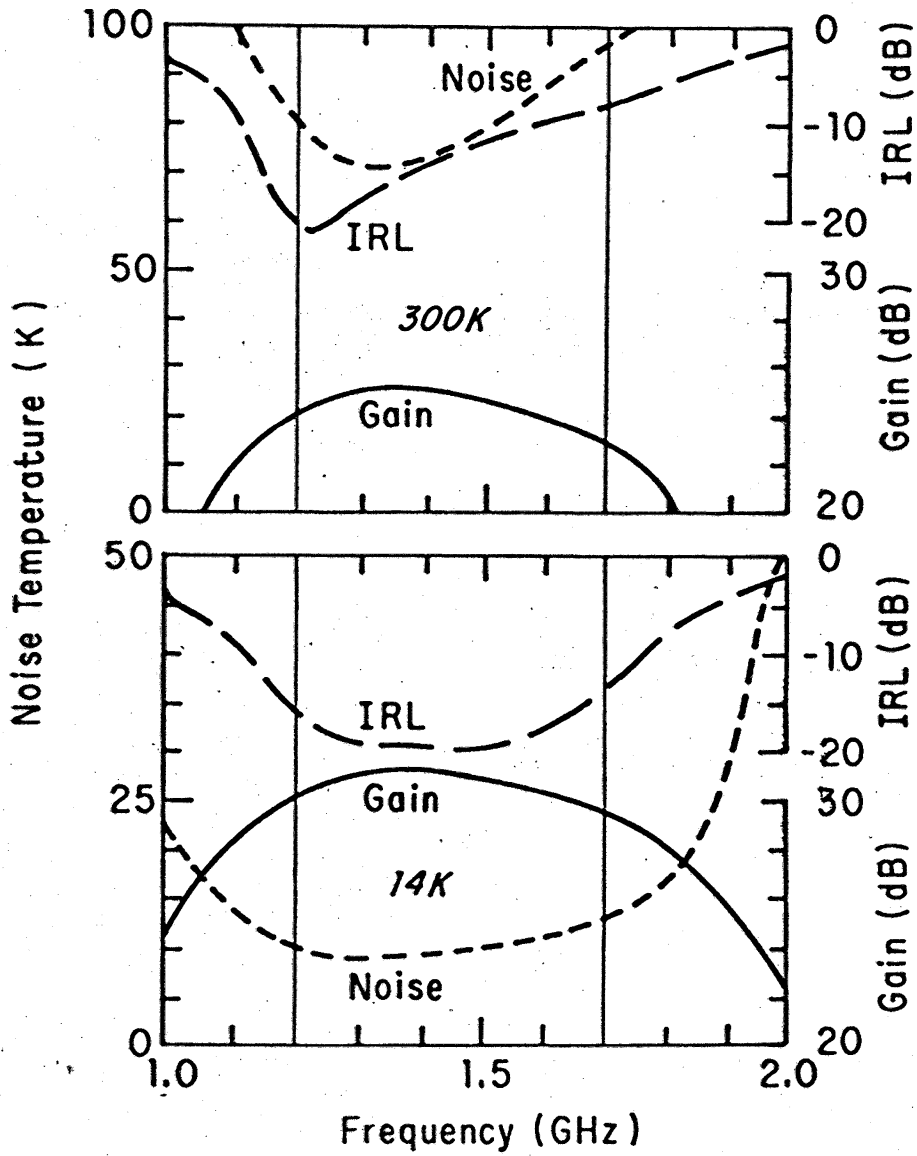
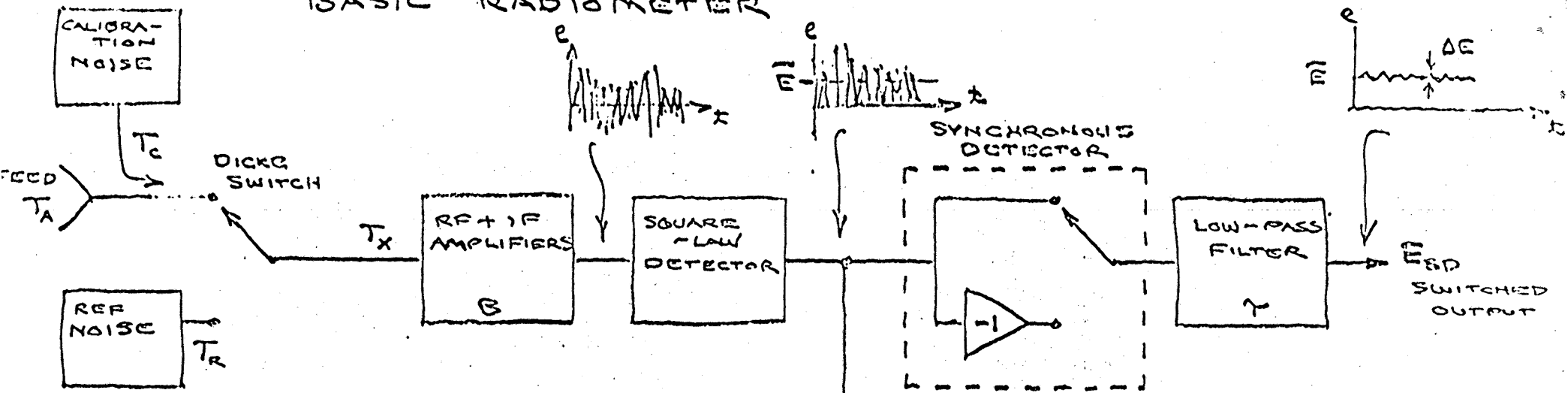


Fig. 6. Input return loss (IRL), gain, and noise temperature of amplifier #74 at 300K (top) and 14K (bottom). Note scale change for noise temperature.

BASIC RADIOMETER



$T_A \sim 0.1$ TO 10^4 K
 $T_x \sim 100$ TO 1000° K
 $T_c \sim 10^4$ K
 $T_r \sim T_A$

WE WISH TO MEASURE T_A

BASIC INPUT - OUTPUT RELATION

$$\left(\begin{array}{c} \text{AVERAGE} \\ \text{DETECTOR} \\ \text{OUTPUT} \\ \text{VOLTAGE,} \\ \bar{E} \end{array} \right) = \left(\begin{array}{c} \approx G \\ \uparrow \quad \uparrow \quad \uparrow \\ 1.38 \times 10^{-23} \quad \text{NOISE} \quad \text{TOTAL} \\ \text{BANDWIDTH} \quad \text{POWER} \\ \text{GAIN} \end{array} \right) \times \left(\begin{array}{c} \text{TOTAL} \\ \text{INPUT} \\ \text{NOISE} \\ \text{TEMPERATURE} \end{array} \right)$$

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

SWITCH UP CAL ON \rightarrow $\bar{E}_C = G(T_x + T_A + T_c)$ CALIBRATION VOLTAGE

SWITCH DOWN CAL OFF OR ON \rightarrow $\bar{E}_R = G(T_x + T_r)$ REFERENCE VOLTAGE

3 EQUATIONS, 3 UNKNOWN (T_A, G, T_x)

SENSITIVITY LIMITATIONS

①

RMS
MEAN

$$\frac{\Delta E}{E} = \frac{\Delta T_A}{T_x + T_A} = \frac{1}{\sqrt{B T_A}}$$

LIMIT DUE TO STATISTICAL
FLUCTUATIONS OF NOISE

NOISE
BANDWIDTH

INTEGRATION
TIME

②

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

LIMIT DUE TO RECEIVER GAIN STABILITY

MODIFICATIONS TO BASIC RECEIVER

① DICKE SWITCHING - SYNCHRONOUS DETECTION

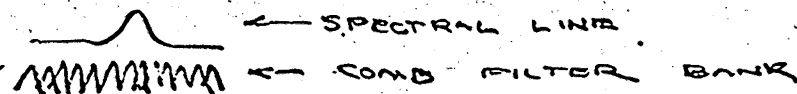
$$\bar{E}_{SD} = E_S - E_R = G(T_A - T_R)$$

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



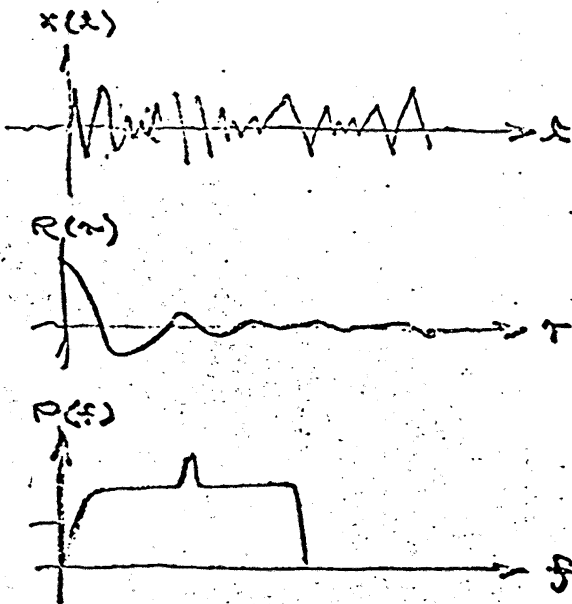
AUTOCORRELATION RECEIVERS

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

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

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

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



MODIFICATIONS TO THEORY

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