EVLA – Polarizers for X, K_u, K and K_a Bands

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Circular Polarization

Plane wave:

$$\epsilon = \hat{x}\, E_x \cos(\omega t - \beta z + \phi_x) + \hat{y}\, E_y \cos(\omega t - \beta z + \phi_y)$$

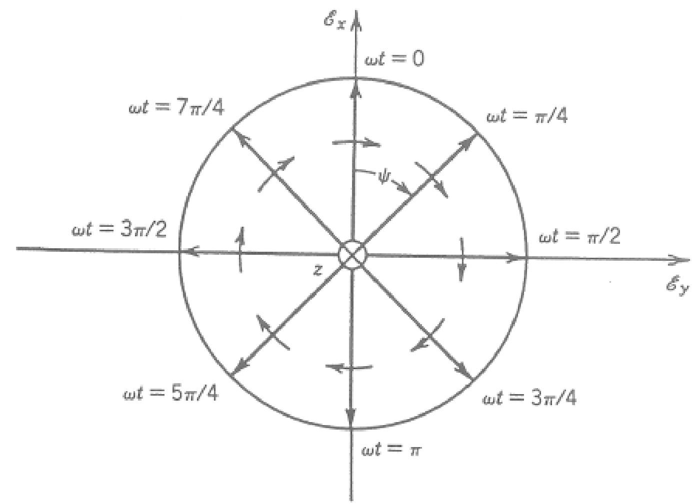
IF

$$\phi_x = 0 \qquad \phi_y = -\frac{\pi}{2}$$

and

$$E_x = E_y = E_0$$

At $z = 0$, $\epsilon = \hat{x}\, E_0 \cos(\omega t) + \hat{y}\, E_0 \sin \omega t$



Right-hand Circularly Polarized Wave

Circular Polarization

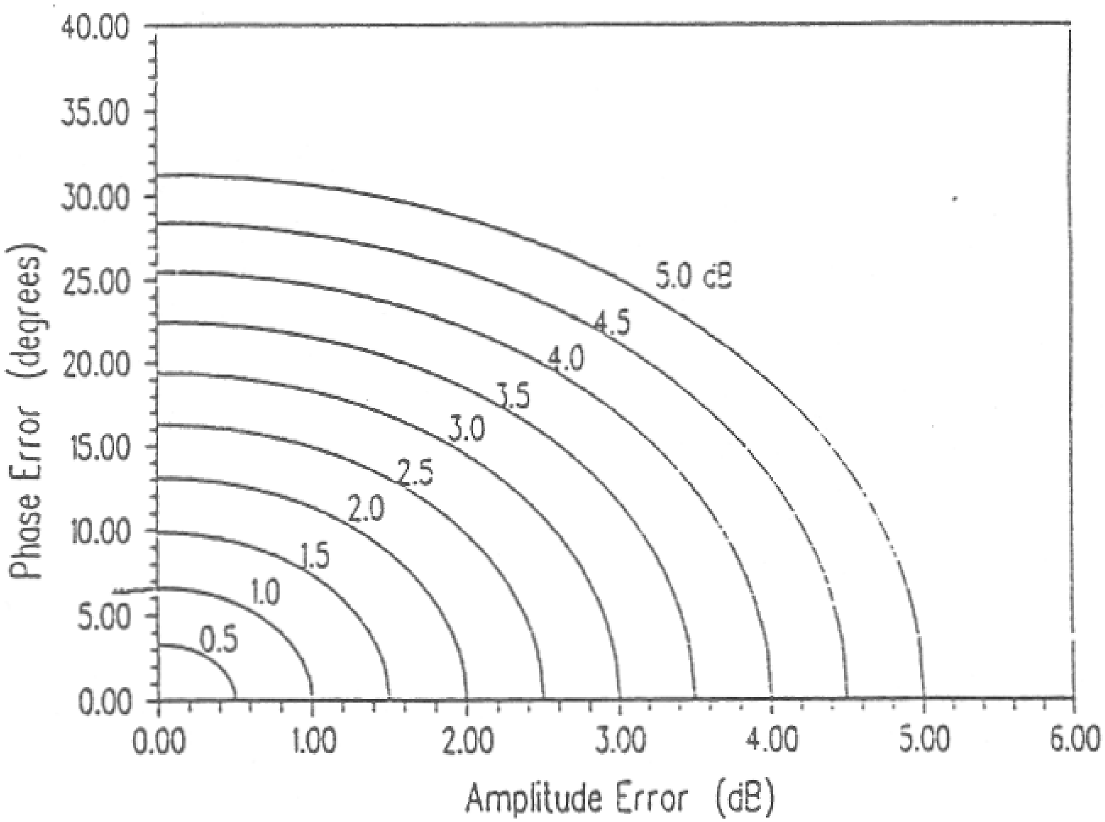
CONDITIONS FOR PURELY CIRCULARLY POLARIZED WAVE:

1. TWO SPATIAL ORTHOGONAL FIELD VECTORS: E_x, E_y

2. $|E_x| = |E_y|$

3. $E_y = E_x e^{\pm j(\pi/2)}$

Contours of Constant Axial Ratio vs. Amplitude and Phase Error



Septum Polarizer

U.S. Patent Oct. 24, 1978 Sheet 1 of 2 4,122,406

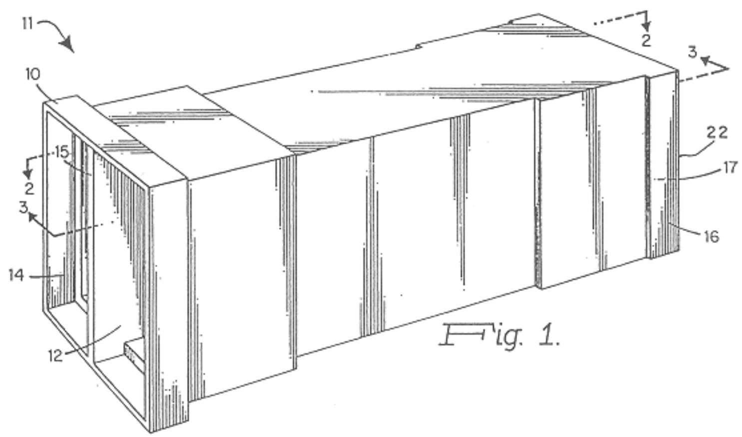


Fig. 1.

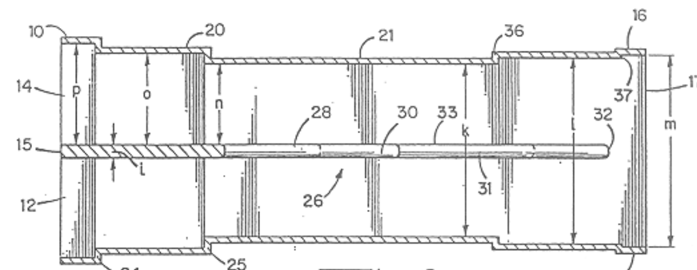


Fig. 2.

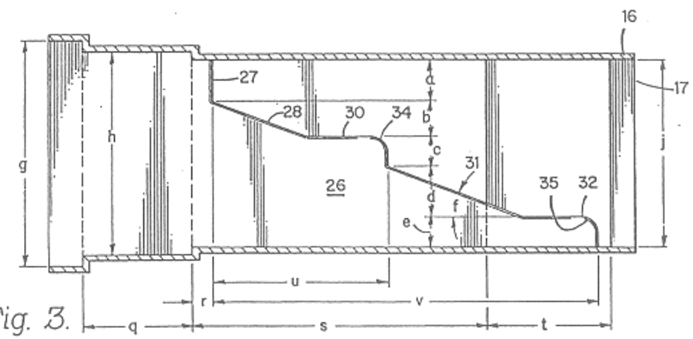


Fig. 3.

Septum Polarizer

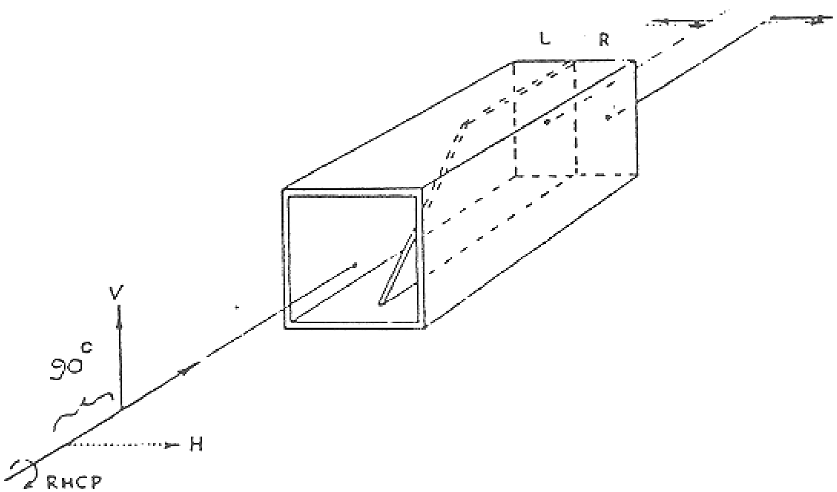


Figure 3. Polarizer operation.

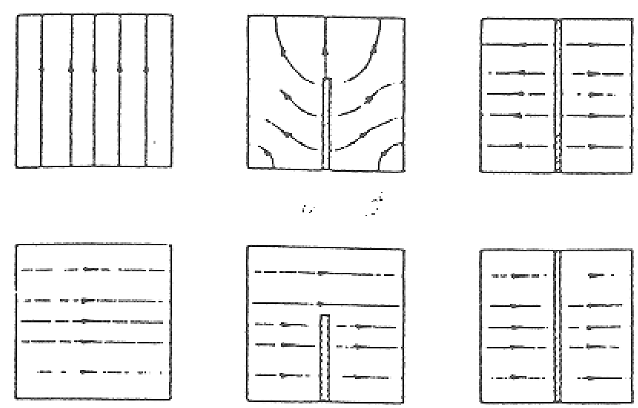
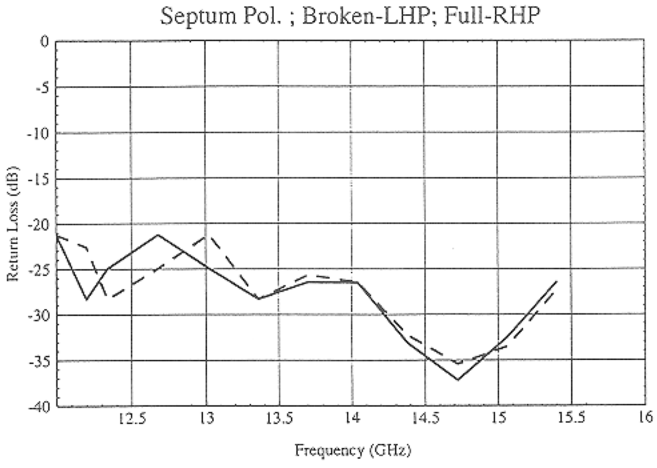
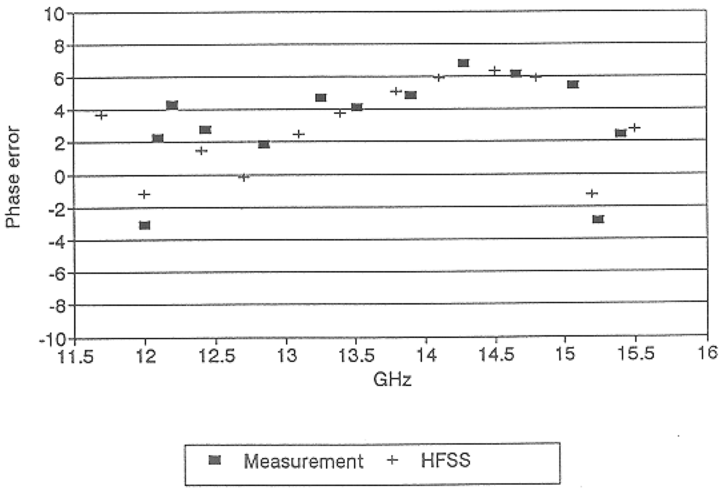


Figure 2. Field transitions.

Septum Polarizer 12-15.4 GHz

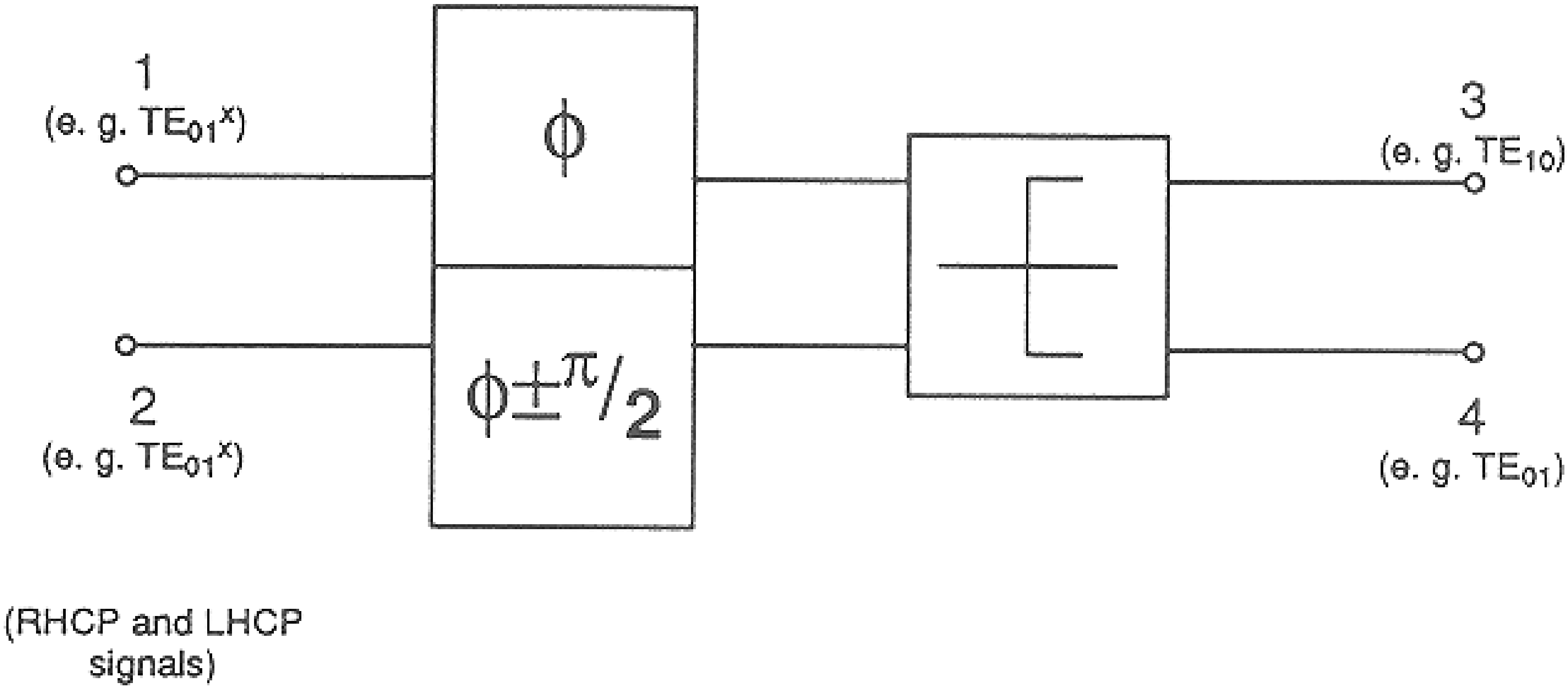


Return Loss

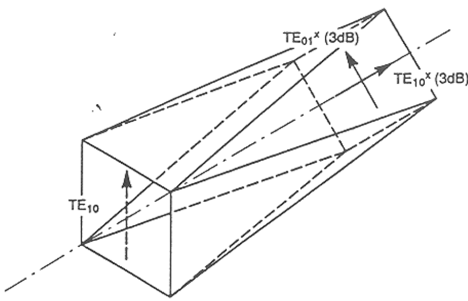


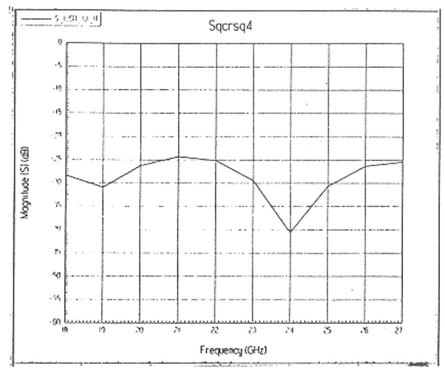
Deviation of $\Delta\phi$ from 90°

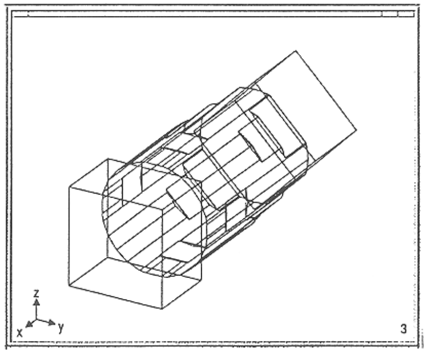
Conventional Polarizer

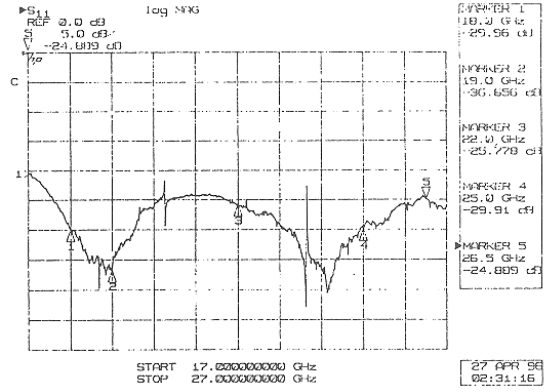


Mode Combiner/Splitter (18-26.5 GHz)

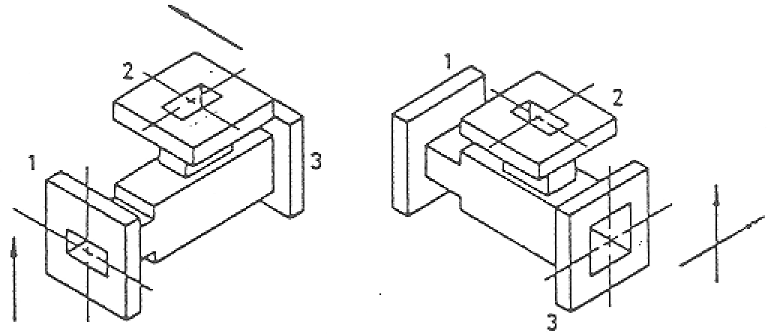




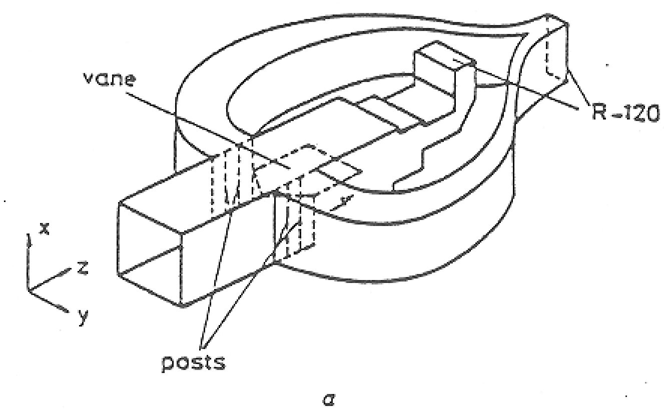




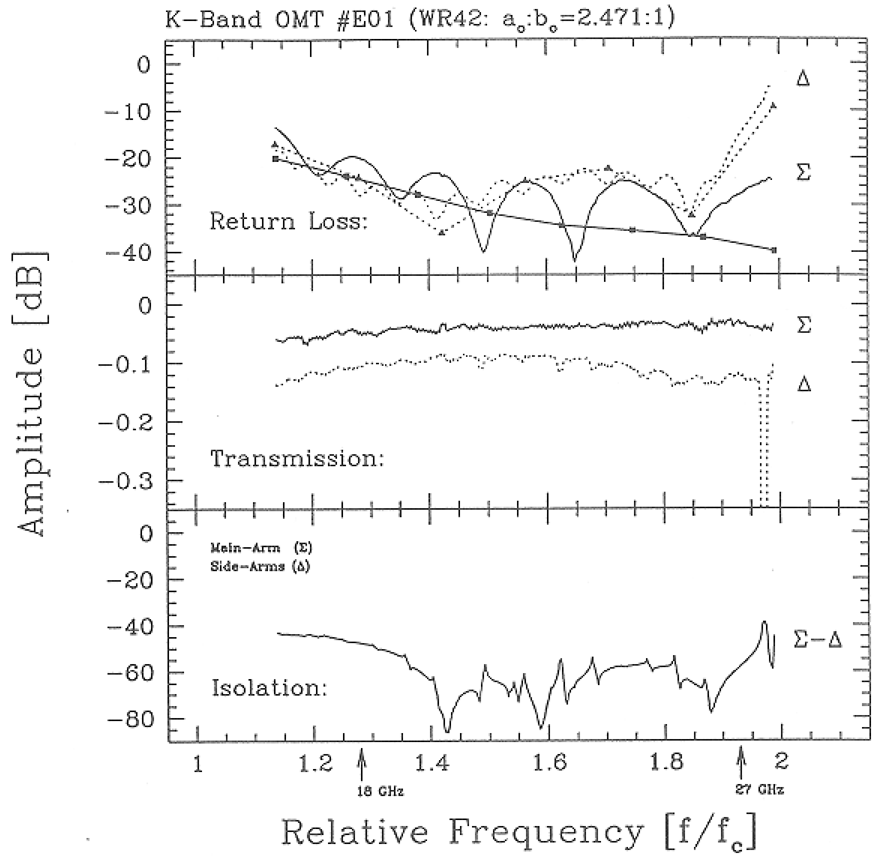
OMT – 18-26.5 GHz



(a) Standard OMT



(b) Full Waveguide Band OMT



Boifot et. al., Proc. IEE, vo1. 137, Dec. '90.

Wollack, EDIR #303, May '96.

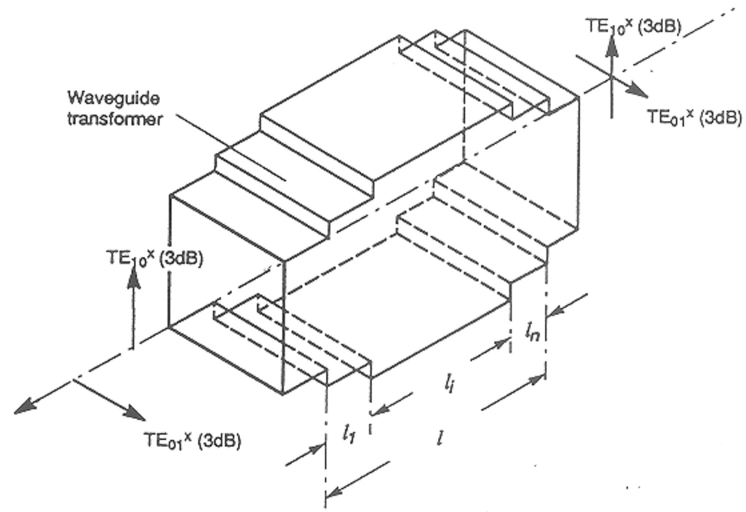
Phase Shifter

PROPAGATION CONSTANT:

$$k_{mode} = \frac{2\pi}{\lambda_{gmode}} = \frac{2\pi}{\lambda_0 / \sqrt{1 - (\lambda_0/\lambda_{cmode})}}$$

PHASE DIFFERENCE BETWEEN MODES:

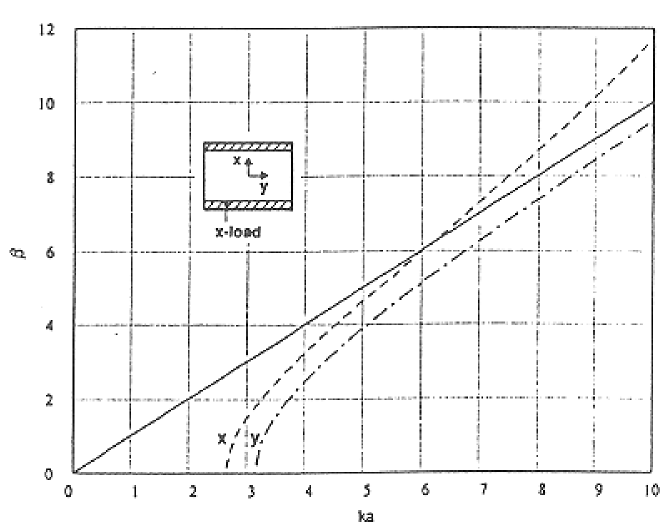
$$\Delta\phi = \ell * (k_{mode1} - k_{mode2})$$



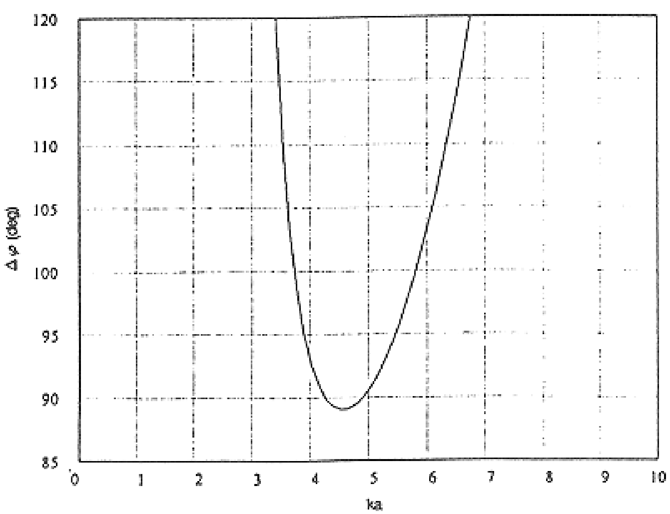
$$\Delta\phi = 2\pi \left[\ell/\lambda_{gTE10} - \sum_{i=1}^{n} \ell_i / \lambda_{giTE01} \right]$$

Phase Shifter

(a) Dispersion characteristics; (b) Differential phase shift vs. the frequency



(a)



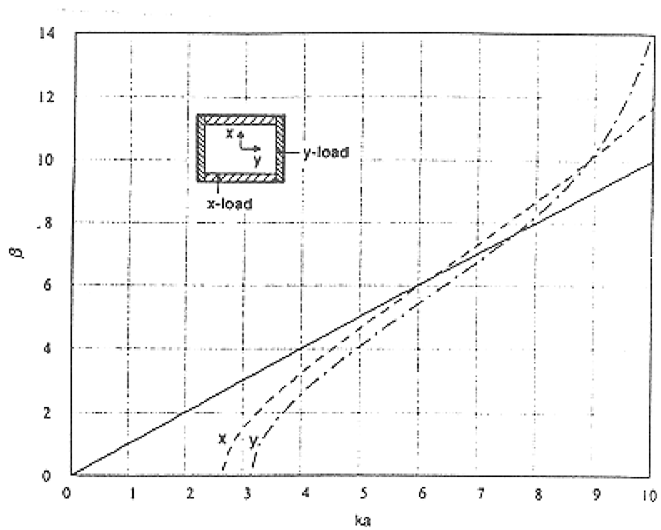
(b)

$$\frac{\delta\beta_x}{\delta f} = \frac{\delta\beta_y}{\delta f}$$

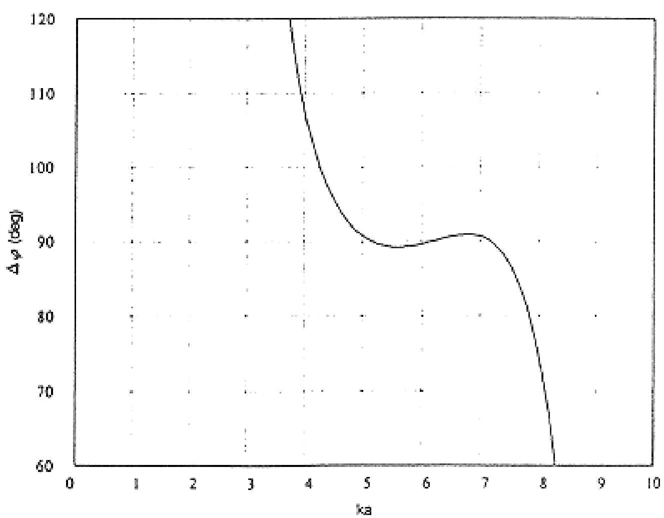
at $f = f_{mid}$

Corrugated/Dielectric Phase Shifter

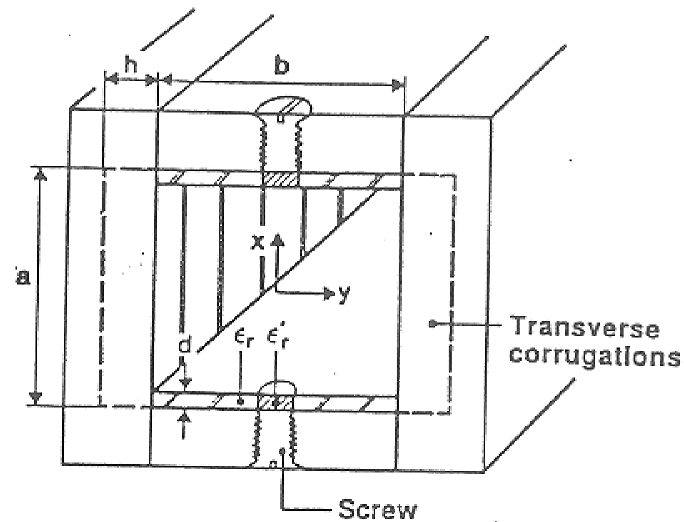
(a) Dispersion characteristics; (b) Differential phase shift vs. the frequency



(a)



(b)



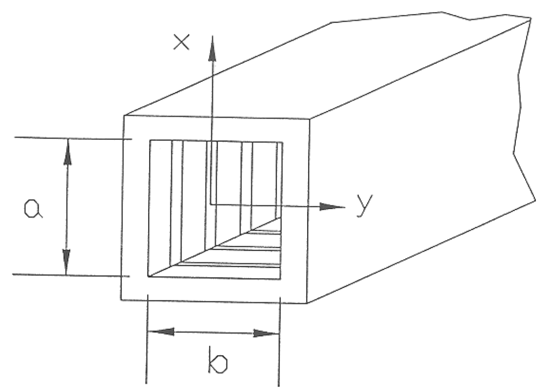
$$\frac{\delta\beta_x}{\delta f} = \frac{\delta\beta_y}{\delta f}$$

at $f = f_1$

and $f = f_2$

Lier et. al., IEEE MTT, vol. 36, Nov. '88.

Corrugated Phase Shifter

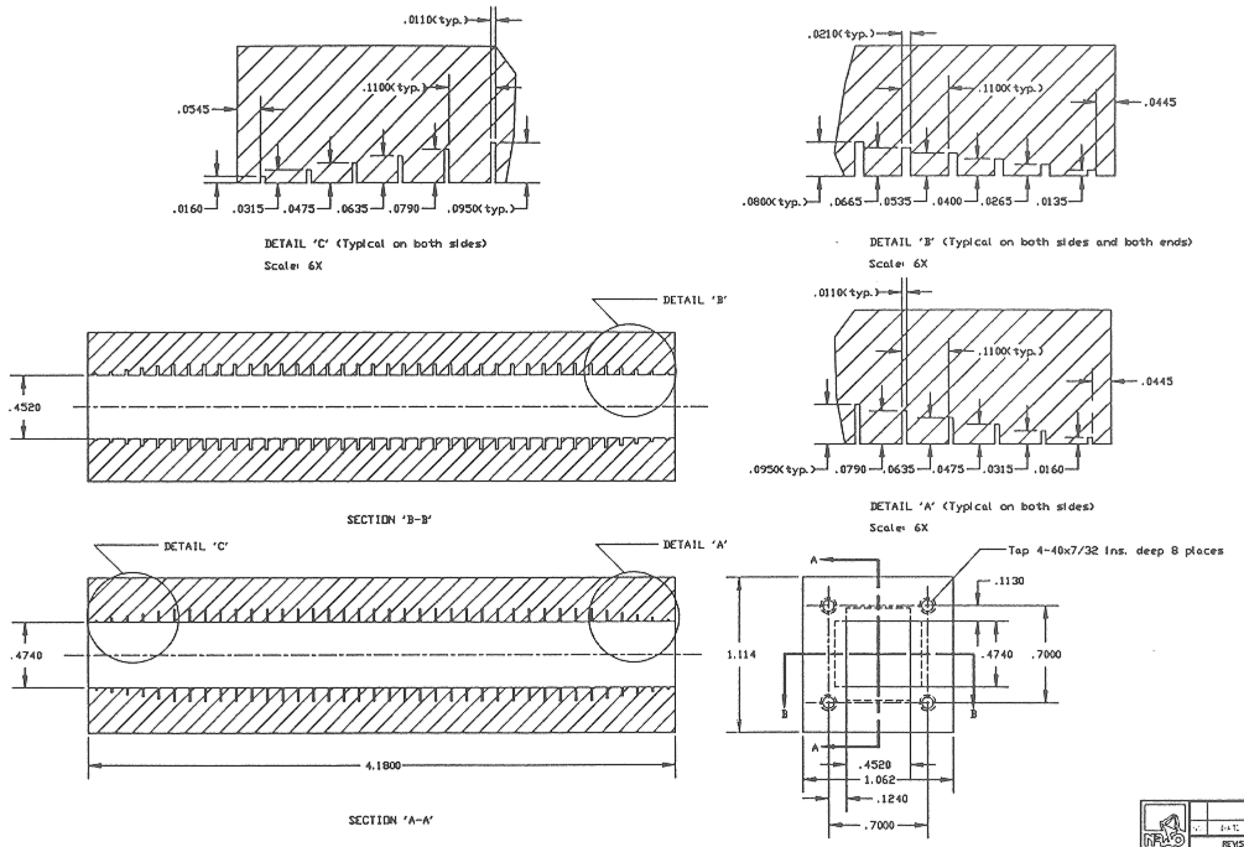


For the corrugated waveguide:

$$k_y \tanh\left(k_y \frac{b}{2}\right) = \frac{w}{p} \beta_1 \tan(\beta_1 h) \qquad k_y = \left[-k^2 + \beta_y^2 + \left(\frac{\pi}{a}\right)^2\right]^{1/2}$$

$$\beta_1 = \left[k^2 - \left(\frac{\pi}{a}\right)^2\right]^{1/2}$$

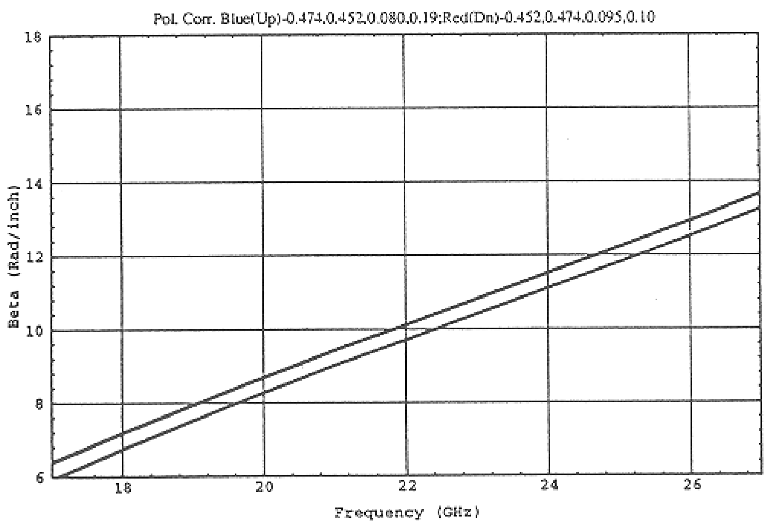
NRAO Phase Shifter (18-26.5 GHz)

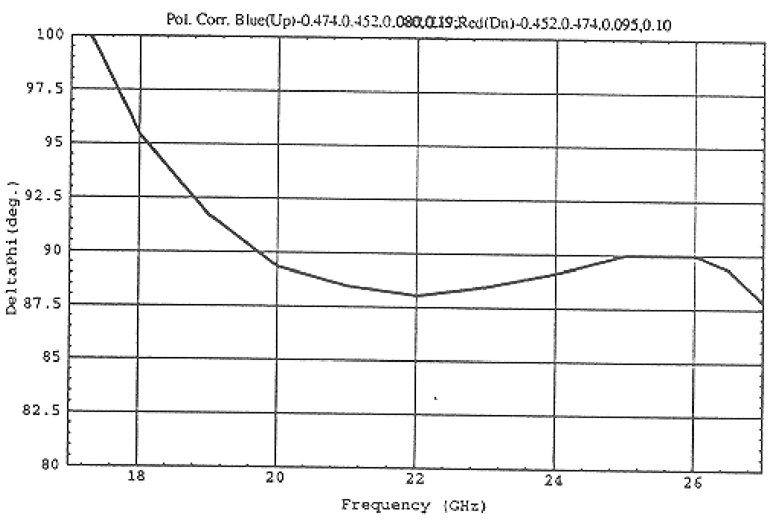


Srikanth, IEEE Microwave & Guided-Wave Ltrs., vol. 7, June '97.

NRAO Phase Shifter (18-26.5 GHz)

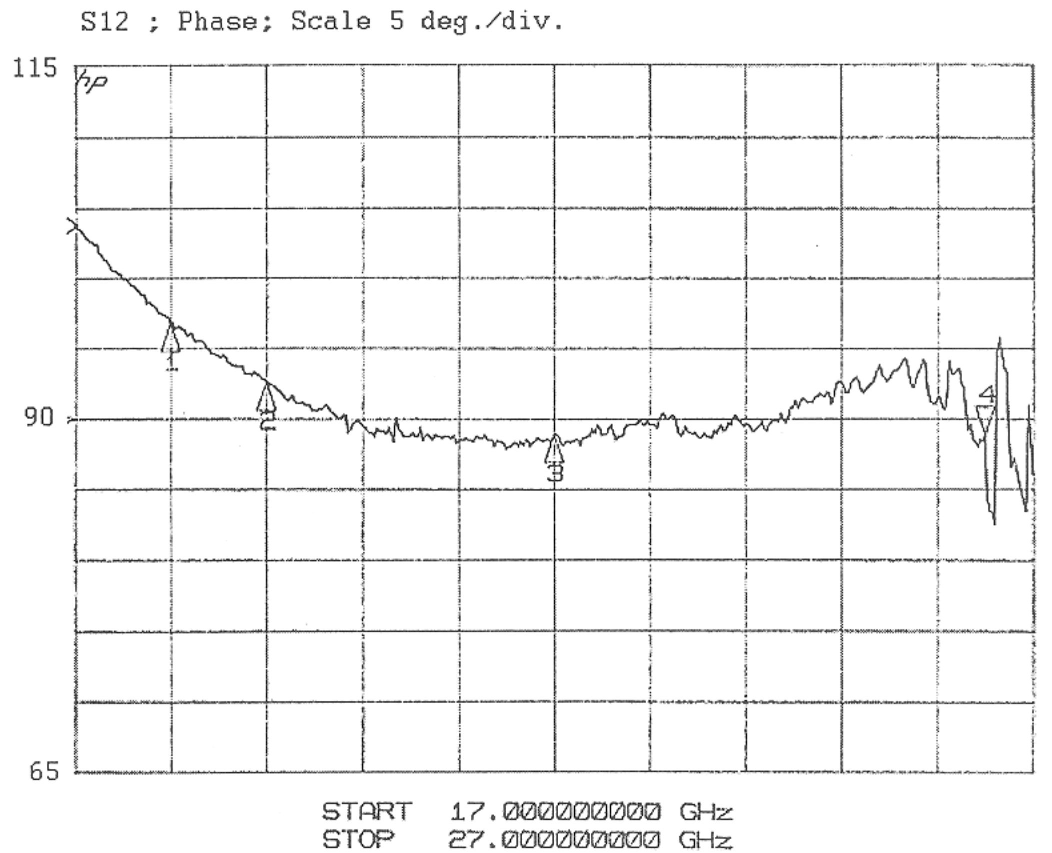
(Theory)



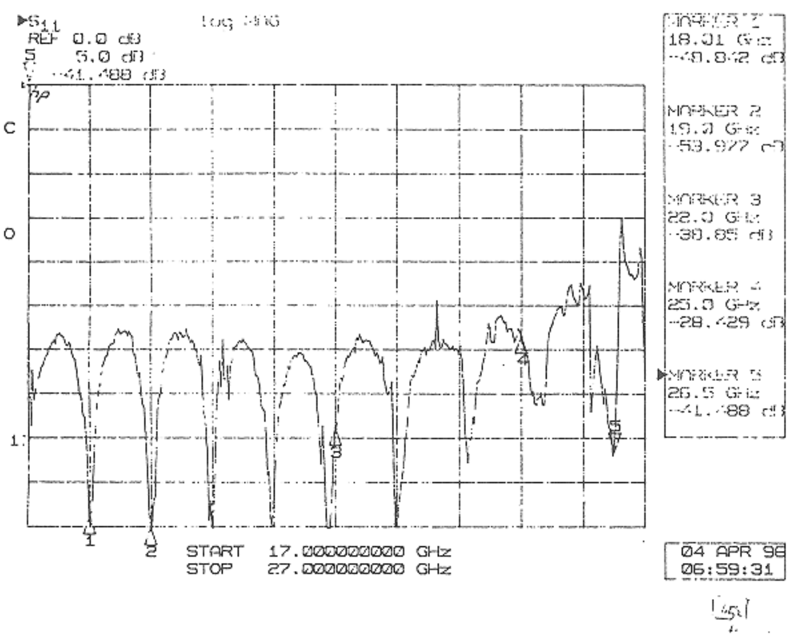


NRAO Phase Shifter (18-26.5 GHz) Measured Δϕ

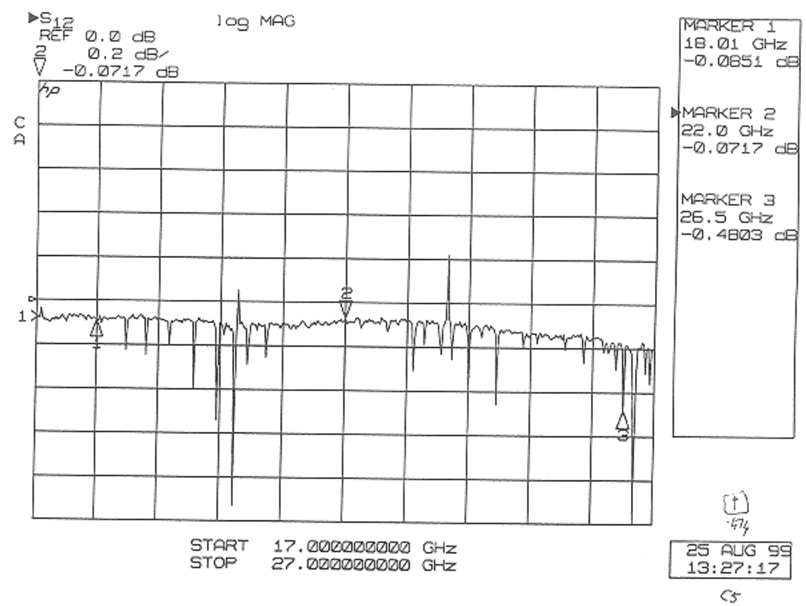
Differential Phase Shift



NRAO Phase Shifter (18-26.5 GHz) Measured S_{11}, S_{12}

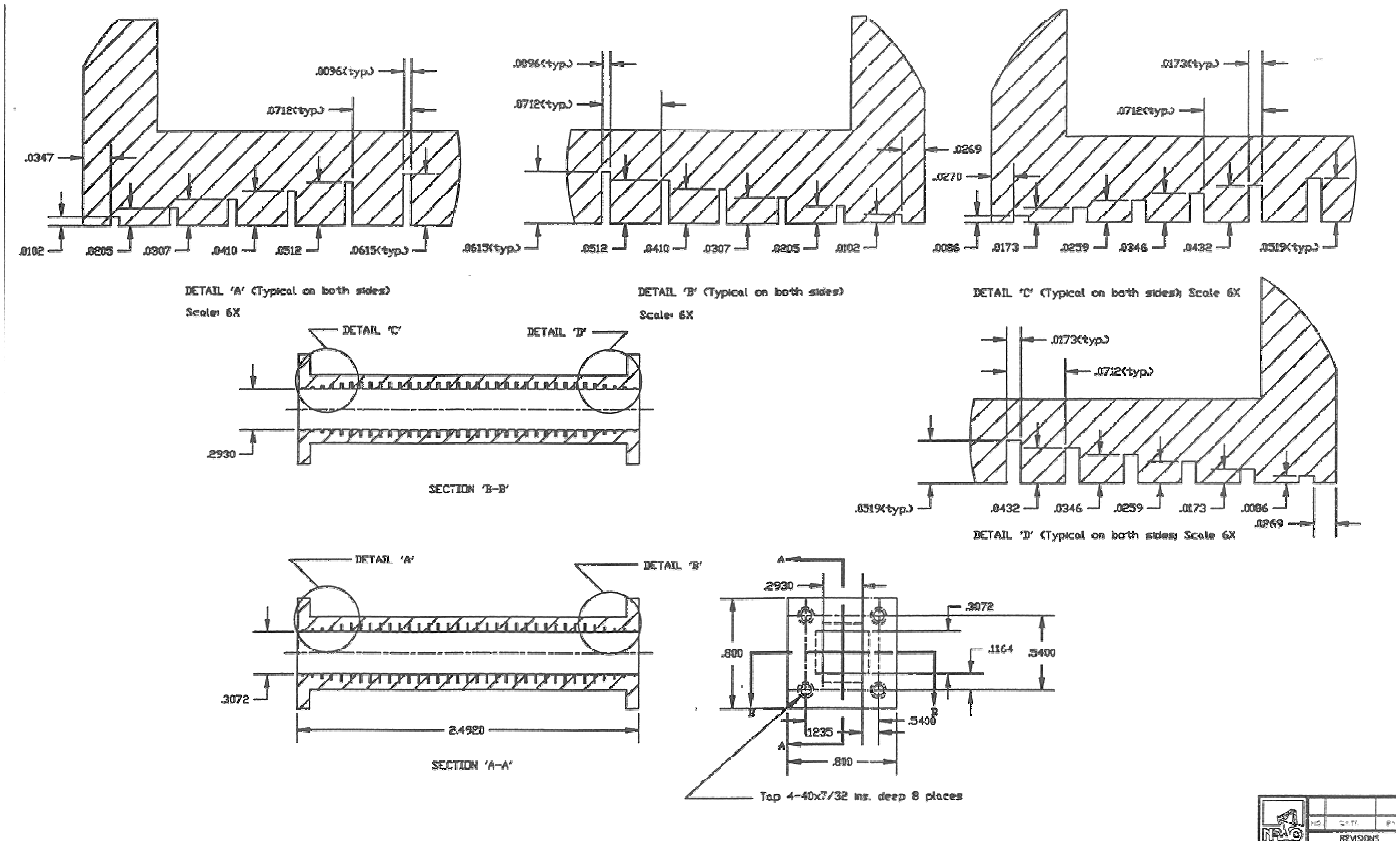


Return Loss



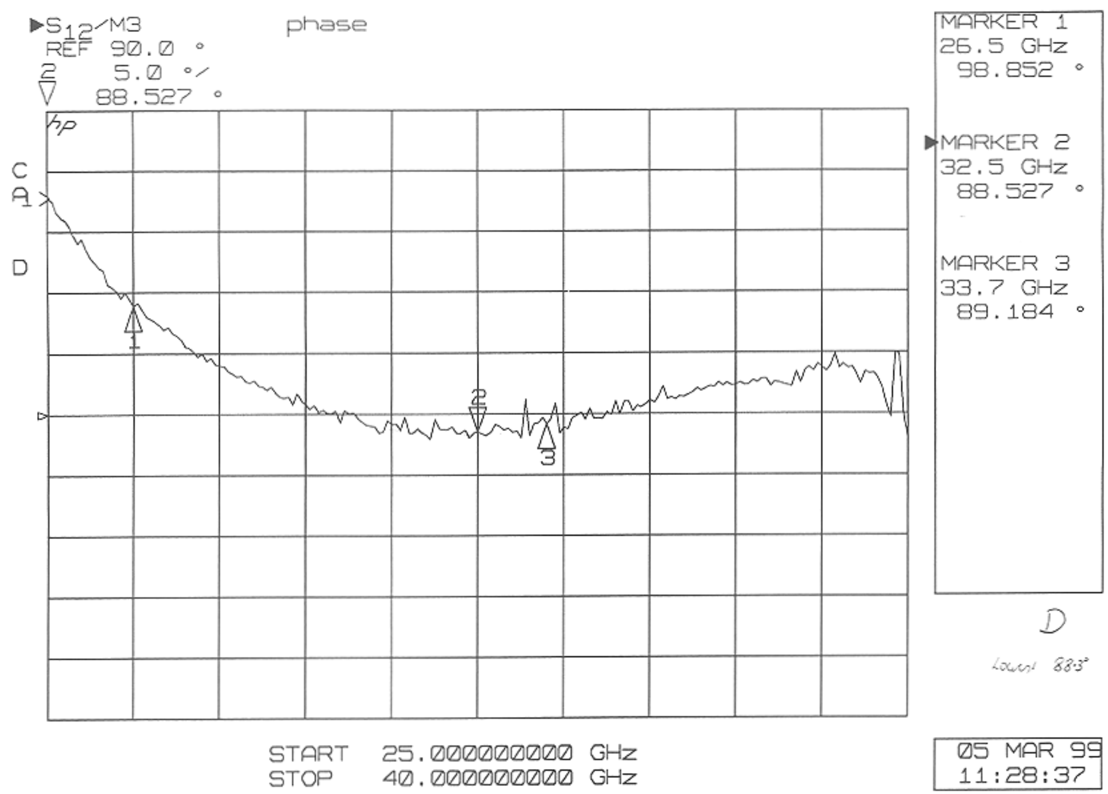
Insertion Loss

NRAO Phase Shifter (26.5-40 GHz)

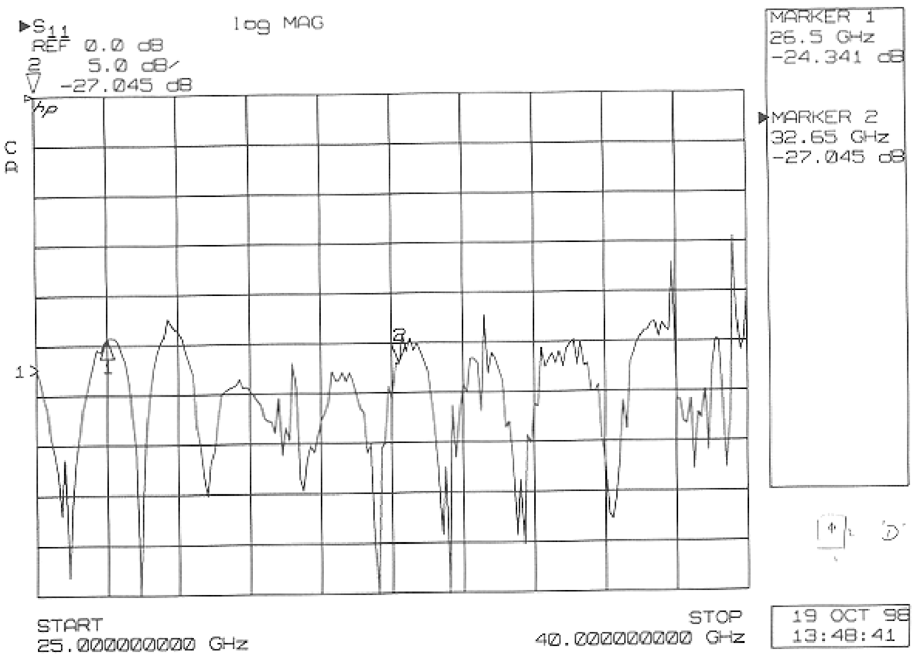


NRAO Phase Shifter (26.5-40 GHz) Measured Δϕ

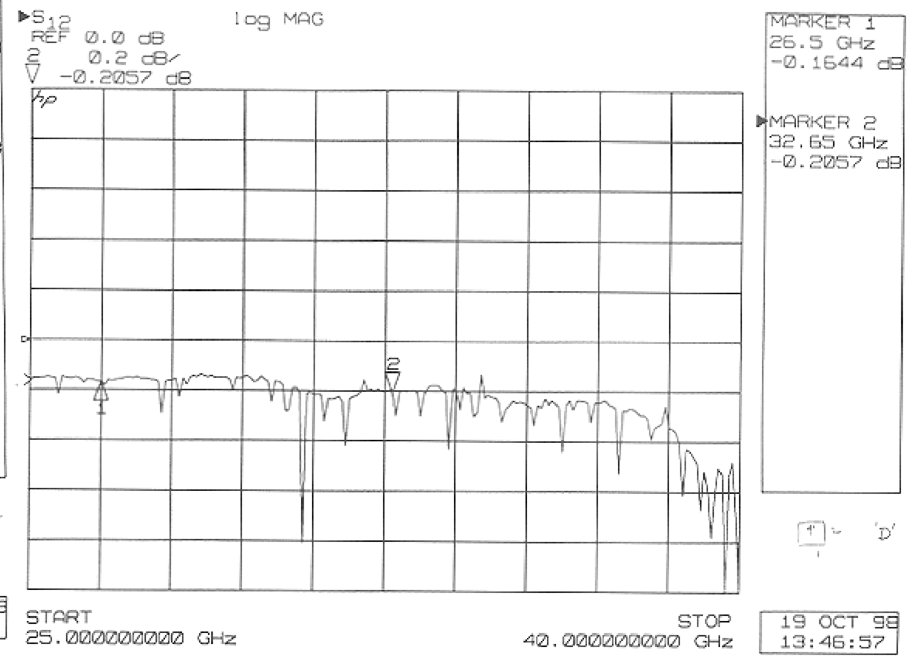
Differential Phase Shift



NRAO Phase Shifter (26.5-40 GHz) Measured S_{11}, S_{12}



Return Loss



Insertion Loss

EVLA Phase Shifters

Freq. (GHz)	Waveguide			Corrugation			
	Width	Height	Length	Pitch	w_1	d_1	d_1/w_1
8-12	1.018	0.971	8.260 (5.60λ)	0.236	0.032	0.204	6.4
12-18	0.678	0.647	5.495 (5.60λ)	0.157	0.021	0.136	6.5
18-26	0.474	0.452	4.180 (6.37λ)	0.110	0.011	0.095	8.6
26-40	0.3072	0.2930	2.4920 (5.60λ)	0.0712	0.0096	0.0615	6.4