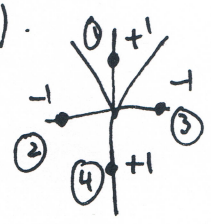
[redacted]

a) $a/\lambda = 0.006$ $\frac{2\ell_r}{\lambda} = 0.466$ $Z_{11} = 59.5\,\Omega$ (from notes)

& Use Tai's formulas to calculate X & R over 470-750 MHz (see plot).

b)



$V_1 = Z_{11}I_1 + Z_{12}I_2 + Z_{13}I_3 + Z_{14}I_4$

$Z_{inp} = V_1/I_1 = Z_{11} - 2Z_{12} + Z_{14}$

$= 59.5 - 2(-22 + j0.5) + (3.5 + j15) = 107 + j14$

$\mathrm{Im}(Z_{in}) > 0$, so shorten antenna to get $-j14 \Rightarrow \frac{2\ell}{\lambda} = 0454$ & $Z_{11} = 55.3 -$

& $Z_{input} = (55.3 - j14) - 2\underbrace{(-22 + j0.5)} + \underbrace{(3.5 + j15)} \simeq \underline{103\,\Omega}$

Do not change much

a) 540 MHz $Z_{input} = (42 - j69) - 2(-13 - j4) + j15 \simeq \underline{68 - j46\,\Omega}$

b) 660 MHz $Z_{input} = (73 + j40) - 2(-23 + j8) + (9 + j15) \simeq \underline{128 - j40\,\Omega}$

This antenna is actually quite wideband with a VSWR < 2 for 540-660 MHz.

[redacted]

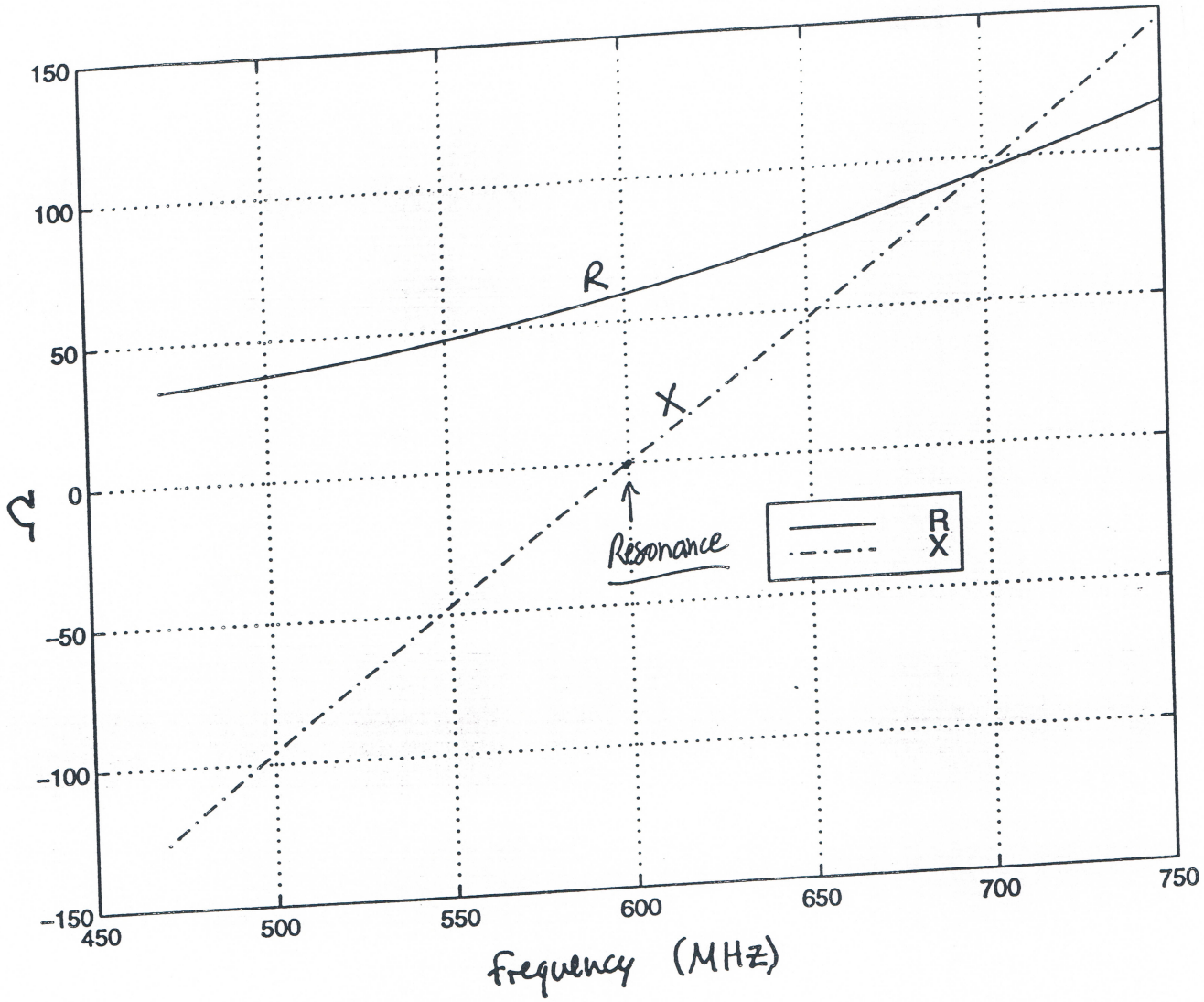
a) Input Gain = T. wave antenna
Lower Gain = log-Periodic Array

b) Impossible. Power Detector $\equiv v^2$ law $\Rightarrow$ loose phase information.
Must have a phase detector & lock the source to the receiver.

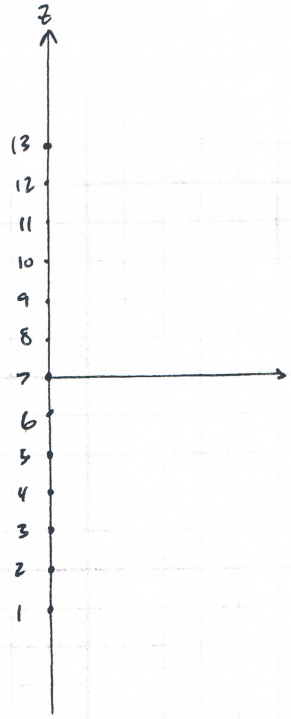
c) (Do not do) But it is done in your notes. $D \simeq 7$-8 dB.

d) High frequency $\equiv$ feed dimensions
low frequency $\equiv$ Outer dimensions

e) Sidelobes: increase
Beamwidth: decrease (a bit)
Directivity: Decrease



Using Tai's formulas in notes -



$$AF = \sum_{i=1}^{13} A_i e^{j\psi_i}$$

$$\psi_i = kd\cos\theta + \alpha_i$$

$$= kd\cos\theta - kd\cos\theta_0, \quad \theta_0 = 55^\circ \text{ (b)}$$

$$A_i = (1-E)\cdot\cos^2\left(\frac{\pi}{12} z_d\right) + E$$

$-6 \le z_d \le 6$, $E \equiv$ edge magnitude

(a) Using an edge amplitude of "E" $\boxed{-11.8\,dB}$

sidelobe levels are at or below $-27dB$.

HPBW = 8.15°

FNBW = 25.6°

D = 10.8 (10.3dB)

} in MATLAB

↑ in MATLAB using $D = \dfrac{\left(\sum_i I_i\right)^2}{\sum_i I_i^2}$

Please see plots → ~~pg. 1~~ pg. 2

(b) Scanning to 55°,

HPBW = 10.0°

FNBN = 32.0°

D = 10.8 (10.3dB)

Sidelobes $\le -27dB$
(Same as with $\alpha = 0$)

Please see plots → pg. 3

(c) Phase shift and magnitude errors were calculated (Excel) and tabulated on pg. 4 →

MATLAB was used to create & plot the total and error patterns.

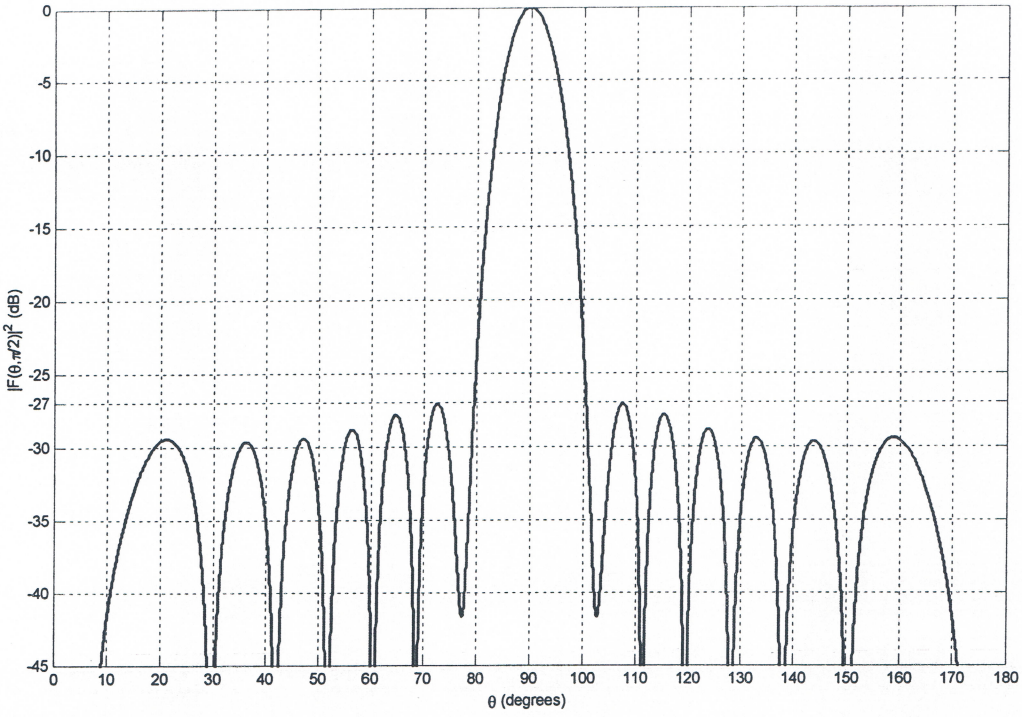
Please see pg. 5 for phase error, pg. 6 for amplitude error, and pg. 7 for the total resulting pattern.

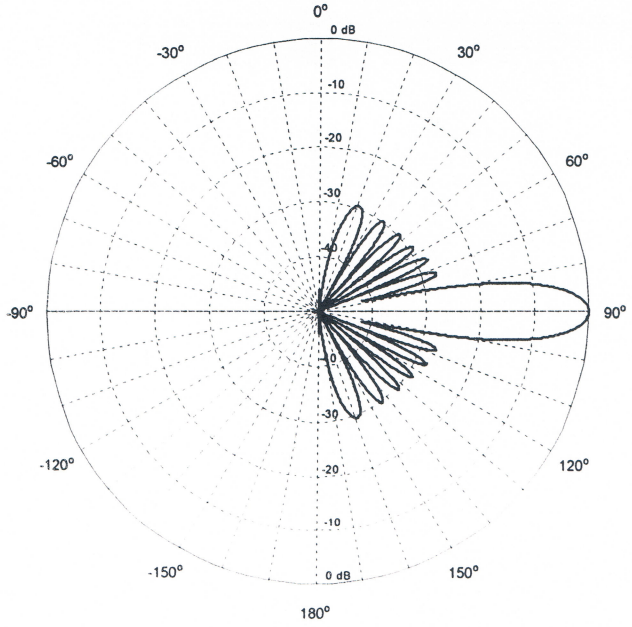
Each page has additional comments (attempting to conserve space

* It is clear that using a 4-bit phase shifter would result in a pattern with less error →

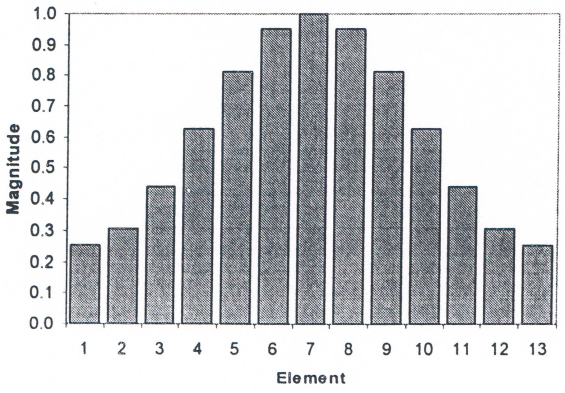
[redacted]

Problem #1a – 13 element array, $\cos^2\theta$ distribution, $\theta_0 = 0°$

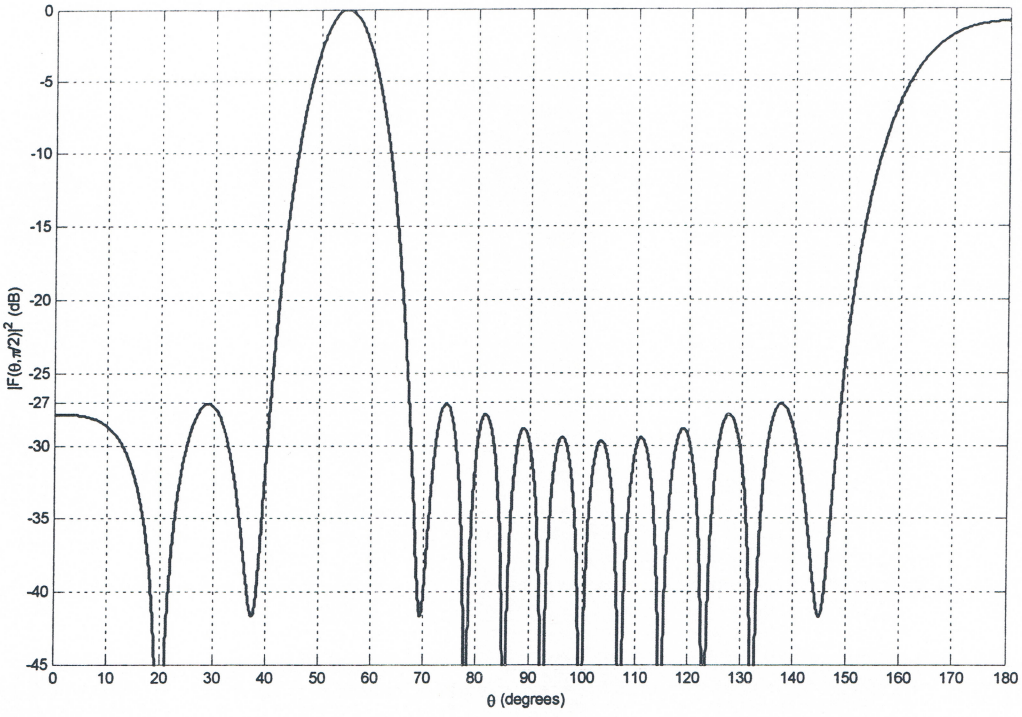


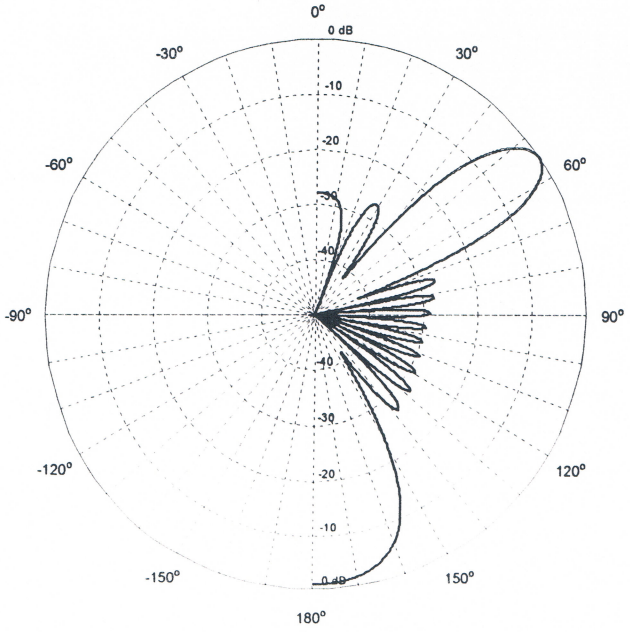


Problem #1a,b – Current Distribution



Problem #1b – 13 element array, $\cos^2\theta$ distribution, $\theta_0 = 55°$





[redacted]

All calculations done in Excel,

$d = 0.62\lambda$, $\theta_0 = 55°$

$I_i = (1-E)\cos^2\left(\frac{\pi}{12}2d\right)+E$, $E = 10^{-11.8/20}$, $-6 \le 2d \le 6$

Problem #1b – 3-bit Phase Shifter Insertion Loss

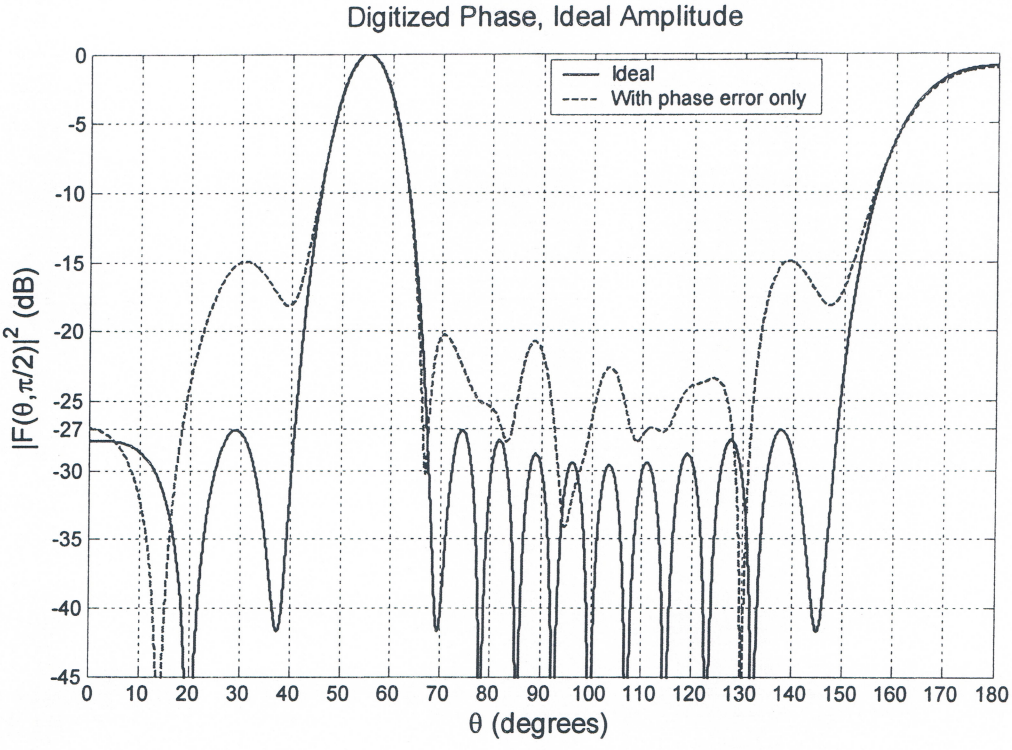
Bit	Phase Shift (degrees)	Insertion Loss (dB)	Magnitude Mult. Factor
0	0	0.00	1.0000
1	-45	0.29	0.9676
2	-90	0.57	0.9363
3	-135	0.86	0.9060
4	-180	1.14	0.8767
5	-225	1.43	0.8483
6	-270	1.71	0.8209
7	-315	2.00	0.7943

Problem #1b – Phase and Amplitude Error

Element	Alpha (deg)	Digital Phase Shift (deg)	Phase Error (deg)	Amplitude Error Factor	Amplitude With Error	Amplitude Error
1	-96	-90	6.27	0.9363	0.2407	-0.0164
2	-328	-315	13.24	0.7943	0.2437	-0.0631
3	-200	-180	20.22	0.8767	0.3882	-0.0546
4	-72	-90	-17.80	0.9363	0.5885	-0.0400
5	-304	-315	-10.82	0.7943	0.6468	-0.1675
6	-176	-180	-3.84	0.8767	0.8331	-0.1172
7	-48	-45	3.13	0.9676	0.9676	-0.0324
8	-280	-270	10.11	0.8209	0.7800	-0.1702
9	-152	-135	17.09	0.9060	0.7377	-0.0765
10	-24	-45	-20.93	0.9676	0.6082	-0.0203
11	-256	-270	-13.96	0.8209	0.3635	-0.0793
12	-128	-135	-6.98	0.9060	0.2780	-0.0288
13	0	0	0.00	1.0000	0.2570	0.0000

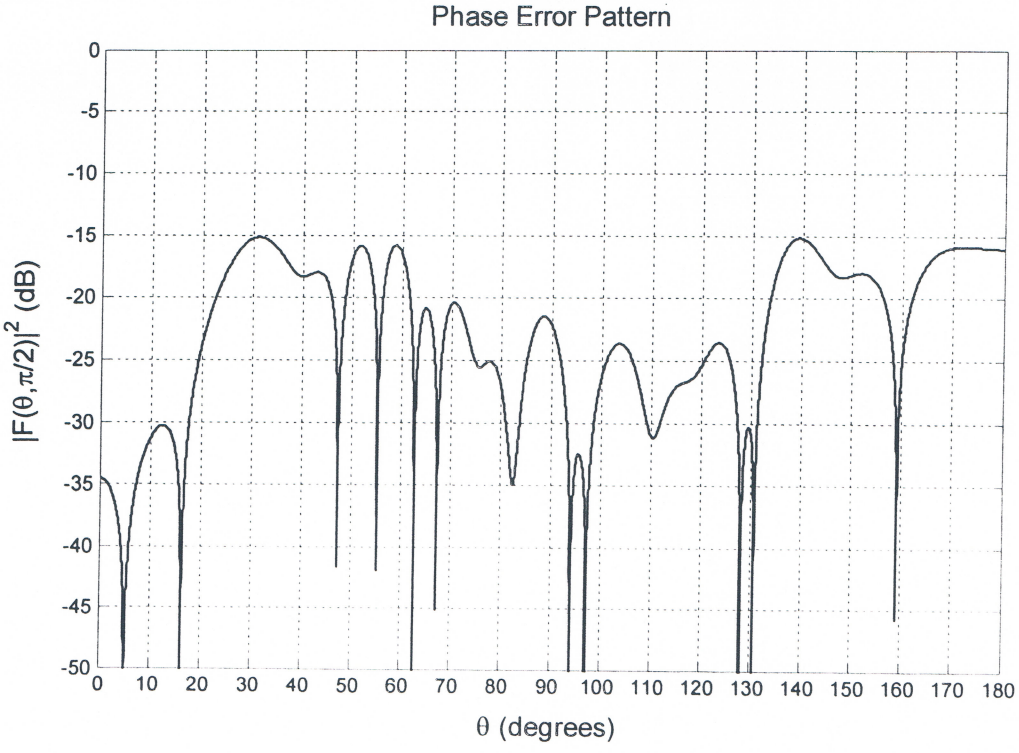
[redacted]

Problem #1c – Phase Error Far-field Patterns



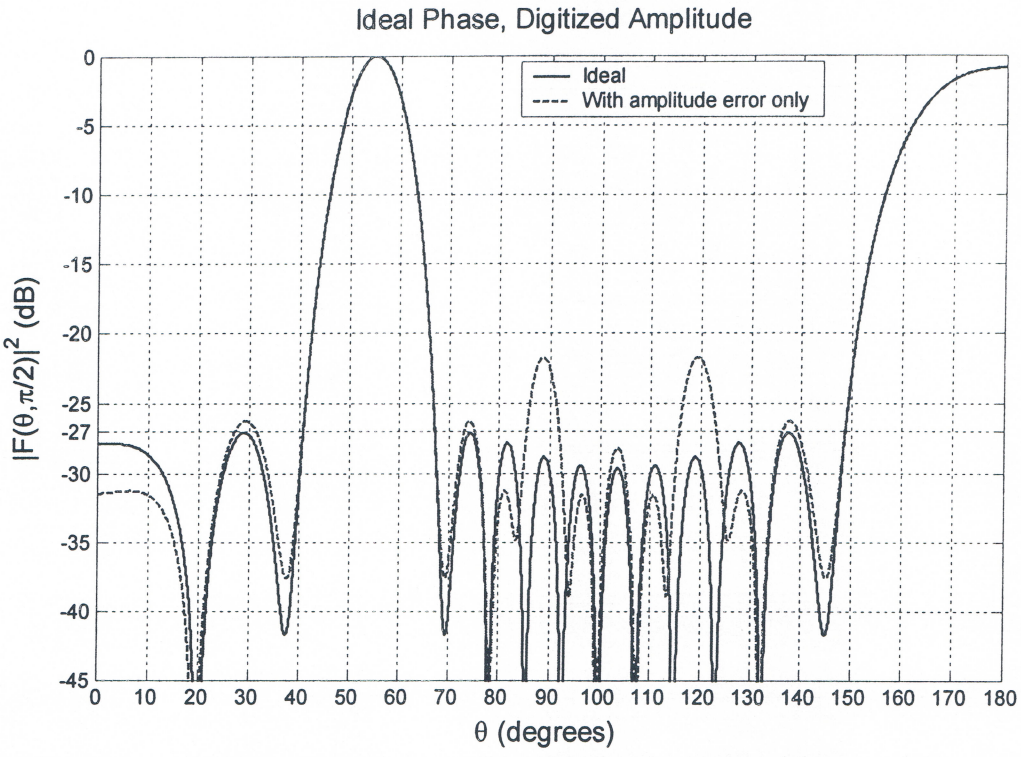
Sidelobes:
≤ -14.9 dB
(does not meet spec!

↑ phase error produces more
↙ pattern error compared with amplitude error.

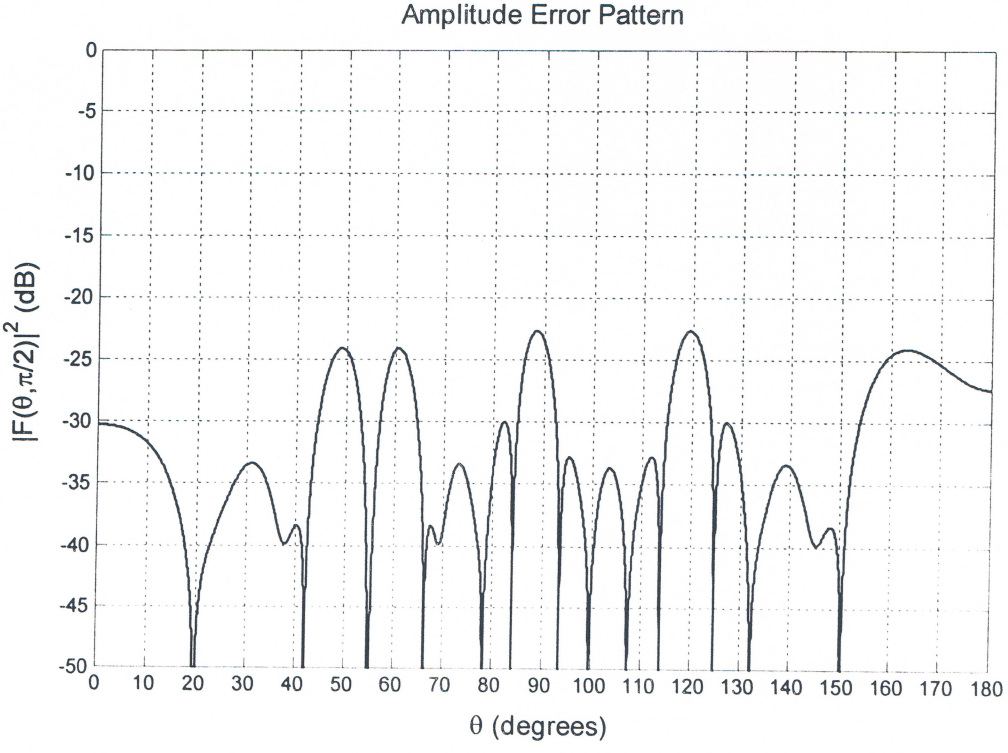


[redacted]

Problem #1c – Amplitude Error Far-field Patterns

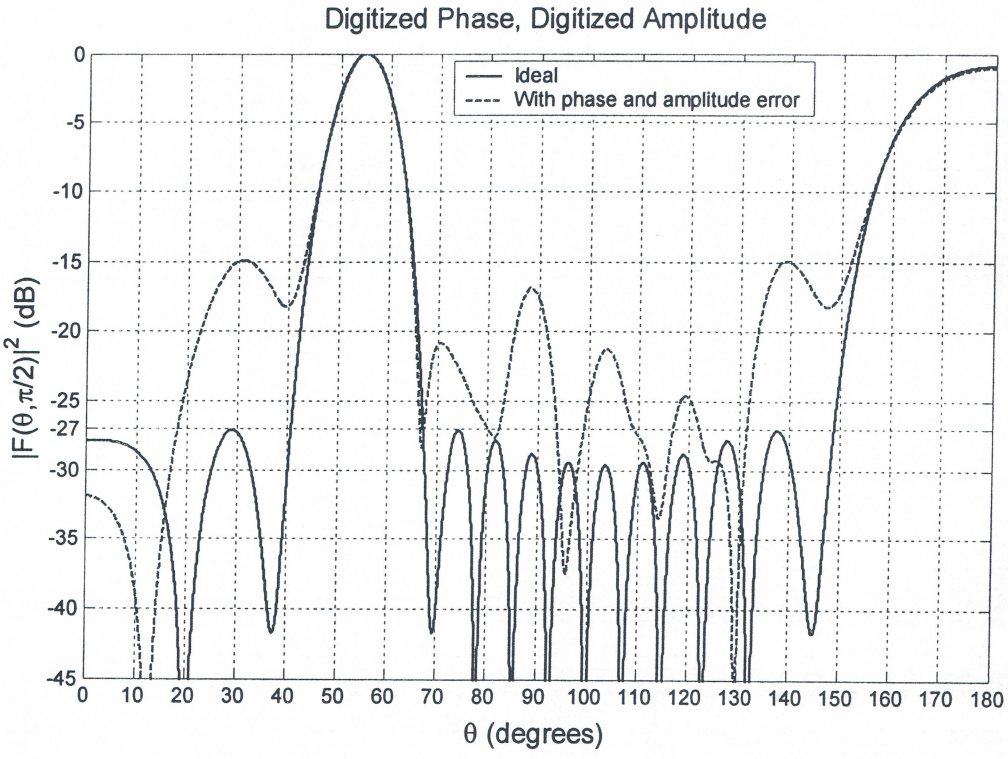


Sidelobes:
≤ -22 dB
(does not meet spec!),
but better than pattern with phase error only.
⇒ Amplitude error produces less pattern error compared with phase er



[redacted]

Problem #1c – Total Pattern with Both Phase and Amplitude Error



Total pattern with both error sources

Sidelobes: ≤ -1

HPBW = 9.94°

FNBW = 27.3°

D = 10.8 (10.3 dB

↑ calculated using magnitude distribution with error (still within 0.1 dB of original patter