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Parameters: \( \varepsilon_r=2.55, \varepsilon_t=2.2, d_1=4.7 \text{mm}, d_2=0.8 \text{mm}, a_1=8.2 \text{mm}, a_2=9.6 \text{mm}, a_3=25.8 \text{mm}, S=0.0 \text{mm}, x_t=3.5 \text{mm}, x_s=5.3 \text{mm}, y_t=0.0 \text{mm}, y_s=0.0 \text{mm}, r_t=0.4 \text{mm}, r_s=0.4 \text{mm} \)
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Fig. 5.13 Variation of directivity with respect to air-gap \(S\)
Series 1: \(r_f=r_s=0.2 \text{ mm, Series 2: } r_f=r_s=0.3 \text{ mm, Series 3: } r_f=r_s=0.4 \text{ mm, Series 4: } r_f=r_s=0.5 \text{ mm}\)

Fig. 5.14 Variation of return loss with respect to air-gap \(S\)
Series 1: \(r_f=r_s=0.2 \text{ mm, Series 2: } r_f=r_s=0.3 \text{ mm, Series 3: } r_f=r_s=0.4 \text{ mm, Series 4: } r_f=r_s=0.5 \text{ mm}\)

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Series 1: \(r_f=r_s=0.2 \text{ mm, Series 2: } r_f=r_s=0.3 \text{ mm, Series 3: } r_f=r_s=0.4 \text{ mm, Series 4: } r_f=r_s=0.5 \text{ mm}\)

Fig. 5.16 Variation of radiation efficiency with respect to air-gap \(S\)
Series 1: \(r_f=r_s=0.2 \text{ mm, Series 2: } r_f=r_s=0.3 \text{ mm, Series 3: } r_f=r_s=0.4 \text{ mm, Series 4: } r_f=r_s=0.5 \text{ mm}\)

Fig. 5.17 Variation of radiation efficiency with respect to air-gap \(S\)
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Series 1: \(r_f=r_s=0.2 \text{ mm, Series 2: } r_f=r_s=0.3 \text{ mm, Series 3: } r_f=r_s=0.4 \text{ mm, Series 4: } r_f=r_s=0.5 \text{ mm}\)
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\( r_1 = r_2 = 0.5 \text{ mm} \)

Series 1: \( r_1 = r_2 = 0.2 \text{ mm} \), Series 2: \( r_1 = r_2 = 0.3 \text{ mm} \), Series 3: \( r_1 = r_2 = 0.4 \text{ mm} \)
Series 4: \( r_1 = r_2 = 0.5 \text{ mm} \)

Fig. 5.23 Variation of cross-polarisation with respect to air-gap (S)  
\( r_1 = 2.55, r_2 = 2.2, d_1 = 4.7 \text{ mm}, d_2 = 1.6 \text{ mm} \)
Series 1: \( r_1 = r_2 = 0.2 \text{ mm} \), Series 2: \( r_1 = r_2 = 0.3 \text{ mm} \), Series 3: \( r_1 = r_2 = 0.4 \text{ mm} \)
Series 4: \( r_1 = r_2 = 0.5 \text{ mm} \)

Fig. 5.24 Variation of directivity with respect to air-gap (S)  
\( r_1 = 2.55, r_2 = 2.2, d_1 = 4.7 \text{ mm}, d_2 = 0.8 \text{ mm} \)
Series 1: \( r_1 = 0.5 \text{ mm}, r_2 = 0.4 \text{ mm} \), Series 2: \( r_1 = 0.4 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 3: \( r_1 = 0.5 \text{ mm}, r_2 = 0.3 \text{ mm} \), Series 4: \( r_1 = 0.3 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 5: \( r_1 = 0.5 \text{ mm}, r_2 = 0.1 \text{ mm} \)

Fig. 5.25 Variation of directivity with respect to air-gap (S)  
\( r_1 = 2.55, r_2 = 2.2, d_1 = 4.7 \text{ mm}, d_2 = 1.6 \text{ mm} \)
Series 1: \( r_1 = 0.5 \text{ mm}, r_2 = 0.4 \text{ mm} \), Series 2: \( r_1 = 0.4 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 3: \( r_1 = 0.5 \text{ mm}, r_2 = 0.3 \text{ mm} \)
Series 4: \( r_1 = 0.3 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 5: \( r_1 = 0.5 \text{ mm}, r_2 = 0.1 \text{ mm} \)

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\( r_1 = 2.55, r_2 = 2.2, d_1 = 4.7 \text{ mm}, d_2 = 0.8 \text{ mm} \)
Series 1: \( r_1 = 0.5 \text{ mm}, r_2 = 0.4 \text{ mm} \), Series 2: \( r_1 = 0.4 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 3: \( r_1 = 0.5 \text{ mm}, r_2 = 0.3 \text{ mm} \), Series 4: \( r_1 = 0.3 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 5: \( r_1 = 0.5 \text{ mm}, r_2 = 0.1 \text{ mm} \)

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\( r_1 = 2.55, r_2 = 2.2, d_1 = 4.7 \text{ mm}, d_2 = 1.6 \text{ mm} \)
Series 1: \( r_1 = 0.5 \text{ mm}, r_2 = 0.4 \text{ mm} \), Series 2: \( r_1 = 0.4 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 3: \( r_1 = 0.5 \text{ mm}, r_2 = 0.3 \text{ mm} \)

Fig. 5.28 Variation of radiation efficiency with respect to air-gap (S)  
\( r_1 = 2.55, r_2 = 2.2, d_1 = 4.7 \text{ mm}, d_2 = 0.8 \text{ mm} \)
Series 1: \( r_1 = 0.5 \text{ mm}, r_2 = 0.4 \text{ mm} \), Series 2: \( r_1 = 0.4 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 3: \( r_1 = 0.5 \text{ mm}, r_2 = 0.3 \text{ mm} \), Series 4: \( r_1 = 0.3 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 5: \( r_1 = 0.5 \text{ mm}, r_2 = 0.1 \text{ mm} \)

Fig. 5.29 Variation of radiation efficiency with respect to air-gap (S)  
\( r_1 = 2.55, r_2 = 2.2, d_1 = 4.7 \text{ mm}, d_2 = 1.6 \text{ mm} \)
Series 1: \( r_1 = 0.5 \text{ mm}, r_2 = 0.4 \text{ mm} \), Series 2: \( r_1 = 0.4 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 3: \( r_1 = 0.5 \text{ mm}, r_2 = 0.3 \text{ mm} \)

Fig. 5.30 Variation of resonant frequency with respect to air-gap (S)  
\( r_1 = 2.55, r_2 = 2.2, d_1 = 4.7 \text{ mm}, d_2 = 0.8 \text{ mm} \)
Series 1: \( r_1 = 0.5 \text{ mm}, r_2 = 0.4 \text{ mm} \), Series 2: \( r_1 = 0.4 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 3: \( r_1 = 0.5 \text{ mm}, r_2 = 0.3 \text{ mm} \), Series 4: \( r_1 = 0.3 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 5: \( r_1 = 0.5 \text{ mm}, r_2 = 0.1 \text{ mm} \)

Fig. 5.31 Variation of resonant frequency with respect to air-gap (S)  
\( r_1 = 2.55, r_2 = 2.2, d_1 = 4.7 \text{ mm}, d_2 = 1.6 \text{ mm} \)
Series 1: \( r_1 = 0.5 \text{ mm}, r_2 = 0.4 \text{ mm} \), Series 2: \( r_1 = 0.4 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 3: \( r_1 = 0.5 \text{ mm}, r_2 = 0.3 \text{ mm} \)

Fig. 5.32 Variation of bandwidth with respect to air-gap (S)  
\( r_1 = 2.55, r_2 = 2.2, d_1 = 4.7 \text{ mm}, d_2 = 0.8 \text{ mm} \)
Series 1: \( r_1 = 0.5 \text{ mm}, r_2 = 0.4 \text{ mm} \), Series 2: \( r_1 = 0.4 \text{ mm}, r_2 = 0.5 \text{ mm} \)
Series 3: \( r_1 = 0.5 \text{ mm}, r_2 = 0.3 \text{ mm} \)
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\[ \varepsilon_r = 2.55, \varepsilon_r = 2.2, d_1 = 4.7mm, d_2 = 1.6mm \]
Series 1: \( r_1 = 0.5mm, r_2 = 0.4mm \), Series 2: \( r_1 = 0.4mm, r_2 = 0.5mm \)
Series 3: \( r_1 = 0.5mm, r_2 = 0.3mm \)

Fig. 5.34 Variation of cross-polarisation with respect to air-gap (S)
\[ \varepsilon_r = 2.55, \varepsilon_r = 2.2, d_1 = 4.7mm, d_2 = 1.6mm \]
Series 1: \( r_1 = 0.5mm, r_2 = 0.4mm \), Series 2: \( r_1 = 0.4mm, r_2 = 0.5mm \)
Series 3: \( r_1 = 0.5mm, r_2 = 0.3mm \)
Series 4: \( r_1 = 0.4mm, r_2 = 0.3mm \)
Series 5: \( r_1 = 0.5mm, r_2 = 0.1mm \)

Fig. 5.35 Variation of cross-polarisation with respect to air-gap (S)
\[ \varepsilon_r = 2.55, \varepsilon_r = 2.2, d_1 = 4.7mm, d_2 = 0.8mm \]
Series 1: \( r_1 = 0.5mm, r_2 = 0.4mm \), Series 2: \( r_1 = 0.4mm, r_2 = 0.5mm \)
Series 3: \( r_1 = 0.5mm, r_2 = 0.3mm \)

Fig. 6.1 Configuration of stacked square ring coupled shorted square microstrip antenna (Normal configuration)

Fig. 6.2 Configuration of stacked square ring coupled shorted square microstrip antenna (Inverted configuration)

Fig. 6.3 (a) Computed and measured input impedance (Normal configuration)
Fig. 6.3 (b) Computed and measured return-loss (Normal configuration)
Parameters: \( \varepsilon_r = 2.55, \varepsilon_r = 2.2, d_1 = 4.7mm, d_2 = 1.6mm, L = 46mm, L_1 = 14mm, L_2 = 14mm, W = 46mm, W_1 = 14mm, W_2 = 14mm, S = 2.5mm, x_r = 3.4mm, x_s = 5.3mm, y_r = 0.0mm, y_s = 0.0mm, r_1 = 0.4mm, r_2 = 0.4mm \)

Fig. 6.3 (c) Computed radiation patterns (\( f_1 = 1.90GHz, f_c = 1.98GHz, f_2 = 2.09GHz \))

Fig. 6.3 (d) Measured radiation patterns (\( f_1 = 1.90GHz, f_c = 1.98GHz, f_2 = 2.09GHz \))

Fig. 6.4 (a) Computed input impedance (Inverted configuration)
Fig. 6.4 (b) Computed return-loss (Inverted configuration)
Parameters: \( \varepsilon_r = 2.55, \varepsilon_r = 2.2, d_1 = 4.7mm, d_2 = 1.6mm, L = 46mm, L_1 = 14mm, L_2 = 14mm, W = 46mm, W_1 = 14mm, W_2 = 14mm, S = 2.5mm, x_r = 3.4mm, x_s = 5.3mm, y_r = 0.0mm, y_s = 0.0mm, r_1 = 0.4mm, r_2 = 0.4mm \)

Fig. 6.4 (c) Computed radiation patterns (\( f_1 = 1.96GHz, f_c = 2.12GHz, f_2 = 2.2GHz \))

Fig. 6.5 (a) Computed input impedance (Normal configuration)
Fig. 6.5 (b) Computed return-loss (Normal configuration)
Parameters: \( \varepsilon_r = 2.55, \varepsilon_r = 2.2, d_1 = 4.7mm, d_2 = 0.8mm, L = 46mm, L_1 = 14mm, L_2 = 14mm, W = 46mm, W_1 = 14mm, W_2 = 14mm, S = 2.0mm, x_r = 3.4mm, x_s = 5.3mm, y_r = 0.0mm, y_s = 0.0mm, r_1 = 0.4mm, r_2 = 0.4mm \)

Fig. 6.5 (c) Computed radiation patterns (\( f_1 = 1.74GHz, f_c = 1.82GHz, f_2 = 1.9GHz \))

Fig. 6.6 (a) Computed and Measured input impedance (Normal Configuration)
Fig. 6.6 (b) Computed and Measured return-loss (Normal Configuration)
Parameters: \( \varepsilon_r = 2.55, \varepsilon_r = 2.2, d_1 = 4.7mm, d_2 = 0.8mm, L = 46mm, L_1 = 14mm, L_2 = 14mm, W = 46mm, W_1 = 14mm, W_2 = 14mm, S = 2.0mm, x_r = 3.4mm, x_s = 5.3mm, y_r = 0.0mm, y_s = 0.0mm, r_1 = 0.4mm, r_2 = 0.4mm \)

Fig. 6.6 (c) Computed radiation patterns (\( f_1 = 1.98GHz, f_c = 2.07GHz, f_2 = 2.1GHz \))

Fig. 6.6 (d) Measured radiation patterns (\( f_1 = 1.98GHz, f_c = 2.07GHz, f_2 = 2.1GHz \))

Fig. 6.7 (a) Computed and Measured input impedance (Inverted configuration)
Fig. 6.7 (b) Computed and Measured return-loss (Inverted configuration)
Parameters: \( \varepsilon_r = 2.55, \varepsilon_r = 2.2, d_1 = 4.7mm, d_2 = 0.8mm, L = 46mm, L_1 = 14mm, L_2 = 14mm, W = 46mm, W_1 = 14mm, W_2 = 14mm, S = 2.0mm, x_r = 3.4mm, x_s = 5.3mm, y_r = 0.0mm, y_s = 0.0mm, r_1 = 0.4mm, r_2 = 0.4mm \)

Fig. 6.7 (c) Computed radiation patterns (\( f_1 = 1.964GHz, f_c = 2.114GHz \))
Fig. 6.7 (d) Measured radiation patterns \((f_1=1.964 \text{ GHz}, f_2=2.114 \text{ GHz})\)

Fig. 6.8 (a) Computed input impedance (Normal configuration)

Fig. 6.8 (b) Computed return-loss (Normal configuration)

Parameters:
- \(\varepsilon_r 1=2.55, \varepsilon_r 2=2.2, d_1=4.7 \text{mm}, d_2=0.8 \text{mm}, L=46 \text{mm}, L_1=14 \text{mm}, L_2=14 \text{mm}, W=46 \text{mm}, W_1=14 \text{mm}, W_2=14 \text{mm}, S=0.0 \text{mm}, x_r=3.4 \text{mm}, x_s=5.3 \text{mm}, y_r=0.0 \text{mm}, y_s=0.0 \text{mm}, r_r=0.4 \text{ mm}, r_s=0.4 \text{ mm}\)

Fig. 6.8 (c) Computed radiation patterns \((f_1=1.715 \text{ GHz}, f_2=1.903 \text{ GHz})\)

Fig. 6.9 Variation of resonant frequency with respect to air-gap

Parameters:
- \(\varepsilon_r 1=2.55, \varepsilon_r 2=2.2, d_1=4.7 \text{mm}, r_r=r_s=0.4 \text{mm}, r=0.4 \text{ mm}, r_s=0.4 \text{ mm}\)

Fig. 6.10 Variation of return loss with respect to air-gap

Fig. 6.11 Variation of bandwidth with respect to air-gap

Fig. 6.12 Variation of directivity with respect to air-gap

Fig. 6.13 Variation of radiation efficiency with respect to air-gap

Fig. 6.14 Variation of cross-polarisation with respect to air-gap

Fig. 7.1 Configuration of stacked rectangular patch (With circular slot) coupled shorted circular microstrip antenna (Normal configuration)

Parameters:
- \(\varepsilon_r 1=2.55, \varepsilon_r 2=2.2, d_1=4.7 \text{mm}, d_2=0.8 \text{mm}, L=55 \text{mm}, W=43.0 \text{ mm}, a_1=8.2 \text{mm}, a_2=10 \text{ mm}, S=1.0 \text{mm}, x_1=3.5 \text{mm}, x_s=5.3 \text{mm}, y_1=0.0 \text{mm}, y_s=0.0 \text{mm}, r_r=0.4 \text{ mm}, r_s=0.4 \text{ mm}\)

Fig. 7.1(a) Computed input impedance

Fig. 7.1(b) Computed return loss

Fig. 7.1(c) Computed radiation patterns \((f_c=2.01 \text{ GHz})\)

Fig. 7.2 Configuration of stacked circular patch (With square slot) coupled shorted square microstrip antenna (Normal configuration)

Parameters:
- \(\varepsilon_r 1=2.55, \varepsilon_r 2=2.2, d_1=4.7 \text{mm}, d_2=0.8 \text{mm}, L_1=17 \text{mm}, L_2=14 \text{mm}, W_1=17 \text{mm}, W_2=14 \text{mm}, a=25.8 \text{mm}, S=2.0 \text{mm}, x_1=3.4 \text{mm}, x_s=5.3 \text{mm}, y_1=0.0 \text{mm}, y_s=0.0 \text{mm}, r_r=0.4 \text{ mm}, r_s=0.4 \text{ mm}\)

Fig. 7.2(a) Computed input impedance

Fig. 7.2(b) Computed return loss

Fig. 7.2(c) Computed radiation patterns \((f_c=2.065 \text{ GHz})\)

Fig. 7.3 Configuration of stacked rectangular patch (With square slot) coupled shorted square microstrip antenna (Normal configuration)

Parameters:
- \(\varepsilon_r 1=2.55, \varepsilon_r 2=2.2, d_1=4.7 \text{mm}, d_2=0.8 \text{mm}, L=43.0 \text{ mm}, L_1=17 \text{mm}, L_2=14 \text{mm}, W=55.0 \text{mm}, W_1=17 \text{mm}, W_2=14 \text{mm}, S=1.0 \text{mm}, x_1=3.4 \text{mm}, x_s=5.3 \text{mm}, y_1=0.0 \text{mm}, y_s=0.0 \text{mm}, r_r=0.4 \text{ mm}, r_s=0.4 \text{ mm}\)
Fig. 7.3(a) Computed input impedance  
Fig. 7.3(b) Computed return loss  
Fig. 7.3(c) Computed radiation patterns (f_c=2.0 GHz)  
Fig. 7.4 Configuration of stacked square patch (With circular slot) coupled shorted circular microstrip antenna (Normal configuration)  
Parameters: \( \varepsilon_r_1=2.55, \varepsilon_r_2=2.2, d_1=4.7\text{mm}, d_2=0.8\text{mm}, L=46\text{mm}, W=46\text{mm}, \)  
\( a_1=8.2\text{mm}, a_2=9.6\text{mm}, S=1.0\text{mm}, x_i=3.5\text{mm}, x_e=5.3\text{mm}, y_i=0.0\text{mm}, y_e=0.0\text{mm}, r_e=0.4\text{mm}, r_s=0.4\text{mm} \)  
Fig. 7.4(a) Computed input impedance  
Fig. 7.4(b) Computed return loss  
Fig. 7.4(c) Computed radiation patterns (f_c=1.9 GHz)  
Fig. 8.1 Configuration of linear array antenna array  
Fig. 9.1 Annular ring coupled shorted circular microstrip antenna array  
Fig. 9.1(a) Measured input impedance  
Fig. 9.1(b) Measured return loss  
Fig. 9.1(c) Measured radiation patterns  
Fig. 9.2 Square ring coupled shorted square microstrip antenna array