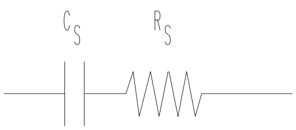
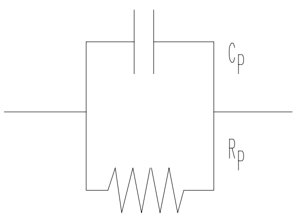
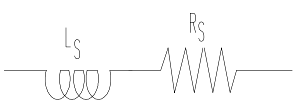
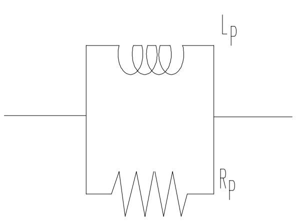
APPENDIX - G

MISCELLANEOUS FORMULAE AND DATA

NOTES

MEASUREMENT PARAMETER FORMULAS

	CONVERSION TO OTHER MODES	Z	D	Q	θ
	$C_P = \frac{1}{1+D^2} C_S$ $R_P = \frac{1+D^2}{D^2} R_S$	$\sqrt{\frac{1}{\omega^2 C_S^2} + R_S^2}$	❄C_S R_S	$\frac{1}{\omega C_S R_S}$	-TAN$^{-1}\left(\frac{1}{\omega C_S R_S}\right)$
	$C_S = \left(1+D^2\right) C_P$ $R_S = \frac{D^2}{1+D^2} R_P$	$\sqrt{\omega^2 C_P^2 + \frac{1}{R_P^2}}$	$\frac{1}{\omega C_P R_P}$	❄$C_P R_P$	-TAN$^{-1}\left(\omega C_P R_P\right)$
	$L_P = \left(1+D^2\right) L_S$ $R_P = \frac{1+D^2}{D^2} R_S$	$\sqrt{\omega^2 L_P^2 + R_S^2}$	$\frac{R_S}{\omega L_S}$	$\frac{\omega L_S}{R_S}$	TAN$^{-1}\left(\frac{\omega L_S}{R_S}\right)$
	$L_S = \frac{1}{1+D^2} L_P$ $R_S = \frac{D^2}{1+D^2} R_P$	$\sqrt{1 + \frac{\omega^2 L_P^2}{R_P^2}}$	$\frac{\omega L_S}{R_P}$	$\frac{R_P}{\omega L_P}$	TAN$^{-1}\left(\frac{R_P}{\omega L_P}\right)$

$$Z = R + jX = |Z|\left(COS\,\theta + j\,SIN\,\theta\right), |Z| = \sqrt{R^2 + X^2}$$

Technical Reference Material

Control Circuits

Important parameters to describe the circuit performance of Control Circuit Elements

Insertion Loss (IL) - Switch is in the "ON" Condition:

Insertion Loss is defined as the ratio

$$IL(dB) = 10\log_{10}\frac{(PL_0)}{(PL_1)}$$

PL = Power delivered to the load with the switch not in the RF circuit.

PL_1 = Power delivered to the load with the switch in the RF current path ("ON Condition").

Isolation (ISO) - Switch is in the "OFF" Condition:

$$ISO(dB) = 10\log_{10}\frac{(PL_0)}{(PL_1)}$$

PL_1 = As above.

PL_2 = Power delivered to the load with the switch in the RF current path ("OFF" Condition).

VSWR (Voltage Standing Wave Ratio)

The SPST switch is a two part network. VSWR at the input port is a measure of the mismatch between the RF Signal Source's internal impedance and the input impedance of the switch. VSWR (input) depends on the switch's load impedance but usually:

$Z_{load} = Z_{10}$
(Characteristic Impedance of the Transmission Medium)

VSWR at the output port of the switch is the measure of impedance mismatch between the switch's load and the switch's output impedance.

The switch as a Reciprocal Circuit Element. If the RF Signal Source's internal impedance and the load impedance equal the transmission line impedance and the switch is a reciprocal network element then:

VSWR (input) = VSWR (output)

VSWR is related to the magnitude of the voltage reflection coefficient.

$$VSWR = \frac{1+|r|}{1-|r|} \qquad |r| = \frac{P_{-1}}{P_R}^{1/2}$$

P_1 = Power incident on the switch

P_R = Power reflected from the switch

Return Loss (RL) is often used to describe the magnitude of transmission line mismatch. Thus RL is defined to be:

$$RL(dB) = 20\log_{10}\frac{1}{|r|}$$

Transmission Loss (TL) describes the transmission properties of the network element and we expect that:

$|r| + |\tau| = 1$

because energy is conserved in the network.

$$TL = 20\log_{10}\frac{1}{|\tau|}$$

$$|\tau| = \frac{P_{-1}}{P_T}$$

PT = Power transmitted through the switch to the load.

A conversion chart of VSWR and Return Loss is given. Thus a Return Loss of 20dB represents a VSWR of approximately 1.22.

Switching Equations for Shunt and Series Elements

Insertion Loss (I_L) and Isolation (I_{SO}) for Shunt and Series Switching Impedances are represented by the following equations:

Shunt: $I_L = 10 \log [1 + (R_R/Z_0)]$
$I_{SO} = 10 \log [1 + (Z_0/2R_S]^2$

Series: $I_L = 10 \log [1 + (R_S/2Z_0)]^2$
$I_{SO} = 10 \log [1 + (X_C/2Z_0]^2$

Shunt: $R_R = Z_0$ ([Antilog $(I_L/10)$]-1)
$R_S = Z_0/2$ [{Antilog $(I_{SO}/20)$}-1]$^{-1}$

Series: $R_S = 2Z_0$ [{Antilog $(I_L/20)$ -1 }]
$X_C = 2Z_0$[{Antilog$(I_{SO})/20)$ -1 }]

VSWR, RETURN LOSS, AND TRANSMISSION LOSS VS TRANSMITTED POWER

VSWR	RETURN LOSS (dB)	TRANS. LOSS (dB)	VOLT REFL COEFF.	POWER TRANS. (%)	POWER REFL (%)	VSWR	RETURN LOSS (dB)	TRANS. LOSS (dB)	VOLT REFL COEFF.	POWER TRANS. (%)	POWER REFL (%)
1.00		0.000	0.00	100.0	0.0	**1.64**	12.3	0.263	0.24	94.1	5.9
1.01	46.1	0.000	0.00	100.0	0.0	**1.66**	12.1	0.276	0.25	93.8	6.2
1.02	40.1	0.000	0.01	100.0	0.0	**1.68**	11.9	0.289	0.25	93.6	6.4
1.03	36.6	0.001	0.01	100.0	0.0	**1.70**	11.7	0.302	0.26	93.3	6.7
1.04	34.2	0.002	0.02	100.0	0.0	**1.72**	11.5	0.315	0.26	93.0	7.0
1.05	32.3	0.003	0.02	99.9	0.1	**1.74**	11.4	0.329	0.27	92.7	7.3
1.06	30.7	0.004	0.03	99.9	0.1	**1.76**	11.2	0.342	0.28	92.4	7.6
1.07	29.4	0.005	0.03	99.9	0.1	**1.78**	11.0	0.356	0.28	92.1	7.9
1.08	28.3	0.006	0.04	99.9	0.1	**1.80**	10.9	0.370	0.29	91.8	8.2
1.09	27.3	0.008	0.04	99.8	0.2	**1.82**	10.7	0.384	0.29	91.5	8.5
1.10	26.4	0.010	0.05	99.8	0.2	**1.84**	10.6	0.398	0.30	91.3	8.7
1.11	25.7	0.012	0.05	99.7	0.3	**1.86**	10.4	0.412	0.30	91.0	9.0
1.12	24.9	0.014	0.06	99.7	0.3	**1.88**	10.3	0.426	0.31	90.7	9.3
1.13	24.3	0.016	0.06	99.6	0.4	**1.90**	10.2	0.440	0.31	90.4	9.6
1.14	23.7	0.019	0.07	99.6	0.4	**1.92**	10.0	0.454	0.32	90.1	9.9
1.15	23.1	0.021	0.07	99.5	0.5	**1.94**	9.9	0.468	0.32	89.8	10.2
1.16	22.6	0.024	0.07	99.5	0.5	**1.96**	9.8	0.483	0.32	89.5	10.5
1.17	22.1	0.027	0.08	99.4	0.6	**1.98**	9.7	0.497	0.33	89.2	10.8
1.18	21.7	0.030	0.08	99.3	0.7	**2.00**	9.5	0.512	0.33	88.9	11.1
1.19	21.2	0.033	0.09	99.2	0.8	**2.50**	7.4	0.881	0.43	81.6	18.4
1.20	20.8	0.036	0.09	99.2	0.8	**3.00**	6.0	1.249	0.50	75.0	25.0
1.21	20.4	0.039	0.10	99.1	0.9	**3.50**	5.1	1.603	0.56	69.1	30.9
1.22	20.1	0.043	0.10	99.0	1.0	**4.00**	4.4	1.938	0.60	64.0	36.0
1.23	19.7	0.046	0.10	98.9	1.1	**4.50**	3.9	2.255	0.64	59.5	40.5
1.24	19.4	0.050	0.11	98.9	1.1	**5.00**	3.5	2.553	0.67	55.6	44.4
1.25	19.1	0.054	0.11	98.8	1.2	**5.50**	3.2	2.834	0.69	52.1	47.9
1.26	18.8	0.058	0.12	98.7	1.3	**6.00**	2.9	3.100	0.71	49.0	51.0
1.27	18.5	0.062	0.12	98.6	1.4	**6.50**	2.7	3.351	0.73	46.2	53.8
1.28	18.2	0.066	0.12	98.5	1.5	**7.00**	2.5	3.590	0.75	43.7	56.2
1.29	17.9	0.070	0.13	98.4	1.6	**7.50**	2.3	3.817	0.76	41.5	58.5
1.30	17.7	0.075	0.13	98.3	1.7	**8.00**	2.2	4.033	0.78	39.5	60.5
1.32	17.2	0.083	0.14	98.1	1.9	**8.50**	2.1	4.240	0.79	37.7	62.3
1.34	15.8	0.093	0.15	97.9	2.1	**9.00**	1.9	4.437	0.80	36.0	64.0
1.36	16.3	0.102	0.15	97.7	2.3	**9.50**	1.8	4.626	0.81	34.5	65.5
1.38	15.9	0.112	0.16	97.5	2.5	**10.00**	1.7	4.807	0.82	33.1	66.9
1.40	15.6	0.122	0.17	97.2	2.8	**11.00**	1.6	5.149	0.83	30.6	69.4
1.42	15.2	0.133	0.17	97.0	3.0	**12.00**	1.5	5.466	0.85	28.4	71.6
1.44	14.9	0.144	0.18	96.7	3.3	**13.00**	1.3	5.762	0.86	26.5	73.5
1.46	14.6	0.155	0.19	96.5	3.5	**14.00**	1.2	6.040	0.87	24.9	75.1
1.48	14.3	0.166	0.19	96.3	3.7	**15.00**	1.2	6.301	0.88	23.4	76.6
1.50	14.0	0.177	0.20	96.0	4.0	**16.00**	1.1	6.547	0.88	22.1	77.9
1.52	13.7	0.189	0.21	95.7	4.3	**17.00**	1.0	6.780	0.89	21.0	79.0
1.54	13.4	0.201	0.21	95.5	4.5	**18.00**	1.0	7.002	0.89	19.9	80.1
1.56	13.2	0.213	0.22	95.2	4.8	**19.00**	0.9	7.212	0.90	19.0	81.0
1.58	13.0	0.225	0.22	94.9	5.1	**20.00**	0.9	7.413	0.90	18.1	81.9
1.60	12.7	0.238	0.23	94.7	5.3	**25.00**	0.7	8.299	0.92	14.8	85.2
1.62	12.5	0.250	0.24	94.4	5.6	**30.00**	0.6	9.035	0.94	12.5	87.5

POWER CONVERSION dBm TO WATTS

dBm	picoWatts	dBm	nanoWatts	dBm	microWatts	dBm	microWatts	dBm	milliWatts	dBm	Watts
-80	10.00	-60	1.00	-40	0.100	-20	10.00	0	1.00	20	0.100
-79	12.59	-59	1.26	-39	0.126	-19	12.59	1	1.26	21	0.126
-78	15.85	-58	1.58	-38	0.158	-18	15.85	2	1.58	22	0.158
-77	19.95	-57	2.00	-37	0.200	-17	19.95	3	2.00	23	0.200
-76	25.12	-56	2.51	-36	0.251	-16	25.12	4	2.51	24	0.251
-75	31.62	-55	3.16	-35	0.316	-15	31.62	5	3.16	25	0.316
-74	39.81	-54	3.98	-34	0.398	-14	39.81	6	3.98	26	0.398
-73	50.12	-53	5.01	-33	0.501	-13	50.12	7	5.01	27	0.501
-72	63.10	-52	6.31	-32	0.631	-12	63.10	8	6.31	28	0.631
-71	79.43	-51	7.94	-31	0.794	-11	79.43	9	7.94	29	0.794
-70	100.00	-50	10.00	-30	1.000	-10	100.00	10	10.00	30	1.000
-69	125.89	-49	12.59	-29	1.259	-9	125.89	11	12.59	31	1.259
-68	158.49	-48	15.85	-28	1.585	-8	158.49	12	15.85	32	1.585
-67	199.53	-47	19.95	-27	1.995	-7	199.53	13	19.95	33	1.995
-66	251.19	-46	25.12	-26	2.512	-6	251.19	14	25.12	34	2.512
-65	316.23	-45	31.62	-25	3.162	-5	316.23	15	31.62	35	3.162
-64	398.11	-44	39.81	-24	3.981	-4	398.11	16	39.81	36	3.981
-63	501.19	-43	50.12	-23	5.012	-3	501.19	17	50.12	37	5.012
-62	630.96	-42	63.10	-22	6.310	-2	630.96	18	63.10	38	6.310
-61	794.33	-41	79.43	-21	7.943	-1	794.33	19	79.43	39	7.943
										40	10.000