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Product Note 82

VSWR++ iTuner Calibration Routine

A Calibration Routine for Highly Accurate Constant-VSWR Tuning

Abstract – The VSWR++ Calibration Routine allows for highly accurate Constant-VSWR tuning at the DUT reference plane. This is accomplished by using *iTuner* capability and a VNA to correct for the tuning interpolation after embedding the S-parameters of the tuner with the S-parameters of the fixture. Tuning accuracy typically improves from -35 to -50dB at VSWR=20:1.

Introduction – Computer Controlled Microwave Tuners are common tools in production and verification test setups. As such, test routines such as **Constant-VSWR** are needed to verify transistors and amplifiers for unconditional stability and conformity to industry standards. The typical approach of a Constant-VSWR routine is to embed the s-parameter of the fixture into the s-parameters of the tuner and use the combined s-parameters to tune to Constant-VSWR at the DUT reference plane. From experience, the accuracy of this approach varies between -35 and -40dB depending on the VSWR itself, or VSWR of 20.75:1 when tuning for VSWR of 20:1. The **VSWR++** routine corrects for this error and allows for a typical accuracy of -50dB, or VSWR of 20.05:1 when tuning for VSWR of 20:1

Product Description - The VSWR++ Calibration Routine works as follows: The tuner tunes and positions itself to the requested VSWR magnitude and phase. The s-parameters are measured using a VNA and validity of the measurement is confirmed. The data is then compared to the requested VSWR; if the data falls within the tolerance set by the user, the routine will continue with the next data point. If the value does not fall within the tolerance, the VNA reading will be used to correct the positioning of the tuner iteratively and based on a gradient optimization algorithm, such that the resulting s-parameters are within the accepted tolerance. A flowchart of the VSWR++ routine can be found in Figure 1.

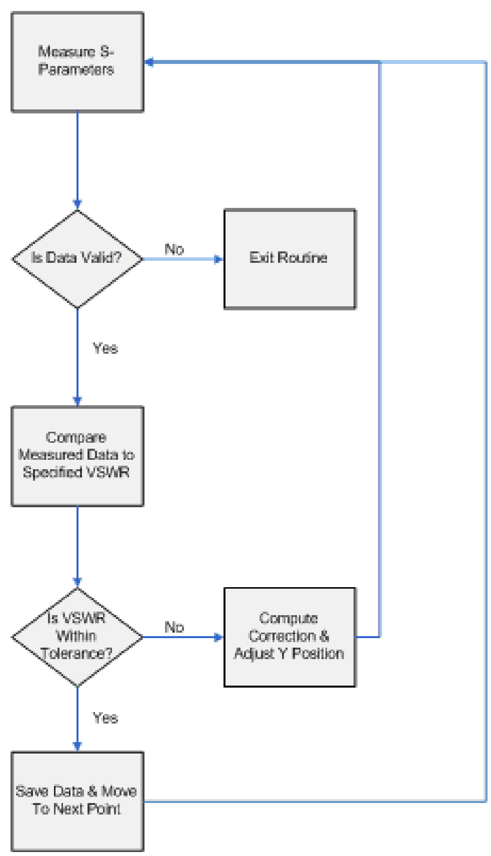

Figure 1: VSWR++ Operational Flowchart

The **VSWR++ Calibration Routine** can be used either within Focus Microwaves' device characterization software **WinPower**, or independently through Focus' **iTuner** technology. The routine is supplied as an **ActiveX** which can be integrated into programming languages such as C++, Basic, LabView, VEE, and others. Because of its easy integration, the routine can be inserted into existing measurement applications with little customization. Before measuring a device, the user would perform a VSWR++ routine which corrects Y-positioning for accurate VSWR tuning. The updated positions are then uploaded to the tuner. Finally, a Constant-VSWR test procedure is then performed as normal using updated tuner positions. A test setup which allows executing this calibration routine consists of a VNA, the tuner itself connected directly to the VNA ports and a control computer with GPIB and TCP/IP (or network) interface, as shown in Figure 2.

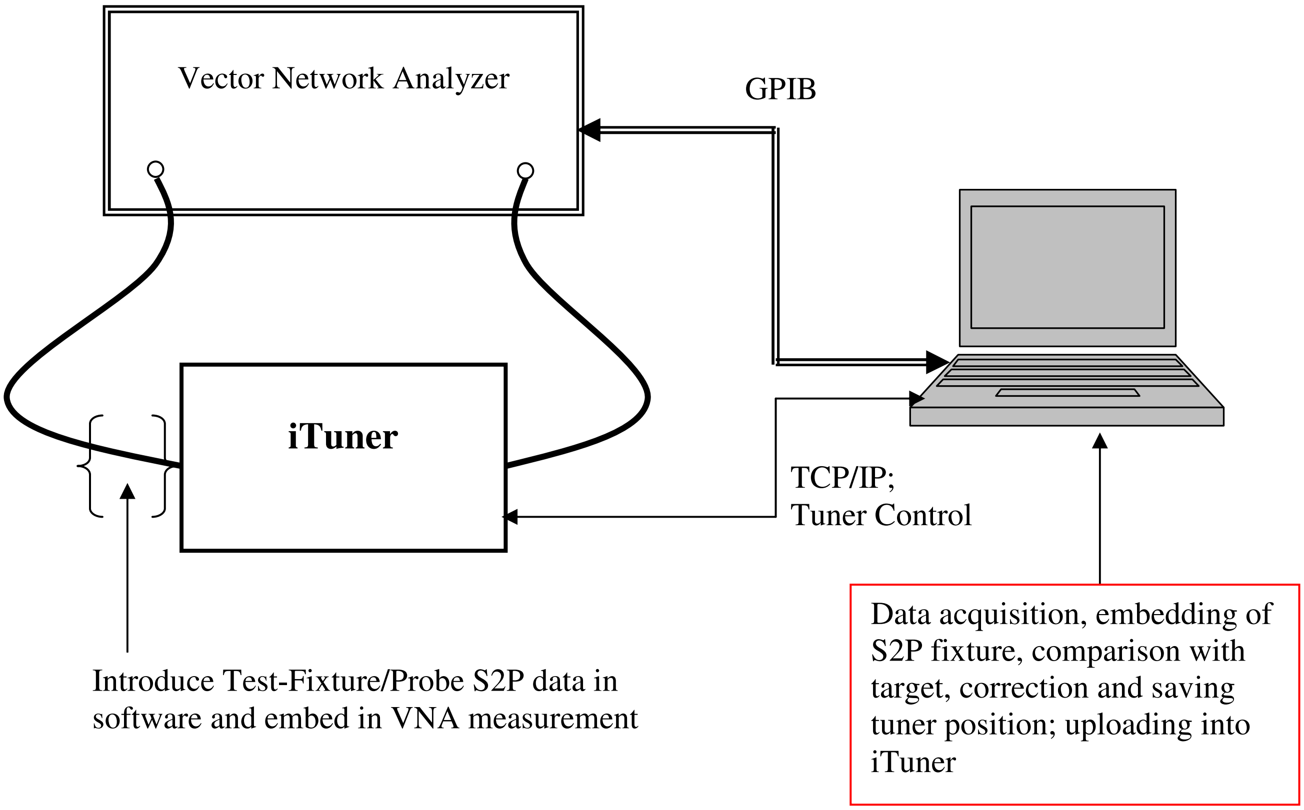

Figure 2: Test setup for VSWR++ Tuner Calibration routine

Table I is an example of VSWR++ implementation in C++:

```
CoInitialize(NULL);
IVSWRPlusPlusPtr vswrApp;
HRESULT hr = vswrApp.CreateInstance("FMW.VSWRPlusPlus");
// Specify vna parameters
int gpibAddress = 20;
int vnaAveraging = 2;
vswrApp->setVNA("FMWDriver.RS_ZVC", gpibAddress, vnaAveraging);
// Specify tuner & frequency to be used
int serialNumber = 1089;
double frequencyGHz = 1.8;
vswrApp->setTuner(serialNumber, frequencyGHz);
// Specify fixture and termination
vswrApp->setFixture("C:\\Focus\\fixture.s2p");
vswrApp->setTermination("C:\\Focus\\term.s1p");
// Set pattern parameters and create pattern
vswrApp->setTolerance(0.1);
vswrApp->setDensity("Low");
vswrApp->setVSWR(20.0);
vswrApp->createPattern("C:\\Focus\\vswrPattern.txt");
// Upload pattern to iTuner
vswrApp->uploadPattern("C:\\Focus\\vswrPattern.txt");
vswrApp->autoTest();
CoUninitialize();
```

Table I: VSWR++ implementation example in C++ for VSWR=20:1 and 10º steps from 0 to 360º

The resulting measured file generated by this routine can be found in Appendix 1. A VSWR of 20:1 represents a $\Gamma=0.9048$. Before VSWR++ correction, the reflection coefficient Γ varied between 0.9021 and 0.9105 representing a VSWR range of 19.43 to 21.34 (Figure 3). After correction, Γ varied between 0.9045 and 0.9050 representing a VSWR range of 19.95 to 20.09 (Figure 4). A graphical representation of the VSWR=20 sweep before and after correction, with 10 degree step size, can be seen in Figures 3 and 4. The VSWR++ Calibration Routine is obviously essential for high precision constant-VSWR testing to -50dB accuracy.

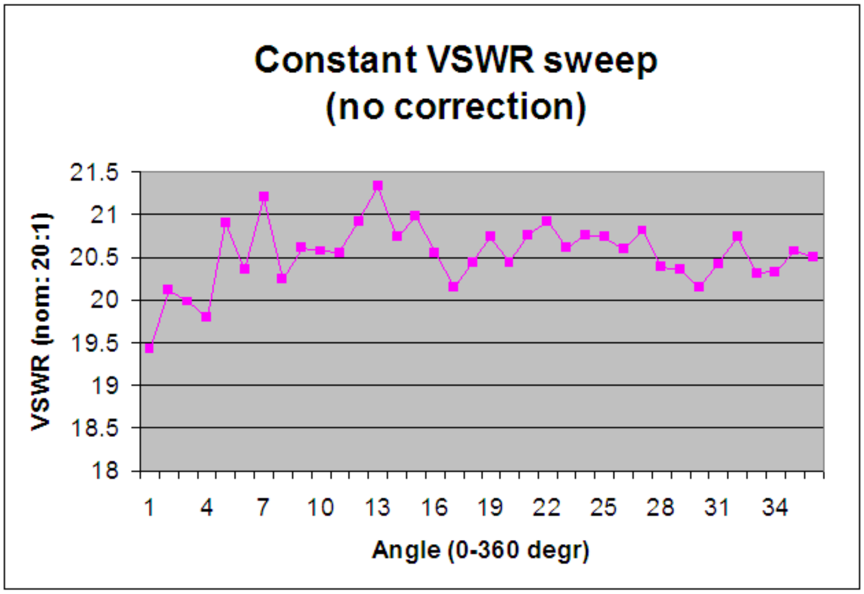

Figure 3: **Uncorrected** Constant-VSWR Sweep at 20:1 in 10 degree steps; frequency = 3GHz

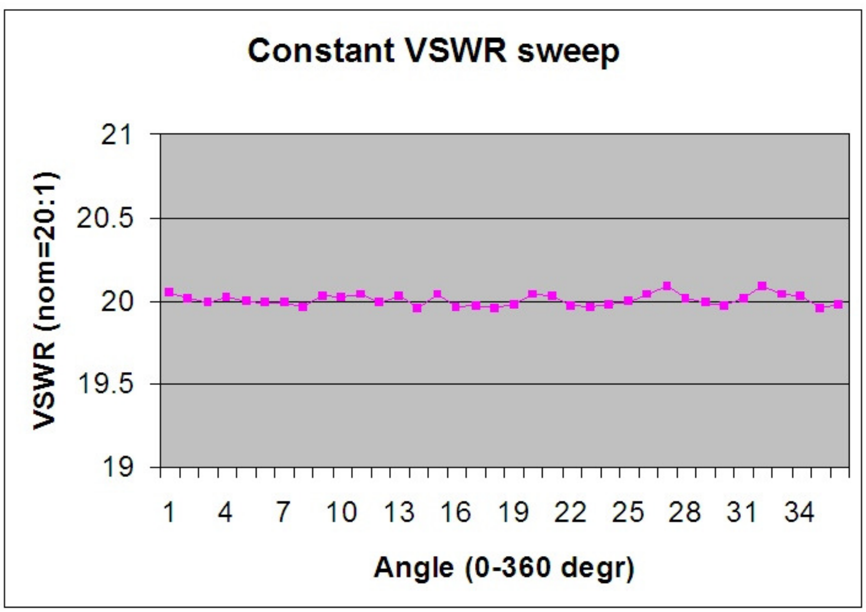

Figure 4: **Corrected** Constant-VSWR Sweep at 20:1 in 10 degree steps; frequency = 3GHz

Appendix 1: Results generated from VSWR++ Calibration Routine

	BEFORE Correction					AFTER Correction					
Point	|Γ|	< Γ	X-Pos	Y-Pos	VSWR	|Γ|	< Γ	X-Pos	Y-Pos	VSWR	Final Error
1	0.9021	0.3	116	9004	19.43	0.9050	-0.2	116	9036	20.05	0.05
2	0.9053	10.3	62	9000	20.12	0.9048	10.3	62	9000	20.01	0.01
3	0.9047	20.3	9	8988	19.99	0.9047	20.3	9	8988	19.99	-0.01
4	0.9038	30.4	1918	8996	19.79	0.9049	30.5	1918	8988	20.02	0.02
5	0.9087	40.5	1864	8996	20.91	0.9047	40.7	1864	8972	20.00	0.00
6	0.9063	50.5	1811	8972	20.35	0.9047	50.3	1811	8980	19.99	-0.01
7	0.9100	60.6	1754	8991	21.21	0.9047	60.7	1754	8972	19.99	-0.01
8	0.9059	70.4	1701	8976	20.25	0.9046	70.3	1701	8976	19.96	-0.04
9	0.9075	80.5	1646	8979	20.61	0.9049	80.6	1646	8967	20.03	0.03
10	0.9073	90.3	1590	8983	20.58	0.9049	90.8	1590	8952	20.02	0.02
11	0.9073	100.6	1535	8969	20.56	0.9049	100.7	1535	8953	20.04	0.04
12	0.9088	110.6	1479	8982	20.93	0.9047	110.9	1479	8950	19.99	-0.01
13	0.9105	120.6	1423	8992	21.34	0.9049	120.9	1423	8960	20.03	0.03
14	0.9080	130.6	1369	8965	20.75	0.9045	130.6	1369	8949	19.95	-0.05
15	0.9091	140.6	1312	8977	20.99	0.9050	140.9	1312	8945	20.04	0.04
16	0.9072	150.5	1258	8968	20.55	0.9046	150.7	1258	8944	19.96	-0.04
17	0.9054	160.4	1203	8960	20.14	0.9046	160.5	1203	8946	19.97	-0.03
18	0.9068	170.5	1146	8965	20.45	0.9045	170.7	1146	8952	19.95	-0.05
19	0.9080	-179.4	1089	8983	20.74	0.9047	-179.2	1089	8961	19.98	-0.02
20	0.9067	-169.4	1034	8983	20.44	0.9049	-169	1034	8953	20.04	0.04
21	0.9081	-159.5	979	8987	20.76	0.9049	-159.2	979	8963	20.03	0.03
22	0.9088	-149.4	924	8993	20.92	0.9046	-149.1	924	8961	19.97	-0.03
23	0.9075	-139.4	869	8991	20.62	0.9046	-139.1	869	8961	19.96	-0.04
24	0.9081	-129.4	815	8995	20.76	0.9047	-129.2	815	8971	19.98	-0.02
25	0.9080	-119.3	761	8997	20.74	0.9048	-119.2	761	8973	20.00	0.00
26	0.9074	-109.2	706	8998	20.60	0.9050	-109.1	706	8974	20.04	0.04
27	0.9083	-99.3	652	8998	20.81	0.9040	-99.3	652	8988	20.09	0.09
28	0.9064	-89.4	599	8996	20.38	0.9048	-89.3	599	8980	20.01	0.01
29	0.9063	-79.4	545	9004	20.35	0.9047	-79.3	545	8988	19.99	-0.01
30	0.9054	-69.4	491	8998	20.14	0.9046	-69.4	491	8990	19.97	-0.03
31	0.9067	-59.4	437	9003	20.43	0.9048	-59.4	437	9001	20.01	0.01
32	0.9080	-49.3	383	9016	20.75	0.9040	-49.3	383	9017	20.09	0.09
33	0.9062	-39.4	330	9014	20.32	0.9049	-39.4	330	9014	20.04	0.04
34	0.9063	-29.4	276	9014	20.34	0.9049	-29.3	276	8997	20.03	0.03
35	0.9073	-19.4	222	9013	20.57	0.9045	-19.2	222	8993	19.95	-0.05
36	0.9070	-9.3	170	9003	20.50	0.9047	-9.5	170	9003	19.98	-0.02

Table II: VSWR++ data for constant-VSWR=20:1 with 10 degree increments

Conclusion

The VSWR++ iTuner Calibration routine responds to enhanced test requirements for VSWR=Constant applications. An overall improvement of tuning precision by a factor of 10 in VSWR accuracy terms has been obtained. The routine has been verified for VSWR values between 10:1 and 50:1.