www.MobileMark.com
US Tel: +1 (847) 671-6690
UK Tel: +44 1543 459555
US/CA Toll Free: +1 (800) 648-2800
U.S. Headquarters: Itasca, IL, USA
UK Office: Hednesford, Staffordshire, UK

TECH BULLETIN

How to setup and measure VSWR?

THE PURPOSE

The purpose of this document is to provide a step-by-step instruction on how to calibrate and measure **V**oltage **S**tanding **W**ave **R**atio (**VSWR**).

VSWR is defined as the ratio between the incident and reflected wave in an RF component or system. It determines the efficiency of power transmission from a source to the load through a transmission line (or cable). The minimum value of VSWR can be 1:1 (or simply 1), which is an ideal condition where 100% of power from source is absorbed by the load. However, in real-world applications, VSWR is rarely found to be 1:1 and systems are designed to keep the VSWR as close to unity as possible. As such, VSWR of <2:1 is generally accepted as the standard in wireless industry.

THE EQUIPMENT

Below is a list of equipment that are needed to perform VSWR calibration and measurement. If the exact equipment is not available, equipment of similar capability can be used as substitutes.

Item #'s:

1) Vector Network Analyzer (covering 300 KHz to 6 GHz)

2) "Open" Termination, HP-85032-60007 (type N-Female open)

3) "Short" Termination, HP-909F

4) "Load" (50 Ohms), Schmitt P/N 00909-60009

5) 2-feet (50 Ohms) RF Coaxial cable (LMR-195) with N-Male to N-Male terminations

6) DUTs (Device Under Test), (e.g., Mobile Mark XW-5X0-FPS13M3)

www.MobileMark.com
US Tel: +1 (847) 671-6690
UK Tel: +44 1543 459555
US/CA Toll Free: +1 (800) 648-2800
U.S. Headquarters: Itasca, IL, USA
UK Office: Hednesford, Staffordshire, UK

THE CALIBRATION

For consistent measurement from batch to batch, equipment calibration shall be performed at the beginning of each production shift or at any point in time should there be concerns on the integrity of the reading.

Step #'s:

1) VNA parameters setup, set…
    a) Format = "VSWR",
    b) Scale = 0.2 (set each segment/row = 0.2 VSWR),
    c) Ref. Position = 5 (set ref. point to half-way of 10 rows x 10 columns),
    d) Typical Value = 2.0 (set 2.0 VSWR at the center of 10 rows),
    e) Freq. Start = 5.0 GHz (each column = 0.1 GHz of 10 columns)
    f) Freq. Stop = 6.0 GHz (to read interested freq. ranging from 5.45 GHz to 6.0 GHz)

2) Calibration – all three "Open", "Short", and "Load" calibration steps needed to be individually calibrated in their respective order to complete the calibration process.
    a) Setup calibration
        - Attach one end (N-Male termination) of the coaxial cable to VNA "Reflection" Port #1
        - Press "CAL" mode
        - Select "Manual" calibration option
        - Select "Port #1" Reflection

    b) "Open" calibration
        - Attach "Open" Termination to the other end (N-Male termination) of the coaxial cable
        - Select "Open", "Male" and "Done"
        - Detach "Open" Termination from the N-Male connector of the coaxial cable

    c) "Short" calibration
        - Attach "Short" Termination to the other end (N-Male termination) of the coaxial cable
        - Select "Short", "Male" and "Done"
        - Detach "Short" Termination from the N-Male connector of the coaxial cable

    d) "Load" (50 Ohms) calibration
        - Attach "Load" Termination to the other end (N-Male termination) of the coaxial cable
        - Select "50 Ohm" and "Done"
        - Detach "Load" Termination from the N-Male connector of the coaxial cable

        Note: To verify that calibration process is completed successfully, VSWR reading should display 1.0:1 across all frequencies when the cable is attached and should display >10.0:1 when the cable is detached.

    e) Enter frequency markers for the desired frequency range (ie. for frequency ranging from 5.45 to 6.00 GHz, Low, Mid, and High frequency markers shall be set as followed…)
        - Press "MKR"
        - Enter "5450" MHz for 5.45 GHz for "Low" frequency
        - Select "High" for 6.00 GHz
        - Select "Mid" for 5.75 GHz

www.MobileMark.com
US Tel: +1 (847) 671-6690
UK Tel: +44 1543 459555
US/CA Toll Free: +1 (800) 648-2800
U.S. Headquarters: Itasca, IL, USA
UK Office: Hednesford, Staffordshire, UK

THE MEASUREMENT

To connect and disconnect the antenna from the VNA, it is understood that operator needs to handle the antenna before and after VSWR reading. However, during VSWR reading, the operator shall not touch the antenna since human body capacitance could affect the reading.

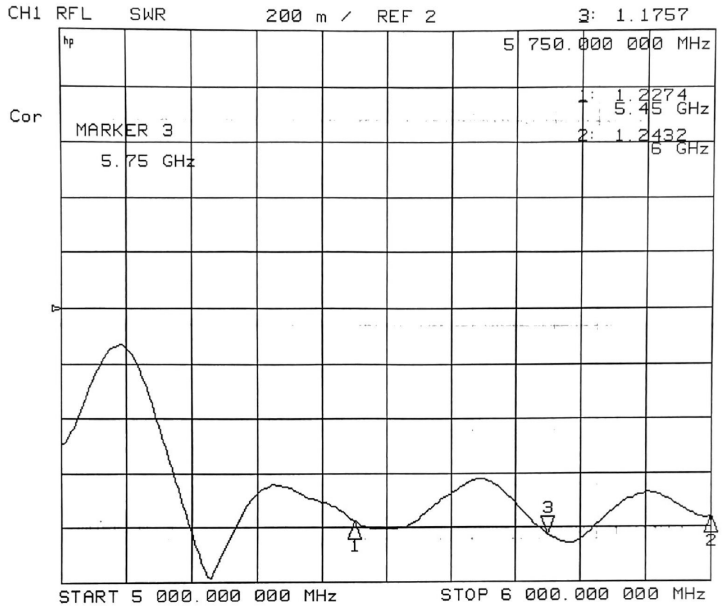
Step #'s:

1) Attach one end (N-Male termination) of the coaxial cable to the VNA "Reflection" Port #1.
2) Attach the other end (N-Male termination) of the coaxial cable to DUT.
3) *PASSED/FAILED test condition - verify that VSWR levels at Low, Mid, and High frequencies are <2:1, the DUT "**PASSED**" the test. If at least one frequency displays VSWR >2:1, the DUT "**FAILED**" the test.
4) Record the VSWR levels at Low, Mid, and High frequencies for each DUT.
5) Remove the DUT from N-Male connector of the coaxial cable and attach another DUT.
6) Repeat Step #3-5 above.

Note: *Make sure that the operator does not touch any parts of the antenna in Step #3 during data capturing and recording.

Below figure is a sample of VSWR readings on VNA at Low/Mid/High frequencies.

- Marker #1: Low Freq @5.45 GHz, VSWR = 1.2274 (<2, Result: PASSED)
- Marker #3: Mid Freq @5.75 GHz, VSWR = 1.1757 (<2, Result: PASSED)
- Marker #2: High Freq @6.00 GHz, VSWR = 1.2432 (<2, Result: PASSED)



By **Cham Phoy**, Product Management

www.MobileMark.com
US Tel: +1 (847) 671-6690
UK Tel: +44 1543 459555
US/CA Toll Free: +1 (800) 648-2800
U.S. Headquarters: Itasca, IL, USA
UK Office: Hednesford, Staffordshire, UK

Special thanks to…

- **Tam Chau**, RF Project Engineer, for providing video instructions and reviewing the contents which were essential in creating this document.
- **www.everythingrf.com** for providing a clear and concise definition of **V**oltage **S**tanding **W**ave **R**atio (**VSWR**) as defined in this document.

About Mobile Mark, Inc.

Tested and trusted Mobile Mark strives for Excellence in Engineering by designing and manufacturing site, mobile and device antennas from 30 MHz – 7.2 GHz. Recognized for introducing innovative designs in 15 wireless industries with applications that include: GPS Tracking & Fleet Management, Cellular 4G LTE & 5G Ready, Wi-Fi, RFID, Public Safety FirstNet, M2M & IoT, Smart City Networks and Autonomous & Connected Cars. Engineering and custom design services are available, Contact Us. Mobile Mark's global headquarters, research facilities and manufacturing plant, are located near Chicago, IL. An additional manufacturing and sales facility is located near Birmingham, UK. Learn More Wireless Solutions.