Modular Frequency Up Conversion For Antenna Ranges

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Introduction

A distributed RF subsystem is a common solution for antenna test ranges where dynamic range is to be optimized. This is especially relevant for electrically large[1] systems since cable losses become prohibitive. For such solutions the locations of the components comprising the RF subsystem are critical. By using remote mixers, amplifiers and multipliers, the use of lower frequency cables with lower loss becomes feasible and this approach dramatically increases the available power level at the transmitting antenna and the sensitivity of the receiver.

In addition to the performance enhancement that a distributed system allows, there is also an additional advantage to be gained: By doing remote frequency conversion, existing lower frequency instrumentation can be used. This is very relevant in a world where mm-wave testing becomes more commonplace and where many existing antenna test ranges are only instrumented up to 18 or 20 GHz.

NSI offers a series of frequency up and down conversion units that allows for the upgrade of such antenna test ranges. These conversion units allow users to expand the upper frequency range of an antenna test range without replacing the existing sources and receiver. The conversion units cover distinct bands spanning 20 GHz – 500 GHz.

Distributed Frequency Conversion

A typical RF subsystem for an electrically small antenna test range is shown in Figure 1 below.

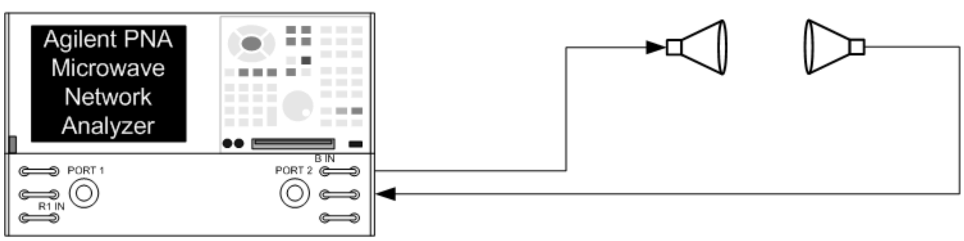

Figure 1: Example 1 – 20/26 GHz RF subsystem block diagram.

This simple configuration is commonly used for planar near-field test systems (eg. NSI-200V-3x3 & NSI-200V-5x5) operating below 20 GHz. In such cases cable losses are not prohibitive and this test system

1 Note that an “electrically large” antenna test range can be a 100m range operating at 10 GHz or a 1m range operating at 100 GHz. It is important to realize that a physically small facility, operating at a sufficiently high frequency will be electrically large and therefore present loss problems that require a distributed solution.

represents the most cost effective solution. When this type of test system is to be upgraded for high frequency operation, an obvious but expensive solution would be to replace the VNA with a higher frequency model. However, cable losses become prohibitive and a distributed RF subsystem is required to achieve optimum dynamic range. An example of this type of solution is shown in Figure 2 below.

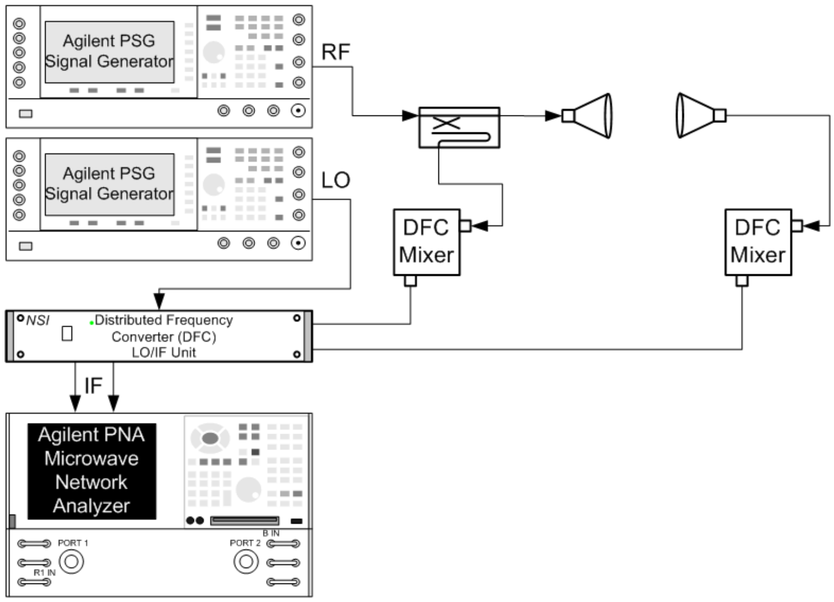

Figure 2: Example 1 – 20 GHz RF subsystem block diagram. External sources and remote mixers used.

In this solution additional external RF and LO sources, a distributed frequency converter and remote mixers are added. This type of system offers excellent dynamic range and is the traditional solution for achieving optimal dynamic range in electrically large antenna test ranges. The distributed frequency converter used here is described in [1] and employs identical test and references mixers as depicted in Figure 3 below. These mixers contain integrated levelling circuitry that precludes the requirement to match cable losses to both units. The mixers both also contain diplexers, allowing for a single LO/IF cable to be used – ideal for antenna test ranges usually fitted with only a single RF rotary joint. This has the further advantage of allowing one to exchange test and reference mixers if desired, making diagnostics and risk mitigation through spares simpler.

Figure 3: Set of 1- 50 GHz mixers for use with NSI distributed frequency converter.

Remote Frequency Multiplication

The distributed RF subsystem depicted in Figure 2 can further be simplified by selecting to use the RF and LO sources internal to the VNA (Agilent PNA-X options 020 and 080 allow for distributed down-conversion using the analyzer's internal LO source). This type of test system in depicted in Figure 4 below.

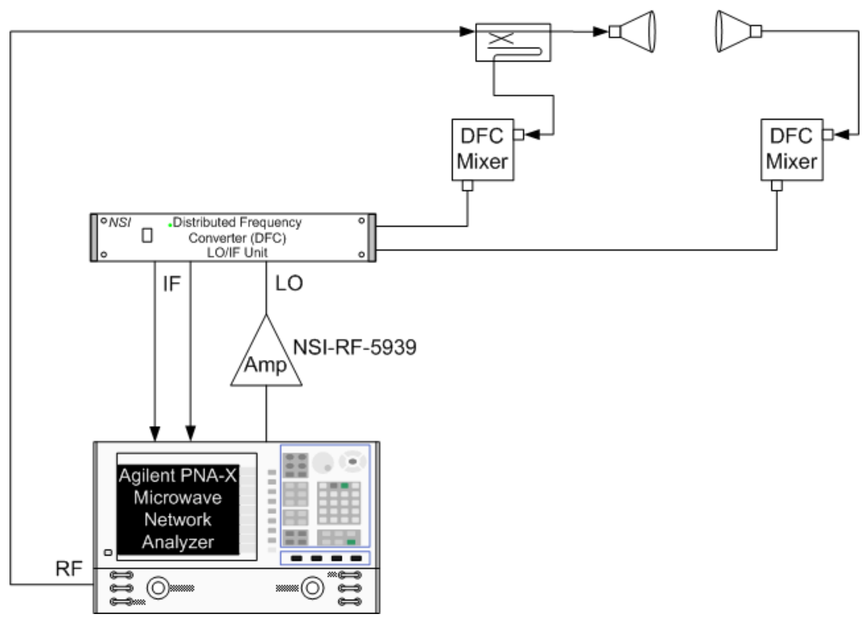

Figure 4: Example 1 – 20/26 GHz RF subsystem block diagram. Remote mixers used.

This system offers the advantage of a remote down conversion process to overcome some RF cable losses as well as the added benefit of reducing the cost through elimination of one source. A further evolution involves the addition of a remote frequency multiplier, resulting in the system shown in Figure 5 below.

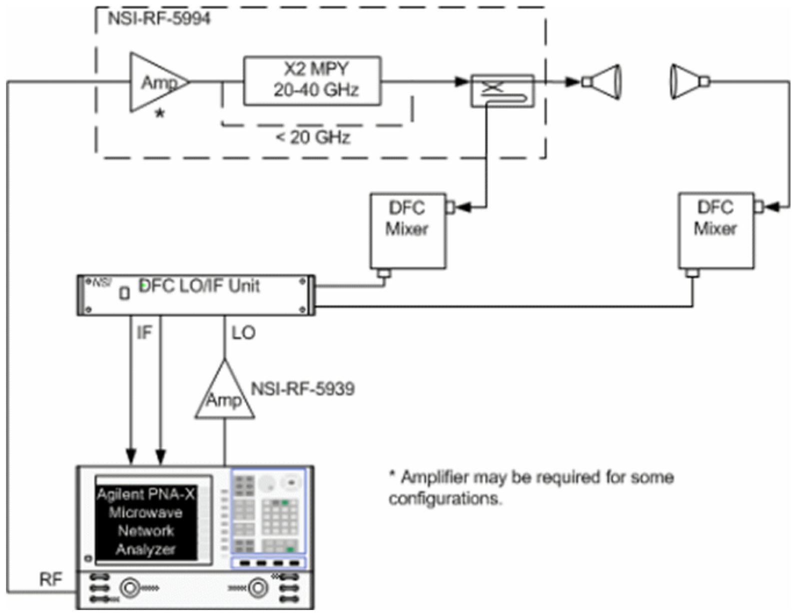

Figure 5: Example 1 – 40 GHz RF subsystem block diagram. Remote multiplier and mixers used.

The components depicted in the dashed box allow for up conversion of the RF signal remotely and has the obvious benefit of shorter high frequency RF cables and therefore the reduction of their losses. However, the most significant advantage of this solution is the fact that an existing 20/26 GHz RF subsystem can be upgraded for higher frequency operation by simply adding a multiplier unit, coupler and a set of mixers. This allows for the upgrading of most existing antenna test ranges for operation at frequencies of up to 500 GHz. A 1- 50 GHz unit is shown below in Figure 6.

Figure 6: Remote 1 – 50 GHz frequency up converter.

A typical RF subsystem block diagram for a 50 – 140 GHz RF subsystem is shown below in Figure 7. This system again consists of the Agilent PNA-X and NSI DFC. However, in this instance a remote mm-wave up converter is used in close proximity to the near-field probe and a similar mm-wave down converter is used at the antenna test port to minimize loss. It is noteworthy that the VNA and DFC units are identical to that used in the lower frequency applications.

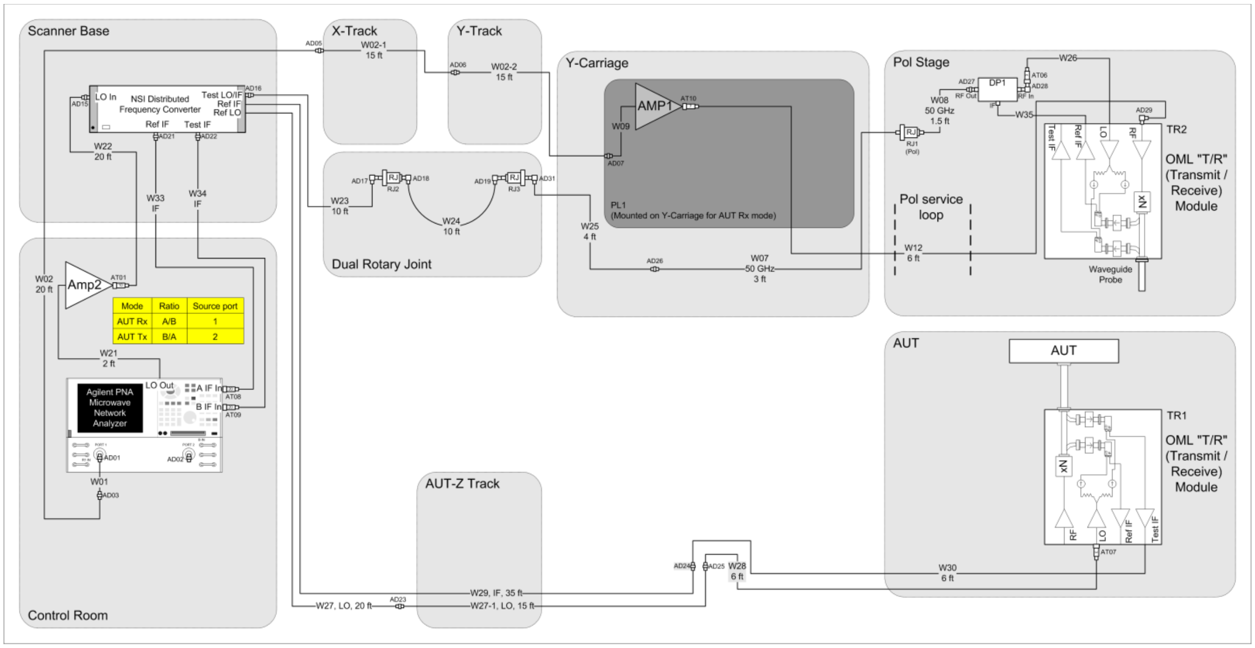

Figure 7: Example 50 – 140 GHz RF subsystem block diagram for planar near-field scanner.

Summary

We have described how existing antenna test range instrumentation can be upgraded to allow for testing at higher frequencies. By adding the equipment needed for remote frequency conversion, the existing lower frequency instrumentation does not need to be replaced. NSI offers a series of frequency up and down conversion units that allow for this type of upgrade. These conversion units allow users to expand the upper frequency range of an antenna test range up to 500 GHz.

References

[1] Bert Schluper & Dave Fooshe, Distributed RF Subsystems For Antenna Testing, AMTA 2009 Proceedings:
http://www.nearfield.com/amta/AMTA_09_Papers/2009_AMTA_DF_Distributed_RF_Systems_for_Antenna_Measurements.pdf

Author Biographies

Daniël Janse van Rensburg has been working in the microwave test industry for 18 years, both as user and supplier of automated antenna test systems. His particular fields of interest are measurement error analysis & computational electromagnetic modeling. He graduated from the University of Pretoria, South Africa and was awarded the B. Eng, M. Eng and Ph.D. degrees in 1985, 1987 and 1991 respectively, all in Electrical Engineering. Dr Janse van Rensburg has been working for Nearfield Systems Inc of Torrance California since 1997. He is also actively involved in academia and was appointed adjunct professor in 2005 in the School of Information Technology and Engineering, University of Ottawa, Ottawa, ON, Canada. He is a Senior Member of the IEEE, Licensed Professional Engineer in Ontario, Canada. He is the author of more than 50 journal and conference papers.

Bruce Williams is the Electronic Products Manager at Nearfield Systems, Torrance, California, where he is active in the development of advanced products and techniques for antenna measurement. Prior to joining NSI, he was responsible for near field testing at Boeing Satellite Systems, El Segundo, California. At Boeing, he developed advanced proprietary methods for satellite testing. Mr. Williams holds a Masters degree from the University of Massachusetts at Amherst and is a graduate of their Microwave Remote Sensing Lab. At this lab, he was influential in the design and test of several types of Millimeter-wave radar for the remote measurement of weather phenomena. His professional experience also includes work in the Entertainment industry, where he was involved in the production of music, film and television.