Implementing RF Measurement System: SNA

Wang Lei

Gävle University, May 2010
Abstract

The thesis purpose is to be implementing a system where a sweeping signal generator connected to a scalar network analyzer (SNA). The SNA is a less complicated that the VNA and normally much cheaper. Between these two instruments only the cable for synchronization between them needed. The synchronization signal is simply low frequency saw tooth signal not so sensitive for disturbance as RF signal. Therefore a very simple cable can be used.

For my part of the project is that use the PC to control the SNA and acquire the data from the SNA. The method is that connect PC with the SNA by GPIB table, then use the Labview to identify the SNA, and build the control driver, use the command code to control and acquire data from the SNA, store the data.
To my parents and my sisters and brother

Acknowledgements

The author of this thesis work would like to give great gratitude to the following persons for their help and support:

Thanks to Jose Chilo, my examiner at Gavle University, for his excellent guidance and patience. Help me find the instruments and check the results and report, then give me some precious suggestions.

Thanks to the two teachers where they are from Peru, they check my programming and help me solve some problems.

Thanks to all the teachers which they have taught and help me. They make me feel happiness during the study at Gävle University.

Thanks to all classmates at University of Gävle. Knowing all of you is my biggest acquirement in Sweden.

Last, but not the least, special thanks for all my friends in ZhengZhou, China. You are the most important treasure in my life. Without your support and encouragement, I would not be here.

Good luck to all

Lei
List of some of the acronyms used

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM</td>
<td>Amplitude Modulation</td>
</tr>
<tr>
<td>FM</td>
<td>Frequency Modulation</td>
</tr>
<tr>
<td>DUT</td>
<td>Device Under Test</td>
</tr>
<tr>
<td>NA</td>
<td>Network Analyzer</td>
</tr>
<tr>
<td>SNA</td>
<td>Scalar Network Analyzer</td>
</tr>
<tr>
<td>VNA</td>
<td>Vector Network Analyzer</td>
</tr>
<tr>
<td>GPIB</td>
<td>General Purpose Interface Bus</td>
</tr>
<tr>
<td>VSWR</td>
<td>Voltage Network Analyzer</td>
</tr>
<tr>
<td>LO</td>
<td>Local Oscillator</td>
</tr>
<tr>
<td>ADC</td>
<td>Analog-to-Digital Converter</td>
</tr>
<tr>
<td>IF</td>
<td>Intermediated Frequency</td>
</tr>
<tr>
<td>DSP</td>
<td>Digital Signal Processing</td>
</tr>
<tr>
<td>PC</td>
<td>Personal Computer</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>SSM</td>
<td>Signal Sideband Modulation</td>
</tr>
</tbody>
</table>
# Table of contents

## 1. Introduction
- 1.1. Background.................................................................................................................. 1
- 1.2 The objective of the measurement.................................................................................. 1

## 2. Theory .......................................................................................................................... 2
- 2.1. The signal...................................................................................................................... 2
- 2.2 The Network analyzer (NA) .......................................................................................... 2
  - 2.2.1. Description of network analyzer (NA)...................................................................... 2
  - 2.2.2 The Scalar Network Analyzer (SNA)......................................................................... 3
  - 2.2.3 The Vector Network Analyzer(SNA)........................................................................... 3
  - 2.2.4 Compare the SNA and VNA...................................................................................... 3
- 2.3 IEEE-488 bus Standard and IEEE-488 bus Card............................................................ 4
  - 2.3.1 Description of the IEEE-488 bus.............................................................................. 4
  - 2.3.2 IEEE 488.1 and IEEE 488.2..................................................................................... 6
  - 2.3.3 The IEEE-488 bus Card.......................................................................................... 6
- 2.4 The instrument with Labview and Matlab.................................................................... 7
  - 2.4.1 The instrument with the Matlab................................................................................ 7
  - 2.4.2 The instrument with the Labview............................................................................. 8
- 2.5 The frequency domain to time domain........................................................................ 9

## 3. Process and Results.................................................................................................... 9
- 3.1 Calibrate and Test the Instruments............................................................................... 9
  - 3.1.1 Calibrate and Test the signal generator...................................................................... 9
  - 3.1.2 Calibrate and Test the SNA...................................................................................... 10
- 3.2 GPIB card in SNA and Computer................................................................................... 12
  - 3.2.1 GPIB card in SNA................................................................................................... 12
  - 3.2.2 GPIB card in Computer.......................................................................................... 13
- 3.3 Connection and response between SNA and PC using GPIB cable............................... 13
- 3.4 Programming of control and measure with the Labview............................................... 14
- 3.5 Presentation of the results of measurements................................................................... 16
  - 3.5.1 Connect SNA with Signal Generator by the cable...................................................... 16
  - 3.5.2 Connect SNA and Signal Generator with Antenna.................................................. 17
- 3.6 Process measurements with Matlab.............................................................................. 18

## 4. Discussion.................................................................................................................... 19

## 5. Conclusions and Future work.................................................................................... 20

## References..................................................................................................................... 20

## Appendices Tables.......................................................................................................... 21
1. Introduction

1.1 The background.

When measurements at radio frequencies (RF) are supposed to be done often vector network analyzers (VNA) are used. These instruments are giving information about the amplitude and phase response of a system. A disadvantage with these instruments is that it can be a problem when it is a long distance between the input and the output, for example when measuring between two antennas. First of all is that the cables are expensive, where the price increases with the cable length. Also losses and interferences from the environment are a problem that also will be depending on the cable length.

1.2 The objective of the measurement

The thesis purpose is to be implementing a system where a sweeping signal generator connected to a scalar network analyzer (SNA). Use the SNA to measure the AM signal, and connect SNA with PC by GPIB cable. Control SNA and get the data using PC. The results will be analyzed, processed using Matlab.

The measurement system will use the old existent instruments in the laboratory of Gavle University, and use new tools as PC and softwares as labview, Matlab and so on.

The method is that connect PC with the SNA by GPIB table, then use the Labview to identify the SNA, and build the control driver, use the command code to control and acquire data from the SNA, store the data.

The measurement system will be showed in Figure1.

![Figure 1 Measurement System](image)

The next section is the theory of Instrument and Measurement.
2. Theory

2.1 Signal

Amplitude modulation (AM) is used to transmit information via a radio carrier wave. AM works by varying the strength of the transmitted signal in relation to the information being sent.

Use the Figure 2 to tell you how about the operation of AM

![Figure 2 the Operation of AM](image)

The Math model of the AM:
The equation [1] for the AM waveform (envelope) is

\[ e = (E_c + E_i \sin \omega t) \sin \omega c t \]

Where \( E_c \) = the peak amplitude of the carrier signal
\( E_i \) = the peak amplitude of the intelligence signal
\( \omega t \) = the radian frequency of the intelligence signal
\( \omega c t \) = the radian frequency of the carrier signal
\( W = 2\pi f \)

Demodulation is that extract the original information-bearing signal from a modulated carrier wave.

The simplest form of AM demodulator consists of a diode which is configured to act as envelope detector. Another type of demodulator, the product detector, can provide better quality demodulation, at the cost of added circuit complexity.

2.2 The Network analyzer(NA)

2.2.1 Description of network analyzer(NA)

A network analyzer is an instrument, measures the electronic network of network parameters. Today, the network analyzer used in the S - parameters, because the reflection and transmission of electronic networks can easily be measured at high frequencies, but there are other network parameters, such as y - parameters set outside,
Z - parameters, and H - parameters. Network analyzer is often used to describe such as amplifiers and filters of two-port network, but they can be used with a network any number of ports.

The two main types of network analyzers are:
Scalar Network Analyzer(SNA)- measures amplitude properties only.
Vector Network Analyzer(VNA)- measures both amplitude and phase properties.

2.2.2 The Scalar Network Analyzer (SNA)

Scalar network analyzer is an RF network analyzer, a device that only measures the amplitude of properties in test form, and in this it is a different type of analyzer simple view. In fact, a scalar network analyzer works only as a spectrum analyzer tracking generator combination. When the tracking generator and spectrum analyzer with the use of power is closely related to its operation. Tracking generator on the same frequency generator, spectrum analyzer sweep signal reception.

From this tracking generator output is connected directly to a spectrum analyzer's input, and keep track line will set out across the generator output amplitude analyzer see on the screen. If the device is placed in the two projects, then the magnitude spectrum analyzer will notice any change. In this example, the response of a filter can be drawn. In the continuous tracking generator output will be passed to the filter, where the filter response will change it according to frequency and that the frequency response of the filter, and in this way the spectrum analyzer should be able to display the anti-filter. It can be seen, the scalar network analyzer is a very useful measurement of the various components of the amplitude of the response [2].

2.2.3 The Vector Network Analyzer(VNA)

Vector network analyzer, network analyzer is a radio frequency than the SNA network analyzer is more useful form, because it is able to measure multiple parameters of the DUT. It is not only measured amplitude response, but in the first stage, it seems good. Therefore, vector network analyzer, network analyzer can also be known as the gain phase table or automatic network analyzer. It can measure the amplitude response, including various different parameters, and network scattering parameters, or S - parameter, which is the device transmission and reflection coefficients of the test. The S - parameters that contain both amplitude and phase information, the vector network analyzer, network analyzer can provide a very comprehensive view of the equipment[3].

2.2.4 Compare the SNA and VNA

Scalar Network Analyzer(SNA)- measures amplitude properties only. Vector Network Analyzer(VNA)- measures both amplitude and phase properties. The VNA
can measure more sensitive signal compare with SNA. The other different is that the price of VNA more expensive than SNA.

2.3 IEEE-488 bus Standard and IEEE-488 bus Card

2.3.1 Description of the IEEE-488 bus

IEEE-488 is a short-range digital communications bus specification. It was created for use with automated test equipment in the late 1960s, and is still in use for that purpose. IEEE-488 was created as HP-IB (Hewlett-Packard Interface Bus), and is commonly called GPIB (General Purpose Interface Bus). It has been the subject of several standards. The bus uses 16 signal lines to effect transfer of data and commands do as many as 15 instruments [4].

The instruments on the bus are connected in parallel, as shown in Figure. Eight of the signal lines (DIO 1 thru DIO 8) are used for the transfer of data and other messages in a byte-serial, bit-parallel form. The others lines are used to communicate timing (handshake), control, and status information.

- 5 control lines
- 3 handshake lines
- 8 bit-directional data lines

The entire bus consists of 24 lines, with the remaining lines occupied by ground wires. Additional features include: TTL logic levels (negative true logic), the ability to communicate in a number of different language formats, and no minimum operational transfer limit. The maximum data transfer rate is determined by a number of factors, but is assumed to be 1Mb/s [5].

Devices exist on the bus in any one of 3 general forms:
1. Controller
2. Talker
3. Listener

A single device may incorporate all three options, although only one option may be active at a time.

In addition to the 3 basic functions of the controller, talker, and listener the system also incorporates a number of operational features, such as; serial poll, parallel poll, secondary talk and listen addresses, remote/local capability, and a device clear (trigger).

The functional information regarding the individual control lines is provided below.
1. ATN(attention), 2. EOI(end or identify), 3.IFC(interface clear), 4.REN(remote enable), 5.SQR(service request).

Device dependent messages are moved over the GPIB in conjunction with the
data byte transfer control lines. These three lines (DAV, NRFD, and NDAC) are used to form a three wire ‘interlocking’ handshake (Figure 6) [6] which controls the passage of data.

Figure 6 Typical Handshake Operations

DAV (data valid), Goes TRUE (arrow 1) when the talker have (1) sensed that NRFD is FALSE, (2) placed a byte of data on the bus, and (3) waited an appropriate length of time for the data to settle.[6]

NRFD (not ready for data). Goes TRUE (arrow 2) when a listener indicates that valid data has not yet been accepted. The time between the events shown by arrows 1 and 2 is variable and depends upon the speed with which a listener can accept the information [7].

NDAC (not data accepted). Goes FALSE to indicate that a listener has accepted the current data byte for internal processing. When the data byte has been accepted, the listener releases its hold on NDAC and allows the line to go FALSE. However since the GPIB is constructed in a wired-OR configuration, NDAC will not go FALSE until all listeners participating in the interchange have also released the line. As show by arrow 3, when DNAC goes FALSE, DAV follows suit a short time later. The FALSE state of DAV indicates that valid data has been removed; consequently, DNAC goes LOW in preparation for the next data interchange (arrow 4).[6]

All lines in the GPIB are tri-state except for ‘SQR’, ‘NRFD’, and ‘NDAC’ which are open-collector. The standard bus termination is a 3K resistor connected to 5 volts in series with a 6.2K resistor to ground - all values having a 5% tolerance.

The standard also allows for identification of the devices on the bus. Each device should have a string of 1 or 2 letters placed somewhere on the body of the device (near or on the GPIB connector). These letters signify the capabilities of the device on the GPIB bus.

C: Controller
Devices are connected together on the bus in a daisy chained fashion. Normally the GPIB connector (after being connected to the device with the male side) has an female interface so that another connector may be attached to it. This allows the devices to be daisy chained. Devices are connected together in either a Linear or Star fashion.

2.3.2 IEEE 488.1 and IEEE 488.2

In 1975, the IEEE standardized the bus as Standard Digital Interface for Programmable Instrumentation, IEEE-488 (now IEEE-488.1). It formalized the mechanical, electrical, and basic protocol parameters of GPIB, but said nothing about the format of commands or data.

In 1987, IEEE introduced Standard Codes, Formats, Protocols, and Common Commands, IEEE-488.2, re-designating the previous specification as IEEE-488.1. IEEE-488.2 provided for basic syntax and format conventions, as well as device-independent commands, data structures, error protocols, and the like. IEEE-488.2 built on -488.1 without superseding it; equipment can conform to IEEE -488.1 without following IEEE -488.2 [4].

While IEEE-488.1 defined the hardware, and IEEE-488.2 defined the protocol, there was still no standard for instrument-specific commands. Commands to control the same class of instrument (e.g., multimeters) would vary between manufacturers and even models. The Standard Commands for Programmable Instrumentation (SCPI) specification builds on the commands given by the IEEE 488.2 specification to define a standard instrument command set that can be used by GPIB or other interfaces.

2.3.3 The IEEE-488 bus Card

The IEEE-488 bus card required for GPIB operation is between the instrument and controller. The card can offer the GPIB interface and storage information.

For the GPIB card in the instrument, it makes remote control possible, and storage some command code.
For the GPIB card in the PC, it makes PC connect with instrument, and make programming control the instrument. Get the data from the instrument. It fits into any free expansion slot in your computer. It has a standard IEEE-488 connector on the rear panel. When possible, the card uses Direct Memory Access, DMA, to transfer data from the IEEE-488 bus straight into the computer's memory at very high speed. The DMA channel and interrupt lines are disconnected by the software when not in use.

2.4 The instrument with Labview and Matlab

2.4.1 The instrument with the Matlab

MATLAB representatives "matrix laboratory", is a numerical computing environment and the fourth-generation programming language. Developed by The Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, and FORTRAN [8].

Although MATLAB is mainly used for numerical calculation, an optional toolbox uses MuPAD symbolic engine, allowing access to symbolic computing power. Another package, simulation, adds the graphical multi-domain dynamic simulation and embedded systems and model-based design.

The Instrument Control Toolbox is one of the Matlab optional toolboxes. It provides a variety of ways to communicate with instruments. The ways include: Instrument drivers, Communication protocols, Graphical user interface, and Simulation blocks.

For this project, The Instrument driver is very important. Most of the instruments have GPIB interface. Using the GPIB cable connects with the PC. We can build some driver to control the instrument through programming in the Instrument Control Toolbox.

The method (Figure 7) of controlling GPIB instrument using Matlab is:
First step: Using GPIB vendor tools to identify and test the GPIB resources.
Second step: Creating a GPIB object.
Third step: configuring the GPIB address.
Forth step: building a M-file and programming.
Fifth step: controlling the instrument and get the data.
2.4.2 The instrument with the Labview

LabVIEW is a graphical programming environment for the millions of engineers and scientists to develop sophisticated measurement, testing, control system uses an intuitive graphical icons and wires, similar to a flowchart.

For the engineers, using the labview is easy to program and build the driver of the instrument. If the programming has problem, the engineers can visually see the wrong place, and immediately changes. For those who do not drive their own equipment, they can be programmed to build a driver without identification[7].

The method (Figure 8) of controlling GIPB instrument using Labview is:
For this project, the instrument has GPIB interface. Using the GPIB cable connects with the PC. We can build the driver with Labview.

2.5 The frequency domain to time domain

Time domain

Time Domain - independent variable is time, that the horizontal axis is time, vertical axis is the signal changes. The dynamic signal \( x(t) \) is to describe the signal values at different time functions.

Frequency domain

Frequency domain - the independent variable is frequency, which is the horizontal frequency, vertical axis is the magnitude of the frequency signal, which is often said that the frequency spectrum. Spectrum describes the frequency of the signal frequency and the frequency of the structure and the relationship between the amplitude of the signal.

The next section is Preocessing and Results of the measurement.

3. Process and results

3.1 Calibrate the SNA

3.1 Calibrate and Test the instruments

3.1.1 Calibrate and Test the signal generator

Connected output interface of the Agilent 33120a with the input interface with the Marconi Instruments 2031, and Connected RF output of Marconi Instruments 2031 with the channel A of the Agilant 54621A oscilloscope[9].

The test for AM:

| Set the Intelligence signal | Square wave  
|                           | Frequency: 20 kHz  
|                           | Amplitude: 5V  
| Set the Carrier Signal    | Sine wave  
|                           | Frequency: 1MHz or 20MHz  
|                           | RF level: -10dBm  
|                           | Signal modulation mode AM depth 50% |
We get the graph from Agilent 54621A oscilloscope:
When the Carrier is 1 MHz, we get the graph is Figure 9
When the Carrier is 20MHz, we get the graph is Figure 10

![Figure 9](image)

**Figure 9** the Intelligence signal and AM signal  
**Figure 10**

The test for FM:

| Set the Intelligence signal | Square wave  
|                           | Frequency: 500 Hz  
|                           | Amplitude: 5V  
| Set the Carrier Signal | Sine wave  
|                           | Frequency: 10kHz  
|                           | RF level: -10dBm  
|                           | FM Devn: 1.5 kHz  

We get the graph (Figure 11) from Agilent 54621A oscilloscope

![Figure 11](image)

**Figure 11** the Intelligence signal and FM signal

The graph is perfect, and accord with the theory, so the Signal generator is good.

3.2.2 Calibrate and Test the SNA

Calibrate the RF analyzer, Wiltron Model 6409 [10], the Figure 12 will show that how to connection:
There are four steps for calibration:

Step 1. Settings: Start Frequency, Stop Frequency, Frequency Data Points

Step 2. Calibrate: Press the Calibration button, then press the select to begin calibrate. Then, connect Chanel A detector to test port. Press the select when ready. Wait, calibration data being taken. Connect test device, Press the select when ready. Finish the Calibration.

Step 3. Measure: Connect the Channel a detector to the antenna port, and get some signals.

Test the SNA directly without the test device, it is difficult. We can’t find the test device, so we should find other way to test the SNA. In Laboratory, have the perfect VAN. We know the VNA is calibrated and exact, Use the SNA and VAN to measure the same signal, then compare the results, if the two results is same, that means the SNA is exact, if not, that means the SNA is not exact.

Setting:

<table>
<thead>
<tr>
<th>Set the Intelligence signal</th>
<th>Square wave Frequency: 20 kHz Amplitude: 5V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set the Carrier Signal</td>
<td>Sine wave Frequency: 20MHz RF level: -10dBm Signal modulation mode AM depth 50%</td>
</tr>
<tr>
<td>Set the SNA and VNA</td>
<td>Power level: 10dBm The center frequency: 20MHz The width frequency: 100 kHz</td>
</tr>
</tbody>
</table>

We couldn’t get the graph from the SNA and VNA, so we take photo for the results. Figure 13 is the Measurement graph using VNA and Figure 14 is the Measurement graph using SNA.
From the pictures, we can see, the shape of graph is not similar. So the SNA is not good.

3.2 GPIB card in SNA and Computer.

3.2.1 GPIB card in SNA

From the Figure 15, the GPIB card in SNA has two part, one is the GPIB interface, and the other part is used to set the address. When use the GPIB to connect the SNA, first you should set a address for the SNA.

The only interconnection required for GPIB operation is between the analyzer and the controller. This interconnection is via a special GPIB cable. The Wilton part number for such a cable is 2100-5, -1,-2, or -4.

The analyzer leaves the factory preset to address 5. If a different address is desired, the address switches on the GPIB connector panel provide for selecting any address number between 0 and 31.

The data is delimiting on the GPIB by either the carriage return ASCII character or both the carriage return and line feed ASCII characters. The 6400 software accommodates either character automatically.
3.2.2 GPIB card in Computer

Figure 16 show the IN PIC GPIB card

Figure 16 the picture of NI PCI-GPIB

The NI PCI-GPIB performs all the basic IEEE-488.1 functions such as talker, listener and system controller. The IEEE-488.2 compatible functions make it fully compliant with the IEEE-488.2 specification. In controller applications, you can control typically up to 15 devices (instruments). If operated as a talker/listener (device) interface it does exchange data and state information with the current controller-in-charge of the GPIB bus.

The NI PCI-GPIB fits into any free expansion slot in your computer. It has a standard IEEE-488 connector on the rear panel. When possible, the card uses Direct Memory Access, DMA, to transfer data from the IEEE-488 bus straight into the computer's memory at very high speed. The DMA channel and interrupt lines are disconnected by the software when not in use.

3.3 Connection and response between SNA and PC using GPIB cable

Figure 17 show the GPIB cable that connected SNA with PC.

Figure 17 the picture of the GPIB cable

There are four steps for connection and get the response.
Step1: use the GPIB cable to connect with GPIB interfaces of SNA and PC.
Step2: set the GPIB address 3, then open the PC and install the software-Measurement & Automation if you don’t install it.
Step3: use this software to scan the instruments, and find a instrument that the address is 3.

Step4: the SAN will test itself and the PC will try to identify the SNA, and get more information about the SNA.

The result is that the PC gets the address of SNA and couldn’t identify the SNA. This is why I use the Labview.

3.4 Programming for controlling and measurement with the Labview [7]

The PC couldn’t identify the SNA, so programming can’t use Matlab. I use Labview 8.5.1 to program.

There are two programming:
First one is used to control the SNA.
Second one is used to acquire the data from the SNA.

Control the SNA programming:
First, build a new x.vi block diagram, and find the function list, then find the Instrument I/O, continue to find the GPIB, and find the GPIB write and GPIB read. Connect them, and give the others. Get command code from the table 2 or 3. Figure 18 and 19 will show the x.vi block diagram and x.vi front panel.

Figure 18 Control programming block diagram
The acquiring the data from the SNA programming:

For this programming, the total idea is that: first, make a marker command code, like M1 100, the marker command code means that the M1 line move to place of 100 MHz. then give the read command code to the SNA and get the value of dB, and storage it. Use the For Loop to circulate and change number of the marker command code. Get the value at different points.

The command codes are from table1-2[11]

Figure 20 and 21 will show the x.vi block diagram and x.vi front panel
3.5 Presentation of the results of measurements

3.5.1 Connect SNA with Signal Generator by the cable

Figure 21 Acquire data programming front panel

Figure 22 show how to connect SNA with signal Generator by cable

Figure 22 Connection with cable
Setting :

<table>
<thead>
<tr>
<th>Setting</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set the Intelligence signal</td>
<td>Square wave</td>
</tr>
<tr>
<td></td>
<td>Frequency: 20 kHz</td>
</tr>
<tr>
<td></td>
<td>Amplitude: 5V</td>
</tr>
<tr>
<td>Set the Carrier Signal</td>
<td>Sine wave</td>
</tr>
<tr>
<td></td>
<td>Frequency: 20MHz</td>
</tr>
<tr>
<td></td>
<td>RF level: -10dBm</td>
</tr>
<tr>
<td></td>
<td>Signal modulation mode AM depth 50%</td>
</tr>
<tr>
<td>Set the SNA</td>
<td>Power level: 10dBm</td>
</tr>
<tr>
<td></td>
<td>The center frequency: 20MHz</td>
</tr>
<tr>
<td></td>
<td>The width frequency: 100 kHz</td>
</tr>
</tbody>
</table>

The maker line move at least 10kHz for one time. So we get 10 points.

Use the PC get the data is:

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>The of dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.95</td>
<td>-9.12</td>
</tr>
<tr>
<td>19.96</td>
<td>-9.44</td>
</tr>
<tr>
<td>19.97</td>
<td>-9.16</td>
</tr>
<tr>
<td>19.98</td>
<td>-9.83</td>
</tr>
<tr>
<td>19.99</td>
<td>-9.02</td>
</tr>
<tr>
<td>20</td>
<td>-9.06</td>
</tr>
<tr>
<td>20.01</td>
<td>-8.39</td>
</tr>
<tr>
<td>20.02</td>
<td>-8.31</td>
</tr>
<tr>
<td>20.03</td>
<td>-8.63</td>
</tr>
<tr>
<td>20.04</td>
<td>-8.72</td>
</tr>
</tbody>
</table>

3.5.2 Connect SNA and Signal Generator with Antenna

Figure 23 show that how to Connect SNA and Signal Generator with Antenna

The maker line move at least 10kHz for one time. So we get 10 points.
Use the PC get the data is:

<table>
<thead>
<tr>
<th>Frequency(MHz)</th>
<th>19.95</th>
<th>19.96</th>
<th>19.97</th>
<th>19.98</th>
<th>19.99</th>
<th>20</th>
<th>20.01</th>
<th>20.02</th>
<th>20.03</th>
<th>20.04</th>
</tr>
</thead>
</table>

The results are not exactly, the main reason is that SNA couldn’t work.

3.6 Process measurements with Matlab

Use the Matlab to get the graph, and also use the inverse fast Fourier transform to get the signal in time domain from the frequency domain.

We get the graphs:
Figure 24 is the graph of the data that connected with cable

![Figure 24 The graph of Data of connected with cable](image)

Figure 25 is the graph of the data that connected with antenna
4. Discussion

For this project, getting the results is not good. I think the first causation is that some elements of the SNA are aging, and lose the precision. The other causation is that the detector didn’t work, and the SNA could not receive the correct signal.

The SNA can be remote controlled, and we can acquire data from the SNA in the real time using PC. When read the data, the SNA couldn’t talk after reading 50 points, I think the first causation is that the Cache of the SNA is too small, it is full after the reading 50 points and the SNA couldn’t continue to read. And the other causation is that the speed of the operation of the SNA is too slow.

Maybe somebody wants to know why I use the so old SNA. The reasons are:

First one: the measurement must be used SNA.
Second one: In our laboratory, I couldn’t find the other style SNA.
5. Conclusions and Future Work

For the total of the thesis work, it is good. Use the PC to control the SNA and acquire data.

The connection with the SNA, use the GPIB cable and connect the SNA with the PC. Using the PC could find the SNA. For the control with the programming, use the Labview to program and build a driver. We can give some command code to the SNA, and control it, and acquire data, then save in a file. Use the Matlab to open it and analyze the data.

The results of the measurement, it is not good. The SAN is too old and it couldn’t natural work.

Future work, use the Matlab to control the SNA and acquire the data.

References


Appendices
Table 1 -1

<table>
<thead>
<tr>
<th>Name of Instrument</th>
<th>Description of Instrument</th>
<th>Feature of Instrument</th>
</tr>
</thead>
</table>
| Wiltron 6409 RF Analyzers   | The 6409 RF Analyzers are complete measurement systems for testing RF components and systems. Each includes a radio frequency analyzer, has its own built-in scalar network analyzer and a scanning frequency source, an external radio frequency detector, and the SWR Autotester. The RF detector is used to measure the transmission loss, and absolute power, while the SWR Autotester is used to measure the return loss. | Frequency Range: 10MHz to 2000MHz  
Frequency Resolution: 10kHz  
Display: 178mm  
Scale Resolution: 0.1 dB to 10dB per division in 0.1 dB step.  
Offset Range: +99.9 dB to -99.9 dB  
Markers: Up to eight individually controllable markers, with 10 kHz resolution, can be placed on the display.  
Transmission Loss Accuracy: Transmission Loss Accuracy = Channel Accuracy + Mismatch Uncertainty.  
Detector: The 6400 series detectors are used to make precision transmission loss or gain and absolute power measurements. |
<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
<th>6.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agilent 54621A oscilloscope</td>
<td>2-channel oscilloscope brings MegaZoom deep memory, high-definition display and flexible all the benefits, triggering the downstream river with the requirements of the designers of these values. 54621A 60 MHz to provide you an affordable way to see a long period of time, while maintaining the high sampling rate, so you can see the details of your design [15].</td>
<td>60 MHz</td>
<td>Lowest cost deep memory scope</td>
<td>Patented high-definition display with superior horizontal resolution</td>
<td>4 MB deep memory mapped to 32 levels for intensity, 25 million vectors/sec.</td>
<td>Powerful, flexible triggering including SPI, LIN, CAN and USB.</td>
<td>Standard built-in floppy, RS-232 and parallel ports, FFT’s.</td>
</tr>
<tr>
<td>Marconi instrument 10kHz-2.7GHz signal generator 2031</td>
<td>The Marconi Instruments 2031 is a used Signal Generator that has a frequency range of 10kHz to 2.7 GHz.</td>
<td>Frequency Range: 10kHz-2.7GHz.</td>
<td>Frequency Resolution: 0.1Hz.</td>
<td>Output Accuracy: 1.0dB.</td>
<td>Output Range: -144dBm - +13dBm.</td>
<td>Output Resolution: 0.1dB.</td>
<td>Programmable Interface: IEEE 488.2.</td>
</tr>
</tbody>
</table>
Hewlett packard 33120 A

Agilent 33120A function/arbitrary generator offers the rock-solid stability of digital synthesis at a price you can feel good about. Not only do you get better performance, you get arbitrary waveforms available for the first time in this price range. Just imagine the ways you could use complex custom waveforms (with 12-bit resolution) from simulating heartbeats and vibrations to testing circuits.

1. 15MHz sine and square wave outputs
2. 12-bit, 40Msa/s, 16000-point deep arbitrary waveforms
3. Sine, triangle, square, ramp, noise and more
4. Direct Digital Synthedid for excellent stability
5. Option 001: hig-Stability Time Base and PLL available

Hewlett Packard 8753D
30kHz-3GHz network analyzer

HP 8753D network analyzer provides affordable excellence in RF network measurement for the lab and production testing. It has an integrated S-parameter test set for longer-lasting calibrations, exceptional reliability, and improved resistance to ESD. The HP 8753D gives you a complete solution for characterizing active or passive networks, devices, or components from 30 kHz to 3 GHz--with a cost savings over the previous model with a test set.

1. 30 kHz to 3GHz (or to 6 GHz w/Option 6 frequency Extension) frequency range.
2. Integrated S-parameter test set
3. Integrated 1-Hz resolution synthesized source Optional time-domain and swept-harmonic measurements
4. Up to 110dB of dynamic range
5. Group delay and deviation from linear phase Save/recall to built-in disk drive built-in accuracy enhancement
Table 1-2

RF Analyzer Command codes

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>Channel A to Autoscale</td>
</tr>
<tr>
<td>ACL</td>
<td>Trace A to Cablibration</td>
</tr>
<tr>
<td>ADD</td>
<td>Trace A Resolution dB/Div</td>
</tr>
<tr>
<td>ADR</td>
<td>Trace A Reference</td>
</tr>
<tr>
<td>AH</td>
<td>Trace A high Limit Line</td>
</tr>
<tr>
<td>AL</td>
<td>Trace A Low Limit Line</td>
</tr>
<tr>
<td>AOF</td>
<td>Trace A Offset</td>
</tr>
<tr>
<td>AP</td>
<td>Channel A to Power</td>
</tr>
<tr>
<td>AR</td>
<td>Channel A to Return Loss</td>
</tr>
<tr>
<td>AS</td>
<td>Trace A Select</td>
</tr>
<tr>
<td>AT</td>
<td>Channel A to Transmission</td>
</tr>
<tr>
<td>CAL</td>
<td>Calbrate Trace</td>
</tr>
<tr>
<td>CON</td>
<td>Continue</td>
</tr>
<tr>
<td>DMR</td>
<td>Display Marker Readout</td>
</tr>
<tr>
<td>DS</td>
<td>Display Area Control</td>
</tr>
<tr>
<td>FM</td>
<td>Frequency Markers</td>
</tr>
<tr>
<td>GR</td>
<td>Graticule On/Off</td>
</tr>
<tr>
<td>HLD</td>
<td>Hold</td>
</tr>
<tr>
<td>HP</td>
<td>Halt Printing</td>
</tr>
<tr>
<td>M1-M8</td>
<td>Markers M1 thru M8</td>
</tr>
<tr>
<td>PG</td>
<td>Pint Graph</td>
</tr>
<tr>
<td>PSS</td>
<td>Panel Setup Recall</td>
</tr>
<tr>
<td>RAM</td>
<td>Read Trace A Marker</td>
</tr>
<tr>
<td>RES</td>
<td>Reset</td>
</tr>
<tr>
<td>RP</td>
<td>Read Parameter</td>
</tr>
<tr>
<td>RS</td>
<td>Read Status</td>
</tr>
<tr>
<td>SAC</td>
<td>sweep Alternate Center Frequency</td>
</tr>
<tr>
<td>SAP</td>
<td>sweep Alternate Stop Frequency</td>
</tr>
<tr>
<td>SAT</td>
<td>sweep Alternate Start Frequency</td>
</tr>
<tr>
<td>SC</td>
<td>Sweep Center Frequency</td>
</tr>
<tr>
<td>SW</td>
<td>Sweep Width</td>
</tr>
<tr>
<td>TST</td>
<td>Self Test</td>
</tr>
</tbody>
</table>