Electrical Engineering Department,

Fourth Year - Communications & Electronics.

EE423 ELECTRONIC AND MICROWAVE MEASUREMENTS

Measurements Lab report

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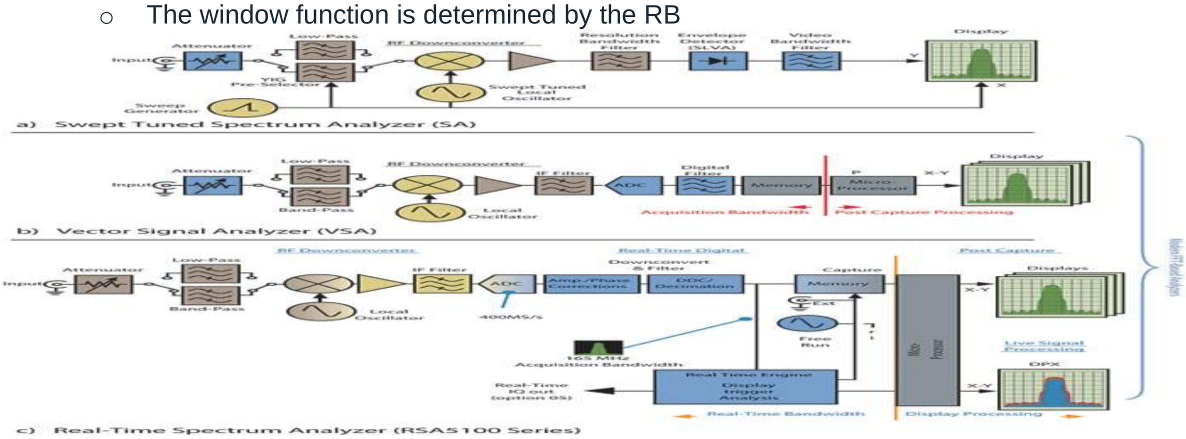
➢ Contents

1. Spectrum analyzer

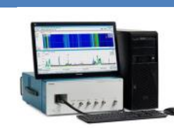
a. Principle of working

Spectrum Analyzers can be classified in 3 basic categories in reference to their architecture – Swept Spectrum Analyzers (SA) and Vector Signal Analyzers (VSA) and Real-time Spectrum Analyzers (RSA).
Modern RSAs can acquire a passband, or span, anywhere within the input frequency range of the analyzer. At the heart of this capability is an RF downconverter followed by a wideband intermediate frequency (IF) section. An ADC digitizes the IF signal and the system carries out all further steps digitally. DSP algorithms perform all signal conditioning and analysis functions.
For spectrum analysis to be classified as real-time, all information contained within the span of interest must be processed indefinitely without gaps. An RTSA must take all information contained in time domain waveform and transform it into frequency domain signals. To do this in real-time requires several important signal processing requirements:

- Enough capture bandwidth to support analysis of the signal of interest
- A high enough ADC clock rate to exceed the Nyquist criteria for the capture bandwidth
- A long enough analysis interval to support the narrowest resolution bandwidth (RBW) of interest
- A fast enough DFT transform rate to exceed the Nyquist criteria for the RBW of interest
- DFT rates exceeding the Nyquist criteria for RBW require overlapping DFT frames:
    - The amount of overlap depends on the window function
    - The window function is determined by the RB



b. *Specifications*

Specification	RSA306B	RSA500	RSA600	RSA5100B	RSA7100
					
Max Frequency Range	9 kHz - 6.2 GHz	9 kHz - 18 GHz	9 kHz - 7.5 GHz	1 Hz - 26.5 GHz	16 kHz - 14/26.5 GHz
Max Acquisition Bandwidth (Real Time)	40 MHz	40 MHz	40 MHz	Options to 165 MHz	Options to 800 MHz
Noise Floor (DANL at 1 GHz, Preamp On, dBm/Hz)	-163	-164	-164	-167	-167

Reference Frequency accuracy, ppm	± 3	± 1 0.003 with GPS lock	± 1 0.003 with GPS lock	± 1 ± 0.1 Opt PFR	± 0.05

HP 8590B and 8592B Spectrum Analyzers

These models offer basic RF and microwave measurement performance at a low cost. The HP 8590B has a frequency range of9 kHz tol.8GHz, a50- or optional 75-ohminput, and a weightofonly13.6kg (30 lb). Amplitude range is a wide -115 to + 30 dBm. The HP 8592B has a frequency range of 9 kHz to 22 GHz (or 25 GHz with Option H25), an internal preselector, and a weight of 15.9 kg (35lb). Amplitude range extends from -114 to + 30 dBm. If ac power is not available, both spectrum analyzers can be operated using the HP 8590lA portable ac power source.

c. Usage

Spectrum analyzers are used for many measurements including:

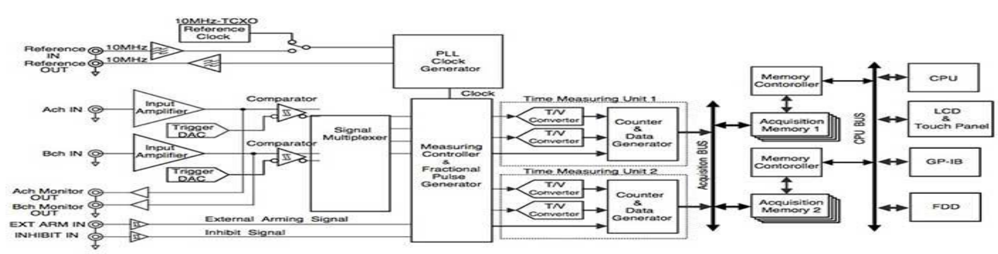
- Frequency Response, Noise and Distortion characteristics of all kinds of radio-frequency circuitry
- Occupied Bandwidth and Interference Sources in Telecommunications
- Basic Pre-Compliance Testing for EMC Testing

Other measurement techniques involve setting up the spectrum analyzer to test harmonics of audio signals by musicians and audio engineers, using reflective or refractive techniques to separate out the wavelengths of light with optical spectrum analyzers, and vibration amplitudes at various component frequencies among many others. The measurement techniques you will use will depend on your application, but hopefully these basics are enough to get started.
Whether you're in the field or in the lab, a Real-Time Spectrum Analyzer can be used for multiple applications like: voice and data communications (like cellular radio or radio communications); video broadcast distributed via satellite using DVB-S and DVB-S2 formats, and digital video is broadcast using the DVB-T format; radar, like radar transmitter test analysis; and spectrum management and interference hunting.
One of the most popular applications is Wireless local area network (WLAN) testing, also known as Wi-fi testing.

2. Time interval analyzer

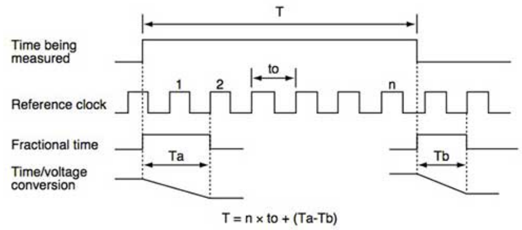
a. Principle of working

illustrates a block diagram of the TA320 time interval analyzer. Signals being measured are sent to the IN terminals of channels A and B, guided through input-coupling (AC/DC) and input-impedance-transforming (50Ω/1 MΩ) circuitry, and then converted to low-impedance signals at the input amplifiers. These signals are further converted by the respective comparators to binary signals appropriate for the trigger voltage. As monitoring signals, output signals from the input amplifiers are tapped at the monitor terminals at a level approximately one fourth the magnitude of the input signals. Thus, using the tapped signals, the operator can check what kinds of waveforms he/she is measuring. This is especially advantageous when making measurements using probes dedicated to oscilloscopes since the operator can adjust the probe for optimum phase compensation while observing the monitoring signals. Comparator output signals are scanned by the multiplexer to select binary signals appropriate for a given measurement function (period, pulse width, A-to-B



interval, etc.), and then supplied to the measurement control circuit. The measurement control circuit in turn controls measurement by means of the number of events, gate time, external arming signal, and inhibit signal. The circuit also generates fractional pulses appropriate for the signals being measured. These pulses are converted to voltage-mode values through the time/voltage converters. Then, the duration of these values are measured at a 100-ps resolution to be added to the values of the counters. The resulting values form a single data item of measurement, enabling continuous measurement by alternately actuating the two time-measuring units.

Model TA320 has two sampling modes: a time stamp mode and a hardware histogram mode. In the time stamp mode, the analyzer stores measured values in acquisition memory 1 and time-stamp data (elapsed time) in acquisition memory 2. In the hardware histogram mode, data on the frequency of each measured value are alternately saved in these two acquisition memories. Data thus captured are read into the CPU by the memory controllers for use in statistical calculations or for display on the LCD.



b Specifications

HP 5372A

The HP 5372A frequency and time-interval analyzers can be used to characterize jitter or phase noise in digital communications, oscillators, and other serial data systems. The HP 5372A adds the capability to display jitter as the variation of the significant instants from the ideal timing position (the time deviation function). Any clock rate, including nonstandard rates, can be accommodated or measurements made without the presence of a clock. The jitter bandwidth can exceed 2 MHz. The HP 5372A is also an exceptional Universal Counter with 11 digits of resolution. We have been working with these for years and are still finding applications for this extremely versatile instrument.

The unit is in excellent physical and electrical condition.   Unit includes a copy of the operators manual.

Frequency range

Single Channel Measurements Channels A & B 125 mHz to 500 MHz

Dual Channel Measurements Channels A & B 250mHz to 500 MHz

Resolution 150ps

Period Range

Single Channel Measurements Channels A & B 2ns to 8.0s

Dual Channel Measurements Channels A & B 2ns to 4.0s

Resolution 150ps rms

Time Interval Range 10ns to 8s   Resolution 150ps rms

Time Deviation Input Range 2ns to 8s   Resolution 150ps rms

Pulse width 1ns to 1ms   Resolution 150ps rms

Measures Duty Cycle & Phase Deviation

Comes with 2 x 54002A 50ohm Input pods.

Time Base - Frequency 100MHz   Stability 5x10(-10)   per 24 hours

1x10(-10) one second average

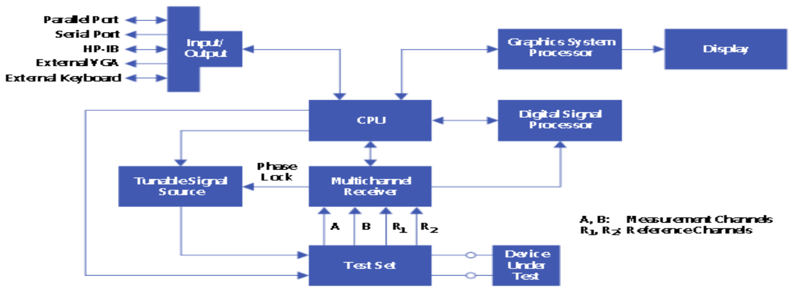
c. Usage

The HP5372A frequency and time interval analyzer makes both frequency and time interval measurements at rates up to 13.3 x 106 measurements per second. This is achieved by dividing the signal under study into arbitrary length frames and analyzing each frame, thus enabling the study the frequency or period variation as a function of time.

3. Network analyzer

a. Principle of working

HP 8720D vector network analyzer



HP 8720D vector network analyzer block diagram. Two reference receivers, R1 and R2, distinguishthe Option 400 model. R2 is always internal; only R1 appears (as R) on the front panel

The components that are measured with a vector network analyzer are used in a wide variety of commercial and militaryproducts: cellular phones, broadcast and cable TV, long-distance telephone transmission, satellite communications,microwave ovens, airplane radar, missile guidance, and so on. Each of these applications uses dozens of components thatare developed and produced with the aid of a vector network analyzer. Thus, the accuracy and measurement speed of thevector network analyzer will have an impact on the performance and cost of these products.The family of HP vector network analyzers known as the HP 8720 family is composed of three members that differ in thefrequency range over which they can make their measurements. The HP 8719D, 8720D, and 8722D cover the frequencyranges from 50 MHz to 13.5 GHz, 50 MHz to 20 GHz, and 50 MHz to 40 GHz respectively. The family made its first appearanceearly in 1988 with the introduction of the HP 8720A and has evolved over the years to the introduction of the D models inMay 1996.The evolution of the HP 8720 family from the A models to the C models was to improve the instruments' hardwareperformance. The recent evolution from the C to the D models was to respond quickly and directly to a change in users'needs. More and more the instrument was being used in a production measurement role as opposed to the previous R&Drole. This change brought with it a need for more measurement speed and expanded I/O capability to allow easier and betterintegration into a larger production test system. Also, the industry trend of higher levels of integration of components madeit necessary to measure components that do not have coaxial connectors—for example, a probe station measuring amplifierchips on an IC wafer. We wanted to respond with something that not only met the new measurement needs, but also had anew look: a state-of-the-art display technology and a smaller, lighter package.The list of improvements we could have made was long, but we could only choose a few because we wanted to respondquickly. This required careful selection and sorting of the customer inputs that come to us directly or through our field salesforce. One difficulty in sorting these inputs was the fact that one fundamental need can manifest itself in several differentways—for example, after thorough investigation, an issue of instrument calibration turned into an issue of measurementspeed. Another difficulty was sorting the unique but strongly stated needs from the broadbased but quietly stated needs.Once the sorting and prioritizing were done, we focused on the most important changes that also allowed us the mostleverage from existing designs. When this was done, we proceeded to improve the HP 8720 family with these design changes: ✔ A liquid crystal display (LCD) gives size and weight reductions plus a larger viewing area. These are importantfeatures in a production environment.

✔ In the HP 8720D Option 400 models, hardware and software additions implement a calibration technique calledTRL (Thru-Reflect-Line), which uses four receivers: two reference and two measurement. This allows accuratemeasurement of components that do not have coaxial connectors. Implementing TRL required some carefulmultiplexing of the receivers' outputs because the instrument is limited to three data channels. ✓ New software algorithms achieve faster acquisition and frequency tuning of the synthesized source to givefaster updates of the measurement data.

b Specifications

50 MHz to 13.5, 20, or 40 GHz frequency coverage

New processor makes measurements and data transfers up to seven times faster

Fast-sweeping, built-in synthesized source

Integrated solid-state switching S-parameter test set

Vecter receiver, error correcton, time domain

Up to 105 dB dynamic range

System dynamic range

These specifications apply to transmission measurements in the full frequency range at 10 Hz IF BW with response and isolation correction or full two-port calibration. Dynamic range is limited by maximum receiver input level and the receiver’s noise floor.

c. Usage

The purpose of a vector network analyzer is to measure the magnitude and phase of the reflection and transmissioncharacteristics of a microwave component (historically called a microwave network) as functions of frequency. Thecomponent is inserted between the test ports, the test signal is rapidly tuned over a span of frequency, and portions ofthis signal are reflected from and transmitted through the component. These reflected and transmitted signals are ratioedwith a portion of the test signal that has been tapped off into the reference channel to display the component’s reflection andtransmission characteristics as functions of frequency. This information is needed by designers to know if their componentswill work properly when inserted into a microwave system.The accuracy of the measurement, which depends on separating the component’s characteristics from the characteristics ofthe instrument, is greatly improved by the ratioing process. The accuracy is further enhanced by a calibration process thatmeasures known standards (calibration components) to characterize and mathematically remove the remaining systematicerrors in the instrument.

4. Network analyzer

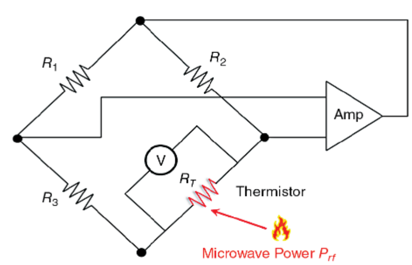
a. Principle of working

The microcalorimeter is used to measure the effective efficiency ηe of a thermistor mount which serves as the reference standard for power measurements. The effective efficiency ηe of a bolometer unit (e.g., a thermistor mount) is defined as the ratio of the changes in the DC-substituted power Psubto the total microwave power Prf dissipated within the bolometer unit, as specified in ref. [11]. That is,

ηe=PsubPrf.E1

It is noted that, in practice, the effective efficiency ηe of a thermistor

mount is determined using the DC substitution technique with a microcalorimeter, in conjunction with a self-balancing bridge circuit.



An example of a self-balancing bridge circuit for monitoring the resistance change in a thermistor mount.

b Specifications

HP model number	Frequency range	Specified power range (dBm)	Best power range (dBm)	Maximum input power (dBm)	RF connector
8481A	10 MHz to 18 GHz	-35 to +20	-25 to +15	25	N
8481H	10 MHz to 18 GHz	-15 to +35	-5 to +25	35	N
8482A	100 KHz to 4 GHz	-35 to +20	-25 to +15	25	N
8484A	10 MHz to 18 GHz	-75 to -20	-65 to -25	20	N
8485A	50 MHz to 26.5 GHz	-30 to +20	-20 to +15	25	3.5 mm
8487D	50 MHz to 50 GHz	-75 to -20	-65 to -25	20	2.4 mm
R8486A	26.5 to 40 GHz	-30 to +20	-20 to +15	25	WR-28

c. Usage A microwave power meter is an instrument which measures the electrical power at microwave frequencies typically in the range 100 MHz to 40 GHz.