Microwave bridge to measure absorption

More accurate methods of measuring microwave attenuation and phase are constantly being sought, particularly for such applications as plasma diagnostics. The microwave bridge technique described here was developed for the study of a quiescent plasma having an electron density of 1015 to 1018 mâˆ’3 corresponding to a plasma frequency of 3 Ã- 108 to 1010 Hz, and an electron collision frequency of 1010 to 1011 sâˆ’1. The plasma had a broad dimension of 0·3 m. For such a plasma a probing frequency of 10 GHz was considered to be the most suitable; at this frequency the attenuation Î± and phase shift Î´Î² expected were 0·1 < Î±< 50 dB and 1° < Î´Î² < 1000° respectively.

A balanced microwave bridge was used measure the absorption. Five-mm power was obtained from the second harmonic generated in a non-linear silicon crystal driven by a 1-cm reflex klystron oscillator. A block diagram of the apparatus is shown in Fig. 1.

The 5-mm radiation was then divided between two nearly identical wave guides and recombined in a bridge T-junction. One output arm of the T fed a matched load and the other fed a harmonic converter. The converter mixed the incoming 5-mm radiation with the second harmonic of another 1-cm local oscillator, and the heterodyne signal current was fed to a 24-Mc/sec. amplifier.

Provisions were made for inserting a step-attenuator pad in the amplifier cascade after three stages of amplification. Both the signal oscillator and local oscillator were frequency-stabilized to a high mode of a 3-cm cavity using a Pound4 and, later, a Zaffarano5 circuit. The frequency of the signal-generator fundamental was measured with the M. I. T. frequency standard. 6.

The signal-generator fundamental was amplitude-modulated with a rotating attenuator at 30 cycles/sec. The detected output from the receiver could then be filtered for the 30-cycle modulations. This modulation was amplified and converted to D. C. with a phase detector.

The signal was read on a milliammeter and the 30-cycle modulation merely provided a convenient monitoring current to amplify after filtering. In operation, the sample arm of the bridge was filled with tank oxygen at 80 cm Hg, and the bridge balanced for no receiver output by means of the r-f phase shifter and attenuator in the sample arm.

The sample was then pumped out and the bridge rebalanced as well as possible by slowly admitting tank argon into the sample arm to an appropriate pressure. The final minimum was achieved with readjustment of the r-f phase shifter. The use of argon for rebalancing allowed the bridge to work under constant impedance conditions.

This procedure proved necessary for accuracy. Argon was chosen because its dielectric constant is similar to that of oxygen. Since argon is monatomic, it has no absorption in the region of these measurements

Check measurements on nitrogen using argon as a balancing agent disclosed no absorption greater than 1 db/km. The minimum signal current was noted and the phase shifter was readjusted to give a maximum output; the 24-Mc/sec. step attenuator was then introduced, and the current-output reading was made as nearly equal to that observed at minimum balance as was possible. The attenuator had a minimum change of 1 db and the readings were taken to 0. 5 db by interpolation. The attenuator reading then gave the value of the maximum to minimum power ratio as: db = 101og (Pmax/Pmin). It can be shown that the attenuation in the gas may be calculated as: where AP = power absorbed, P = incident power on sample, a = Pmax/Pmin.

APPLICATION OF MICROWAVE BRIDGES

COMPACT MICROWAVE ELECTRON SPIN RESONANCE SPECTROMETER ESR-1000

ESR spectrometer is an ideal instrument for on- and off-line ESR testing under laboratory and plant conditions. When using additional and software means the spectrometer becomes not only for routine measurements, but also a research instrument for develop.

METER USING A MICROWAVE BRIDGE DETECTOR FOR MEASURING FLUID MIXTURES

A meter comprising a waveguide through which a substance to be measured can flow; a transmitting antenna in the waveguide; a detecting antenna in the waveguide spaced a predetermined distance from the transmitting antenna along the flow path of the waveguide; a microwave bridge having a power input port, a transmitting output port connected to the transmitting antenna, a detecting output port connected to the detecting antenna, and a bridge output port which measures the difference in the power to the two antennas; a microwave generator connected to the input of the microwave bridge;

A phase sensitive detection system connected to the bridge output port for providing an output of a frequency characteristic of microwave propagation within the waveguide; and a switch connected to each of the ports of the microwave bridge for switching the microwave bridge out of the circuit and connecting the transmitting antenna to the microwave generator and the detecting antenna to the phase sensitive detection system.

INVESTIGATION OF STEP-EDGE MICROBRIDGES FOR APPLICATION AS MICROWAVE DETECTORS

Step-edge micro bridges of Y-Ba-Cu-O are investigated for use as microwave detectors at 35 GHz. The superconducting thin films is laser deposited upon a defined substrate step-edge, which is formed by wet chemical etching of an SrTiO3 layer, which again was laser deposited on an LaAlO3 substrate. The voltage response of the device is directly proportional to the power of the microwave signals within a dynamic range of 50 dB and exhibits an NEP of 3. 2*10-9 W/Hz1/2 at 74 K.

STATIC AND DYNAMIC TESTING OF BRIDGES THROUGH MICROWAVE INTERFEROMETRY

A novel microwave sensor capable of remote detection of structural displacements is experimented as geotechnical instrument for static and dynamic testing of bridges. The sensor is based on an interferometric radar providing range imaging capability and sub-millimetric accuracy range displacement measurement.

Dynamic monitoring calls for sampling rate high enough for transient analysis, while static monitoring requires long-term stability. The instrument has been designed in order to provide both these features. The results of a validation campaign on a railway bridge during the final test before going into service are reported.

UNLOCKING FREE RADICALS WITH MICRO ELECTRON SPIN RESONANCE

Free radicals are highly reactive chemical species that govern many fundamental chemical processes in nature, most notably combustion and oxidation. Until now, direct measurement of the composition and concentration of free radicals has represented a challenge for chemists due to the complexity and expense of the necessary equipment.

An innovation in sensor design, the Micro Electron Spin Resonance spectrometer (Micro-ESR), measures free radicals with a compact, low-cost and ruggedized device.

The spectrometer enables new low-cost applications such as online measurement of lubricant breakdown in engines and machinery, online airborne particulates monitoring in diesel engine exhaust and even spin immunoassay medical diagnostics.

PHASE-LOCK MICROWAVE BRIDGES FREQUENCY STABILIZERS TO ELECTRON PARAMAGNETIC RESONANCE SPECTROMETERS

Several electronic systems are described which lock the frequency of the microwave power source to the resonant frequency of the sample cavity in an electron paramagnetic resonance spectrometer while retaining the spectral purity obtainable when the microwave power source is phase-locked to a high stability (MHz) crystal oscillator.

A SIMPLE AND STABLE MICROWAVE SQUID

A new, simple and stable type of microwave SQUID has been developed successfully at 10 GHz by using a bridge type junction which can be fabricated very easily. In consequence of adopting a junction of this type, the microwave SQUID has the merit of being free from adjustment and endures several heating cycles between room and liquid He temperatures. This type of SQUID has a slightly poorer S/N ratio, to be improved in future, but has the same characteristics as previously reported SQUIDs with a point contact junction

INTEGRATED DIRECTIONAL MICROWAVE BRIDGE

With the advent of electronic equipment, radio frequency (" RF"), microwave, and millimeter wave circuits are common. As telecommunication systems continue to advance, there is a constant need to increase the bandwidth, speed, efficiency, and miniaturization of new telecommunication devices while constantly increasing the quality of the telecommunication devices and reducing the manufacturing costs.

Typically, telecommunication devices, and electronic equipment in general, include numerous types of electronic components and circuits including directional couplers and directional bridges. Generally, directional couplers and directional bridges are electronic devices utilized in RF, microwave, and millimeter wave signal routing for isolating, separating or combining signals. Typically, directional couplers are utilized as impedance bridges for microwave and millimeter wave measurements and for power monitoring.

Directional couplers and directional bridges (generally known as “ directional circuits”) are usually three-port or four-port devices/circuits that have a signal input port (from a source) and a signal output port (to a load) and at least one coupled port whose output is proportional to either the incident wave (from the source) or the reflected wave (from the load). It is appreciated by those skilled in the art that it is common practice in RF, microwave, and millimeter wave engineering to consider an electrical signal in an electronic circuit/device as the sum of an incident and a reflected travelling wave to and from a source and load, respectively, relative to a characteristic impedance Z. sub. 0 of the electronic circuit/device (typically about 50 ohms). A directional circuit generally separates a transmitted signal into the detection circuit or coupled port based on the direction of the signal propagation. There are many uses for these directional circuits including network analysis and monitoring the output signal levels of a travelling wave incident on a load.

At present, there are numerous approaches to implementing a directional circuit. One example is to implement a directional coupler as a device that has a physical length over which two transmission lines couple together electromagnetically or that utilizes the phase shift along a length of transmission line. Another example approach (known as a directional bridge) may utilize lumped elements that may include transformers and resistors.

Examples of an implementation of known directional couplers 100 are shown. The directional coupler 100 may include three ports such as a signal input port (“ port A 102”), a signal output port (“ port B 104”), and at least one coupled port (“ port C 106”). The directional coupler 100 may be in signal communication with a signal source 108 via signal source impedance (“ Z. sub. source”) 110, and a load having load impedance (“ Z. sub. load”) 112. As an example of operation, the directional coupler 100 may be utilized to unequally split the signal 114 flowing in from the load at port B 104 while simultaneously fully passing the signal 116 flowing in from the opposite direction from the source 108 into port A 102. Ideally the signal 114 flowing in from the load at port B 104 will pass to the coupled port C 106 and appear as coupled signal 118. Similarly, an input signal 120 at port C 106 would pass to port B 104. However, port A 102 and port C 106 are isolated in that any signal 116 flowing into port A 102 will not appear at port C 106 but will propagate through to port B 104. Additionally, port B 104 is isolated from port A 102 because any signal 114 from port B 104 will flow to port C 106 not port A 102. An example of an implementation of the known directional coupler 100 is shown utilizing two transformers T1 and T2 and a resistor R.

Unfortunately, directional couplers have the disadvantage that they are typically too large to be practical for an integrated circuit (“ IC”) except at very high frequencies because at low frequencies approaching direct current (“ DC”) they are typically too large to be practical for many electronic instruments. As an example, directional couplers are usually limited by size limitations to low frequency operation of about 10 megahertz (“ MHz”) in most electronic devices.

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