Tracor Model 527E
FREQUENCY DIFFERENCE METER

Built-in meter provides signal-quality assessment
Reference and signal frequencies need not be the same

Frequency difference is measured instantly

General Description

The Tracor all-silicon, solid-state Model 527E Frequency Difference Meter is designed for instant determination of the fractional frequency difference, with an accuracy of one part in 10^{11}, between two stable oscillators. The fractional frequency difference is presented on a zero-center front-panel meter in parts in 10^{7}, 10^{8}, 10^{9}, 10^{10}, or 10^{11} as selected by a front-panel METER RANGE switch. Full-scale reading is plus or minus ten parts in 10^{N}. An OVERRANGE lamp is provided on the front panel to indicate an excessively noisy signal or a fractional frequency difference which exceeds the meter range.

A second front-panel meter indicates the phase relationship between the two input signals with the fractional frequency difference multiplied by 10, 100, 1,000, or 10,000 as selected by the DIFF MULT (METER RANGE) switch. Observation of the phase change, over a period of several minutes permits a measurement of fractional frequency difference even more precise than that available by means of the frequency meter reading. For example, on the most sensitive scale one complete full scale meter traversal in 100 seconds indicates a fractional frequency difference of one part in 10^{12}.

An EXTERNAL RECORDER connector on the back panel provides a dc voltage proportional to the fractional frequency difference for presentation on an external chart recorder. Thus, the rate of frequency change or long-term stability between two frequency standards can be obtained by recording the dc output with respect to time.

The Model 527E accepts input signals with nominal frequencies of 100 kHz, 1 MHz, 2.5 MHz, and 5 MHz. No switching is required when the input frequencies are changed, and the two input frequencies need not be the same. For example, if a signal of 1 MHz that is high by 1 part in 10^{11} is used as the "reference" and an unknown "signal" of 5 MHz that is low by 7 parts in 10^{11} is compared to the "reference," the meter will read minus 8 in 10^{11}.

Application

The Tracor Model 527E Frequency Difference Meter is capable of, but not limited to the following basic applications:

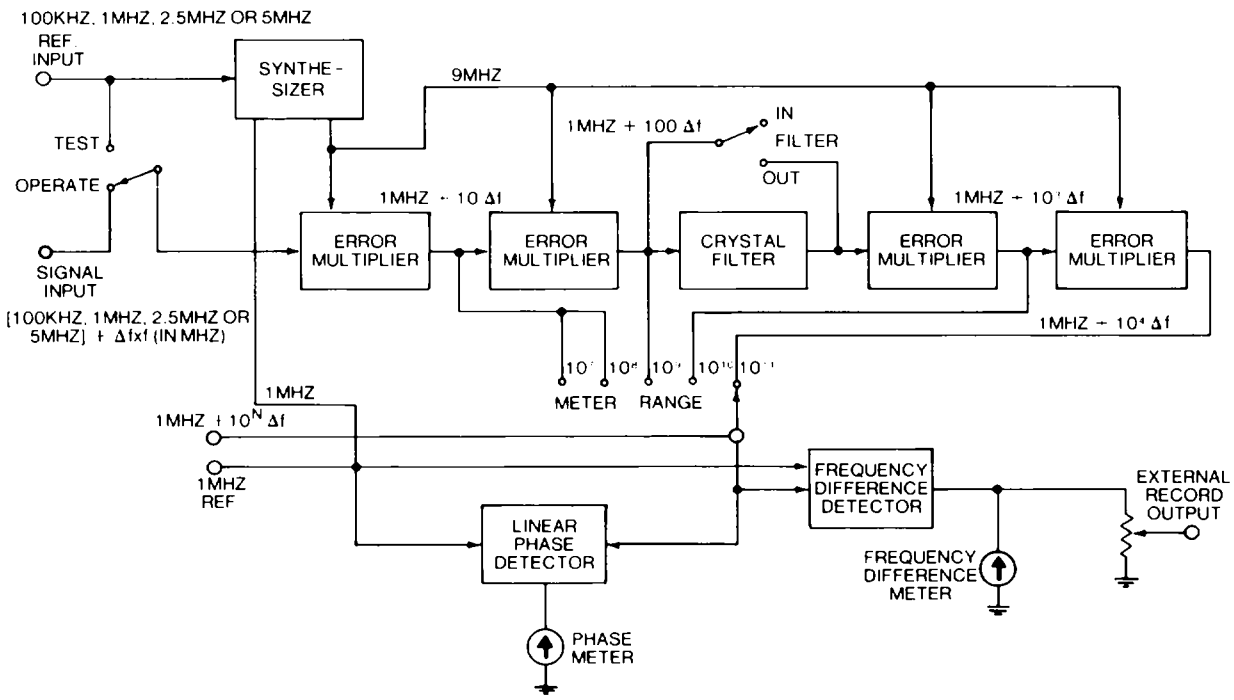
1. The adjustment of two oscillators to the same frequency.
2. The measurement of frequency difference between two oscillators.
3. The offsetting of one oscillator from another by a specified amount.
4. The analysis of oscillator short-term stability.
5. The measurement of oscillator long-term stability.

Read-out of the frequency difference between two stable oscillators can be readily accomplished by any of the following methods:

1. Frequency meter read-out: The fractional frequency difference between the two input signals may be read directly from the meter, provided the frequency difference is within the instrument's range and the METER RANGE switch is in the proper position. Accuracy is up to 1×10^{-11}.
2. Phase meter reading: The rate of change of phase is proportional to the fractional frequency difference between the two input signals. Using time averaging techniques, the user can extend the accuracy to 1×10^{-12}.
3. External Recorder: Any $\pm$ 0.5 milliampere recorder having an input resistance from zero to 2000 ohms can be calibrated for recording the fractional frequency difference.
4. External comparison: Two output connectors on the back panel make available a 1 MHz reference and a 1 MHz + 10^{N} Δ F signal, permitting external comparison of the "reference" and the unknown "signal" after multiplication.

Details of Operation

Shown below is a simplified block diagram of the Model 527E Frequency Difference Meter. It consists of a synthesizer, four error multipliers, crystal filter, linear phase detector and frequency difference detector. The synthesizer converts the ref input signal to a 9 MHz signal for the error multipliers and a 1 MHz signal for the display circuits and 1 MHz ref output. The first error multiplier converts the input signal to a 1 MHz signal with ten times the fractional frequency offset of the input. The second, third, and fourth error multipliers have outputs of 1 MHz with 10^2, 10^3, and 10^4 times the fractional frequency offset of the input. A crystal filter between the second and third error multipliers can be inserted by means of a front-panel switch to allow more difference multiplication of "noisy" oscillator signals. The phase detector measures the phase difference between the 1 MHz reference and the output of the error multiplier, and provides a phase meter readout. The frequency difference detector converts the $10^N \Delta f$ difference between the 1 MHz reference and 1 MHz + $10^N \Delta F$ signal to a dc voltage. The block diagram below indicates the relationships between the error multiplier outputs and the signal inputs. It is assumed that the reference input is exactly 100 kHz, 1 MHz, 2.5 MHz or 5 MHz.



Block Diagram of the Model 527E Frequency Difference Meter

Specifications

INPUT	
Frequencies	100 kHz ±0.25%; 1 MHz ±0.50%; 2.5 MHz ±0.50%; 5 MHz ±0.50%. 10 MHz ±0.50% Reference and signal frequencies need not be the same. No switching required with frequency change.
Voltages	0.5 to 10.0 volts rms
Impedance	1000 Ohms nominal
Connectors	BNC on both front and back panels
OUTPUT	
Frequencies	1 MHz derived from REFERENCE input; 1 MHz ÷ 10^NΔF signal input
Voltage	2 volts peak-to-peak
Impedance	2000 Ohms nominal
Connectors	BNC on back panel
Record Output	DC current proportional to front panel meter reading. Potentiometer available for calibration of ±0.5 ma recorder with resistance less than 2K. Back panel binding posts on 0.75-inch centers.
FREQUENCY DIFFERENCE INDICATORS	
Frequency Meter	Front panel; zero center. Scale from −10 to −10 parts in $(10)^N$.
Phase Meter	The phase of the signal with multiplied differential error is shown with respect to the reference.
OVERRANGE LAMP	Indicates excessively noisy input signal, or frequency difference exceeding meter range.
DIFFERENCE MULTIPLICATION	Fractional frequency error is multiplied by 10, 100, 1000, or 10,000. (Use of 10,000 multiplication with 100 kHz input requires exceptionally pure and stable input signal.)
ACCURACY	±5% of full scale reading on all ranges.
FILTER	Crystal filter with front panel switch permits operation with relatively noisy input signals.
TEMPERATURE RANGE	
Operating	0 to 55°C.
POWER REQUIREMENTS	115V ±15% or 230V ±15% selectable by rear panel switch; 48-420 Hz; approximately 20 watts.
DIMENSIONS	3.5 inches high, 12.75 inches deep; bench model 16.875 inches wide. Rack mounting accomplished by use of detachable "ears."
WEIGHT	15 pounds.

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