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AUTOMATIC PEAK POWER
MEASUREMENT OF SHORT
RF PULSES

Technological Spinoff Report

Prepared by:
K. E. Hardinger
and
E. E. Peterson

August 1974

MASTER

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**Kansas City
Division**

MASTER

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Technical Communications

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AUTOMATIC PEAK POWER MEASUREMENT OF SHORT RF PULSES

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August 1974

Prepared by K. E. Hardinger and E. E. Peterson, D/864

A method was needed to measure the peak radiofrequency (rf) power of short-width rf pulses of the type used in telemetry and radar. A closed-loop pulse height leveling system has been developed which can be constructed from readily available original equipment manufacturer (OEM) microwave and electronic components. The system measures peak power, to within ± 0.5 dB, of pulsed or cw rf signals.

THE BENDIX CORPORATION

KANSAS CITY DIVISION

KANSAS CITY, MISSOURI

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SUMMARY

A method for automatically measuring the peak rf power of a short-width rf pulse was needed for use in automated testers and to reduce operator errors in open setup and manual testers. The main problem with classical methods for such measurement is that none of the techniques which provide a direct readout of the power are suitable for short (less than 250 ns) pulse width signals.

The classical method of CW substitution was chosen to automate because of its inherent accuracy and ease of calibration. As modified for this application, the technique can be called "closed-loop pulse height leveling." This technique utilizes a linear voltage controlled rf attenuator which drives a detector and video amplifier. As designed, this gives a very sensitive leveling circuit in which the peaks of a signal are leveled irrespective of the average power of the total pulse train.

The system was fabricated and was evaluated in testers. All indications are that the peak power indication is accurate to within ± 0.5 dB. No variation of reading with pulse width was observed for pulses of 100 ns or greater width.

This peak power measurement system can be constructed from readily available OEM microwave and electronic components for around \$1500 and provides a measurement versatility not currently available with commercial test equipment.

DISCUSSION

SCOPE AND PURPOSE

The objective of this effort was to develop and refine a method for automatically measuring the peak rf power of a short-width rf pulse. A secondary benefit of the technique described provides a peak-leveled rf signal useful in performing pulse width measurements and measuring rf frequency by the "spectrum comparison" method.

PRIOR WORK

Several techniques have been used in the past to measure the "peak" rf power of a short-pulsed rf signal. Table 1 shows a summary of these methods with their inherent advantages and disadvantages. The main problem with the classical methods is that none of the techniques which provide a direct readout of the power are suitable for short (less than 250 ns) pulse width signals. Such a readout is desirable for automated testers and to reduce operator errors in open setup and manual testers.

ACTIVITY

The classical method of CW substitution was chosen to automate because of its inherent accuracy and ease of calibration. The closed-loop pulse height leveling technique to be described varies to some extent but the principle is the same. A block diagram of the technique is shown in Figure 1. A literature search was made to see if a device of this type was commercially available. None was found, so hardware to test this approach was designed and built by Test Equipment Engineering. The remainder of this report discusses this hardware and its evaluation in actual testers.

Technical Description

This technique utilizes a linear voltage controlled rf attenuator which drives a detector and video amplifier. The attenuator dc control voltage is derived from integration of the processed video signal. The amplifier video signal is applied to a transistor transistor logic (TTL) circuit which essentially provides a "low" signal whenever detected rf (from 50 ns to infinite pulse width) is present at a level above the comparator reference level. This is accomplished by "or'ing" a retriggerable monostable with the input signal. The output of the logic circuit is applied to an operational amplifier (OP-AMP) integrator with

Table 1. Classical Peak Power Measurement Techniques

Method	Readout	Operation	Signal	Comments
Average Power With Duty Factor Correction	Must be Calculated	Manual	Short Widths Reduce Signal Levels and Accuracies	Generally Acceptable for High Duty Factors and Nicely Shaped Pulses
Fast Crystal Peak rf Voltmeters (e.g., PRD 6690)	Direct, but Readout Cannot be Calibrated Into System	Automatic	Good only for Widths Greater Than 250 ns	Not Usable for Short Pulse Signals
Notch Wattmeter	Indirect Operator Decision	Manual	No Restraints	Good Only for Low Duty Cycle
CW Substitution	Indirect Operator Decision	Manual	No Restraints	Accurate but Must be Manually Operated and Read Out

Figure 1. Block Diagram of the Closed-Loop Height Leveling Method of Measuring Peak Power

a reference of 2.5 volts (mid-point of TTL swing). It thus serves as an up-down integrator with its output clamped between 0 and 3 Vdc. The output of the integrator is then fed back as the attenuator control voltage. This creates a very sensitive leveling circuit in which the peaks of a signal are leveled irrespective of the average power of the total pulse train. With no signal present, the integrator is driven to zero so that the attenuator is at minimum value. In order for integration towards + 3 volts to occur, the integrator drive must be low more than 50 percent of the time. Therefore, the monostable duration must be greater than 50 percent of the pulse period and may be many periods. The system is otherwise insensitive to pulse period and works well with cw or square wave modulated signals.

Since the voltage-controlled attenuator with the log driver has a calibrated 10 dB/V attenuation characteristic, the dc component of the signal appearing on the output of the integrator in a closed loop situation is directly proportional to the rf power in decibels. This signal can be biased and applied to a digital panel meter (DPM) for display in dBm. Digital output DPM's or separate analog-to-digital converters could be used to provide digital output signals.

The accuracy of this approach depends mainly upon the linearity of the voltage controlled attenuator and the response of the threshold detector circuit. This limitation did prove to be a serious design problem; however, the circuit devised using modern Schottky Barrier comparators seemed to be satisfactory for initial evaluation. A commercial video threshold detector made by AERTECH (model 1515) was discovered after one had already been designed. Its advertised specifications seem to be adequate to perform the threshold detection function. The General Microwave attenuator and logarithmic driver also have good enough specifications for this application; however, for any improved system accuracy this attenuator would have to be replaced by one with more accuracy. It is expected that voltage controlled attenuators will continue to improve in accuracy since they have been in use for only a relatively short period of time.

Evaluation

Preliminary evaluation of this technique has been performed in testers. All indications are that the peak power indication is accurate to within ± 0.5 dB (the linearity specification of the attenuator). No variation of reading with pulse width was observed for pulses of 100 ns or greater width. The unit was calibrated by comparing the reading obtained from a square wave modulated source with a reading from a HP432-B average power meter. The source was modulated at various other duty factors and the peak reading was observed to be constant. Several other refinements were discovered in the process of evaluation. Since the voltage controlled atten-

uators have much better tracking above 10 dB, the integrator control voltage should be biased to keep the attenuator always operating above this level. This feature was added to the version used in one tester. It is also recommended that circuitry for this peak power measurement device be self-contained and not combined with other circuitry in a tester due to noise sensitivity of the threshold detector. Figure 2 is a complete schematic diagram of the most refined version of the system. This version contains a window comparator on the integrator voltage to blank the display when the input signal is out of range.

ACCOMPLISHMENTS

This peak power measurement system, which can be constructed from readily available OEM microwave and electronic components for around \$1500, provides a measurement versatility not currently available with commercial test equipment. Its operation is especially useful in automatic acceptance testing.

FUTURE WORK

Further evaluation of voltage controlled attenuators and commercial threshold detectors should be made to find a better attenuator and a threshold detector which can be commercially obtained. Continued research in these areas should eventually produce ± 0.1 dB measurement accuracies with this technique.

Figure 2. Schematic of RF Pulse Peak Power Measurement System