AN AUTOMATED RECEIVER TEST CONCEPT

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Abstract

An advanced microwave measurement concept has provided a significant breakthrough in the automated characterization of microwave receivers. The system integrates the accurate RF 0.1-GHz to 18-GHz signal source and digital computer of an automatic network analyzer (ANA) with sophisticated decoding/encoding circuitry and RF signal conditioning hardware of a receiver adapter to provide fast, accurate, and economical automatic testing of microwave receivers.

Introduction

The test concept addressed in this paper is the measurement system developed at IBM's Federal Systems Division to perform assembly level checkout of microwave receivers. Advanced user-oriented control programs coordinate the integrated system.

Automatic Test Equipment (ATE) architecture usually dedicates special equipment to test specific hardware automatically to simple go/no-go criteria. This test philosophy is fast because of its computer base, but lacks the flexibility of adapting to different hardware configurations. The receiver Adapter Console discussed here provides this versatility.

We have extended the capability of the automatic network analyzer to test the nonlinear conversion process of the microwave mixer. This added dimension to automatic microwave measurements is significant in that the mixer is the essence of RF down-conversion schemes.

The ensuing discussion will present the functional receiver test concept.

System Function

The system configuration shown in Figure 1 depicts the receiver test environment. The digital computer controls the receiver sequencing and processing of the incident RF signal. The Receiver Adapter coordinates input/output (I/O) encoding, decoding, RF signal conditioning, and peripheral equipment. Figure 2 shows the interrelationships between the test stimuli and a typical receiver.

The ANA provides the frequency-synthesized RF signal, which is modulated and/or power-leveled by the adapter console prior to application to the receiver. The console also decodes ANA computer digital control words, formatting them to properly coordinate the RF conversion process.

Microwave Receiver Requirements

The discrete frequency-synthesized signal technique employed by the ANA is well-suited to the variety of step-scan receivers that this system characterizes.

The fundamental requirements of these receivers are to passively acquire and identify microwave emitters. Fast scan speeds over the operating RF bandwidth are achieved by the digitally stepped local oscillator (LO) (refer to Figure 3). The emitter frequency identification is contingent upon the LO stability.

The Receiver Adapter system is unique in that it provides the accurate synthesized RF signal (simulated emitter) and then determines the receivers performance relative to this "standard". This is achieved while the receiver is tuned as if in its system environment. For receivers without an internal local oscillator, the Adapter provides an external solid-state digitally controlled source, (nonphase locked). The combined stability (ANA and source) provides a coherent IF signal from the mixer conversion process that will phase lock the 1-kHz bandwidth of standard phase/amplitude measurement equipment.

Other parameters that characterize a receiver's performance are conversion gain/loss, sensitivity, linearity over a specific dynamic range, VSWR, channel-to-channel amplitude/phase tracking, and frequency discrimination of the IF signal. Each can be measured and processed by the Receiver Adapter system, either via special IF/video signal processing circuits, or standard RF measurement equipment (power meter, frequency counter, digital voltmeter, vectorvoltmeter, etc.). Figure 4 shows a composite of several of these parameters as graphically displayed for the operator.

The traceability of the ANA to the National Bureau of Standard (NBS) provides an added advantage to this system; i.e., a self-calibration function. This calibration is done periodically or whenever measurement integrity is questioned. The Adapter Console RF signal contitioning transmission path is calibrated prior to each receiver test. This calibration information is stored in the computer for error correction. The analog encoding circuitry is also checked automatically when required.

System Software Requirements

The IBM Receiver Adapter required as much software development as it did hardware effort. The key to the extension of the ANA test concept to the receiver level was the advanced user-oriented programs generated at IBM. The versatility to address many receiver configurations was also a desired goal.

The I/O control requires the addition of general purpose interface cards between the computer and peripheral device (via an I/O extender). I/O subroutines are then inserted in the operating software, giving the user the callable option.

Other requirements of the receiver test software include:

- Mathematical, statistical, and clerical tasks
- Data formating and graphics
- Real-time testing; i.e., test interrupt and refreshed graphics
- Military security coding (if required)

The software languages available (with the ANA) are ASSEMBLY, FORTRAN, and BASIC. The tradeoffs of usage are concerned with computer core size and program sophistication (see Figure 5). ASSEMBLY language provides the most efficient core usage but is tedious as far as initial generation and debug. FORTRAN and BASIC are higher-level languages where instructions are in the form of statements. Our present programming philosophy is to write the composite program in BASIC for ease of editing but employ FORTRAN or ASSEMBLY language-callable subroutines where possible.

Conclusions and Summary

A versatile state-of-the-art microwave receiver test concept has been implemented. It clearly improves the quality of production hardware while demonstrating a 10:1 recurring test cost saving. The real-time aspect expedites debug and provides diagnostic information.

The system growth potential is outstanding, since system flexibility permits modification with minimum effort. The IBM system is presently being expanded to include computer-aided receiver design and optimization functions.

Acknowledgements

We are grateful to Frank Owen who assisted in the evolution of the test concept and Russ Whatley who helped implement it.

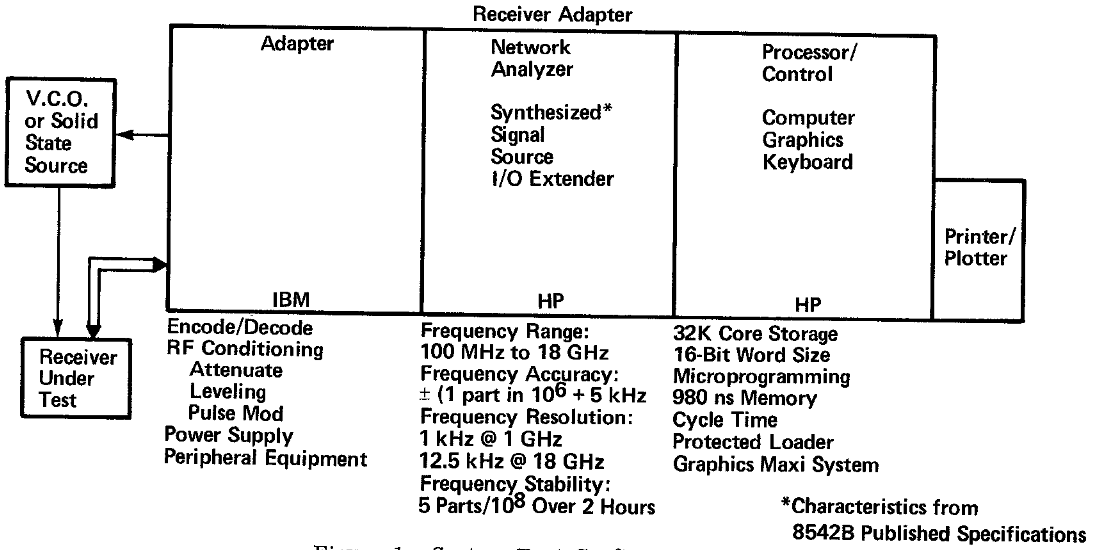


Figure 1. System Test Configuration

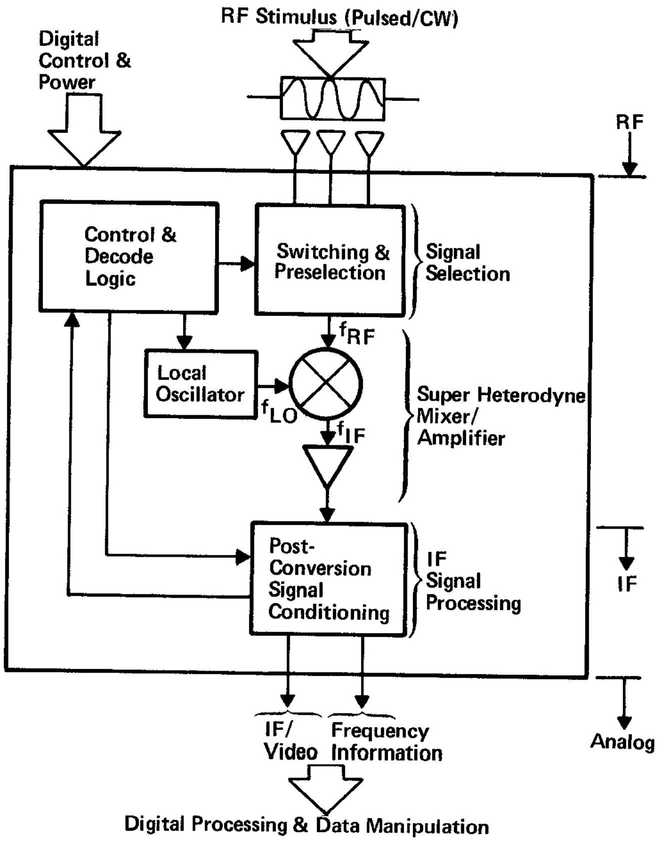


Figure 2. Typical Scanning Receiver

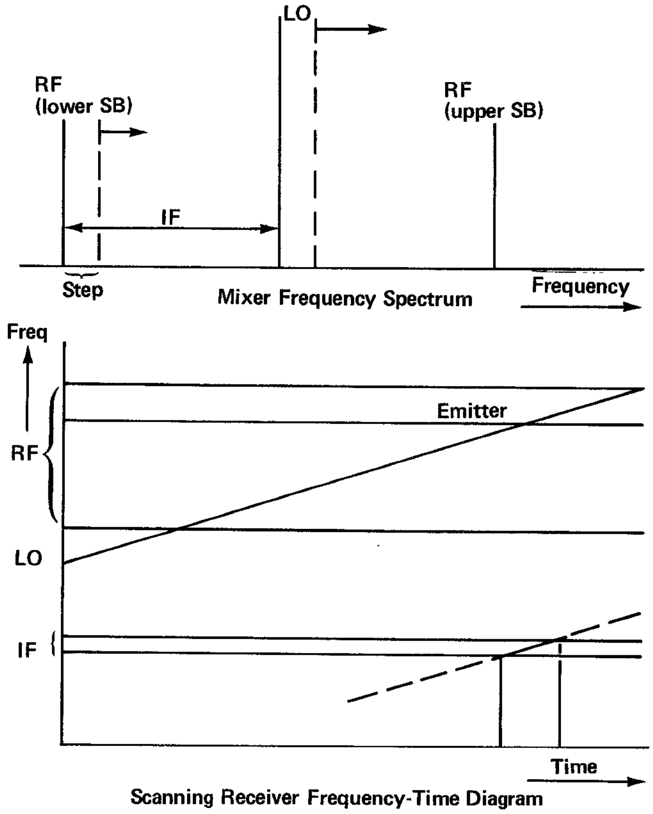
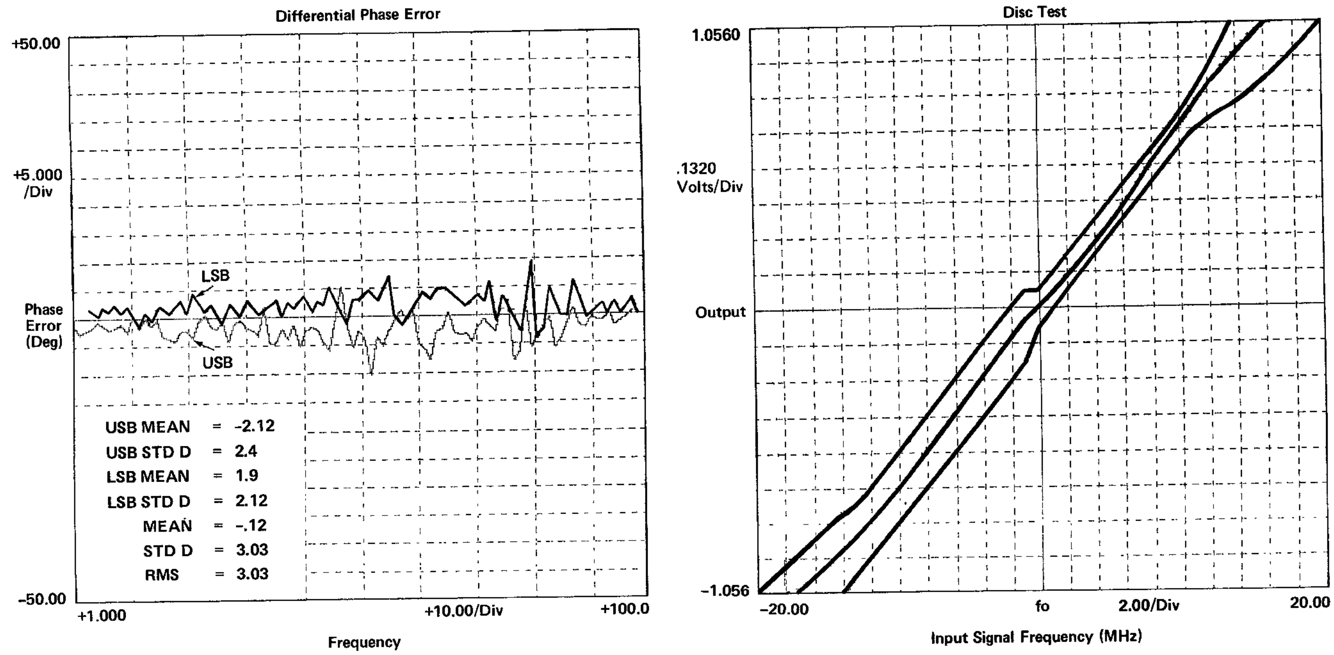
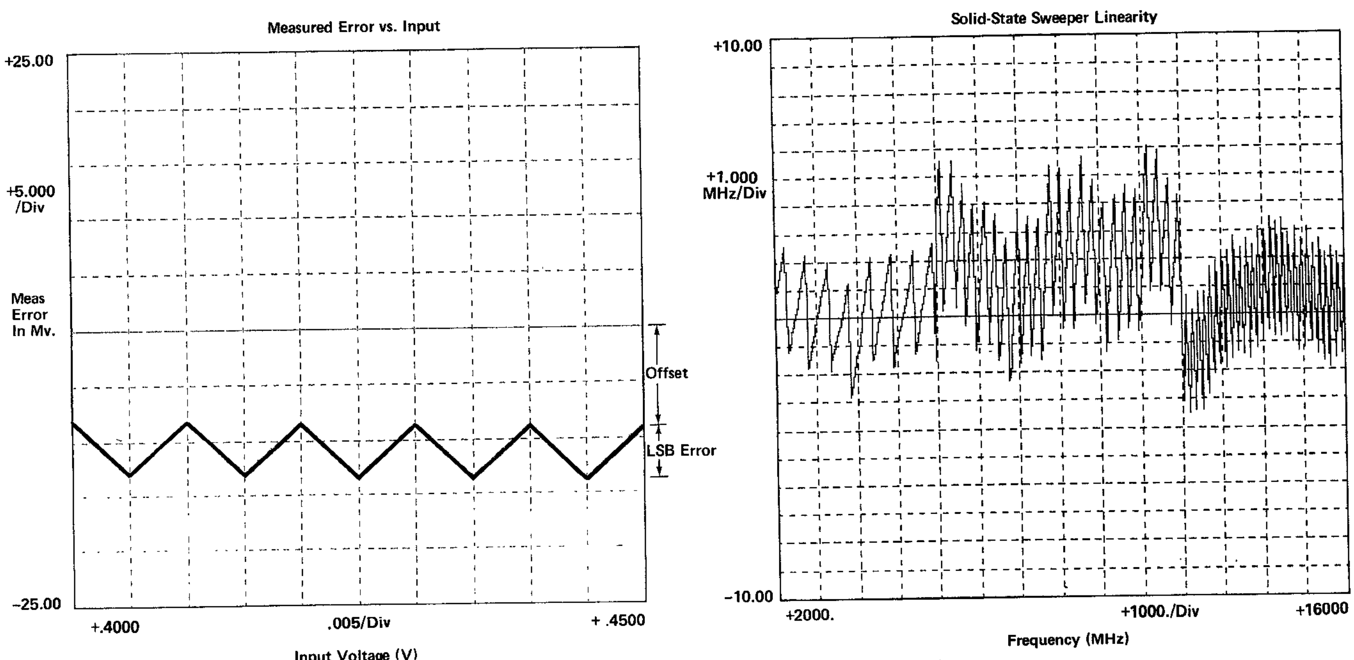


Figure 3. Frequency and Time Diagrams



a. Typical Receiver Test Graphics



b. Typical Adapter Diagnostic Graphic Displays

Figure 4. Receiver Performance Parameters

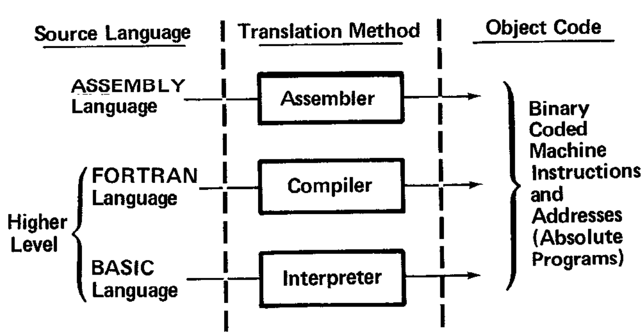


Figure 5. Software Generation Process