GATES ENGINEERING REPORT

HIGH SPEED AUTOMATED TEST SET

HARRIS INTERTYPE CORPORATION

GATES

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HIGH SPEED AUTOMATED TEST SET

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Gates' policy of 100% test of all its products, with their increasing complexity and more stringent specifications, taxes the capacity of existing test equipment to provide a sufficient margin for accuracy. This equipment should have a residual performance that is at least 10 dB superior to the product specifications to prevent coloring the test results. We have found that this margin can be substantially increased with individual fixed frequency components that avoid the compromises necessary to track from one end of the frequency spectrum to the other.

Manual operation of the test equipment can be dull, repetitive and time consuming but very important to the customer and manufacturer. It is subject to misinterpretation, incorrect levels, operator distraction and many other variables that degrade the accuracy of the test results. We have found an unchangeable trait in our Test Technicians to "twiddle" the knobs for that last small dip in the reading, even if it is well below specifications. This serves no useful purpose in the production testing of products, where the information thus gained is seldom recorded.

These problems resulted in the design and implementation of High Speed Automated Test Equipments that could reliably perform the routine, repetitive tests with a degree of accuracy unobtainable with manual test equipment. This Test Set has eliminated the possibility of improper attenuator settings, meter scale readings, parallax error, time consuming distortion analyzer nulling (even the new automatic nulling is slow) and missed steps in a test procedure through the use of a preset automatic sequence with GO/NO GO readouts. An important by-product has been a substantial reduction of test time. This test set does not even require the services of a skilled Test Technician, since it can be operated by anyone who understands the GO/NO GO concept. A skilled Test Technician is employed, however, to make every new test setup and to recheck the calibration on a daily basis.

The test set performs 14 performance checks and tells the operator through 3 GO and 3 NO GO lights whether or not the product under test is performing within specified limits. The list of performance checks are:

- 1 kHz Maximum Gain (for use with products employing attenuators or volume controls)
- 1 kHz Reference Set, Full Output, Nominal Gain Condition
- 30 Hz Response
- 50 Hz Response
- 100 Hz Response
- 10 kHz Response
- 15 kHz Response
- 1 kHz Distortion (Total Harmonic)
- 30 Hz Distortion
- 50 Hz Distortion
- 100 Hz Distortion
- 10 kHz Distortion
- 15 kHz Distortion
- Signal-to-Noise Ratio (20 to 20 kHz Bandwidth)

As frequency response and total harmonic distortion at a given frequency are checked simultaneously, the checkout is reduced to 8 sequential steps, requiring a maximum of 10 seconds to perform. Thus, the operation is performed with a single 8 position rotary switch which allows the operator to watch the readout lamps without the distraction of looking at individual or push-button switches. The system is easily adaptable to alternate methods of control such as punched tape, punched cards, magnetic tape, etc.

These 8 steps are:

1. Overall Gain at 1 kHz
2. 1 kHz Set/Distortion
3. 30 Hz Response/Distortion
4. 50 Hz Response/Distortion
5. 100 Hz Response/Distortion
6. 10 kHz Response/Distortion
7. 15 kHz Response/Distortion
8. Signal-to-Noise Ratio

The complete test set consists of 3 basic subsystems: Oscillator/Transmission section, Switching section and Measurement section. Referring to Figure 1, the Oscillator/Transmission subsystem employs 6 fixed frequency oscillators switched to a transmission section consisting of 3 precision attenuators and a high quality matching transformer. Each oscillator is followed by an individual attenuator allowing either a flat or an equalized output. Up to 40 dB of pre-emphasis or de-emphasis can be obtained with these individual oscillator attenuators for turntable or tape preamplifier, or even FM transmitter testing. An additional 40 dB continuously variable attenuator is switched in on step 1 to reduce the output for maximum gain measurements on products employing one or more gain controls. The controls would be adjusted for minimum attenuation in step 1, then adjusted for nominal operating gain in step 2.

The output impedance of the transmission section is 600, 150 or 50 ohms and switch selectable. During noise measurements, the transmission section is disconnected from the output terminals and a low noise resistive termination of the proper impedance is switched to the output terminals.

Each of the 6 fixed frequency oscillators employs 2 silicon FET and 3 silicon bipolar transistors to achieve the necessary stability and reliability. Maximum total harmonic distortion of any frequency at the output terminals is 0.04%, including distortion introduced by the output transformer.

Transistor switches are used to provide the necessary logic voltage to the switching relays in the oscillator and measuring sections. This permits low current and low voltage command signals for control, and the inherent flexibility of the control circuitry will make any desired changeover a minor operation.

The heart of the test system is the measuring unit. This unit will accept a signal from 7.75 mVRMS to 100 VRMS without the necessity of external pads, booster amplifiers or load resistors. All measurements are made on a GO/NO GO basis with meter relays employing photoelectrically operated set points for Gain and Response limits. Comparator driven lights provde GO/NO GO indications on distortion and noise measurements.

Figures 2, 3 and 4 represent the 3 basic channels used in the measuring unit. Extensive relay switching is employed to minimize the number of amplifiers in the unit for maximum reliability. Gain and Response measurements are made through one channel, as shown in Figure 2. These measurements are generally performed at the full rated output of the product under test rather than the customary 10 dB below full rated output. This is possible because of the simultaneous testing for specified distortion. An amplifier could have a rise in response that would cause rejection if read at a level 10 dB below maximum output; yet this rise in response might be clipped at maximum output level sufficiently to pass the specifications for response. With this test set, the simultaneous measurement of total harmonic distortion would detect the clipping and show a NO GO indication that would still reject the product. Although this is a slight departure from the conventional method, it has proven to be a satisfactory arrangement. Functionally, this channel is essentially a straightforward A.C. Voltmeter. The input attenuators, however, are calibrated to give a predetermined set point reading on the GAIN meter for a given input voltage. The meter trip points are set for the desired amplifier gain tolerance.

The 1 kHz D.C. bus voltages, the same bus used for gain measurements, is sampled and held for frequency response measurements. The difference between the bus voltage at 30, 50, 100, 10,000 and 15,000 Hz and the stored 1,000 Hz reference level is monitored on a zero center voltmeter employing another dual limit meter relay. The meter trip points and a preceding sensitivity control are used to set the response limits. Note that the tolerance of gain variation and frequency response variation does not accumulate for the response measurements. Thus, it is possible to preset a gain tolerance of ± 1 dB, and then preset a succeeding tolerance of only ± 0.25 dB for response. The 1 kHz gain reading is stored in the comparator and used as a reference for the closer tolerance response readings.

This method gives a true 1 kHz reference for frequency response measurements. The sensitivity of the meter can be varied to give a ± 0.5 dB to ± 5.0 dB full scale deflection. As the meter relay limit resolution is ½% of full scale, the limit can be set to reject a product with as little as 0.0025 dB above specifications. This is beyond the capability of the best non-digital A.C. Voltmeters and taxes the resolution of most digital A.C. Voltmeters.

Distortion measurements are monitored through a closed loop system as shown in Figure 3. The top chain of amplifiers provides a reference voltage and eliminates inaccuracies caused by possible amplifier gain and response variations. The bottom chain passes the signal through switch selected high-pass filters followed by a maximum voltage amplification of 5,000.

Each high-pass filter module includes a 7 pole Tchebyshev design high-pass filter to attenuate the fundamental a minimum of 65 dB, and a switch selected potentiometer with an attenuation coefficient inversely proportional to the distortion limit desired. The distortion products are amplified and RMS detected. At the preset limit, the level of the detected products equals the DC reference level set by the upper system chains. If the distortion limit is exceeded, the RMS value of the detected distortion products will exceed the DC reference voltage. This condition, monitored by a comparator, will give a NO GO light indication. Similarly, if the distortion is less than the preset limit, the detected distortion product level will be less than the DC reference voltage and the comparator will give a GO light indication. The comparator resolution is high enough to make the uncertainty region between GO and NO GO less than 1% of the limit. Thus, the test set can be set to pass a product with 0.25%, yet reject one with 0.2525% total harmonic distortion.

Amplifier output noise is amplified as shown in Figure 4. The response of the channel is bandwidth limited from 20 to 20,000 Hz. The input attenuators allow preselection of the desired Signal-to-Noise ratio limit. This limit is determined by a comparator system similar to that used to set distortion limits. In this case, the 1 kHz sampled-and-held DC output provides the reference voltage. A GO/NO GO light pair driven by the comparator indicates whether or not the amplified RMS noise level exceeds the reference level.

Although we have used test fixtures and jigs for many years to expedite the connection and switching through multi-channel equipments, further improvements are being incorporated to operate all circuit paths at critical levels, etc. The ratio of time necessary to connect and operate test fixtures to time expended in actually making the test (which we refer to as "pure test time") has greatly increased. This has resulted in a review and some revision to enhance the performance of the test fixtures.

The increased mechanical and improved electrical testing which has been an important by-product of the efficiency of the High Speed Automated Test Set benefits the customer by providing better products. The combination of these two factors gives the user the best possibe equipment without any increase in cost in the testing area. On a recent run of several hundred microphone preamplifiers there was a net test time savings of 3.41 minutes per unit and the testing was more comprehensive and more accurate.

The automated test equipments have been used in our audio products area to date, which covers a wide range of differing units. Most of these products have been readily adaptable to the new test system. With some specialized features, we expect to be testing AM and FM transmitters with the new automated equipment in the near future. During the initial tune-up of a new transmitter, many of the tests are performed repeatedly to recheck the effect of various tuning elements. The new test system is ideal for extremely rapid and highly accurate testing of these important parameters.

In conclusion, the conditions which fostered this new testing concept to permit 100% test with improved accuracy and, if possible, reduced test time, have been satisfied. The routine test operator has to make no decisions and any marginal operation will be called to the attention of the product engineer and other responsible parties. Mechanical inspection in all products has been increased as a result of more available time due to the increased efficiency of electrical testing. Two of the test systems have already been employed in our production testing with targeted results; and, although their initial cost is appreciably more than commercially available equipment, the results achieved more than justify the initial investment.

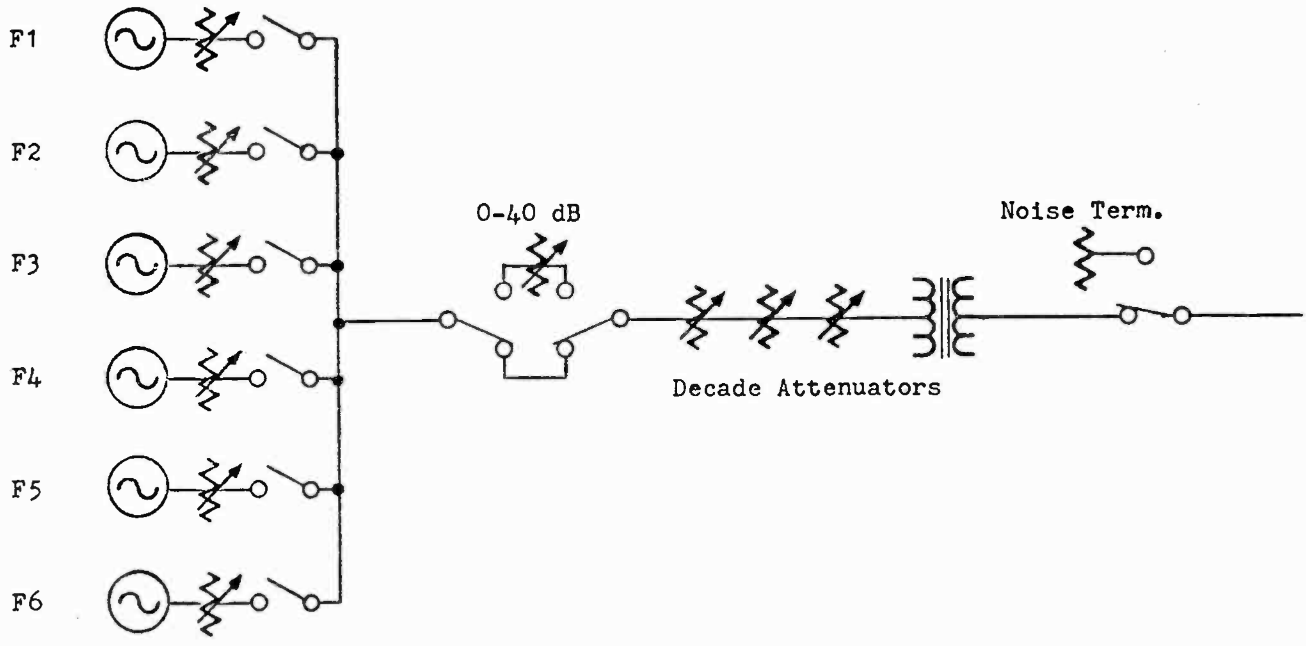

Figure 1. Oscillator/Transmission Unit

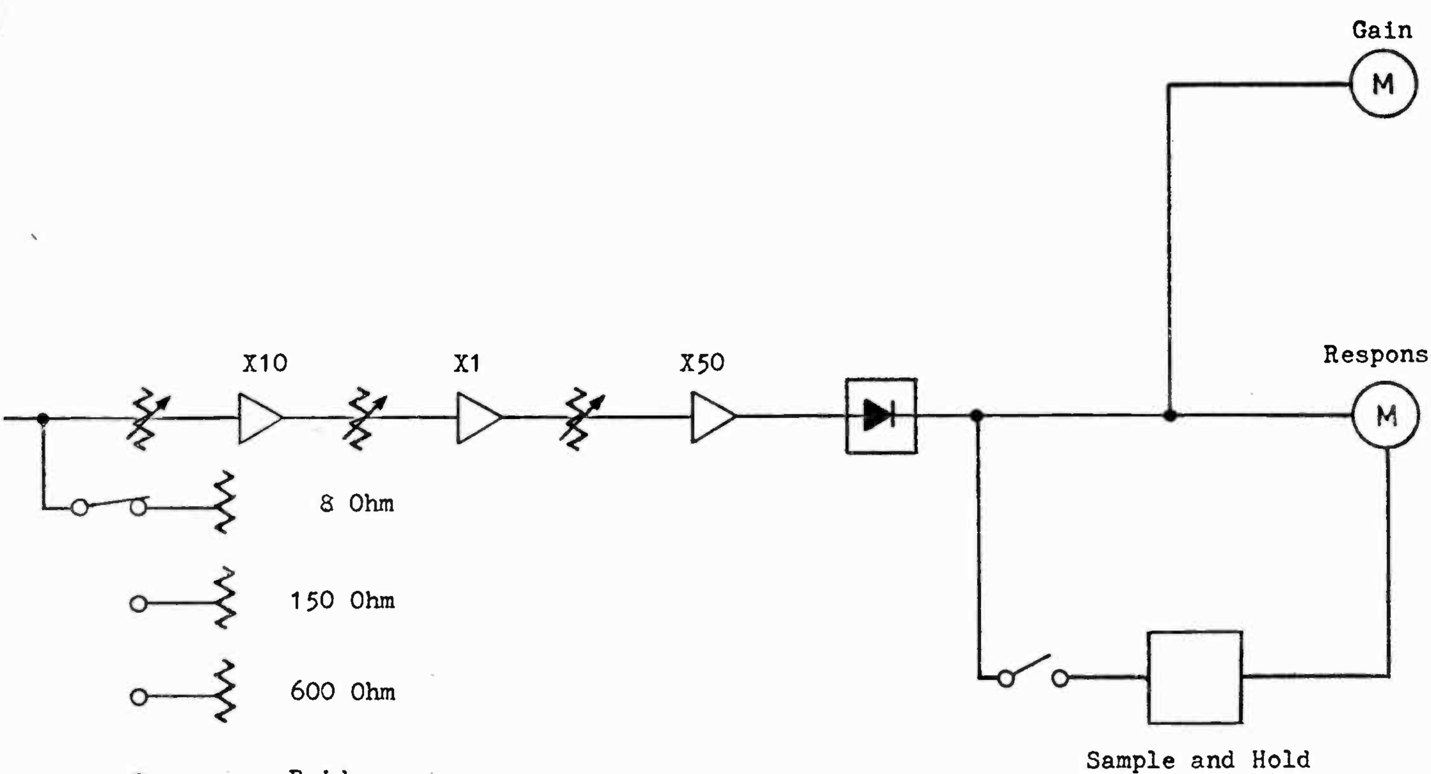

Figure 2. Gain/Response Channel

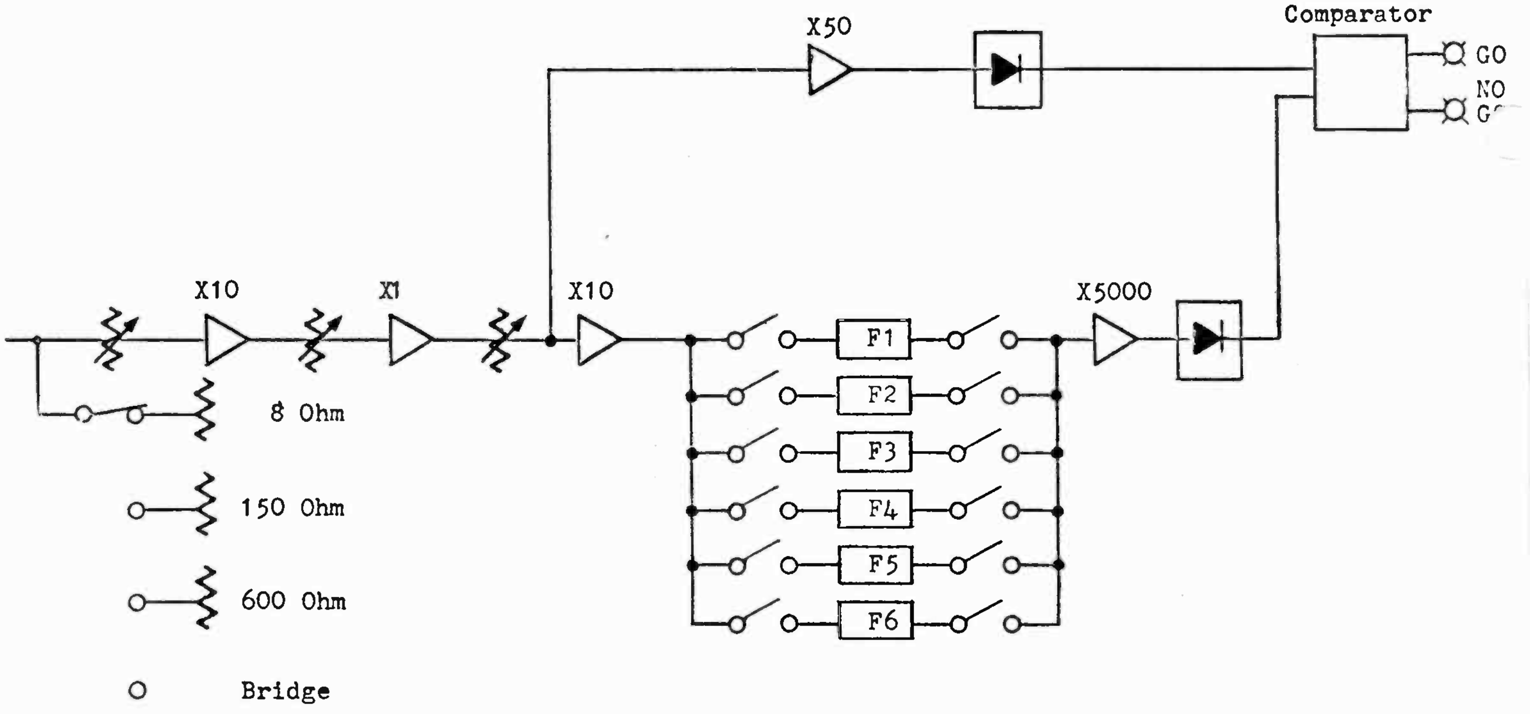

Figure 3. Distortion Channel

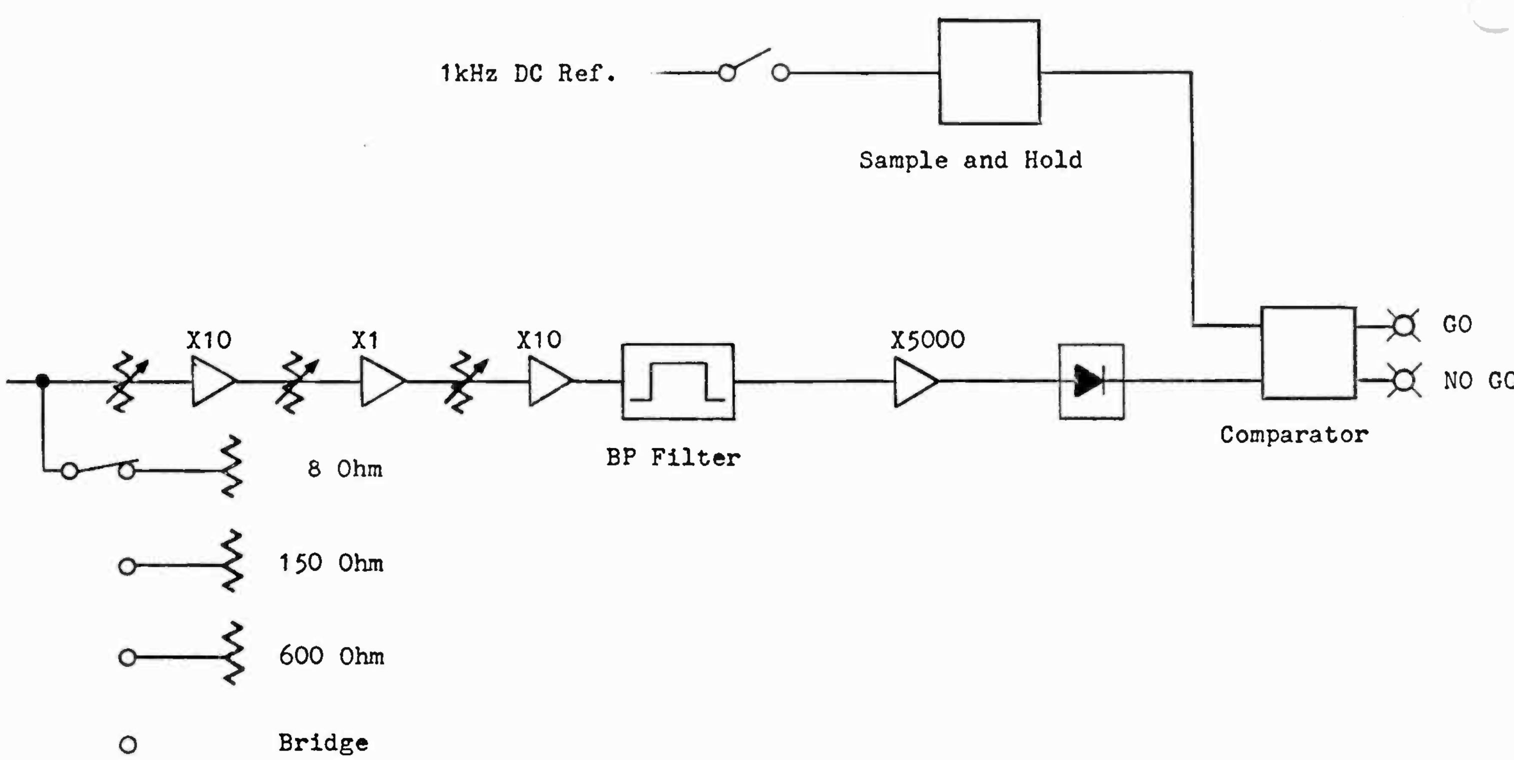

Figure 4. Noise Channel

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