

gain code is a 4-bit binary code which is decoded into 15 gain levels.

The first function controlled by the gain code is the two gain levels of the parallel post-amplifiers. The second function controlled by the gain code is the selection of the output of the upper post-amplifier or the lower post-amplifier. The amplifier output, selected in this way, is then commutated by the system channel multiplexer with the other seismic channels--each with an AGR amplifier. The channel-multiplexed output then goes to the final amplifier--a buffer amplifier with four gains under the control of the gain code. The output of this amplifier is the output of the AGR amplifier and is applied to the system digitizer.

MEETING SEISMIC NEEDS

The advanced gain-ranging amplifier meets the needs of geophysicists for wide dynamic range, automatic gain selection and recording, accurate amplitude recovery, and precise time correlation. Drawing upon the latest knowledge in electronic and digital design, the amplifier exhibits excellent gain-step accuracy and gain linearity, very low harmonic distortion, and close-to-theoretically-minimum noise. How these objectives have been achieved will be the subject of the following sections.

Wide Dynamic Range

In order to take full advantage of the precision with which the digital computer can process seismic data, the Series 1010 system is designed to accommodate a very wide range of signal amplitude. This range is customarily expressed, in digital systems, as resolution and, in analog systems, as dynamic range.

Resolution

First, the amplifier supplies half of the total resolution. With the lowest gain taken as 1, each succeeding level doubles that value, that is, 2, 4, 8, etc., up to the fifteenth level, 16,384. In other words, the static range of the amplifier is doubled automatically fourteen

times to accommodate the declining seismic input signal. If the lowest range is considered to be a resolution of 1, then the highest range represents a resolution of 16,384. In effect, the gain code reporting the gain level in use also indicates the resolution being achieved by the amplifier.

Second, the digitizer supplies the other half of the total resolution. When the output signal on any one of the amplifier ranges is applied to the digitizer, it is separated into 16,384 amplitude levels. This is the resolving power of a 14-bit-plus-sign analog-to-digital converter. In the binary number system, each bit added, after the first one, doubles the resolution.

Thus, the resolving power of the amplifier-digitizer combination is one part in 2^{28} or one part in 268,435,456.

Dynamic Range

Dynamic range is the ratio of the maximum signal handled to the minimum signal distinguishable. By using the following relationship, dynamic range can be expressed in decibels:

$$\text{db} = 20 \log_{10} \frac{e_{\text{max}}}{e_{\text{min}}} = 20 \log 2 = 20(0.301) = 6$$

Thus, each time the gain level is doubled or each time the binary resolution is doubled, the dynamic range is increased by 6 db. With 14 gain changes, the amplifier resolution may be expressed as 84 db. Similarly, 14 binary bits after the first one are also equivalent to 84 db. Together the amplifier and the digitizer cover a dynamic range, derived from their resolution figures, of 168 db. On the basis of analog experience, this figure may seem unrealistically high.

In the case of the amplifier, the maximum signal is 1 volt and the noise--which sets the lower distinguishable level in analog work--is specified to be typically 0.1 microvolt rms, both referred to input. This ratio is 10^7 or 140 db. Maximum noise is specified to be 0.2 microvolt rms. On this noise basis, the dynamic range would be reduced to 134 db.