TN-7200
MULTICHANNEL ANALYZER
OPERATOR'S MANUAL
1.00 BRIEF SYSTEM DESCRIPTION

The TN-7200 is a microprocessor-based multichannel analyzer. Standard features include:

- 50 MHz Wilkinson type ADC
- Two analysis modes:
  - Pulse Height Analysis
  - Multichannel Scaling
- Data processing capabilities
- 5 inch diagonal video monitor for spectral data display
- ASCII serial I/O port
- Front panel controls incorporating a set of pressure-sensitive switches for convenient control of data acquisition, display, data processing, parameter entry, and I/O.
- Built-in diagnostic programs to verify proper system performance.

The TN-7200 is contained in an 8.5" x 11" x 15" chassis which can be used as a table-top unit, or mounted in a standard 19" rack (configuration must be specified at time of purchase). All normally used controls are accessible from either the front or rear panels. Table-top units have a fold-down support to provide an optimum viewing angle and convenient operation of the front panel.
2.00 THEORY AND OPERATING PRINCIPLES

The TN-7200 can perform data acquisitions in two basic modes: Pulse Height Analysis and Multichannel Scaling.

Pulse Height Analysis

Pulse Height Analysis (PHA) is the principle means of data acquisition for the TN-7200. In the most common application of pulse height analysis, a detector [NaI, Si(Li), Ge(Li)] is placed near a radioactive source, commonly a gamma emitter. When it is struck by a radioactive emission, the detector produces a voltage pulse whose amplitude is proportional to the energy of the incident radiation. Figure 2a is a graph of voltage pulses as they might appear at the output of an amplifier.

![Figure 2a AMPLIFIER OUTPUT](image)

**Live Time/Dead Time/Real Time**

The stream of pulses is then fed to the Analog-to-Digital Converter (ADC). Figure 2b illustrates what happens as pulses arrive at the ADC input. When the first pulse is detected, the ADC begins the
conversion process. While this pulse is being converted and stored in memory, the ADC is unable to accept any other incoming pulses. This interval, from the time a pulse is accepted for conversion until it is stored, is called "Dead Time". The total dead time for an acquisition is the amount of time the ADC spent converting and storing incoming pulses. The % Dead Time Meter (front panel) indicates the instantaneous percentage of dead time during an acquisition.

Figure 2b LIVE TIME/DEAD TIME/REAL TIME

After the first pulse has been converted and tallied in the proper data memory channel, the ADC can accept a new pulse for conversion. The interval, from the time the preceding pulse was stored to the time a new pulse is accepted for conversion, is called "Live Time". The total live time for an acquisition is
conversion process. While this pulse is being converted and stored in memory, the ADC is unable to accept any other incoming pulses. This interval, from the time a pulse is accepted for conversion until it is stored, is called "Dead Time". The total dead time for an acquisition is the amount of time the ADC spent converting and storing incoming pulses. The Dead Time Meter (front panel) indicates the instantaneous percentage of dead time during an acquisition.

After the first pulse has been converted and tallied in the proper data memory channel, the ADC can accept a new pulse for conversion. The interval, from the time the preceding pulse was stored to the time a new pulse is accepted for conversion, is called "Live Time". The total live time for an acquisition is
indicates the number of counts per data channel. Since the conversion gain is 10 and there are 10 data channels, the entire input voltage range is represented by the histogram. As shown in figure 2c, the 3 counts in channel 5 correspond to the three pulses whose amplitudes were greater than or equal to $V_5$ and less than $V_6$.

![PHASE HISTOGRAM](image)

**Figure 2c PHA HISTOGRAM**

Figure 2d shows a typical TN-7200 PHA spectrum. Each radioisotope produces a characteristic and readily identifiable spectrum of this type. Each point in the spectral trace represents the counts tallied in a single data channel. Even though the TN-7200 displays each channel as a single dot, remember that each channel represents a voltage interval.

![TYPICAL PHA SPECTRUM](image)

**Figure 2d TYPICAL PHA SPECTRUM**
Varying Conversion Gain

When a one to one relationship exists between the conversion gain and the number of data channels (as in the previous example), the entire input range (every ADC count value) is stored in the data memory. For most acquisitions, the conversion gain is set equal to the number of data channels in the acquiring memory group causing the entire input range to be stored. However, as stated earlier, the TN-7200 ADC provides a number of different conversion gain settings. When the conversion gain is set so that there are more ADC channels than data memory channels, the full input range is not stored.

Figure 2e shows the stream of pulses from Figure 2a but with a conversion gain of 20. This means that there are now 20 ADC channels covering the full input range. Figure 2f shows how the 10-channel data memory would store the count values from Figure 2e. Only count values from the lower ten voltage intervals (V0-V9) are stored while the upper ten (V10-V20) are ignored since no storage locations exist for them.

Figure 2e  AMPLIFIER OUTPUT
2.15 Digital Offset

A comparison of the histograms in Figure 2c and 2f shows that the count values which were stored in channels 0 through 4 in Figure 2c are stored in channels 0 through 9 in Figure 2f. This represents an increase in resolution for that portion of the input range.

The TN-7200 incorporates a feature called Digital Offset which allows any portion of the full input range (spectrum) to be acquired at a higher resolution. When a digital offset is applied to data acquisition, the count value for some ADC channel above 0 (specified prior to acquisition) is routed to channel 0 of the data memory. ADC channels below the one specified are not analyzed. Figure 2g shows how the stream of pulses in Figure 2e would be stored with a digital offset of 8.
The count values from the interval V8-V9 are routed to channel 0 of the data memory. The count values from the intervals V9-V17 are placed in the remaining data channels. The count values below V8 and above V18 are not analyzed.

**Multichannel Scaling (MCS)**

MCS analysis is used to obtain histograms representing frequency of occurrence (intensity) vs. elapsed time. The input signal is a train of pulses, each of which represents a single event. There is no information contained in the amplitude or width of these pulses — they are "logic" pulses in the sense that the occurrence of a pulse signals an event. MCS operation effectively employs the data memory as a series of scalers (pulse counters). As the pulses are detected at the MCS input, they are counted in a high-speed register for a preset interval (dwell time). At the end of each interval the value in the scaler is added to the contents of the current memory channel and the scaler is cleared and advanced for the next dwell interval — the value of the scaler for this next dwell will be added to the next channel, and so on. When pulses have been tallied in all of the data memory channels being used for the acquisition, a "sweep" has occurred. The "sweep time" is the time it takes for one complete sweep (Sweep Time = Number of Data Channels * Dwell Time).

Figures 2h and 2i illustrate MCS acquisition in simplified form. A series of incident logic pulses is shown in Figure 2h. The contents of memory after one MCS scan are shown in Figure 2i. An MCS spectrum is an integral histogram; that is, each channel represents the integral (total) of all counts within a time interval, not the instantaneous counting rate. Thus the peak in channel 4 represents the 5 events which were detected in the interval T4-T5. Figure 2j shows an MCS spectrum.

![Figure 2h INCIDENT LOGIC PULSES](image-url)
MCS analysis is useful in several diverse applications where it is necessary to study the distribution of events vs. time. One of the simplest of such applications is the study of nuclear decay - the MCS spectrum then represents the exponential decay curve.

Many other applications involve the synchronization of the MCS scan to an external device. The channels of the MCS spectrum then are directly related to a position or condition of the external apparatus. Such applications include Mossbauer analysis, where the channels relate to source velocity, and X-ray "line scanning", where the channels represent the traverse of an electron beam on a sample.