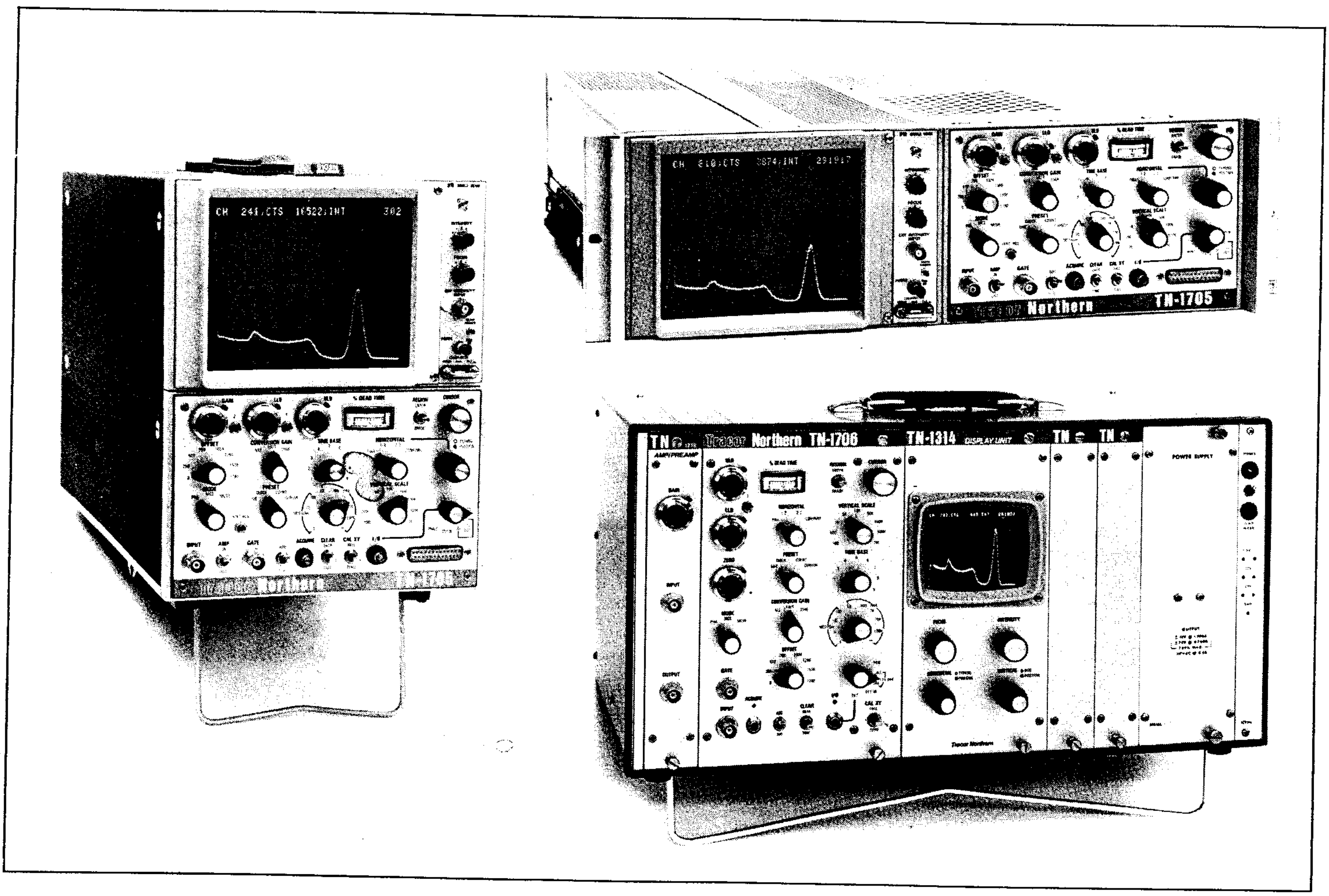
INSTRUCTION MANUAL for TN-1705 and TN-1706 PULSE HEIGHT ANALYZERS

INCLUDING TN-1314 NIM DISPLAY MODULE AND TN-1218 NIM PREAMP/AMPLIFIER



Tracor Northern, INC.

2551 WEST BELTLINE HIGHWAY

MIDDLETON, WISCONSIN 53562

Phone (608) ~~836-6511~~

831-6511

Dick Dewar - Service

SN 1176306

TN-1705/1706 INSTRUCTION MANUAL

TABLE OF CONTENTS

SECTION ONE - GENERAL SYSTEM DESCRIPTION

1.1 INTRODUCTION

The TN-1705 and TN-1706 are compact multichannel pulse height analyzers designed to provide the experimenter with maximum versatility, accuracy, and efficiency at a low cost. These analyzers incorporate low power multi-function ICs (integrated circuits) and a static N-MOS RAM (Random Access Memory). Extensive use of this state-of-the-art circuitry substantially reduces the size and weight of the TN-1705 and TN-1706 analyzers, and provides for features not previously found in low cost laboratory instrumentation.

The TN-1705 is a multichannel analyzer plug-in module which fits into the Tektronix 5103-N oscilloscope mainframe. The TN-1706 is a 4-wide NIM (Nuclear Instrument Module) analyzer which slides into a standard NIM bin enclosure. Two other NIM modules, the TN-1314 Display Module and the TN-1218 preamp/amplifier, are used in conjunction with the TN-1706 to form a complete analyzer system. The TN-1705 and TN-1706 (with its associated modules) are essentially identical in functional capabilities and operating characteristics.

This manual is designed to acquaint TN-1705 and TN-1706 users with the capabilities and proper use of these systems. Subsection 1.2 below offers a general description of the TN-1705 system, while subsection 1.3 gives a general description of the TN-1706 system. The user of either instrument can easily follow this manual to achieve proficiency in operating his particular system, since virtually all controls are identical and any distinctions between the TN-1705 and the TN-1706 are clearly noted in the controls and procedures sections. Since the use of multichannel analyzers is no longer restricted to specialized research laboratories staffed with instrumentation experts, we have included fundamental introductory material for the first-time analyzer user.

1.2 TN-1705 System Description

The TN-1705 plug-in analyzer module draws its power from the Tektronix 5103-N oscilloscope system mainframe. The Tektronix power supply provides all necessary voltages for the analyzer module itself. The power consumption for the TN-1705 module itself is 16 watts, well below the 60 watts maximum power consumption allowable for plug-in modules within the Tektronix package. The total power consumption of the TN-1705 system is 72 watts; this low power consumption allows the TN-1705 to operate without the need for cooling fans or other special precautions. Because we have not modified the Tektronix power supply, all standard Tektronix plug-in modules are usable without going through tedious conversion procedures.

In addition to the power supply, the TN-1705 is composed of three functional subsystems. The first of these subsystems consists of the front-end analog input circuitry and the analog to digital converter (ADC). The front end circuitry includes an internal preamplifier/amplifier, which accepts negative current pulses from the anode of a photomultiplier tube such as used with scintillation detectors. The ADC utilizes either this built-in preamplifier/amplifier, or a high-level 0 to 10 volt input from an external amplifier. Some features of the ADC are a 50 MHz digitizing rate, resolution to 2048 channels, digital offset, coincidence/anticoincidence gating, and a direct-coupled input.

The solid-state memory and associated control circuitry make up the second subsystem. The memory size is 1024 channels, with 10^6-1 counts per channel capacity. The memory cycle time is 1.2 microseconds. Provision has been included for subdividing the memory into halves, so the experimenter can acquire data in halves and then directly compare two separately acquired spectra. All data in memory is available to the outside world through the serial ASCII input/output interface. A multichannel scaling (MCS) input provides for serial entry of data into the data registers; the maximum MCS input rate is 300 kHz. A 100 kHz crystal controlled time base provides for both MCS dwell time selection and live/clock timing for pulse height analysis.

The third subsystem consists of the CRT (cathode ray tube) display, the input/output circuitry, and several other operating control features. The 6.5" CRT display provides live, crisp, flicker-free display of spectra, along with alphanumeric character display of data and labels. The movable CURSOR control visually defines individual channels with an intensified point, with the channel number and contents read out on the CRT. The standard input/output circuitry includes the ASR-33 teletype input/output interface and readout interface for X-Y recorder or point plotter. Optional input/output interface capability is available for parallel printer, magnetic tape cassette, and EIA data modem output. Standard operating control features included are the four modes of preset operation (live time, clock time, CURSOR, count). Optional features include Region-of-Interest selection with integration and a 12 volt DC to AC inverter for portable operation.

1.3 TN-1706 System Description

The TN-1706 and its companion modules, the TN-1314 Display Module and the TN-1218 preamp/amplifier, offer the flexibility and interchangeability associated with NIM systems. The NIM (Nuclear Instrument Module) system is a standard modular system that has gained acceptance in nuclear instrumentation laboratories throughout the world. The TN-1706, TN-1218, and TN-1314 are NIM-standard modules which slide into a NIM bin. A NIM bin is an enclosure that accommodates a multiplicity of NIM modules and provides power at the proper voltages to the modules that are inserted into the bin. A typical NIM bin includes 12 sets of guides and 12 connectors so as to accept 12 single-width modules or a lesser number of multiple-width modules. A standard NIM bin provides dc voltages of +12.00, -12.00, +24.00, and -24.00 on its connector busses. The power requirements for the three modules are summarized in the table below.

	TN-1706	TN-1314	TN-1218
+12V	.080 ampere	.460 ampere	.015 ampere
-12V	.090 ampere	.008 ampere	.015 ampere
+24V	.300 ampere	---	---
-24V	.070 ampere	.005 ampere	---

These low power requirements ensure power supply economy and non-degradation of the 12/24V power supplied to other modules.

The "front-end" of the TN-1706 system consists of the 0 to 10 volt input, the analog-to-digital converter (ADC) and the various controls used to shape and modify analog signals. The 0 to 10 volt direct coupled input to the ADC accepts pulses from a radiation detector/spectroscopy amplifier. Our TN-1218 NIM preamp/amplifier is directly compatible with the TN-1706 input; this preamp/amplifier accepts negative current pulses from proportional counters or from photomultiplier tubes such as used with scintillation detectors. The TN-1706 ADC converts pulses from the TN-1218, or from any other spectroscopy amplifier. Some notable features of the TN-1706 ADC are a 50 MHz digitizing rate, resolution to 2048 channels, digital offset, and coincidence/anticoincidence gating operation.

All data is stored in the newly-designed solid state memory which has a total of 1024 channels, each having a capacity of 10^6-1 counts. The memory can be subdivided into halves, so the experimenter can acquire two separate spectra in 512-channel halves and then directly compare these halves. Access to all data in memory is available through the standard serial ASCII input/output interface, should the user wish to interface with an external device. A multichannel scaling input provides for serial entry of data into the data registers at rates to 300 kHz. A 100 kHz crystal-controlled time base provides precise control of MCS dwell time selection and live/clock timing for pulse height analysis.

The TN-1314 Display Module provides a 8.6 cm CRT (cathode ray tube) for viewing spectral data. This CRT features crisp, dynamic, flicker free display of spectra along with alphanumeric character display of data and labels. The movable CURSOR control visually defines individual channels with an intensified point, with the channel number of the CURSOR and the number of counts in that channel displayed live in alphanumeric characters on the CRT.

Standard TN-1706 peripheral input/output circuitry includes an interface for ASR-33 Teletype, so data can be read out to teletype page printer and read back into the TN-1705 from paper tape. Also included standard is the readout interface for analog X-Y recorder or point plotter. Optional input/output interfacing capabilities are available for parallel printer, magnetic tape cassette, and EIA level ASCII input/output.

Operating control features included as standard with the TN-1706 are four modes of preset operation (live time, clock time, CURSOR, and count). Also included is a rear-panel connector which provides for externally controlling and monitoring TN-1706 system operations. Control signals associated with this connector include external start and stop of analysis, External MCS Dwell Advance, output of the two most significant address bits during MCS analysis, and several other control and monitoring signals. Available as an option is a region of interest with dynamic integration between region limits. This option allows for preset integral mode of operation.

1.4 Modes of Analysis

The TN-1705 and TN-1706 provide capability for two modes of analysis, pulse height analysis (PHA) and multichannel scaling (MCS). These two analysis modes and their applications are discussed below.

1.4.1 Pulse Height Analysis (PHA)

In the PHA mode, a train of pulses from a radiation detector/spectroscopy amplifier is applied to the input of the TN-1705/1706. These pulses have amplitudes (heights) which vary in proportion to the energies of the incident radiation that was absorbed by the detector. By counting the number of occurrences of pulses of each height and forming a histogram, the TN-1705/1706 measures the energy spectrum as seen by the detector.

Pulse Height Analysis might then more properly be termed Pulse Height Distribution Analysis, since the essential characteristic of this form of analysis is that input pulses are sorted by voltage amplitude to form a histogram representing frequency of occurrence vs. pulse height. Figure 1.1 illustrates this process in simplified form. Figure 1.1a depicts a series of voltage pulses as they might appear at the input of the TN-1705/1706. The vertical axis has been divided into 10 equally spaced intervals; the number of pulses whose amplitude falls within each interval is tabulated to the right. Figure 1.1b shows the pulse height distribution in histogram form. The horizontal axis is divided into channels corresponding to the voltage intervals of 1.1a. The vertical

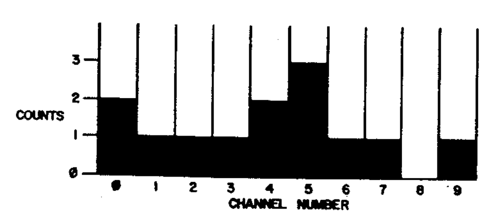


Figure 1.1b. PHA Histogram.

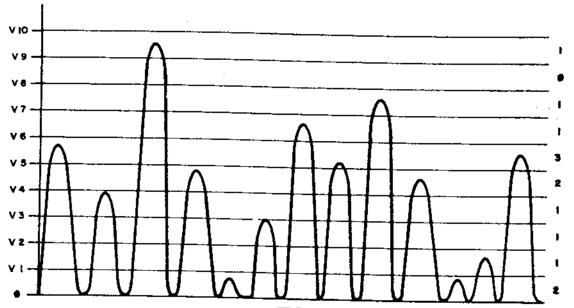


Figure 1.1a. Input voltage pulses.

axis of this histogram is divided into increments representing the tally of counts in the corresponding voltage interval. Thus the three counts in channel 5 correspond to the number of pulses whose amplitude was greater than or equal to V5 and less than V6.

Pulse Height Analysis is a particularly powerful technique for measuring and counting the output signals of radiation detectors whose output signals are voltage pulses proportional in amplitude to the energies absorbed by the detector. Typical of such detectors are:

Scintillation Detectors (NaI, Organics)
Semiconductor Detectors (Ge(Li), Si(Li))
Gas Proportional Detectors

A common characteristic of such radiation detectors is that each voltage pulse produced by the detector corresponds to the energy deposited by an individual photon or particle. Since the nuclear or atomic decay which generates the incident emission is a randomly occurring process, the pulse train measured is a time-random mixture of pulses of all possible amplitudes. The random nature of the occurrence of these pulses is illustrated in figure 1.2a, which is an oscilloscope trace of the output of a NaI scintillation detector. When sorted by amplitude and stored in the memory of the TN-1705/1706 analyzer, the distribution of pulse heights as a function of energy becomes quite apparent, as in figure 1.2b.

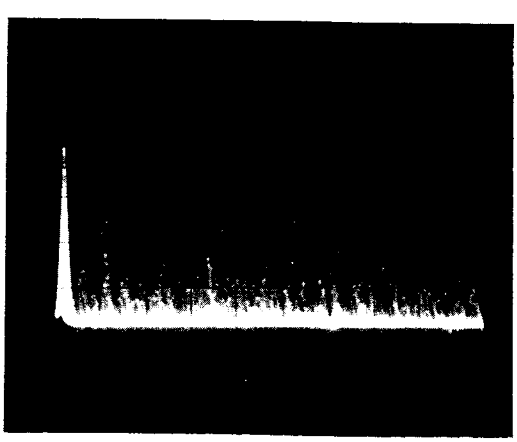


Figure 1.2a.

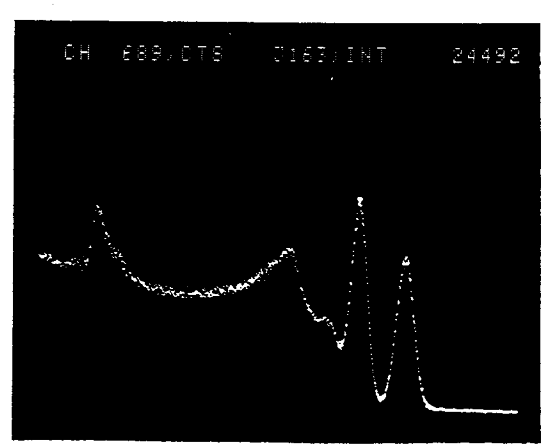


Figure 1.2b.

Figure 1.2b is a 1024 channel PHA gamma-ray spectrum of radioactive Cobalt-60, taken with a NaI detector. This 1024 channel histogram is similar to the 10 channel histogram of figure 1.1b, but is of far greater resolution. That is, we have sorted the input pulse amplitudes into 1024 discrete amplitudes, whereas in figure 1.1b we have sorted the input pulse amplitudes into only 10 discrete amplitudes. Each point in figure 1.2b represents the number of counts accumulated in one channel. Even though we now display each channel as a single dot, it is important to keep in mind that each channel still represents an interval range of input pulse amplitudes, and thus an interval range of incident energies.

Figure 1.3 is a simplified block diagram of the PHA components employed in the TN-1706/1706 analyzers.

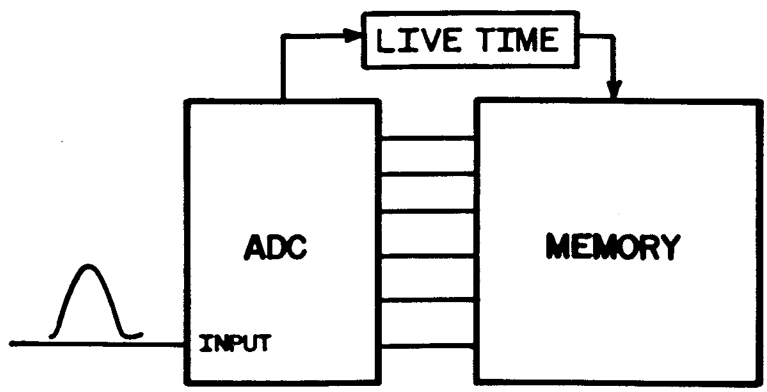


Figure 1.3. Block diagram of PHA components.

The Analog-to-Digital Converter (ADC) is a specialized and sophisticated component which is capable of rapidly and accurately measuring the peak height of input voltage pulses. The memory is composed of a series of 1024 data storage channels, each channel having a storage capacity of 10^6-1 counts. The ADC takes an analog voltage pulse from the detector/amplifier and converts it to a number of digital pulses; this number is proportional to the height of the pulse detected. The channel in memory whose address corresponds to this digital value is then incremented by one count. This convert-and-increment activity is triggered by the appearance of a voltage pulse of acceptable peak amplitude at the TN-1705/

1706 input.

Since the rate of count accumulation in any channel of memory is directly proportional to the frequency of occurrence of emissions detected within the corresponding energy interval, it follows that the net accumulation of counts in a spectral peak for a specific time interval can be directly related to the abundance of the emitter in the analyzed sample. However, since the analog-to-digital conversion process requires a finite amount of time to perform, there is a fraction of time during which the ADC is incapable of accepting further pulses. Since the input pulses appear at random intervals, a substantial fraction of the input pulses will arrive at the ADC while it is "busy", that is, incapable of accepting pulses. If uncompensated for, the effect of this "dead time" would be non-linearity of stored counts vs. input pulse rate. A solution to this difficulty is to inhibit the "live-time" clock while the ADC is incapable of processing inputs. Thus, for high input rates the live-time clock "ticks" proportionally slower, such that the live-time indication corresponds to the true analysis live-time. The operator can tell the TN-1705/1706 to keep track of analysis live time, or, since in some instances it is desirable to know the total elapsed time, the operator can tell the TN-1705/1706 to keep track of "clock time". In general, the elapsed clock time for an acquired spectrum will be somewhat greater than the live time indicated; clock time = live time + dead time. The TN-1705/1706 is also furnished with a % dead time meter.

1.4.1.1 PHA Parameters

From the preceding discussion it is clear that the goal of pulse height analysis is to measure the distribution of pulse heights. It is also apparent from comparison of figure 1.1b with figure 1.2b that the resolution of the acquired spectrum is a function of the size of the voltage divisions defining a channel. The full scale analog input range is fixed (0 to 8 volts), and the number of discrete ADC channels that the analog input range will be sorted into is referred to as the conversion gain. If the entire energy range from zero to full scale is to be analyzed, the operator selects a conversion gain value which matches the size of the memory he is using for data storage. Using a conversion gain of 1024 and a storage memory of 1024 channels means that the ADC divides the input signal range into 1024 equal sized intervals and that the full spectrum is stored in 1024 channels. A conversion gain of 1024 thus means that there are 1024 discrete peak amplitudes within the 0 to 8V input range which can be sensed. When the ADC detects a pulse at the input, it precisely measures its peak height and assigns it a numeric value ranging from 0 to the maximum value of 1023. Since the amplitude of the voltage pulse which comes out of the detector/amplifier is directly proportional to the energy of the detected radiation, and since the ADC measures the voltage pulse amplitudes with a resolution of 1024, it then follows that the energy of the detected radiation can be quantified to a resolution of one part in 1024. The same spectrum can be analyzed with half the resolution by using a conversion gain of 512 and a storage memory of 512 channels.

The operator might wish to analyze only a portion of the full spectrum at a higher level of resolution. For example, if a conversion gain of 2048 and a storage memory of 512 channels are selected, only one-fourth of the full scale spectrum is stored. That is, the ADC divides the input range into 2048 discrete intervals, but pulses occurring within only 512 of these discrete intervals are stored in memory. The stored spectrum now represents one-fourth of the full-scale spectrum, and each channel in the stored spectrum represents an energy interval which is one-fourth of that obtained with a conversion gain of 512. The conversion gain is thus a parameter which is selected according to the desired spectral resolution and the number of memory channels used.

Another PHA parameter is referred to as "Digital Zero Offset" (DZO). Until now, we have assumed that the ADC channels and the memory channels are numbered in the same way. Digital Zero Offset is a means of shifting the "zero" channel of the storage memory to correspond to a desired ADC channel. Thus, a Digital Zero Offset of 512 causes channel 512 of the ADC to be stored in the lowest channel (channel zero) of memory. There is a linear translation of scales such that channels 0, 1, 2, 3, . . . N of storage memory correspond to channels 512, 513, 514, . . . , 512 + N of the ADC. DZO is a useful parameter in that it allows one to study a portion of a spectrum at a higher level of resolution than would otherwise be possible for the same memory size. This is illustrated in figure 1.4 below. Figure 1.4a is the gamma-ray spectrum of radioactive Co^{60} taken with a NaI detector, using a conversion gain of 1024 and a 1024 channel storage memory.

Figure 1.4a.

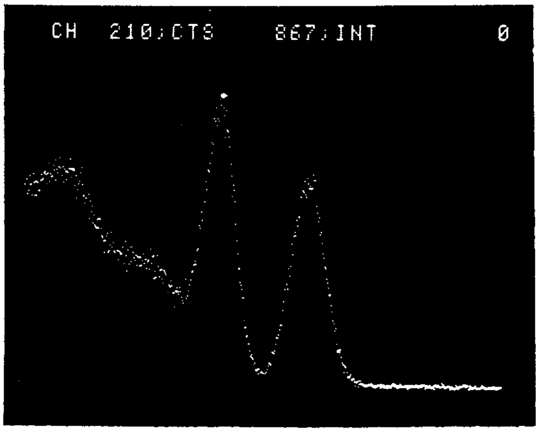


Figure 1.4b.

Figure 1.4b is the peak region of figure 1.4a acquired with a DZO of 1024, a conversion gain of 2048, and a storage memory of 1024 channels. The ADC has divided the full scale input range into 2048 discrete channels, but only ADC channels 1024 through 2047 are stored in the memory. Figure 1.4b represents one-half of the spectral energy range represented by figure 1.4a. Each memory channel in figure 1.4b represents an energy interval which is one-half of that energy interval represented by each channel in figure 1.4a. Thus, DZO and conversion gain can be used in combination to study a segment of the full scale spectrum at a higher level of resolution.

1.4.2 Multichannel Scaling (MCS)

MCS analysis yields a histogram representing frequency of occurrence (intensity) vs. elapsed time. The input signal is a train of pulses, each of which represents a single event. MCS analysis yields no information concerning the amplitude or width of these pulses; these are "logic" pulses in the sense that the occurrence of a pulse signals that an event has occurred. As pulses are detected at the TN-1705/1706 INPUT during MCS analysis, they are counted one-by-one into the current memory channel for a preset period of dwell time. At the end of each dwell interval, the MCS time base advances to the next memory channel address, which will now count pulses as they occur during the preset dwell interval. Each memory channel address is thus sequentially selected as a function of time.

Figure 1.5 illustrates MCS acquisition in simplified form. A series of incident logic pulses is shown in figure 1.5a. The contents in memory after one MCS sweep are shown in figure 1.5b. Note that an MCS analysis yields an integral histogram; each channel represents the integral summation of all counts within a time interval, not the instantaneous count rate. Thus the peak in channel 4 represents the five events which were detected during the interval T_4 - T_5.

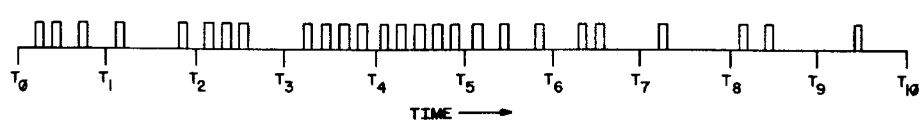


FIGURE 1. 5a. INCIDENT LOGIC PULSES

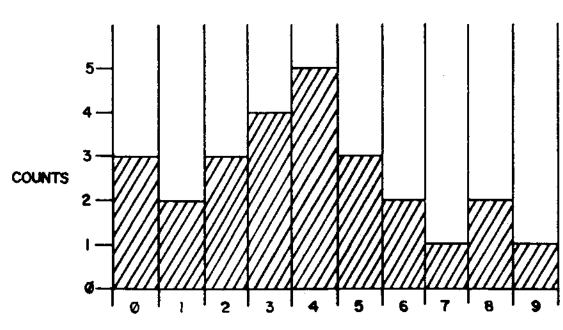


FIGURE 1.5b. MCS HISTOGRAM

MCS analysis finds use in several diverse applications involving the study of the distribution of events occurring as a function of time. One fundamental MCS application is the study of nuclear decay; the MCS histogram then represents the exponential decay curve.

Many other applications involve the synchronization of the MCS sweep to an external device. The channels of the MCS spectrum are then directly related to a position or condition of the external apparatus. Such applications include Mossbauer spectrometry, 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.

The choice of an appropriate MCS dwell interval is dependent upon several factors:

1. Desired time for entire sweep.
2. Number of channels used for storage.
3. Desired statistics (number of counts/channel).
4. Scan rate of an external device.

In some instances, several of these criteria may be incompatible. For example, the scan rate of the external device may be too rapid to allow collection of adequate statistics in one MCS sweep. In such cases, it may be possible to perform repetitive sweeps in order to build up an acceptable level of counts in each channel. This, of course, requires that the external device and the MCS sweep be precisely synchronized.

Synchronization of the MCS sweep to an external mechanism can be accomplished by choosing an appropriate dwell interval using the internal TN-1705/1706 clock. Alternatively, an external time base can be used to supply a channel advance pulse. An EXTERNAL DWELL ADVANCE signal can be supplied to the TN-1706 rear panel CONTROL SIGNALS connector to control the MCS experiment. For the TN-1705, EXTERNAL DWELL ADVANCE is available as an option.

SECTION TWO - INSTALLATION

2.1 Unpacking

Upon receiving the instrument, carefully inspect for any possible damage incurred during shipping. We recommend that all packaging materials be saved for possible future shipping of the instrument.

2.2 Warranty

The TN-1705 and TN-1706 analyzers and TN-1218 and TN-1314 modules are fully warranted against defective materials and workmanship for a period of one year. During the applicable warranty period repairs will be made without charge, provided that failures are not due to misuse of equipment. Tracor Northern reserves the right to determine whether equipment has been subjected to misuse. All equipment to be repaired will be repaired at Tracor Northern. All equipment to be returned for warranty service must be shipped freight prepaid, and only with prior approval from Tracor Northern.

2.3 Operating Voltage

TN-1705

The TN-1705 is delivered set for the AC line voltage and frequency anticipated in the user's working environment, usually 110 or 220 volt, 50 - 60 Hz. The Tektronix power supply transformer allows for conversion to different AC line conditions; refer to the Tektronix 5103 N Oscilloscope System Instruction Manual, pp. 2-1, 2, for such conversion procedures.

TN-1706

The TN-1706 and its associated modules draw their power from the NIM bin power supplies; the NIM bin connector busses supply power at the correct operating voltages for these NIM modules. Refer to your specific NIM bin literature for information regarding AC line connection and conversion procedures.

2.4 Operating Temperature

TN-1705

The TN-1705 may be operated in an environment where the ambient temperature ranges between +10°C and +40°C. A thermal circuit breaker in the Tektronix power supply provides thermal protection by disconnecting power to the instrument if the internal temperature exceeds a safe operating level. This cutout device will automatically re-apply power when the temperature returns to a safe level.

TN-1706

The TN-1706 and its associated NIM modules may be operated in an environment where the ambient temperature ranges between +10°C and +40°C. Most NIM bins are supplied with protection circuitry and temperature warning indicators.

2.4 Initial Connection and Power Start-Up

TN-1705

The TN-1705 is shipped from the factory in fully operational status; no further interconnections are necessary. The captive AC line cord should be plugged into a chassis ground (three prong) receptacle which applies the correct AC power.

If it is desired to incorporate standard Tektronix modules in the Tektronix mainframe for use as an oscilloscope, the TN-1705 plug-in module must be removed from the mainframe. To do this, first remove the cabinet panel on the right side of the Tektronix mainframe. The cabinet panels of the oscilloscope are held in place by slotted fasteners. Turn each fastener clockwise with a screwdriver or coin, and lift the panel away. Then unfasten the two screws which hold the black metal flange in place, as shown in figure 2.1 above. Once the metal flange is removed, the TN-1705 can easily be pulled out of the Tektronix mainframe. CAUTION: The POWER switch should be OFF when removing any modules from the Tektronix mainframe or whenever the oscilloscope side panels are removed.

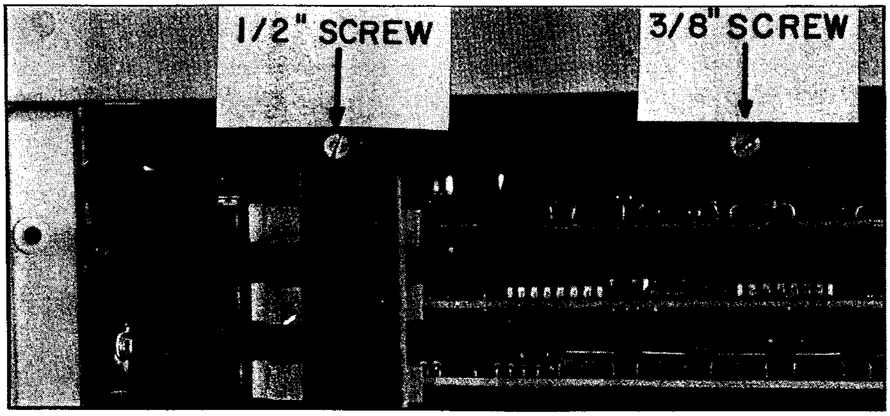


Figure 2.1.

TN-1706

Insert the TN-1706 and associated modules fully into the NIM bin. It is recommended that the bin power be OFF before inserting or removing modules. When using a portable mini or midi NIM bin which has its power transformer on the right side, we suggest that the TN-1314 Display Module be installed one or two NIM widths removed from the power transformer; this will ensure that the display will suffer no distortion due to a weak magnetic field generated by the transformer.

Interconnect the TN-1706 with the TN-1314 Display Module by using the cable provided. The cable connectors have keyed slots which assure correct orientation of the connectors.

SECTION THREE - TN-1705/1706 OPERATING CONTROLS

In order to use either the TN-1705 or TN-1706 to full capability, the operator must be familiar with the functions of all the operating controls. The purpose of this section is to describe the function of each of the controls for the TN-1705 and TN-1706 analyzers. With few exceptions, the TN-1705 and TN-1706 are identical with respect to control functions and labeling of controls. Any distinctions between TN-1705 and TN-1706 controls are clearly noted in appropriate subsections below. Included in this summary of control functions are controls for the TN-1314 NIM display module and the TN-1218 NIM preamp/amplifier.

We have arranged this treatment of control functions by starting with the source input and proceeding in the order in which the controls would be used in a typical experiment. Actual operating procedures are covered in Section Four of this manual.

3.1 Inputs and Analog Signal Modification Controls

3.1.1 TN-1705 INPUT and AMP-IN/OUT Controls

With the AMP toggle switch set to the IN position, the BNC connector labeled INPUT serves as the input to the TN-1705 internal preamp/amplifier. This input is provided for use with scintillation detectors such as NaI (Tl). The input stage is a charge-sensitive preamplifier designed for negative current pulses from a photomultiplier tube anode. RC pulse shaping is provided with 1.6 uSec time constant and pole-zero cancellation. Passive baseline restoration is provided.

With the AMP toggle switch set in the OUT position, the TN-1705 INPUT connector serves as the high-level input for an external amplifier and baseline restorer. Input levels may range from 0 to +10V, unipolar only; full scale input is 8V, with 25% overrange for use with digital offset. Input pulses must have a minimum duration of 1 uSec, rise time ranging from .1 to 5 uSec, fall time .1 to 10 uSec. Input impedance: 1K ohm. Coupling: direct. Internal delay: none.

The INPUT connector is used for MCS mode as well as PHA mode. For counting negative current pulses from a photomultiplier tube as a function of time during MCS analysis, the AMP switch is set to the IN position. With the AMP switch set to the OUT position, logic pulses (usually +3.5 to +5V) presented to INPUT are counted as a function of time. Maximum input frequency is 300 kHz. Double/multiple pulse resolution is 3.3 uSec.

3.1.2 TN-1218 Preamp/Amplifier INPUT and OUTPUT

The TN-1218 NIM preamp/amplifier is designed for use with the TN-1706 NIM analyzer, and is identical to the internal preamp/amplifier employed in the TN-1705 analyzer. Refer to the INPUT and AMP-IN discussion in 3.1.1 above for description of TN-1218 INPUT characteristics and specifications.

The TN-1218 OUTPUT is directly compatible with the TN-1706 INPUT connector. The OUTPUT impedance is 50 ohms, and the maximum pulse amplitude delivered to the TN-1706 1K ohm INPUT impedance is nominally 8V.

3.1.3 TN-1706 INPUT

The BNC connector labeled INPUT serves as the high-level input to the TN-1706 analyzer. This input is identical in all respects to the high-level input for the TN-1705; refer to the INPUT and AMP-OUT discussion in 3.1.1 above for description of TN-1706 INPUT characteristics and specifications.

3.1.4 GAIN

This control is a 10-turn Helipot used to adjust the gain of the TN-1705 internal preamp/amplifier or the TN-1218 preamp/amplifier. GAIN is adjusted such that the desired spectral energy range falls within the 0 to 8V full-scale input range of the ADC. The adjustment range is 20:1, maximum gain is 3.3V out per picocoulomb in.

3.1.5 LLD (Lower Level Discriminator)

This 10-turn Helipot control sets the lower energy limit for analog signals to be converted by the ADC during data acquisition. Input signals below the LLD setting are not converted by the ADC, and thus they contribute minimally to system dead time. The adjustment range is 0 to 100% of the full scale analog input range. In PHA mode the LLD is set to be above the level of input noise or unwanted signals. In MCS mode the LLD is used to establish the lower limit of the energy window to be scaled.

3.1.6 ULD (Upper Level Discriminator)

This 10-turn Helipot control sets the upper energy limit for analog signals to be converted by the ADC during data acquisition. The adjustment range is 5 to 125% of full scale analog input range. For PHA acquisition, dead time can be reduced considerably by adjusting the ULD to be just above the maximum signal of interest. In MCS analysis the ULD is used to set the upper limit of the energy window to be scaled.

3.1.7 Zero Intercept Control (Labeled "Z" on TN-1705, 20-turn screwdriver-adjustable potentiometer; labeled "ZERO" on TN-1706, 10-turn Helipot.)

This control adjusts the analog zero intercept of the ADC; the analog zero intercept is that analog input level which corresponds to channel zero (extrapolated) in the stored analysis. Adjusting the Zero control shifts the entire spectrum so that the unit can be calibrated to have 0 keV in channel zero. The adjustment range is -0.5% to +10%. This control is set at Tracor Northern and does not generally require field adjustment. Zero adjustment might be necessary if an external amplifier which has its DC zero level set greater than $\pm$ 50 mV is connected to the TN-1705/1706, or when precise zero energy intercept calibration is required. Refer to the APPENDIX of this manual for details on Zero Intercept Adjustment.

3.1.8 T (Threshold)

This 20-turn screwdriver adjustable potentiometer sets the threshold level for input pulses to be analyzed by the ADC. The function of Threshold is to discriminate the incoming signals from the low-level noise present in the system. For a given signal, system dead time begins with the rise-time of the signal above Threshold. Threshold is set at Tracor Northern and does not generally require field adjustment. Adjustment of the Threshold control is occasionally necessary when using an external amplifier; refer to APPENDIX for details on adjustment.

3.1.9 % DEAD TIME Meter

This meter indicates the percentage of time that the ADC is "busy" during data acquisition. This meter is a useful monitor of input source strength, and is also a useful monitor for making LLD, ULD, and T adjustments. The dead time per event (Fixed + Variable) is as follows:

Fixed: 2.2 uSec per conversion

Variable: (.02 N + bp) uSec, where N is the ADC channel in which the event was detected (ADC address), and bp is the input risetime from Threshold to peak amplitude.

The risetime for any signal above Threshold contributes to system dead time. If a signal falls below the LLD setting, it will not be converted by the ADC; however, the pulse duration between Threshold and LLD contributes to system dead time. For signals above the ULD setting, the contribution to system dead time is equal to signal time above Threshold.

3.1.10 GATE

This BNC connector provides for input of an external logic signal for coincidence or anticoincidence operation of the ADC. The BNC is normally biased in the anticoincidence mode, and must be brought to ground for coincidence operation. For operating details and timing requirements, refer to APPENDIX.

3.2 Analysis Setup and Data Acquisition Controls

3.2.1 MODE

This three-position selector switch selects the desired mode of data acquisition. PHA selects pulse height analysis. MCS selects multichannel scaling, preset for one sweep of the selected memory group. MCSR selects multichannel scaling-recurrent, that is, continuous MCS sweeps of the selected memory group.

3.2.2 HORIZONTAL FULL 1/2 2/2 COMPARE (Memory Group Selector)

This switch provides for selecting full memory or halves of memory for data storage, display, or output. FULL selects full memory, 1024 channels, numbered 0 through 1023. 1/2 selects first half of memory, 512 channels, numbered 0 through 511. 2/2 selects second half of memory, 512 channels, also numbered 0 through 511. If 1/2 or 2/2 is selected, it will be displayed to full horizontal scale on the CRT, just as FULL memory. COMPARE allows simultaneous full-scale display of first and second memory halves; second half is displayed above first half on the CRT.

3.2.2 OFFSET

This switch is used to select values of digital zero offset. Values of

OFFSET are selectable from 0 to 1792 in 256 channel steps. Selection of digital OFFSET shifts the zero channel of storage memory to correspond to a desired ADC channel. Counts detected in ADC channels lower than the selected offset value are not stored in memory. The OFFSET selector is used in combination with the CONVERSION GAIN selector to analyze a segment of the full-scale spectrum at higher resolution.

3.2.3 CONVERSION GAIN 512 1024 2048

This three-position selector switch is used to select the resolution of the ADC; the number of discrete intervals that the full-scale analog input range will be sorted into is a function of the setting of this switch. If the entire energy range from zero to full-scale is to be analyzed, the CONVERSION GAIN switch is set to the number which matches the size of the memory group selected. When the operator wishes to analyze a smaller segment of the full-scale spectrum with greater resolution, the CONVERSION GAIN switch is operated at a setting which is twice or four times the size of the memory group employed. For example, if a CONVERSION GAIN setting of 2048 is selected and FULL 1024 channel memory is used, the ADC will sort the full-scale spectrum into 2048 channels, but only half of the full-scale spectrum will be stored in memory. CONVERSION GAIN is thus set to correspond to the size of the data storage memory used and the spectral resolution desired.

3.2.4 PRESET

This four-position switch selects the desired preset mode of operation. With this control set in the LIVE position, PHA acquisition automatically terminates when the analysis live-time reaches the value selected by the TIME BASE controls. With this control set in the CLOCK position, PHA acquisition automatically terminates when elapsed clock time reaches the value selected by the TIME BASE controls. Elapsed live time or clock time is stored in channel zero of the selected memory group, depending upon whether the PRESET control was in the LIVE or CLOCK position at initiation of PHA acquisition. Channel zero is thus called the "time channel".

With PRESET set in the COUNT position, PHA acquisition terminates when any data channel within the selected memory group attains or exceeds the number of counts selected by the TIME BASE controls. With PRESET set in the CURSOR position, PHA acquisition terminates when the CURSOR channel attains or exceeds the number of counts selected by the TIME BASE controls.

The TN-1705/1706 thus stops data acquisition when the preset count is reached in the memory. The PRESET control tells the analyzer whether to look only at the time channel (PRESET-LIVE or CLOCK) in checking for a preset count, or to look only at the CURSOR channel, or to look at all channels except the time channel (PRESET-COUNT). Counts are stored in the time channel (channel zero) at a 1 Hz rate in the PRESET-CLOCK position. In the PRESET-LIVE position, system dead time is accounted for, so that the live-time recorded corresponds to the true analysis time.

3.2.5 TIME BASE Controls

These two switches are used to select values of preset time or preset counts for PHA acquisition and channel dwell times for MCS analysis.

Preset time or counts for PHA acquisition are selected by positioning the lower switch to one of the PHA labeled positions. The PHA values range from 10 to 100,000 (5 decades), times a multiplier of 1 through 9 (the upper selector switch serves as a multiplier). An infinity (∞) position is provided, allowing PHA acquisition to proceed unchecked. If a preset time of ∞ is selected, live-time or clock time is still stored in channel zero, but acquisition will not automatically terminate.

MCS channel dwell times are selected from the mSec-labeled positions. Dwell intervals thus may be selected from a range of 100 microseconds to 100 milliseconds (4 decades); this range is extended to 900 milliseconds by use of the 1 through 9 multiplier switch.

In addition, the MCS-TIME BASE positions determine the rate of PEN output to X-Y recorder device. Pen output rates are usually selected within the range of 20 mSec/channel (50 channels per second) to 500 mSec/channel (2 channels per second).

3.2.6 REGION : ENTER/ERASE (Optional)

This control provides for the setup of a spectral region of interest with lower and upper limits. The CURSOR is placed on that channel desired as the lower limit, and the REGION toggle switch is momentarily set to the ENTER position. The CURSOR is then moved to the desired upper limit and the switch is again momentarily set to the ENTER position. The region thus selected is visually defined on the CRT by intensified trace of the channels included within the region. The total number of counts (integral) contained within the region is read out on the CRT display as INT YYYYYYYY. The total integral counts capacity is 10^8-1.

Momentarily setting the REGION switch in the ERASE position erases the region previously selected, and a new region may then be selected.

The integral number of counts contained within the region of interest is stored in the last channel in memory, channel 1023 (which is labeled 511 when 2/2 of memory is used). The TN-1705/1706 can thus be set up to automatically terminate a PHA analysis when a selected region of interest reaches or exceeds a preset number of counts. This is done by setting up the region of interest, placing the CURSOR in channel 1023 (or 511 for 2/2 of memory), setting PRESET to the CURSOR position, and selecting the preset integral value with the TIME BASE selector switches. Note that this preset integral operation cannot be used for acquisition in 1/2 of memory. Note also that for preset integral operation, the intensified CURSOR point must be located in the last channel of the memory group selected. Rotating the CURSOR control beyond the last channel will cause the intensfied CURSOR point to move offscreen, although the alphanumeric readout still reads CH 1023 or CH 511. Preset integral operation cannot be implemented if the CURSOR intensified location is offscreen.

3.2.7 ADD/SUB Toggle Switch

This control selects additive or subtractive data acquisition. In the ADD position, new data adds to existing data in the memory for either PHA or MCS modes. In the SUB position, new data subtracts from previous data contained in the memory. This control allows for subtracting background from an acquired spectrum. (In either the ADD or the SUB position, the time channel accumulates additively.)

3.2.8 ACQUIRE Pushbutton

This control starts and stops data acquisition. ACQUIRE is illuminated only when data acquisition is in progress.

3.2.9 CLEAR DATA/TIME

Momentarily depressing this control to the CLEAR DATA position erases all data from the currently selected memory group. CLEAR TIME erases only the time channel (channel zero), which stores the elapsed PHA live time or clock time or the number of MCSR sweeps.

3.3 CRT Display Controls

The controls described below are used for adjusting and modifying the CRT display. Included are controls located on the TN-1705 and TN-1706 front panels, Tektronix 5103 mainframe, and TN-1213 NIM display module.

3.3.1 POWER (TN-1705)

This push/pull switch is located on the front panel of the Tektronix 5103 Oscilloscope mainframe. Pulling this switch out applies AC power to the TN-1705; pushing places the TN-1705 in an off state.

3.3.2 INTENSITY

This variable potentiometer control provides for adjusting the CRT display intensity for optimum visual definition and most pleasing display.

3.3.3 FOCUS

This variable potentiometer control provides for adjusting the CRT display focus for optimum visual definition.

3.3.4 VERTICAL SCALE

This nine-position rotary switch selects the full-scale count value. VERTICAL SCALE is adjusted to attain optimum peak display definition and to prevent count overflow. The maximum count capacity for any channel is 10^6-1 or 999,999. If any channel contains more than 10^6-1 counts or more counts than the current VERTICAL SCALE setting, the channel will "overflow". A peak in which this happens will show as having its top cut off and coming up again from zero. VERTICAL SCALE is changed during data acquisition such that the appropriate scale factor is chosen as data accumulates.

The VERTICAL SCALE control is also used to define the full-scale count value for data that will be output to PEN (X-Y recorder device). The CRT display and PEN output are both analog output devices.

3.3.5 CURSOR (10-turn Rotational Control)

Rotating this control moves the CURSOR (intensified point) to the desired channel. The CURSOR channel number is read out on the CRT, as well as the number of counts contained within the CURSOR channel (CH XXX ; CT YYYY).

3.3.6 HORIZONTAL O EXPAND ● POSITION

These are concentric potentiometer controls which provide for horizontal expansion and positioning of the CRT display. The outer EXPAND control allows expansion of the CRT display up to three times normal display scale. The inner POSITION control allows the operator to view any specific segment of the displayed spectrum at full expansion. These controls are primarily useful for expanding and positioning a limited portion of a spectral display so that individual peaks may be viewed in greater detail. Note that these controls have no affect on alphanumeric characters displayed.

3.3.7 VERT POS (Vertical Position; TN-1705 only)

VERT POS is a 20-turn screwdriver adjustable potentiometer. This control allows the operator to vertically position the CRT display to line up with the graticule baseline.

3.3.8 VERTICAL O SIZE ● POSITION (TN-1314 only)

These concentric potentiometer controls provide for vertical positioning and size adjustment of the TN-1314 CRT display. Alphanumeric characters displayed are affected by these controls.

3.3.9 EXT INTENSITY INPUT, BEAM FINDER, CALIBRATION (TN-1705 only)

Refer to the Tektronix 5103N Oscilloscope Instruction Manual for description of the functions of these controls. These controls are not used in basic TN-1705 operation.

3.3.10 TN-1314 DISPLAY MODULE (7-pin connector located on rear panel of TN-1706)

This connector provides for interconnection of the TN-1706 and the

TN-1314 Display Module. An identical connector is located on the rear panel of the TN-1314, and a cable is provided for interconnection.

3.4 Peripheral Input/Output Controls

3.4.1 I/O Peripheral Selector Switch

(labeled PEN OUT-ALL/SEL IN on TN-1705;
PEN OUT-ALL/SEL IN EXT on TN-1706)

This switch selects the mode of peripheral data input or output.

PEN selects analog output mode to X-Y recorder; the analog representations of the horizontal and vertical axes are routed to the I/O connector, and these voltages are used to drive an analog X-Y recording device.

OUT-ALL selects data readout to Teletype or parallel printer; all channels of the selected memory group are output to Teletype page printer or parallel printer device.

OUT-SEL reads out to Teletype or parallel printer only the channels contained within the region selected by REGION SELECT.

IN selects readin of data on punched paper tape previously output by the TN-1705/1706, or readin of data recorded on magnetic cassette tape via the optional TN-1114 Portable Cassette Data Recorder.

The TN-1706 EXT position is provided for future TN-1706 system expansion and development.

3.4.2 I/O 25-pin Connector (located on front panel of TN-1705, rear panel of TN-1706)

This connector provides for connection of peripheral input/output device (ASR-33 Teletype, X-Y recorder, parallel printer, magnetic cassette tape). Refer to APPENDIX for pin assignments and signal characteristics.

3.4.3 CAL XY FULL/ZERO

This momentary toggle switch allows the operator to calibrate the coordinates of his particular X-Y recorder to the full-scale and zero analog output levels of the TN-1705/1706. Depressing this control to the FULL position sends a +5V analog output level for both axes, corresponding to X_{max}, Y_{max} for the X-Y recorder. Depressing CAL XY to the ZERO position sends a nominal 0V analog output, corresponding to 0, 0 for the X-Y recorder.

3.4.4 I/O Pushbutton

This control initiates peripheral input and output operations, and is illuminated only during input/output operations.

3.4.5 X-Y RECORDER(7-pin Connector TN-1706 rear panel)

This connector provides for connection of an X-Y recorder to the TN-1706. Refer to APPENDIX for pin assignments and signal characteristics. These signals are also provided in the TN-1706 25-pin rear panel I/O connector.

3.4.6 CONTROL SIGNALS (15-pin connector, TN-1706 rear panel)

This connector provides for externally controlling and monitoring TN-1706 system operations. Refer to APPENDIX for pin assignments, characteristics, and operating details.

SECTION FOUR - OPERATING PROCEDURES

The purpose of this section is to outline operating procedures for the two modes of analysis and for the standard modes of peripheral input/output. We have presented these procedures in a sequential format, and we suggest that the reader follow these procedures step-by-step while actually operating the instrument.

4.1 Pulse Height Analysis

We will start with initial PHA setup, outlining the procedure for fundamental nuclear pulse height analysis. Subsections which follow list procedures for realizing maximum efficiency and the full capabilities of the TN-1705/1706 system.

4.1.1 Initial PHA Setup

1. Apply AC power to the TN-1705/1706. For TN-1705, pull POWER switch OUT. For TN-1706, place NIM bin POWER switch ON.
2. Momentarily depress the CLEAR toggle switch to the DATA position, then release. This erases any previous data.
3. TN-1705

   Set the AMP toggle switch to the appropriate position. When using the TN-1705 internal preamp/amplifier, set this toggle switch to the IN position. When using an external amplifier, set to the OUT position. Using a BNC coaxial cable, connect the signal source to the BNC connector labeled INPUT.

   TN-1706

   If using the TN-1218 preamp/amplifier, connect the output from the detector photomultiplier tube to the TN-1218 INPUT by means of a BNC coaxial cable. Connect the TN-1218 OUTPUT (or other amplifier OUTPUT) to the TN-1706 INPUT by means of a BNC coaxial cable.
4. Set the LLD one-quarter turn from its full counterclockwise position (25 setting on small dial).
5. Set the MODE selector switch to the PHA position.

6. Select the memory size to be used for data storage. Select FULL for full 1024 channel memory, 1/2 or 2/2 for first or second half of memory, 512 channels.
7. Set the CONVERSION GAIN switch to the position which matches the size of the storage memory used.
8. Set the OFFSET switch to the 0 position.
9. Set the lower TIME BASE control to the PHA- ∞ position. This will allow acquisition to proceed unchecked during initial setup.
10. Set the ADD/SUB toggle switch to the ADD position.
11. Depress the ACQUIRE pushbutton ON. This initiates the acquisition and display of a PHA spectrum.
12. Adjust the CRT INTENSITY and FOCUS controls for best visual definition. Also, set the VERTICAL SCALE control to choose the appropriate display factor while acquiring.
13. Adjust the amplifier GAIN control such that the spectral energy range desired for analysis falls within the 0 to 8V full-scale analog input range of the ADC. It is helpful to repeatedly CLEAR DATA while adjusting the amplifier GAIN; adjust the GAIN until the spectral energy range of interest is displayed.
14. Adjust the ULD such that the high energy region of the spectrum is being acquired to full scale.

The above sequence results in the storage and display of a PHA spectrum spanning the entire analog input range from zero to full scale.

COMMENTS:

The % DEAD TIME meter is a useful monitor of proper PHA setup. If the % DEAD TIME meter reads an excessively high value, the ADC may be triggering on noise. If the LLD is set at too low a level, input noise will exceed the discriminator level and trigger the ADC. Analysis of these useless noise pulses greatly increases ADC dead time. For best LLD adjustment, start with the LLD at its full counterclockwise position, turn the LLD clockwise until you observe a steep decrease from 100% dead time, then turn the LLD clockwise one-eighth turn above this point.

The ULD inhibits conversion of signals above the upper level setting. ADC dead time can be reduced substantially by adjusting the ULD to be just above the maximum signal of interest. While acquiring a PHA spectrum, adjust the ULD until a "cutoff" is observed at the desired upper limit of analysis; it is helpful to repeatedly CLEAR DATA while acquiring when making this ULD adjustment. At low count rates this adjustment is not important, but at high count rates considerable system dead time can be eliminated by proper setting of this control.

If the % DEAD TIME meter still reads close to 100% after making the appropriate LLD and ULD adjustments, or if the % DEAD TIME seems excessive for the source count rate, the instrument may require some adjustment of the T (Threshold) control. Refer to the APPENDIX of this manual for the correct T adjustment procedure.

Normally it is not necessary to adjust the Z (Zero Intercept) control on the TN-1705/1706, as this control is set at the factory. If precise zero energy intercept (0 keV in channel zero) calibration is required, follow the procedure outlined in the APPENDIX of this manual.

4.1.2 Higher Resolution PHA: CONVERSION GAIN and OFFSET Controls

Segments of the full scale PHA spectrum can be analyzed at higher resolution by using the CONVERSION GAIN and OFFSET controls in combination. To analyze a segment of the spectrum at a higher level of resolution, follow the procedure listed below.

1. With the CONVERSION GAIN switch set to the position which matches the size of the memory group being used, and with OFFSET set to 0, acquire a PHA spectrum.
2. Determine that area of the spectrum to be analyzed at higher resolution. CLEAR DATA and shift this spectral area into the lower half of the memory group by appropriately positioning the OFFSET switch.
3. Set the CONVERSION GAIN switch to the next higher position, and double the OFFSET setting.
4. After setting up the spectral region with the desired resolution by using the OFFSET and CONVERSION GAIN controls, the LLD and

ULD can be adjusted to reduce dead time. This is done by adjusting the LLD and ULD controls while acquiring the spectrum; the LLD and ULD should be set just below and above the desired spectral area. At low count rates, this adjustment is not important; however, at higher count rates, considerable dead time can be eliminated by rejecting input signals outside of the desired analysis region before they are converted by the ADC.

Figures 4.1 and 4.2 below illustrate the use of OFFSET and CONVERSION GAIN to obtain spectra of higher resolution. Figure 4.1 shows a full-scale PHA spectrum of Cs^{137}, taken with a NaI (Tl) scintillation detector and stored in 1/2 (first half) of memory, 512 channels. An OFFSET of 0 and a CONVERSION GAIN of 512 have been selected.

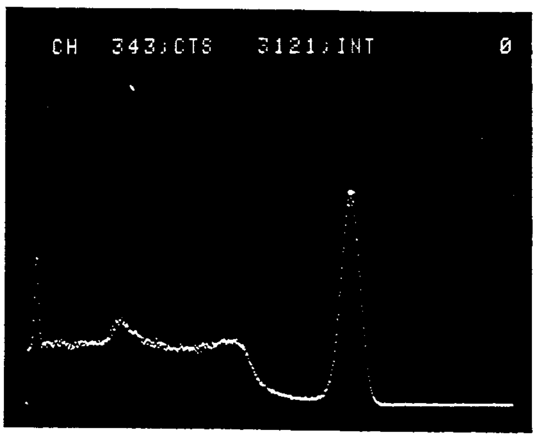


Figure 4.1.

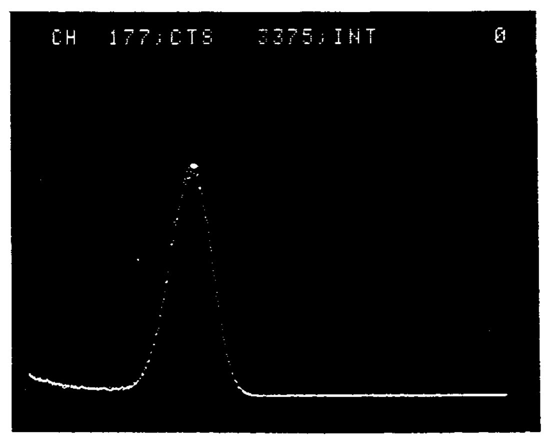


Figure 4.2.

Figure 4.2 shows the 662 keV peak region of the Cs^{137} spectrum. An OFFSET of 512 and a CONVERSION GAIN of 1024 have been selected. Thus, the full scale spectrum has been sorted into 1024 ADC channels, and ADC channels 512 through 1024 are stored in the memory. Since in figure 4.2 we have sorted the full scale spectrum into 1024 channels whereas in figure 4.1 we sorted the full scale spectrum into 512 channels, figure 4.2 has twice the resolution of 4.1. This means that each memory channel in figure 4.2 represents an energy interval which is one-half of that energy interval represented by each channel in figure 4.1. We are therefore analyzing and viewing the 662 keV photopeak in finer detail.

4.1.3 Preset Operation and Region Setup

The PRESET control selects the mode of automatic PHA termination, and the two TIME BASE controls select values of preset time or counts for automatic termination of PHA acquisition. Preset operation is quite straightforward and is adequately covered in subsections 3.2.4 and 3.2.5 of this manual.

The REGION option allows the operator to select a region of interest, with the integral number of counts contained in the region read out on the CRT display. Refer to subsection 3.2.6 of the manual for region of interest setup. Note that the REGION option allows the operator to select a preset integral value for PHA acquisition; acquisition is automatically terminated when the integral number of counts within the selected region equals or exceeds the value of the preset integral.

4.1.4 Background Correction

The ADD/SUB toggle switch allows the operator to correct for background counts internally by following a timed measurement of the sample of interest with a timed measurement of the background alone. During the background measurement, the 1705/1706 subtracts counts from the acquired spectrum of the sample + background.

1. With the toggle switch in the ADD position, acquire a PHA spectrum of the sample of interest + background. Acquire this PHA spectrum up to a preset live-time.
2. Depress CLEAR TIME, then release. This action erases elapsed live-time from channel zero.
3. With the toggle switch in the SUB position, acquire a PHA spectrum of background alone. Acquire this background spectrum up to the same preset live-time as the sample + background.

The spectrum that results is of the sample of interest only, with background effectively subtracted. If a region of interest had been set up with the REGION SELECT control, the INT readout will read the net integral counts above background.

4.2 Multichannel Scaling (MCS) Mode

In MCS mode the TN-1705/1706 functions as a series of 512 or 1024 scalers which sequentially count input pulses through intervals of selected dwell time. During each dwell interval, the pulses applied to the INPUT are counted one-by-one into the current memory channel; at the end of the channel dwell interval, the channel address selector is advanced to the next memory channel, which will now count pulses for the selected dwell interval. Dwell time intervals ranging from 100 microseconds to .9 seconds may be selected by appropriately positioning the MCS-mSec and 1 → 9 TIME BASE controls. (An external time base may be used to supply a channel advance pulse in lieu of the TN-1705/1706 internal time base. An EXTERNAL DWELL ADVANCE signal can be presented to the TN-1706 rear panel CONTROL SIGNALS connector to control the MCS experiment; refer to CONTROL SIGNALS in the APPENDIX of this manual. External Dwell Advance is available in the TN-1705 as an option.)

With the MODE selector in the MCS position, the TN-1705 performs a single multichannel scaling sweep of all selected memory channels, followed by an automatic stop. In some applications it may be necessary to perform repetitive sweeps; the MCSR (multichannel scaling-recurrent) mode permits continuous MCS sweeps. This means that the memory channels will be sequentially swept from 0 to 1023 (or 511), then reset to zero and swept up again to 1023 (or 511). MCSR acquisition is terminated manually by depressing the ACQUIRE pushbutton → OFF. Termination of MCSR acquisition is not synchronized to the end of sweep, and thus MCSR analysis may result in partial sweeps at the end of acquisition. The number of completed MCS sweeps is recorded in channel zero (the time channel) of the selected memory group.

For MCS analysis the LLD and ULD discriminators serve the function of defining the "energy window" for pulses to be counted. The discriminators then serve as a single channel analyzer (SCA); the function of a single channel analyzer is to set a lower and upper energy limit on energy events, thus allowing only events between these limits to be counted. The LLD and ULD, when serving as a single channel analyzer, become very useful for some MCS applications involving selective energy range studies. MCS mode is also frequently directed to applications involving the input of +3.5 to +5V logic pulses, which are counted as a function of time. In such applications, it is essential that logic 0 of the signal source be lower than the LLD setting; this will ensure that the desired input logic signals will be counted. The input pulse requirements for MCS analysis are as follows:

Input Pulse Amplitude: 0 to +10V
Maximum Frequency: 300 kHz
Minimum Pulse Duration: 1 uSec
Double/Multiple Pulse Resolution: 3.3 uSec

4.2.1 MCS Setup Procedure

1. TN-1705

   Place the AMP toggle switch in the appropriate position. When using the TN-1705 internal preamp/amplifier, place the toggle switch to the IN position. When using an external amplifier or logic pulse source, place to the OUT position. Connect the signal source to the TN-1705 INPUT by means of a BNC coaxial cable.

   TN-1706

   If using the TN-1218 NIM preamp/amplifier, connect the photomultiplier tube output to the TN-1218 INPUT by means of a BNC coaxial cable. Connect the TN-1218 OUTPUT or other amplifier/logic pulse source to the TN-1706 INPUT by means of a BNC coaxial cable.

2. Select the memory group to be used for data acquisition (FULL, 1/2, or 2/2).

3. At this time, define the "energy window" for input pulses to be counted during MCS analysis. This is done by first setting up the TN-1705/1706 for PHA acquisition, using an OFFSET of 0 and a conversion gain setting to match the size of the memory being used. Then, depress ACQUIRE → ON, and adjust the LLD and ULD to bracket the energy window for pulses to be scaled (it is helpful to repeatedly CLEAR DATA while acquiring and adjusting

LLD and ULD). See for example figure 4. 3 below; the FULL memory has been employed, with an OFFSET of 0 and conversion gain of 1024. The LLD and ULD have been set to bracket the Cs^{137} photopeak. Only pulses within this energy "window" will be scaled during subsequent MCS analysis. After establishing the energy window, depress ACQUIRE → OFF and CLEAR DATA.

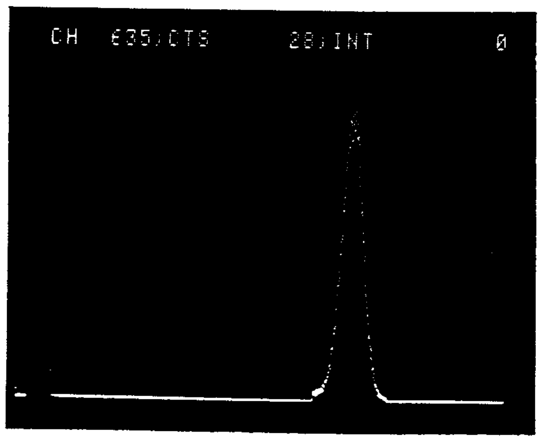


Figure 4. 3.

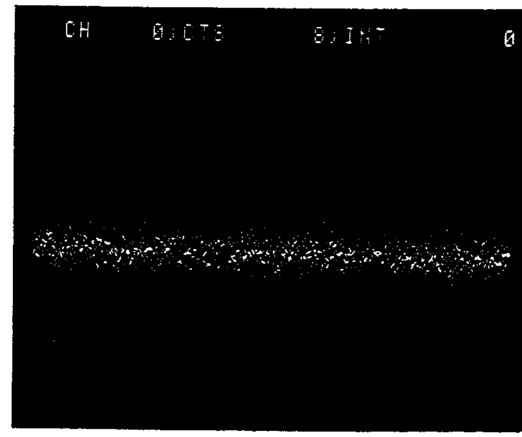


Figure 4. 4.

When presenting digital logic pulses directly to the INPUT (AMP → OUT position), it may not be necessary to follow this preliminary "window" setup procedure. However, following this procedure may help to ensure that only desired logic pulses will be counted during subsequent MCS analysis.

4. Place MODE selector switch to the MCS position (or MCSR if multiple MCS sweeps are desired).
5. Select the desired MCS channel dwell period by appropriately positioning the MCS-mSec and 1 → 9 TIME BASE selectors.
6. Depress ACQUIRE → ON. The TN-1705/1706 will now sequentially count pulses within each dwell interval until end of sweep. For MCS (single sweep), acquisition is automatically terminated at the end of sweep. For MCSR (multiple sweeps), acquisition is terminated manually by depressing ACQUIRE → OFF. Refer to figure 4. 4 above; MCSR has been selected, using FULL memory and a channel dwell interval of 30 mSec. Acquisition was manually

stopped after 8 sweeps. Note that the number of completed MCS sweeps is stored in channel zero (CH 0 ; CTS 8).

4.3 Peripheral Input/Output

The TN-1705 and TN-1706 provide as standard interface capabilities for ASR-33 teletype input/output and pen output to X-Y recorder or point plotter. The desired input/output mode is selected with the I/O peripheral selector switch. The I/O pushbutton switch initiates I/O operations and is illuminated during I/O operations. I/O operations cannot be initiated while data acquisition is in progress.

The 25-pin I/O connector provides for input from or output to peripheral device. Refer to APPENDIX of this manual for specifics regarding pin assignments and signal characteristics.

4.3.1 Teletype Output

With the I/O selector switch in either of the OUT positions (ALL or SEL), serial decimal information is presented to the I/O connector teletype interface. This information is sent to the teletype as a 20 milliampere pulse train. The TN-1705/1706 teletype interface operates in half-duplex format, that is, data is read out and read in on the same two lines. Any ASR-33 teletype supplied by Tracor Northern for use with the TN-1705/1706 is wired for 20 mA, half-duplex operation. If the operator has an ASR-33 teletype wired in some configuration other than 20 mA half-duplex, conversion to 20 mA half-duplex is easily accomplished; refer to specific teletype literature for this conversion procedure.

If OUT-ALL has been selected, then all data within the selected memory group is read out to the teletype page printer. If the TN-1705/1706 is equipped with the Region of Interest-Integration option, the selected region data can be output by setting the selector switch to the OUT-SEL position. For teletype output, the readout of only the selected region substantially reduces the time required for readout of meaningful data.

The procedure for teletype output is outlined below.

1. Connect the cable connector from the teletype device to the I/O connector.
2. Select OUT, ALL or SELect.

3. Apply power to the teletype device by placing its front panel control to the LINE position. Enable the punch if paper tape is desired. It is advisable to punch several frames of leader to facilitate future input of punched paper tape. Depressing the HERE IS key on the teletype device punches twenty frames of leader, null code 0.

4. Depress the I/O pushbutton. This initiates the readout of data to teletype device.

Below is an abbreviated sample Teletype OUT-ALL readout of one-half memory (512 channels), with explanatory labels added.

starting channel number for line of eight channels

eight channels per line

Ø	39	1Ø35	416	319	244	631	16647	22557
8	21328	18797	14693	11115	7878	5615	44Ø6	3476
16	2983	2837	2735	2826	278Ø	2822	2785	2729
24	277Ø	283Ø	2779	2735	2791	2775	2777	2768
32	2772	2687	2658	26Ø3	2738	2728	26Ø2	2557
4Ø	2581	2652	[illegible]	27Ø2	265[illegible]	2628	2467	2577
488	119	1Ø3	1Ø8	1Ø4	1Ø4	11[illegible]	99	[illegible]
496	1Ø9	97	94	99	82	99	87	84
5Ø4	9Ø	9Ø	85	89	97	77	82	1Ø4

At completion of data output, the I/O pushbutton automatically turns off.

A sample Teletype OUT-SEL readout is shown below, with explanatory labels added.

"Time Pass" readout; reads contents of channel zero (elapsed clock time, live time, or number of MCS scans).

INTEGRAL readout; reads total counts contained in selected region

T\P= 6Ø INTEGRAL= 158568

<SELECT REGION>

365	6198	6634	7Ø8Ø	7351	7921	7859	8181	8443
373	8646	8451	8422	8519	8369	8167	7925	7724
381	7228	7Ø11	665Ø	6125	5664			

All channel values within the region of interest are thus read out, followed by termination of output.

4.3.2 Teletype Input

With the I/O selector in the IN position, depressing the I/O pushbutton initiates the read-in of punched paper tape previously output by the TN-1705/1706. Previously punched tape is inserted in the reader of the teletype, and at initiation of input the data stored on tape is read back into the selected memory. It is not necessary to perform a CLEAR DATA step prior to initiation of TTY INPUT; each memory channel is automatically erased before the input data is stored in the channel. The Teletype INput procedure is outlined below.

1. Position leader frames over the teletype reader head (reader in FREE position).
2. Select IN.
3. Prepare teletype device (Teletype in LINE position, reader in STOP position).
4. Select memory area to be employed for data input (FULL, 1/2, or 2/2).
5. Depress the I/O pushbutton.
6. Place TTY reader switch to the START position. This begins the read-in operation. The TN-1705/1706 proceeds to read in the tape, line by line; each line is terminated by carriage-return code. To assist the operator in following the progress of the input operation, an intensified point is displayed at the corresponding memory location as each channel is stored. The read-in operation terminates when the selected memory configuration is filled or the operator depresses the I/O pushbutton OFF.

4.3.3 PEN Output (X-Y Recorder or Point Plotter)

The PEN position selects the output of analog data to X-Y recorder or point plotter. Full-scale output signals on the X and Y outputs are +5V. The CAL XY toggle switch allows the operator to calibrate his particular X-Y recorder to the full-scale and zero analog output levels of the TN-1705/1706. Refer to the I/O CONNECTOR SIGNALS listing in the APPENDIX of this manual for pin numbers and signal characteristics.

The MCS-mSec TIME BASE selectors are used to select the rate of analog data output to PEN device. An X-Y recorder which incorporates a null detector may be used for point-plotting a spectrum. However, the TN-1705/1706 does not work on the principle of "closed loop" plotting. That is, the TN-1705/1706 does not wait for a "plot complete" signal from the plotter device before advancing to the next channel; instead, the MCS-mSec TIME BASE is used to select the rate of channel advance for output to the plotter. The rate of pen output should thus be set to be compatible with the slewing speed and peak acceleration of the particular X-Y recording device employed.

The procedure for calibration and readout of data to the X-Y recorder is outlined below.

1. Connect X-Y recorder device to I/O connector (for the TN-1706, either the I/O connector or the X-Y RECORDER connector may be used).
2. Place I/O selector to PEN position.
3. Select the memory group to be output (FULL, 1/2, or 2/2).
4. Use the VERTICAL SCALE control to define on the CRT display the data that will be read out to the recorder. The CRT display and X-Y recorder are both analog output devices; if a peak shows overflow on the CRT, the recorder pen will "cut off" the peak at full scale.
5. Prepare recorder device (for TN-1140 series and Hewlett-Packard recorders, enable POWER, CHART, and SERVO → ON; recorder in SETUP mode, PEN → OFF).
6. Depress the CAL XY toggle switch to the ZERO position or adjust the recorder X and Y zero (or balance) controls to define the X = 0, Y = 0 location.

7. Depress the CAL XY toggle switch to the FULL position; this causes the TN-1705/1706 X and Y output signals to go to full scale (+5V). While holding CAL XY in the FULL position, adjust the X and Y gain (attenuator or vernier) controls on the recorder so that the pen is at desired full scale X = MAX, Y = MAX location.
8. Select the data output rate from the MCS-mSec TIME BASE selector. The pen output rate is usually selected within the range of 20 mSec/channel (50 channels per second) to 500 mSec/channel (2 channels per second); a rate of 100 mSec/channel (10 channels per second) is usually satisfactory for most X-Y recorders and point plotters.
9. Depress the I/O pushbutton → ON (recorder in RECORD mode, PEN enabled → ON).

The data channels are now plotted by the recording device. The I/O pushbutton automatically turns off and the output-operation is terminated after the last channel is plotted.

4.3.4 Parallel Printer Output (Option)

Output of data to parallel printer requires the optional TN-1705/1706-1 Parallel Printer Interface, which is compatible with Hewlett-Packard 5055A and Digitek model 6100 Parallel Printers.

1. Connect TN-1705/1706-1 Parallel Printer Interface to TN-1705/1706 I/O connector; connect the Parallel Printer Interface to parallel printer.
2. I/O Selector → OUT position, ALL or SEL.
3. Enable I/O pushbutton.

Each data channel is output on a separate line; the rate of data output is dependent upon the particular parallel printer employed.

APPENDIX

A.1 T (Threshold) and Z (Zero Intercept) Screwdriver Adjustments

Threshold and Zero Intercept controls are set at Tracor Northern and do not generally require further adjustment. However, since the INPUT is direct-connected, as are all internal analog circuits, it is possible for the signal source driving the ADC to disrupt proper operation. All adjustments made during check-out at the factory are made with a signal source whose baseline reference is 0.000V. Most spectroscopy amplifiers/baseline restorers have a front panel DC offset or zero adjustment. Adjusting this control for 0 $\pm$ 10 mV at the amplifier output will ensure proper ADC operation with no adjustment of T or Z necessary. If this amplifier adjustment cannot be made, the following adjustment procedures will ensure proper Threshold and Zero adjustment.

A.1.1 Threshold Adjustment. The function of Threshold is to discriminate the incoming signals from the low-level noise present in the system. Note that if the factory T setting is changed it should be rechecked if another signal source is used or if the amplifier DC offset is changed.

1. Set up the TN-1705/1706 for normal PHA acquisition.
2. Connect the amplifier output to the TN-1705/1706 INPUT (for TN-1705, place AMP toggle switch to OUT position).
3. Turn the LLD one full turn clockwise from its counterclockwise limit.
4. Remove radioactive source so that amplifier output is essentially noise only.
5. Depress ACQUIRE pushbutton (PRESET on infinity position).
6. Turn T full counterclockwise or until the % DEAD TIME meter reads 100%.
7. Adjust T clockwise until a steep decrease in % dead time is observed; the % DEAD TIME meter should read virtually 0% dead time.
8. Turn T one more turn clockwise.

9. Acquire data with a typical source at expected count rate and amplifier adjustments. Inspect the % DEAD TIME meter and if % dead time seems excessive for the count rate, turn T clockwise until ± 1/2 turn has little effect on % dead time. If more than one turn is required, check the amplifier pole-zero adjustment by using an oscilloscope and the amplifier manufacturer's instructions. Proper pole-zero adjustment is essential for proper ADC operation and dead time correction.

A. 1. 2 Zero Intercept Adjustment. The TN-1705/1706 zero control adjusts the analog zero intercept of the ADC; the analog zero intercept is that analog input level which corresponds to channel zero in the stored analysis (extrapolated). Signals below the zero level are not analyzed by the ADC. Adjusting the Z control shifts the entire spectrum so that the instrument can be calibrated to have 0 keV in channel zero. As the Z control is turned clockwise, the channel number for a given energy is decreased; this has the effect of shifting the entire spectrum to lower numbered channels.

If the amplifier connected to the TN-1705/1706 has its DC zero set reasonably close to 0V (± 50 mV) the Z control need not be changed unless true 0, 0 (0 keV in channel zero) is desired. For precise zero energy intercept adjustment, follow the procedure below.

1. Acquire a PHA spectrum containing two known reference energy peaks (e.g., Cs^{137}, 32 keV and 662 keV). For precision, the reference peaks selected should be as widely separate in energy as possible. Use no digital offset in PHA setup.
2. Calculate the keV/channel by dividing the energy difference of the two reference peaks by the number of channels separating the two peaks. Suppose for example that the Cs^{137} 32 keV peak centroid is in channel 58 and that the 662 keV peak centroid is in channel 1010. The difference in energy is 662 - 32 = 630 keV, and the number of channels separating the peaks is 1010 - 58 = 952; the energy-per-channel is thus 630/952 = .66 keV/channel.

3. Calculate the channel number that a particular reference peak centroid should be in to yield 0 keV in channel zero. This is obtained by dividing the reference peak energy by the energy-per-channel. In our example, 32 keV ÷ .66 keV/channel = channel 48.

4. Place the CURSOR in that channel (48 in our example). Acquire a spectrum and adjust the Z control until the reference peak centroid falls in the CURSOR channel. It is helpful to repeatedly CLEAR DATA while adjusting the Z control.

Note that changing the amplifier GAIN control effects a change in peak separation (keV/channel), while changing the Z control effects a uniform shift of the spectrum (energy peaks move with a fixed separation). A plot of energy vs. channel number would follow the equation for a straight line; that is,

$$y = m x + b$$

where y = energy, m = energy/channel (slope), x = channel number, and b = energy (y) intercept. Changing the amplifier GAIN control changes the value of m, while changing the Z control changes the value of b. In steps 3 and 4 above we have set b equal to zero.

A. 2 Coincidence/Anti Coincidence Operation

A front panel BNC labeled GATE provides for several specialized ADC functions:

1. Time-coincident ADC operation
2. DC control of ADC analysis
3. Sampling of DC inputs using a strobe pulse.

For time-coincident ADC operation, either coincidence or anti-coincidence mode operation is possible. The open-circuit voltage at the GATE input is approximately 3.5V (the input to a standard TTL gate). Coincidence operation is achieved by providing a low impedance to ground for the GATE input. Internally, the ADC linear gate is closed and all inputs are blocked. To analyze a desired input, a 3.5 to 5V positive pulse to the GATE must be provided in time-coincidence with the desired input. Timing requirements for the GATE input are as follows:

1. The leading edge of the positive gate pulse must precede the peak amplitude of ADC input by .5 uSec minimum.
2. Duration of the GATE pulse is not critical, but it must be long enough to bracket peak time of the ADC input and meet requirement 1. above.
3. Inputs applied during ADC busy will have no effect on analysis.

For anti-coincidence operation, the inhibiting pulse must be applied to the GATE input in time-coincidence with the undesired ADC input. The inhibiting pulse must switch from the quiescent 3 - 5V level to ground, with the following timing:

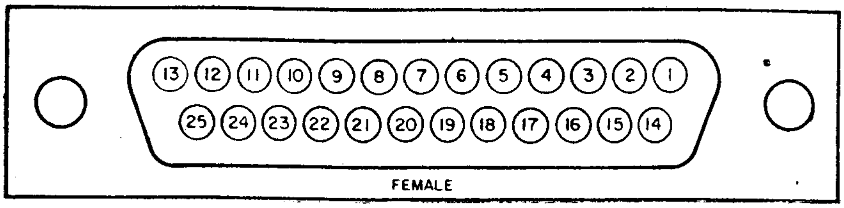
1. The anti-coincidence input pulse must be at 0V before the ADC input reaches the LLD threshold.
2. The duration of the pulse must completely bracket the baseline-to-baseline input pulse.
3. Failure to completely bracket the ADC input will produce low-level analyses which may be eliminated by increasing the LLD threshold.

DC control of analysis can be effected by grounding the GATE input for blocking analyses and releasing the input (or driving it to +3 to 5V) when analysis is desired. The analyzer must be placed in the ACQUIRE mode prior to using the GATE input for analysis control. The DC control of the ADC input does not also control the live time clock, so preset time is not preset analysis time.

The GATE input can also be used to sample DC or slowly varying AC signals which are connected to the ADC input. The GATE input is held at 0V in the quiescent state and a +3 to 5V pulse of .5 to 2 uSec duration is applied to "sample" the ADC input. The ADC will analyze positive inputs only; any negative portion of an AC signal will be rejected. Inputs to negative 10V will cause no damage. An analysis is triggered for each "sample" input unless the ADC is busy. Application during busy will not affect accurate conversion.

A. 3 CONNECTOR SIGNALS AND DESCRIPTIONS

TN-1705/1706 I/O CONNECTOR



Cannon DB-25S or Equivalent
Mating Connector Cannon DB-25P or Equivalent

Pin #	Signal	Description
1	TT OUT (EIA OUT)	Serial ASCII output for hard copy device. Normally supplied as 20 milliampere output for Teletype page printers. Optionally supplied as a voltage output for terminals such as the TI Silent 700 series.
2	TT IN (EIA IN)	Serial ASCII input from external device such as Teletype printers. Pins 1 and 2 are jumpered for half-duplex operation. Optionally supplied as EIA level compatible for devices such as the TI Silent 700 series.
3 4 5 6	Q1 Q2 Q4 Q8	Byte parallel output. Used for optional parallel printer interface TN-1705-1.
7	$\overline{\text{TRL}}$	Byte load strobe for Q1-Q8.
8	$\overline{\text{T GATE}}$	Data inhibit from Parallel Printer Interface.
9	+5S	5 volt power to parallel printer interface. Maximum load 10 milliamperes.
10	PPC	PRINT/PLOT COMMAND. Command causing printer to print a line of data or point plotter to plot XY point.
11	$\overline{\text{PEN}}$	Pen Enable - Quiescent +3.5V, 0 when true. Used to enable X-Y plotter or recorder for calibration or recording.
12	H PLOT	Horizontal (X axis) output for XY plotters and recorders. Nominally 0V to +5V F.S., Z_O=1K.
13	V PLOT	Vertical (Y axis) output for XY plotters and recorders. Nominally 0V to +5V F.S., Z_O=1K.

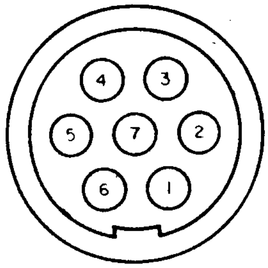
modified to 76·8 KHz (4800 BAUD)

14	$\overline{RC1}$	Remote Clock 1. When low, enables high-speed clock for EIA or TN-1114 magnetic cassette data recorder.
15	DIN	Data IN-Data input from TN-1114 tape recorder.
16	DO	Data OUT-Data to TN-1114 tape recorder.
17	CIN	Clock IN-Clock input from TN-1114 14 tape recorder.
18	CO	Clock Output-Clock output to TN-1114 tape recorder.
19	$\overline{RC2}$	Remote Clock 2. When low, enables high-speed clock for TN-1705/1706-1 Parallel Printer Interface. 50 KHz
20	N. C.	BRD E, 30A
21	N. C.	BRD E, 29A
22	N. C.	$\overline{ADIT}$ BRD B, 26A
23	N. C.	
24	N. C.	$\overline{SA9}$ BRD C, 5B (SEE HORIZONTAL SWITCH)
25	GROUND	

REMOTE REQUIRE (4J4)

4R3 — $\overline{ACC}$ MOTHER BOARD pin 1A on A or D CONNECTOR
Source is BRD D, U14, 8

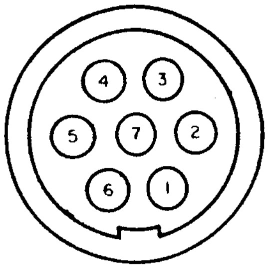
TN-1706 OUTPUT CONNECTOR TO TN-1314 DISPLAY MODULE



Rear Panel Amphenol 91-T-3478 Female Connector
Mating Connector: Amphenol 91-T-3475-1 or Equivalent

Pin #	Signal	Description
1	V	0 to 5V nominal Full Scale Vertical Deflection. Output impedance 100 ohms.
2	H	0 to 5V nominal Full Scale Horizontal Deflection. Output impedance 100 ohms.
3	N.C.	
4	CHAR	A logic 0 level (< .8V) allows character information to be displayed.
5	N.C.	
6	UNBLANK	TTL Logic 1 level blanks the display.
7	VGND, HGND	Shield conductor for Vertical and Horizontal analog signals.

TN-1314 DISPLAY MODULE INPUT CONNECTOR



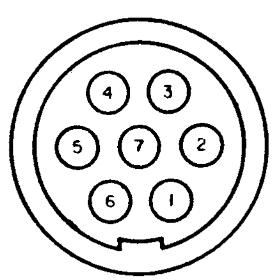
Rear Panel Amphenol 91-T-3478 Female Connector
Mating Connector: Amphenol 91-T-3475-1 or Equivalent

Pin #	Signal	Description
1	V	0 to 5V nominal Full Scale Vertical Deflection, 10K input impedance.
2	H	0 to 5V nominal Full Scale Horizontal Deflection, 10K input impedance.
3	N.C.	
4	CHAR	A Logic 1 level (<.8V) allows character information to be displayed.
5	N.C.	
6	UNBLANK	TTL Logic 1 level blanks the display.
7	VGND, HGND	Shield conductor for Vertical and Horizontal analog signals.

TN-1706 X-Y RECORDER OUTPUT CONNECTOR

Rear Panel Amphenol 91-T-3478 Female Connector
Mating Connector: Amphenol 91-T-3475-1 or Equivalent

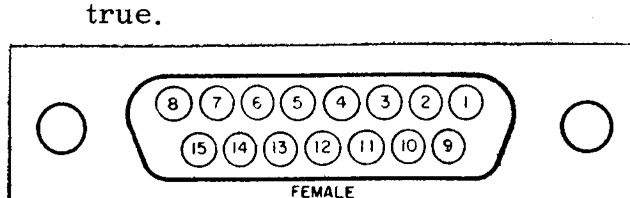
Pin #	Signal	Description
1	H PLOT	Horizontal (X-axis) output for X-Y recorders and point plotters. Nominally 0V to +5V Full Scale, Z_O=1K.
2	V PLOT	Vertical (Y-axis) output for X-Y recorders and point plotters. Nominally 0V to +5V Full Scale, Z_O=1K.
3	$\overline{\text{PEN}}$	Pen Enable signal, quiescently +3.5V, 0V when true. Used to enable X-Y recorder or plotter for recording or calibration.
4	$\overline{\text{PPC}}$	Point Plot Command. Command causing point plotter to plot an X-Y point.
5	N.C.	
6	N.C.	
7	GND	



TN-1706 CONTROL SIGNALS CONNECTOR

Rear Panel Amphenol 91-T-3478 Female Connector
Mating Connector: Amphenol 91-T-3475-1 or Equivalent

Pin #	Signal	Description
1	$\overline{\text{STA}}$	Analysis Control. When brought low this signal will cause the analysis to change state (enable or disable acquisition). This pulse should be driven from an open-collector source, and should be a minimum of 15 uSec wide. This input is disabled if the analyzer is engaged in an I/O operation.
2	$\overline{\text{STR}}$	Input/Output Control. When brought low this signal will cause the I/O operation to change state (either enable or disable I/O operation). This signal should be driven from an open-collector source and should be a minimum of 15 uSec wide. This input is disabled if the TN-1706 is engaged in an Acquire operation.
3	$\overline{\text{A+R}}$	System Inactive. This output is low when the analyzer is not engaged in an Acquire or I/O operation and positive at all other times.
4	$\overline{\text{ACQ}}$	Acquisition Status Flag. This output is low whenever the analyzer is engaged in an acquisition and high at all other times.
5	$\overline{\text{RO}}$	I/O Status Flag. This output is low whenever the analyzer is engaged in an I/O operation and high at all other times.
6	$\overline{\text{CHO}}$	Channel Zero. When the signal is low, the current MCS memory address is at the least significant location for the memory group selected. This signal is only meaningful during MCS mode acquisition, and is a useful external time pass monitor.
7	$\overline{\text{INH ADV}}$	Inhibit Address Advance. Holding this line low inhibits address advance during MCS mode acquisition.
8	$\overline{\text{ADV}}$	External Address Advance. External address advance for MCS mode. Should be used only when INH ADV is true.



9 10	M8 M9	Two most significant address bits indicating which quarter or half of memory is being accessed. Meaningful only for MCS mode acquisition, and useful for monitoring Mossbauer spectrometry experiments.

Signal Logic Level		Memory Area Accessed
M9	M8	Memory Area Accessed
1	1	768 - 1023
1	0	512 - 767
0	1	256 - 511
0	0	0 - 255

11	SCA	Single Channel Analyzer output pulse. Delivers a logic pulse (3.5V) for any event occurring within the LLD and ULD window.
12	$\overline{\text{AOFT}}$	Address Reset. Usable for resetting the address during recurrent MCS acquisition.
13	Undefined	
14	N.C.	
15	GND	