INSTRUCTION MANUAL

TC 862

TAC

Oxford Instruments Inc
Nuclear Measurements Group
601 Oak Ridge Turnpike, Oak Ridge, TN 37831-2560
Telephone (615) 483-8405 ■ Fax (615) 483-5891

N862MT00F01

1.0 INTRODUCTION

The TENNELEC model TC 862 Time-to-Amplitude Converter (TAC) provides a 0 to 10 volt full-scale output signal proportional to the time difference between the START and STOP input signals. Housed in a single-width NIM module, the TC 862 is useful in such applications as laser induced florescence spectroscopy with microchannel plate (MCP) detectors, position sensitive proportional counter systems, and time-of-flight and positron lifetime measurements. In addition to its superior performance specifications, several new features make the TC 862 easier and more convenient to use.

Twelve full-scale time ranges are available from 25 nanoseconds (nsec) to 3 milliseconds (msec). A selectable x10 multiplier with LED indicator provides access to the longer time ranges. Each time range is continuously variable from 0.5 to 1.5 times the selected full-scale range via a front-panel mounted ten-turn precision potentiometer. This exclusive feature is valuable in position sensitive proportional counter systems as it eliminates the need for a biased amplifier in many applications. The usable time range extends from 5 nsec to 3 msec, thus providing a useful dynamic range of 600,000:1.

Superior performance features make the TC 862 the TAC of choice for critical time measurements. The differential nonlinearity is less than $\pm$1% from 10 nsec (or 2% of full scale, whichever is greater) to 100% of full scale. Integral nonlinearity is less than $\pm$0.1% over the same time range. Time resolution is less than 0.01% of full scale plus 5 picoseconds (psec) FWHM. The TC 862 START and STOP inputs will respond to input pulses as narrow as 1 nsec with a pulses-pair resolution of 5 nsec, thus equating to a periodic count rate capability of 200 MHz.

An adjustable output delay of 0.25 to 25 microseconds (usec) and variable output pulse width of 1 to 10 usec allows the experimenter to optimize timing parameters and adapt the TC 862 to a wide range of Analog-to-Digital Converters (ADCs). A three-position front-panel switch selects OFF, COINCidence or ANTIcoincidence input gating. A rear-panel switch selects either INTernal or EXTernal output STROBE mode for further flexibility.

Ease and convenience of use are stressed in the TC 862. Five LED indicators allow the unit to be quickly set up and provide valuable information on the correct functioning of the TC 862. A x10 multiplier LED, when activated, indicates that the top six time ranges are effectively extended by a factor of ten. OVER RANGE and VALID CONVersion LEDs assist in selecting the proper time range for an experiment. The % BUSY bicolor LED monitors overall deadtime and gives positive visual feedback of TAC pulse processing capability. A TAC OUTput LED serves to verify that the entire timing system is providing output pulses within the selected time parameters.

2.0 SPECIFICATIONS

2.1 PERFORMANCE

TIME RANGES	Twelve basic time ranges in a 1-2-5 sequence with internally selectable x10 multiplier and continuously variable x0.5 to x1.5 multiplier. Full-scale range is continuously variable from 25 nsec to 3 msec.
TIME RESOLUTION	Less than 0.01% of full scale plus 5 psec FWHM on all ranges.
DIFFERENTIAL NONLINEARITY	Less than $\pm$1% from 10 nsec (or 2% of full scale, whichever is greater) to 100% of full scale. Less than $\pm$2% between 5 and 10 nsec on the 50 and 100 nsec base RANGE selections.
INTEGRAL NONLINEARITY	Less than $\pm$0.1% from 5 nsec (or 2% of full scale, whichever is greater) to 100% of full scale.
MINIMUM USEFUL CONVERSION TIME	5 nsec.

CONVERTER RESET TIME

BASE RANGE (usec)	RESET TIME (usec)
0.05	0.5
0.1	0.65
0.2 to 2	0.75
5 to 200	1.0
50 to 2k (with x10 MULT)	5.0

TAC OUTPUT TEMPERATURE INSTABILITY	Less than ±0.01%/°C of full scale (or ±10 psec/°C, whichever is greater).
OPERATING TEMPERATURE RANGE	0 to 50 °C.

2.2 CONTROLS AND INDICATORS

2.2.1 FRONT-PANEL CONTROLS AND INDICATORS

RANGE	Twelve-position rotary switch selects basic full-scale time ranges from 0.05 to 200 usec in a 1-2-5 sequence. An internal x10 multiplier jumper extends the upper six ranges to cover 50 to 2k usec full scale. A front-panel multiplier control allows the basic time range to be varied over a x0.5 to x1.5 range.
X10	A Red LED illuminates to indicate that the x10 RANGE MULTiplier is active on the upper six time RANGEs.
MULTIPLIER	Continuously variable ten-turn control varies the full-scale time of the TAC from 0.5 to 1.5 times the selected basic RANGE.
OVER RANGE	A red LED illuminates to indicate that the previous conversion exceeded the full-scale time range of the TAC.
VALID CONV	A red LED illuminates to indicate that the previous conversion was within the full-scale time range of the TAC.
% BUSY	A multi-color LED illuminates to provide visual feedback of the relative conversion rates. This indicator appears green for low conversion rates, yellow for medium conversion rates and red for high conversion rates.

OUTPUT DELAY — Multi-turn screwdriver adjustable control logarithmically adjusts the output delay interval from 0.25 to 25 usec. Interval is triggered at valid conversion. Control functions as a variable reset-delay-interval in the external strobe mode.

OUTPUT WIDTH — Multi-turn screwdriver adjustable control logarithmically adjusts the output pulse width from 1 to 10 usec for compatibility with various ADCs. Output is internally triggered following the output-delay-interval when operated in the internal strobe mode and externally triggered during reset delay interval when operated in the external strobe mode.

COINC-OFF-ANTI — Three-position toggle switch selects input gating mode. The COINCidence mode requires that the START input occur during a GATE interval for the event to be processed. The ANTIcoincidence mode requires that the START input not occur during a GATE interval for the event to be processed. The OFF position disables the gating function such that all events are processed.

TAC OUT — A red LED illuminates to indicate that a converted event is being output from the TAC. This serves as an overall indication that the timing system is functioning.

2.2.2 REAR-PANEL CONTROLS

INT-EXT — Two-position toggle switch selects either INTernal or EXTernal strobe operation. Internal strobe automatically generates an output following the OUTPUT DELAY interval. External strobe allows external initiation of the output signal during the adjusted reset-delay-interval (OUTPUT DELAY).

LOGIC POWER — Two-position locking toggle switch selects operating power from the ±6 or ±12 volt power supply bus. The module exceeds the single-width NIM current allotment for ±12 volts when operated in the ±12 volt position; however, when operated in the ±12 volt position a ±6 volt power supply is not required. The module is within the single-width NIM current allotment on ±12 volts when operated in the ±6 volt position. The module exceeds the single-width NIM current allotment for +24 volts in either LOGIC POWER switch position.

2.2.3 INTERNAL CONTROLS

RANGE MULT — Three two-position jumpers select either the base (x1) range or the extended (x10) range for the upper six positions of the RANGE control. All three jumpers MUST be set to the same position to ensure proper operation of the unit. A front-panel LED illuminates to indicate that the selected time range is extended by a factor of ten (x10).

GATE — Two-position jumper selects either positive (+) NIM-standard input logic levels with a 1k ohms input impedance or negative (-) NIM-standard input logic levels with a 50 ohms input impedance.

START — Two-position jumper selects either positive (+) NIM-standard input logic levels with a 1k ohms input impedance or negative (-) NIM-standard input logic levels with a 50 ohms input impedance.

STOP — Two-position jumper selects either positive (+) NIM-standard input logic levels with a 1k ohms input impedance or negative (-) NIM-standard input logic levels with a 50 ohms input impedance.

RESET	Two-position jumper selects either positive (+) NIM-standard input logic levels with a 1k ohms input impedance or negative (-) NIM-standard input logic levels with a 50 ohms input impedance.
STROBE	Two-position jumper selects either positive (+) NIM-standard input logic levels with a 1k ohms input impedance or negative (-) NIM-standard input logic levels with a 50 ohms input impedance.
VLD START	Two-position jumper selects either true (active high) or compliment (active low) logic for the VALID START OUTput. Logic levels are positive NIM-standard in either jumper position.
VLD CONV	Two-position jumper selects either true (active high) or compliment (active low) logic for the VALID CONVersion OUTput. Logic levels are positive NIM-standard in either jumper position.
Z_o	Individual two-position jumpers selects either <1 ohms or 50 ohms output impedance for the front- and rear-panel TAC OUTput connectors.

2.3 CONNECTORS

The following inputs are dc-coupled and have PCB-mounted jumpers to select either negative or positive NIM-standard input logic levels. All are leading-edge triggered with thresholds of approximately -350 mV for negative input mode and +1.5 V for positive input mode. Input impedance is 50 ohms for negative input mode and 1k ohms for positive input mode.

2.3.1 FRONT-PANEL CONNECTORS

GATE IN	BNC type connector accepts NIM-standard logic signals which enable or disable the START input. The gate input must occur a minimum of 5 nsec before the START input and extend a minimum of 5 nsec past the trigger edge of the START signal. The GATE INput is selectable as either NIM positive logic levels or NIM negative logic levels by an internal GATE (+ or -) jumper.
START IN	BNC type connector accepts NIM-standard logic signals which initiate a timing interval. The start signal must have a minimum pulse width of 1 nsec at -350 mV and a minimum pulse spacing of 5 nsec. The START INput is selectable as either NIM positive logic levels or NIM negative logic levels by an internal START (+ or -) jumper.
STOP IN	BNC type connector accepts NIM-standard logic signals which terminate a timing interval. The stop signal must have a minimum pulse width of 1 nsec at -350 mV and a minimum pulse spacing of 5 nsec. The STOP INput is selectable as either NIM positive logic levels or NIM negative logic levels by an internal STOP (+ or -) jumper.
TAC OUT	BNC type connector provides a positive 0 to 10 volt signal proportional to the time difference between the START and STOP inputs. The output pulses are near-rectangular shape with a 0.4 usec rise/fall time and and adjustable 50%-amplitude-width of 1 to 10 usec. Selectable output impedance of either <1 ohms or 50 ohms. Output has a dc level of 0 $\pm$ 5 mV and is short circuit protected.

2.3.2 REAR-PANEL CONNECTORS

TAC OUT	Refer to TAC OUT of Sec. 2.3.1.
VALID START OUT	BNC type connector provides a positive NIM-standard logic signal that goes true upon acceptance of a START input signal and returns to the false condition after reset of the converter circuit. The overall pulse width while true represents the instrument busy time. The output is internally selectable as either true (active high) or compliment (active low) logic. The output is dc-coupled and has an output impedance of 50 ohms.
VALID CONV OUT	BNC type connector provides a positive NIM-standard logic signal that goes true upon acceptance of a STOP input signal if the start-to-stop time interval was within the selected conversion range. The VALID CONV OUT returns to the false condition after reset of the converter circuit. During external strobe operation, this output indicates that a valid time interval has been converted and the module is awaiting an external strobe input to initiate the TAC OUTput. The output is internally selectable as either true (active high) or compliment (active low) logic. The output is dc-coupled and has an output impedance of 50 ohms.
RESET IN	BNC type connector accepts NIM-standard logic signals which abort the conversion in progress and inhibits further conversions while the reset signal is present. The reset signal must have a minimum pulse width of 50 nsec. The RESET INput is selectable as either NIM positive logic levels or NIM negative logic levels by an internal RESET (+ or -) jumper.

	STROBE IN	BNC type connector accepts NIM-standard logic signals which initiate a TAC OUTput pulse when operating in the external strobe mode. Triggered by a low-to-high transition during the reset-delay-interval (OUTPUT DELAY) or a logic true present at the start of the reset-delay-interval. The strobe signal must have a minimum pulse width of 50 nsec. The STROBE INput is selectable as either NIM positive logic levels or NIM negative logic levels by an internal STROBE (+ or -) jumper.

2.4 LOGIC SIGNAL LEVELS

2.4.1 INPUT LEVELS

Each input of the TC 862 will accept either NIM-standard positive logic levels or NIM-standard negative logic levels as selected by an internal jumper. The positive logic threshold (+1.5 V) is compatible with both NIM-standard positive logic and TTL levels. The negative logic threshold (-350 mV) is optimized for operation with fast NIM-standard negative logic signals. Logic inputs are protected to ±25 volt overloads.

2.4.2 OUTPUT LEVELS

Each logic output of the TC 862 provides signal levels which are compatible with either NIM-standard positive logic or TTL requirements. Each output can be selected as either true (active high) or compliment (active low) logic by an internal jumper. Logic outputs have an output impedance of 50 ohms, dc-coupled.

2.5 POWER REQUIREMENTS

	Logic Power Switch Position ±6 V	±12 V
+24 V	120 mA	120 mA
-24 V	70 mA	70 mA
+12 V	150 mA	370 mA
-12 V	165 mA	565 mA
+6 V	220 mA	not used
-6 V	400 mA	not used

2.6 OTHER INFORMATION

WEIGHT	(Shipping)	4.0 lbs. (1.8 kg)
	(Net)	2.0 lbs. (0.9 kg)
DIMENSIONS	NIM-standard single width module (1.35 x 8.714 in.) per TID 20893 (Rev.).	
INSTRUCTION MANUAL	One provided with each instrument ordered.	

3.0 INSTALLATION

3.1 POWER CONNECTION

The TC 862 Time-to-Amplitude Converter (TAC) requires a NIM-standard Bin and Power Supply, such as the TENNELEC TB 4 / TC 911 Turbo, for operation. The bin provides mechanical mounting and power supply distribution. Always turn OFF the bin power supply when inserting or removing any modules.

The TC 862 requires a large amount of power due to the fast ECL logic used in the front-end. The LOGIC POWER switch allows the user to select whether the power for the ECL logic is drawn from the ±12 or ±6 volt power supplies.

In applications where ±6 volts is not available from the NIM Power Supply the unit MUST be operated with the LOGIC POWER switch in the ±12 volt position.

If the NIM Power Supply has ±6 volts available, then the user can choose whether the power for the logic is drawn from the ±6 or ±12 volt supplies. If the NIM Bin contains a lot of modules which require high current from the ±6 volt supplies, then it may be advantageous to power the TAC's logic from ±12 volts.

3.2 SELECTING INPUT LOGIC LEVELS

Each input of the TC 862 will accept either NIM-standard positive logic levels (0->+5V) or NIM-standard negative logic levels (-16mA into 50 ohms) as selected by an internal jumper. The positive logic (+) position's threshold (+1.5V) is compatible with both NIM-standard positive logic and TTL levels, and has an input impedance of 1k ohms. The negative logic (-) position's threshold (-350mV) is optimized for operation with fast NIM-standard negative logic signals, and has an input impedance of 50 ohms.

The input mode is selected by removing the unit's right side shield (as viewed from the front of the module) and moving the appropriate jumper to the required position.

POSITIVE

NEGATIVE

Fig. 3.2 Typical Input Polarity Selection

3.3 SELECTING TRUE OR COMPLEMENT LOGIC OUTPUTS

Each logic output of the TC 862 provides signal levels which are compatible with either NIM-standard positive logic or TTL requirements (0 -> +5V). Each output can be selected as either true (+ selects active high) or compliment (- selects active low) logic by an internal jumper. Logic outputs have an output impedance of 50 ohms.

The output mode is selected by removing the unit's right side shield (as viewed from the front of the module) and moving the appropriate jumper to the required position.

TRUE

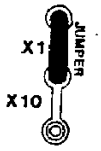
COMPLIMENT

Fig. 3.3 Typical Output Mode Selection

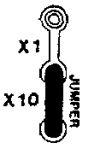
3.4 SELECTING INTERNAL RANGE MULTIPLIER

The TC 862 contains three internal two-position jumpers which allow the upper six RANGE switch positions to be extended by a factor of ten (x10). A front-panel indicator illuminates whenever the jumpers are in the x10 position and one of the upper six RANGE positions is selected.

The RANGE MULTiplication is selected by removing the unit's right side shield (as viewed from the front of the module) and moving all three jumpers to the required position. **ALL THREE JUMPERS MUST BE SET TO THE SAME POSITION (x1 or x10) FOR PROPER OPERATION OF THE UNIT.**



x1 RANGE



x10 RANGE

Fig. 3.4 Selecting Range Multiplication

3.5 SELECTING LINEAR OUTPUT IMPEDANCE

Individual two-position jumpers selects either <1 ohm or 50 ohms output impedance for the front- and rear-panel TAC OUTput connectors.

Series 50 ohm termination is recommended for general applications and is required for long cable lengths and/or high noise environments. In extreme situations series termination along with shunt termination at the receiving end may be required; however, this reduces the signal amplitude at the receiving end of the cable to 50% of the non-shunt-termination value. An inline 50 ohm terminator or BNC Tee and 50 ohm terminator may be used for shunt termination.

The <1 ohm termination is useful when driving several instruments from the same TAC OUTput connector. The output signal amplitude will be relatively independent of the load impedance, which is not the case with series 50 ohm termination; however, the TAC OUTput may oscillate when driven into overload.

When the TAC must drive two instruments, use both the front- and rear-panel TAC OUTputs with each set for series 50 ohm termination.

<1 OHM 50 OHM

Fig. 3.5 Selecting TAC Output Impedance

4.0 OPERATING PROCEDURES

4.1 FULL-SCALE TIME RANGE SELECTION

The full-scale time range of the TC 862 is continuously variable from 25 nsec to 3 msec. The full-scale time range is the product of the front-panel RANGE and MULTIPLIER controls along with the internal RANGE MULTiplier jumpers. For example, a RANGE of 0.1 usec times a MULTIPLIER of 1.25 times a RANGE MULTiplier of xl results in a full-scale time range of 125 nsec.

The full-scale time range is the time difference between the START and STOP inputs that results in a positive 10 volt signal at the TAC OUTput.

Many ADC's have a full-scale input range of 8 volts. The variable MULTIPLIER control allows the TAC's output signal to be compressed such that the timing spectrum occupies a 0 to 8 volt span. Setting the TAC for 1.25 times the desired 8 volt full-scale range results in the appropriate range. For example, setting the TAC for 1.25 usec results in a 1.0 usec full-scale time range when used with a 8 volt input ADC.

The variable MULTIPLIER control also allows for calibrating the TAC and ADC for a specific time per channel. This feature is very useful in position sensitive detector systems where a direct distance-to-channel number calibration is desired.

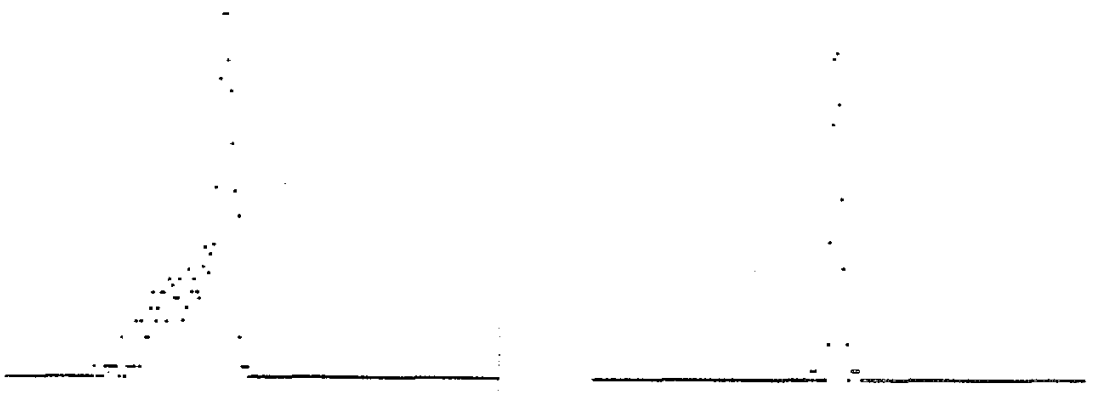
4.2 START AND STOP SIGNAL CONNECTION

It is **very** important that 50 ohm impedance cables be used when connecting to the START and STOP inputs of the TAC. Improper impedance cables can result in cable reflections which will degrade the linearity and resolution of the TAC.

4.3 PROPER ADJUSTMENT OF TAC OUTPUT WIDTH

Many ADCs are **very** sensitive to the width of the analog input signal. Their sensitivities can result in both peak shift and resolution degradation as the counting rate is increased. The resolution degradation often manifests itself as a lower or higher time tail on a timing line.

The TC 862's TAC OUTput width can be adjusted to overcome the shortcomings of the ADC's peak detector. Most ADCs seem to favor a 2.0 to 3.0 usec width, with shorter signals producing a lower time tail and longer signals producing a higher time tail. This tailing is more obvious when viewed on the log scale of the MCA.



TAC OUTPUT TOO SHORT

OPTIMAL TAC OUTPUT

Fig. 4.3 MCA Input Pulse Width Sensitivity