NIM MODEL 620D
8-CHANNEL DISCRIMINATOR

Rev: November 19, 1981

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ANY APPLICATION OR USE QUESTIONS, which will enhance your use of this instrument will be happily answered by a member of our Engineering Services Department, telephone 914-425-2000 or your local distributor. You may address any correspondence to:

LeCroy Research Systems Corp., 700 S. Main Street,
Spring Valley, New York 10977, ATTN: Engineering Services Dept.

European Customers can contact:

LeCroy Research Systems Ltd.
Elms Court
Botley
Oxford OX9 2LP England

LeCroy Research Sys. S.a.r.l.
Avenue Du Parana
Z.A. De Courtaboeuf
F-91940 Les Ulis, France

LeCroy Research Systems SA
81 Avenue Louis Casai
1216 Cointrin-Geneva
Switzerland

LeCroy Research Systems GmbH
Treitschkestrasse 3
Postfach 10 37 67
69 Heidelberg
West Germany

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SEE POCKET IN BACK OF MANUAL FOR SCHEMATICS, PARTS LISTS, AND ADDITIONAL ADDENDA WITH ANY CHANGES TO MANUAL.

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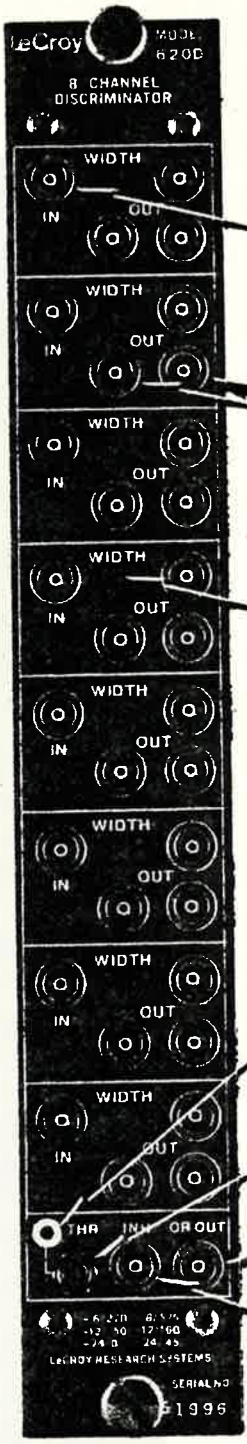

IN: 50 Ω input.

OUT: Voltage source outputs; Logical "0" = 0 V; Logical "1" = ≥-800 mV.

WIDTH Adjustment: 5 nsec fully counterclockwise; 22 nsec fully clockwise.

Threshold Monitor Point: Reads 10X actual threshold.

THRESHOLD adjust: -30 mV to -1 volt; stability <0.2%/°C.

OUTPUT: Summing output supplies a current pulse of -2mA for each output in the Logical "1" state.

INHIBIT Input: Requires NIM level signal to inhibit all eight channels; Input Z = 50 Ω.

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TECHNICAL DATA

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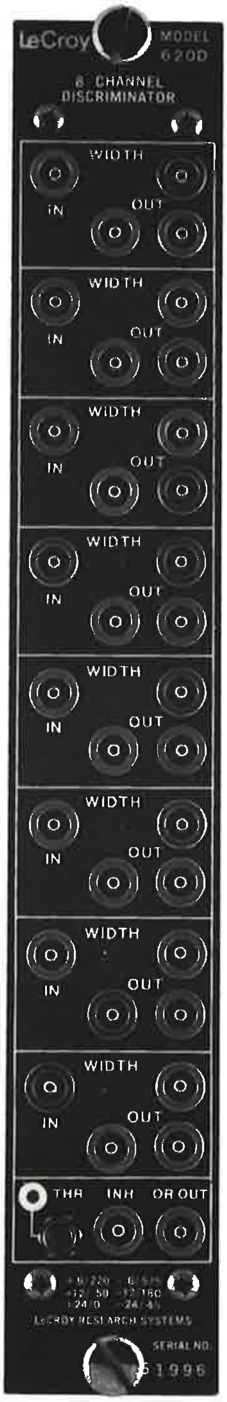

NIM Model 620D

8-Channel Discriminator

With Veto and Summing Output

The LeCroy Model 620D is an economy 100 MHz octal discriminator. Its common Inhibit and Summing Output make it a versatile instrument for a variety of physics applications. The 620D is based upon the Model LD601, a hybrid discriminator front end which is used in many of the popular LeCroy high energy physics discriminators.

The 620D offers a low minimum threshold of −30 mV, which is continuously variable up to −1 volt via front-panel screwdriver adjustment. A threshold monitor point is provided to permit the measurement of the threshold level with a common voltmeter. The stability of the threshold is <0.2%/°C to assure accurate results in varied operating environments. The low input reflections of <4% provide substantial protection against multiple-pulsing due to reflections, a special necessity when working with low thresholds.

Designed to operate at maximum CW rates in excess of 100 MHz, the 620D offers a double-pulse resolution of 9 nsec and a propagation delay of 7.5 nsec. These discriminators are non-updating, requiring that the output returns to zero before retriggering can occur.

The discriminator outputs are low impedance voltage outputs providing output levels greater than −800 mV into a 50 Ω load. The output durations are presettable via front-panel screwdriver adjustment from 5 nsec to 20 nsec. Output risetimes and falltimes are <2.5 nsec.

A front panel summing output supplies a current pulse of −2 mA amplitude and 2.5 nsec risetime for each discriminator output which is in the logical 1 state. This feature may be used for multiplicity logic decisions in hodoscope systems, lead glass, or scintillator arrays.

The Model 620D has a built-in front-panel fast veto input which permits all channels in common to be inhibited for the duration of the veto signal. Veto must overlap the leading edge of the signal to be inhibited and must precede it by approximately 5 nsec.

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Innovators in Instrumentation

HIGH ENERGY PHYSICS DIVISION
LeCROY RESEARCH SYSTEMS CORPORATION • 700 SOUTH MAIN STREET • SPRING VALLEY, N.Y. 10977
TWX: 710-577-2832 CABLE: LERESCO TELEPHONE: (914) 425-2000

SPECIFICATIONS
NIM Model 620D
8-CHANNEL DISCRIMINATOR WITH VETO AND SUMMING OUTPUT

INPUT CHARACTERISTICS

Signal Input: Threshold −30 mV to approximately −1.0 volt, (common to all channels); front-panel screwdriver adjust (screwdriver included); 50 Ω ± 1%, protected to ± 5 A for 0.5 μsec clamping at +1 and −7 volts; reflections <4% for input pulses of 2 nsec risetime; stability <0.2%/°C to 60°C operating range; offset 0 ± 1 mV; threshold monitor 10:1 ratio of monitor voltage to actual voltage.

Bin Gate: Slow gate via rear connector and read panel ON-OFF switch; risetimes and falltimes approximately 50 nsec; clamp to ground from +5 inhibits; direct-coupled.

Veto Input: One; requires fast NIM-level signal (> −600 mV); 50 Ω; must overlap leading edge of signal to be inhibited, and must precede input by approximately 5 nsec.

OUTPUT CHARACTERISTICS

Logic Outputs: 3 NIM-level voltage outputs, quiescently 0 volts, −800 volts during output; duration: 5 nsec to > 20 nsec, continuously variable via front-panel screwdriver control (narrower minimum width possible at slight expense of amplitude), risetimes and falltimes typically 2.0 nsec (max. 2.5 nsec) 10% to 90%. Width stability better than ± 0.2%/°C maximum. At least 2 outputs should be terminated in 50 Ω for optimum pulse shape.

Summing Output: A front-panel summing output supplies a 2.5 nsec risetime current pulse of −2 mA amplitude for each output which is in the logical 1 state. Although this output is a current source, it cannot be cascaded (wire ORed with other summing outputs) since it is internally back-terminated in a complex impedance. For optimum waveshape in fast decision logic applications all normal outputs must be terminated in 50 Ω. Output widths should be set to ≥ 10 nsec for multiplicity detection > 3. Input-to-"OR" output delay, 8 ± 1 nsec.

GENERAL

Maximum Rate: >100 MHz, input and output.

Double-Pulse Resolution: Less than 9 nsec at minimum width setting.

Time Slewing: 1 nsec for input amplitudes 100% of threshold and above.

Input-Output Delay: 7.5 nsec nominal

Multiple-Pulsing: None; one and only one output pulse of preset duration is produced for each input pulse, regardless of input pulse amplitude or duration.

Packaging: In RF-shielded AEC/NIM #1 module (AEC Report #TID-20893); Lemo-type connectors.

Current Requirements:

+6 V at 220 mA	−6 V at 575 mA
+12 V at 50 mA	−12 V at 160 mA
+24 V at 0 mA	−24 V at 45 mA

SPECIFICATIONS SUBJECT TO CHANGE

4. OPERATIONAL DESCRIPTION

4a. Input Characteristics

Threshold Range: The threshold range of the Model 620D Quad Discriminators is -30 mV to -1 volt. Because the front panel screwdriver adjustable potentiometer gets more and more sensitive as the threshold is increased, it eventually reaches a point (approximately -600 mV) beyond which it becomes difficult to set. Thus, beyond the -600 mV level it should be assumed that the discriminator will attain its maximum threshold setting of -1 volt with almost negligible additional turning of the pot.

The low minimum threshold of the Model 620D units makes it possible to use lower gain photomulitpliers, lower high voltage in the phototubes, and to drive PM signals over longer cable lengths than would be possible with higher thresholds. Compared with a -50 mV discriminator, for instance, utilizing RG-58 cable, the -30 mV discriminator would permit cable runs 66.7 feet longer than those permitted by a -50 mV discriminator for equal amplitude pulses. In addition, the low minimum threshold helps make it possible for one to back-terminate at the photomultiplier to absorb reflections and high amplitude noise. (In this case, the PM drives 25 Ω, the tube current is shared, and the amplitude is half that of the unterminated system.)

Threshold Uncertainty: While most people consider the threshold of a discriminator to be that value which is written on a spec sheet or determined by a front panel pot, in reality the actual value not only varies from channel to channel, but can be a strong function of other environmental conditions. The external factors with the strongest effect upon the threshold value are the temperature coefficient of threshold and the power supply coefficient of threshold. Combining these, the actual threshold value V_T is given by:

V_T = Threshold according to front panel control setting ± dc offset ± temperature coefficient X temperature change from calibration temperature ± supply coefficient X voltage change from calibration voltage.

SEE FIGURE 1

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Threshold Memory: In order for an experimenter to be assured of a well defined threshold value, it must be independent of the typical conditions encountered in its use. While one does not expect large changes in basic pulse shape, etc., a discriminator does experience all varieties of pulse pair separation. If a discriminator's threshold is affected by previous events, it is said to have threshold memory. To the experimental physicist, this is additional threshold uncertainty, since the discriminator's threshold for any given event depends upon the elapsed time from the preceding threshold crossing. In most discriminators, threshold memory (or second pulse sensitivity) becomes much larger as the pulse separations are reduced. The effect can be further aggravated by the amplitude of the preceding signal, so much so with some circuits, that an overload or noise pulse can effectively paralyze the discriminator for threshold level signals for 10's of nanoseconds following the overload.

Note that in figure 2 the threshold memory effect for the second pulse is ≤6% for all spacing wider than 9 nsec. The second graph (i.e., the one more favorable to the discriminator) shows exceptionally clear response with virtually no effect in evidence above 10.5 nsec.

Threshold Calibration: Determination of the input threshold set by the front panel control has typically required the experimenter to calibrate each change in setting with an external pulse source and oscilloscope. Newer discriminators offer a front panel test point whose dc level is proportional to the actual discriminator threshold. Not only does this allow rapid and simple determination of threshold, but it also allows the experimenter to easily return the threshold level to a previously recorded setting. The convenience, and therefore the usefulness, of this feature is strongly dependent upon the characteristics of this monitor voltage, particularly its linear proportionality with the threshold setting. Figure 3 indicates the characteristic curve for the LeCroy Model 620D discriminators.

4b. <u>620D Threshold Hysteresis</u>

Hysteresis is built into the front end, such that every threshold crossing will not trigger the discriminator unless the previous signal has returned to below approximately -15 mV. This avoids multiple pulsing due to, for example, fine structure riding on a flat-topped pulse that may bring the pulse above and below threshold. See figure 4.

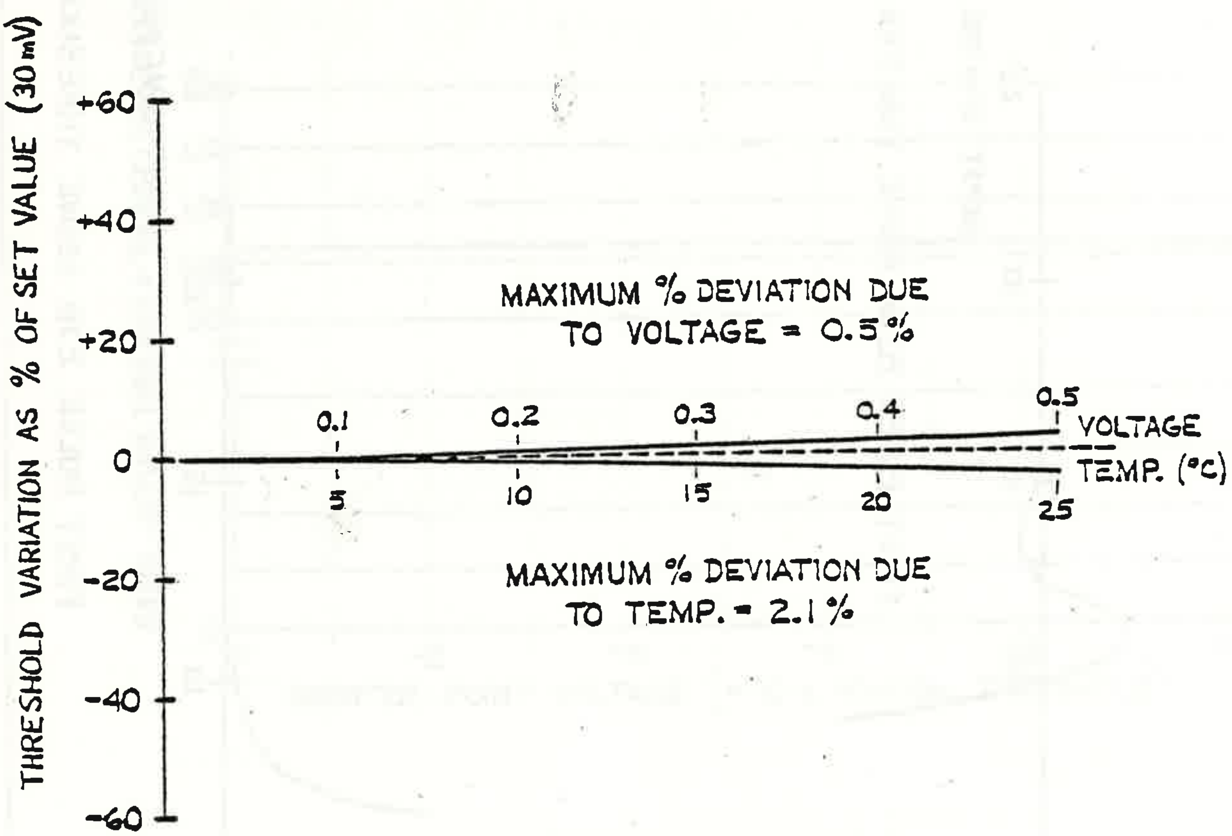

FIGURE 1

Threshold variations for 620D Discriminator

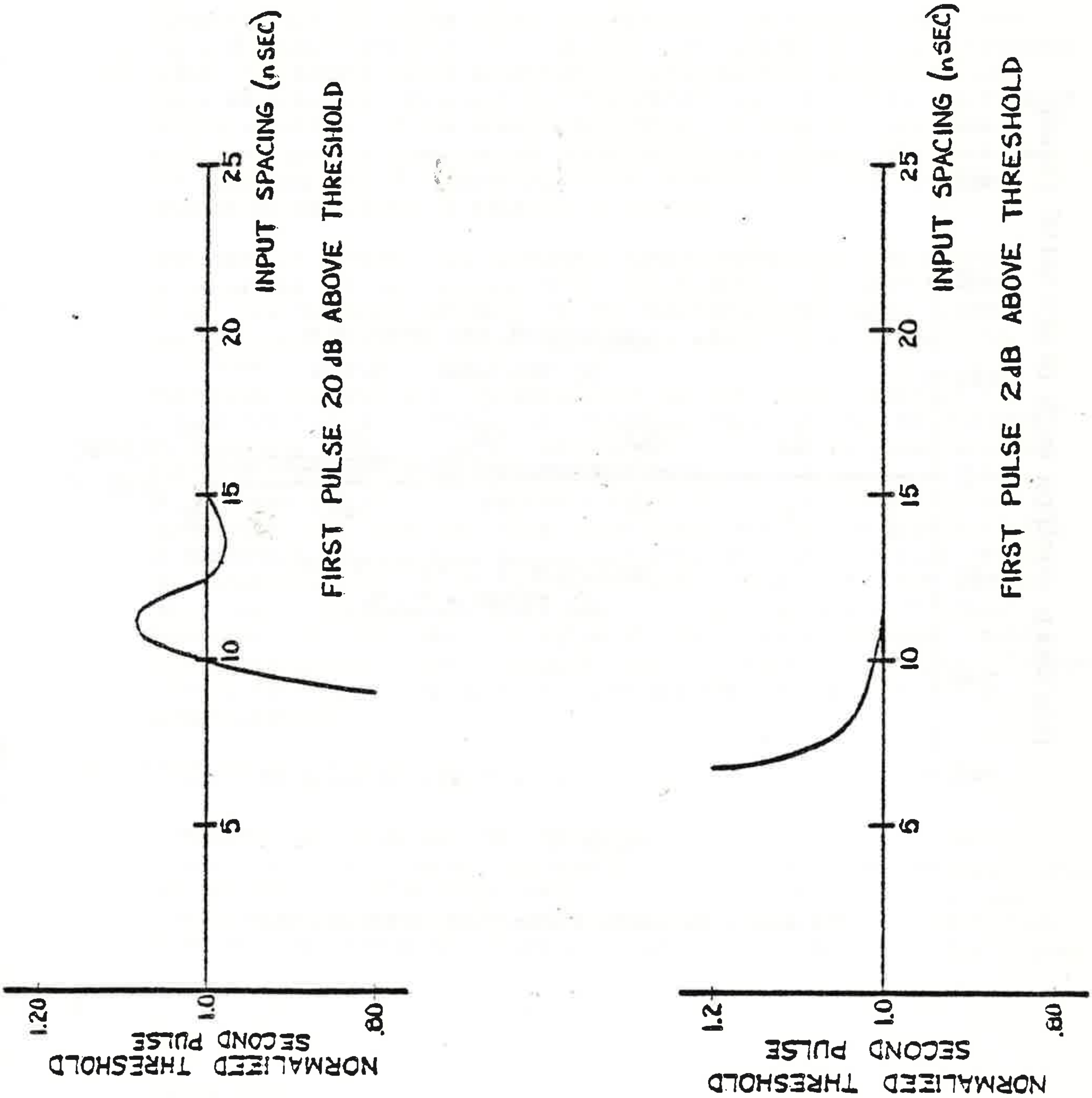

FIGURE 2

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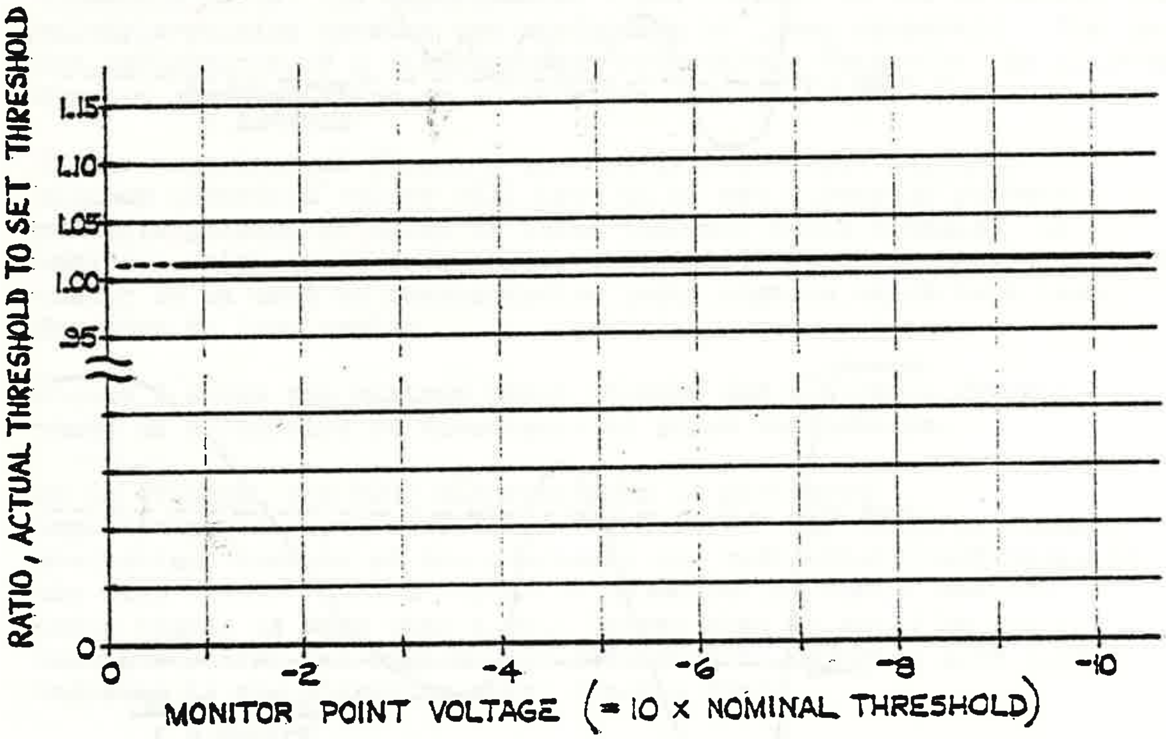
RATIO, ACTUAL THRESHOLD TO SET THRESHOLD
1.15
1.10
1.05
1.00
.95
0
0
-2
-4
-6
-8
-10
MONITOR POINT VOLTAGE (= 10 x NOMINAL THRESHOLD)

FIGURE 3

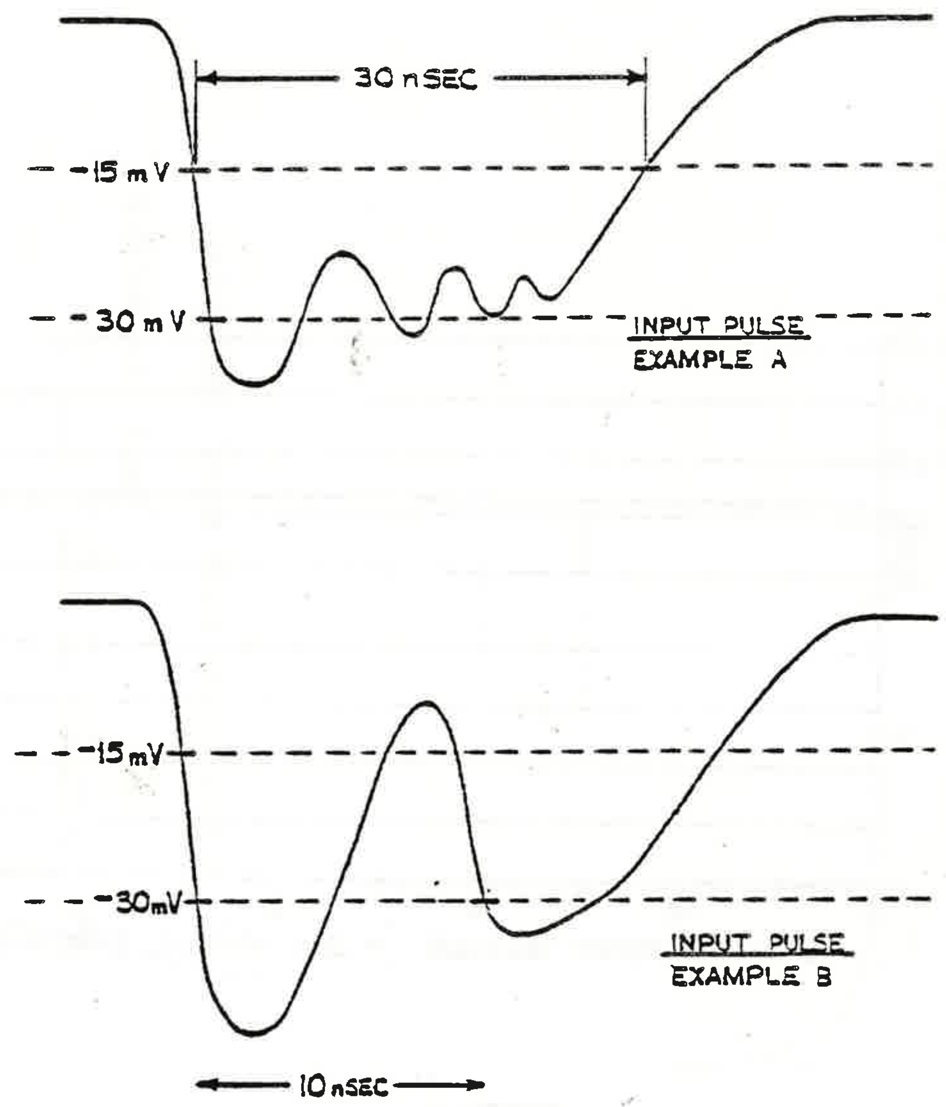

FIGURE 4

In Example A, the pulse shape variations of the input pulse will not re-trigger the discriminator even though they cross the threshold level at a time exceeding the DPR of the unit. In Example B, since the input signal does go back through -15 mV and then once again rises to exceed the -30 mV threshold level, two discriminator outputs would result. Since LeCroy discriminators are most often used with photomultipliers and plastic scintillators, and since the characteristic pulses out of this type detector are typically smooth for each individual event, multiple outputs should only occur when they represent multiple events.

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4c. Input Reflections

Input reflections probably account for the majority of discriminator multiple-pulsing problems encountered in an experiment. As discriminator thresholds have become lower, the amount of reflected signal required to retrigger the unit has decreased proportionally. Unless the percentage of input reflections is reduced along with the minimum threshold value, the experimenter finds himself in the situation where multiple-pulsing negates the usefulness of lower threshold. The input reflections of a discriminator effectively determine the allowable dynamic range of event or noise input signals.

On the experimental floor, a limited dynamic range may mean that minimum threshold values will have to be set higher to prevent multiple-pulsing on noise or large (shower) event signals. In addition, high input reflections also limit the ability of a discriminator to be used to restandardize logic signals which have been degraded by long cables.

Figure 5 shows the maximum input voltage and allowable dynamic range as a function of discriminator input reflections.

As is evident, the 620D discriminator is protected improvement in input reflection suppression over those previously available. Because of the extremely low reflection coefficient of the 620D (i.e., <2% for inputs of risetime ≥2 nsec), maximum input signal is more than a volt larger than it would be for a unit exhibiting the typical 10% reflections, offering five times increase in the discriminators' dynamic range.

4d. Input Protection

The inputs of the Model 620D discriminators are protected to 5 A for 0.5 μsec, clamping at +1 and -7 volts.

The DC protection is limited by the 0.25 watt dissipation limit of the input resistor, which can be assumed to offer protection against DC signals between -5 volts and +5 volts.

4e. Inhibit Input

The Model 620D provides an inhibit function for all eight channels. The input impedance is 50 Ω and requires an input pulse with a negative amplitude equal to or greater than 600 mV (standard NIM level pulse). To ensure proper operation when inhibiting, the inhibit input pulse must overlap the leading edge of the input signal (to be inhibited) and must precede it by 5 nsec. When in its time state, the inhibit driver will inhibit the dV/dt section of the LD601 (see the Functional Block Diagram), it will not inhibit the input amplifier on the hybrid.

4f. Output Characteristics

Low Impedance Voltage Output: The Model 620D discriminator requires only one output driver (for 3 outputs) per channel. This driver requires no quiescent current, thereby permitting extremely small average power dissipation while still providing fast output response time. The output amplitude, although somewhat dependent on the number of output loads, will always be more negative than -800 mV in the logic "1" state.

The low impedance voltage output stage response times will be optimum when driving at least two 50 Ω loads.

4g. Summing Output: The summing output (unlike the low impedance voltage output) provides a relatively high impedance output. It provides a -2 mA amplitude pulse for each channel that is in the logic "1" condition. Since the summing output is obtained by a diode OR gate, it is not a true current source output, and therefore, should not be wire-OR'ed with other summing outputs.

The output shape and response times can be optimized by loading at least two of the three outputs on each channel that will provide current to the summing outputs.

4h. Non-Updating Operation

The LeCroy Model 620D discriminator is non-updating. In a non-updating discriminator the output will not be extended if a second pulse comes in before the first output returns to zero. The second pulse will not be run by the discriminator.

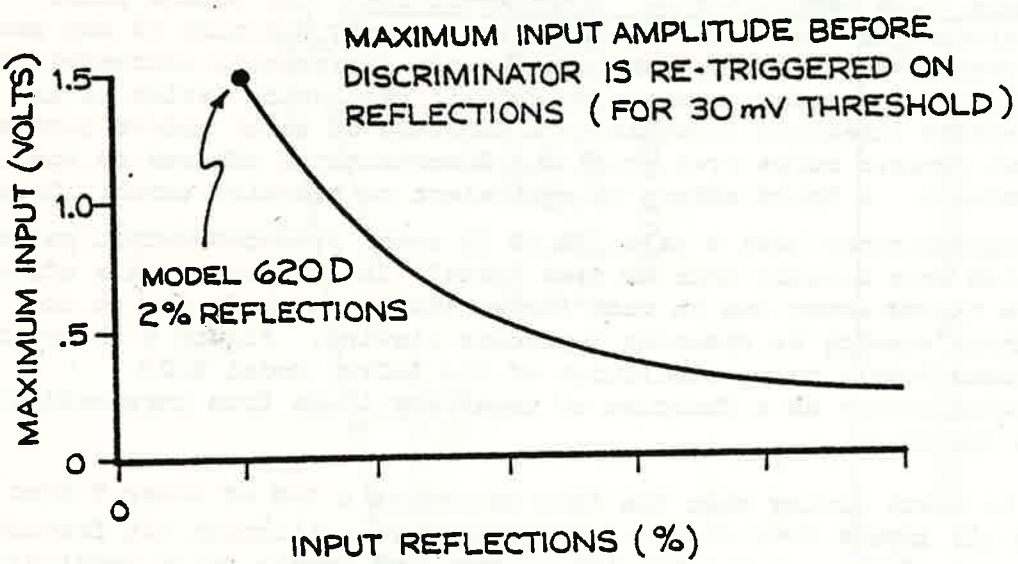
MAXIMUM INPUT AMPLITUDE BEFORE DISCRIMINATOR IS RE-TRIGGERED ON REFLECTIONS (FOR 30 mV THRESHOLD)
MAXIMUM INPUT (VOLTS)
1.5
1.0
.5
0
0
MODEL 620 D
2% REFLECTIONS
INPUT REFLECTIONS (%)

FIGURE 5

4i. Timing Characteristics

Maximum Rate: Maximum CW rate capability of the 620D discriminator is guaranteed at 100 MHz. Typically, the maximum rate is 110 MHz, with some units being capable of operation up to 120 MHz for small bursts of input pulses.

Double Pulse Resolution: The speed of a discriminator is practically defined by its double pulse resolution or the time between the leading edges of the most closely spaced pulse pair to which the discriminator produces two distinct output pulses. Although simple in concept, this specification can be misleading unless the input conditions are precisely defined and ambiguities in performance are disclosed. Characteristic curves which more adequately describe double pulse resolution are indicated and discussed below and in figure 6.

Double Pulse Resolution vs. Input Amplitude: The double pulse resolution of some discriminators is a strong function of the amount of overdrive. Typical anomalies include substantial increases in amplitude to achieve minimum pulse pair resolution (which is an effective threshold increase as a function of rate) and/or limited input dynamic range over which the discriminator adheres to specifications. A third effect is equivalent to tracking error. Does a discriminator have 8 nsec DPR if it never produces output pulses spaced more closely than 10 nsec apart? In some cases this effective timing error can be much larger than time shift due to intrinsic slewing or risetime dependent slewing. Figure 6 shows the minimum double pulse resolution of the LeCroy Model 620D discriminators as a function of input amplitude from threshold to 10X threshold.

It is worth noting that the 620D maintains a DPR of under 9 nsec for all inputs over the 10:1 dynamic range. Although not featured as part of the general specifications, the double pulse resolution is much better than specified over most of the measured dynamic range. Also significant is the absence of tracking error at the limit of the discriminator's input performance. Throughout the measured range, the time shift of the output averages 2.54% or approximately 200 psec.

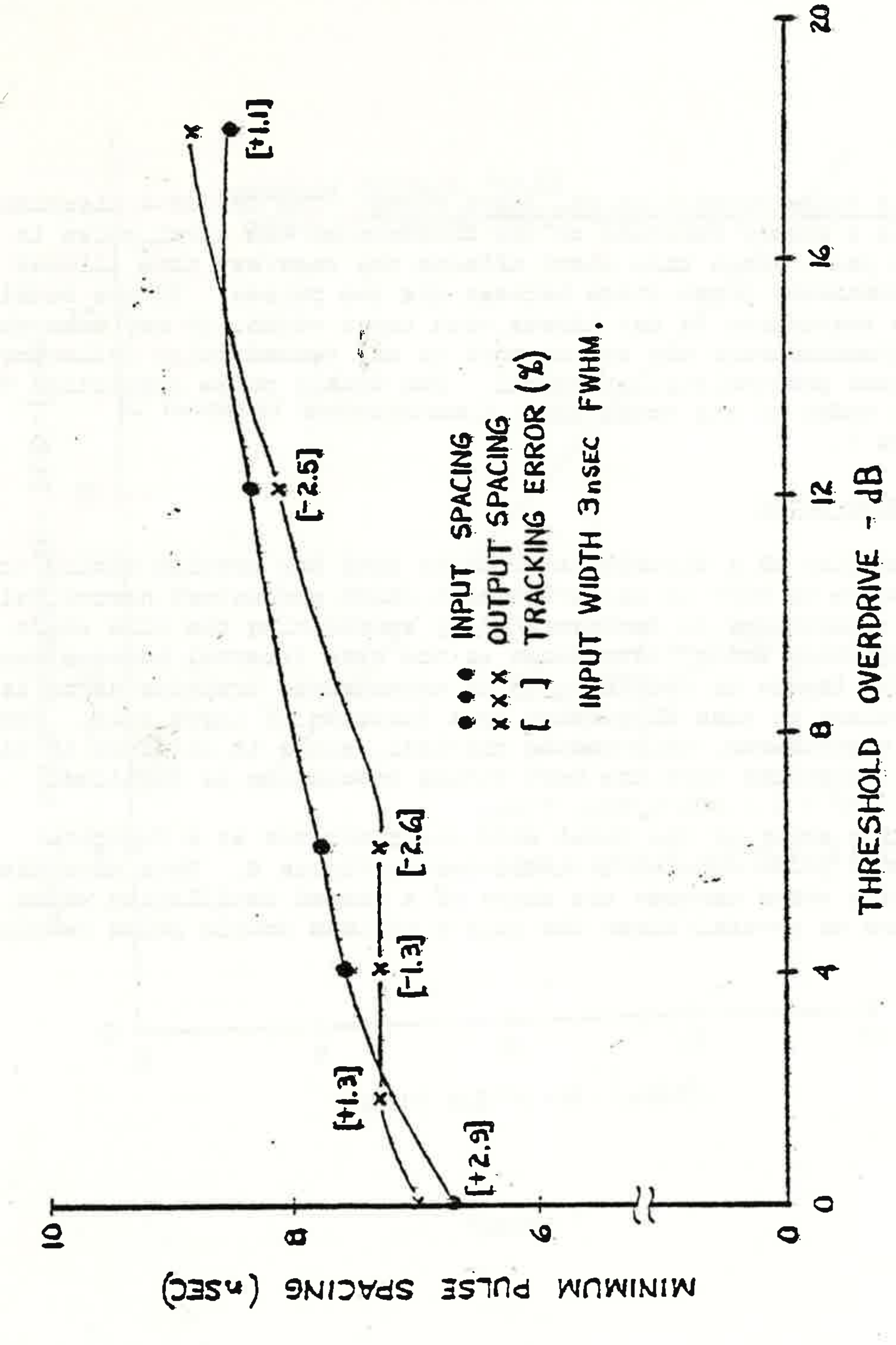

FIGURE 6

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Double Pulse Resolution VS. Input Width: The DPR of a discriminator is a strong function of the duration of the first pulse in an input pair, since this width affects the recovery time allowed the discriminator input stage between the two pulses. If the double pulse resolution is not linear with input width, it may mean that the discriminator may not respond to the second pulse following an overload photomultiplier signal. The double pulse resolution VS. input width of the Model 620D discriminator is shown in figure 7.

4j. Tracking Error

The ability of a discriminator to be used for precise timing (coincidence or TOF) in an environment which encounters narrow pulse pair separations is demonstrated by considering the time shift (or tracking error) introduced as the time interval between successive inputs is reduced. In an experiment, tracking error is equivalent to time dispersion as a function of input rate. For many experiments, this can be critical, since it is often in high rate situations that the best timing resolution is required.

Tracking error of the Model 620D discriminator as a function of input pulse spacing is indicated in figure 8. Note that the tracking error assumes the shape of a damped oscillation which decays to zero at several times the unit's minimum double pulse resolution.

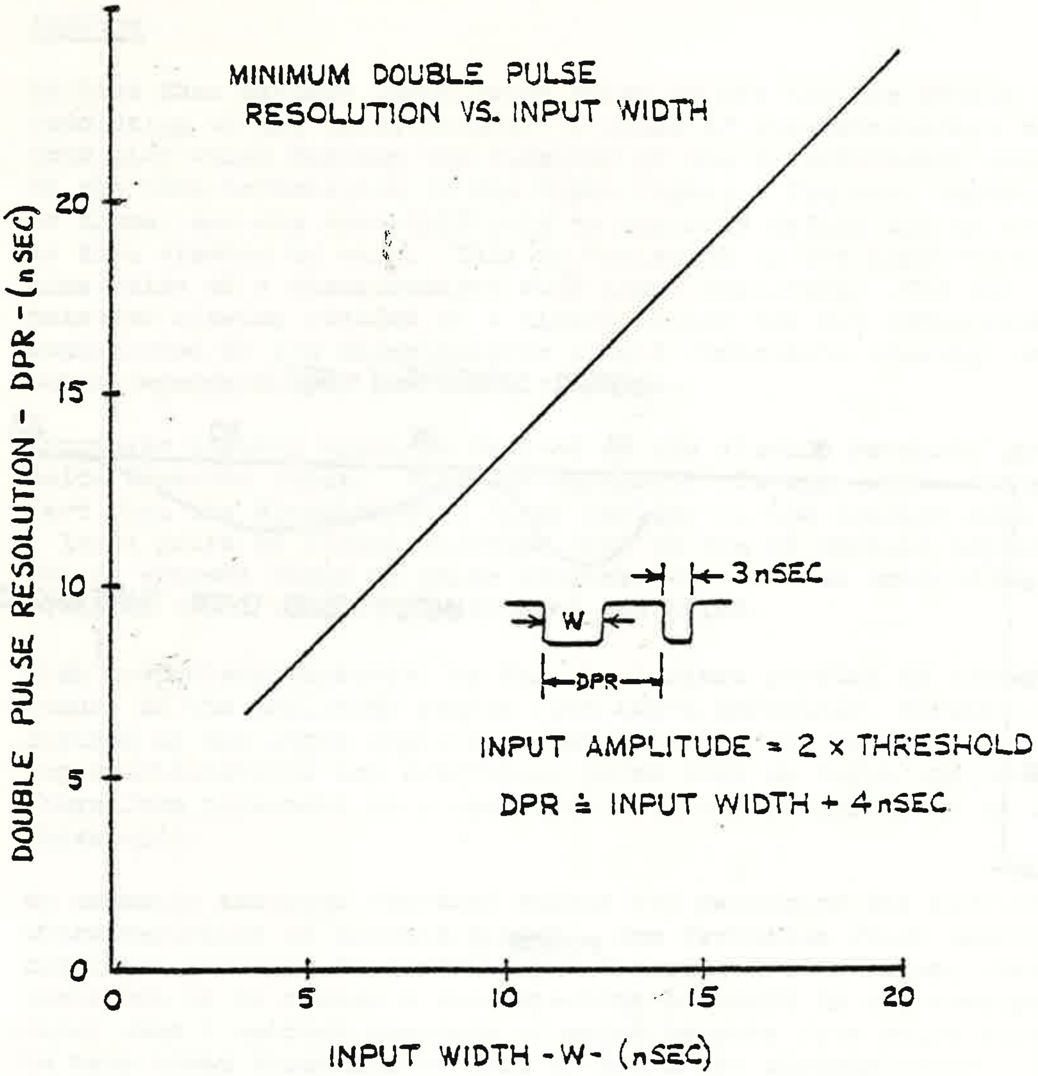
MINIMUM DOUBLE PULSE
RESOLUTION VS. INPUT WIDTH
DOUBLE PULSE RESOLUTION - DPR - (nSEC)
0
5
10
15
20
INPUT WIDTH -W- (nSEC)
3 nSEC
W
DPR
INPUT AMPLITUDE = 2 x THRESHOLD
DPR ≐ INPUT WIDTH + 4 nSEC

FIGURE 7

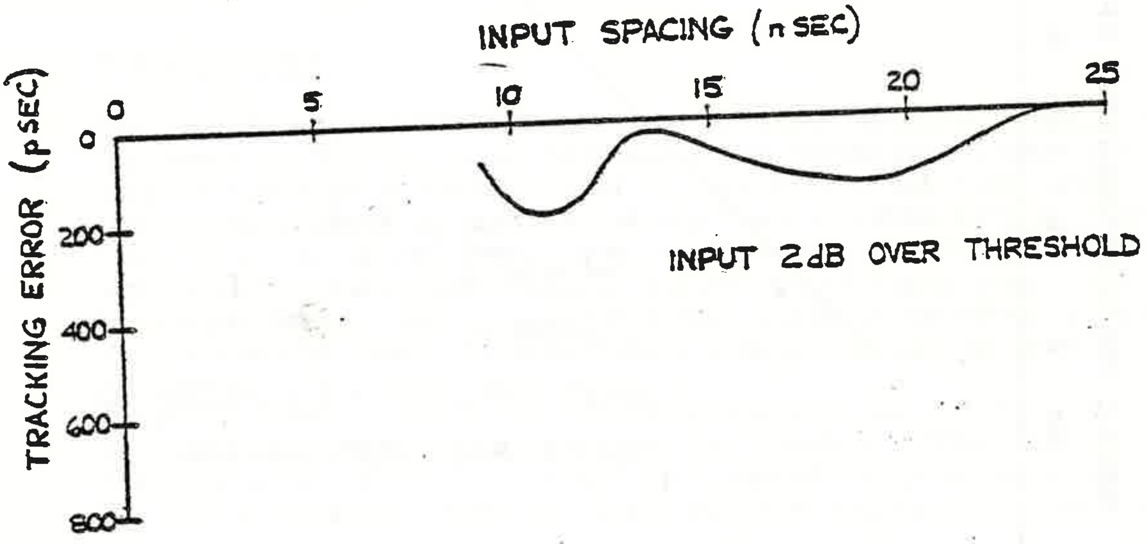

FIGURE 8

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4k. Slewing

At less than maximum input rates which do not tax the double pulse resolution of the discriminator, a class of characteristics comes into play which defines the fidelity of the discriminator output to the time information in the input signal. The most important of these, and the most difficult to strictly define and to measure, is time slewing or walk. This is variation in the input-to-output time delay of a discriminator with input amplitude. The net measured slewing yielded by a discriminator has two components, one contributed by the discriminator itself (intrinsic slewing) and the other dependent upon the input risetime.

Intrinsic slewing might be defined as the slewing measured with a delta function input. Risetime-dependent slewing arises from the fact that the discriminator fires earlier on the leading edge of a large pulse of finite risetime than on one of smaller amplitude. For an extreme range of pulse heights, the maximum contribution is equal to the 0 to 100% risetime of the pulse.

With most discriminators, by far the largest portion of the slewing occurs in the amplitude region just above threshold, threshold being defined as the input amplitude that produces 50% triggering. Slewing specifications are frequently given over an input amplitude range from threshold to a specified overload factor (such as 10X threshold).

No commonly accepted standard exists for measuring the slewing characteristics of discriminators. One technique which LeCroy considers relevant to describing a discriminator's timing characteristics is to obtain a time spectrum of shift in input-output delay when a uniform spectrum of pulse heights from below threshold to many times threshold is used to drive the discriminator. Such an input spectrum constitutes a relatively severe test of the discriminator's timing performance for it contains a relatively higher proportion of near threshold pulses than does a usual beam-derived photomultiplier spectrum. It takes into account all aspects of discriminator slewing performance and presents their combined effect in terms of a time dispersion curve such as indicated in Figures 9 & 10.

4l. Packaging

The 620D discriminator is packaged in a #1 Nim module with LEMO-type connectors. Due to front panel space limitations, the 620D is not offered with BNC's.

4m. Current Requirements

The current usage of the 620 series is low enough to permit the use of 12 modules per standard 96-watt NIM bin offering a 5 A of ±6 V, 2 A of ±12 V, and 1 A of ±24 V. Its total power is 6.5 watts, which does not exceed the 8 watts recommended by the NIM standard for a single NIM slot.

4n. Recommended Use of the NIM Power Bins

It is highly recommended to keep any NIM bin at as constant a temperature as possible, using air conditioning in the trailer or experimental station and definitely using fans to assure an air flow through all modules in every bin. Elimination of large temperature variations removes the worry of temperature drift effects upon modules of any manufacturer, and the forced air flow is good insurance against the potential failure of components in the modules due to excessive heating for extended periods of time. Despite the fact that all components are pre-aged and burned-in before insertion into LeCroy modules, and the modules themselves are temperature cycled for days under power between initial test and final test, it is recommended to avoid subjecting any modules to adverse operating conditions if it could be avoided.

5. FUNCTIONAL DESCRIPTION

5a. General

Each of the eight channels of the Model 620D is composed of two basic sections: the input and discriminator stage, and the output stage. A block diagram of the Model 620 D can be seen in figure 9. and a complete schematic of the specific model can be found at the end of this manual.

5b. Input and Discriminator

The input and discriminator stage is based on the LeCroy Model LD601E hybrid. This unit contains all of the circuitry of the discriminator with the exception of the input termination and input protection. The latter two functions are self-explanatory in the schematic enclosed, and the LD601E is functionally presented in figure 10. The threshold level is set by changing the voltage bias on a fast differential amplifier which has a small amount of positive feedback to provide regeneration at threshold. In actual operation the V_T input is obtained by a voltage follower (IC PB). The voltage on the wiper of the front panel threshold potentiometer appears on the test point for monitoring the threshold.

The measured voltage will be 10 times the actual threshold voltage. When an input signal applied to -IN is equal to the threshold voltage at +IN, the amplifier output will begin to go positive. This will force +IN closer to 0 volts, which increases the differential input voltage in such a direction that the output locks and then the cycle reverses. The amplifier output thus provides a time-over-threshold pulse with fixed amplitude. This pulse can be monitored at the AMPL. OUT point (pin 6). The quiescent level should be nominally -2.4 volts going to -1.6 volts during the pulse. The leading edge of this output sets the latch circuit which is used as a pulse width standardizer. Before the latch can be set, the inhibit inputs must be off. The required level at pin 16 of the LD601E must be 0 to -1.6V to enable, and -2.5 to -6.0 to disable. (The common bin gate driver shifts this so that 0 volts at the Bin Gate input will inhibit, greater than +3 volts will enable.) Once the latch is set, a latch OUTPUT is available to drive the output stage. The OUTPUT amplitude and leading edge should be similar in appearance to the AMPL OUT (Figure 12), but the width of the output will be independent

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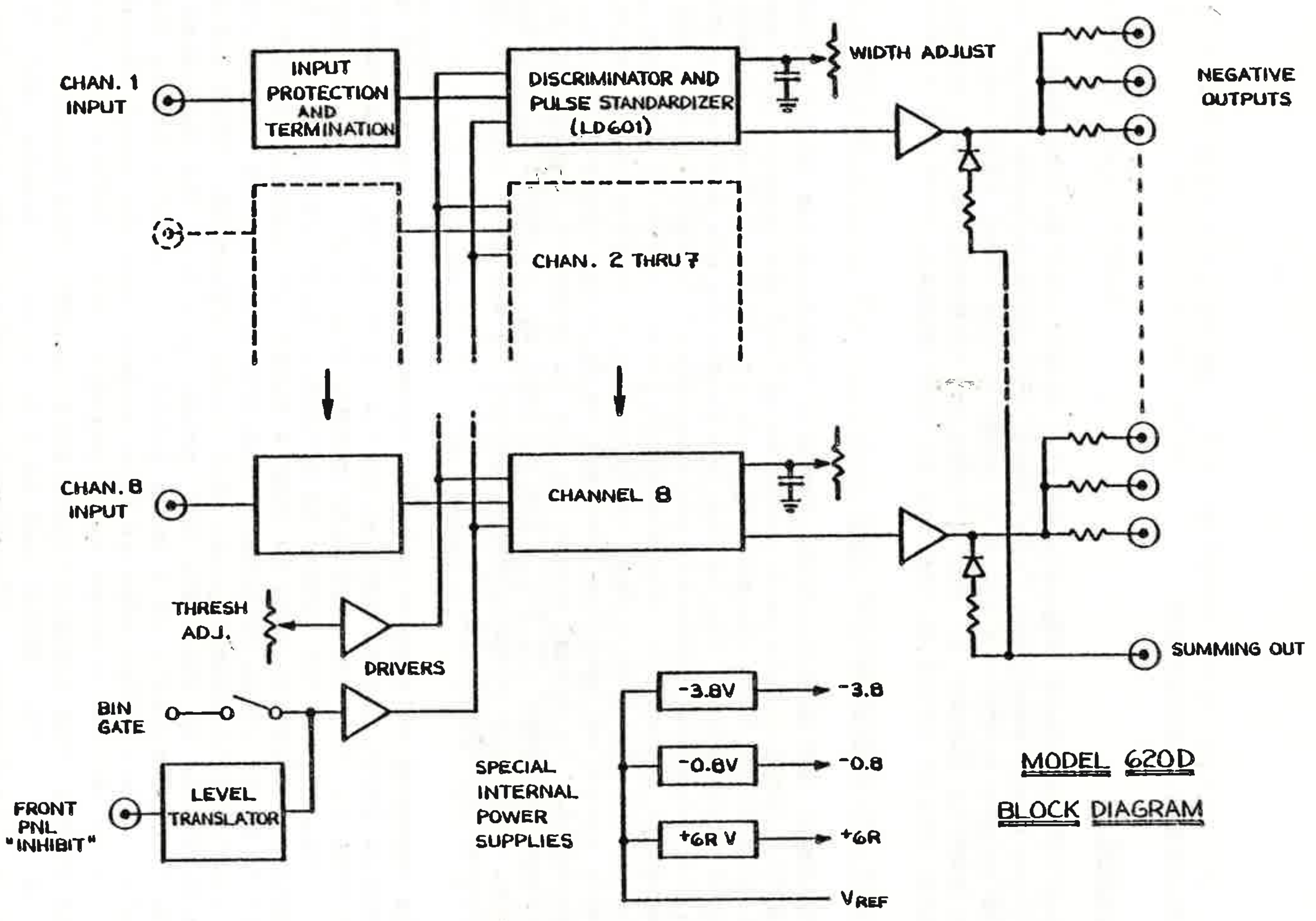

FIGURE 9

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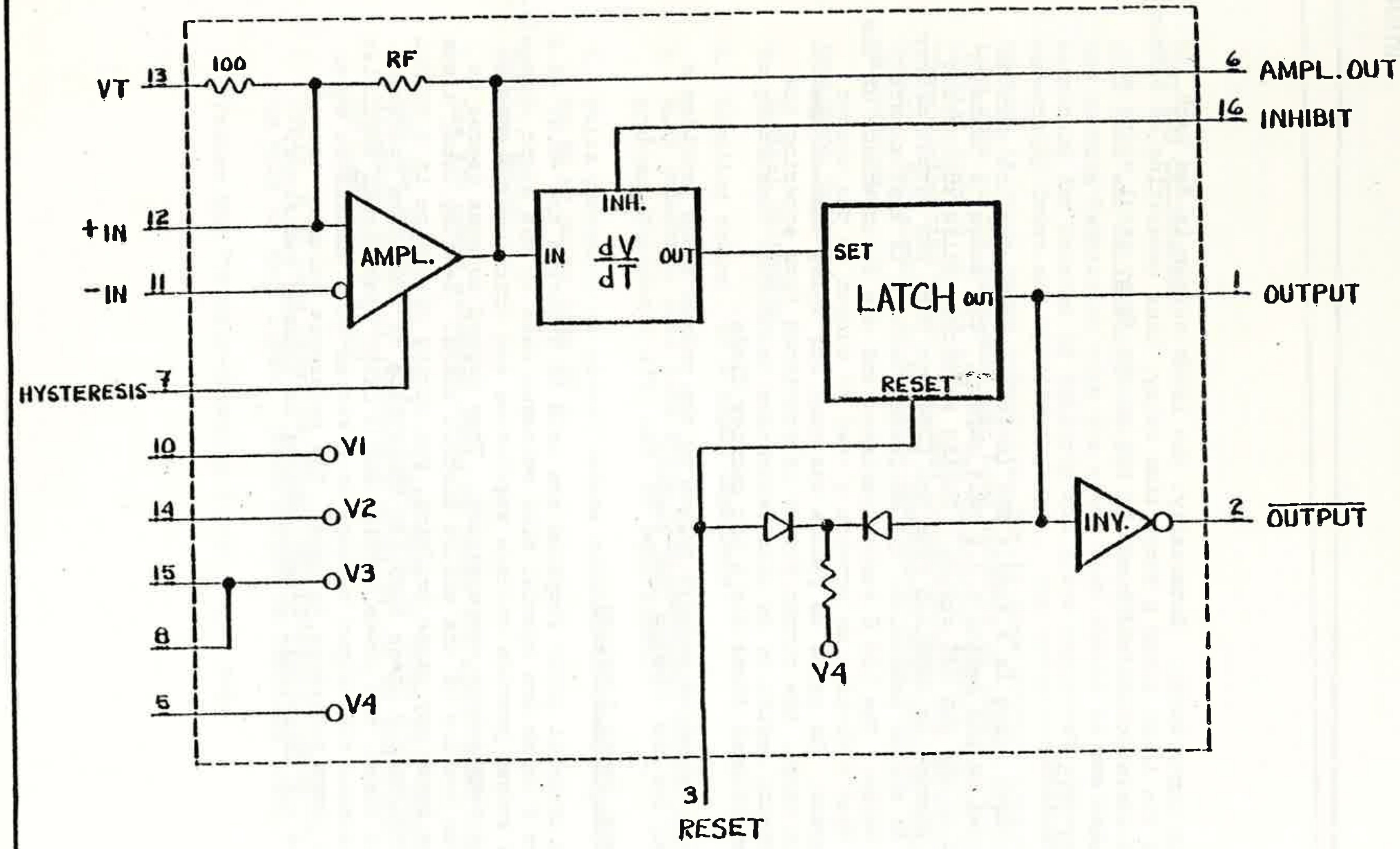

BLOCK DIAGRAM – LD 601E DISCRIMINATOR HYBRID

FIGURE 10

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of the input width. Internally, the latch output is fed back to reset the latch after a short time delay, thus generating an output pulse whose actual width can be set by the front panel width adjustment pot.

5c. Output Stage

The output stage is a simple NPN inverter stage with the emitter returned to the negative 3.8 volt supply. The stage is normally based in the cut off region. During an output pulse sufficient base current is supplied from the LD601 to turn the output driver on. In the on condition, the collector voltage is approximately -2.7 volts. The 110 Ω series resistor and the 50 impedance of the load form a divider to provide a -840 mV output to the output connector. In order to reduce the turn off delay time of the output stage, the output driver is prevented from entering the saturation region by an anti-saturation technique, consisting of a conventional diode and a hot carrier diode.

A diode switching network driven by the output stage provides a signal for the summing (OR) output.

5d. Internal Power Supplies

Three internal power supplies are used to generate the -0.8, -3.8 and +6 V which are special bias voltages used by the eight channels. These stages provide voltage regulation and tracking and provide proper temperature compensation. They depend to some degree on uniform heating of the entire circuit board. Heating local areas of the board may cause drifting, but during operation in a normal bin environment these supplies compensate to stabilize operation. In all cases, the power supply uses a LM301 operational amplifier to maintain the output voltage so a series-pass transistor equal to an input reference voltage. The reference voltages are adjusted via individual potentiometers or trimmed resistors.

6. TEST AND CALIBRATION

This test and calibration section has been included to familiarize the service technician with the areas that should be checked when searching for sources of failures and after replacing components, especially front end hybrids (LD601E). The trouble-shooting section is by no means exhaustive, but it does provide insight into some of the problems that have occurred at LeCroy during the initial testing of the 620D. The technician should follow the "Trouble-Shooting Guide" for ease in determining the defective component. Replacement of critical components will require some recalibration.

6a. Equipment Required

1. Digital voltmeter.
2. Sampling scope; 50 Ω input impedance.
3. High impedance real time scope with bandwidth of 150 MHz or greater (Tektronix 475, 485 or equivalent).
4. Pulse generator or signal source capable of producing 10 nsec to 50 mV pulse into 50 Ω.

6b. Initial Setup

1. Use NIM power extended cable to power the 620 D under test.
2. Set the threshold and all width pots to their full counterclockwise position (threshold equal to -30 mV and width equal to less than 5 nsec).
3. Apply a 10 nsec negative pulse (approximately equal to -50 mV) in turn to each input. Check output on sampling scope.
4. Follow the "Trouble-Shooting Guide", next page.

TROUBLE SHOOTING GUIDE

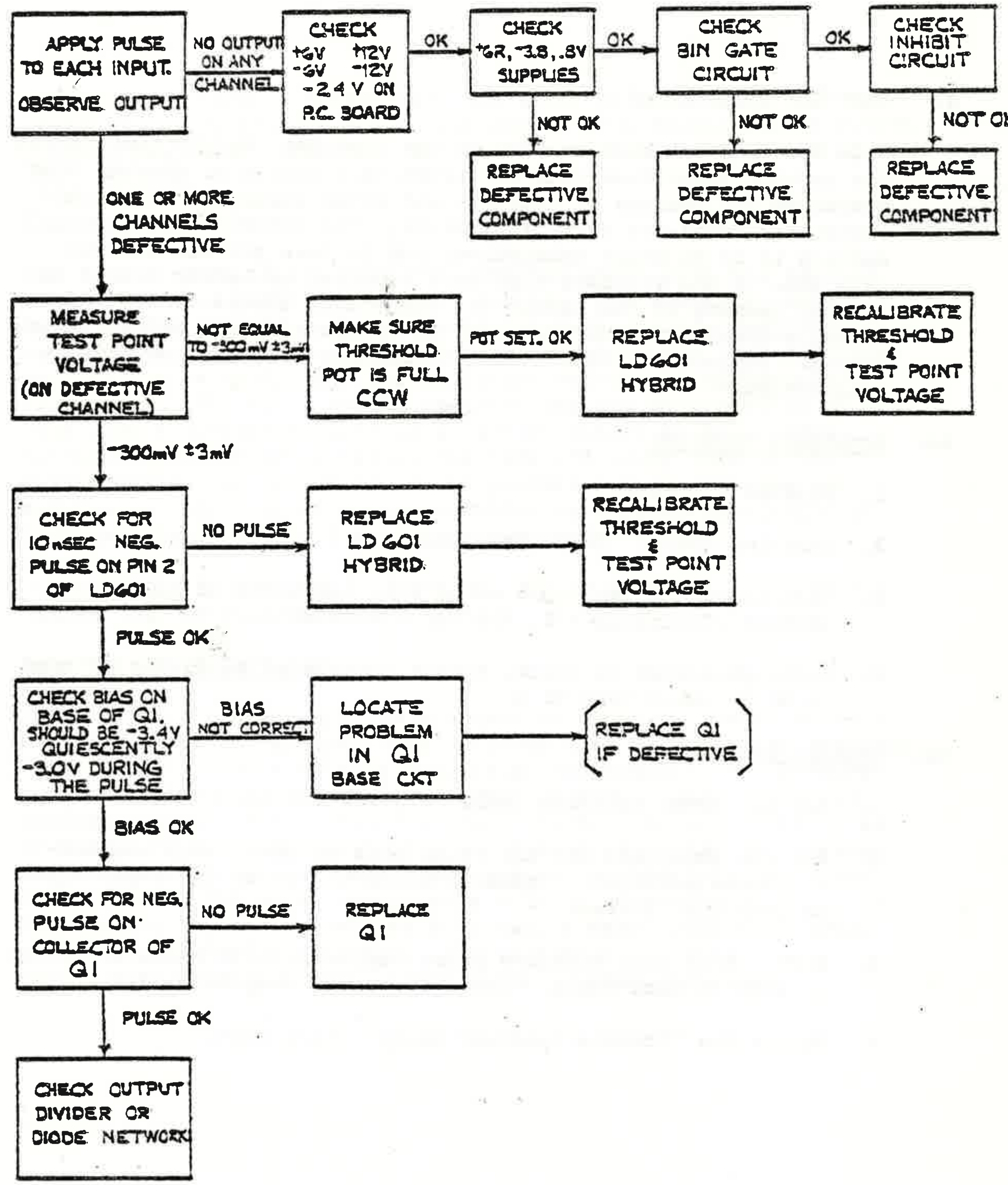

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Figure 14

6c. <u>Required Recalibration if LD601 is Replaced</u>

Replacement of LD601E. If any LD601E was found to be defective and required replacement, the Threshold and Test Point voltage should be recalibrated.

Procedure:

1. Set front panel Threshold pot to minimum (counterclockwise).
2. Measure Test Point voltage. If not equal to -300 ±5 mV, replace existing trim resistor (across 620 Ω resistor) with proper resistance to bring Test Point voltage into required range.
3. Check Threshold level with a 5 nsec wide pulse; if it is not -30 mV, replace existing trim resistor (pin 12 of the LD601E) with proper resistance.

* Approximate production dates can be determined by the dates written on the rear panel Test and Calibration stickers.