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SDC
SOLENOIDAL DETECTOR NOTES

SDC TRIGGER R&D REPORT

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Muon Trigger R&D

The general scheme of the muon trigger is described in the SDC Technical Design Report.[1] (TDR) for the collaboration. University of Michigan staff supported in part by SDC and TNRLC funds contributed major sections of the muon system design and description represented in the TDR. Initially the level 1 muon trigger work focused on the general trigger design and connectivity. A choice of coordinate configuration[2] was made that utilizes toroids for an independent momentum measurement. The modularity of the muon system was chosen to keep the physical units of the system manageable in size. The design incorporates projective wires and scintillation counters. The Michigan work on testing and selection of the scintillation material and lightguide design is described elsewhere in this report. Figure 1 illustrates the two sources of information for the trigger. A particle passing through the scintillator and a pair of projective wire drift tubes sends pulses to scintillator and wire signal processing circuits. These two sources of track detection have different characteristics. The scintillator signal is fast and the wire signal has excellent positional resolution. For triggering purposes the scintillator provides identification on the crossing responsible for the muon and the wires provide a transverse momentum selection.

Two components of the trigger scheme[3,4] are naturally implemented in custom IC devices. The first is the scintillator signal processing unit for crossing determination and the second is the wire pair processing unit for momentum selection. For each of these functions a prototype CMOS chip has been designed and fabricated. Successful performance of the scintillator chip is illustrated below. The prototype of the wire chip has just been received from the fabricators and has been observed to perform as designed in all features tested to date. These preliminary test results are also presented.

Chip Test Results

The scintillator signal processing chip performs mean timing of the two signals from the phototubes located on opposing ends of a single scintillator slat, outputs timed pulses in four positional segments along the slat, latchs these pulses for each 16ns crossing, and stages the latched hit for N (programmable) crossings. The operations listed above are accomplished in a series of steps within the chip. Our testing of the chip exercises separately the steps performed. Figure 1 demonstrates the mean timer operation. The points plotted represent the arrival of a pulse from the mean-timer at a specific time as a function of times of the two input pulses. If the input times average to the sensed output time within a preset acceptance window, a dot is plotted. The function that the two inputs must satisfy to meet this condition is a straight line of slope=-1. The function displayed in Figure 1 has this form. The width of the line represents the acceptance tolerance of the circuit. It depends on the widths of the pulses input to the mean-timer. The prototype scintillator trigger chip permits external control of these widths. All four positional segment outputs of the chip are represented in Figure 2. These segments have been observed to overlap so in cases where the track enters at the boundary between sections of the scintillator as designed. The third and fourth functions of the chip are demonstrated in Figure 3 where the pulse is shown latched and delayed. In the two examples of Figure 3, 5 and 12 clock steps were programmed into the chip.

The wire signal processing chip performs differential timing of the projective wires as required to select the P_t regions, in a second stage it widens these signals to guarantee coincidence with the delayed scintillator signals, and in the last stage forms the scintillator coincidence. The P_t selections are independently programmable and result in separate signal paths in the remainder of the chip. Figure 4 displays the behavior two of these independent outputs. In these plots external signals from a simulated projective wire pair have been input to the P_t selection circuit. In the upper plot the time separation of the two pulses is representative of a high P_t track and in the lower plot the signals typify an intermediate P_t track. Both the high and medium momentum outputs are displayed. Correct outputs are observed in both the upper and lower plots. The second stage of the wire trigger chip stretches the binned P_t signals to the full drift time so that they are guaranteed to overlap with the delayed scintillator chip output. This function must be "retriggerable" to avoid any efficiency loss from unrelated earlier tracks or debris. The

operation of the retriggerable stretcher is shown in Figure 5. The upper and lower plots demonstrate that the stretcher length is programmable and illustrate the retriggerable nature of the circuit.

Myron Campbell, J. Chapman, Seong Hong, Khurshid Hashim, and Colleen Murphy attended Rocky Mountain Consortium Workshop July 18-25 to work on SDC muon level 1 and 2 trigger rates and to present material on various aspects of the muon trigger development. Several new analysis were performed during the workshop. The sharpness of the muon triggering threshold was determined for various combinations of data from both the muon system and from combinations of the muon and tracking systems. The threshold determined from the resolution studies was folded with the cross sections for muon production to derive the triggering rate for various possible trigger schemes. The preliminary results of these calculations are represented in the Table 1. The minimal trigger as proposed in the TDR is labeled "Exit Angle" in the table and the additional conditions studied in the workshop involve linking a single layer of the central tracker to the muon system layers BW1 and BW3, using the central tracker P_t after linking to multiple layers of the tracker, and by determination of the entry and exit angle (angle/angle) difference between BW1 and BW2/3 in the muon system alone. The surprising performance of the angle/angle measurement is being further studied with the full GEANT simulation of the muon system. If we find that this performance is demonstrated in the complete simulation, we will incorporate into the wire trigger chips the additional features needed to accomplish this angle/angle measurement.

Mini-Tower Test

Plans are underway to construct a muon scintillator trigger card and a wire trigger card to be used in a min-tower prototype test to be carried out at KEK in Japan during March 1993. This test will be in conjunction with our Japanese SDC collaborators and will be the first actual beam test of the SDC muon chambers with the scintillators and trigger electronics in place. Results from this test will guide the development of scintillators and trigger circuits for the full supertower test planned for late 1993 in Dallas. The KEK test will involve the use of the SDC standard portable data acquisition system, the Japanese

Table 1

Rates for $0 < |\eta| < 1.5$

50% point at 20 GeV

Trigger	Rate
Exit Angle (2 of 4)	4.7kHz
Additional Condition	Rate
ϕ Link to BW3	0.95kHz
ϕ Link to BW1	0.85kHz
Angle/angle	0.80kHz
Tracker P_t	0.75kHz

supplied SDC TDC cards (called the TMC cards), and our trigger cards. One of the prototype scintillator units developed at Michigan will also be used in the test.

Straw Trigger R&D

The straw trigger project has continued both in simulation and in the development of radiation hardened chips. The first UTMC fabrication of radiation hardened chips is complete and test are beginning on these chips to evaluate their performance compared to the radiation soft chips previously constructed. Test fixtures are designed and are currently in fabrication.

The simulation work has resulted in a transfer to Dr. Chiba at Tokyo Metropolitan University the code used at Michigan for trigger studies in the straw tracker. The research group at TMU as available 40 DECstations. On this cluster of machines they have managed to simulate nearly 10,000 events. The results are consistent with the smaller sample generated at Michigan. The discrepancies can be traced to the fact that the TMU events

were generated without the silicon detector enabled. This choice removes the simulation of silicon material in the particle path to the straw detector. Work with TMU is continuing. We anticipate that they will execute the program for simulations including code for the recently installed muon package.

At the RMCHEP this past July a standard set of muon system labels was defined and a set of muon trigger data was specified for simulations. The code now incorporates this data and work is proceeding at Michigan to provide the additional code to generate a set of trigger files that will permit study of the muon trigger and straw tracking trigger symultaneously. This will enable us to do correlated trigger studies for both level 1 and level 2 triggers

REFERENCES

1. The SDC Technical Proposal, SDC Collaboration, April 1992
2. Iron-Scintillator Configurations for SDC Muon Triggers, R. Thun, SDC-90-00077, (1990)
3. SDC Muon Trigger Preliminary Conceptual Design, J. Chapman and R. Thun, in preparation (Fall 1991)
4. SDC Trigger Preliminary Conceptual Design, W. Smith *et.al.*, August 1991

Simplified Muon Trigger

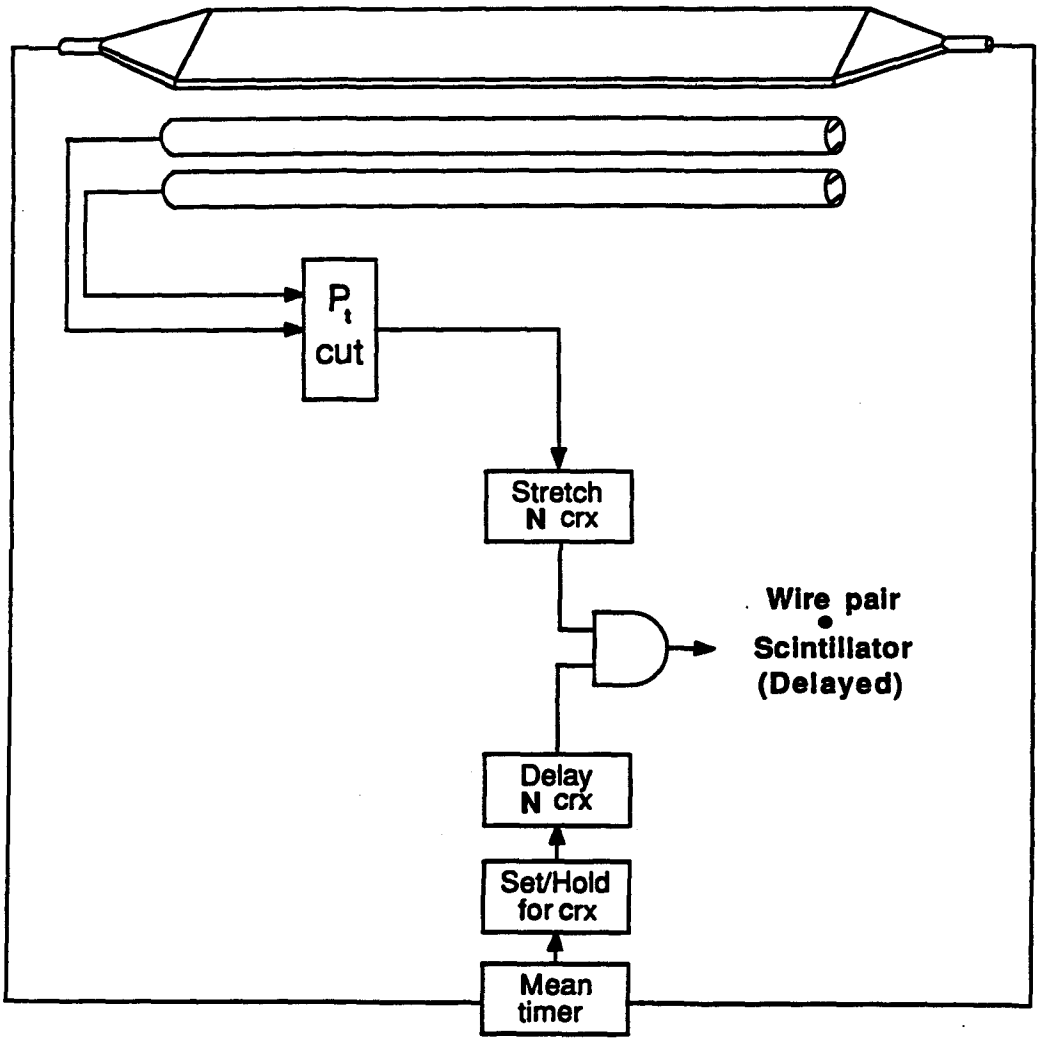
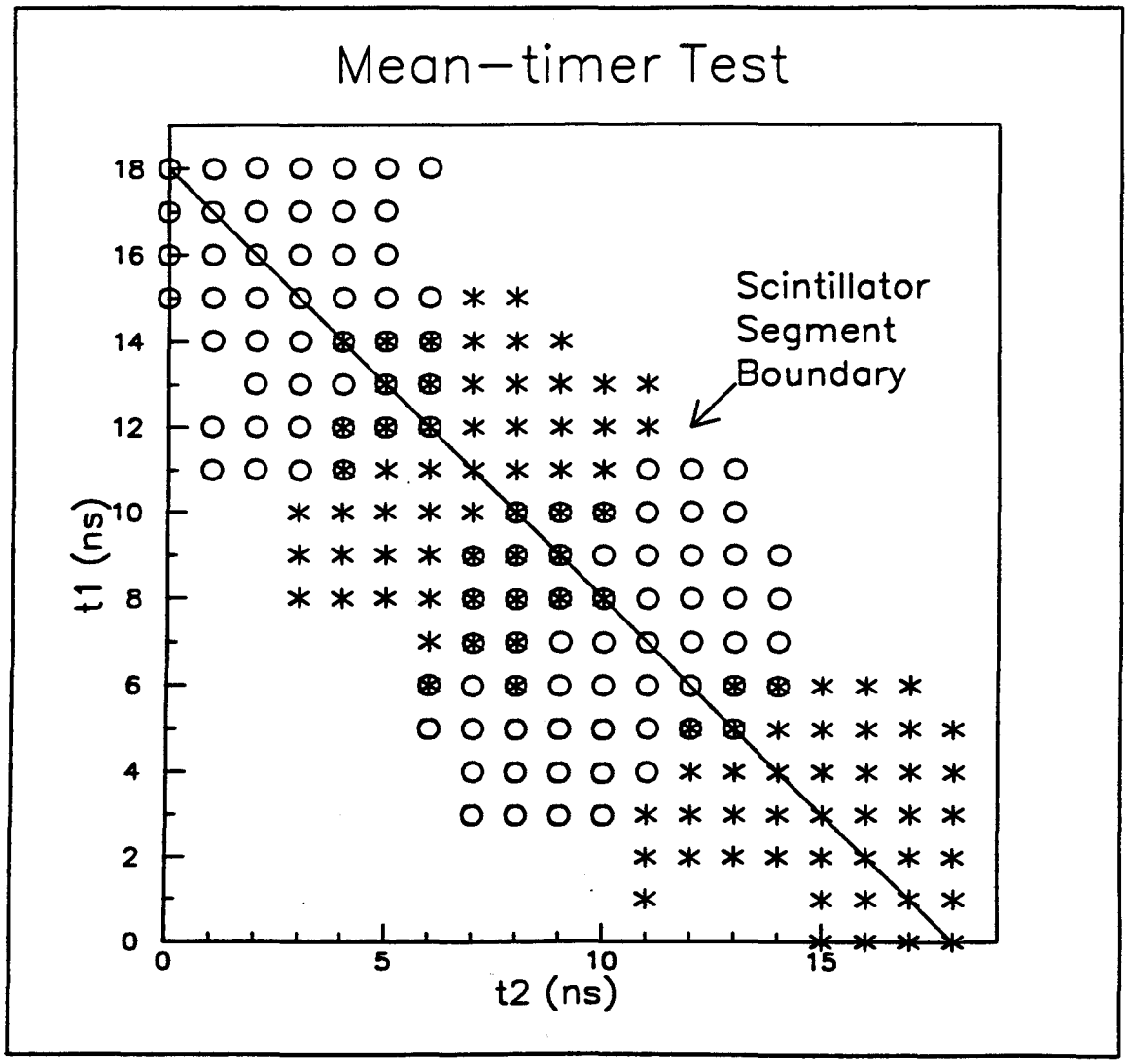


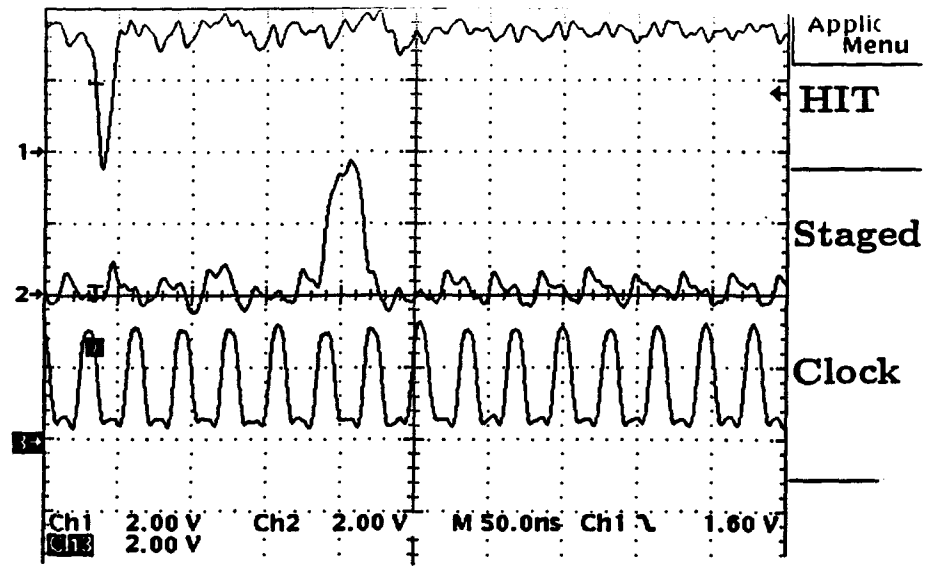
Figure 1.

Segmentation and Mean-timing

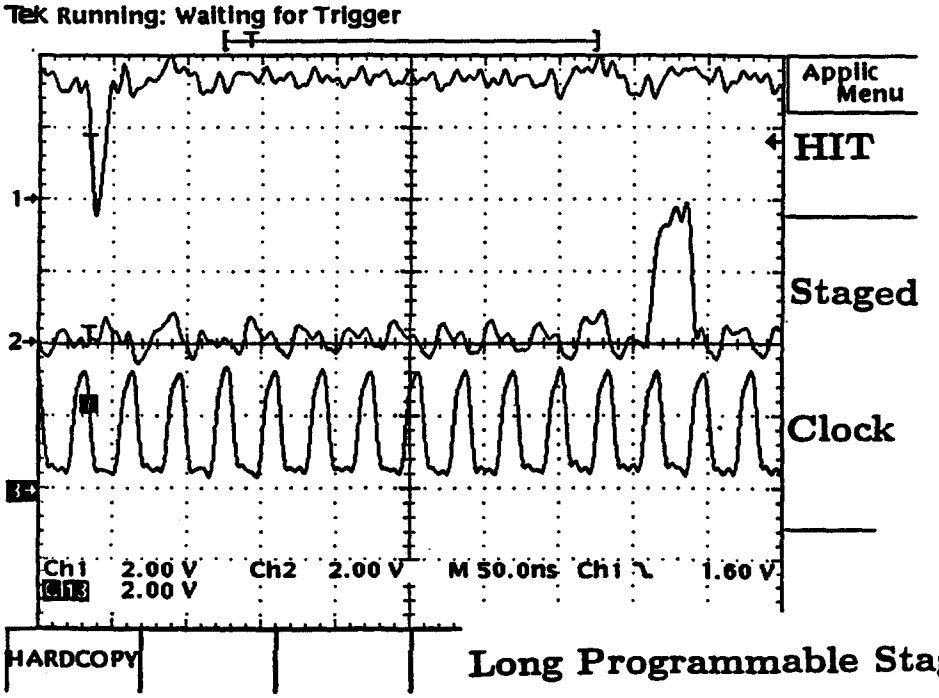


Scintillator Chip Tests

Figure 2.



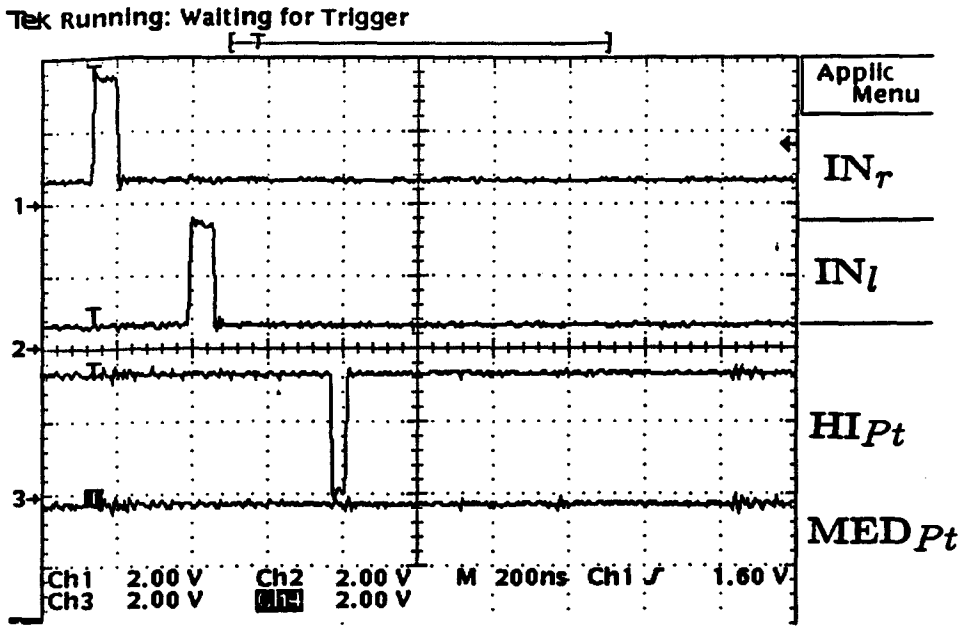
Short Programmable Staging



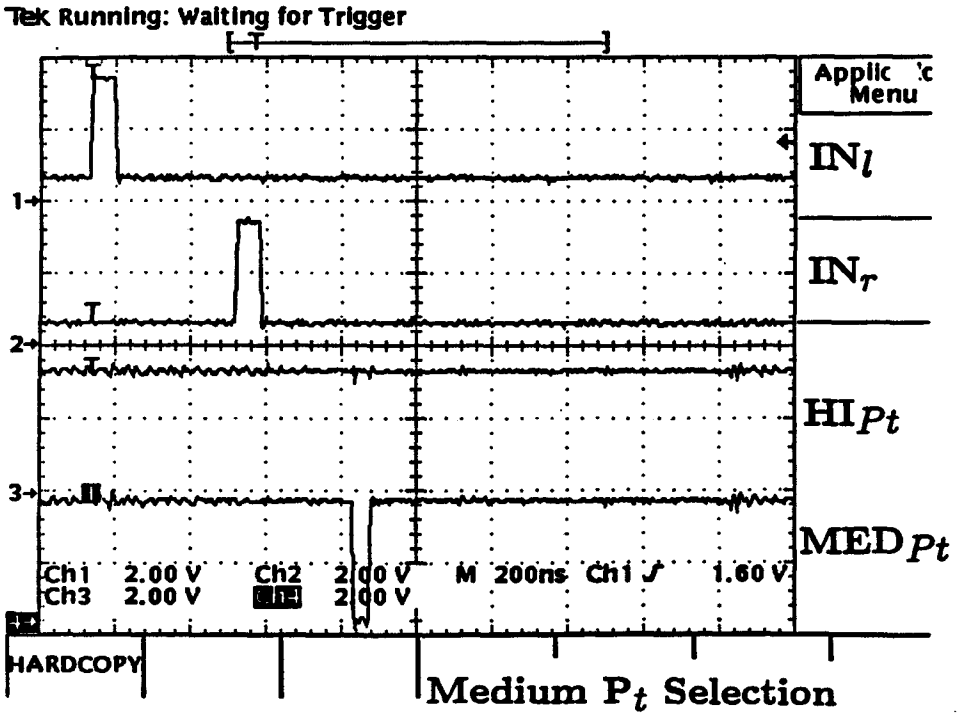
Long Programmable Staging

Figure 3.

Scintillator Chip Tests



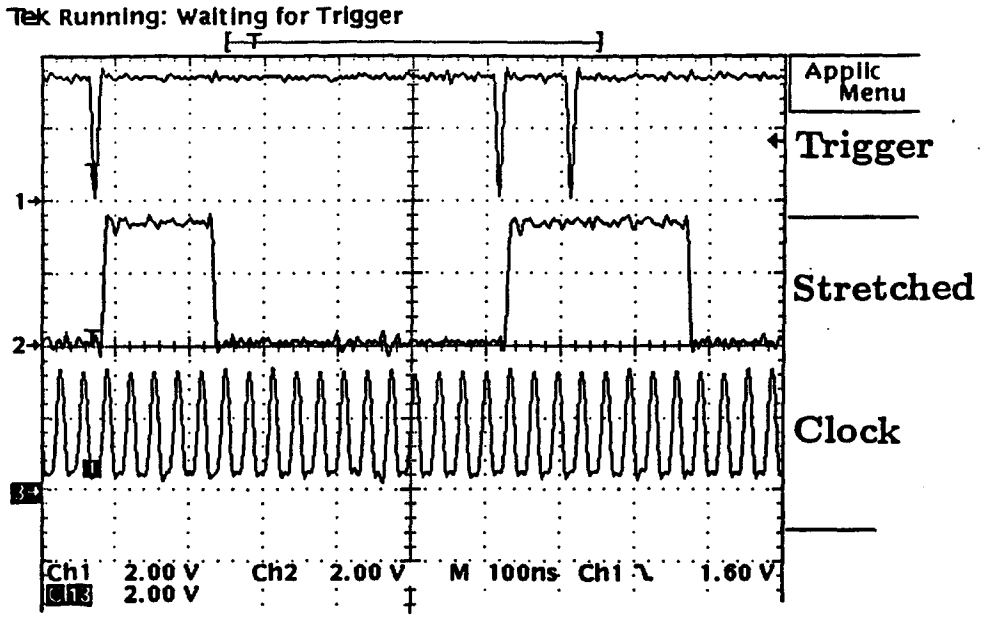
High P_t Selection



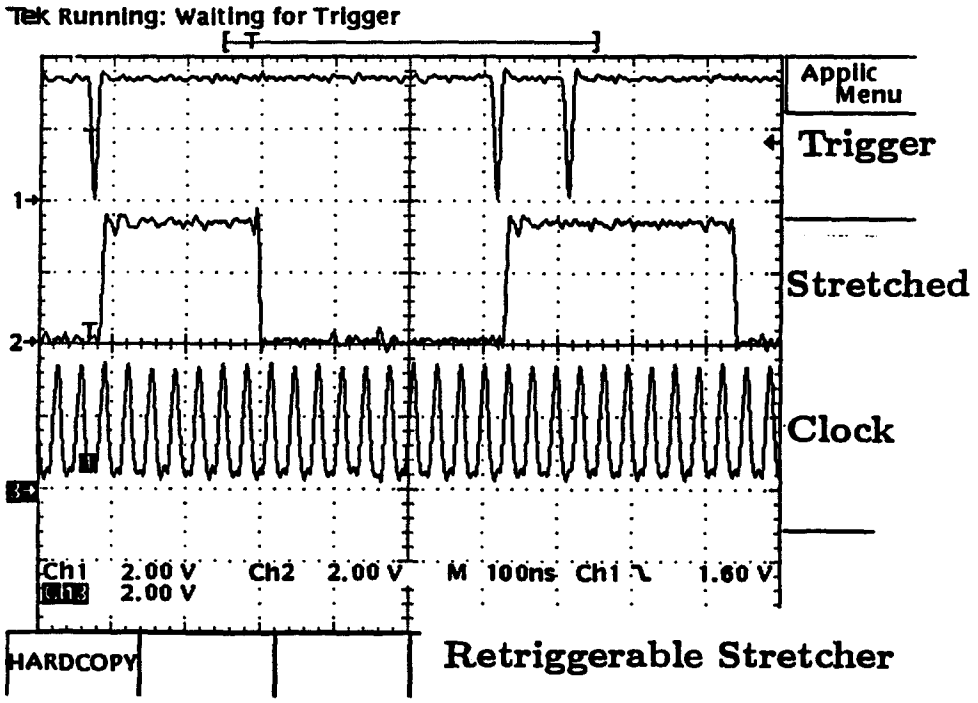
Medium P_t Selection

Figure 4.

Wire Chip Tests



Retriggerable Stretcher



Retriggerable Stretcher

Figure 5.

Wire Chip Tests