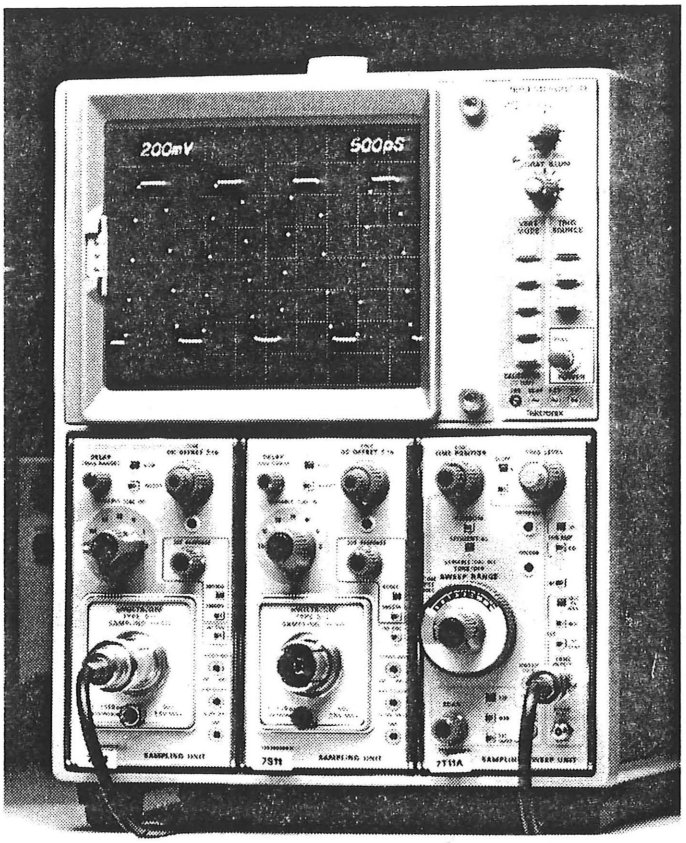



Student
Workbook

# High Speed Measurements Using Sampling Techniques

Tektronix®

*HIGH SPEED SAMPLING*
*TDR MEASUREMENTS*

Tektronix



*Objectives*

**PARTICIPANTS WILL UNDERSTAND SAMPLING:**

- ☐ **Typical measurements**
- ☐ **Equivalent time concepts**
- ☐ **Basic circuit blocks**
- ☐ **Operation of 7S11/S4/7T11A and 7S12/S4/S53**

## *History*

- ☐ **1960 N Unit**
- ☐ **1969 7S11, 7T11**
- ☐ **1971 7S12**
- ☐ **1974 5S14N, 7S14**
- ☐ **198X More**

## *Sampling Users*

- ☐ **Laser**
- ☐ **Fiber optics**
- ☐ **Gallium arsenide**
- ☐ **Communications**

## *TYPICAL SAMPLING MEASUREMENTS*

PULSE PARAMETERS
PROPAGATION DELAY
PHASE RELATIONSHIPS
SETTLING TIME
TDR

*Tektronix Sampling Products Are:*

MEASUREMENT TOOLS

- ☐ Maximum frequency – 14 GHz
- ☐ Fastest risetime – 25 ps
- ☐ Maximum trig frequency – 18 GHz
- ☐ TDR capabilities
- ☐ Adaptability

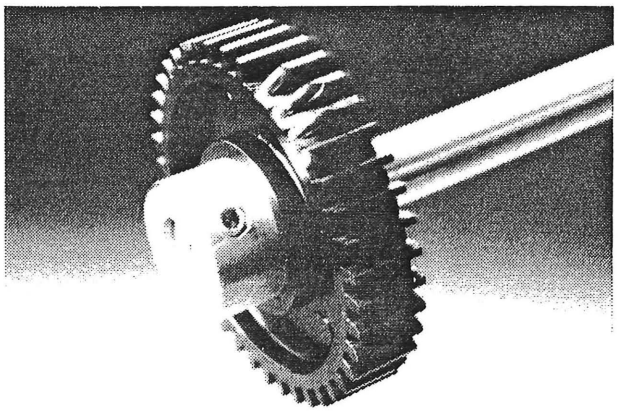
## *Sampling Concepts*

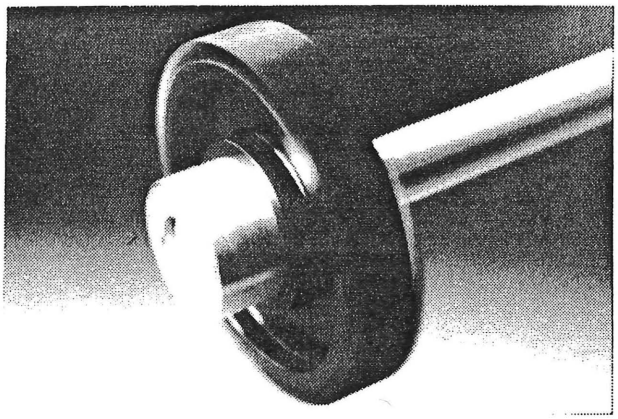
*Sampling Techniques*

**EQUIVALENT TIME**

- ☐ **Sequential**
- ☐ **Random**

**REAL-TIME**





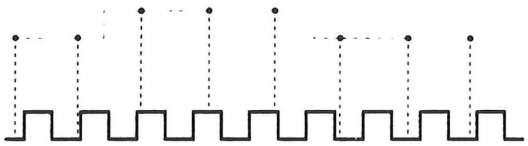
## *Equivalent Time*

**SEQUENTIAL**

- **Takes samples sequentially and places dots sequentially on the screen.**

## *Equivalent Time*

**SEQUENTIAL**



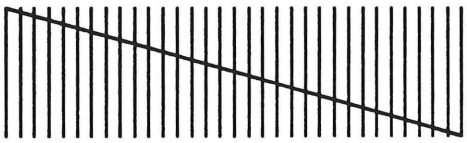
## *Equivalent Time*

**SEQUENTIAL**

- **Takes each subsequent sample at a slightly later point in relation to the trigger.**

*Equivalent Time*

**SEQUENTIAL**



*Equivalent Time*

**SEQUENTIAL**

- ☐ **Available in all Tektronix sampling products**

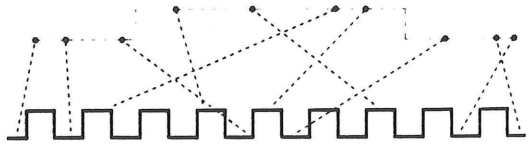
*Equivalent Time*

**RANDOM**

- ☐ **May take samples in a random manner.**

## *Equivalent Time*

**RANDOM**



## *Equivalent Time*

**RANDOM**

- ☐ **Monitors the trigger rep rate**
- ☐ **Uses this rep rate to estimate a pretrigger point**

## *Equivalent Time*

**RANDOM**

- ☐ **Places samples at the vertical and horizontal position of the sample.**

## *Equivalent Time*

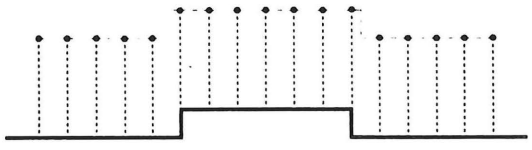
**RANDOM**

- ☐ **Tektronix offers this in the 7S11/7T11A combination**

## *Real-Time*

- ☐ **Makes enough samples to draw the signal in one sweep.**

## *Real-Time*



## *Real-Time*

- ☐ **Sampling rate must be at least 5 times faster than the signal frequency.**

## *Sampling Circuits*

**VERTICAL SAMPLING AND AMPLIFIERS**

**HORIZONTAL SWEEP AND TRIGGER CIRCUITS**

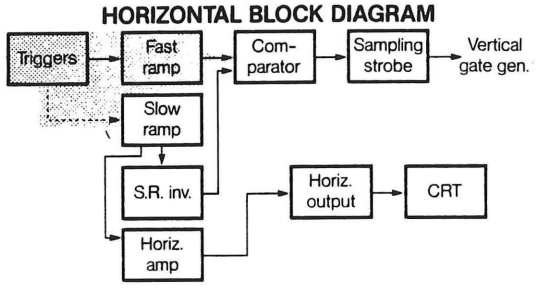
## *Sampling Circuits*

**HORIZONTAL CIRCUITS**

- ☐ **Triggers**
- ☐ **Slow ramp generator**
- ☐ **Fast ramp**
- ☐ **Comparator**
- ☐ **Strobe pulse**
- ☐ **Sweep circuits**

## *Sampling Circuits*

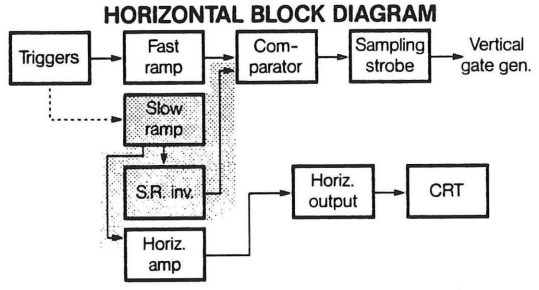
**HORIZONTAL BLOCK DIAGRAM**





## *Sampling Circuits*

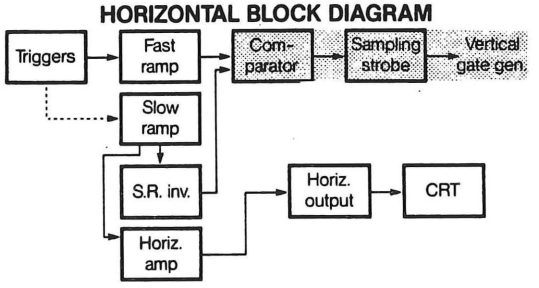
**HORIZONTAL BLOCK DIAGRAM**

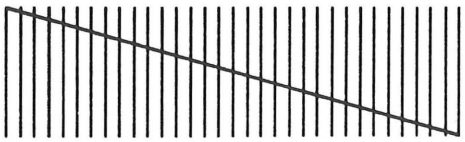


## *Sampling Circuits*

**HORIZONTAL BLOCK DIAGRAM**

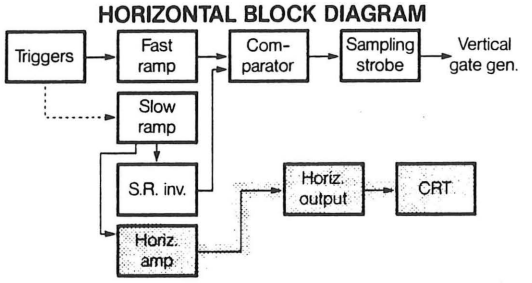



**SEQUENTIAL**



*Sampling Circuits*

**HORIZONTAL BLOCK DIAGRAM**



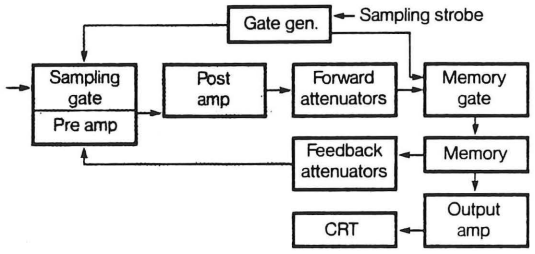

*Sampling Circuits*

**VERTICAL CIRCUITS**

- ☐ **Sampling gate**
- ☐ **Pre-amplifier**
- ☐ **Post-amplifier**
- ☐ **Memory gate**
- ☐ **Memory**
- ☐ **Vertical output**

## *Sampling Circuits*

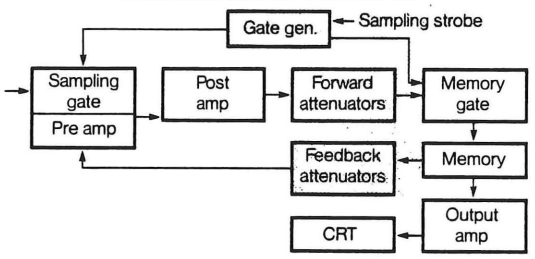
**VERTICAL BLOCK DIAGRAM**





## *Sampling Circuits*

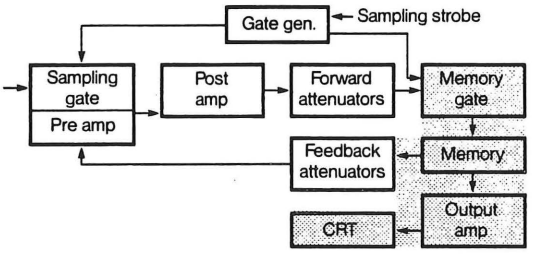
**VERTICAL BLOCK DIAGRAM**



## *Sampling Circuits*

**VERTICAL BLOCK DIAGRAM**

## *Helpful Tips (Trigger Stability)*

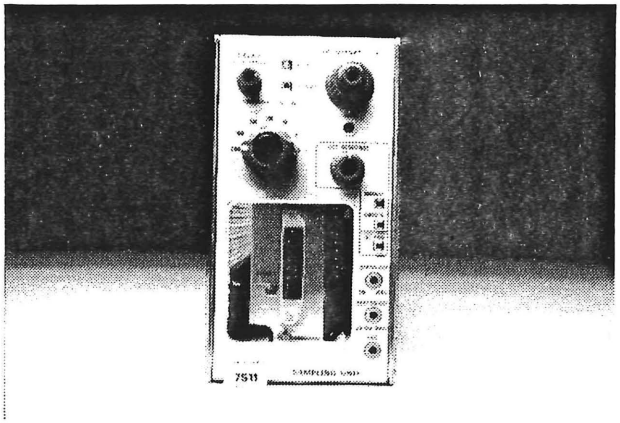
**FOR THE MOST STABLE TRIGGERS,**

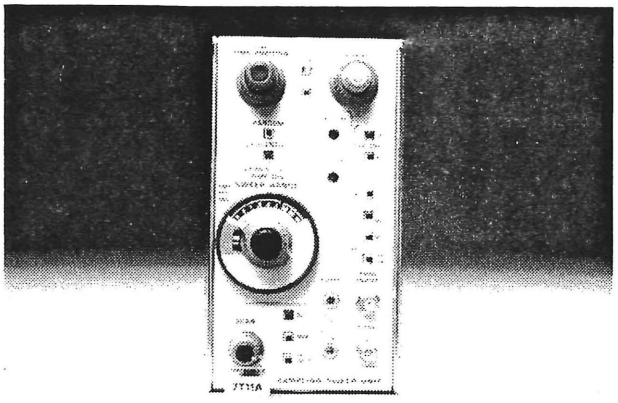
- ☐ **Start with stability pot completely CCW. (minimum current applied).**
- ☐ **While adjusting trigger level, slowly increase the current applied with the stability pot until triggered.**

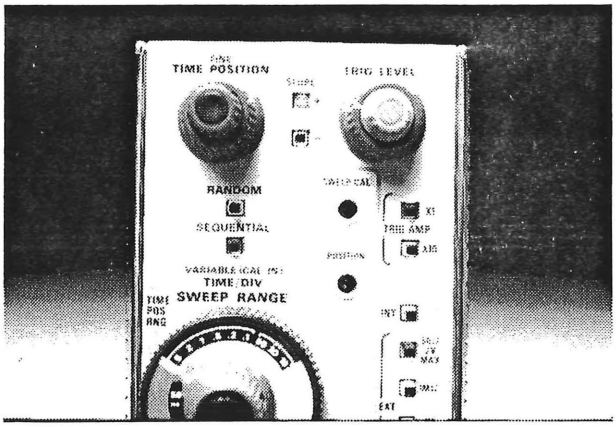
## *MAX INPUT & DC OFFSET*

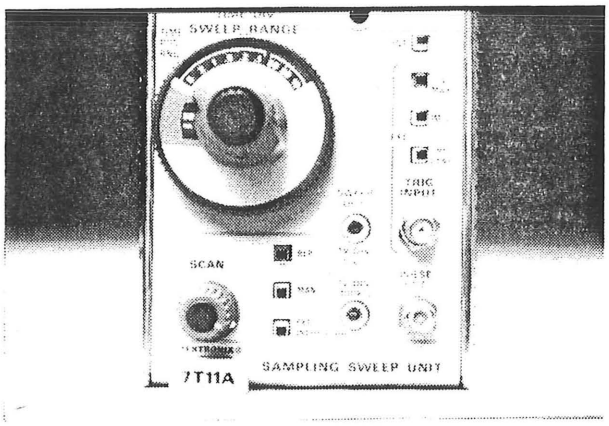
## *Sampling Head Selection*

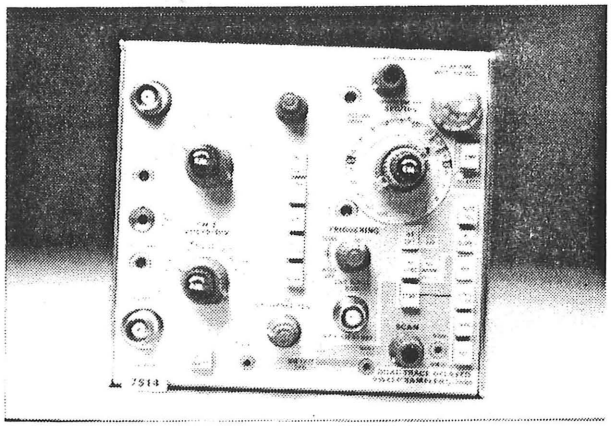
| | 350 MHz | 1 GHz | 4.6 GHz | 11.5 GHz | 14 GHz |
|---|---|---|---|---|---|
| 50Ω | | S-1 | S-2 | | S-4 |
| 100 kΩ | | S-3A | | | |
| 1 MΩ | S-5 | | | | |
| Externally Terminated | | | | S-6 | |

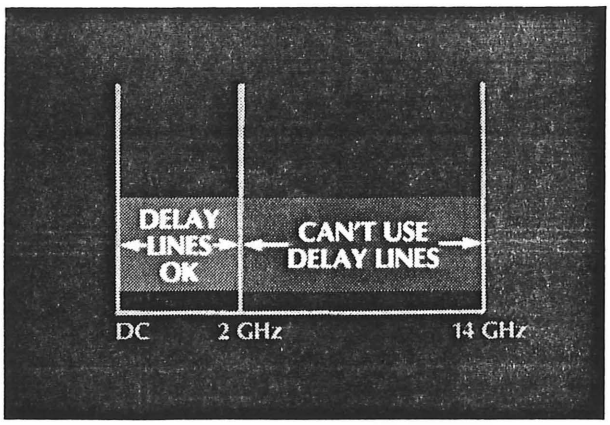


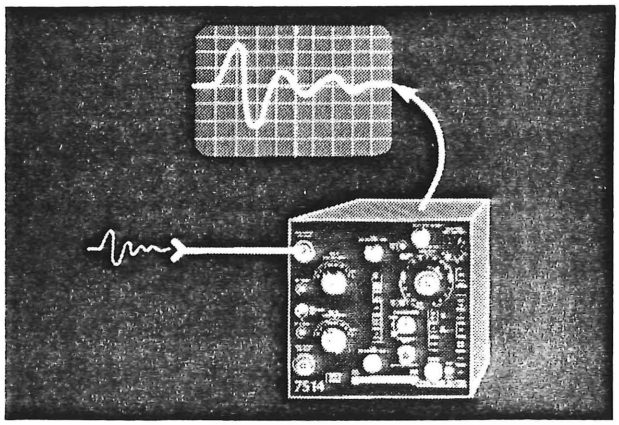


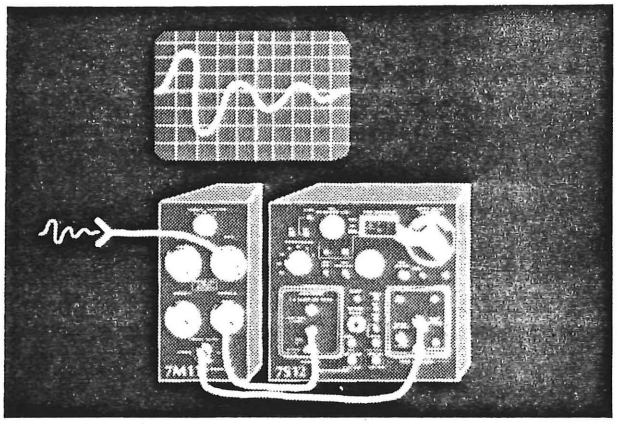

TIME POSITION
TRIG LEVEL
RANDOM
SEQUENTIAL
TRIG AMP
TIME/DIV
SWEEP RANGE
INT
EXT

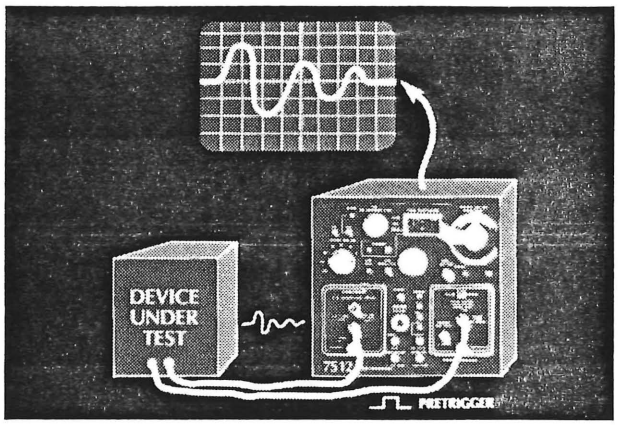

SWEEP RANGE
SCAN
7T11A
SAMPLING SWEEP UNIT

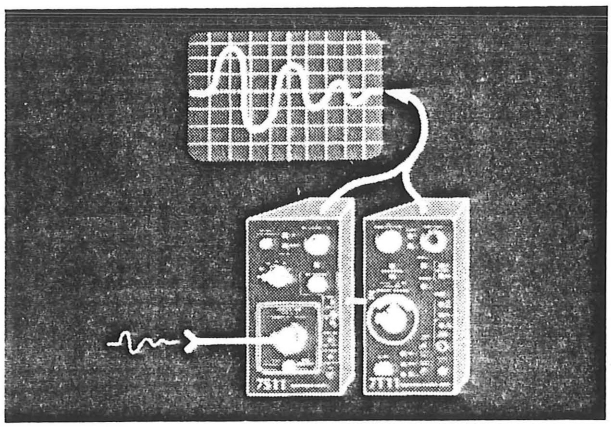



DELAY LINES OK
CAN'T USE DELAY LINES
DC
2 GHz
14 GHz


7514

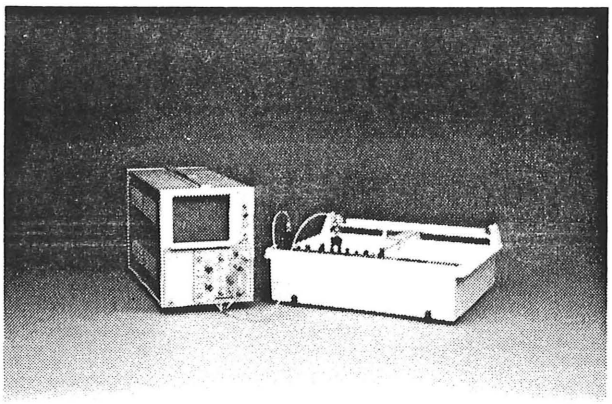

7M11
7S12

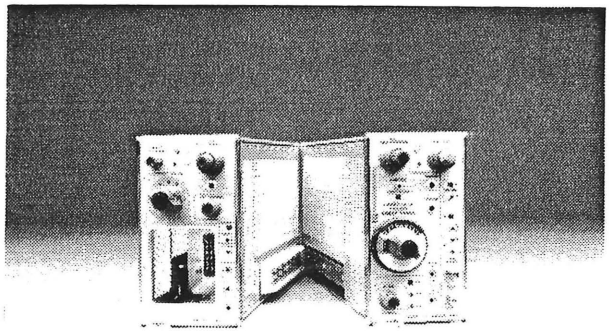

DEVICE
UNDER
TEST
7S12
PRETRIGGER

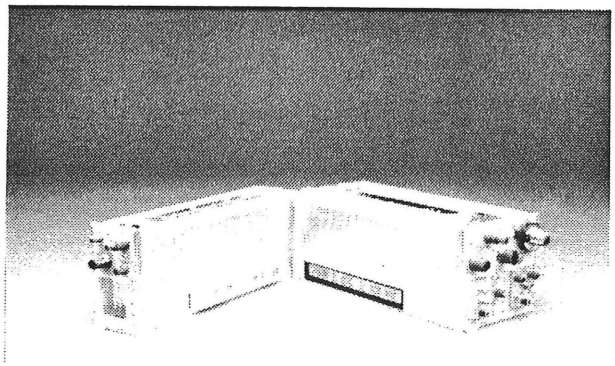


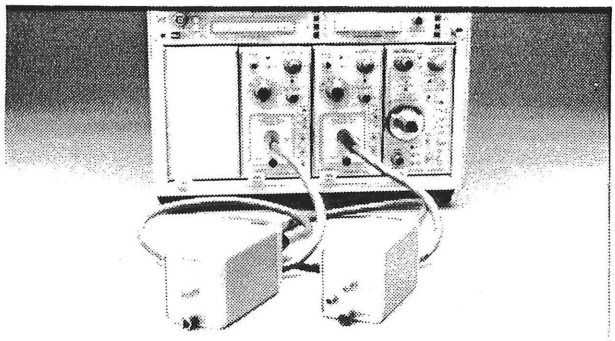
5S14N or 7S14

- Pulse Generators
- Logic Circuits
- Laser or Fiber Optics
- Time Coincidence
- Amplifier Response
- Accurate Measurements
- Magnified Display









# *TIME DOMAIN REFLECTOMETRY (TDR)*

## *Objectives*

**PARTICIPANTS WILL UNDERSTAND:**

- ☐ **Typical measurements**
- ☐ **Measurement parameters**
  - **— Distance**
  - **— RHo**
- ☐ **Operation of 7S12/S-6/S-52**

## *TDR Users*

- ☐ **Cable manufacturers**
- ☐ **Connector manufacturers**
- ☐ **Circuit board manufacturers**
- ☐ **Users of each**

## *TDR*

**CHECKING CIRCUIT BOARDS**
**CHECKING CABLES**
**CHECKING CONNECTORS**
**CHECKING DEVICES**

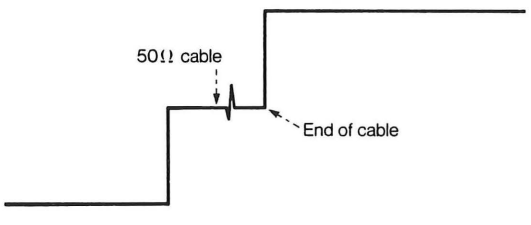
## *TDR*

**RADAR PULSE TESTING TECHNIQUE**

- ☐ **Measures lengths**
- ☐ **Measures impedances**
- ☐ **Identifies faults**

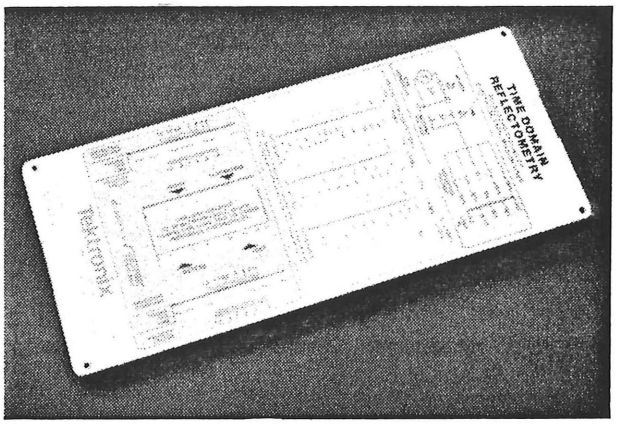
## *TDR*

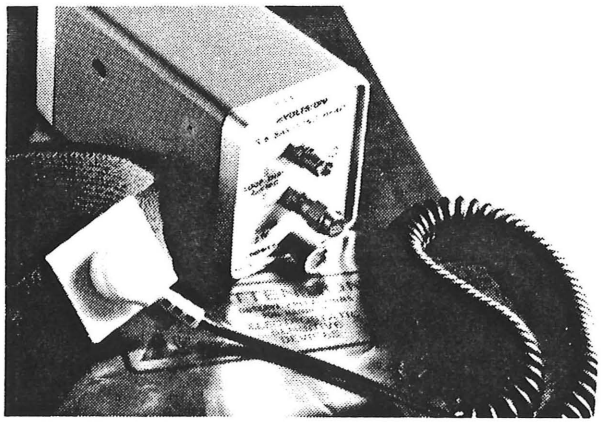
**OPEN CABLE**

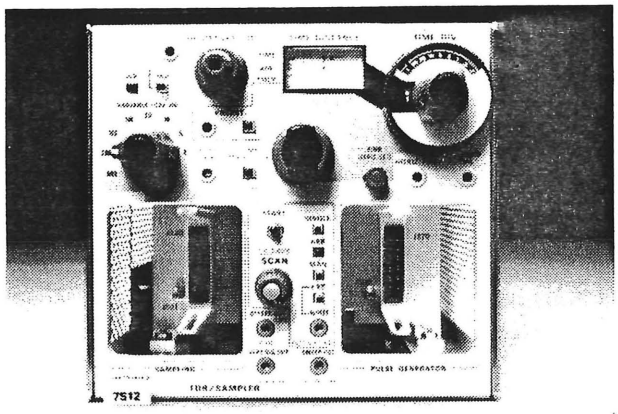


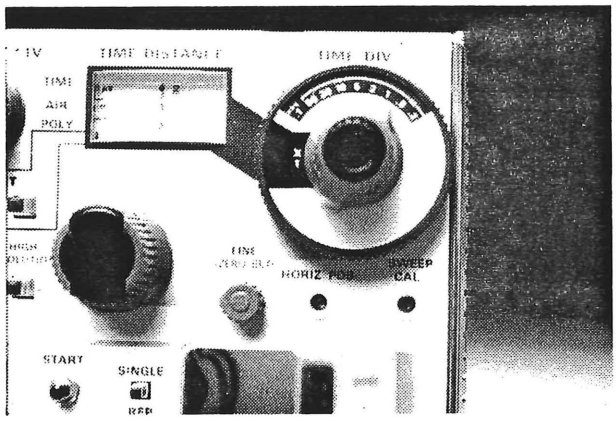
Rho ($\rho$)

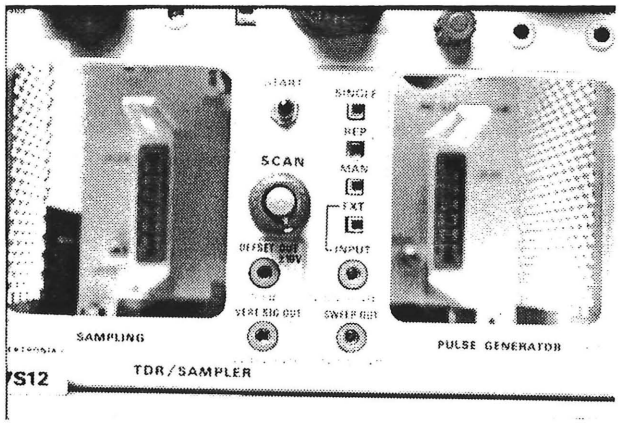
$$RL = Zo\left(\frac{1+\rho}{1-\rho}\right)$$

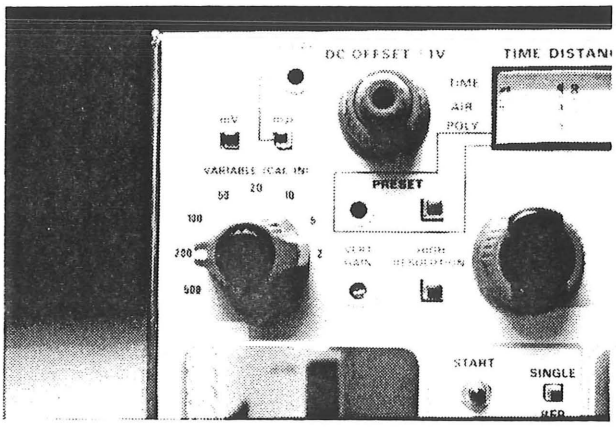


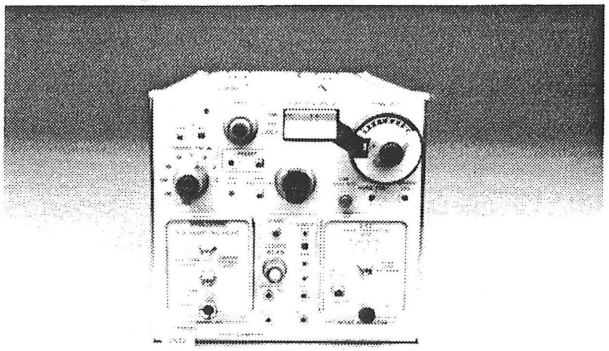



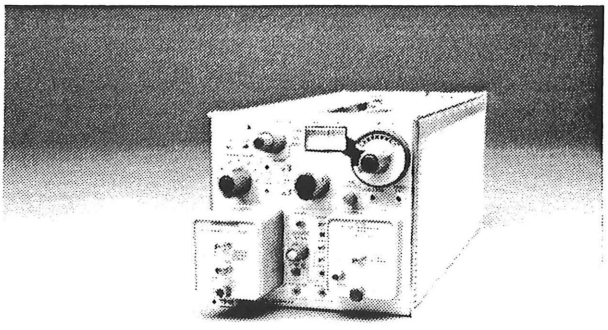

SCAN
TDR/SAMPLER
PULSE GENERATOR
7S12

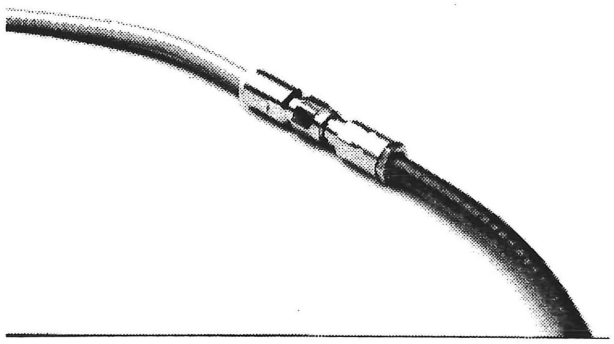

TIME DIV
TIME
AIR
POLY
START
SINGLE
REP
SWEEP
CAL

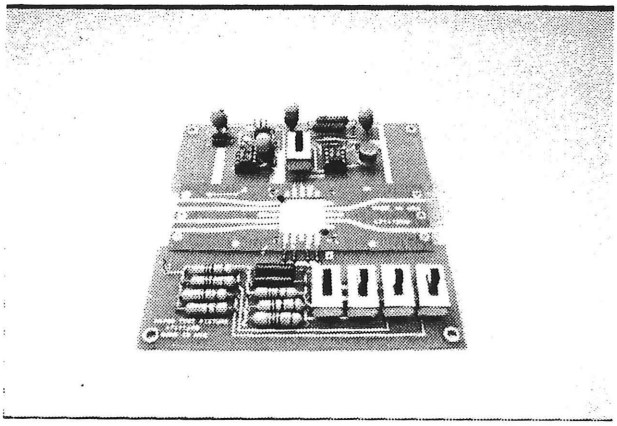

START
SINGLE
REP
SCAN
MAN
EXT
INPUT
SAMPLING
PULSE GENERATOR
TDR/SAMPLER

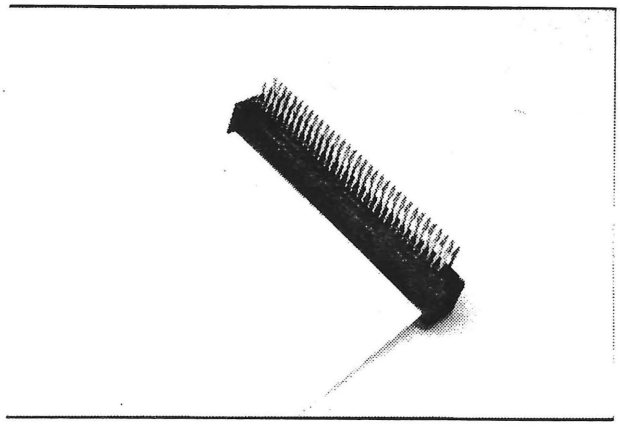

DC OFFSET
TIME DISTAN
TIME
AIR
POLY
PRESET
VARIABLE
50
20
10
100
5
200
2
500
START
SINGLE

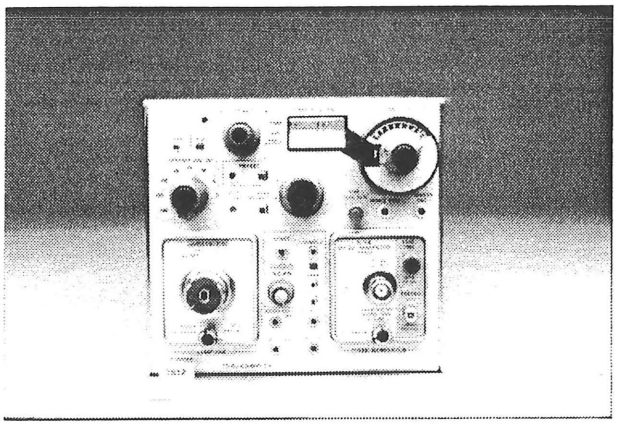




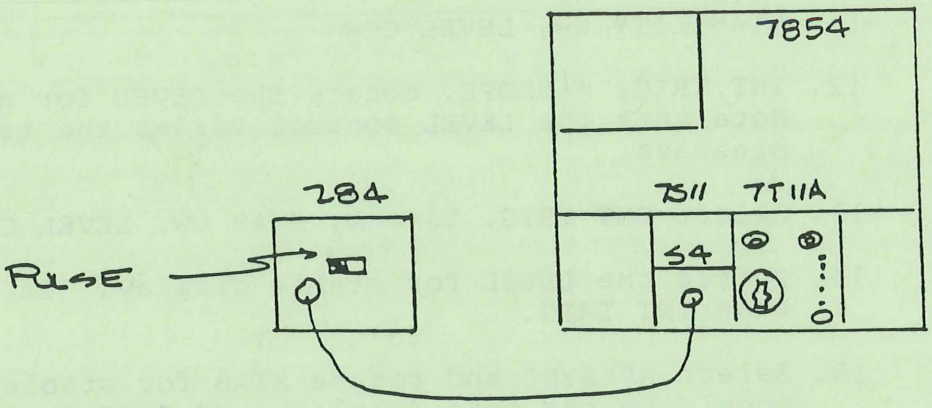








# SAMPLING LAB OUTLINE




| | | | |
|---|---|---|---|
| 7S11: | 100MV<br>NORMAL<br>INT TRIG | 7T11A: | TIME POSITION RANGE(TDR): 50uS<br>SWEEP SPEED (SS): 5uS<br>TRIG: INT X1<br>SCAN: REP<br>MODE: SEQUENTIAL<br>TIME POSITION (TP): don't care<br>STABILITY: CCW<br>LEVEL: CW |

1. Bring LEVEL CCW until a trace appears.
2. Using the TPR, TP and SS, what is the fastest SS you can get to view the leading edge of one pulse. (50uS and 10nS trailing only)
3. Select RANDOM and display a transition at 50nS, TPR and 50pS, SS.
4. Get the best possible display you can in RANDOM.
5. Connect an external trigger from the 284 to the 7T11A.
6. Select EXT TRIG, 50 OHM, X1 and SEQ.
7. Relocate the transition (TP) to the screen center and note the better display when using a pre-trigger signal from the source.
8. Measure the risetime (tr). Approx. 60pS

9. Measure the tr using the 7854.

10. Apply the 1GHz. sinewave from the 284.

11. STABILITY CW, LEVEL CCW

12. INT TRIG, + SLOPE, rotate the LEVEL for a triggered display. Note that the LEVEL control varies the trigger point on the sinewave.

13. Select EXT TRIG, 50 ohm, STAB CW, LEVEL CCW.

14. Rotate the LEVEL for stable display. It should be better than INT TRIG.

15. Select HF SYNC and rotate STAB for stable display. This should be the best display. HF SYNC is best for sinewave.

16. Note that +, - lights are off in HF SYNC. and that the LEVEL control has little affect.

17. Measure the frequency with the 7854.

ADDED CHALLENGE

1. Using the 285/S-52 as a signal source, determine the following:

    a. Pulse width of the narrow pulse measured over 7 or 8 horizontal divisions.

    b. Pulse width of the wide pulse measured over 7 or 8 horizontal divisions.

    c. Risetime of the system.

ADDED ADDED CHALLENGE

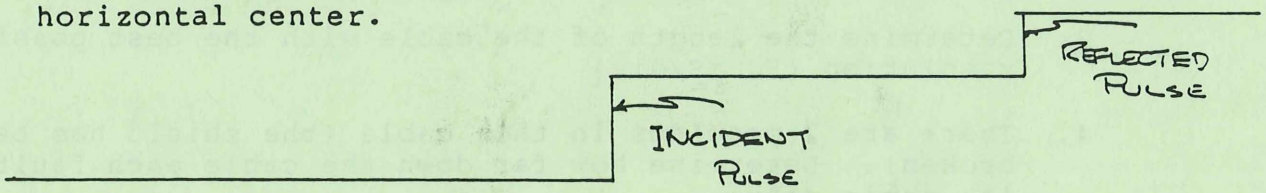
1. Remove 7S11/7T11A and install 7S12.

2. Install an S-4 in the left compartment and an S-53 in the right compartment.

3. Make the 3 measurements (a,b & c above), using the 7S12 in the sampling mode.

# TDR LAB OUTLINE

1. Equipment - 7S12, S6, S52, S12 in center 2 compartments.
2. Connect CALIBRATOR, 4V into S6 with other S6 input terminated in 50 ohms.
3. Select MANUAL SCAN and 100 mV/div.
4. Set VERT GAIN to 4 divisions.
5. Disconnect BNC cable and select REP.
6. Connect "U" rigid 3mm conductor from S52 to S6 and remove the 50 ohm terminator from the S6.
7. At 1 ns/div and 100 mV/div, note the step near the center of the transition. This is a reflection from the open connector of the S6.
8. To prove this, replace the 3mm, 50 ohm terminator and notice that the step went away. This is the case because the terminator absorbs the energy.
9. Remove the terminator and increase the sweep speed to 200 pS.
10. With the FINE (Zero Set) control, position the steps near the horizontal center.




11. Here we see the incident pulse and because the S6 output is open, we have all of the energy reflected.
12. Select mp (rho) and 500 mp.
13. Connect the brown semi-rigid, 3mm cable to the S6 and measure its length. (Approx 1.4 ft.)
14. Return TIME-DISTANCE tape to zero and select 10 nS/div.
15. Now we'll adjust p (rho) using the 2cm AIRLINE as a reference 50 ohms.
16. Select 200 mp/div and 1 ns/div. (Place the display near the top of the CRT)
17. When we connect the AIRLINE, the 50 ohm reference will be just to the left of the second step.

18. Connect the AIRLINE and note that the second pulse moved to the right the length of the AIRLINE.

19. Recall that the 50 ohm reference is just to the left of the second pulse. This reference will be used throughout the remainder of this lab.

20. With the DC OFFSET and the p (rho) CAL, adjust the amplitude for exactly 5 divisions.

21. Connect a BNC cable and measure its length. (approx. 3.5 ft.)

22. Install a RED ATTENUATOR on the end of the BNC cable and determine the impedence.

    HINT: Find the 50 ohm reference and position it on the 2nd vertical graticule line and select 50 mp/div. You should have about 5 divisions from the 50 ohm reference to the top of the reflected pulse. With a slide rule, determine the value of the ATTENUATOR (approx. 82 ohms)

ADDED CHALLENGE

1. Remove the BNC cable and install the "TEST CABLE".

2. Measure the Zo of the cable. Note that the display dribbles up slightly along the cable length. So, measure the amplitude just in front of the reflected pulse. You should have about 4 divisions of 50 mp/div = 75 ohm.

3. Determine the length of the cable with the best possible resolution (50 pS/div)

4. There are 2 problems in this cable (the shield has been broken). Determine how far down the cable each fault is and its ohmic value.