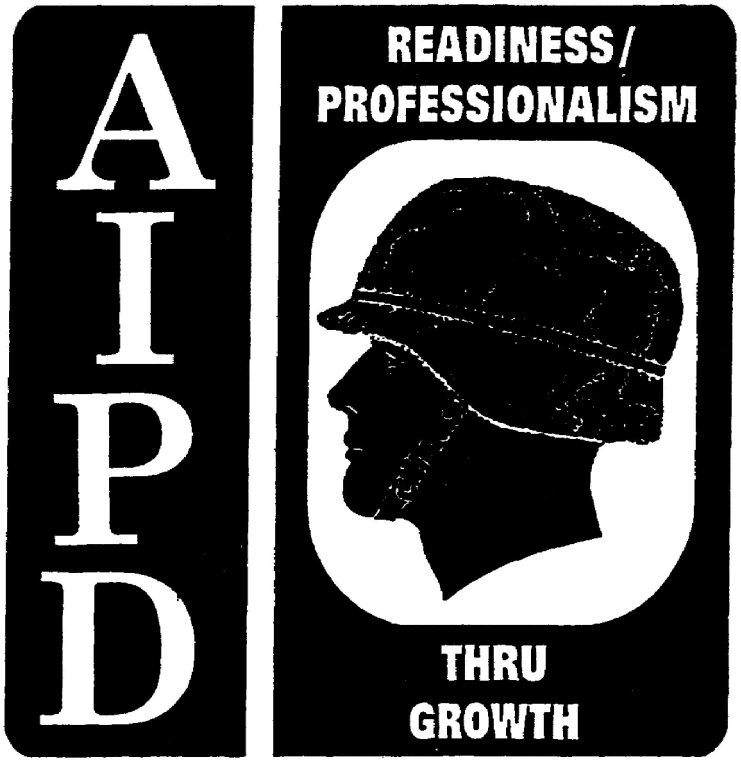
SUBCOURSE
OD1402

EDITION
9

BASIC OSCILLOSCOPE



THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT

ARMY CORRESPONDENCE COURSE PROGRAM

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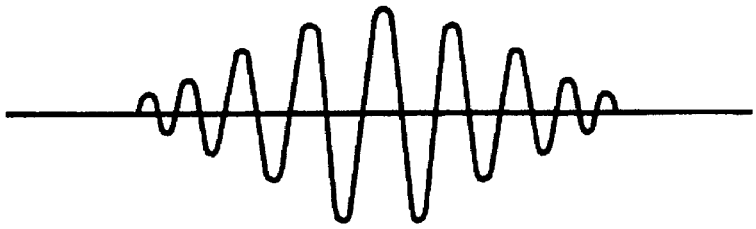

BASIC OSCILLOSCOPE

SUBCOURSE OD1402
EDITION 9

United States Army Combined Arms Support Command
Fort Lee, VA 23801-1809

5 CREDIT HOURS
NEW: 1989

GENERAL

The purpose of this subcourse is to familiarize the tank turret repairer with the information necessary to operate the AN/USM-281C oscilloscope. This will include descriptions of controls, indicators, and initial set-up procedures. This subcourse will also train the repairer on proper procedures to measure voltage amplitude and frequency using the screen grids.

LESSON 1: BASIC OSCILLOSCOPE

TASK: Describe the purpose and the initial position of the basic controls and switches. Describe the use of screen grids to interpret voltage amplitude and frequency measurements on the basic oscilloscope.

CONDITIONS: The student will complete the subcourse and examination in a self-study environment, given the subcourse booklet. After successful completion of the examination, the student should be able to perform the task, given TM 9-254 and TM 11-6625-2658-14.

STANDARD: Demonstrate your comprehension of the task by correctly answering 70% of the questions on the examination in accordance with the listed references.

(This objective supports Soldier's Manual (SM) task: 091-499-3012.)

TABLE OF CONTENTS

INTRODUCTION

Electronically speaking, an oscilloscope is a device that makes the invisible become visible. The invisible things we are interested in seeing are the galaxy of different electronic signals present in electronic circuitry. Connect the oscilloscope to any signal circuit and you can follow the progress of the ever-growing signal as it weaves its way from the input to the output terminals. The luminous trace on the oscilloscope's screen shows you the signal's every up, down, and twist. As you move the scope's probe from stage to stage, you can view each stage's effect on the signal.

What can you do with an oscilloscope? Because the instrument is so versatile, it's hard to find a point to begin talking about it. It can be used to design circuitry, adjust variable component values, and calibrate circuitry. It can also be used to troubleshoot faulty circuitry when you know the correct waveform at each point in the circuit. You just move the probe from stage to stage until you find an out-of-shape waveform. You can also measure voltages of alternating and direct currents and determine the frequency of the cycles.

You get the idea. Throughout this subcourse, you will use the oscilloscope to view various waveforms. You will also learn how to determine the voltage and frequency of these waveforms. All of this information should help the tank turret repairer become comfortable with using the oscilloscope as a tool of his trade.

LESSON 1

BASIC OSCILLOSCOPE

TASK

Describe the purpose and the initial position of the basic controls and switches. Describe the use of screen grids to interpret voltage amplitude and frequency measurements on the basic oscilloscope.

CONDITIONS

The student will complete the subcourse and examination in a self-study environment, given the subcourse booklet. After successful completion of the examination, the student should be able to perform the learning event, given TM 9-254 and TM 11-6625-2658-14.

STANDARD

Demonstrate your comprehension of the task by correctly answering 70% of the questions on the examination in accordance with the latest references.

REFERENCES

TM 9-254
TM 11-6625-2658-14

Learning Event 1:

DESCRIBE THE PURPOSE AND THE INITIAL POSITION OF THE FUNDAMENTAL CONTROLS AND SWITCHES OF THE BASIC OSCILLOSCOPE

GENERAL

The oscilloscope is used to visually display electrical impulses. Some oscilloscopes are designed specifically for

displaying only one trace. These are classified as single trace oscilloscopes. They consist of one vertical amplifier and one horizontal sweep generator connected to a cathode ray tube (CRT). The oscilloscope (AN/USM 281C) used in this subcourse provides dual trace operation. A dual trace oscilloscope has two vertical amplifiers and two horizontal sweep generators. This provides dual trace operation for the comparison of two electrical impulses at the same time.

Sometimes, the recurring signal rate is so slow that it becomes impossible to observe it on a conventional oscilloscope. Then, a storage oscilloscope must be used. The storage oscilloscope is designed to store the signal in its memory and then display the signal on the CRT. In addition, the storage oscilloscope can be operated as a conventional oscilloscope.

EQUIPMENT DESCRIPTION

The AN/USM 281C oscilloscope (figure 1, on the next page) is a light-weight, solid state instrument designed for general purpose signal waveform measurements. It has single or dual trace capabilities. The oscilloscope consists of the oscilloscope main frame, two vertical amplifier plug-in units, and the dual time base plug-in unit. These units are described in the following paragraphs.

Main Frame

The main frame contains the CRT and power supply components and provides three plug-in compartments for the vertical amplifiers and dual time base units. Of the three plug-in compartments, the two on the left are connected to the vertical deflection circuits. The one on the right is connected to the horizontal deflection system. Electronic switching between the vertical amplifiers allows a dual trace vertical display.

Vertical Amplifier

The vertical amplifier is a wide-band amplifier that provides vertical deflection signals to the mainframe vertical amplifier circuits. There are two vertical amplifier compartments in the mainframe. This allows one amplifier to be used alone, for single trace operation, or two amplifiers to be used for dual trace operation.

Dual Time Base

The dual time base provides a horizontal deflection signal to the main frame CRT circuits for each of the two traces.

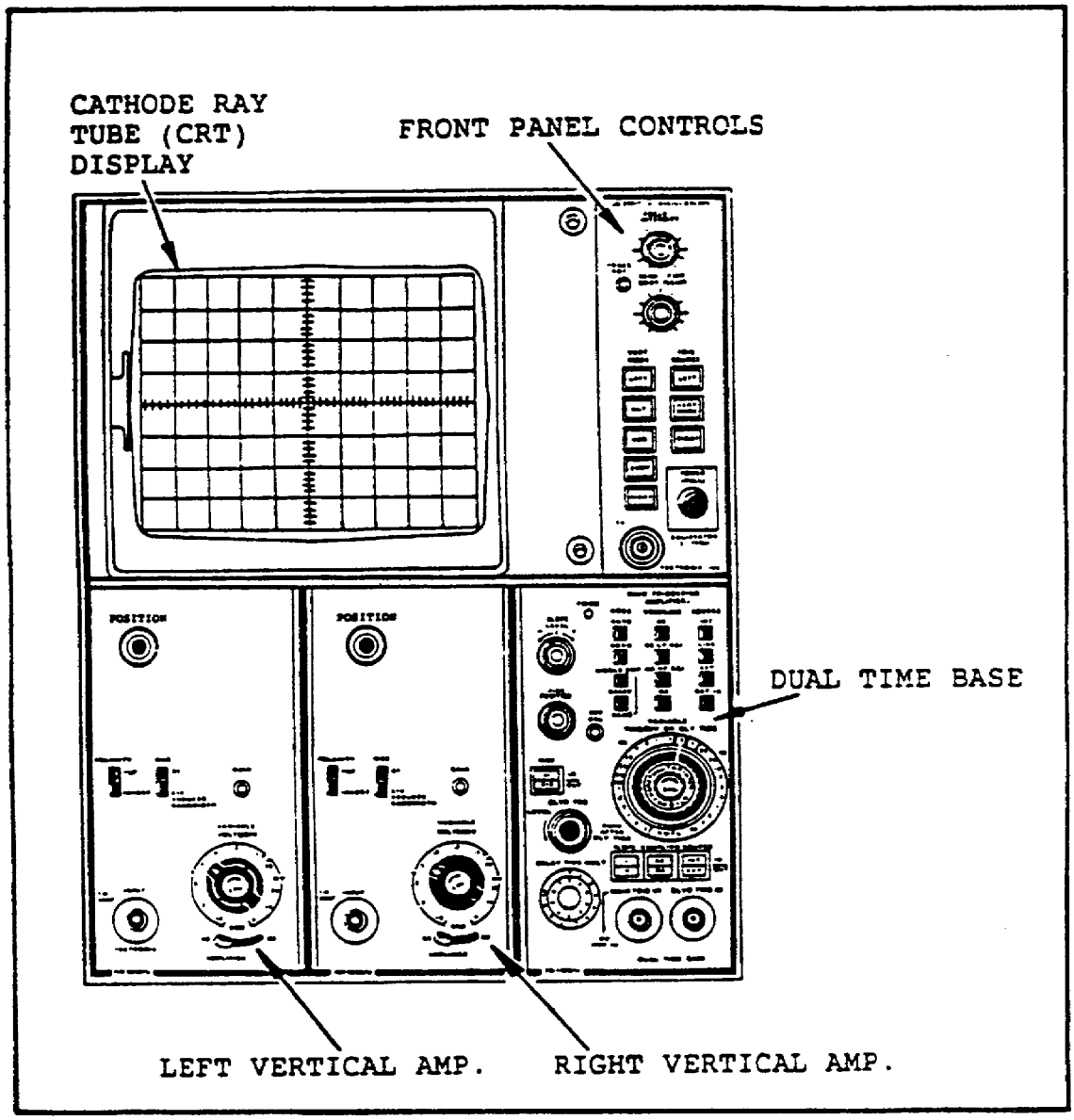

FIGURE 1. OSCILLOSCOPE SUBASSEMBLIES.

OSCILLOSCOPE CONTROLS

The controls for the AN/USM 281C oscilloscope are located on the front and rear panels. The most commonly used controls will be discussed in this subcourse. The more complex

controls will not be covered. These controls are for special applications. For their uses, refer to the operator's manual of the particular oscilloscope you are using.

Oscilloscope Front Panel Controls

The function of the oscilloscope front panel controls (figure 2, on the next page) are as follows:

Intensity Control. Controls the brightness of the display.

Focus Knob. Controls the definition (focus) of the display.

Trace Rotation Control. Controls the alignment of the trace with the screen grids (graticule lines).

Grat Illum (Graticule Illumination) Knob. Controls the brightness of the graticule lines.

Beam Finder Switch. When pressed, causes the display to be compressed within the graticule area.

Vertical Mode Switches. Selects the signal from the vertical amplifiers. It consists of the following five function switches:

- Left - Selects the signal from the left-hand vertical amplifier for display.

- Alt - Selects signals from the left-hand and the right-hand vertical amplifiers in alternating patterns for display. Signals are switched after each sweep.

- Add - Selects signals from both vertical amplifiers for display. Signals are added together and the sum is displayed.

- Chop - Selects signals from both vertical amplifiers in an alternating pattern. Signals are switched at a 1-megahertz rate, under the control of an internal oscillator.

- Right - Selects signal from the right hand vertical amplifier for display.

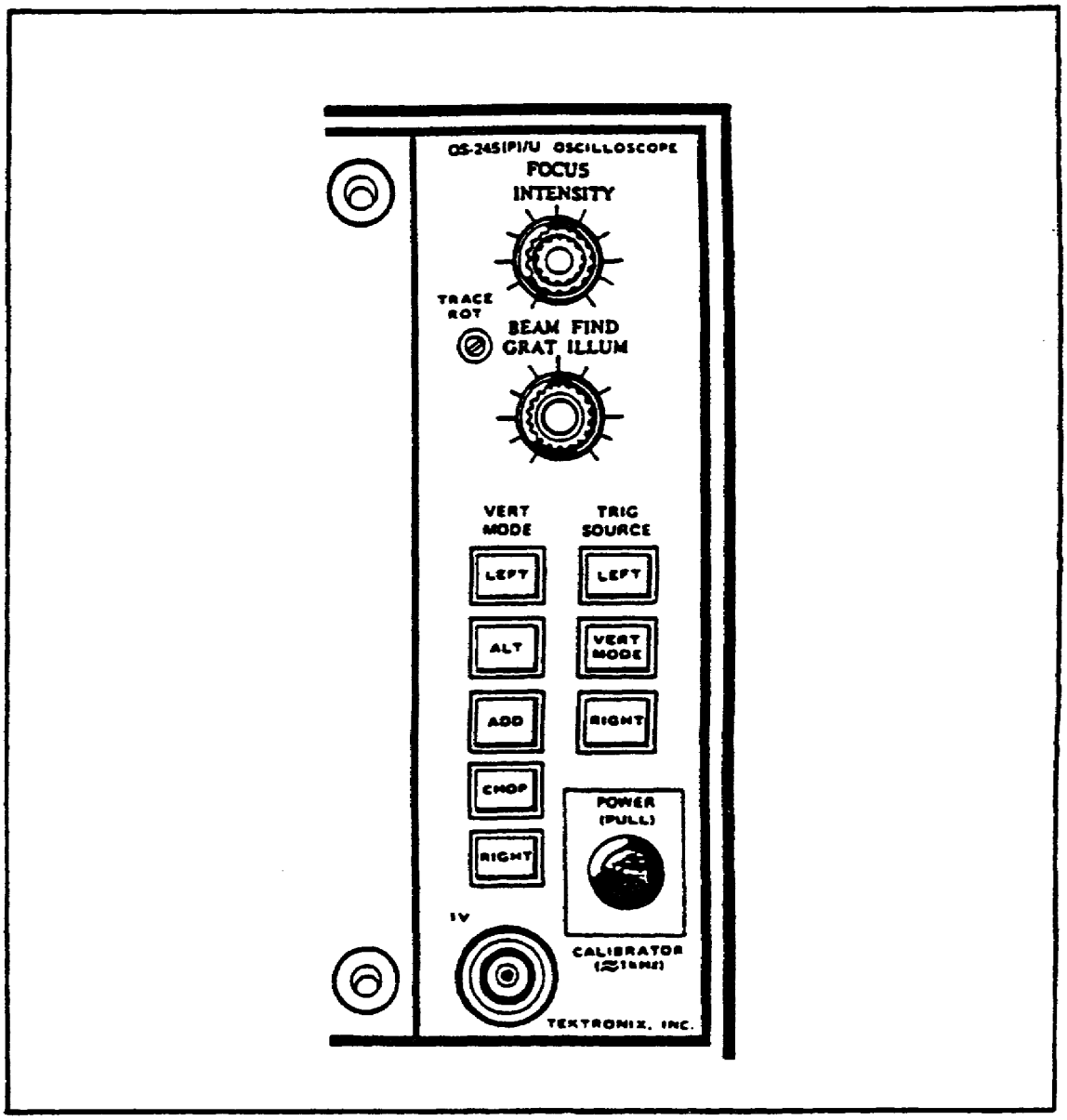

FIGURE 2. FRONT PANEL CONTROLS.

Trigger Source Switches. Provide a trigger signal to give you a stable display on the CRT. The trigger signal comes from three sources:

o Left - Selects the trigger signal from the left vertical amplifier.

o Vert - Mode -Trigger signal automatically follows the vertical display, except in the chopped mode. In the chopped mode, the trigger occurs at a 1-megahertz rate, under the control of an internal oscillator.

o Right -Selects the trigger signal from the right vertical amplifier.

Power Switch. Controls power to the oscilloscope.

Calibrator Connector. Provides for connecting a cable to the calibrator output signal.

Vertical Amplifier Controls

The functions of the vertical amplifier controls (figure 3, on the next page) are as follows:

Position Control. Controls the vertical position of the trace.

Polarity Switch. Provides for display inversion. In the +UP position, positive signals will cause an upward trace deflection. In the INVERT position, a positive signal will cause a downward trace deflection.

Mag Switch. Provides for a decreasing deflection factor.

In the x1 position, the deflection factor is not changed. In the x10 position, the deflection factor is 1/10th of that selected by the VOLTS/DIV switch.

Gain Control. Fine tuning of the deflection factor.

Input Connector. Provides for connecting the amplifier input signal cable.

Volts/Div Switch. Provides for selecting calibrated selection factors, from 5 millivolts to 10 volts per division.

Variable (Calibrate) Knob. Can multiply the Volts/Div switch setting up to 2.5 times. Extends the range to 25 volts per division or more.

AC/GND/DC Switch. In the AC position, any AC signal is passed to the amplifier and any DC signal is blocked. In the ground (GND) position, no signal is passed to the amplifier. In the DC position, all components of the signal (AC and DC) are coupled to the amplifier input.

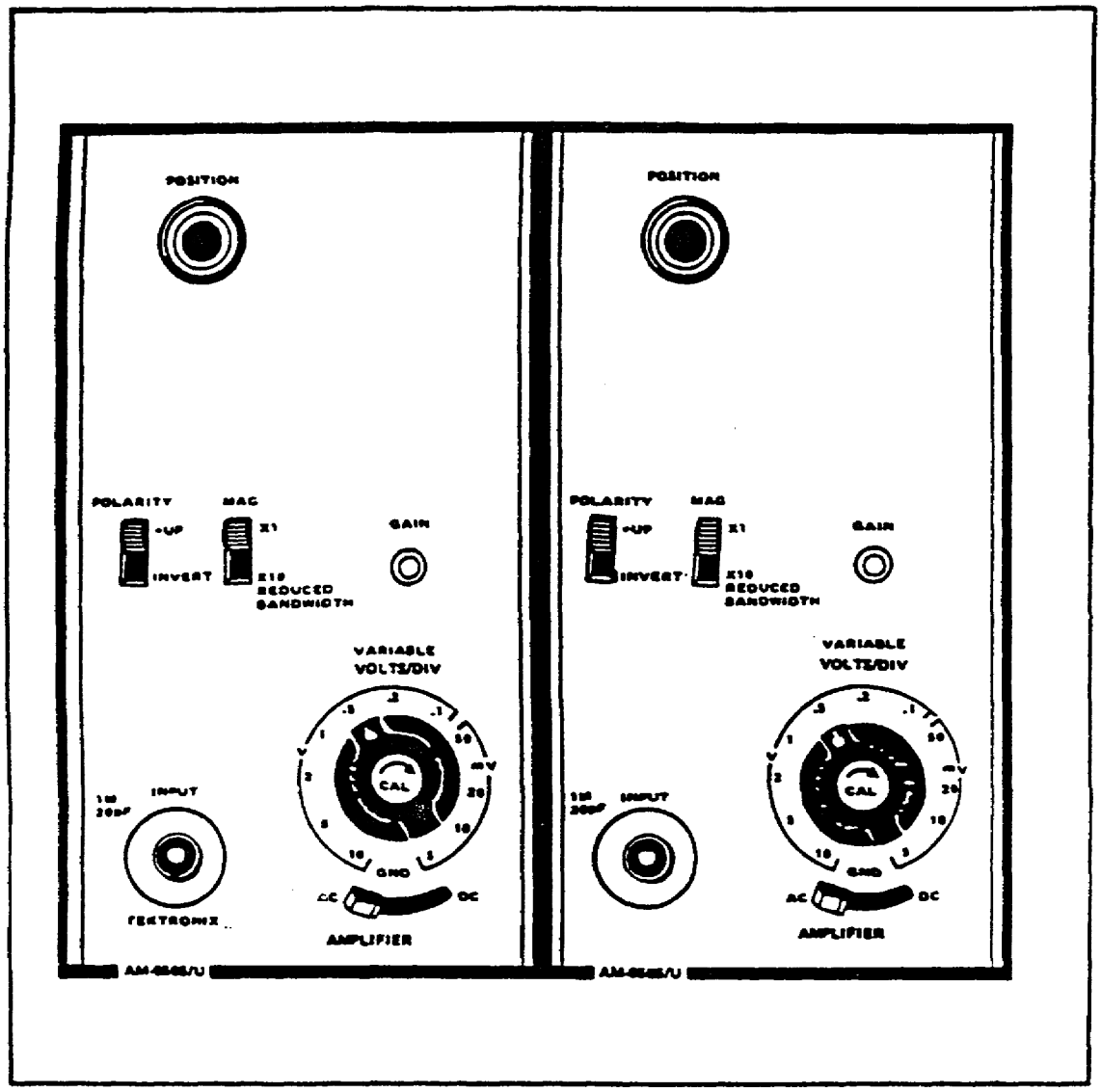

FIGURE 3. VERTICAL AMPLIFIER CONTROLS.

Dual Time Base Controls

The functions of the dual time base controls (figure 4, on the next page) are discussed next.

Level Knob. Provides for selecting the amplitude point on the trigger signal at which triggering occurs.

Slope Switch. Provides for selecting either the positive or negative going slope of the trigger signal on which to trigger.

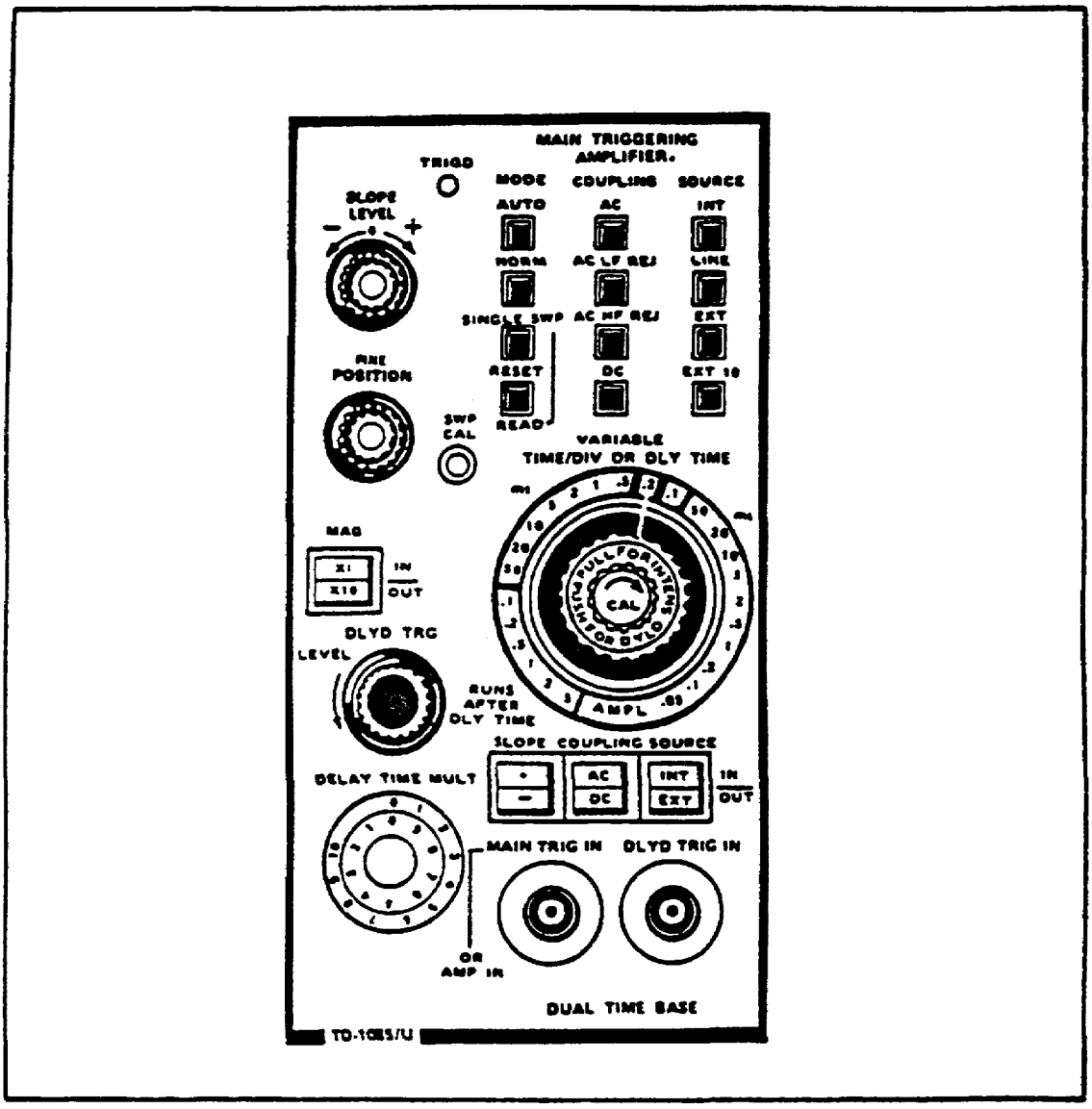

FIGURE 4. DUAL TIME BASE CONTROLS.

Trig'd Indicator. Lights up to indicate that the main sweep is triggered and will produce a display if the position and intensity controls are properly adjusted.

Main Triggering MODE Switches. Provide for the selection of main triggering mode and indicate selection. They are as follows:

o Auto - When pressed, sweep is initiated by the trigger signal applied by the LEVEL and SLOPE controls, if the trigger frequency is above 30 hertz and within the range

selected by the COUPLING switch. Triggered sweep can be obtained only over the amplitude range of the applied trigger signal. When the level control is set outside the amplitude range, the sweep will free run, at a rate selected by the TIME/DIV switch, to provide a reference trace.

o Norm - When pressed, sweep is initiated by the trigger signal applied by the LEVEL and SLOPE controls, within the range selected by the COUPLING switch. When the level control is set outside the amplitude range, no trace will be displayed.

o Single Swp - When pressed, only one sweep can be displayed until the RESET switch is pressed.

o Reset-Ready - When pressed while in the single sweep mode, one sweep is displayed at the next trigger pulse.

Amplifier Coupling Switches. These four switches provide for the selection of main trigger coupling. They are as follows:

o AC - When pressed, DC components of signals are rejected and AC signals below 30 hertz are attenuated. AC signals between 30 hertz and 50 megahertz are accepted intact.

o AC LF REJ - When pressed, DC components of signals are rejected and AC signals below 30 kilohertz are attenuated. AC signals between 30 kilohertz and 50 megahertz are accepted.

o AC HP REJ - When pressed, DC components and AC signals below 30 hertz and above 50 kilohertz range are attenuated. Signals within the 30 hertz to 50 kilohertz range are accepted intact.

o DC - When pressed, all signals from DC to 50 megahertz AC are accepted.

Amplifier Source Switches. Provide for selection of the main trigger source. They are as follows:

o INT - When pressed, trigger signal is obtained from the vertical amplifier.

o LINE - When pressed, trigger signal is obtained from a sample of the oscilloscope's input power frequency.

o EXT - When pressed, trigger signal is obtained from an external source connected to the MAIN TRIG IN connector.

o EXT 10 - Same as EXT, except signal is decreased to approximately 10 percent of the input amplitude.

Position Knob. Provides for coarse adjustment of the horizontal position of the trace.

Fine Knob. Provides for fine adjustment of the horizontal position of the trace.

Swp Cal (Sweep Calibrate) Control. Provides an adjustment to match the gain of the Dual Time Base to the Main Frame for calibrated sweep rates.

Mag (Magnification) Switch. Provides for selection of horizontal magnification. The switch has the following specific functions:

o x1 (In) selects unmagnified sweep at a rate determined by the TIME/DIV switch setting.

o x10 (Out) expands the center centimeter of the display ten times.

Time/Div or Div Time Switch (outer ring). Provides for the selection of the basic sweep rate and the delay time. This allows for operation in intensified or delayed sweep display modes. MAG switch must be in xl position, and VARIABLE switch in the CAL position for the indicated sweep rate.

Delayed Time/Division Switch (center ring). Selects the sweep rate for operation in displayed sweep and intensified display modes. The VARIABLE (CAL) control must be in the extreme clockwise (CAL) position, and the MAG switch must be in the x1 position for the indicated sweep rate.

NOTE

The relationships between the TIME/DIV OR DLY TIME switch, the DELAYED TIME/DIVISION switch, and the INTENSIFY switch are complex. For efficient use of these functions, the following definitions of the display modes must be understood.

The display modes are as follows:

o Main Sweep - In MAIN SWEEP mode, the time base switches are locked together and the time per division (sweep rate) is bracketed by the black lines on the TIME/DIV OR DLY TIME switch. Only the main time base (sweep) generator operates in this mode.

o Intensified Sweep - In this mode, both time base generators are used, but only the main sweep is displayed. One sweep generator signal is used to brighten (intensify) the main sweep display. The main time base sweep rate is bracketed by the black lines on the TIME/DIV OR DLY TIME switch. The delayed time base sweep rate is selected by pulling the DELAYED TIME/DIVISION switch out and turning it clockwise. With the switch pulled out, an intensified zone appears on the main sweep. The purpose of the INTENSIFIED SWEEP mode is to locate the portion of the trace that is to be displayed in the DELAYED SWEEP mode.

o Delayed Sweep - In this mode, the DELAYED TIME/DIVISION switch is pushed in. The part of the display shown in the intensified zone is then displayed on the DELAYED SWEEP and expanded over the entire screen. The delayed sweep mode enables the operator to select any part of the main sweep display and expand that part for more careful study.

VARIABLE (CAL) Knob. When this switch is in the counter-clockwise direction, it enables you to vary the calibrated settings of the TIME/DIV OR DLY TIME switch by at least 12.5 seconds per division. When the control is set to the extreme clockwise setting, the switch is operated to select calibrated deflection factors.

Dly'd Trig (Delayed Trigger) Knob. Selects mode and level for delayed triggering. When the control is turned to extreme clockwise, delayed sweep runs immediately following the delay time. Delayed SLOPE, COUPLING, and SOURCE switches are not activated. When the switch is turned counter-clockwise, the delayed sweep is triggerable. The LEVEL control then selects the point on the trigger signal at which the delayed sweep is triggered. Delayed SLOPE, COUPLING, and SOURCE switches are activated.

Slope Switch. Selects the portion of the trigger signal that starts the delayed sweep. The + (IN) position provides that the delayed sweep is triggered from the positive-going portion of the trigger signal. The -(OUT) position provides that the delayed sweep is triggered from the negative-going portion of the signal.

Coupling Switch. Selects the method of coupling the trigger signal to the delayed trigger circuits. The AC (IN) position rejects DC signals, AC signals below 30 hertz are attenuated.-Signals between 30 hertz and 50 megahertz are accepted intact. The DC (OUT) position provides that all signals from DC and AC to 50 megahertz are accepted intact.

Source Switch. Selects the source of the delayed trigger signal and determines the function of the DLY'D TRIG IN connector. The INT (IN) position provides that the delayed trigger signal is provided by the vertical amplifier. The EXT (OUT) position provides that the delayed trigger signal is obtained from an external source, through the DLY'D TRIG IN connector.

Delay Time Mult Knob. Provides for selecting a variable sweep delay between 0 and 10 times the delay indicated by the TIME/DIV or DLY TIME switch setting.

Main Trig In or Amp In Connector. Provides for connecting a cable to the Dual Time Base for an external triggering signal input. Also, when the Main Triggering Amplifier Source is EXT or EXT 10, and the TIME/DIV or DLY TIME switch is set to AMPL, this connector can be used for an external horizontal input.

Dly'd Trig In Connector. Provides for connecting a cable to the Dual Time base for external delayed triggering signal input.

Now we have covered the functions of all the controls and connectors on the front of the oscilloscope. Let's begin preparing the oscilloscope for operation.

INITIAL CONTROL SETTINGS

Perform the initial control settings before turning on the oscilloscope for the first time. Once the oscilloscope has been in use, it should not be necessary to repeat the initial control settings, unless the front controls have been completely maladjusted.

Initial Settings for Main Frame Front Panel Controls

Position the oscilloscope front panel controls as follows:

- Set the INTENSITY knob fully counterclockwise.
- Turn the FOCUS knob to midrange.
- Turn the GRAT ILLUM knob to midrange.
- Under the VERT MODE, press the LEFT button.

NOTE

Be sure only one TRIG SOURCE switch remains pressed in at a time.

- Under the TRIG SOURCE column, press in the VERT MODE button.

Initial Settings for Vertical Amplifier Controls Preposition the controls on the vertical amplifiers as follows:

- Set the POSITION knob to midrange.
- Set the POLARITY switch to the + UP position.
- Set the MAG switch to the xl position.
- Turn the VOLTS/DIV switch to the .5 position.
- Turn the VARIABLE (CAL)(Red Knob) fully clockwise until it clicks in place.
- Set the AC/GND/DC switch to AC.

OD1402 - Lesson 1/Learning Event 1

Initial Settings for the Dual Time Base

Set the dual time base front panel controls as follows:

- o Turn the LEVEL knob to midrange.
- o Turn the SLOPE knob fully clockwise to +.
- o Set the MODE SWITCH to AUTO.
- o Set the COUPLING switch to AC.
- o Set the SOURCE switch to INT.
- o Turn the POSITION knob and FINE knob to midrange.
- o Set the MAG switch to x1 by depressing the button.

NOTE

The TIME/DIV OR DLY TIME switch is four controls in one. Care must be taken to see that each is positioned properly.

- o Set the innermost TIME/DIV switch to the 1ms position.
- o Set the DLY. TIME switch to the 1ms position and then push it in.
- o Turn the VARIABLE (CAL) knob fully clockwise until it clicks in place.
- o Turn the DLYD TRG knob fully clockwise to RUNS AFTER DLY TIME.
- o Set the SLOPE to +, COUPLING to AC, and SOURCE to INT by depressing the pushbuttons.
- o Turn the DELAY TIME MULT knob to the 0 position.

So far, the basic controls of the oscilloscope and their functions have been discussed, as well as the initial set-up of those controls that must be accomplished prior to turning on the scope. You are now ready to turn on the oscilloscope.

In the next learning event, how to turn on and adjust the oscilloscope for a single trace will be discussed. Then, you will learn how to measure the voltage amplitude and frequency of a signal by using the screen grid.

Learning Event 2:

INTERPRET THE VOLTAGE AMPLITUDE AND FREQUENCY MEASUREMENTS ON THE BASIC OSCILLOSCOPE BY THE USE OF SCREEN GRIDS

SIMPLIFIED OPERATING PROCEDURES

The following methods are provided to aid in quickly setting the oscilloscope controls to present a display. Before attempting these procedures, the operator should become thoroughly familiar with the functions of all controls, indicators, and connectors, as described in Learning Event 1.

Single Trace Display

The following procedures will produce a display of the input signal of one vertical amplifier, on one trace, by the dual time base. In this case, the left-hand vertical amplifier is used. The right-hand vertical amplifier can be used by making the appropriate changes to the procedure.

To produce a display of the input signal of the left-hand vertical amplifier, use the following steps:

Step 1. Pre-set all the controls as described in Learning Event 1, pages 13 and 14.

Step 2. Pull the POWER switch knob out to apply power and allow the oscilloscope to warm up for five minutes or more.

Step 3. Turn the INTENSITY knob clockwise until a display is visible. If no display is visible by the midrange position on the INTENSITY knob, perform steps 4 through 8 below.

Step 4. Press and hold the BEAM FINDER switch.

Step 5. Set the VOLTS/DIV switch on the left-hand vertical amplifier for a display that remains within the vertical area of the screen.

Step 6. Adjust the POSITION knob on the left-hand vertical amplifier for the desired vertical position of the display.

Step 7. Adjust the POSITION knob on the dual time base for the desired horizontal position of the display.

Step 8. Release the BEAM FINDER switch.

Step 9. If necessary, adjust the LEVEL control on the dual time base for a stable display.

Step 10. Adjust the FOCUS control for a well defined display. The oscilloscope is now set up for a single trace display (see figure 5, below).

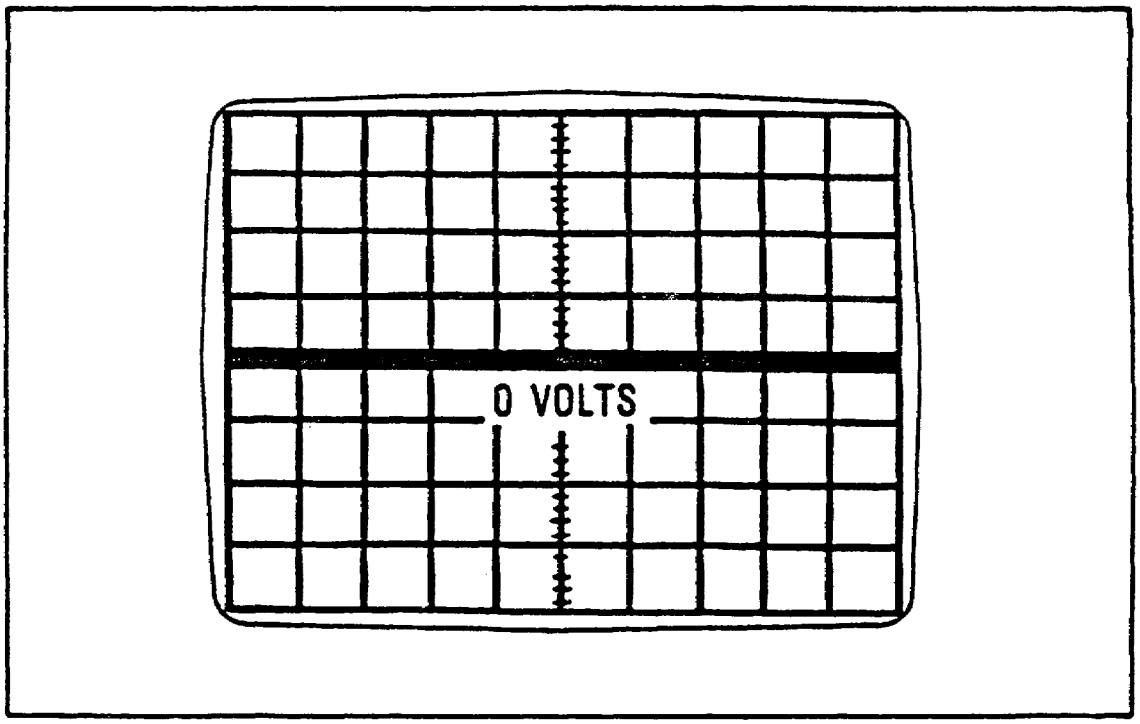

FIGURE 5. SINGLE TRACE - NO SIGNAL APPLIED.

Dual Trace Display

The following procedure will produce a display of the input signals of two vertical amplifiers, on two traces, by the dual time base.

To produce a display of the input signals of two vertical amplifiers on two traces, use the following steps:

Step 1. Preset all the controls, as described in Learning Event 1, pages 13 and 14.

Step 2. Pull POWER switch knob out to apply power. Allow the oscilloscope to warm up for five minutes or more.

Step 3. Turn the INTENSITY knob clockwise until a display is visible. If no display is visible by the midrange position on the INTENSITY knob, perform steps 4 through 8.

Step 4. Press and hold the BEAM FINDER switch.

Step 5. Set the VOLTS/DIV switch on the left-hand vertical amplifier for a display that remains within the vertical area of the screen.

Step 6. Adjust the POSITION control on the left hand vertical amplifier for the desired vertical position of the display.

Step 7. Adjust the POSITION control on the dual time base for the desired horizontal position of the display.

Step 8. Release the BEAM FINDER switch.

Step 9. If necessary, adjust the LEVEL control on the dual time base for a stable display.

Step 10. Adjust the FOCUS control for a well defined display.

Step 11. Adjust the POSITION control on the left-hand vertical amplifier to place the trace in the upper half of the graticule (screen) area.

Step 12. Press the VERT MODE RIGHT switch in.

Step 13. If display of the second trace is not visible, adjust the POSITION control on the right-hand vertical amplifier until trace is visible.

Step 14. Adjust the POSITION control on the right-hand vertical amplifier to place the display in the lower half of the graticule (screen) area.

Step 15. Press the VERT MODE ALT switch in. The dual trace should now appear on the screen (see figure 6, below).

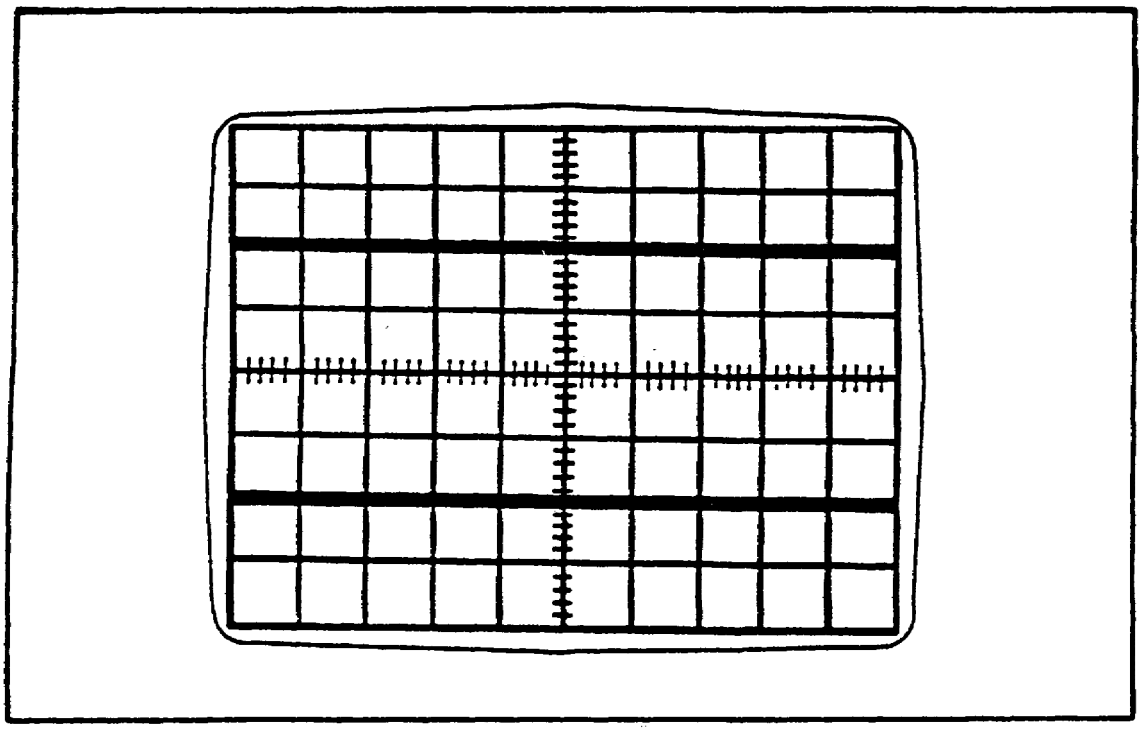

FIGURE 6. DUAL TRACE - NO SIGNAL APPLIED.

Applying a Signal

Now that you are able to perform the turn-on procedure and adjust the oscilloscope for a stable trace, you are ready to display a signal.

To display a signal, use the following steps:

Step 1. Perform the turn-on procedure for a single trace display.

Step 2. Depress the LEFT vertical mode.

Step 3. Set the TIME/DIV OR DLY TIME control switches (figure 7, below) as follows. Turn the TIME/DIV switch to the .2 ms position. Since the gray DLY TIME switch is pushed in, the two switches turn as a single unit. Turn the VARIABLE (CAL) sweep switch fully clockwise until it clicks. This means that each horizontal square equals .2 millisecond.

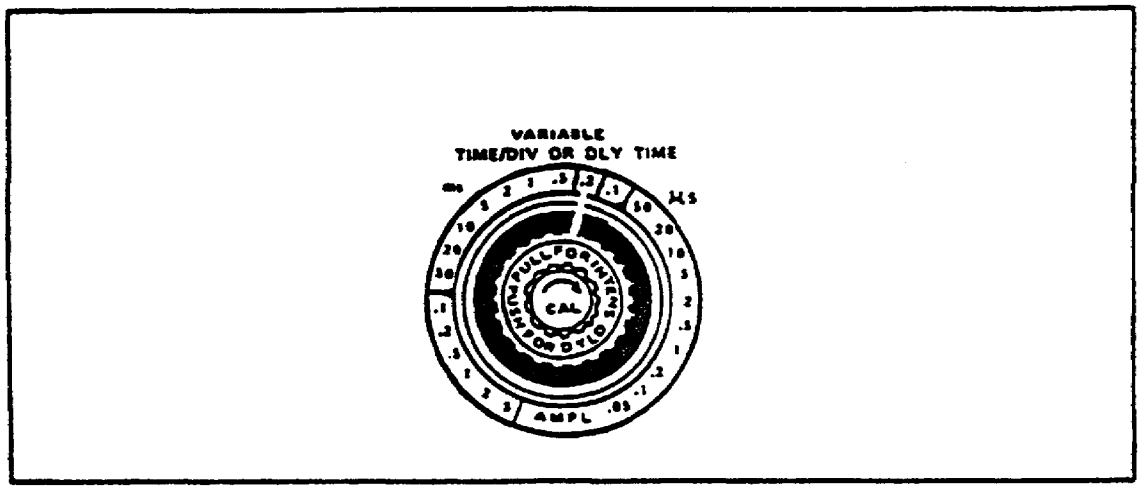

FIGURE 7. TIME/DIV OR DLY TIME CONTROL.

Step 4. Place the input coupling AC/GND/DC to the AC position. Turn the VOLTS/DIV switch (figure 8, on the next page) to the .5 position. Turn the red VARIABLE (CAL) switch fully clockwise until it clicks. This mean that each vertical square on the screen is equal to .5 volts of input signal.

Step 5. Connect one end of a coax cable to the CALIBRATOR connector located on the main frame of the scope. Connect the other end to the INPUT connector of the left vertical amplifier. You should have two complete cycles of a square wave displayed on the screen (figure 9, on the next page). It may be necessary to adjust the LEVEL control to obtain a stable display. Adjust both POSITION controls to center the displayed waveform.

Step 6. If the waveform is not exactly two divisions or grid squares high, the gain of the vertical amplifier should be adjusted. Use a small screwdriver and adjust the GAIN control for a waveform exactly two divisions high (1 volt peak-to-peak) as shown in figure 9.

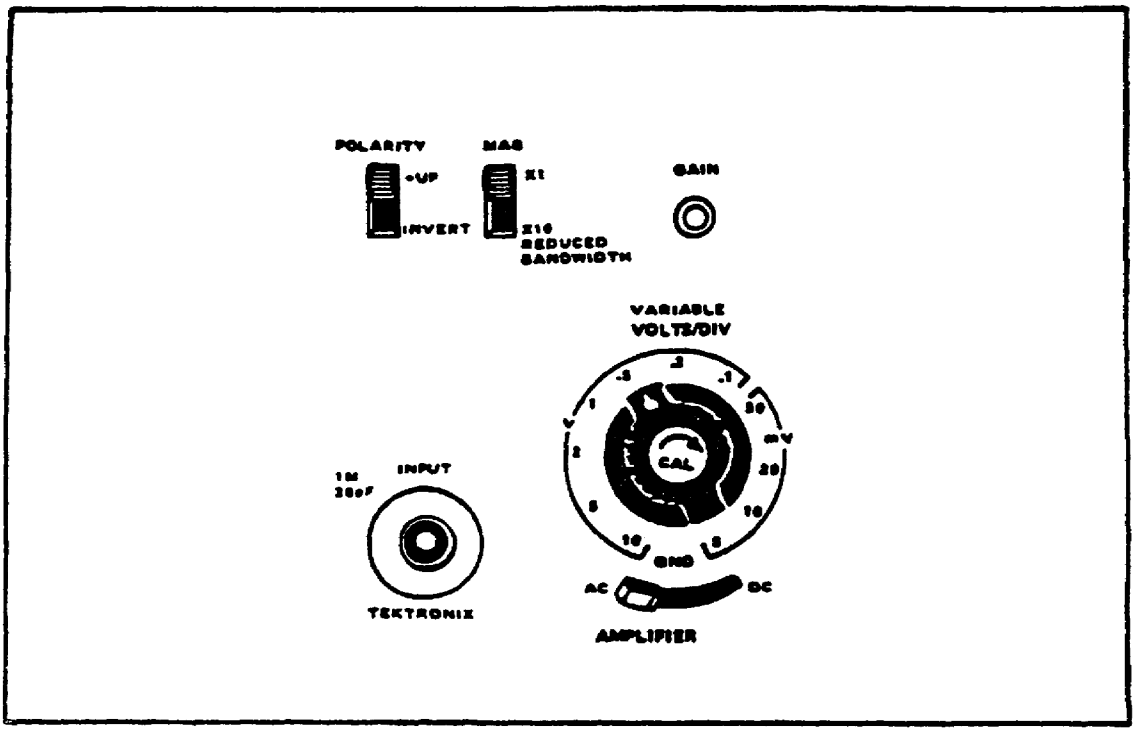

FIGURE 8. VOLTS/DIV SWITCH.

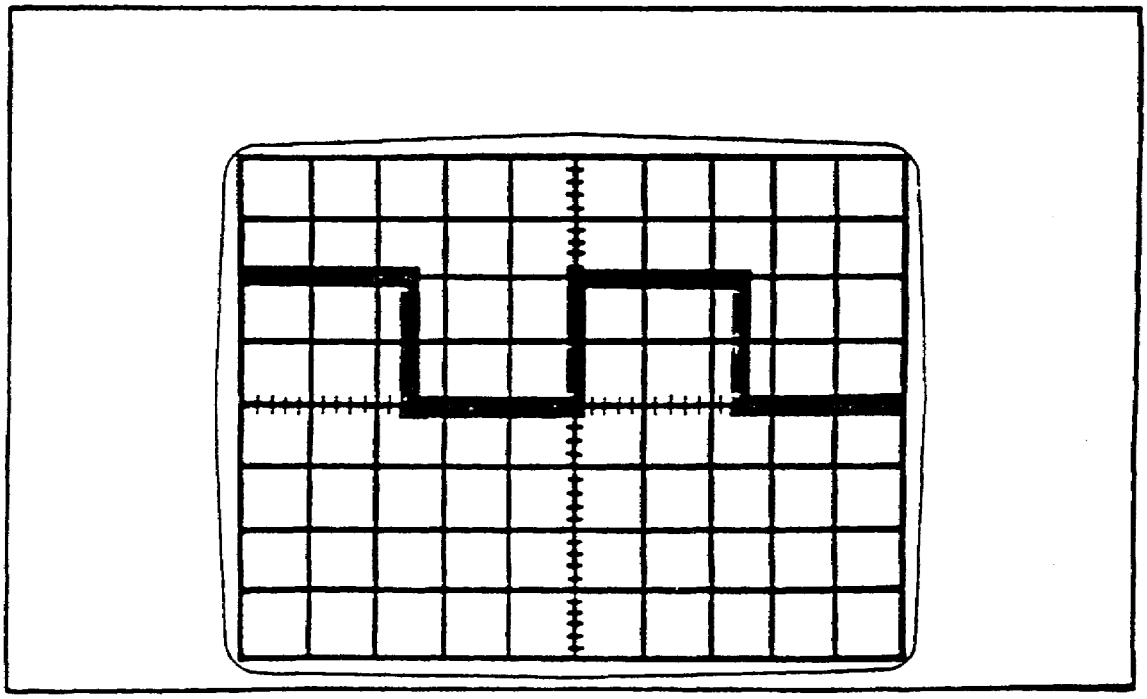

FIGURE 9. TWO SQUARE WAVES.

NOTE

The signal can also be changed with the red vernier on the VOLTS/DIV knob. However, when this control is used the vertical amplitude is no longer calibrated. Always leave this vernier fully clockwise to CAL when measuring amplitude.

Step 7. Disconnect the cable between the INPUT of the vertical amplifier and the CALIBRATOR connector. Connect a probe or a signal input cable to the INPUT connector of the left vertical amplifier.

The Graticule

Before we can start determining voltage amplitudes and frequencies, we must know a little about the screen grids (graticule). The graticule is marked on the inside of the CRT faceplate, providing for distortion-free measurements. The graticule (figure 10, below) is arranged in 8 vertical and 10 horizontal divisions, with each division 1 centimeter square. Thus, with calibrated vertical and horizontal circuits, accurate measurements can be made.

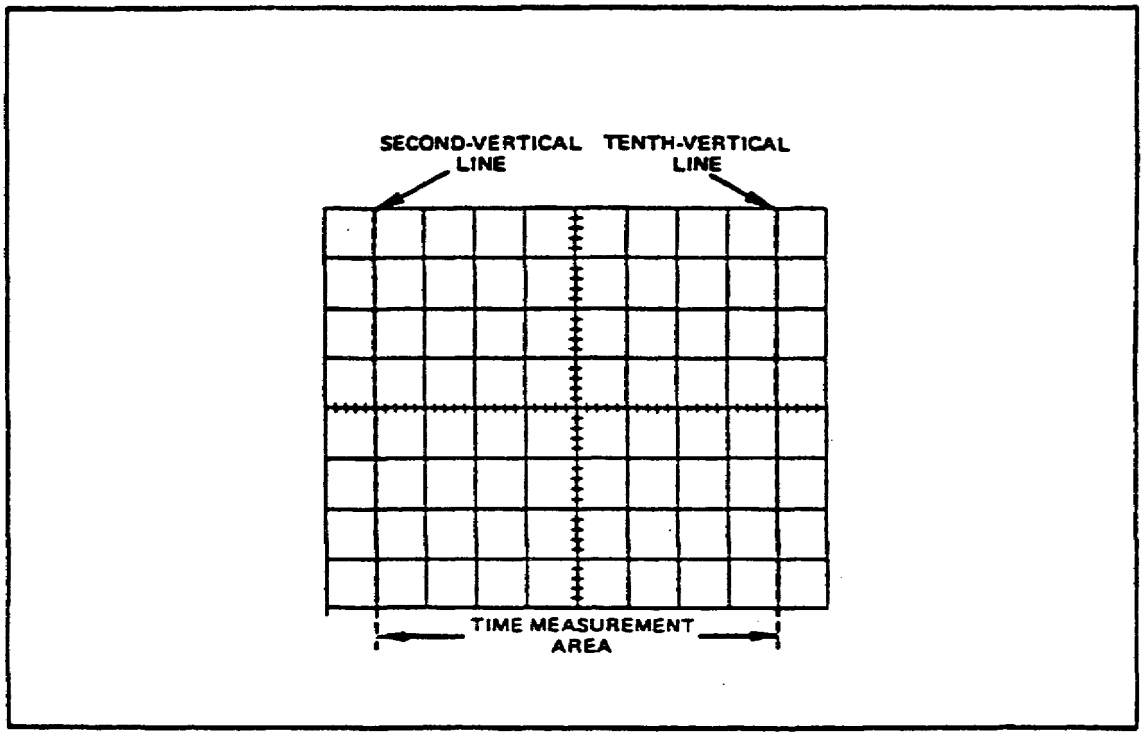

FIGURE 10. GRATICULE MEASUREMENT LINES.

Control of the graticule lines' brightness is provided by the GRAT ILLUM control. Figure 10 shows the graticule layout and defines the various measurements lines.

CALCULATING VOLTAGE MEASUREMENTS

AC Voltages

We calculate AC voltages in this manner: the number of centimeters (cm) or grid squares of vertical deflection of signal amplitude, times the setting of the VOLTS/DIV switch, equals the peak-to-peak voltage of the input signal.

Signal Amplitude (cm)	x	VOLTS/DIV Switch Setting	=	Peak-to-Peak Voltage

Using the formula, you should be able to calculate the peak-to-peak voltage of the displayed waveform (figure 11, below).

Your answer should be 1 volt. 2(cm) x .5 volts = 1 volt peak-to-peak.

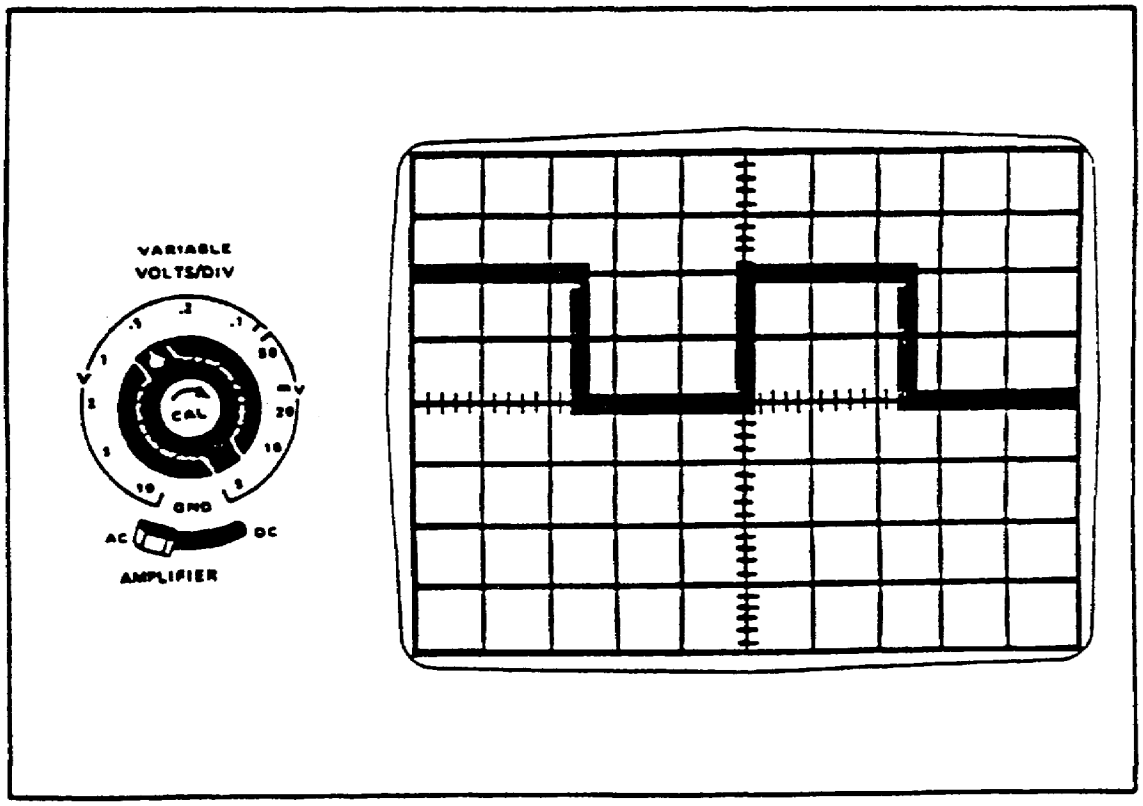

FIGURE 11. CALCULATING AC VOLTAGE.

For more practice, compute the following voltages:

Signal Amplitude		VOLTS/DIV Switch Setting		Peak-to-Peak Voltage
2	x	5	=	_____
4	x	.5	=	_____
7	x	10	=	_____
6	x	50 mv	=	_____
3	x	2	=	_____

Your answers should be 10, 2, 70, .3, and 6 volts, in that order.

Remember that when the VOLTS/DIV switch setting is in millivolts, we must convert the millivolts to volts by dividing by 1000.

MEASURING DC LEVELS

To measure the DC level of a waveform, the AC amplitude must be measured as before. The DC level will be measured by observing the vertical movement of the top or bottom of the waveform when you switch the vertical coupling AC/GND/DC switch from the AC to the DC position. (Refer to figure 12, on the next page.) In this figure, the AC signal is one volt. The VOLTS/DIV switch is set to .5 and the AC/GND/DC switch is set to AC. The AC/GND/DC switch is then set to the DC position. The waveform moves down three centimeters. Therefore, the DC level of the signal is -1.5 volts. Notice that a downward deflection is a negative DC level and an upward deflection is a positive DC level.

TIME AND FREQUENCY MEASUREMENTS

The time and frequency of a waveform is always measured along the horizontal axis of the graduated scale on the face of the CRT. Therefore, we must calibrate the scope horizontally, just as we calibrated the scope vertically before making voltage measurements.

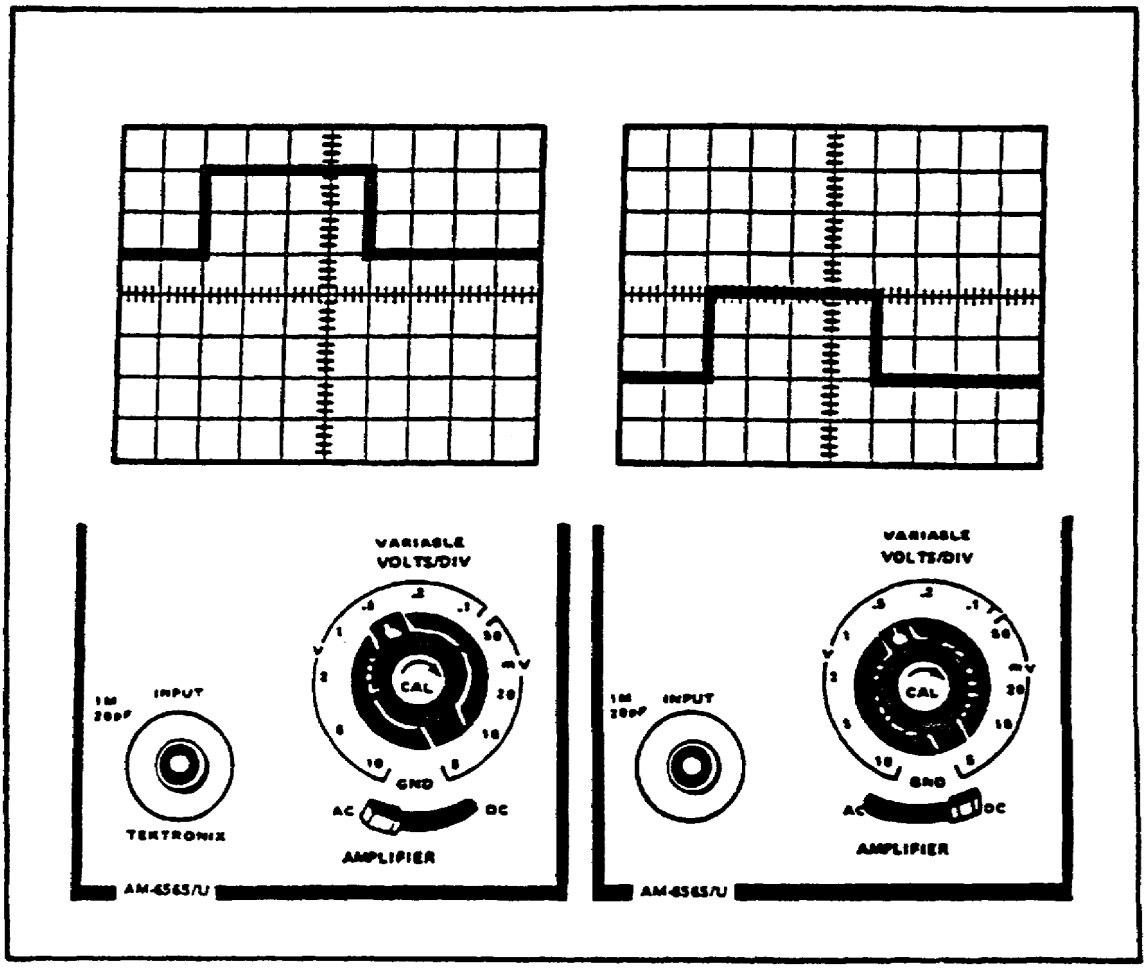

FIGURE 12. MEASURING DC LEVEL.

Horizontal Calibration

Step 1. Connect a cable between the CALIBRATOR connector and the INPUT connector of the left vertical amplifier. The output frequency of the CALIBRATOR is 1000 Hertz, with a voltage of 1 volt peak-to-peak.

Step 2. Turn the TIME/DIV OR DLY TIME switch to the .1ms position. One cycle should be displayed on the CRT.

Step 3. With a small screwdriver, rotate the SWP CAL control until the displayed waveform of one cycle covers exactly 10 divisions horizontally (figure 13, on the next page).

NOTE

The number of horizontal squares occupied by the signal can be changed in a similar way with the TIME/DIV controls. Setting the TIME/DIV switch on 20 u sec will double the number of cycles displayed. The red VERNIER (CAL) will also increase the number of cycles displayed if it is turned counterclockwise. However, when this control is used, the time base is no longer calibrated. Always leave the VERNIER fully clockwise to CAL when measuring periods or calculating frequencies.

Step 4. Reset the TIME/DIV OR DLY TIME switch to .2ms to obtain two complete cycles on the screen. When you change signals, or the TIME/DIV switch, it may be necessary to adjust the LEVEL to stabilize the signal.

Calculating Time Periods

To calculate the frequency of a signal you must first find the time of one complete cycle of the displayed waveform.

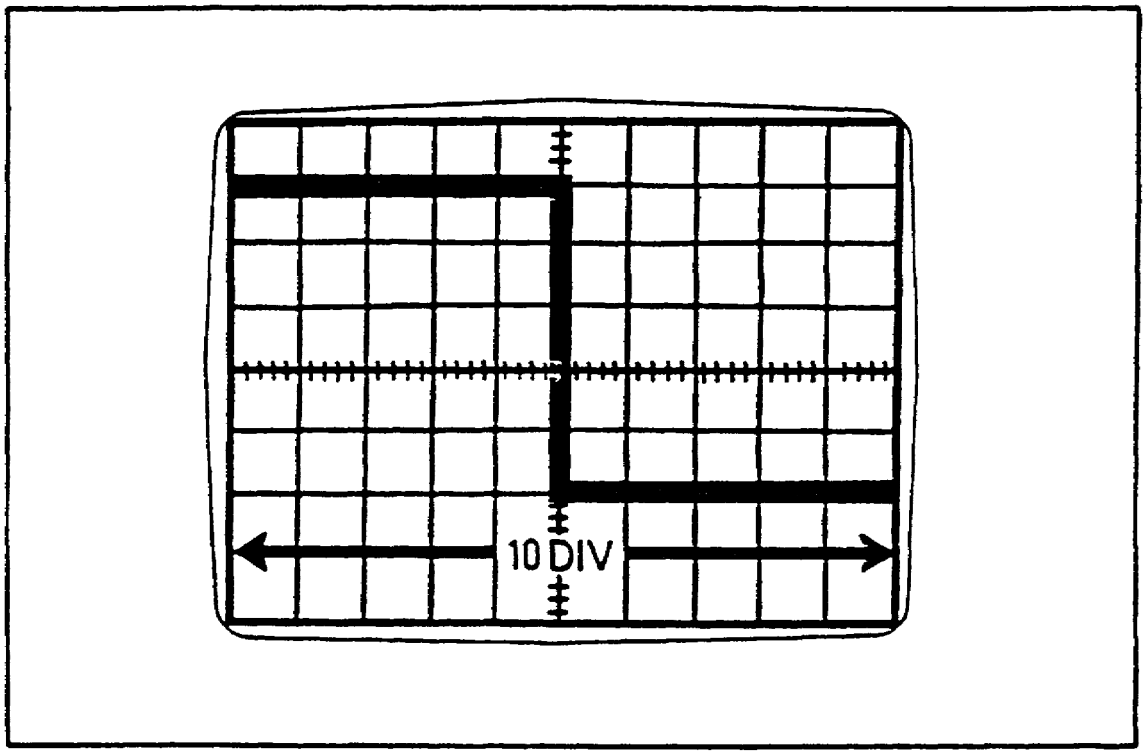

FIGURE 13. CALIBRATED SIGNAL DISPLAY.

To do this, you must use the controls of the Main Triggering Amplifier on the dual time base (refer back to figure 4 on page 8). The TIME/DIV switch controls the horizontal display time of the oscilloscope.

Two complete cycles should be displayed on the CRT (figure 14, below) Before you can calculate the frequency, you must first compute the time duration of one complete cycle. Count the number of divisions of horizontal deflection for one complete cycle and use the following formula:

Horizontal Deflection (in cm per cycle)	x	TIME/DIV OR DLY TIME Switch Setting	=	Time Period

In Figure 14, the Time Period would be calculated like this:

5 cm per cycle x .2 ms = 1 ms

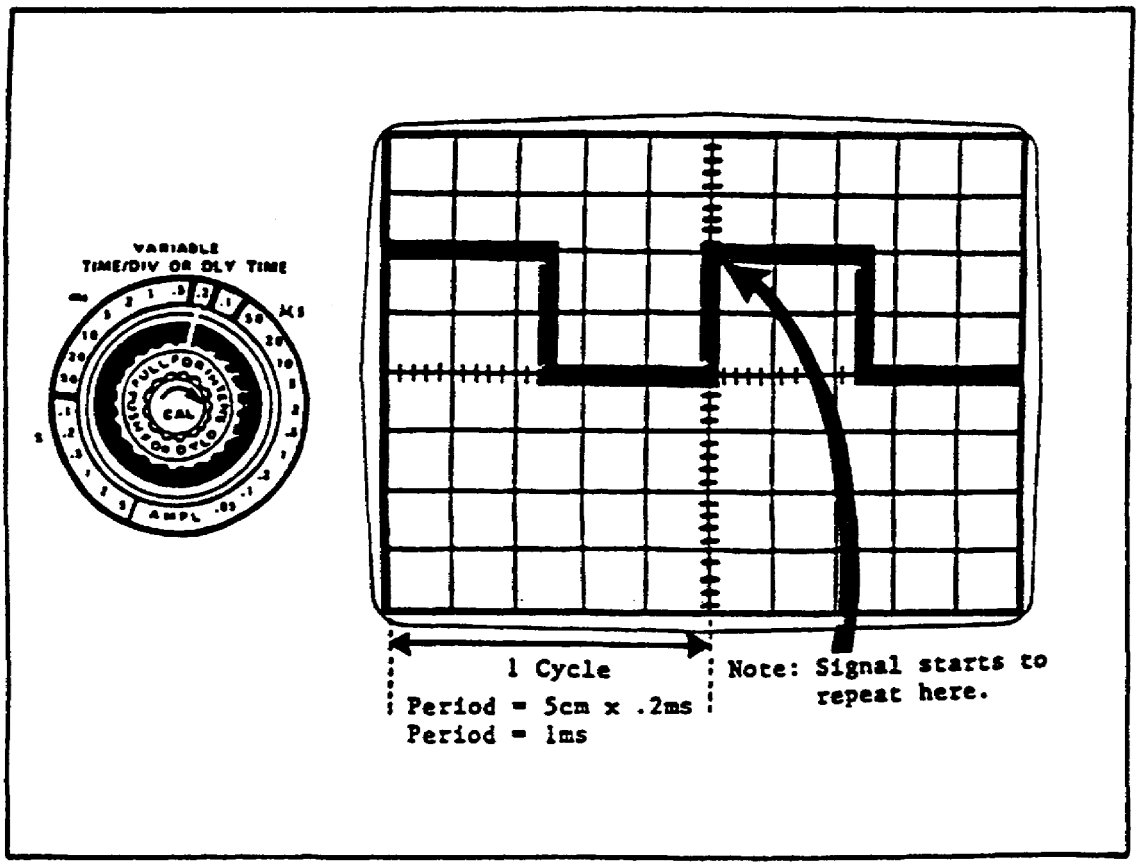

FIGURE 14. CALCULATING PERIOD AND FREQUENCY.

Calculating Frequency

To determine the frequency of the waveform, we must divide the Time Period of one cycle into 1. Use the following formula:

$$\frac{1}{\text{Time Period (in seconds)}} = \text{Frequency (in Hertz)}$$

Let's determine the frequency of the waveform in figure 14. Remember: We must change the milliseconds to seconds before we divide:

$$\frac{1}{1 \text{ millisecond}} = \frac{1}{.001 \text{ second}} = 1000 \text{ Hz}$$

The frequency is 1000 Hertz.

Calculate the following frequencies:

Horizontal Deflection (in cm per cycle)	TIME/DIV OR DLY TIME Switch Setting
5	10 ms
4	.5 ms
5	1 ms
10	.1 sec

The correct answers are 20 Hz, 500 Hz, 200 Hz, and 1 Hz.

Let's review the first question:

First, figure the time period for one cycle:

5 cm x 10 ms = 50 ms (time period)

Then calculate the frequency:

$$\frac{1}{50 \text{ ms}} = \frac{1}{.050 \text{ sec}} = 20 \text{ Hertz}$$

OSCILLOSCOPE PROBES

When a waveform is to be analyzed, a probe may be used. Most probes are supplied with more than one tip, which can be inserted on the end of the probe (figure 15, below). These tips may be changed by unscrewing them from the end of the probe and screwing the desired tip in place.

Probe Ground Strap

A ground strap is also supplied with the probe. The spring clip of the grounding strap clamps over the bared portion of cable at the upper end of the probe. The other end of the ground strap uses an alligator clip for connection to the

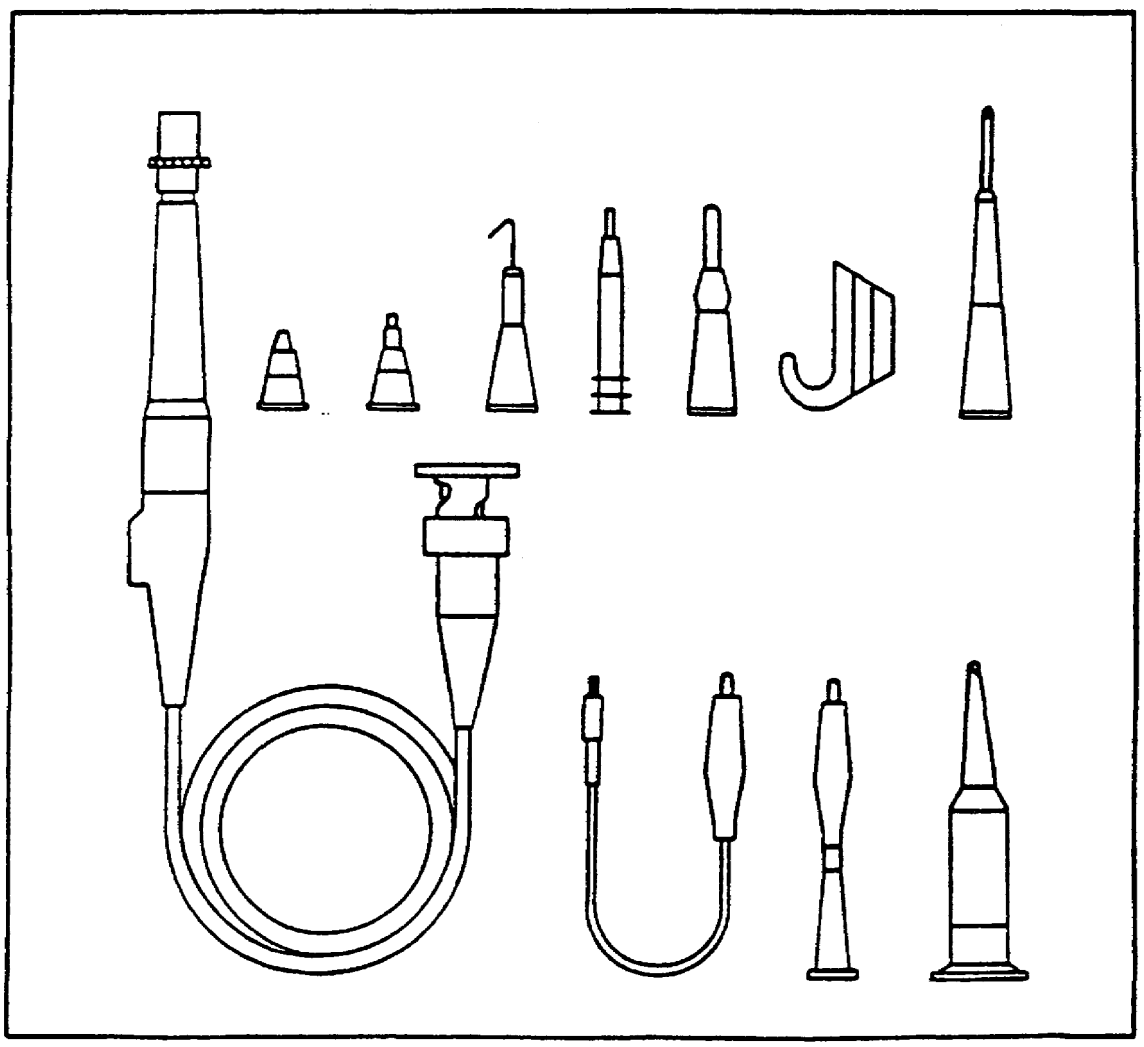

FIGURE 15. OSCILLOSCOPE PROBES.

chassis ground of the equipment under test. This completes the ground connection between the equipment under test and the oscilloscope. The probe ground strap must always be connected when measuring signals.

Attenuation Factor

A probe may have an attenuation factor of ten (10) or one hundred (100). The signal amplitude is reduced by the attenuation factor of the probe. This is done to allow for the measurement of signal amplitudes that exceed the rated input of the vertical amplifier.

Voltage Calculation with Probe Attenuation

When using a probe that has attenuation, an additional step must be added to the procedure for computing the voltage.

Signal Amplitude	X	VOLTS/DIV Switch Setting	X	Probe Attenuation	=	Peak-to-Peak Voltage

Probe Calibration

When a probe is used with an oscilloscope for the first time, or when it is transferred from one plug-in unit to another, the probe must be calibrated. This will ensure accurate attenuation of signals. Calibrate the probe as follows:

Step 1. Touch the probe tip to the center CALIBRATOR OUTPUT connector and adjust the oscilloscope to display several cycles of the signal.

Step 2. Loosen the locking sleeve and turn the probe body tip assembly until the correct waveform is displayed on the screen (figure 16, on the next page).

Step 3. After the correct adjustment has been made, hold the probe body and tighten the locking sleeve. The probe is now ready for use.

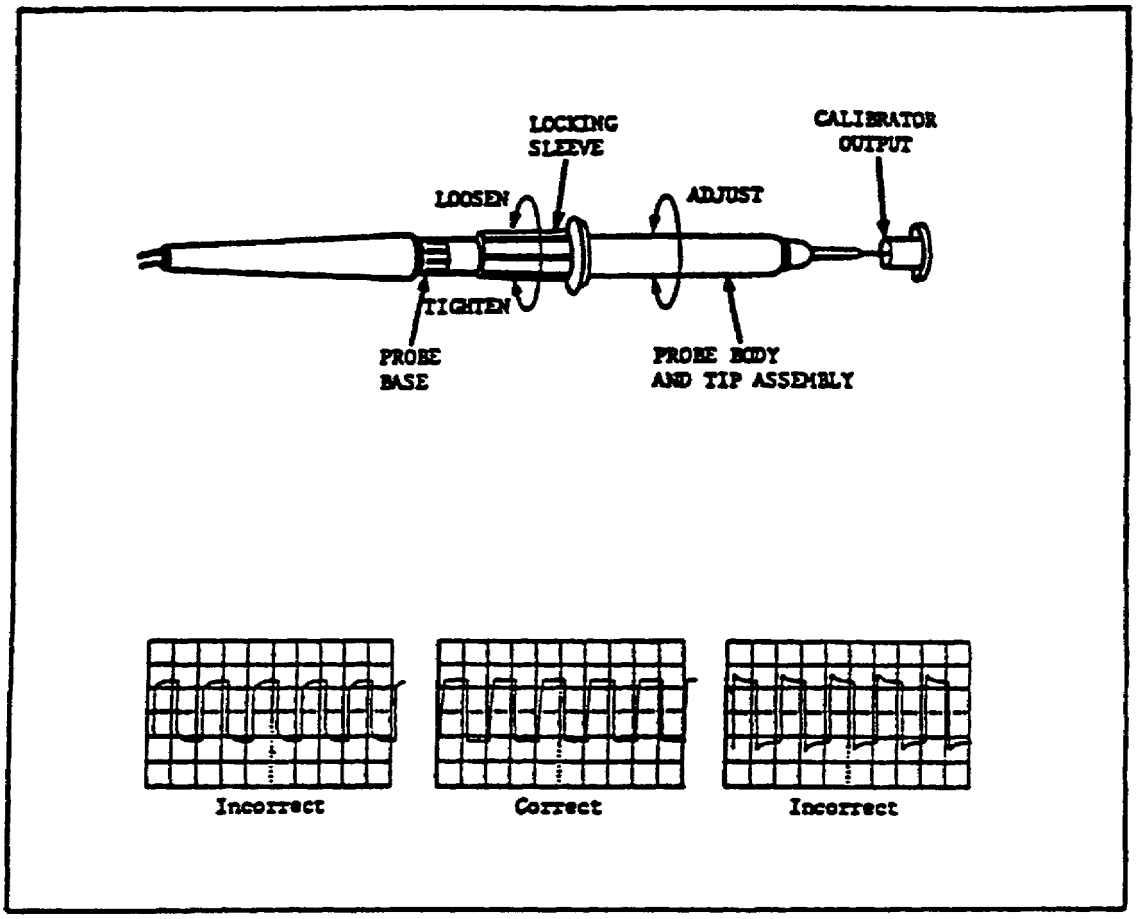

FIGURE 16. PROBE ADJUSTMENT AND WAVEFORMS.

PREVENTIVE MAINTENANCE

Preventive maintenance on the oscilloscope consists of periodic inspection and cleaning procedures. Lubrication is not required on this equipment. Cleaning should be accomplished carefully to prevent damage. The oscilloscope should be cleaned at least once monthly under normal operating conditions. Operations in dusty or other severe conditions may require more frequent cleaning.

Accumulation of dirt in the oscilloscope can cause overheating and component breakdown. Dirt on components acts as an insulating blanket and prevents heat from escaping. Dirt and dust can also provide a possible electrical path that could cause a circuit failure or a severe shock to the operator. It is important to clean the oscilloscope at regular intervals.

Inspection

An inspection of the oscilloscope should be performed at least once weekly. The following procedure is used:

o Inspect the cabinet for obvious damage, such as dents, scratches, broken parts, frayed or otherwise damaged cables, damaged indicators, etc.

o Inspect all switches for free movement, proper alignment with cabinet markings, and operation.

o Inspect all moving controls for free movement, scratching, etc., over their entire range of control.

Cleaning

Thorough cleaning of the surfaces of the oscilloscope should be performed at least monthly. Make sure the oscilloscope is unplugged from the power source before cleaning. The following procedure is used:

o Use a cloth and brush to remove loose dirt and dust from cabinet surfaces. Use the brush to remove dirt on and around the front panel controls. Remove caked dirt with a cloth dampened in a mild detergent and water. Wipe afterward with a cloth dampened in clean water.

o Clean the CRT plastic light filter, faceplate protector, and the CRT face with a soft, lint-free cloth dampened in alcohol.

NOTE

Do not use chemical cleaning agents containing solvents that might damage the plastic parts in the oscilloscope. Avoid cleaning agents that contain benzene, toluene, xylene, acetone, or similar solvents.

o Clean dust from the mesh filter that covers the blower fan by holding the filter vertically and brushing with a soft-bristled brush. Clean greasy residue or caked dirt from the mesh filter by gently scrubbing with a soft brush and a mild detergent and water solution. Rinse the filter in clean water and allow it to air dry.

Interior Cleaning

If, during weekly preventive maintenance inspection, you observe that the interior of the oscilloscope is becoming dusty and dirty, the scope should be referred to your supervisor and sent to intermediate direct support maintenance for cleaning.

SAFETY

The Tank Turret Repairer should be extremely careful while working around electronic instruments with the oscilloscope. The following safety precautions should be followed:

- Always have at least two persons present when working on high voltage units, one to give first aid, or summon help in case of an accident.

- When working on equipment in inclement weather, protect yourself and the equipment with a tarpaulin. Dry the equipment with a hot air dryer before making measurements or adjustments.

- Only qualified personnel are permitted to make adjustments or modifications to electrical components.

- Under certain conditions, such as wet surfaces, even low voltages can be dangerous to your life. Make sure you always follow the same safety rules used for high voltages.

- Before attaching any grounds, always make the ground end of the connection first. When removing grounds, disconnect the ground end of the connection last.

- Treat every wire as if it were energized.

- Use only the proper tools for the job. Make sure all pliers and other electrical hand tools are properly insulated.

- Keep $C0_2$ or a dry chemical (Class C or D) type fire extinguisher handy. Regularly check it to ensure that the extinguisher is pressurized.

- Do not use gasoline or other explosive solvents near electrical equipment that may produce a spark.

- Make all connections to de-energized conductors. Do not apply power to the circuit until after the last connection is made.

o Whenever the operation permits, keep one hand in your pocket, or away from the equipment. This will reduce the chance of current flowing through your body.

CONCLUSION

This subcourse has provided you with the basic information necessary for the operation of the AN/USM 281C oscilloscope. These same guidelines can be used to operate almost any oscilloscope, with only minor changes to the procedures.

We have discussed the controls on the oscilloscope and their various functions. We have also learned how to properly preset these controls prior to turning on the scope. You have learned how to turn on and adjust the scope for either single trace or dual trace operation. You should be familiar with the formulas for voltage amplitude measurements and frequency.

You should now be ready to take the practice exercise on the next page. If you have problems with any of the answers, review the text and repeat the exercise.

PRACTICE EXERCISE 1

INSTRUCTIONS

This practice exercise will show you how much you have learned in this lesson. Answer each question. When you are done, turn the page to check your answers.

SITUATION: You are a tank turret repairer assigned the task of troubleshooting an electronic malfunction in the turret. Your supervisor advises you to use an AN/USM 281C oscilloscope to check the voltages and electrical frequencies of the circuits.

1. The AN/USM 281C is a dual trace oscilloscope that consists of two _____ _____ and two horizontal sweep generators, connected to a cathode ray tube (CRT).

2. Match the following controls to their function:

A. _____ Intensity

B. _____ Focus

C. _____ Power

D. _____ Gain

E. _____ Position (Vertical Amplifier)

F. _____ Fine

G. _____ Position (Dual Time Base)

1. Fine adjustment of the horizontal position of the trace
2. Controls the brightness of the display
3. Fine tuning of the deflection factor
4. Controls the definition of the display
5. Controls power to the oscilloscope
6. Coarse adjustment of the horizontal position of the display
7. Controls the vertical position of the trace

3. What position should the Main Frame Front Panel controls be set to prior to turning on the oscilloscope?

CONTROL	POSITION
A. Intensity	_____
B. Focus	_____
C. Grat Illum	_____
D. Vert Mode	_____
E. Trig Source	_____

4. The TIME/DIV OR DLY TIME switch is how many controls in one?

A. 2

B. 3

C. 4

D. 5

5. You have turned on the oscilloscope and have a trace across the screen. If necessary, you must adjust the _____ control on the dual time base for a stable display.

A. Level

B. Slope

C. Position

D. Dlyd Trg

6. The output of the CALIBRATOR connector is _____ volt(s) peak-to-peak and _____ hertz.

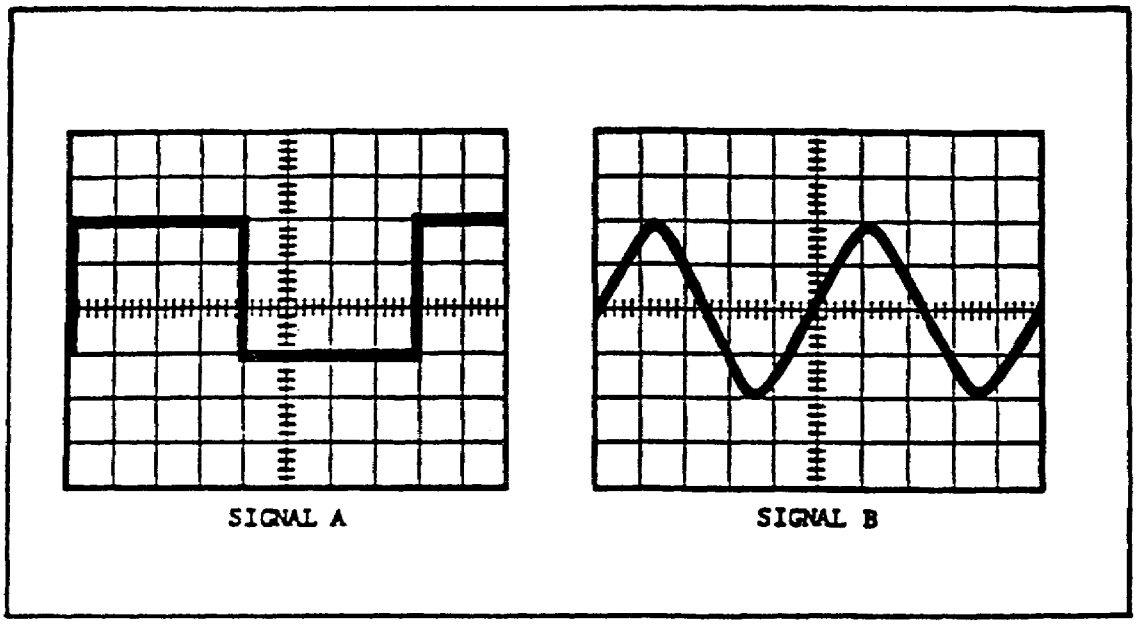

FIGURE 17. OSCILLOSCOPE WAVEFORMS.

QUESTIONS 7 THROUGH 10 REFER TO THE WAVEFORMS IN FIGURE 17.

7. The VOLTS/ DIV switch is set at 2 (CAL). The peak-to-peak voltage of Signal A is _____ .

8. The TIME/DIV switch is set at 2 ms (CAL). The frequency of the waveform in Signal A is _____ .

9. The VOLTS/DIV switch is set at .5 (CAL). The amplitude of Signal B is _____ .

10. The TIME/DIV switch is set at 10 us (CAL). The frequency of the waveform in Signal B is _____ .

11. The VOLTS/DIV switch is set at 5 (CAL). When the AC/GND/DC switch is changed from AC to DC, the waveform moves up three centimeters. What is the DC level of the waveform?

12. The VOLTS/DIV switch is set at 2 (CAL). When the AC/GND/DC switch is changed from AC to DC, the trace moves down four centimeters. What is the DC level of the waveform?

LESSON 1. PRACTICE EXERCISE - ANSWERS

1. Vertical amplifiers (page 2, para 1)

2. A 2 (page 4, para 3)
   B 4 (page 4, para 4)
   C 5 (page 6, para 2)
   D 3 (page 6, para 8)
   E 7 (page 6, para 5)
   F 1 (page 9, para 7)
   G 6 (page 9, para 6)

3. Intensity fully counterclockwise
   Focus midrange
   Grat Illum midrange
   Vert Mode Left
   Trig Source Vert Mode (page 13, paras 1 through 9)

4. C (page 14, para 10)

5. A (page 16, para 3)

6. 1 volt peak-to-peak and 1000 hertz (page 24, para 1)

7. 6 volts (page 22, para 2)

8. 62.5 Hz (page 27, para 3)

9. 2 volts (page 22, para 2)

10. 20 kHz (20,000 Hz) (page 27, para 1)

11. +15 volts (page 23, para 1)

12. -8 volts (page 23, para 1)

If you had a hard time getting the right answers, go back and review the lesson. If you did well on this practice exercise, you should be ready to take the exam.