Chapter 3 – Using Modulation Analysis

How Modulation Analysis Works

Switchmode power conversion circuits use some method of transferring energy from an unregulated source to a regulated output(s) on a cycle-by-cycle basis. Output regulation is achieved by modulating the amount of energy transferred in each cycle. The most common modulation method used is **P**ulse **W**idth **M**odulation (**PWM**).

The Modulation Analysis section of PMA1 is intended to provide the user with tools to view the information contained in the control circuit's modulated signals. The most common method of controlling the energy-per-cycle transfer in power conversion circuits is through the use of PWM. Other methods (such as frequency modulation) also are used, but no matter which method is used it is difficult to view and analyze the modulation.

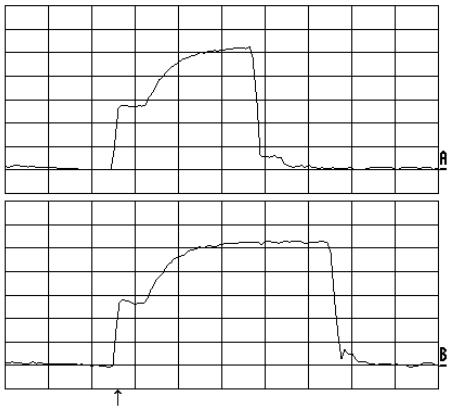


Figure 3.1:
(A) *Gate drive pulse width at minimum load*
(B) *Gate drive pulse width at full load*

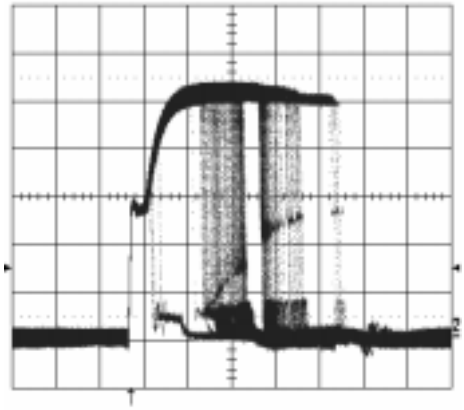


Figure 3.2: *Analog Persistence™ display shows pulse widths at minimum and maximum load, as well as other pulse widths that occur during load transition.*

When operating in steady state, a power supply's pulse width will be narrow during periods of low load and wider when the load is higher. This difference is easy to see on a DSO in the XY display mode. What happens to the pulse width during a change in load or some other EVENT is much harder to see. The use of Analog Persistence mode yields more information about the supply's step response, but does not display the change-in-width information as a function of elapsed time.

Modulation Analysis provides the user with a method of seeing the information contained in the modulated signal. It does this by taking the time (width) information in the modulated signal that is normally displayed on the horizontal axis along with elapsed time and displays it on the vertical axis.

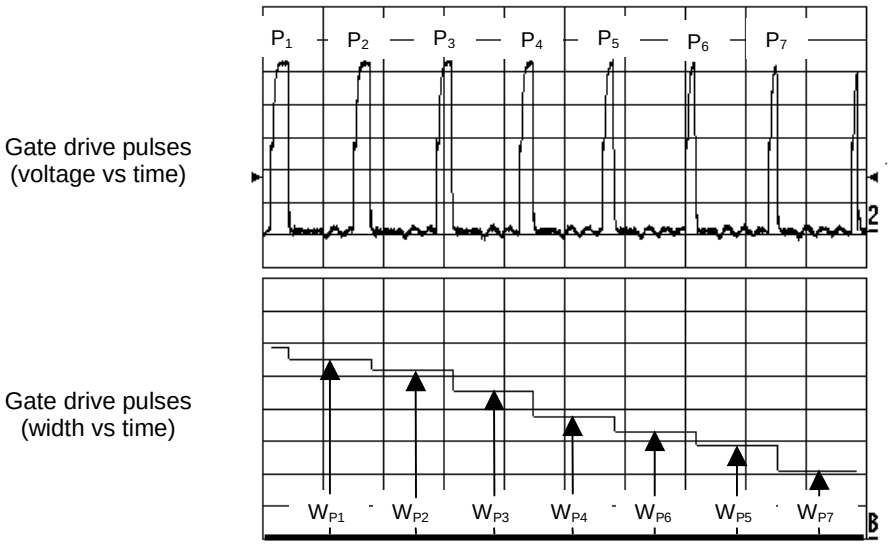


Figure 3.3: *Example of how Modulation Analysis measures the width of individual pulses and displays their value on the vertical axis.*

As the number of pulses increase per division, the display of their individual widths forms a “waveform” that represents the change in pulse width as a function of elapsed time. This “waveform” can be used to gain valuable information about the power supply’s response to various events, such as load change (step response) or its soft start performance.

The Modulation Analysis Display

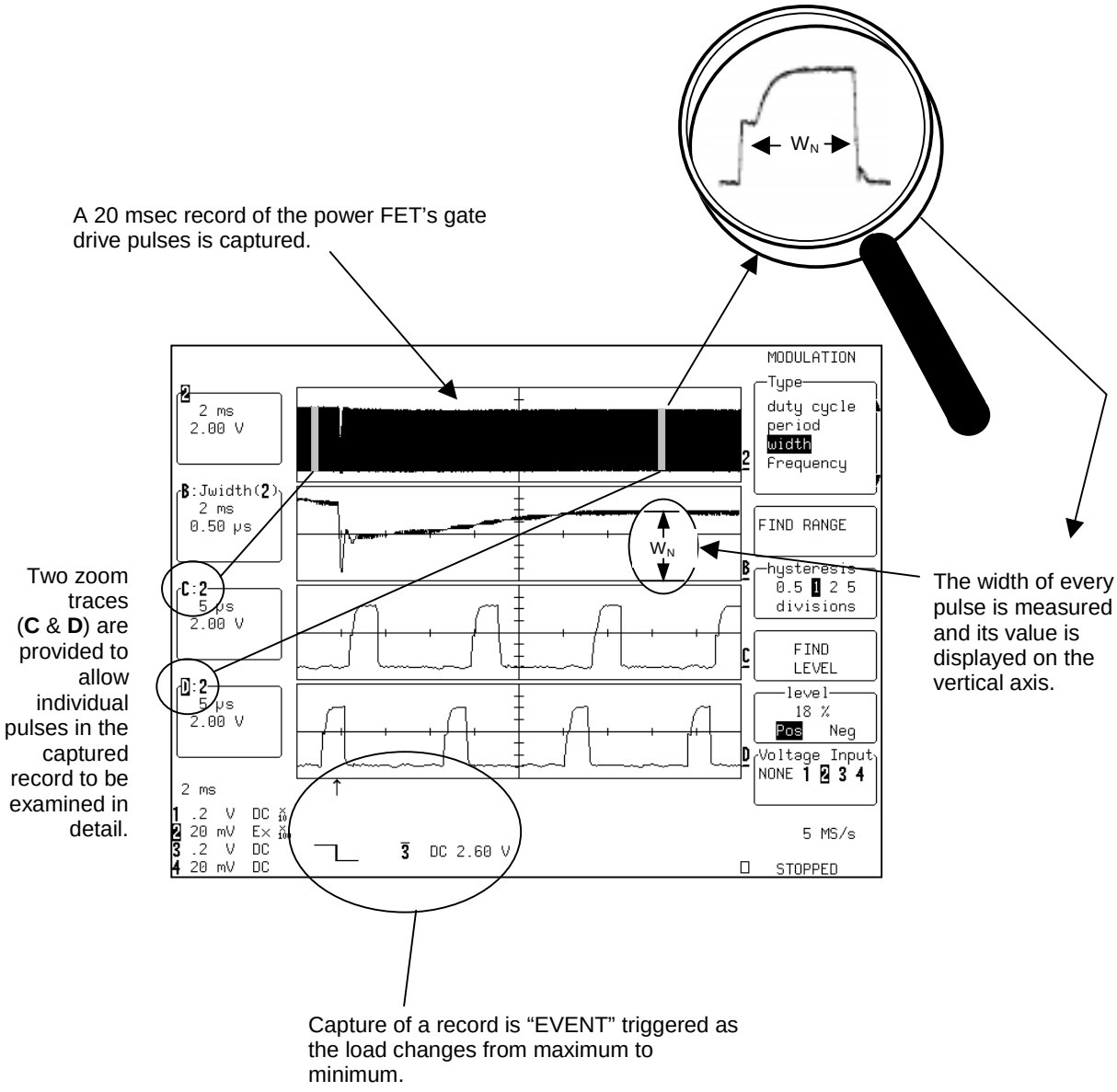


Figure 3.4: *Modulation Analysis displays a PWM circuit's step response as the output load changes from maximum to minimum. In this example, over 1000 gate drive pulses are recorded in the first grid [**2**], and a record of their individual widths is displayed in the second grid [**B**: Jwidth (**2**)].*

Configuring for Modulation Analysis

The Modulation Analysis portion of PMA1 lets the user capturie and analyze information contained in the power conversion circuit's modulation. The exact setup for this measurement may be different depending on the specific circuit topology and where in the circuit under test the modulation signal is to be acquired.

The following diagram shows a typical setup used to acquire the modulated signal at the power FET's gate in an off-line switching power supply. The LeCroy DA1855A Differential Amplifier is used to acquire the device's gate drive signal.

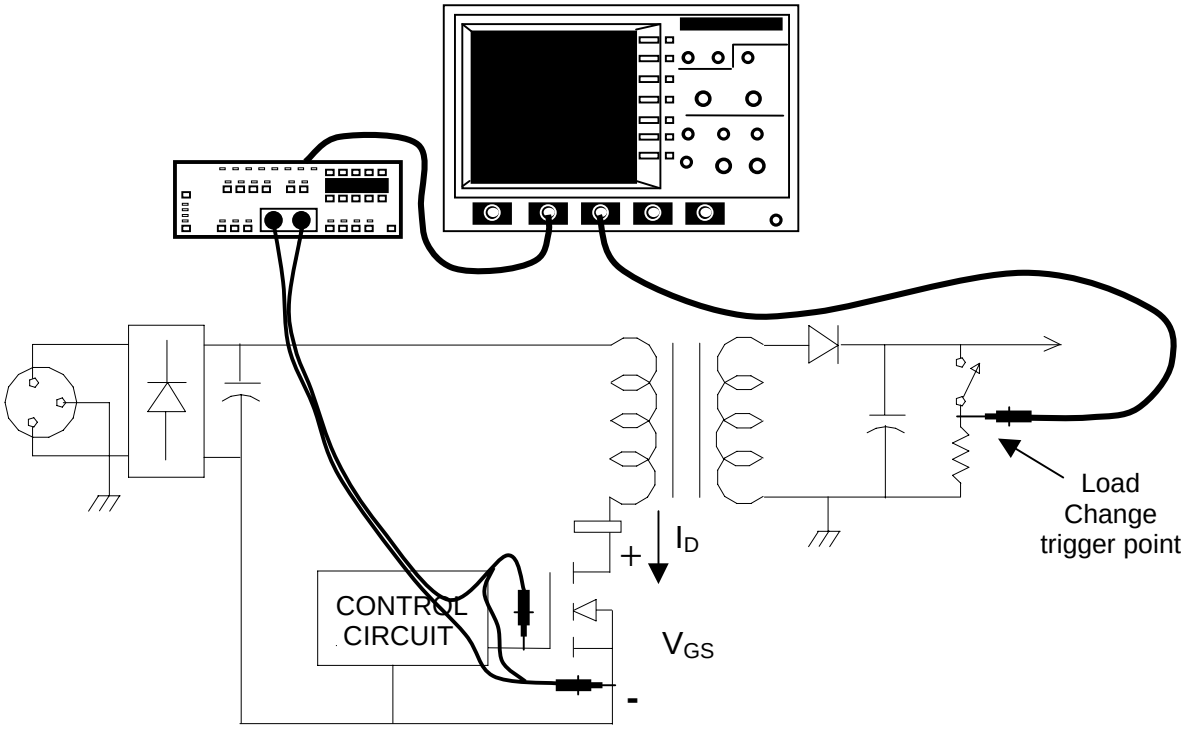


Figure 3.5: *Typical connections to a circuit under test needed to acquire the power device's gate drive signal from which the circuit's Pulse Width Modulation can be obtained.*

The circuit shown is an off-line flyback power supply. Examples in this section are based on connections to a circuit of this type. Other signals in the circuit can be used to measure the modulation, but the gate drive signal is usually a good place to acquire a relatively noise-free signal.

Setup for Modulation Analysis Measurements

Plan the measurement in advance and do a preliminary setup before evoking the PMA1 Power Measurement menus. This will minimize the number of times it is necessary to leave the menu structure.

Modulated Signal and Trigger Setup

Modulation analysis measurements usually are made to find the circuit's response to some event. Identify which signal in the circuit is to be used as a source of modulation information (modulated signal) and a signal (EVENT) that can be used to trigger the acquisition of the record of the modulated signal. Connect the differential probes to the appropriate points in the circuit under test to acquire the modulated signal. An "EVENT" such as turn-on, turn-off, line trigger, or load change can be used to trigger the modulated signal record acquisition. In Figure 3.3, the power transistor's gate drive signal is used as the source of modulation information, and a load change on the output is used as the "EVENT" Trigger.

IMPORTANT – If possible, establish a stable display of the modulated signal and determine the source of the EVENT trigger **before** entering the PowerMeasure software menu.

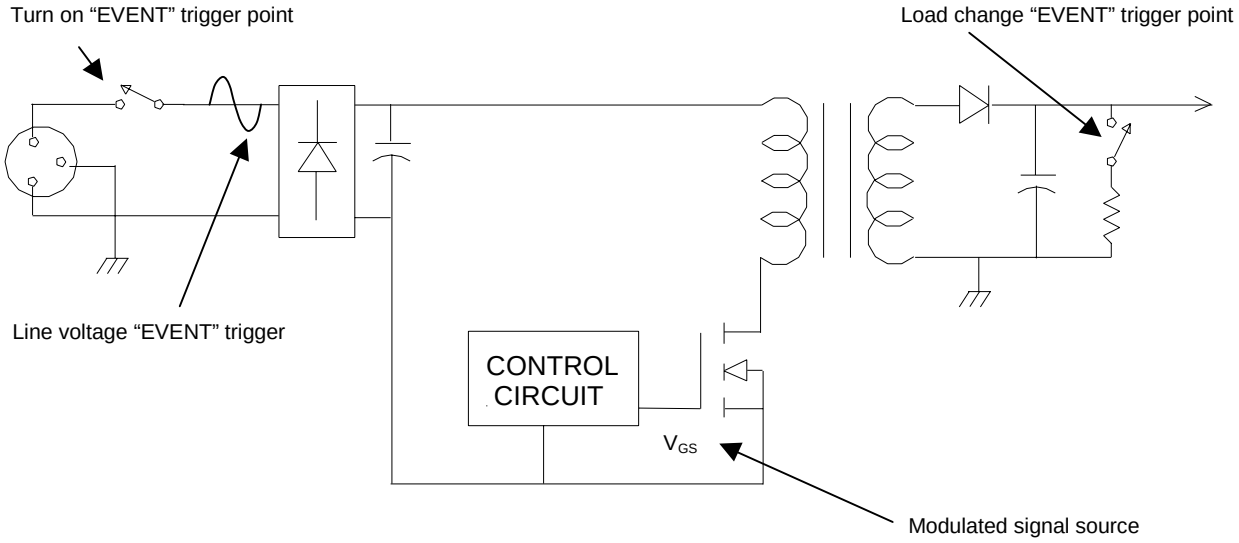
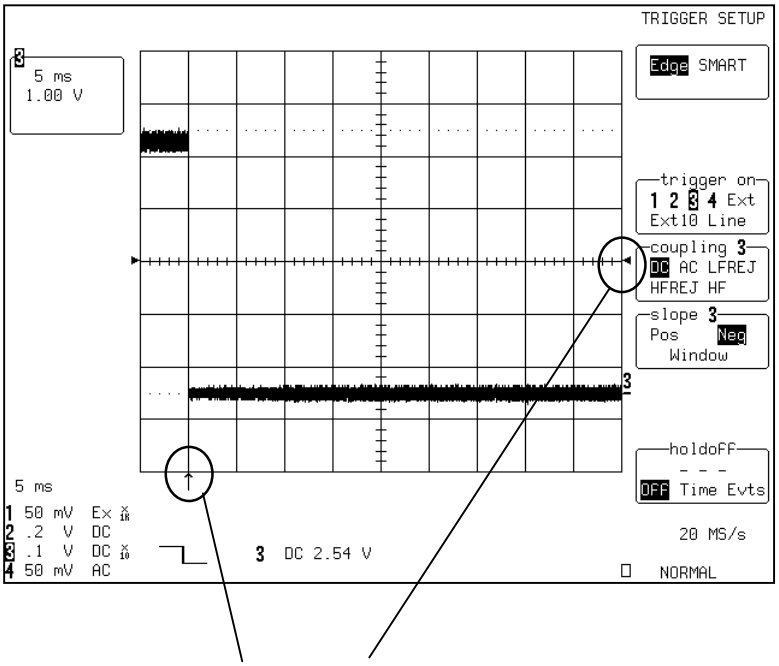


Figure 3.4: *Typical connections to the circuit under test for acquiring a source of the feedback modulation and various EVENT trigger sources.*

Trigger Setup – The Event Trigger

Determine the event around which the acquisition of an extended signal modulation record will be required. Triggering the acquisition of the modulated signal on these “EVENTS” can test the circuit’s response to events such as line voltage change, turn-on, turn-off, and load change. Typical trigger points are illustrated in Figure 3.4.

In the example used here, the acquisition is triggered as the power supply’s 5 V supply load changes from maximum to minimum. Presetting the trigger of such an event will make the final modulation measurement setup easier.

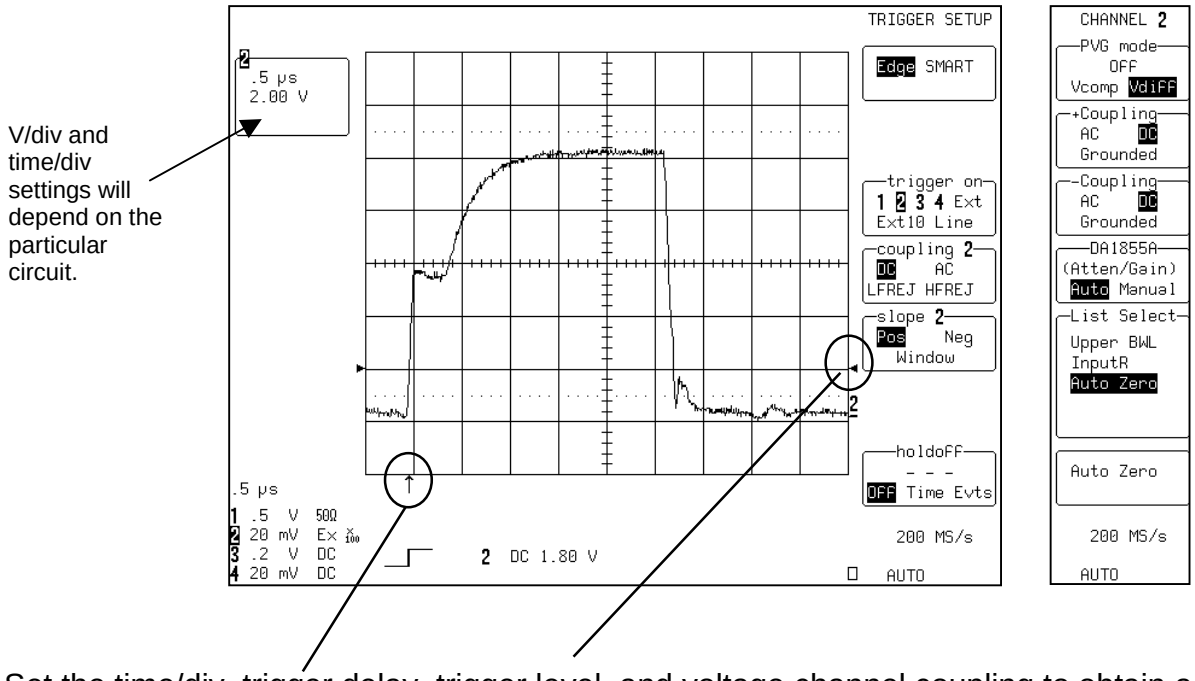


Set the time/div, trigger delay, and trigger level for the “EVENT” trigger channel to obtain a display similar to that shown above. If the modulated signal is to be acquired as the result of a one-time event such as turn-on, test the “EVENT” trigger for satisfactory operation in SINGLE trigger mode.

In this example, Channel 3 is used to acquire the load change signal, and the DSO is set up to trigger from this channel. Other channels or the DSO’s **EXT** trigger input also could be used for this purpose.

Initial Setup – The Modulated Signal

Set up a stable display of the signal that will be used as the source of the modulation information. Ensure that a clean signal can be acquired that will allow the signal's width (or other characteristic) to be readily measured. The following example uses the power transistor's gate-to-source voltage as a modulation signal source.



Set the time/div, trigger delay, trigger level, and voltage channel coupling to obtain a display similar to that shown above.

Finishing the Setup and Making Modulation Measurements

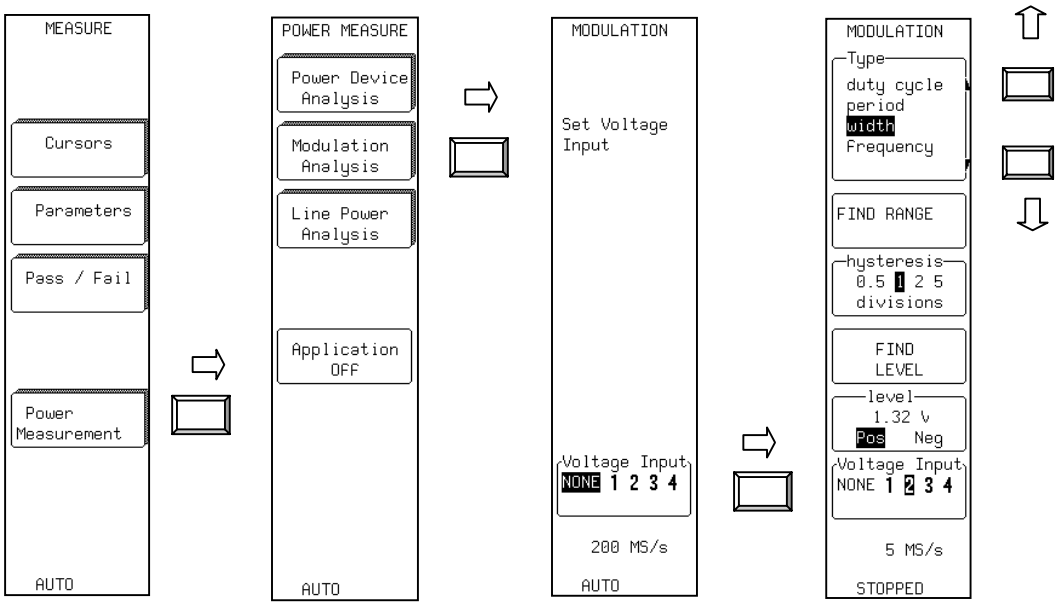
After the measurement is planned, the modulated signal channel is identified, the probes are connected to the proper point in the circuit under test, and preliminary triggering is established, use the PMA1 software to finish the setup and measure the signal's modulation.

Change the trigger source to the "EVENT" trigger previously set up (Channel 3 in the example). If the event is repetitive, the DSO's **NORMAL** trigger can be used. For events that occur only once, such as start-up, **SINGLE** trigger should be used.

Activating the Modulation Analysis Menu

Press the **MEASURE TOOLS** (LT Series) or **CURSORS/MEASURE** (LC Series) button on the DSO front panel to bring up the ***MEASURE*** menu, which includes the ***Power Measurement*** selection.

Follow the menu sequence given below:

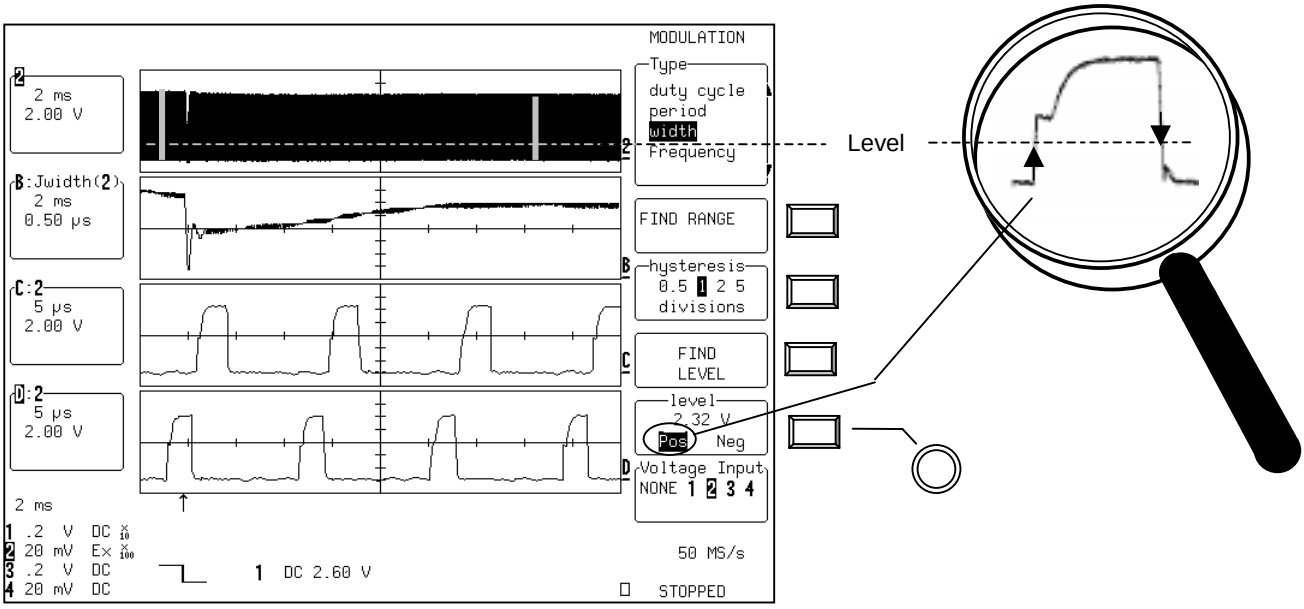


Press the ***Voltage Input***  to select the previously set up modulated signal voltage channel.

In the ***Type*** menu, select the form of modulation to be analyzed. ***Width*** is selected for this example and is the selection that is used for PWM modulation analysis.

Modulation Analysis Controls

Change the horizontal time/div to a value that will allow the capture of a modulated signal record sufficiently long to cover the time of interest and use the pre-selected "EVENT" trigger to acquire a record.



Press the ***POS*** ▭ in the ***level*** menu to measure the width between a positive-going edge and the next falling edge.

Press the ***FIND LEVEL*** ▭ to find the 50% level of the modulated signal's width.

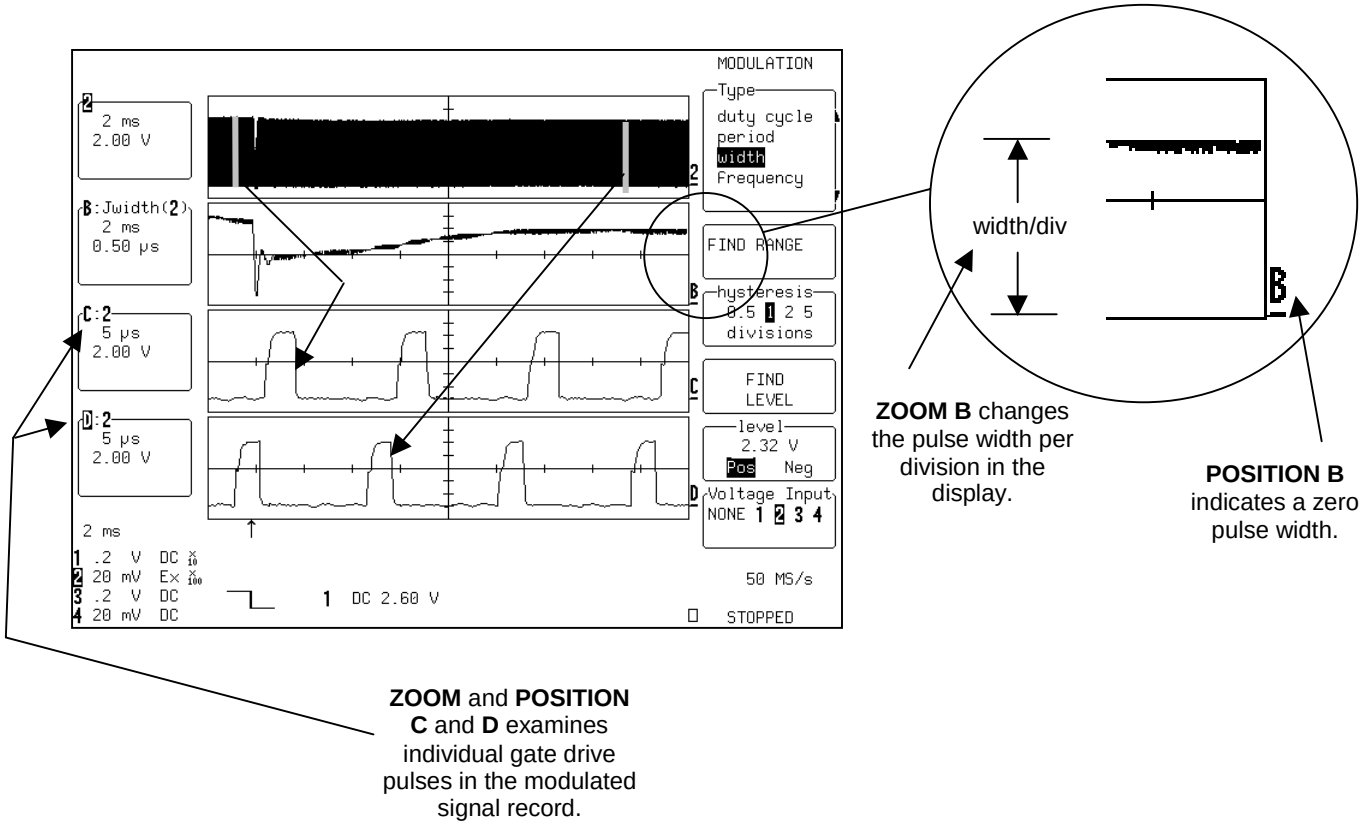
Turn the ***level*** ◎ knob to set the voltage level on the modulated signal at which the width is to be measured. Set this to a level on the modulated signal where both the rising and falling edges are free from noise. When measuring the modulation of the gate drive signal, it is best to avoid placing the level around the pedestal.

Press the ***hysteresis*** ▭ to select the number of divisions the modulated signal must change before a slope change is recognized.

Press the ***FIND RANGE*** ▭ to find the range of the modulated signal's width.

Optimizing the Display

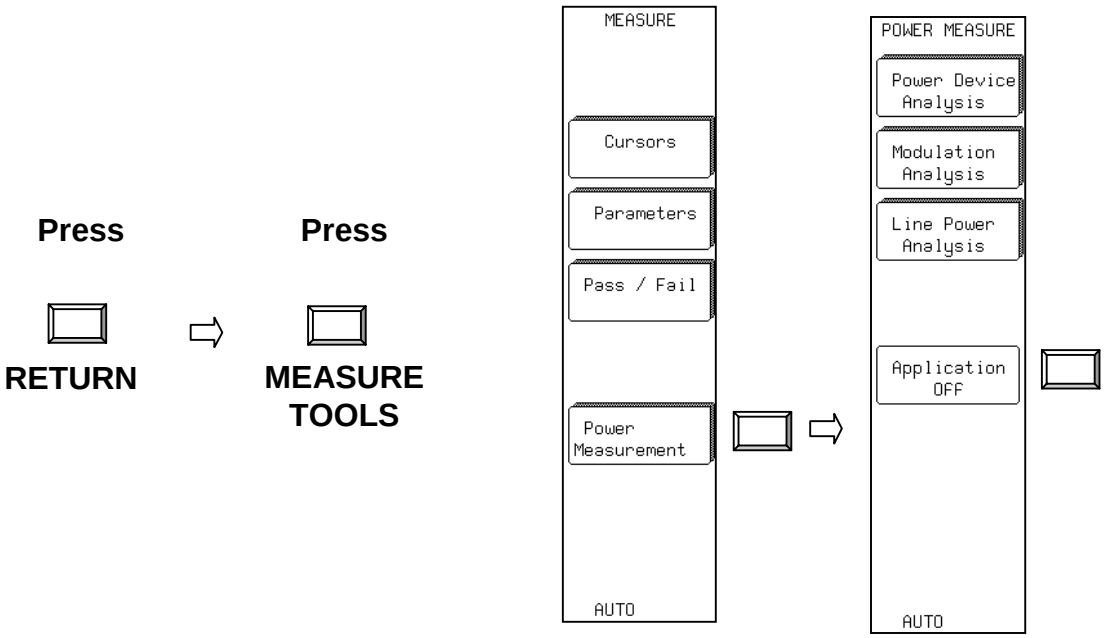
Use the DSO's **ZOOM + MATH** position and zoom controls to optimize the display.



The modulated signal (**2**) is displayed in the first grid (the gate drive voltage waveform in this example). The waveform that results from measuring the width of each pulse (**B**) is displayed in the second grid, and zoom traces (**C**) and (**D**) of the modulated signal (**2**) are displayed in the third and fourth grids. These grids are used to expand the waveform B so individual cycles of a multiple-cycle record can be viewed.

Clearing the Modulation Analysis Setup

After using the Modulation Analysis section of PMA1, it is important to clear the channel assignments and other alterations that were made while making measurements. Press the **RETURN** ▭ until the on-screen menu is cleared. Then press the **MEASURE/TOOLS** ▭ to bring up the ***MEASURE*** menu.



Selecting ***Application OFF*** in the Power Measure menu changes the ***Voltage Input*** assignment to ***NONE***.