Application Report
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OPA361 and TV Detection

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ABSTRACT

This document describes the concept and application of a practical method to detect if a television (TV), videocassette recorder (VCR) or any other 75Ω video load is connected to the output of the OPA361 video buffer, which is the video buffer for the OMAP242x™ series of products from Texas Instruments. In addition to TV detection, timing and layout requirements are also discussed.

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1 TV Detection Application

1.1 Basic Concept

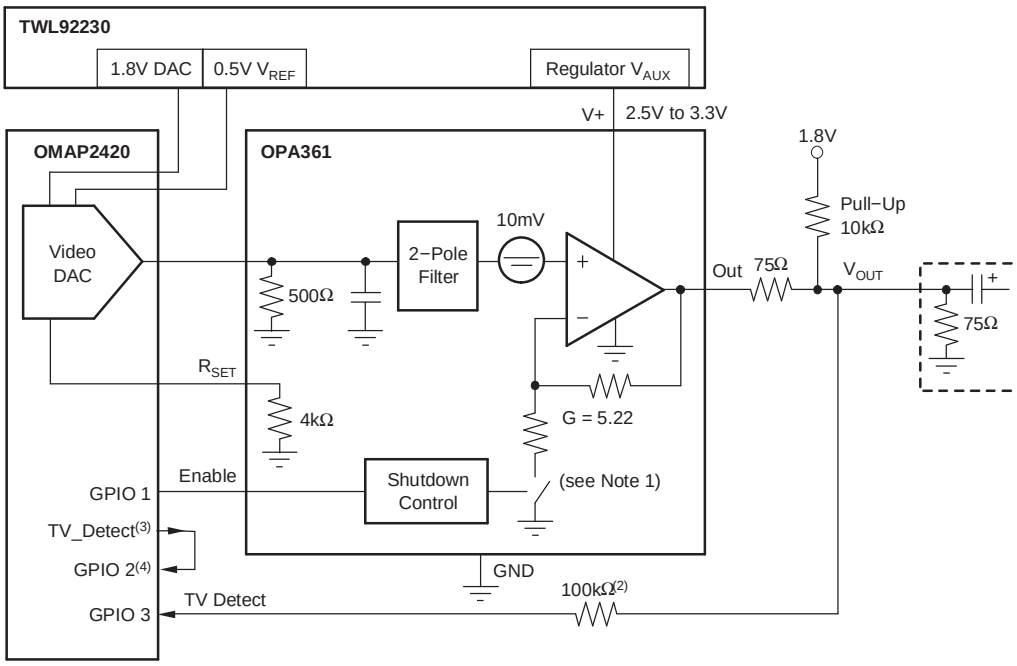
The OMAP242x architecture is designed for mobile entertainment and communications. The OPA361 video amplifier is used within this system to buffer the video output signal. The OMAP2 processor must be able to determine if a TV or other video load has been connected to the OPA361 output.

To detect whether a TV, VCR or other 75Ω video load is connected to the output of the OPA361, connect a 10kΩ pull-up resistor between the op amp output and a 1.8V pull-up supply voltage. The voltage at the op amp output (see Figure 1) will indicate the status of the video load as follows:

- TV connected:
  V_{OUT} = 0V
- TV disconnected:
  V_{OUT} = 1.8V
- Use the OMAP2420 general-purpose input/output (GPIO) to monitor whether or not a television is connected.

1.2 Block Diagram and Flow Chart

Figure 1 shows a block diagram of the OPA361 together with the OMAP2420.



(1) Closed when enabled during normal operation; open when shut down.
(2) Protects GPIO against over-voltage conditions during active video transmission.
(3) Potentially, the TV_Detect signal could be used to shut off the OPA361.
(4) GPIO must be able to generate interrupt. Interrupt could potentially also be software generated.

Figure 1. Block Diagram of OPA361 Together with OMAP2420

- GPIO 1 is used to enable or disable the OPA361.
- The TV_Detect signal can be used to generate the timing for the TV Detection process.
- GPIO 2 is connected to the TV_Detect signal; it generates an interrupt that initiates the TV Detection cycle.
- GPIO 3 monitors the video line. If a TV is connected, the internal 75Ω load of the device pulls GPIO 3 low. If no TV is connected, GPIO 3 will be pulled high.

The flowchart in Figure 2 illustrates this process.

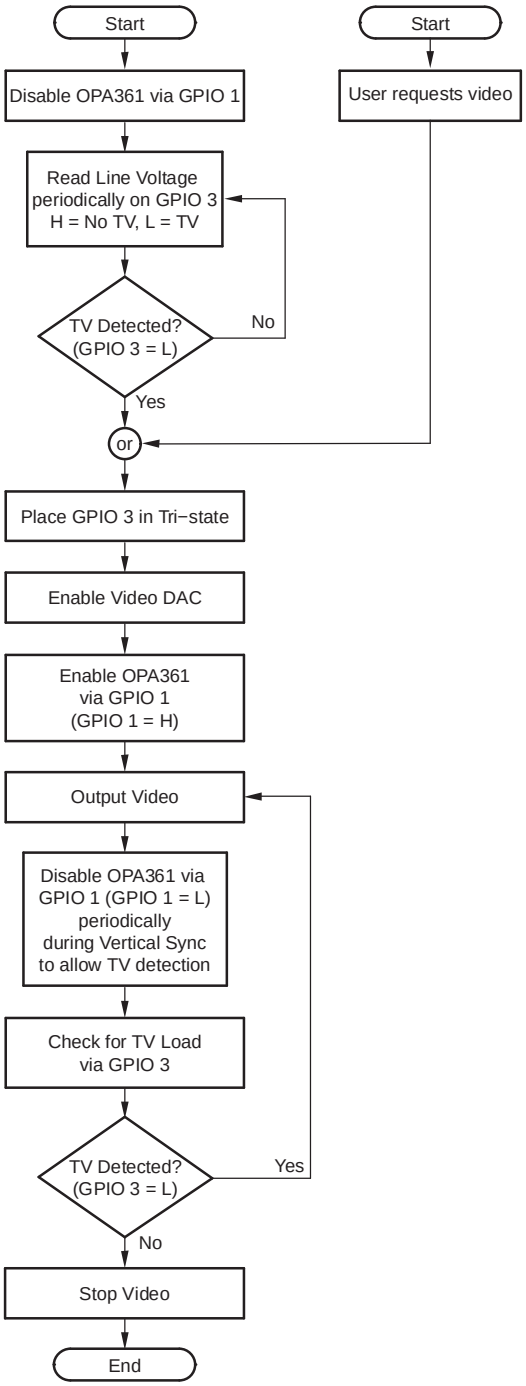


Figure 2. Flowchart for TV Detection Process

1.3 Automatic Video Start

To configure the OPA361 for automatic video start monitoring, use this procedure:

- The OPA361 should be disabled.
- Permanent pull-up to 1.8V on the OPA361 output allows easy detection of a 75Ω device connection:
  - The GPIO 3 line reads '0' if a TV (or other external 75Ω device) is connected;
  - The GPIO 3 line reads '1' if there is no external device connected.
- Periodically read the TV Detect Line via GPIO 3 in order to determine if a TV has been connected. If a TV or other external device has been connected, start video transmission through TV_out.
- Timing of the monitoring process is not critical; detection can be done whenever it is convenient for the processor.
- A user can start the video manually, if desired.

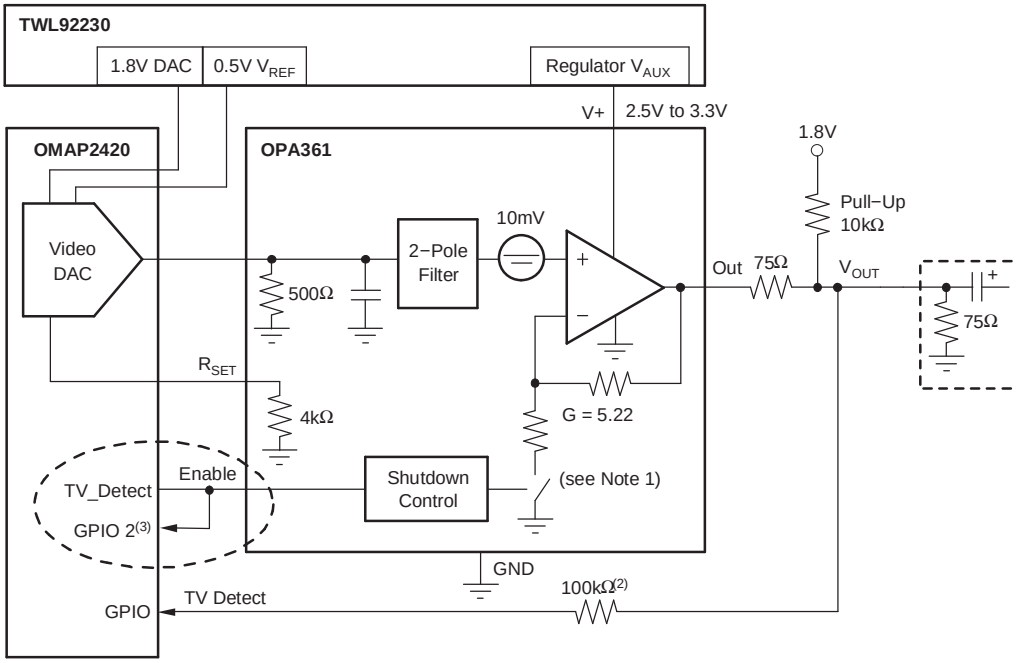
1.4 Automatic Video Stop

To configure the OPA361 for automatic video stop monitoring, use this procedure:

- TV detection can be performed while the OPA361 is turned off for a short period of time. There are several suitable places within the video signal to perform this detection with no visible screen or display effects. Please see the *Timing of TV Detection* section for more details.
- The OPA361 would be disabled via GPIO 1, or alternatively by using the TV_Detect signal. See the section, *Use of TV_Detect Signal in OMAP2420 to Disable OPA361* for additional details.
- When the OPA361 is disabled, the line voltage on the GPIO 3 will read '0' if a TV is connected. It will read '1' if no TV or external 75Ω device is connected.
- GPIO 3 should be placed in tri-state mode during standard video transmission.
- TV detection does not have to be performed at every frame; it can be done every two or three seconds or as infrequently as two to three minutes.

2 Use of TV_Detect Signal in OMAP2420 to Disable OPA361

The programming of the OMAP2420 TV_Detect signal is very flexible. It supports the selection of start and stop lines. In addition, the TV_Detect signal supports start and stop pixels within these lines, as well as the polarity of the respective line and whether it is enabled or not. This flexibility allows the TV_Detect signal to be directly connected to the Enable pin of the OPA361, as shown in Figure 3. This capability saves one GPIO on the OMPA2420.



(1) Closed when enabled during normal operation; open when shut down.
(2) Protects GPIO against over-voltage conditions during active video transmission.
(3) GPIO must be able to generate interrupt. Interrupt could potentially also be software generated.

Figure 3. Using TV_Detect Signal to Disable or Enable OPA361

2.1 OPA361 Registers

Table 1. TVDETGP_INT_START_X

Subaddress = 0XB0, 0XB1
Default = x01, 0x00

7	6	5	4	3	2	1	0
TDISX [7:0]							
RESERVED						TDISX [9:8]	

TDISX [9:0] **TVDETGP internal start.**
These bits define TVDETGP internal start pixel value.

Table 2. TVDETGP_INT_STOP_X

Subaddress = 0XB2, 0XB3
Default = 0x14, 0x00

7	6	5	4	3	2	1	0
TDISPX [7:0]							
RESERVED						TDISPX [9:8]	

TDISPX [9:0] **TVDETGP internal stop.**
These bits define TVDETGP internal stop pixel value.

Table 3. TVDETGP_INT_START_Y

Subaddress = 0XB4, 0XB5
Default = 0x01, 0x00

7	6	5	4	3	2	1	0
TDISY [7:0]							
RESERVED						TDISY [9:8]	

TDISY [9:0] **TVDETGP internal start.**
These bits define TVDETGP internal start line value.

Table 4. TVDETGP_INT_STOP_Y

Subaddress = 0XB6, 0XB7
Default = 0x01, 0x00

7	6	5	4	3	2	1	0
TDISPY [7:0]							
RESERVED						TDISPY [9:8]	

TDISPY [9:0] **TVDETGP internal stop.**
These bits define TVDETGP internal stop line value.

Table 5. TVDETGP_EN

Subaddress = 0XB8
Default = 0x00

7	6	5	4	3	2	1	0
RESERVED							EN

TVDETGP_EN [9:0] **TVDETGP generation enable.**
0 = Disabled (default).
1 = Enabled.

Table 6. SYNC_POLARITY

Subaddress = 0xBA
Default = 0xFF

7	6	5	4	3	2	1	0
HIP	VIP	HEP	VEP	AVIDP	FIP	FEP	TVDP

TVDP TVDETGP polarity.
0 = Active low.
1 = Active high (default).

Programming the TV_Detect signal to support the timing diagrams below (see Figure 4) allows Enable / Disable of the OPA361. See the *Timing of TV-Detection* section for further details on the timing constraints.

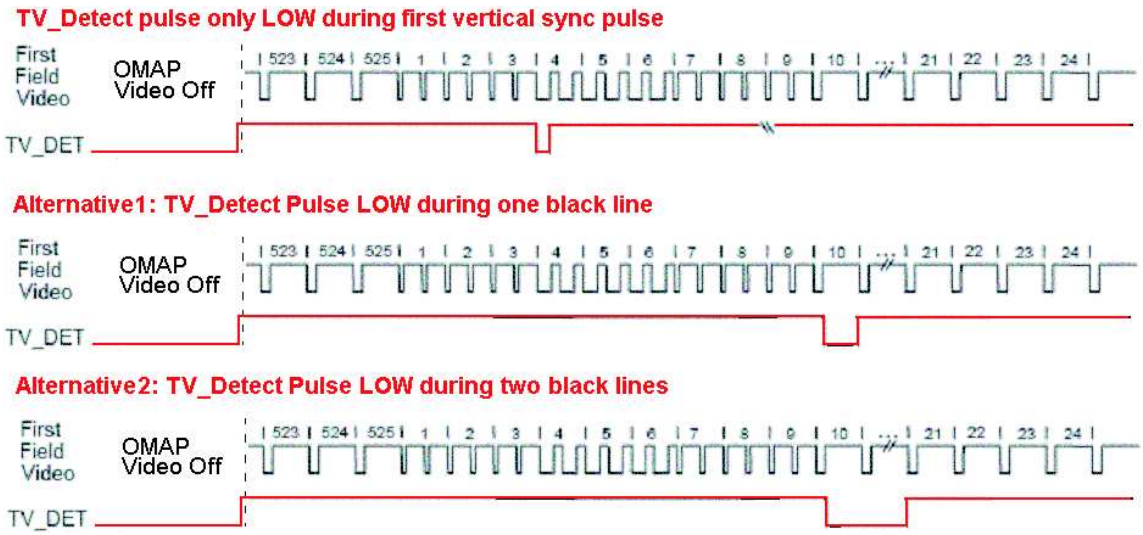


Figure 4. TV_Detect Pulse Timing Options

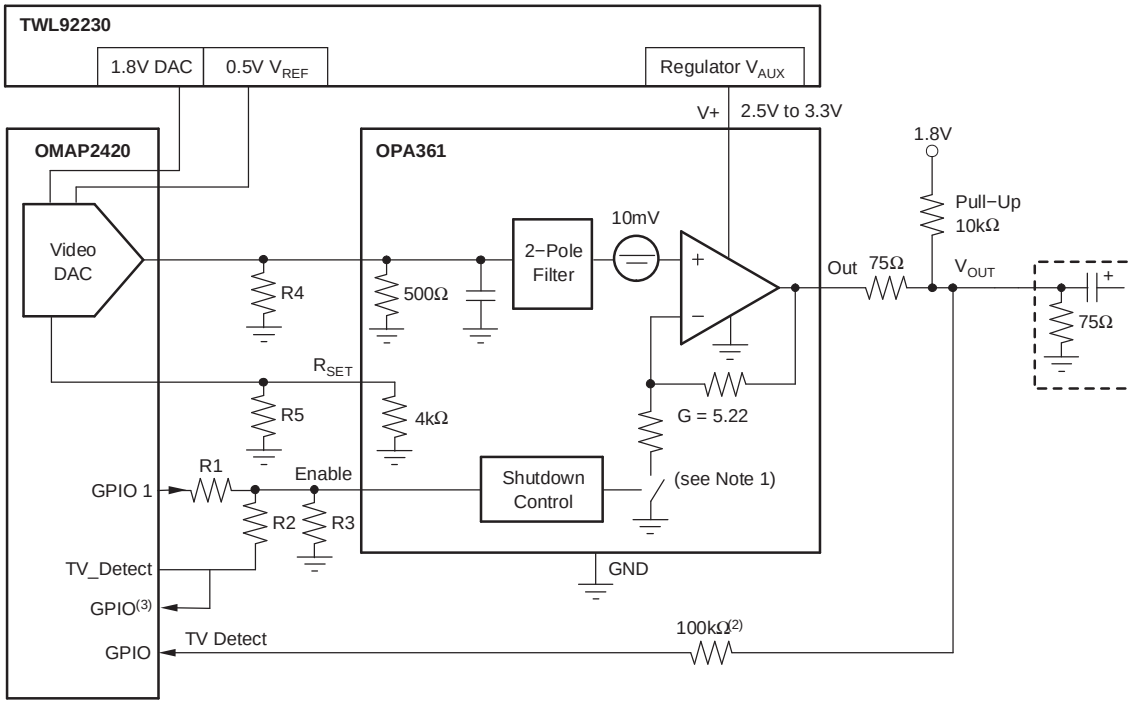
The register descriptions illustrate that the TV_Detect pulse is **Disabled** by default; the default polarity of the TV_Detect pulse is **Active High**. This default setting means that on device power-up, the signal level should be '0'. Consequently, the OPA361 would be disabled and draw <5µA of supply current.

During video transmission, the TV_Detect signal should be **Enabled**, and the signal polarity should be programmed to be **Active Low**. The start and stop lines, and start and stop pixels, should be programmed according to the discussion in the *Timing of TV Detection* section.

The TV_Detect signal is multiplexed with a GPIO in OMAP applications. This cell allows the user to program for active pull-up or pull-down after reset. To save power, the cell should be programmed for active pull-down to disable the OPA361 by default.

2.2 A Note on Hardware Layout

Board layout should allow for a shutdown function using either a general GPIO or via TV_Detect signal. This configuration can be easily accomplished by routing the signals through 0Ω resistors similar to those shown (see Figure 5). Only one 0Ω resistor should be populated.



(1) Closed when enabled during normal operation; open when shut down.
(2) Protects GPIO against over-voltage conditions during active video transmission.
(3) GPIO must be able to generate interrupt. Interrupt could potentially also be software generated.

Resistor Descriptions:
R1 / R2: If the TV_Detect signal is used, populate R2 = 0Ω, R1 = open. If general I/O is used, R2 = open, R1 = 0Ω
R3: R3 = 0Ω Populate only if GPIO is High−Z state after Power-On or Reset to make sure that OPA361 is disabled.
R4: Populate only if internal gain (500Ω) of OPA361 needs to be modified.
R5: Populate only if internal R_{SET} needs to be modified.

Figure 5. Adding Flexibility to the Hardware Configuration

3 Timing of TV Detection

3.1 Measurement Circuit

All of the following measurements were taken using the OPA361 and a video signal generator. The video signal generator provided the video signals as a vertical-sync signal. The disable signal for the OPA361 was generated out of the vertical-sync signal from the video generator. See Figure 6.

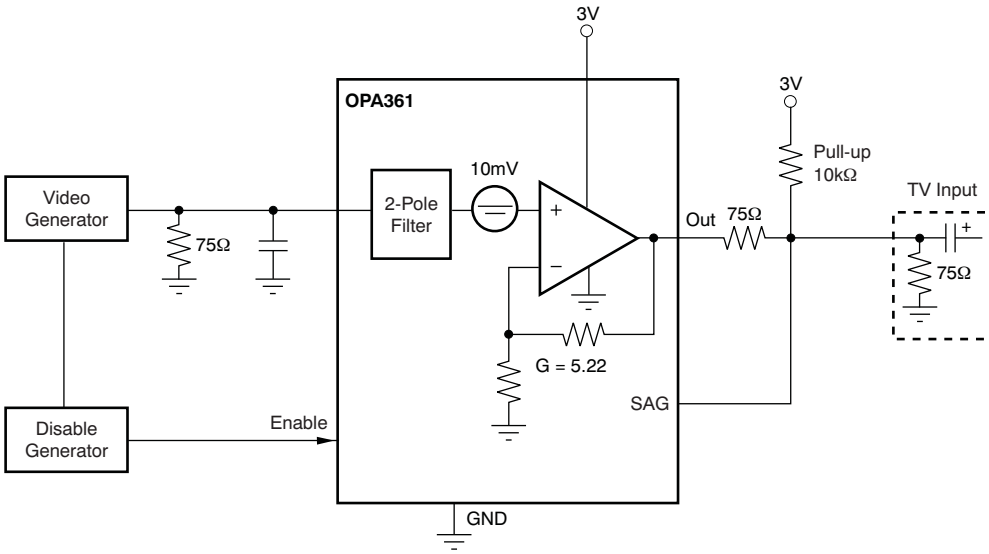


Figure 6. Evaluation System for the TV Detection Concept

The vertical blank period is well-suited for the detection of a TV presence because the video signal level is at or below *black* level during the entire time. Any manipulation of the video signal during this period is not visible on the screen.

The vertical blanking period consists of three distinct areas, as Figure 7 shows:

- Equalization Pulses
- Vertical Sync Pulses
- Black *retrace* lines

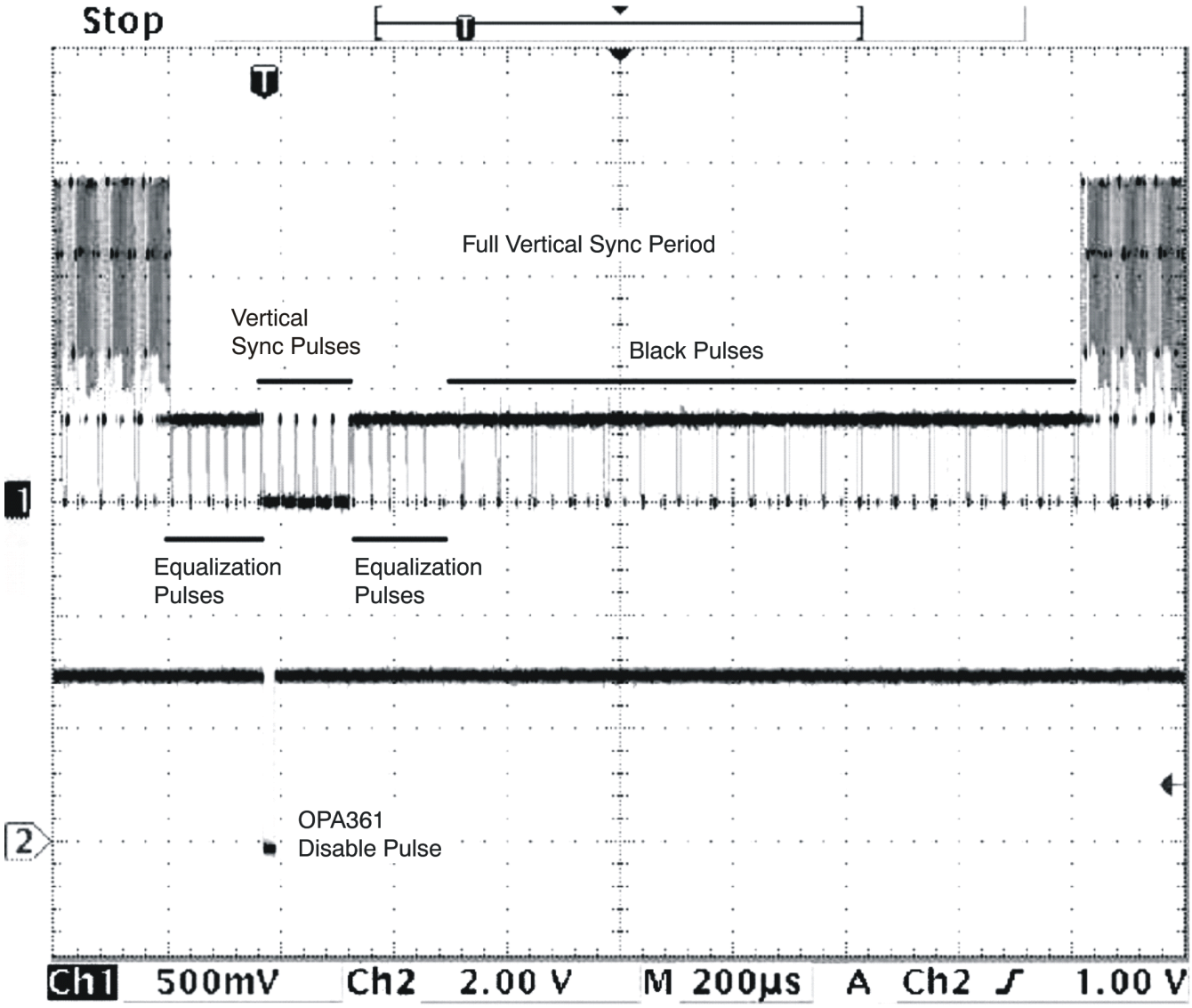


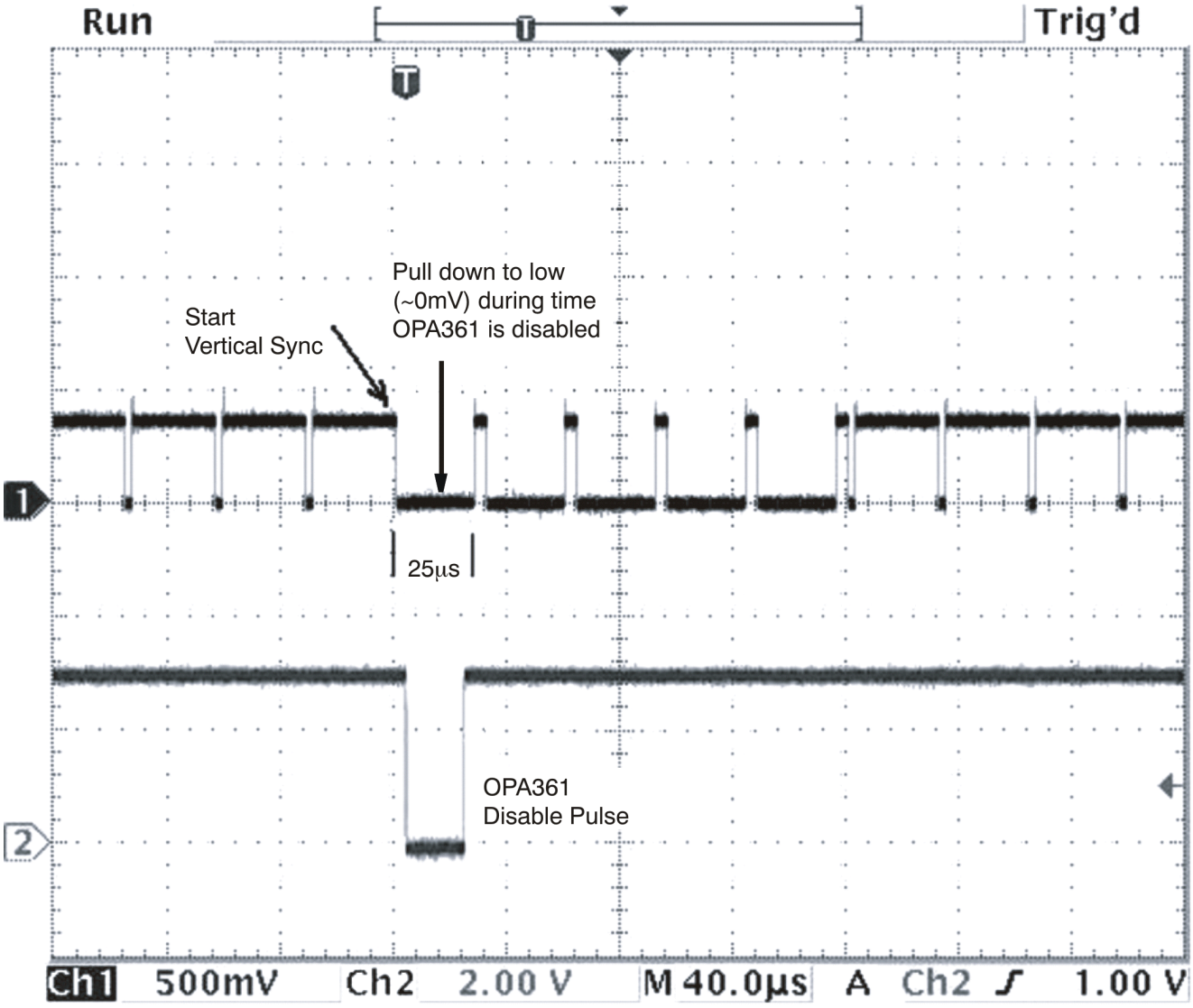
Figure 7. Full Vertical Blanking Period

The ideal place to disable the OPA361 is at the first vertical pulse, because the signal decreases to almost 0V at this point. When the TV is connected, the 75Ω load in the TV pulls the output to 0V, even though the OPA361 is disabled at this time. Therefore, the video signal remains virtually unchanged. However, detection of the TV during the first vertical pulse is the most demanding in terms of timing requirements. Section 3.2 describes the timing in more detail.

The alternative method requires disabling the OPA361 during one or more of the black *retrace* lines. This option leads to a change in the video signal because the signal will be pulled to 0V through the 75Ω TV load. However, the change in the video signal will not be visible on screen because 0V is lower than the *black* level. The timing of TV detection during the black retrace is less demanding than when the detect process is done during the first vertical pulse. Section 3.3 (*Detection During Black Lines*) describes the timing in more detail.

3.2 Detection Timing During the First Vertical-Sync Pulse

The OPA361 is disabled during the low level portion of the first vertical sync pulse, as Figure 8 ilustrates. The ~0mV level shown during this time indicates that a TV is connected.

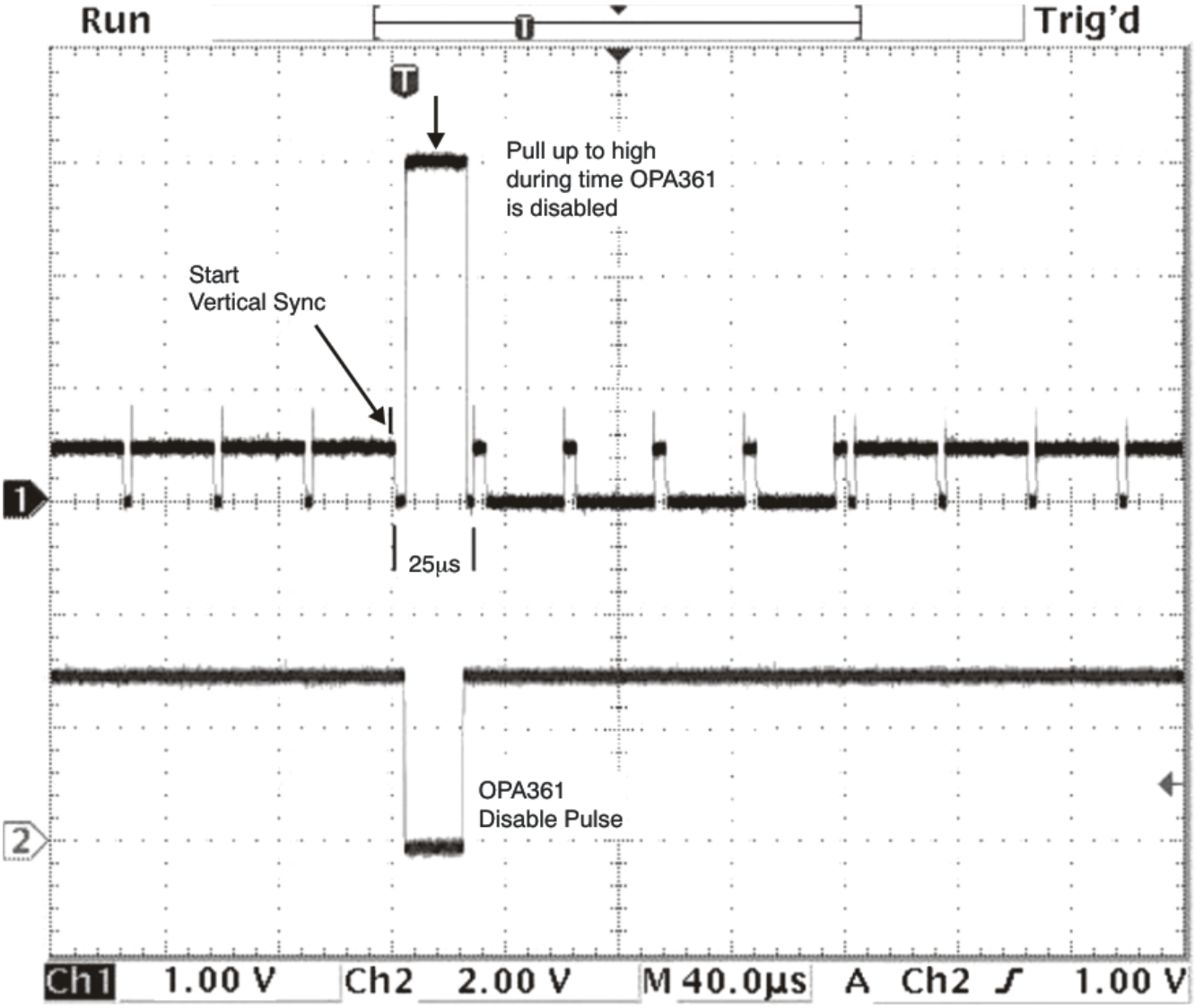


Note: TV is connected.

Figure 8. Line Output Shows Low During Disable Period

The OPA361 remains disabled during the vertical sync pulse period. The output also remains at 0V, which indicates that a TV is currently connected.

According to the ITU-R BT.470-6 TV standard, the full time for the vertical sync pulse is 27.1µs for NTSC signals and 27.3µs for PAL signals. Therefore, the timing for the TV detection should be within approximately 25µs to comply with the timing defined in both of these standards. Figure 9 shows this condition.



Note: TV is disconnected.

Figure 9. Line Output Shows High During Disable Period

If no TV is connected, the output of the video line is pulled high during the Disable Pulse. See Figure 9 and Figure 10.

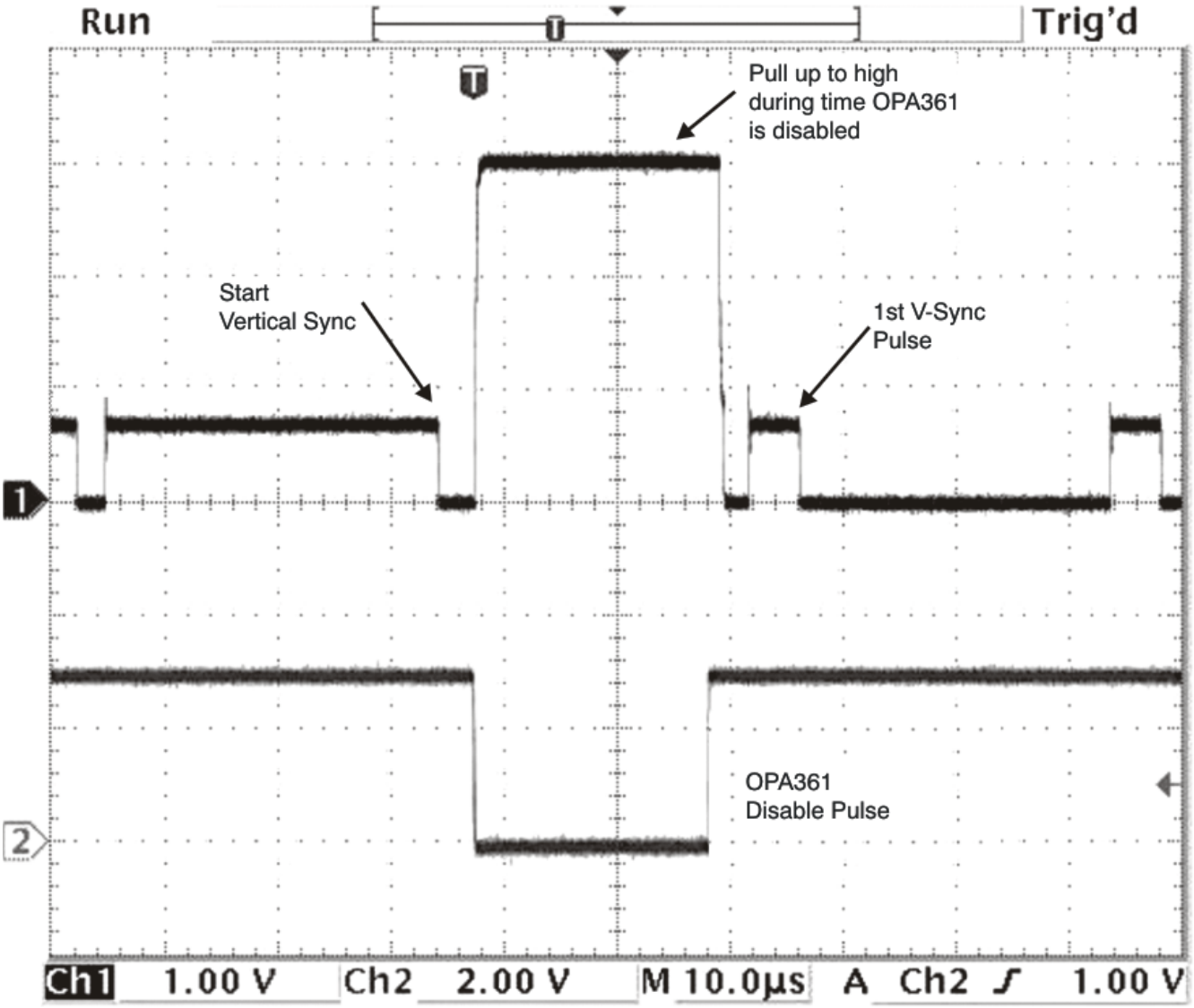


Figure 10. Detailed View of Disable and Enable Timing for OPA361

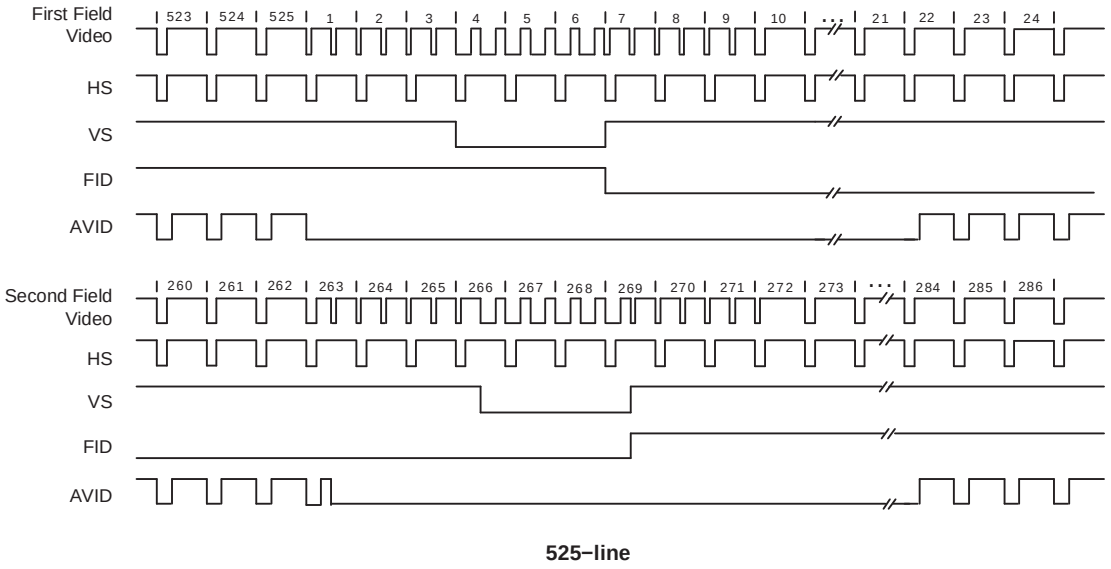
The OPA361 (Rev 1) output disables very fast (<<1µs). Enabling the OPA361 takes about 1µs to 2µs.

Broadening the disable time did not show any effect on the screen until the second-to-last vertical sync pulse. Disabling the OPA361 through the second-to-last sync pulse resulted in loss of vertical sync. However, this loss will depend heavily on the TV that is used. It is safest to disable only during the first 25µs, because this brief period will not affect the TV circuit that extracts the vertical sync information.

3.3 Detection During Black Lines

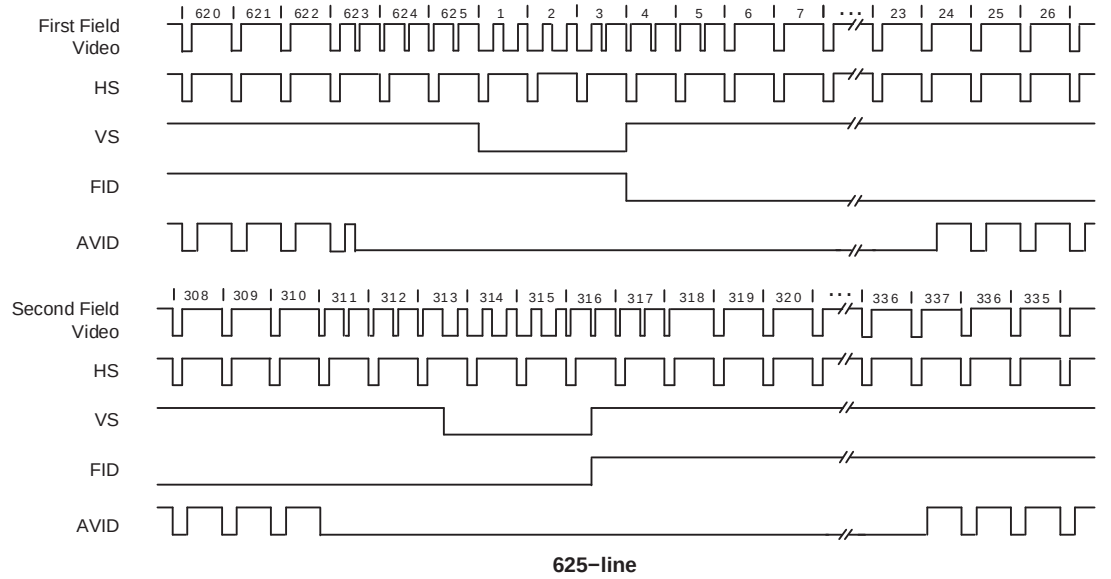
If the timing during the first vertical sync pulse is not feasible with the OMAP2420 processor, the alternative to detect the presence of a TV is to conduct the procedure during one of the *black* retrace lines in the vertical sync interval.

The number of black lines varies depending on the video system (NTSC or PAL), as Figure 11 and Figure 12 show.



Note: Line numbering from ITU-R 470-4.

Figure 11. HSYNC, VSYNC, FID and AVID for NTSC

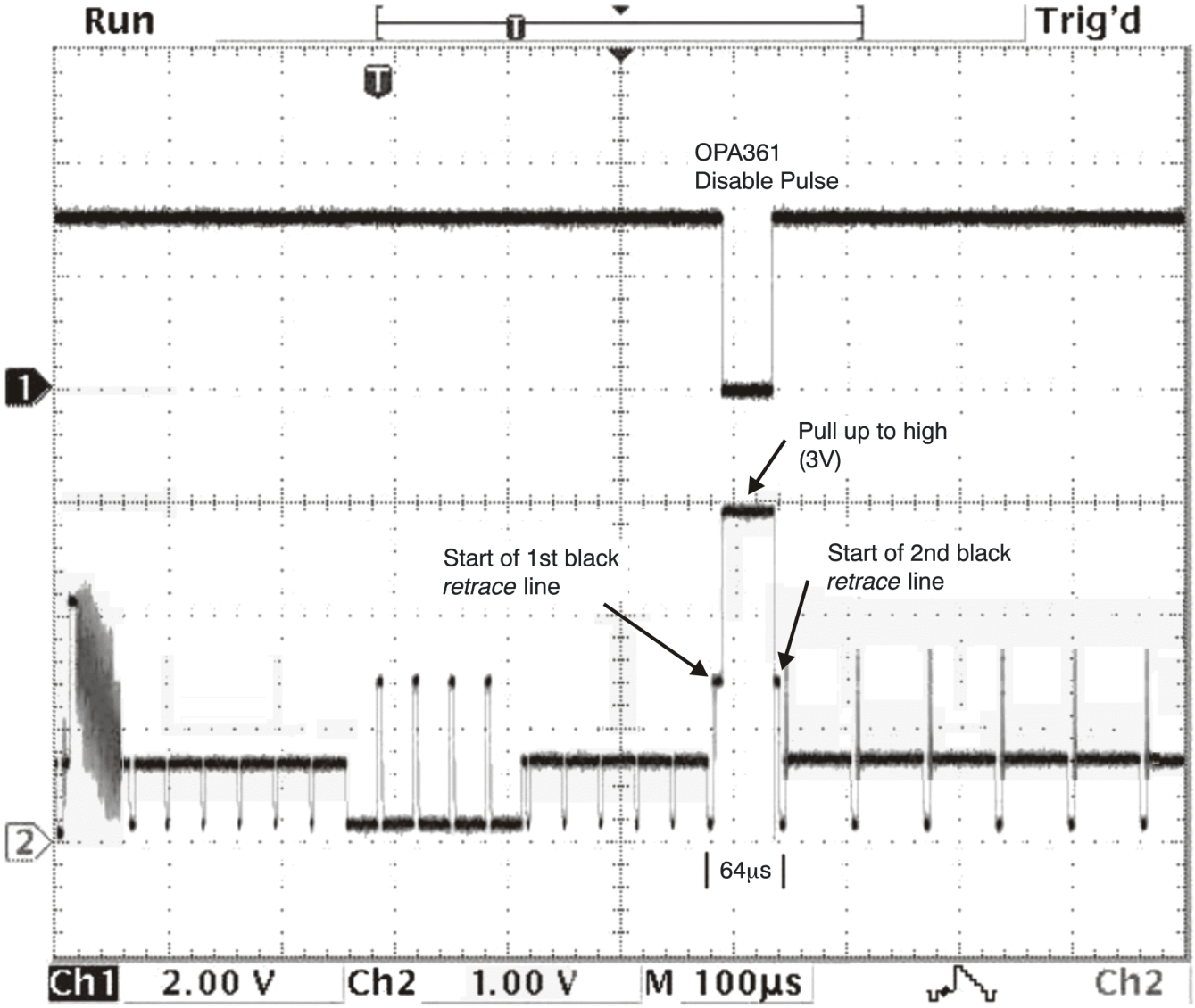


Note: Line numbering from ITU-R 470-4.

Figure 12. HSYNC, VSYNC, FID and AVID for PAL

These diagrams show that the black retrace lines for the first field video in NTSC format start at line 10 and end at line 21. For PAL video format, the first field black retrace lines start at line 6 and end at line 23.

The following experiments show that any of these lines could be suitable for the TV Detection. However, the early lines are are preferable because they are furthest away from the visible part of the picture displayed on the TV.

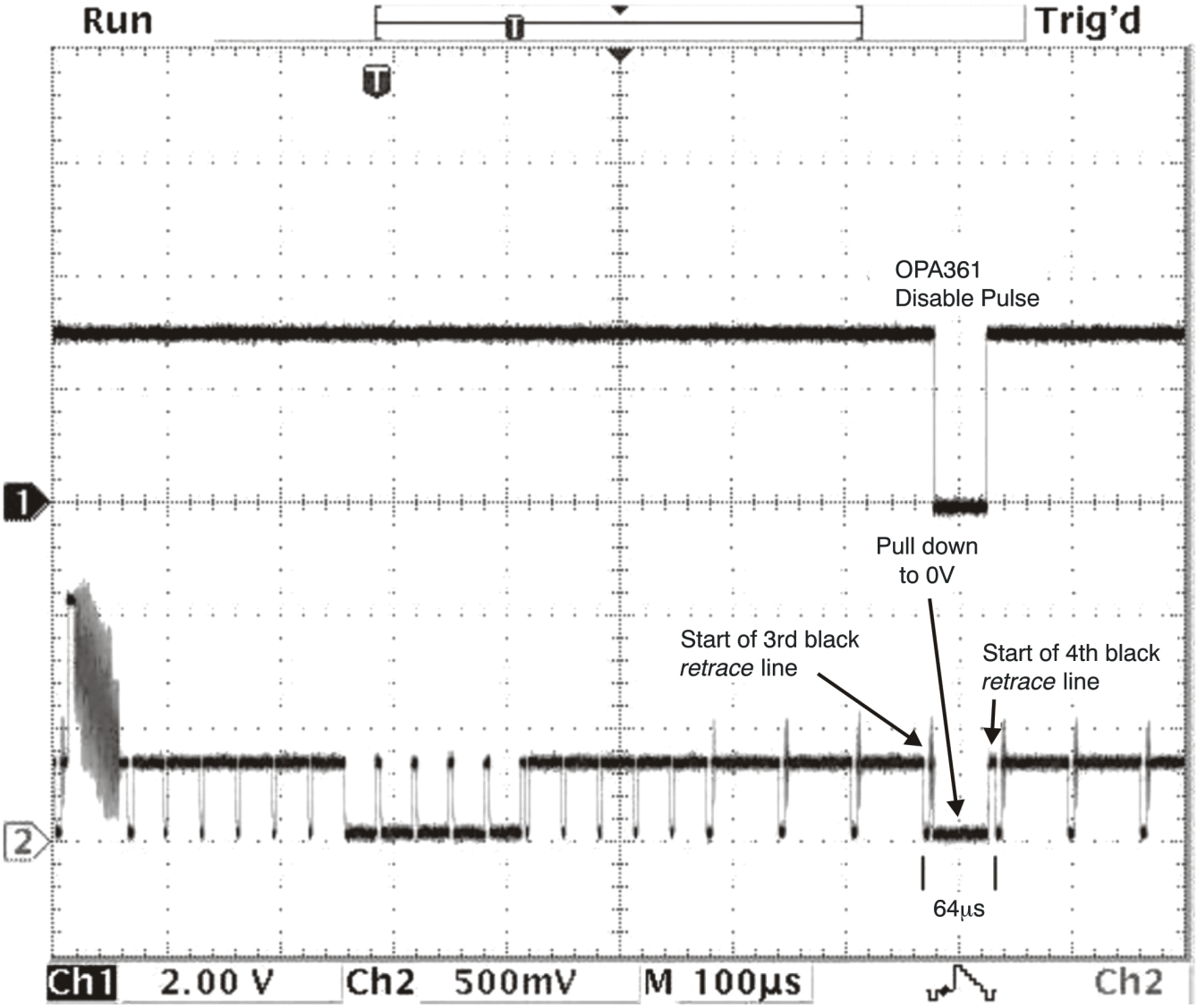


Note: TV is disconnected.

Figure 13. TV Detection During First Black Retrace Line

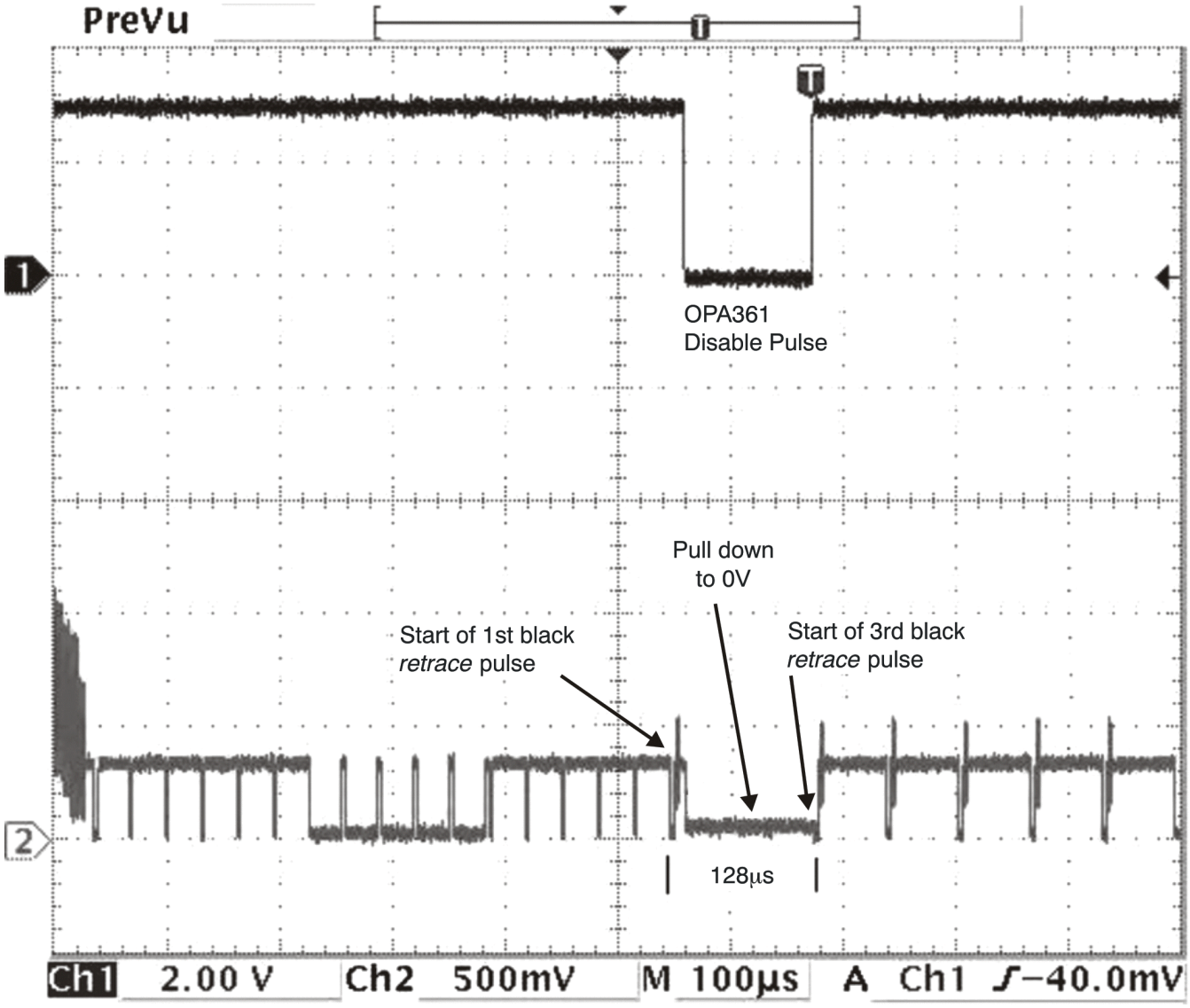
As seen in Figure 13, a black retrace line is approximately 64µs long, from the start of the synchronization pulse to the next pulse. The ideal time to disable the OPA361 for the TV detection would be right after the end of the sub-carrier burst, after approximately 10µs. The OPA361 should be enabled again approximately 2µs before the beginning of the next sync pulse. This timing leaves approximately 52µs of detection time compared to the 25µs in the method described in Section 3.2.

As expected, the 75µ load in the TV pulls the video signal down. The change in the video signal did not have any effect on the TV screen display because the voltage level is lower than the black level. There is also no difference between performing the TV-detection during the first or fourth black line. See Figure 14 and Figure 15.



Note: TV is connected.

Figure 14. TV Detection During Fourth Black Retrace Line



Note: TV is connected.

Figure 15. TV Detection During First and Second Black Retrace Line

By disabling the OPA361 during two pulses, the effective detection time can be prolonged to approximately 118µs. However, the disadvantage of this approach is that one horizontal sync pulse and one color sub-carrier burst for the second black line have been removed from the signal. This removal did not have any noticeable effect on the TV screen. Theoretically, more than two lines could be used for the TV detection scheme with minimal impact on the signal displayed on the TV screen. However, if too many lines are used, problems with line synchronization or color synchronization could potentially occur.

3.4 Random/Unsynchronized Detection

If the timing described in Section 3.2 and Section 3.3 is still not feasible, the TV detection process could also be performed completely unsynchronized to the video signal. The visual effect on the screen depends heavily on the frequency and duration of the TV detection (that is, the disabling of the OPA361). If TV detection is performed every 1 to 2 minutes and the OPA361 is disabled for only one horizontal line (~64µs), the visual effects on the screen are minimal and very difficult to detect because they are far apart in time. They will be especially difficult, if not impossible, to detect when moving pictures are viewed on the screen instead of still images.

In this procedure, only the GPIO used to disable the OPA361 and the one monitoring the TV line are needed. If the TV_Detect signal is used to disable the OPA361, only one GPIO line is used.

This method is the most simple from a timing standpoint; however, there will be some small artifacts visible on the screen for a very brief period of time.

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