

# **AN- 1237 RSDS™ Flat Panel Display Design Guidelines Part 2**

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## **ABSTRACT**

This application report presents part 2 of the flat panel display design guidelines.

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## 1 Overview

Part 1 focused on the Timing Controller (TCON) and Column Driver RSDS™ interface. Part 2 focuses on the voltage references and power supply generation. In a typical flat panel display, there can be 12 or more different supply voltages that need to be generated and stabilized to maximize the panel performance.

## 2 DC-DC Conversion

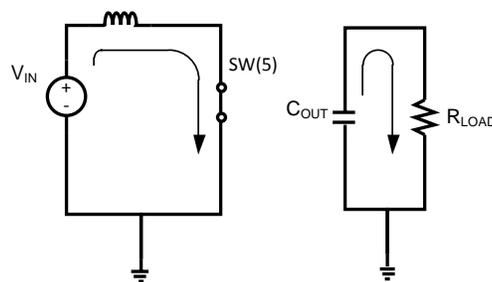
Power supply design is very different from the high-speed digital design that dominates the rest of the flat panel display system. Texas Instruments™ has an industry best support structure for analog and power supply design including the award winning WebBench™ software and numerous application notes (*AN-556: Introduction to Power Supplies* ([SNVA006](#)) and *AN-1149: Layout Guidelines for Switching Power Supplies* ([SNVA021](#)) are particularly helpful). All of TI™ documentation is available on the corporate website ([www.ti.com](#)).

Panels will normally have only a low voltage digital supply (typically +3.3V), and will use that supply to generate the higher voltages needed by the column drivers and the row drivers. The most common method for developing these voltages is to use a step-up converter. There are many variations on the market, and TI™ has a variety of options designed specifically to meet the needs of flat panel displays.

In this application note, examples are given that will illustrate how to use TI's LM2622 and a +3.3V supply to generate the following voltages:

- +9.0V for Column Driver Analog Supply
- +18.0V for Row Driver "on" Voltage
- -9.0V for Row Driver "off" Voltage

The basic operation of the LM2622 is outlined in [Figure 1](#) and [Figure 2](#). All of the components shown are external to the device except the switch, which is attached to the circuit by the SW pin on the IC. In the first cycle, the switch is closed (shown in [Figure 1](#)) and the diode is reverse biased (the diode acts like an open circuit and has been removed from the figure). Energy is stored in the inductor and the current for the load is supplied by  $C_{OUT}$ . In the second cycle (shown in [Figure 2](#)), the switch is open and the energy stored in the inductor is transferred to the load and  $C_{OUT}$ . For more details on the operation of the LM2622 and switching power supplies in general, please see *LM2622 600kHz/1.3MHz Step-up PWM DC/DC Converter* ([SNVS068](#)) and *Linear and Switching Voltage Regulator Fundamentals*, ([SNVA559](#)).



**Figure 1. Basic Operation of the LM2622 (switch closed)**

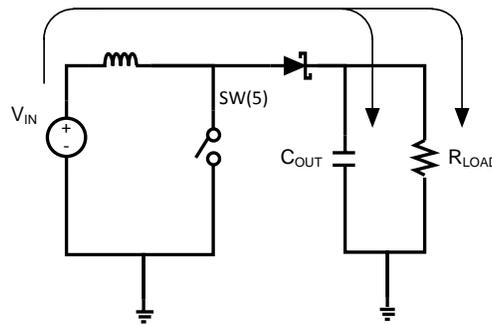


Figure 2. Basic Operation of the LM2622 (switch open)

### +9.0V for Column Driver Analog Supply

Normally, the analog supply for the column drivers is between +8.0V and +10.0V. The LM2622 is capable of generating a controlled, stable voltage of up to +12.0V from a +3.3V supply. Column drivers will consume 8-10mA of analog current under worst-case conditions. For XGA and SXGA applications, the DC-DC converter must be able to supply 100-150mA of current. LM2622 can provide 100-200mA of current at over 90% efficiency, making it perfectly suited to supply the column driver analog voltage

Figure 3 shows an example of how to generate +9.0V using the LM2622. In this configuration, the LM2622 is set to operate at 600kHz (it can also operate at 1.3MHz if the FSLCT pin is tied high). The circuit comprising of L1, D1, C3, and the SW pin of the IC operate as described above in Figure 1 and Figure 2. The analog output voltage is controlled by the resistor-divider of R1 and R2. The voltage on the FB pin is internally fixed at +1.26V, so in order to have a +9.0V output, resistor values of 51kΩ for R1 and 8.3kΩ for R2 can be used. Voltages other than +9.0V can be generated by changing the ratio of R1 and R2.

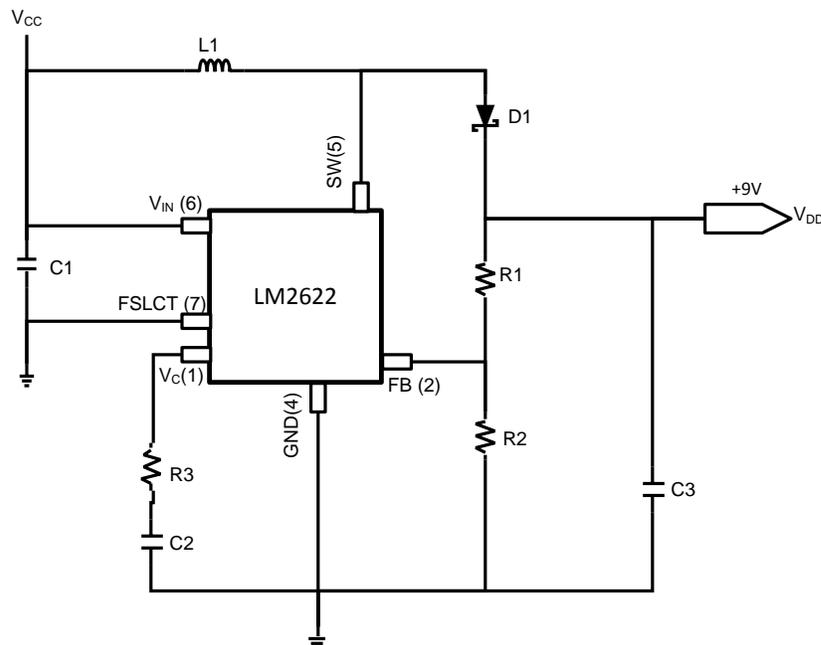


Figure 3. Using the LM2622 to Generate +9.0V DC

There are six main recommendations for implementing the circuit shown in Figure 3.

1. Use a low EMI inductor with a ferrite type closed core such as a torroid or an encased E core. This will lower the overall emissions and reduce the noise in the power supply. A 10μH inductor should provide a stable output supply for most applications.

2. All the filter capacitors should be placed as close to the IC as possible. The filter capacitor is shown as C1 in Figure 3. Keeping the filter capacitors close to the IC reduces the affects of the trace inductance. All the board components should be surface mount to save space and lead length.
3. Place the inductor, the diode and the capacitor that bypasses the +9.0V supply as close together as possible. In Figure 3, these are L1, D1, and C3. This will help reduce EMI, noise, ringing, and other unwanted supply effects.
4. Keep the feedback loop and trace as far away from the inductor as possible. Noise that is coupled into the feedback loop can easily make its way into the supply voltage. It is also wise to make the feedback loop trace as wide as possible, but there are board space limitations that will limit the overall width of the trace. If possible, the feedback trace should be run on the other side of the PCB from the inductor and diode with a ground plane between them. For the RSDS™ system, the power supply circuitry can use a small portion of the bottom layer without disturbing the RSDS™ bus.
5. Arrange the components so that the switching current loops curl in the same direction. For a switching regulator, there are two states, the switch is open or the switch is closed. For both of these conditions, there will be current flowing through a loop made by the components. If the loops curl in the same direction, it will help to reduce EMI.
6. Make all the high current traces as short and thick as possible and use as complete of a ground plane as possible.

### +18.0V for Row Driver "on" Voltage

The +18V supply is used by the row drivers to turn on the gate of the flat panel display's thin film transistor (TFT). The current requirements of this supply are low compared to the 3.3V supply and the +9.0V supply. A simple, cost-effective method to generate a +18V supply from the LM2622 is to use capacitor charge pumps.

In Figure 4 below, only the components needed to generate the +18V supply are used. The remaining components (as shown in Figure 3) are not shown. The charge pump works in 2 stages. First, when the switch on the LM2622 is closed, C4 charges to approximately +9.0V. When the switch is open, D2 conducts and the voltage across C5 is +9.0V. Because C5 is referenced to +9.0V node, the voltage is +18V (developed across C6) when referenced to ground. The +18V supply is unregulated, but sufficient to provide the "on" voltage for the row drivers. It is also possible to add an additional capacitor charge pump stage to bring the total generated voltage to +27V. In general, this configuration can provide either a 2x or 3x multiple of the column driver analog output voltage as the row driver "on" voltage.

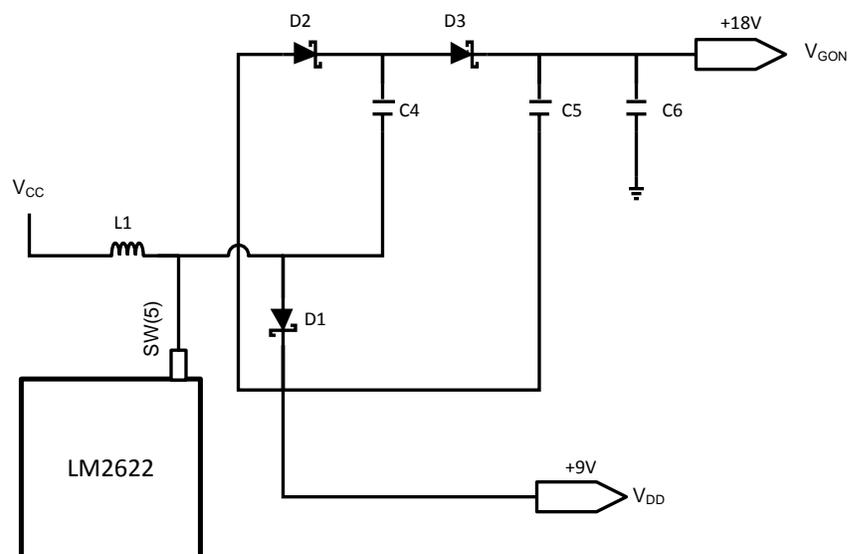


Figure 4. Using the LM2622 to Generate +18.0V DC Unregulated

### -9.0V for Row Driver "off" Voltage

To generate the -9V supply that is used by the row drivers as the off voltage for the TFT gate, the LM2622 can be used in conjunction with a diode inverter circuit as shown in Figure 5. The diode inverter works in the following manner. When the switch of the LM2622 is open, D4 conducts and the voltage across C7 charges to approximately +9.0V. When the switch closes, the voltage on the SW pin is suddenly dropped to GND. Because the voltage across C7 cannot change instantaneously, the voltage between D4 and D5 is -9.0V when referenced to GND. In general, this configuration will generate an unregulated voltage that is equal in magnitude but opposite in sign to the regulated supply.

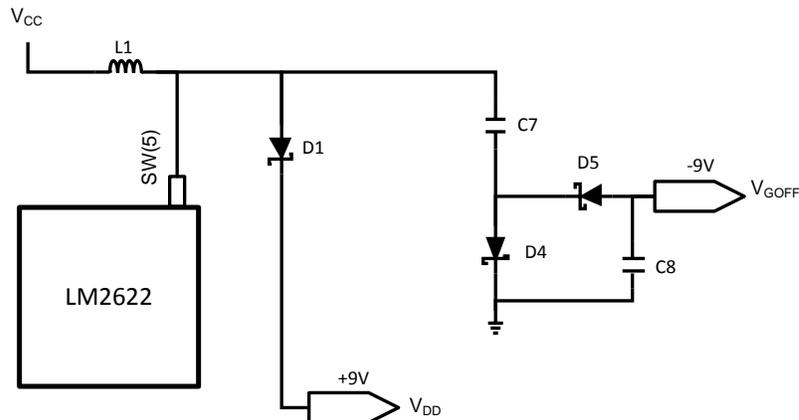


Figure 5. Using the LM2622 to Generate -9.0V DC Unregulated

Figure 6 shows the complete schematic using the LM2622 to generate a +9V regulated supply and +18V and -9V unregulated supplies. Component values and part numbers are recommended wherever possible, and should work in most applications. For further assistance in selecting the component value for your particular application, contact your TI representative.

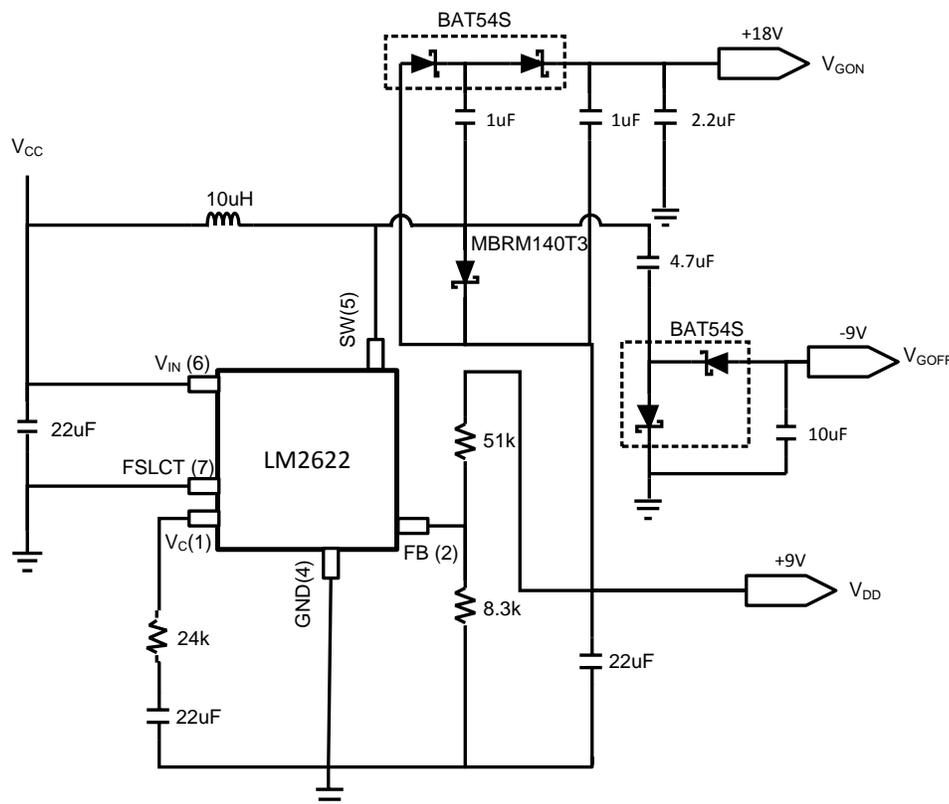


Figure 6. Complete Schematic Using the LM2622 to Generate +9.0V, +18.0V, and -9.0V

### 3 VCOM and Gamma Reference Buffering

#### VCOM

In almost every system, the VCOM voltage must be driven with an external buffer. Due to the high load of the VCOM node, TI recommends using an amplifier such as the LM8272 or equivalent to drive VCOM. For a single chip solution, the LM2702 combines the DC-DC converter of the LM2622 with a VCOM buffer in a single 16-pin package. Contact your local representative for more information.

#### Gamma References

There are a number of options for buffering the gamma reference voltages. In general, they trade off price for performance. Noise and voltage fluctuations on the gamma reference voltages can be directly passed on to the outputs, depending on when the voltage fluctuations occur. This is significant because even fluctuations as small as 20-30mV can be a full gray shade difference. All of the following gamma reference buffer options can be accomplished with TI devices.

##### No Buffering/ Resistor String Only

This is the least expensive and the most susceptible to noise. It is also the most common implementation for XGA and SXGA TN displays. In the end, the cost savings of not using buffer amplifiers may be outweighed by the yield loss due to poor panel performance.

The basic structure of the resistor string only method is shown in Figure 7. Note that the external resistor string defined by resistors R1 through R11 is directly connected to the internal RDAC. In order to accurately define the gamma reference voltages, the resistor string on the column drivers must be taken into consideration. TI's column drivers typically have an internal resistor string totaling 15kΩ for the upper gamma range and an equivalent resistor string for the lower gamma range. This results in about 3.0kΩ-4.0kΩ in parallel with the external resistor string (there are typically 8 or 10 column drivers in parallel). It is also important to recognize that the upper and lower gamma strings are isolated from each other in the column driver. For example, an external resistor connecting GMA5 and GMA6 on the FPD33584 will not have a resistance in parallel due to the column drivers. The column driver datasheet will give the resistance values between each of the gamma reference tap points.

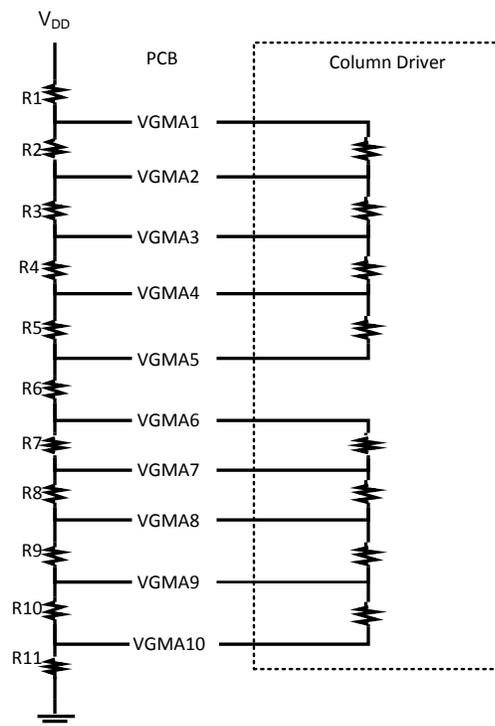


Figure 7. Resistor-String Only Gamma Reference Implementation

##### End Tap Point Buffering

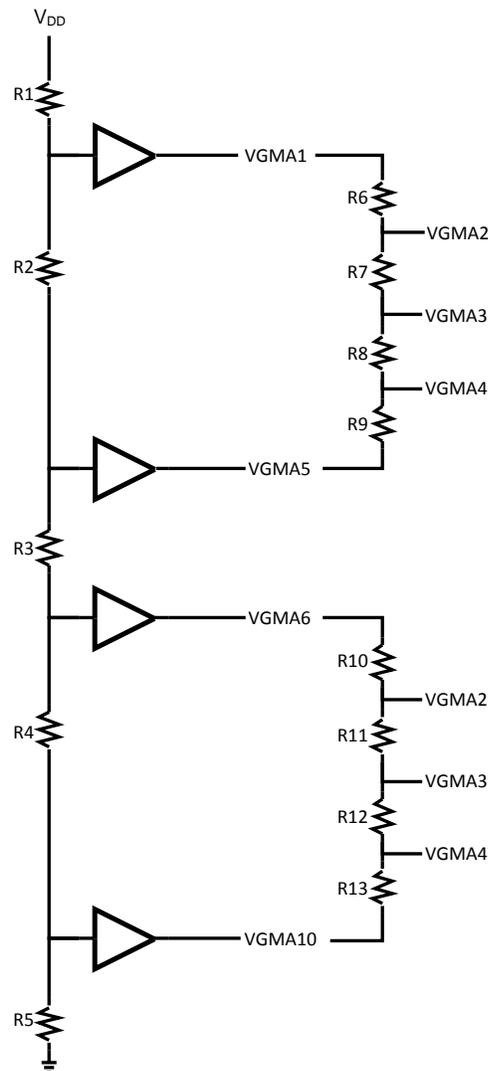
A second option is to only buffer the gamma reference voltages at the ends of the column driver's RDAC. This would include VGMA1, VGMA5, VGMA6, and VGMA10. This will provide a balance of low cost and good performance.

The basic structure of the end tap point buffering scheme is shown in [Figure 8](#). All components in this figure are external to the column driver and all the tap points connect into the same points on the column driver's internal resistor string that they did in [Figure 7](#). The main resistor string made up of R1 through R5 in [Figure 8](#) is completely isolated from the column driver's internal resistor string. It does not have to account for the parallel resistance of the column driver internal RDAC. The resistors that define the intermediate tap points (R6 through R13) are directly connected to the column driver's resistors and must take into account the resistance internal to the column drivers.

A quad, rail-to-rail operational amplifier can be used as a single chip solution for the gamma buffering scheme shown in [Figure 8](#). Texas Instruments provides numerous options that will meet the requirements, such as the LMC6134 and LM6484. Check with your local TI representative for the most updated information on product availability. A rail-to-rail amplifier is needed because the outer tap points (VGMA1 and VGMA10) often come within 200mV of the rail.

It is also possible to use a single rail-to-rail op amp to drive one of the end points and a standard quad op amp to drive the remaining three gamma references. Many quad op amps can drive all the way to the negative rail (TI's LM2902 and LMC6024 are good examples), but cannot drive all the way to the top rail. These op amps are normally much less expensive than rail-to-rail amplifiers, and can reduce the overall cost of the gamma reference buffering scheme at the expense of adding an extra component.. In order to buffer VGMA1, a full rail-to-rail amplifier such as the LMC8101 is needed.

TI also has two single-chip solutions for the DC-DC converter and gamma reference generation. The LM2711 combines the DC-DC converter of the LM2622 with four gamma reference buffers in a single 20-pin package. The LM2710 adds a VCOM buffer to the LM2711. Using the LM2710 or LM2711 will allow system designers to use a single, small package to address their voltage generation and voltage buffering needs..



**Figure 8. End Gamma Reference Buffering Implementation**

### *Full Tap Point Buffering*

The best solution from a performance standpoint is to buffer all the tap points. An example of the full tap point buffering scheme is shown in [Figure 9](#). The advantage of this scheme is that the column driver's resistor string is completely isolated from the resistor string on the PCB. This scheme can be implemented using 3 op amps from Texas Instruments. A dual rail-to-rail op amp can be used to drive VGMA1 and VGMA10 (U1 and U10), and two quad op amps can be used to drive VGMA2 through VGMA9 (U2 through U9). Because only a dual rail-to-rail op amp is required and the op amps with standard range outputs are relatively inexpensive, driving all of the gamma reference voltages can be close to the same cost as driving only the end gamma voltages. Some of the potential TI's semiconductor devices that could be used in this scheme are the LM2902 for the intermediate tap points and the LMC6482 or LM6132 for the rail-to-rail amplifier.

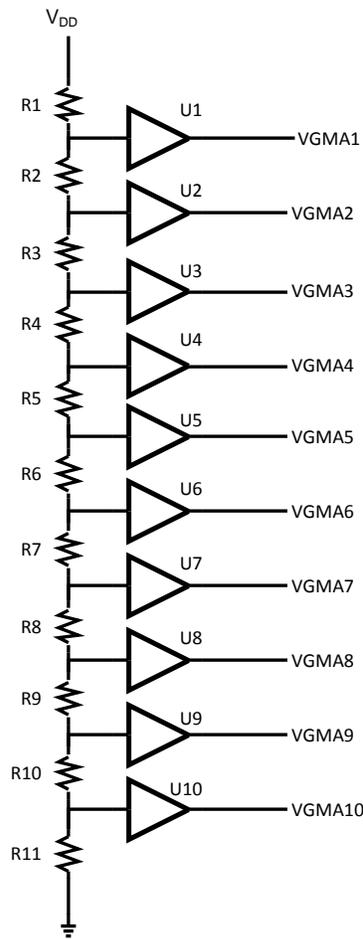


Figure 9. Full Gamma Reference Buffering Implementation

#### 4 Summary

Texas Instruments provides a complete system solution for flat panel displays using Reduced Swing Differential Signaling (RSDS). RSDS will reduce power consumption and EMI compared to traditional TTL based interfaces. It also allows for smaller boards that use less components and save cost. [Figure 10](#) shows a basic system block diagram for a flat panel display. The functional blocks with a bold outline are currently available from Texas Instruments.

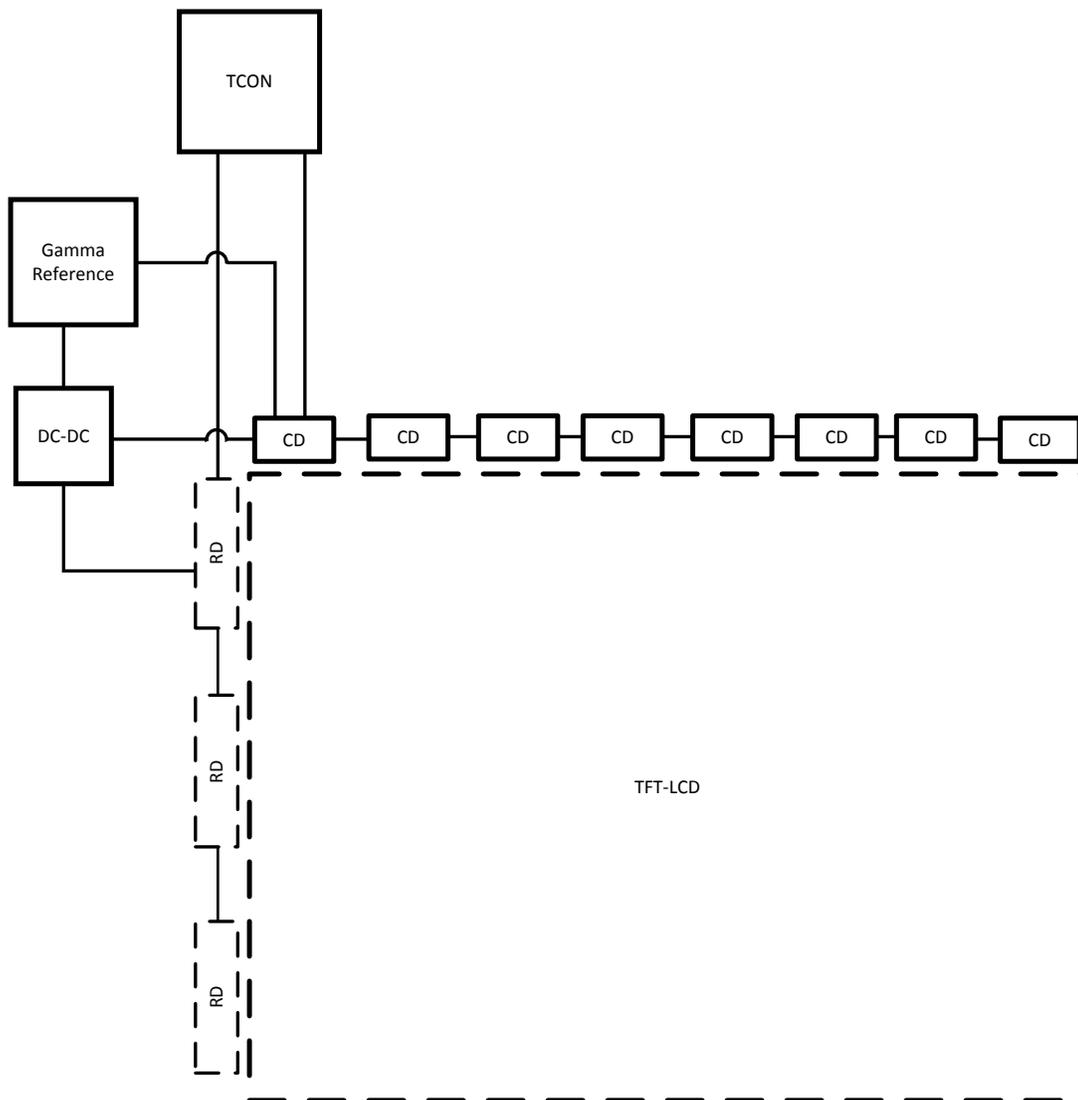


Figure 10. TI Available Components for a TFT-LCD System

## 5 References

*Layout Guidelines for Switching Power Supplies* ([SNVA021](#))

*Introduction to Power Supplies* ([SNVA006](#))

*Linear and Switching Voltage Regulator Fundamentals.*([SNVA559](#))

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