EVALUATION BOARD DATA SHEET

EV183

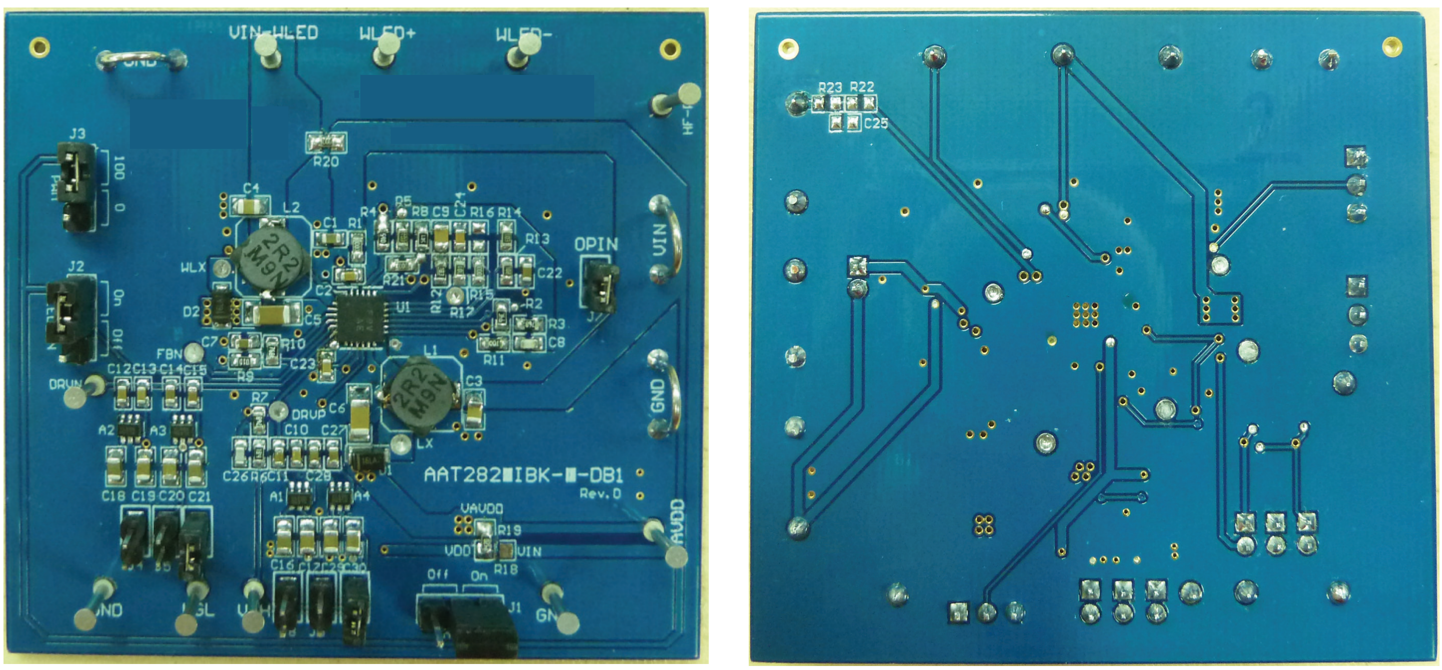
Evaluation Board for the AAT2822/2823/2824/2825 TFT-LCD DC-DC Converter with WLED Driver and VCOM Buffer

Introduction

The AAT282x family (AAT2822, AAT2823, AAT2824, AAT2825) of integrated panel power solutions provides the regulated voltages required by an active-matrix thin-film transistor (TFT) liquid-crystal display (LCD). The AAT282x family includes a boost DC-DC converter for LCD bias up to 14.5V, two charge pumps up to ±30V, a WLED backlight driver up to 28V, and a VCOM buffer in a 4 mm x 4mm TQFN package. The AAT282x have power sequence of VAVDD -> VGH -> VGL. The AAT282x-1 have power sequence of VAVDD -> VGL -> VGH.

This document highlights the use of the AAT282x family evaluation board to demonstrate the functions and performance of the AAT282x power ICs. A brief “Getting Started” section is included to help the user to set up and operate the evaluation board. The board is shown in Figure 1. Figure 2 and Figure 15 depict the board schematic and layout. For additional information, refer to the AAT282x product datasheets.

Board Pictures



(a) Top

(b) Bottom

Figure 1: AAT282xIBK Evaluation Board.

Board Schematic

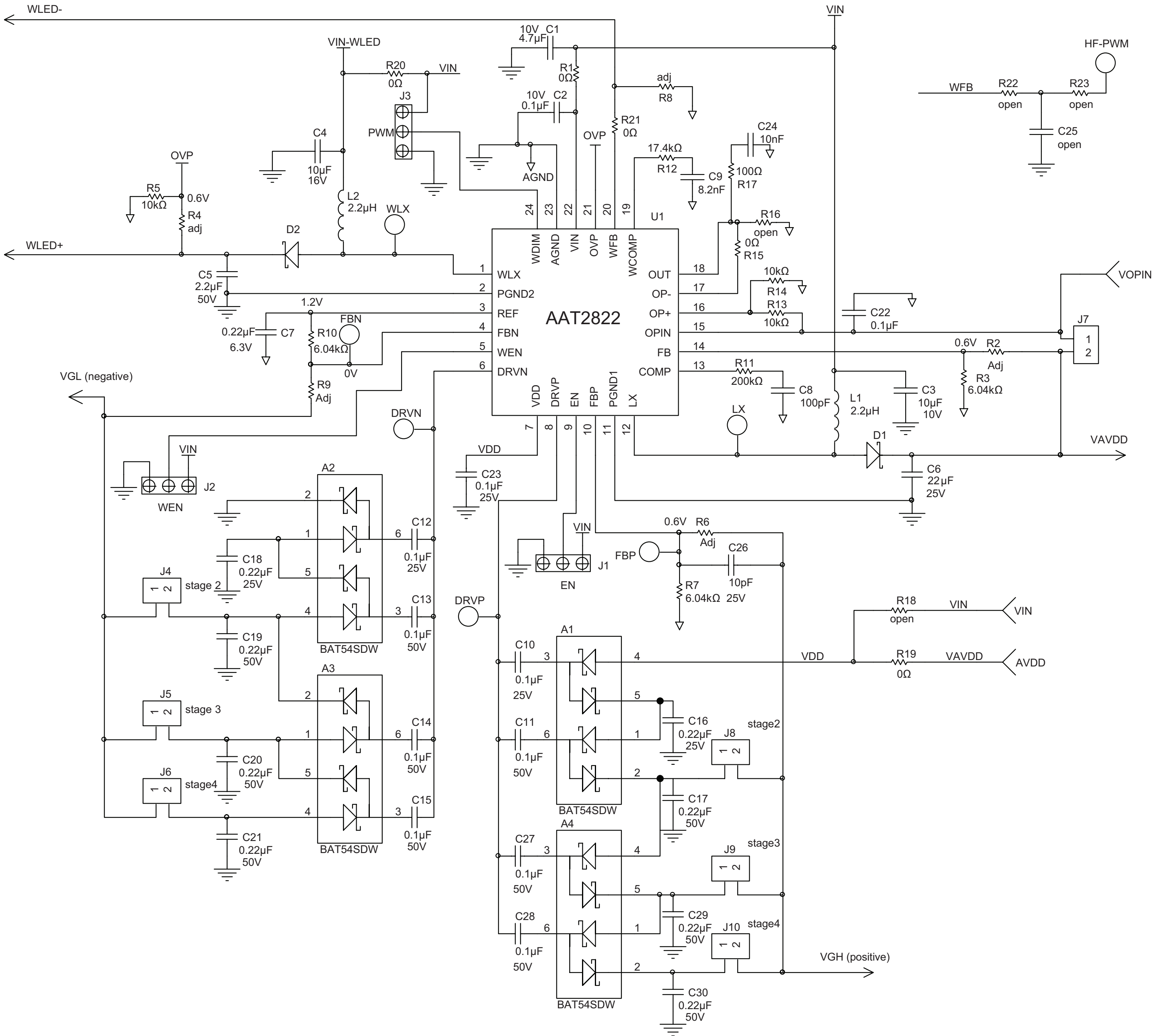


Figure 2: AAT2822IBK Evaluation Board Schematic.

Evaluation Board for the AAT2822/2823/2824/2825 TFT-LCD DC-DC Converter with WLED Driver and VCOM Buffer

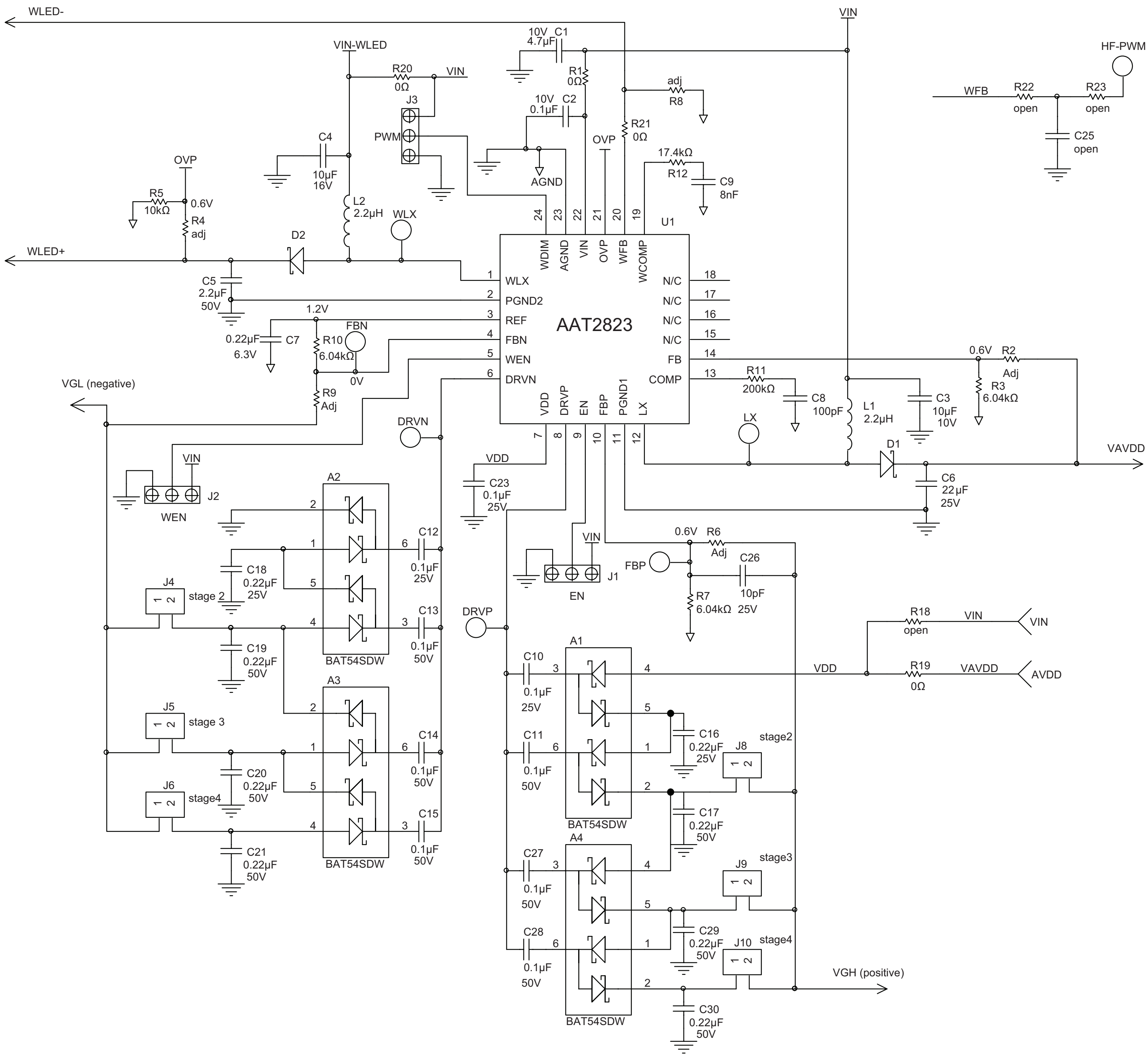


Figure 3: AAT2823IBK Evaluation Board Schematic.

Evaluation Board for the AAT2822/2823/2824/2825
TFT-LCD DC-DC Converter with WLED Driver and VCOM Buffer

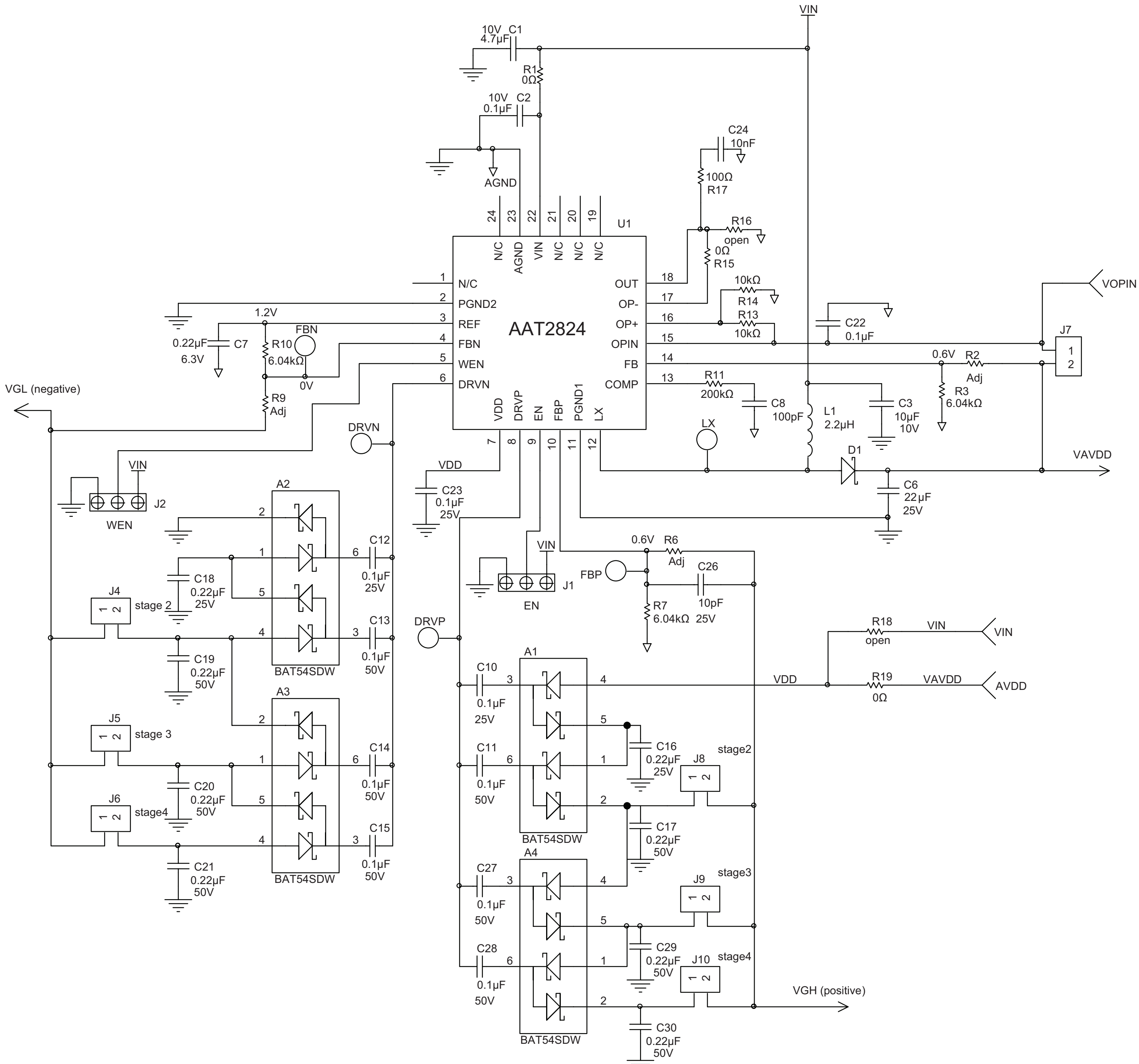


Figure 4: AAT2824IBK Evaluation Board Schematic.

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Evaluation Board for the AAT2822/2823/2824/2825 TFT-LCD DC-DC Converter with WLED Driver and VCOM Buffer

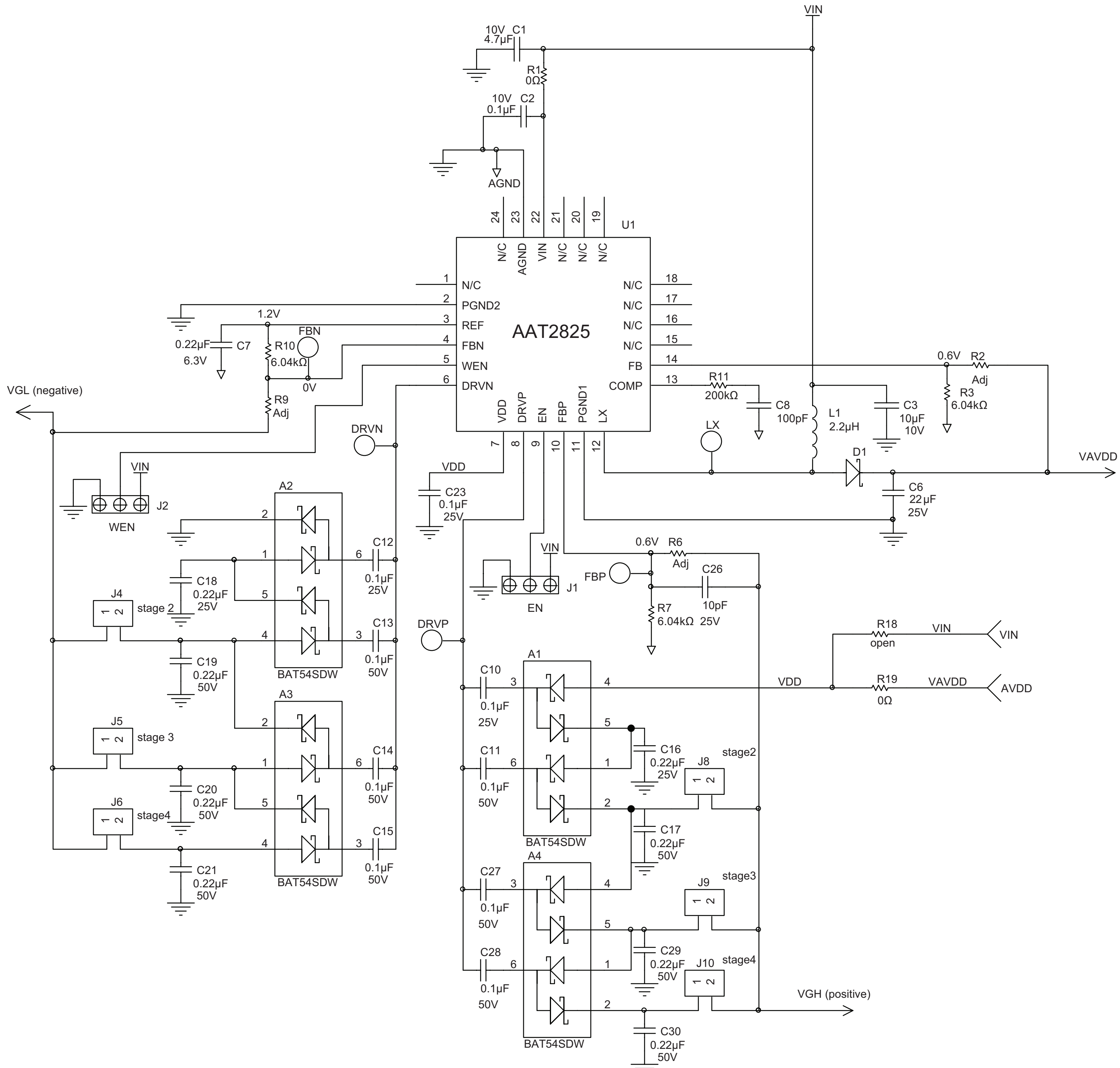


Figure 5: AAT2825IBK Evaluation Board Schematic.

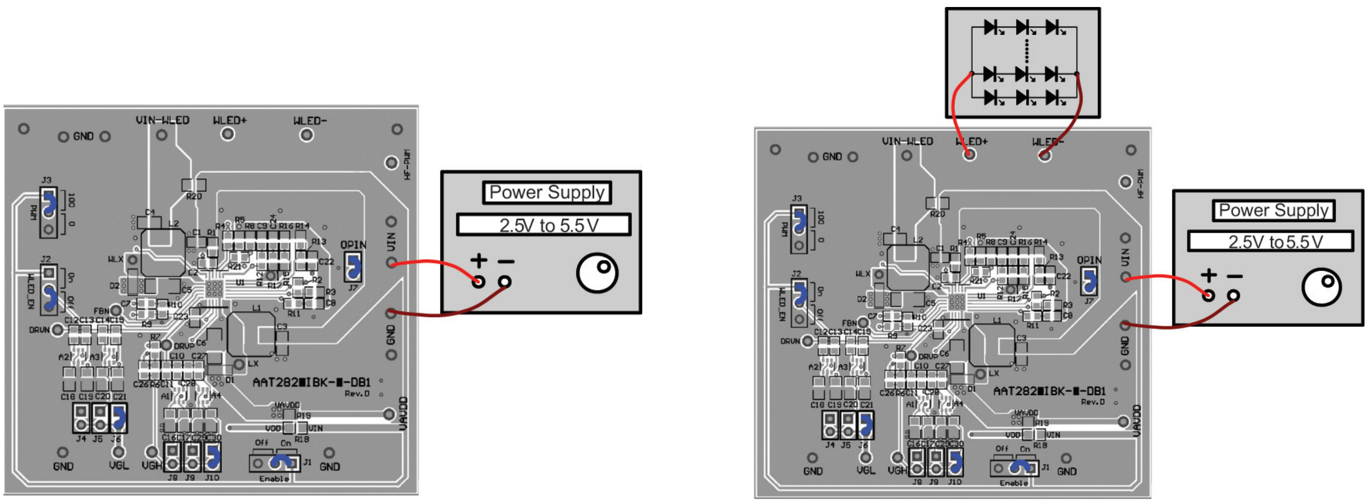
Evaluation Board for the AAT2822/2823/2824/2825 TFT-LCD DC-DC Converter with WLED Driver and VCOM Buffer

Getting Started

Setup

1. Connect an input power source (to supply between 2.5V and 5.5V) between VIN and ground.
2. Connect the jumpers to the positions shown in Figure 6.
3. Place the J2 jumper to the ON position before connecting the external WLED.

To reduce inrush current, do not enable the main boost and the white LED driver concurrently.



(a) Jumper Position when WLED Disabled **b) Jumper Position when WLED Enabled**

Figure 6: AAT282x Evaluation Board Measurement Configuration.

Table 1 shows the jumper functions.

Jumper	Description
J1	Enable the V_{AVDD}, V_{GH}, and V_{GL} channels by setting the jumper EN from OFF to ON position.
J2	Enable the WLED by setting the jumper WEN from OFF to ON position.
J3	LED dimming control input to WDIM. Set to “100” position for maximum brightness and “0” position for shut down. Apply an external PWM signal up to 1 kHz to pin 2 of J3 by removing the jumper and adjust the duty cycle of the PWM signal from 100% to 5%, the LED brightness will change proportionally.
J4, J5, J6	Stage select for V_{GL} channel with one of the three jumpers: J4 for two stages selection; J5 for three and J6 for four. Detail stage selection is discussed in section: “Boost and Dual Charge Pump Output Setting.”
J8, J9, J10	Stage select for V_{GH} channel with one of the three jumpers: J4 for two stages selection; J5 for three and J6 for four. Detail stage selection is discussed in section: “Boost and Dual Charge Pump Output Setting.”
J7	Connect J7 OPIN for using V_{AVDD} as VCOM buffer input voltage (V_{OPIN}). The maximum input bias voltage for the VCOM buffer cannot exceed 13V. To prevent damage to the device when V_{AVDD} is greater than 13V, OPIN should be connected to an external supply to the top pin of J7 by removing the jumper.

Table 1: AAT282x Evaluation Board Jumper Functionality.

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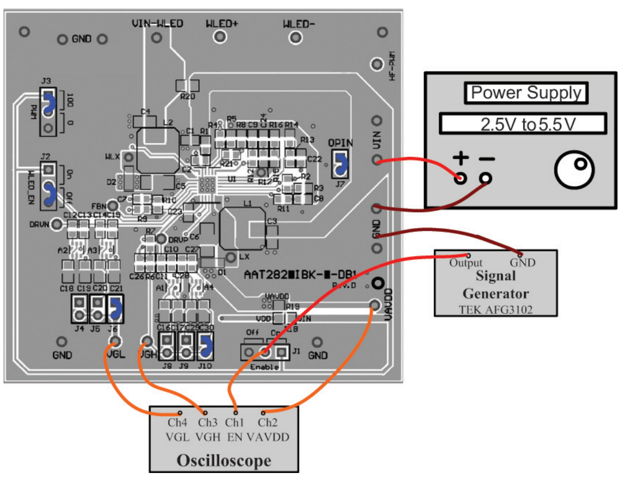
Functional Testing and Evaluation

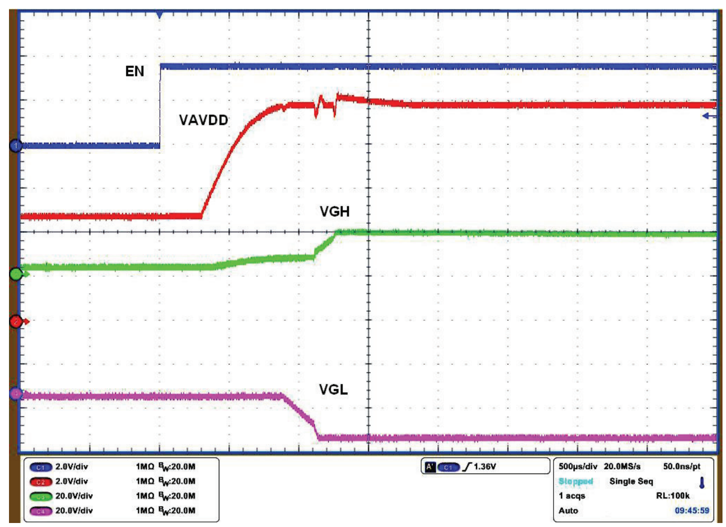
Measurement for Boost and Dual Charge Pumps

The boost of LCD bias and dual charge pumps can be measured by test points of VAVDD, VGH and VGL. The boost output voltage can be set up to 14.5V and the outputs, VGH and VGL, of the two charge pumps can be set up to +30V and -30V by external resistor dividers. For details refer to the section: "Boost and Dual Charge Pumps Output Setting".

Figure 7 shows the configuration and the waveforms for the power up sequencing of the AAT282x-1 boost and the dual charge pumps. A 1Hz pulse signal is fed in to the Enable pin, EN. V_{IN} is 5V, V_{AVDD} is 10V, V_{GH} is 18V, V_{GL} is 20V. The waveform shows the power sequence is V_{AVDD} -> V_{GL} -> V_{GH}.



(a) Measurement Configuration



(b) Waveform of AAT2822-1 Power-up Sequence

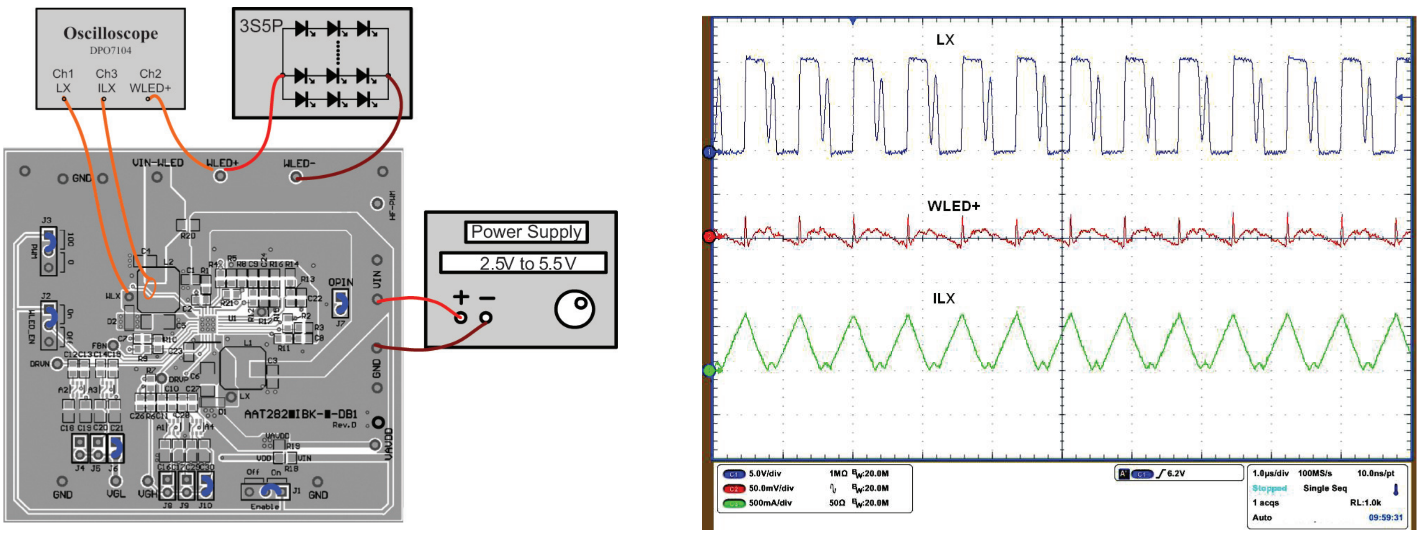
Figure 7: AAT2822 Evaluation Board Boost and Dual Charge Pump Measurement.

Measurement for WLED Backlight Driver

The WLED backlight driver is a step-up DC-DC converter with sense resistor to provide feedback voltage. Its input voltage, V_{DD}, on the board is either V_{AVDD} with R19 set to 0Ω or external V_{IN} with R18 set to 0Ω.

The WLED brightness can be adjusted by either the PWM dimming or the ballast resistor (R8). The PWM signal can be fed in through WDIM pin at pin2 of jumper J3. The ballast resistor is used to set the maximum WLED current. For details refer to the section: "WLED Backlight".

Figure 8 shows the configuration and the measurement waveforms with R8 = 3Ω at 5V V_{IN}. The current for each string is 20mA. In this configuration, 3 series 5 parallels WLEDs (3S5P), the total current is 100mA.



(a) Measurement Configuration **(b) Waveform for WLED 3S5P Configuration**

Figure 8: AAT2822 Evaluation Board Backlight Driver Measurement Operation.

Measurement for LCD VCOM Buffer

The VCOM buffer is designed to drive the voltage on the backplane of an LCD display. The VCOM output voltage is typically set to half of the main boost output (V_{AVDD}). Figure 9 shows the configuration for the measurement. The maximum input bias voltage for the VCOM buffer (V_{OPIN}) cannot exceed 13V. To prevent damage to the device, connect V_{OPIN} to an external supply when V_{AVDD} is greater than 13V and leave the jumper J7 open to disconnect V_{AVDD} from V_{OPIN}.

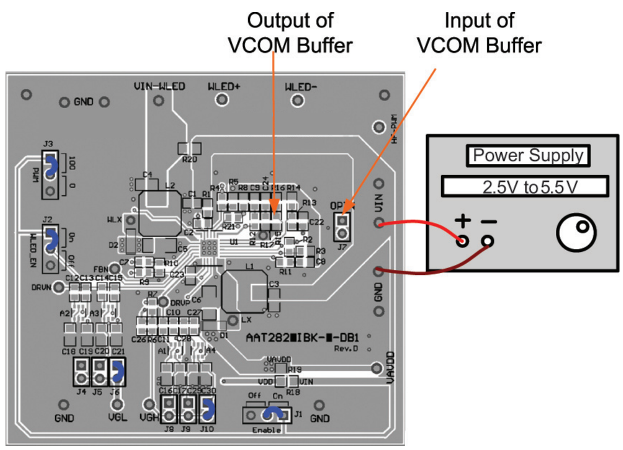


Figure 9: AAT282x Evaluation Board: Measurement Configuration for VCOM Buffer Output.

Boost and Dual Charge Pump Output Setting

The output voltage V_{AVDD} of the LCD bias boost is set by external resistor divider R2 and R3. The dual charge pumps output voltages are determined by both resistor divider and charge pump stages. Table 2 shows the resistor divider selection equation and table 3 shows the charge pump stage selection equation.

Output Channel	Output Range	Equation For Adjustable Resistor
V_{AVDD}	V_{IN} - V_{DIODE} to 14.5V	$R2 = R3 \cdot \left(\frac{V_{AVDD}}{V_{FB}} - 1\right) = R3 \cdot \left(\frac{V_{AVDD}}{0.6V} - 1\right)$ **Eq.1**
V_{GL}	VDD to 30V	$R9 = \frac{V_{GL}}{V_{REF}} \cdot R10 = \frac{V_{GL}}{1.2V} \cdot R10$ **Eq.2**
V_{GH}	-VDD to -30V	$R6 = R7 \cdot \left(\frac{V_{GH}}{V_{FBP}} - 1\right) = R7 \cdot \left(\frac{V_{GH}}{0.6V} - 1\right)$ **Eq.3**

Table 2: Resistor Divider Equations for Boost and Dual Charge Pumps.

Charge Pump	Equation For Stage Selection	
V_{GL}	$n_N = \frac{V_{GL}}{2V_F - V_{AVDD(MIN)}}$	**Eq.4**
V_{GH}	$n_P = \frac{V_{GH} - V_{AVDD(MIN)}}{V_{AVDD(MIN)} - 2V_F}$	**Eq.5**

Table 3: Charge Pump Stage Selection Equations.

For example, if V_{AVDD} = 5V, V_{GH} = 18V and the forward voltage of the Schottky diode V_F is 0.31V.

$$n_P = \frac{18 - 5}{5 - 2 \cdot 0.31} = 2.97$$

So, to set V_{GH} to 18V, three stages need to be used (J5 must be connected and J4, J6 left open).

WLED Backlight

WLED brightness can be adjusted either by setting the ballast resistor for max WLED current or by varying the duty cycle of the PWM signal.

Ballast Resistor Selection

The white LED driver can be enabled by setting J2 from OFF to ON position. The backlight current is set by an external ballast resistor (R8) up to a maximum of 260mA at 12V or 50mA at 28V. The AAT282x can drive from 3 WLEDs up to a maximum of 7 WLEDs in series. The number of WLEDs depends on the LCD panel size. Table 4 gives some examples of different LCD panel size and corresponding WLED configurations. The brightness of the white LED can be controlled by a PWM signal. By connecting a 1 kHz PWM signal to the WDIM pin and adjusting the duty cycle of the PWM signal from 100% to 5%, the brightness of the LED will change proportionally. The higher frequencies are achieved by filtered PWM and the value of R21, R22, R23, C25 should be calculated. See AAT2282 datasheet for more details.

The equation for calculating OVP adjustable resistor (R4) is:

$$R4 = R5 \cdot \left(\frac{V_{LED(MAX)}}{V_{OVP}} - 1\right) = R5 \cdot \left(\frac{V_{LED(MAX)}}{0.6V} - 1\right)$$

where

$V_{LED(MAX)}$ equals the forward voltage of the WLED series plus 0.3V V_{WFB}.

The equation for the number of series-connected LEDs is given by:

$$N = \left(\frac{V_{OVP(MIN)} - V_{WFB(MAX)}}{V_{FLED(MAX)}}\right) = \left(\frac{V_{OVP(MIN)} - 0.3V}{3.5V}\right)$$

So, for example, when $V_{OVP(MIN)}$ = 28V, $V_{WFB(MAX)}$ = 0.3V, and $V_{FLED(MAX)}$ = 3.5V

$$N = \left(\frac{28V - 0.6V}{3.5V}\right) = 7.8 \text{ LEDs}$$

The maximum number of WLEDs in series for the given V_{OVP} output range is, therefore, seven.

The equation for calculating ballast resistor (R8) is:

$$R8 = \frac{V_{WFB(MAX)}}{I_{LED(MAX)}} = \frac{0.3V}{I_{LED(MAX)}}$$

For example, for a 10-inch panel with 3 series and 13 parallel (3S13P) string configuration and the maximum current in each string being 20mA:

$$R8 = \frac{0.3V}{13 \cdot 20mA} = 1.15\Omega$$

WLED Matrix (Series and Parallel)	Maximum I_{LED} Current (mA)	Ballast Resistor R8 (Ω)	WLED Matrix (Series and Parallel)	Maximum I_{LED} Current (mA)	Ballast Resistor R8 (Ω)
3S5P	5	12.0	3S13P	5	4.62
	10	6.0		10	2.31
	15	4.0		15	1.54
	20	3.0		20	1.15
	25	2.4		25	0.92
	30	2.0		30	0.77

Table 4: Ballast Resistor Selection.

Maximum WLED Output Current

Maximum WLED output current is determined by both WLED driver input voltage V_{IN_WLED} and WLED string voltage V_{LED}. Figure 10 shows the relationship of the three factors.

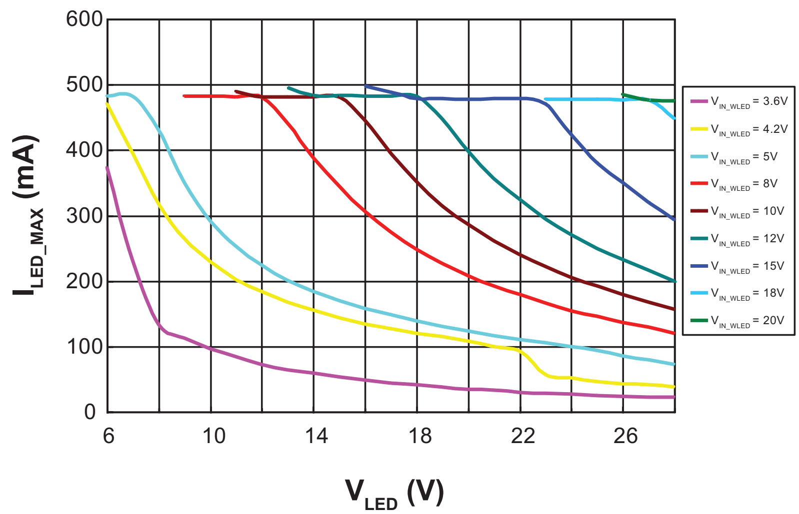


Figure 10: WLED Driver Maximum Output Current for different V_{LED} Voltage.

PWM Dimming

The brightness of the white LED can be controlled using a PWM signal. By connecting a 1 kHz PWM signal to pin 2 of jumper J3 and adjusting the duty cycle of the PWM signal from 5% to 100%, the brightness of the LED will change proportionally. Figure 11 shows the variation of ILED with the PWM duty cycle.

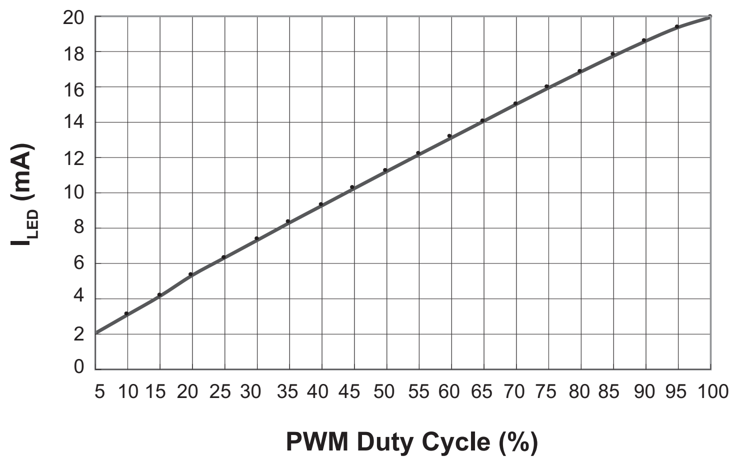


Figure 11: 1kHz PWM control (V_{IN} = 5V, $I_{LED(MAX)}$ is set to 20mA).

For applications requiring a PWM frequency higher than 1kHz, an external filter PWM is connected to the WFB pin to control the dimming of the white LED. Connect the PWM signal from "HF-PWM" test point and connect WDIM Pin to VIN. Figure 12 shows a low path filter used in the high frequency PWM control application. In this method, the LED dimming has relationship with both PWM high voltage level and duty cycle.

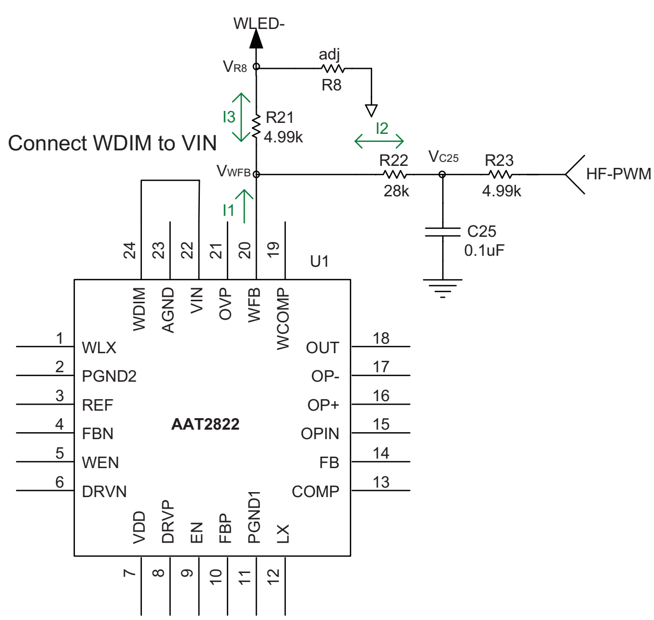


Figure 12: Low-Pass Filter PWM Dimming Control.

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When the PWM duty cycle is adjusted, the average voltage on C25(V_{C25}) will change. Because the V_{WFB} is fixed at 0.3V, so I2 and I3 will change. The changed I3 will adjust the voltage drop, V_{DROP}, across R21. The voltage across resistor R8, V_{R8}, changes, leading to the change of the white LED current. Figure 13 shows PWM control by changing the PWM duty cycle with 2.4V high level and 0V low level. Figure 14 shows PWM control by varying the PWM high level with 50% fixed duty cycle.

The following example illustrates the calculations for I_{LED} in a 3S5P matrix where the PWM high level voltage is 1.2V, the frequency is 10kHz the duty cycle is 50%, and R8 = 3Ω.

$$I3 = I1 + I2 = 0 + \frac{\frac{1.2}{2} - 0.3}{28k\Omega} = 0.01mA$$

$$V_{R8} = V_{WFB} - I3 \cdot R21 = 0.3 - 0.01mA \cdot 4.99k\Omega = 0.2501V$$

$$I_{LED} = \frac{V_{R8}}{R8} = \frac{0.2501}{3} = 83mA \text{ (Total current in 5 parallel strings)}$$

Note: If the voltage in C25 is lower than V_{WFB}, the current direction will reverse and I3 will equal I1 - I2. This will cause V_{R8} to be pulled up and decrease I_{LED}.

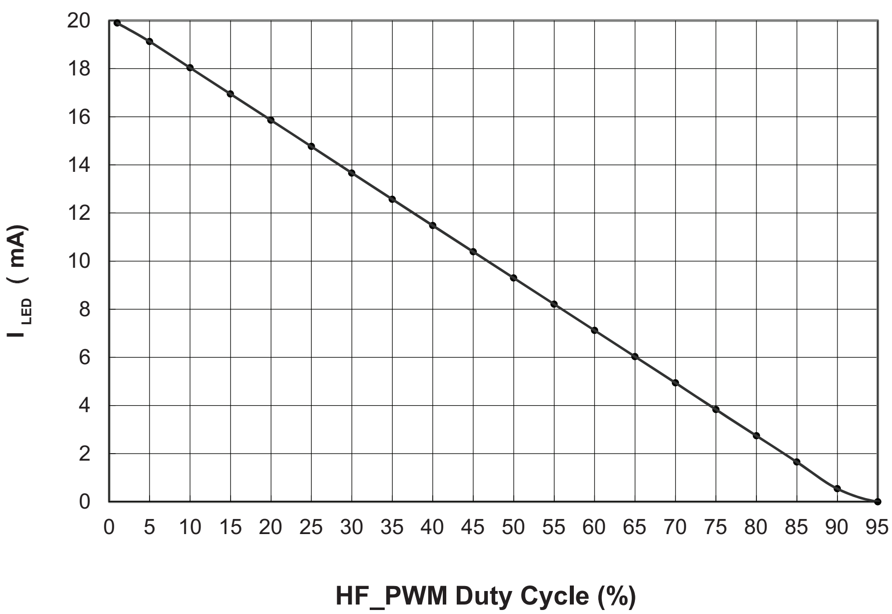


Figure 13: 10kHz High Frequency PWM Control by PWM Duty Cycle (V_{IN} = 5V, $I_{LED(MAX)}$ = 20mA).

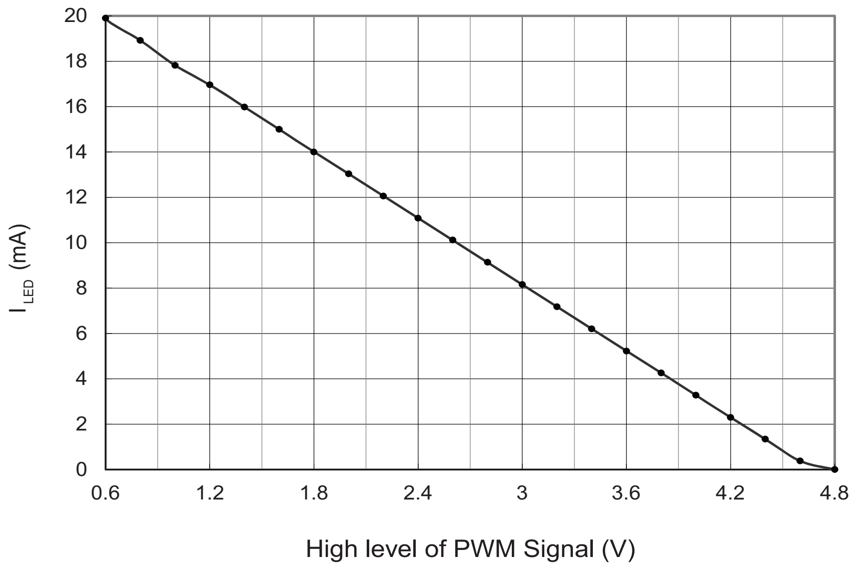
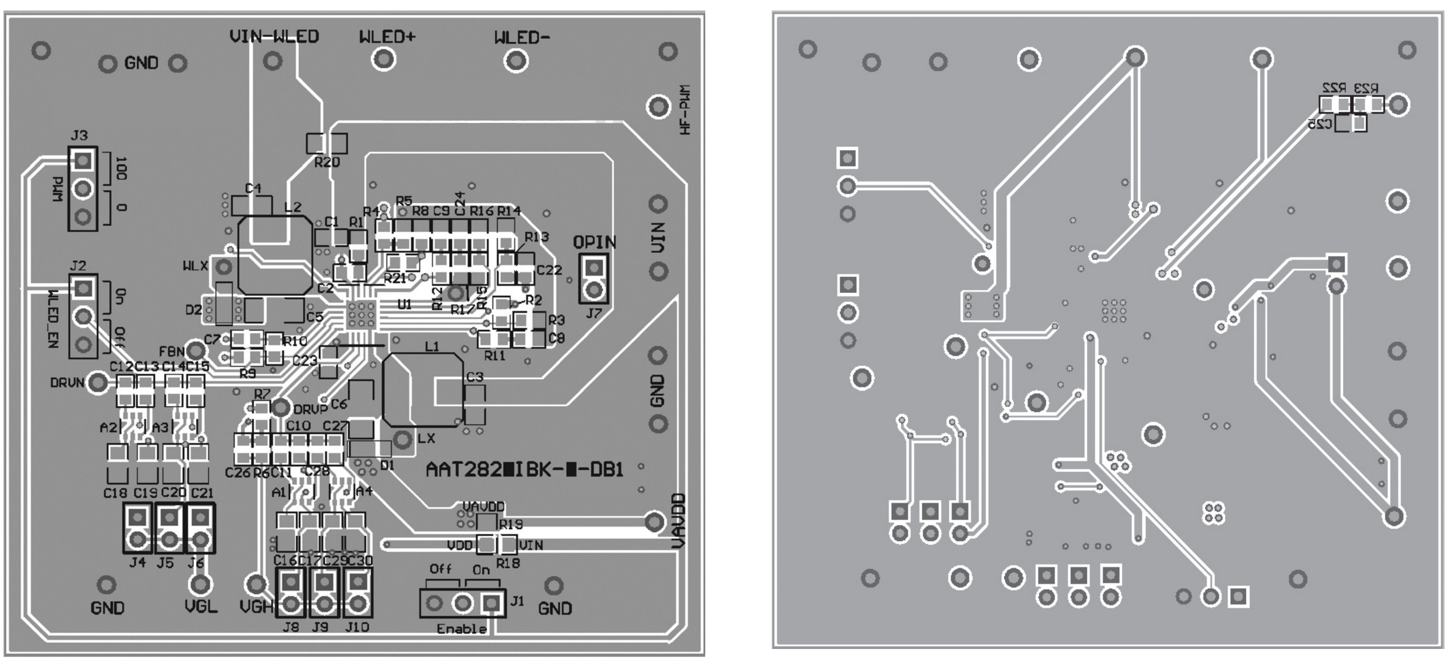


Figure 14: 10kHz High Frequency PWM Control by PWM High Level Voltage (V_{IN} = 5V, $I_{LED(MAX)}$ = 20mA).

Printed Circuit Board



(a) Top Layer **(b) Bottom Layer**

Figure 15: AAT282xIBK Evaluation Board.

Layout Guidelines

Use the following guidelines to ensure proper operation of the AAT282x:

1. Minimize the distance from the input capacitor negative terminal to the GND pins.
2. Maintain a ground plane and connect to the IC GND pin(s) as well as the GND connections of CIN and COUT.
3. Connect PGND and AGND as close as possible to the package and maximize the heat sinking space for overall performance.
4. To maximize package thermal dissipation and power handling capacity of the TQFN44-24 package, solder the exposed paddle of the IC onto the thermal landing of the PCB, where the thermal landing is connected to the ground plane.

AAT282x EVAL Board Component Listing

Component	Part Number	Description	Manufacturer
U1	AAT2822/3/4/5IBK	TFT-LCD DC-DC Converter with WLED Driver and VCOM Buffer	Skyworks
C1	GRM188R61A475K	CAP CERAMIC 4.7µF 0603 X5R 10V 10%	Murata
C2	GRM188R71C104K	CAP CERAMIC 0.1µF 0603 X7R 16V 10%	
C3, C4	GRM21BR61C106K	CAP CERAMIC 10µF 0805 X5R 16V 10%	
C5	GRM31CR71H225K	CAP CERAMIC 2.2µF 1206 X7R 50V 10%	
C6	GRM31CR61E226M	CAP CERAMIC 22µF 1206 X5R 25V 20%	
C7	GRM188R71A224K	CAP CERAMIC 0.22µF 0603 X7R 10V10%	
C8	GRM1885C1H101J	CAP CERAMIC 100pF 0603 COG 50V 5%	
C9	GRM2195C1H822J	CAP CERAMIC 8.2nF 0805 X7R 50V 10%	
C10, C12, C22, C23	GRM188R61E104K	CAP CERAMIC 0.1µF 0603 X5R 25V 10%	
C11, C13, C14, C15, C27, C28	GRM188R71H104K	CAP CERAMIC 0.1µF 0603 X7R 50V 10%	
C16, C18	GRM188R61E224K	CAP CERAMIC 0.22µF 0603 X5R 25V10%	
C17, C19, C20, C21, C29, C30	GRM21BR71H224K	CAP CERAMIC 0.22µF 0805 X7R 50V10%	
C24	GRM188R71H103K	CAP CERAMIC 10nF 0603 X7R 50V 10%	
C25	NC		
C26	GRM1885C1H100J	CAP CERAMIC 10pF 0603 COG 50V 5%	
A1, A2, A3, A4	BAT54SDW-7-F	Schottky Diode Array 30V SC70-6	Diode Inc
D1, D2	SS16L	Schottky Diode 1A 60V Micro SMP	Taiwan Semiconductor
L1, L2	CDRH5D16-2R2	POWER INDUCTOR 2.2µH 3.0A SMD	Sumida
R2, R4, R6, R8, R9		Adjustable Value (See Equations 1 – 5 and Table 4); 0603 SMD	Yageo
R3, R7, R10	RC0603FR-076K04L	Res 6.04kΩ 1/10W 1% 0603 SMD	
R5, R13, R14	RC0603FR-0710KL	Res 10kΩ 1/10W 1% 0603 SMD	
R11	RC0603FR-07200KL	Res 200kΩ 1/10W 1% 0603 SMD	
R12	RC0603FR-0717K4L	Res 17.4kΩ 1/10W 1% 0603 SMD	
R15, R19, R20, R21	RC0603FR-070RL	Res 0Ω 1/10W 1% 0603 SMD	
R17	RC0603FR-07100RL	Res 100Ω 1/10W 1% 0603 SMD	
R16, R18, R22, R23, R25	Not Populated		

Table 5: AAT2822 Evaluation Board Bill of Materials.