9-Channel Level Shifter With Gate Voltage Shaping and Discharge Functions

FEATURES

- **9-Channel Level Shifter Supports 6 × CLK, VST, ODD, and EVEN Signals**
- **Organized as Two Groups of 7 + 2 Channels**
- **Separate Positive Supplies (V_{GHX}) for Each Group**
- **V_{GHX} Levels up to 38V**
- **V_{GL} Levels Down to –13V**
- **Panel DISCHARGE Function**
- **Suitable for 4-Phase and 6-Phase Applications**
- **Gate Voltage Shaping on Channels 1 to 6**
- **Supports Single and Multiple Flicker Clocks**
- **Peak Output Currents greater than 500mA**
- **28-Pin 5×5 mm QFN Package**

APPLICATIONS

- **LCD Displays Using Gate-in-Panel (GIP) Technology**

DESCRIPTION

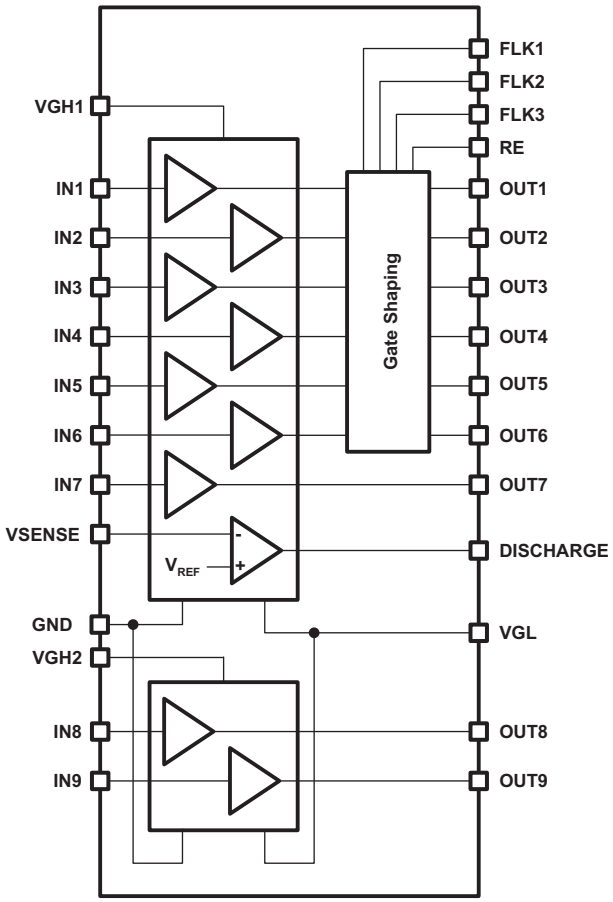
The TPS65192 is a 9 channel level-shifter intended for use in LCD display applications such as TVs and monitors. The device converts the logic-level signals generated by the Timing Controller (T-CON) to the high-level signals used by the display panel.

The 9 level shifter channels are organized as two groups. Channels 1 through 7 are powered from V_{GH1} and V_{GL}, and channels 8 and 9 are powered from V_{GH2} and V_{GL}. Each level-shifter channel features low impedance output stages that achieve fast rise and fall times even when driving the capacitive loading typically present in LCD display applications.

Level shifter channels 1 through 6 support gate voltage shaping, which can be used to improve picture quality by reducing image sticking. Novel decoding logic enables a single flicker clock signal to control gate voltage shaping for all CLK channels without the need for synchronization. The device also supports the use of multiple flicker clocks. The rate of decay is set by an external resistor or resistor network connected to the RE pin.

A tenth level shifter channel specially configured with a comparator input stage allows designers to implement panel discharging during power-down.

BLOCK DIAGRAM



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These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

ORDERING INFORMATION(1)

T_A	ORDERING	PACKAGE	PACKAGE MARKING
–40°C to 85°C	TPS65192RHDR	28-Pin QFN	TPS65192

(1) The device is supplied taped and reeled, with 3000 devices per reel.

ABSOLUTE MAXIMUM RATINGS

over operating free-air temperature range (unless otherwise noted)(1)

		VALUE	UNIT
Supply voltage (2)	VGH1, VGH2	–0.3 to 45	V
	VGL	0.3 to –15	V
Input voltage(2)	IN1 through IN9, VSENSE, FLK1, FLK2, FLK3	–0.3 to 7.0	V
	RE	–0.3 to 45	V
Output current	RE	0.1	A
ESD rating	HBM	2	kV
	MM	200	V
	CDM	700	V
Continuous power dissipation		See Dissipation Rating Table	
Operating ambient temperature range		–40 to 85	°C
Operating junction temperature range		–40 to 150	°C
Storage temperature range		–65 to 150	°C
Lead temperature (soldering, 10 sec)		300	°C

(1) Stresses beyond those listed under *absolute maximum ratings* may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under *recommended operating conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values are with respect to the GND pin.

DISSIPATION RATINGS

PACKAGE	θ_{JA}	$T_A \leq 25°C$ POWER RATING	$T_A = 70°C$ POWER RATING	$T_A = 85°C$ POWER RATING
28-Pin QFN(1)	35°C/W	3.57W	2.29W	1.86W

(1) This data is based on using a JEDEC High-K board with the exposed die pad connected to a Cu pad on the board connected to the ground plane by a 2x3 thermal via matrix.

RECOMMENDED OPERATING CONDITIONS

		MIN	TYP	MAX	UNIT
V_{GH1}, V_{GH2}	Positive supply voltage range	12	30	38	V
V_{GL}	Negative supply voltage range	–13	–7	–2	V
T_A	Operating ambient temperature	–40		85	°C
T_J	Operating junction temperature	–40		125	°C

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ELECTRICAL CHARACTERISTICS

V_{GH1} = V_{GH2} = 30V; V_{GL} = –7 V; T_A = –40°C to 85°C; typical values are at 25°C (unless otherwise noted).

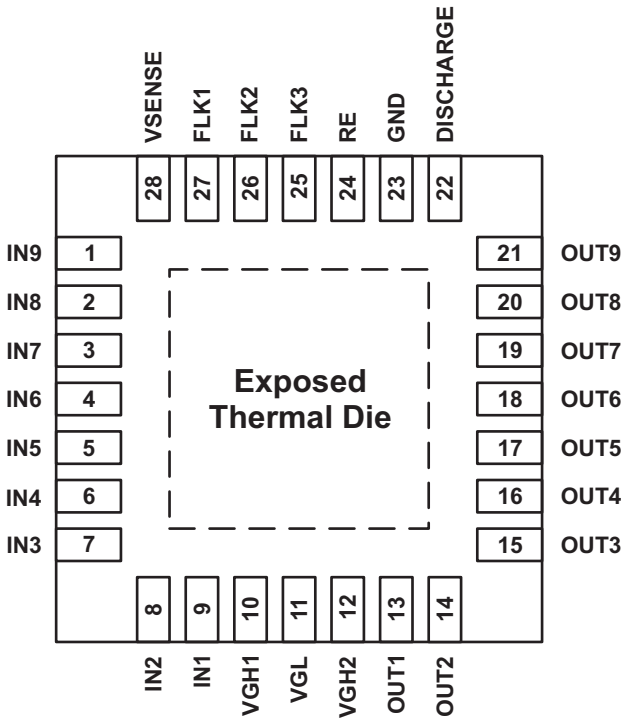
PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER SUPPLY						
I_{GH1}	V_{GH1} Supply current	IN1 to IN7 = GND; V_{SENSE} = 0V		0.35	3	mA
I_{GH2}	V_{GH2} Supply current	IN8 and IN9 = GND; V_{SENSE} =0V		0.012	1	mA
I_{GL}	V_{GL} Supply current	IN1 to IN9 = GND; V_{SENSE} = 0V		0.144	4	mA
V_{UVLO}	Undervoltage lockout threshold	V_{GH1} rising	10.5		13.5	V
V_{HYS}	Undervoltage lockout hysteresis	V_{GH1} falling		450		mV
LEVEL SHIFTERS						
I_{OUTX}	Output current	Continuous; OUT1 to OUT7	±15			mA
		Peak; OUT1 to OUT7	±300	±650		
		Continuous; OUT8 and OUT9, DISCHARGE	±15			mA
		Peak; OUT8 an OUT9, DISCHARGE	±150	±250		
I_{INX}	Input current	IN1 to IN9 = GND			±1	µA
		IN1 to IN9 = 3.3 V			±1	
V_{IH}	High level input voltage	IN1 to IN9			2.0	V
V_{IL}	Low level input voltage	IN1 to IN9	0.5			V
V_{DROPH}	Output voltage drop high	OUT1 to OUT7; I_{LOAD} = 10 mA		0.12	0.4	V
		OUT8 and OUT9, DISCHARGE; I_{LOAD} = 10 mA		0.36	1.0	
V_{DROPL}	Output voltage drop low	OUT1 to OUT7; I_{LOAD} = –10 mA		0.07	0.3	V
		OUT8 and OUT9, DISCHARGE; I_{LOAD} = –10 mA		0.17	1.0	
t_R	Rise time	OUT1 to OUT7; C_{LOAD} = 4.7 nF(1)		275	520	ns
		OUT8 and OUT9; C_{LOAD} = 4.7 nF(1)		761	1000	
t_F	Fall time	OUT1 to OUT7; C_{LOAD} = 4.7nF(1)		220	370	ns
		OUT8 and OUT9; C_{LOAD} = 4.7 nF(1)		526	850	
t_{PH}	Propagation delay	Rising edge, C_L = 150 pF			60	ns
t_{PL}		Falling edge, C_L = 150 pF			60	
GATE VOLTAGE SHAPING						
t_{PH}	Propagation delay – gate voltage shaping enabled	FLK falling			100	ns
t_{SU}	Set-up time	Time active IN signals must be stable before falling edge of FLK			70	ns
$r_{DS(on)}$	Resistance between OUT and RE pins			70	100	Ω
I_{LEAK}	Leakage current from RE pin				±10	µA
DISCHARGE						
V_{SENSE}	Discharge voltage sense threshold	V_{SENSE} falling	1.275	1.5	1.725	V
I_{SENSE}	Discharge voltage sense input current	V_{SENSE} = 2V			±1	µA
V_{HYS}	Discharge voltage sense hysteresis	V_{SENSE} rising		40		mV

(1) Rise and fall times are measured between 10% and 90% of the waveform's amplitude.

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DEVICE INFORMATION

PIN ASSIGNMENT



PIN FUNCTIONS

PIN		I/O	DESCRIPTION
NAME	NO.		
IN9	1	I	Level shifter channel 9 input. Connect this pin to GND, if not used.
IN8	2	I	Level shifter channel 8 input. Connect this pin to GND, if not used.
IN7	3	I	Level shifter channel 7 input. Connect this pin to GND, if not used.
IN6	4	I	Level shifter channel 6 input. Connect this pin to GND, if not used.
IN5	5	I	Level shifter channel 5 input. Connect this pin to GND, if not used.
IN4	6	I	Level shifter channel 4 input. Connect this pin to GND, if not used.
IN3	7	I	Level shifter channel 3 input. Connect this pin to GND, if not used.
IN2	8	I	Level shifter channel 2 input. Connect this pin to GND, if not used.
IN1	9	I	Level shifter channel 1 input. Connect this pin to GND, if not used.
VGH1	10	P	Positive supply voltage for level shifter channels 1 through 7 and discharge function. Bypass this pin with a parallel combination of 10µF and 100nF ceramic capacitors.
VGL	11	P	Negative supply voltage. Bypass this pin with a parallel combination of 10µF and 100nF ceramic capacitors.
VGH2	12	P	Positive supply voltage for level shifter channels 8 and 9. Bypass this pin with a parallel combination of 10µF and 100nF ceramic capacitors.
OUT1	13	O	Level shifter channel 1 output. Leave this pin floating, if not used.
OUT2	14	O	Level shifter channel 2 output. Leave this pin floating, if not used.
OUT3	15	O	Level shifter channel 3 output. Leave this pin floating, if not used.
OUT4	16	O	Level shifter channel 4 output. Leave this pin floating, if not used.
OUT5	17	O	Level shifter channel 5 output. Leave this pin floating, if not used.
OUT6	18	O	Level shifter channel 6 output. Leave this pin floating, if not used.
OUT7	19	O	Level shifter channel 7 output. Leave this pin floating, if not used.

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PIN FUNCTIONS (continued)

PIN		I/O	DESCRIPTION
NAME	NO.		
OUT8	20	O	Level shifter channel 8 output. Leave this pin floating, if not used.
OUT9	21	O	Level shifter channel 9 output. Leave this pin floating, if not used.
DISCHARGE	22	O	Panel discharge output. Leave this pin floating, if not used.
GND	23	P	Ground.
RE	24	O	Gate voltage shaping discharge resistor connection. Leave this pin floating, if not used.
FLK3	25	I	Gate voltage shaping flicker clock input for channels 3 and 6. Connect this pin to GND if not used.
FLK2	26	I	Gate voltage shaping flicker clock input for channels 2 and 5. Connect this pin to GND if not used.
FLK1	27	I	Gate voltage shaping flicker clock input for channels 1 and 4. Connect this pin to GND if not used.
VSENSE	28	I	Panel discharge voltage sense. Connect this pin to GND, if not used.
Exposed Thermal Die	Pad	P	Connect to VGL

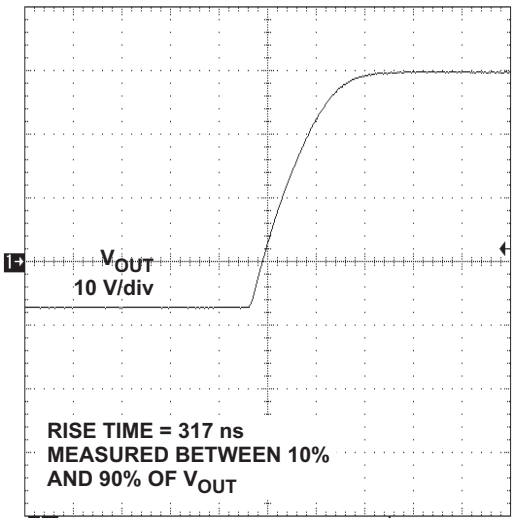
TYPICAL CHARACTERISTICS

TABLE OF GRAPHS

		FIGURE
Output Rise and Fall Time	Channels 1 to 7, C_L = 4.7 nF, rising edge	Figure 1
	Channels 1 to 7, C_L = 4.7 nF, falling edge	Figure 2
	Channels 8 to 9, C_L = 4.7 nF, rising edge	Figure 3
	Channels 8 to 9, C_L = 4.7 nF, falling edge	Figure 4
	Channels 1 to 7, C_L = 8 pF, rising edge	Figure 5
	Channels 1 to 7, C_L = 8 pF, falling edge	Figure 6
	Channels 8 to 9, C_L = 8 pF, rising edge	Figure 7
	Channels 8 to 9, C_L = 8 pF, falling edge	Figure 8
Propagation Delay	IN to OUT, channels 1 to 7, C_L = 150 pF, rising edge	Figure 9
	IN to OUT, channels 1 to 7, C_L = 150 pF, falling edge	Figure 10
	IN to OUT, channels 8 to 9, C_L = 150 pF, rising edge	Figure 11
	IN to OUT, channels 8 to 9, C_L = 150 pF, falling edge	Figure 12
	FLK to OUT, channels 1 to 6, C_L = 150 pF, RE = 1 kΩ	Figure 13
Output Current	Channels 1 to 7, C_L = 10 nF	Figure 14
	Channels 8 to 9, C_L = 10 nF	Figure 15
Panel Discharge	Power-on sequencing	Figure 16
	Power-off-sequencing	Figure 17

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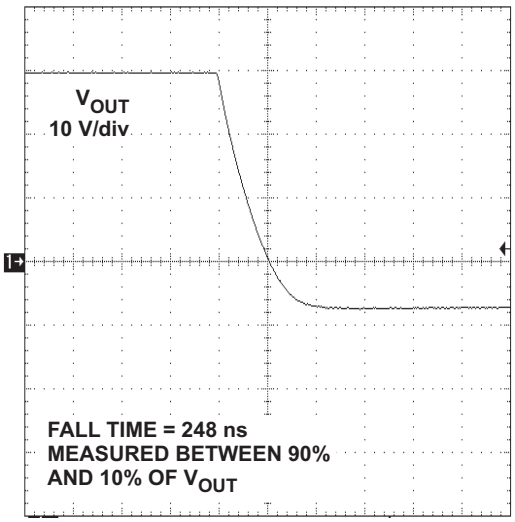
OUTPUT RISE TIME
CHANNELS 1-7, C_{OUT} = 4.7 nF



200 ns/div

Figure 1.

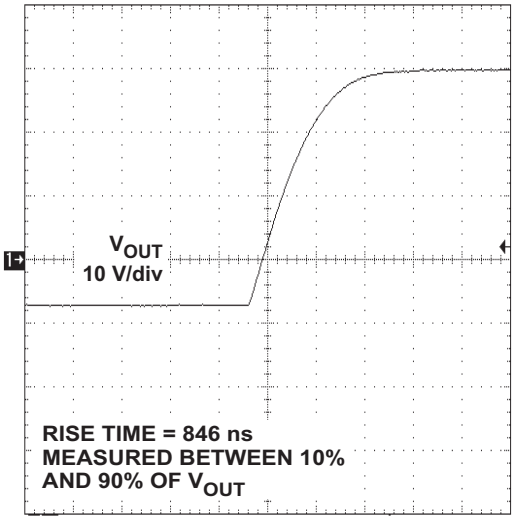
OUTPUT FALL TIME
CHANNELS 1-7, C_{OUT} = 4.7 nF



200 ns/div

Figure 2.

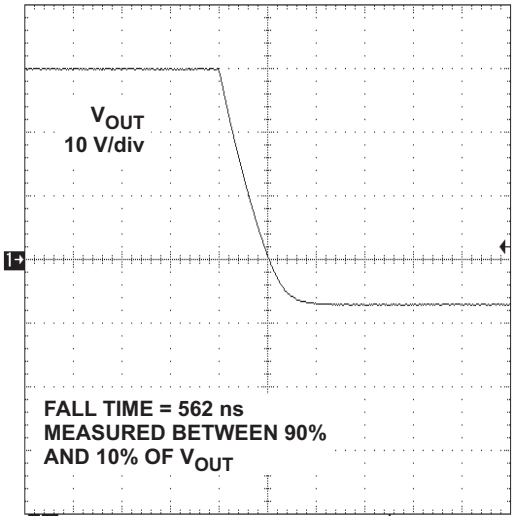
OUTPUT RISE TIME
CHANNELS 8-9, C_{OUT} = 4.7 nF



500 ns/div

Figure 3.

OUTPUT FALL TIME
CHANNELS 8-9, C_{OUT} = 4.7 nF



500 ns/div

Figure 4.

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OUTPUT RISE TIME
CHANNELS 1-7, C_{OUT} = 8 pF

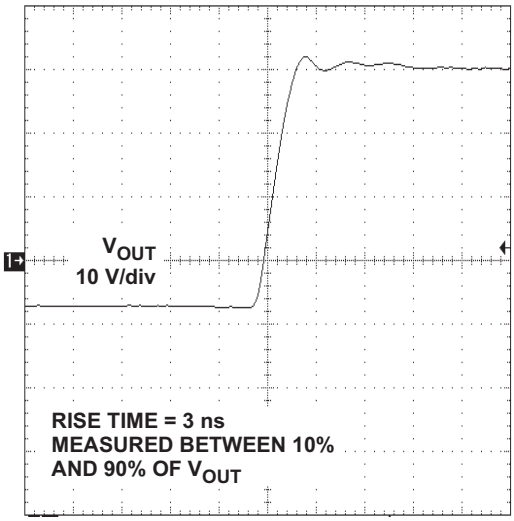


Figure 5.

OUTPUT FALL TIME
CHANNELS 1-7, C_{OUT} = 8 pF

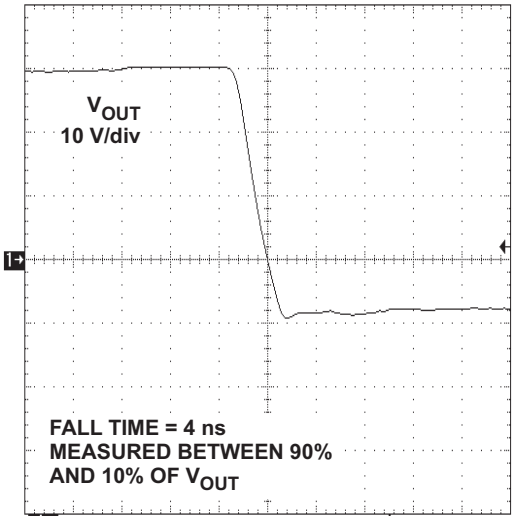


Figure 6.

OUTPUT RISE TIME
CHANNELS 8-9, C_{OUT} = 8 pF

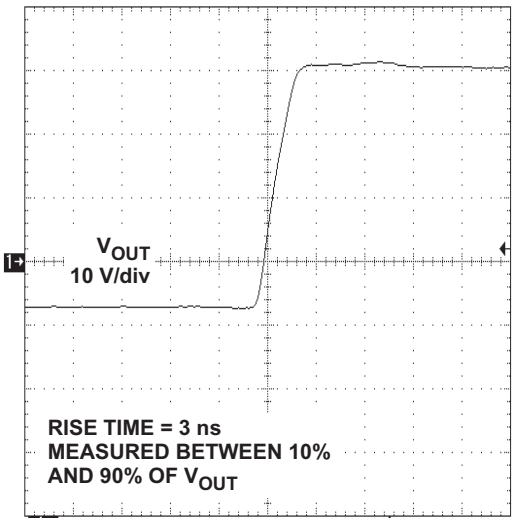


Figure 7.

OUTPUT FALL TIME
CHANNELS 8-9, C_{OUT} = 8 pF

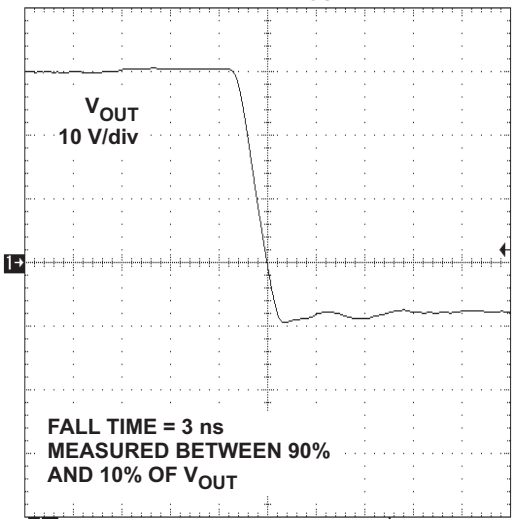
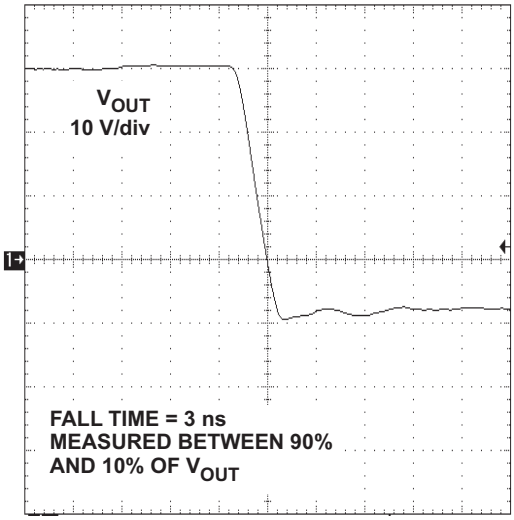


Figure 8.

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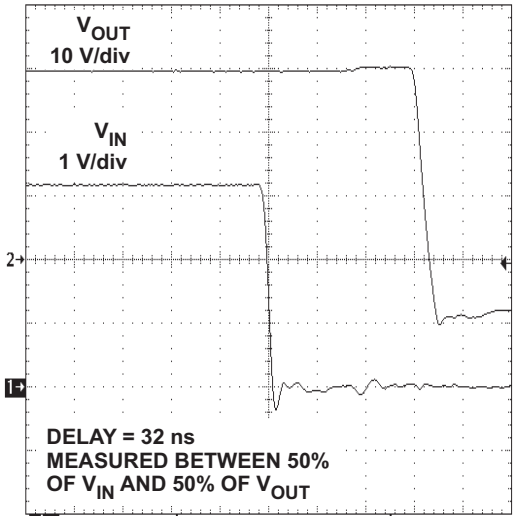
OUTPUT FALL TIME
CHANNELS 8-9, C_{OUT} = 8 pF



5 ns/div

Figure 9.

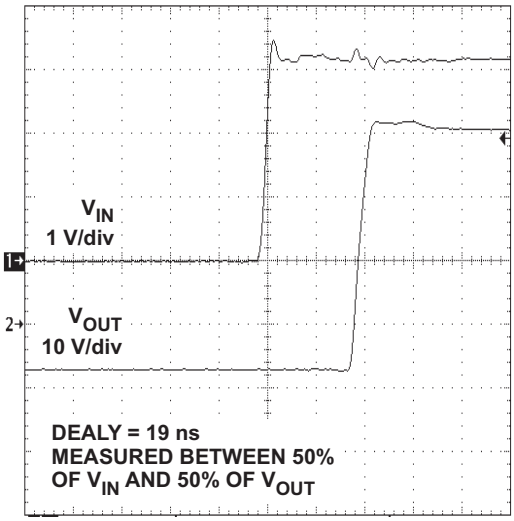
PROPAGATION DELAY – FALLING
IN-OUT, CHANNELS 1-7, C_{OUT} = 8 pF



10 ns/div

Figure 10.

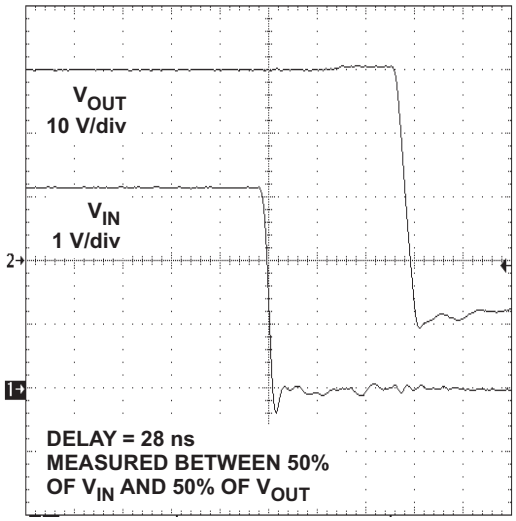
PROPAGATION DELAY – RISING
IN-OUT, CHANNELS 8-9, C_{OUT} = 8 pF



10 ns/div

Figure 11.

PROPAGATION DELAY – FALLING
IN-OUT, CHANNELS 8-9, C_{OUT} = 8 pF



100 ns/div

Figure 12.

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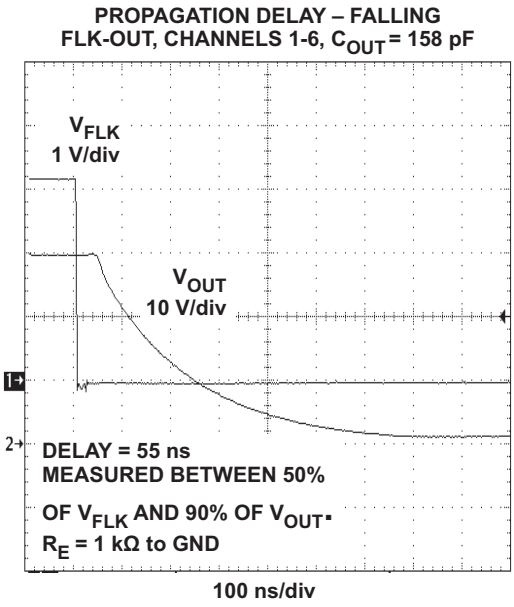


Figure 13.

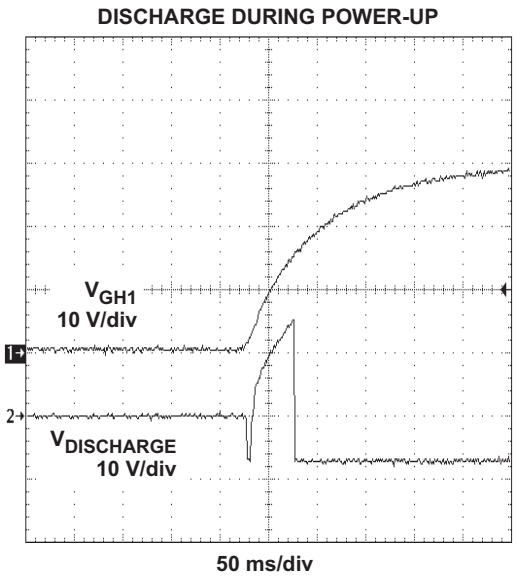


Figure 14.

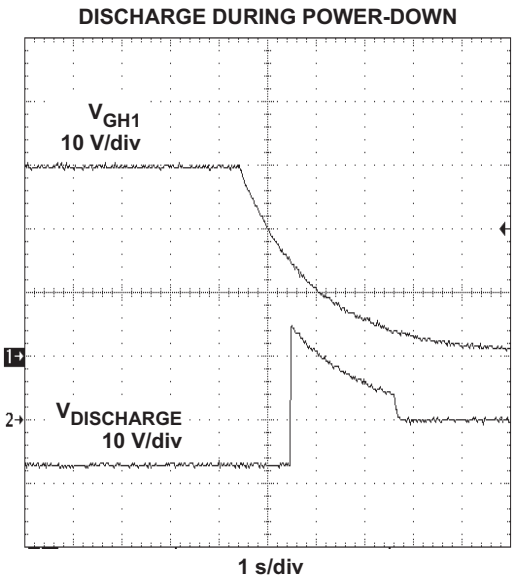


Figure 15.

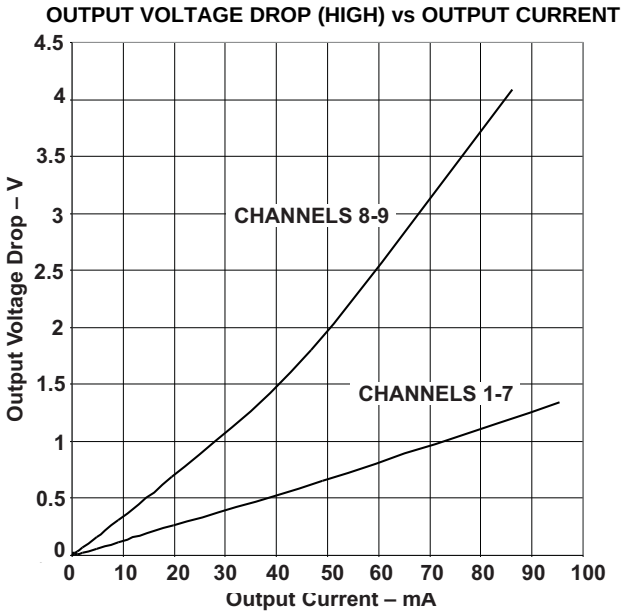


Figure 16.

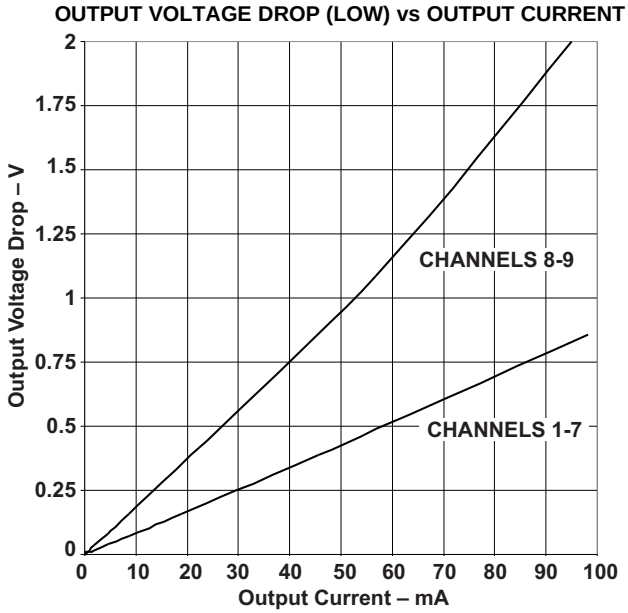


Figure 17.

DETAILED DESCRIPTION

LEVEL SHIFTERS

The 9 level shifter channels in the TPS65192 are divided into two groups. Channels 1 through 7 are powered from V_{GH1} and V_{GL}, channels 8 and 9 are powered from V_{GH2} and V_{GL}. Channels 1 to 6 support gate shaping and channels 7 through 9 do not (see the block diagram on page 1).

Figure 18 contains a simplified block diagram of one channel with gate voltage shaping.

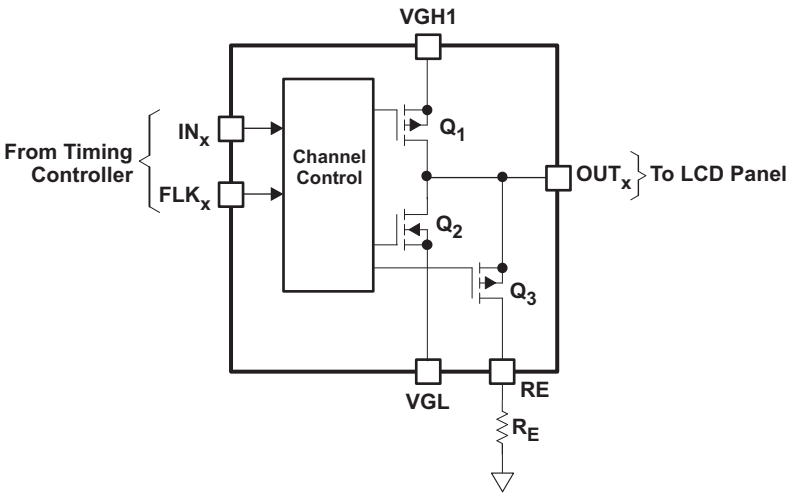


Figure 18. Level Shifter Channel With Gate Voltage Shaping

On the rising edge of IN, Q_1 turns on, Q_2 and Q_3 turn off, and OUT is driven to V_{GH1}. On the falling edge of FLK, Q_1 turns off, Q_3 is turned on, and the panel now discharges through Q_3 and RE (see Figure 19). On the falling edge of IN, Q_2 turns on and Q_3 turns off, and OUT is driven to V_{GL}. This sequence is repeated in turn for each channel.

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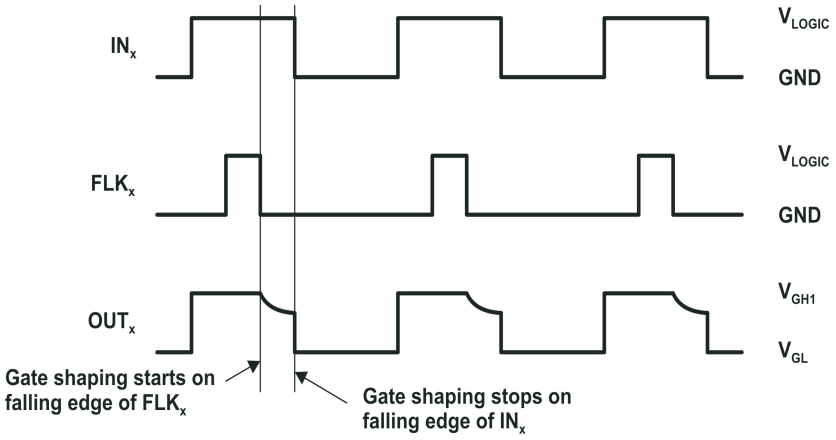


Figure 19. Gate Voltage Shaping Timing Diagram

The alternative configuration shown in Figure 20 can be used to define a minimum gate voltage reached during gate voltage shaping.

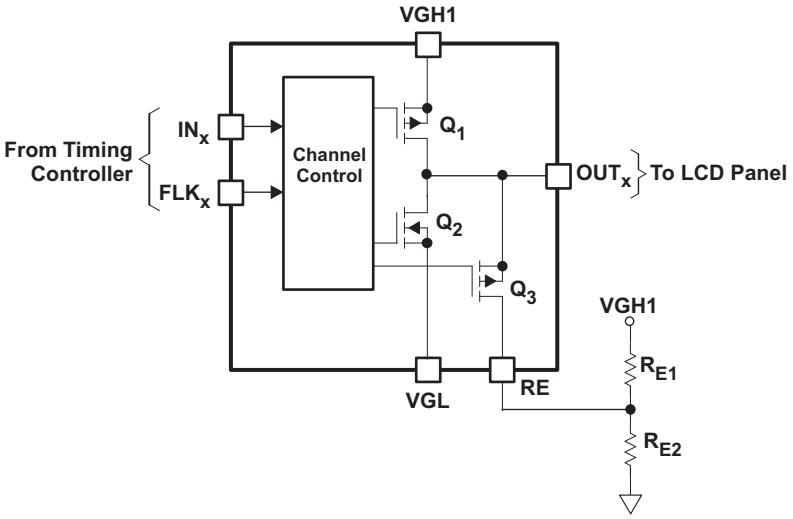


Figure 20. Alternative Gate Voltage Shaping Circuit Configuration

In this circuit, resistors R_{E1} and R_{E2} define both the rate of change of gate voltage decay and the minimum gate voltage V_{MIN}. Using the Thevenin equivalent, the operating parameters of Figure 20 are easily expressed as follows:

$$V_{MIN} = V_{VGH1} \times \left(\frac{R_{E2}}{R_{E1} + R_{E2}} \right)$$

$$R_E = \frac{R_{E1} \times R_{E2}}{R_{E1} + R_{E2}} \quad (1)$$

FLICKER CLOCKS

The gate voltage shaping control logic in the TPS65192 allows the device to be used with one, two or three flicker clock signals, according to the application requirements.

In 6-phase applications where one signal controls gate voltage shaping for six CLK channels, the flicker clock should be connected to FLK1 and the unused pins FLK2 and FLK3 connected to GND.

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In 6-phase applications where three signals control gate voltage shaping for six CLK channels, the flicker clock for channels 1 and 4 should be connected to FLK1, the flicker clock for channels 2 and 5 connected to FLK2, and the flicker clock for channels 3 and 6 connected to FLK3.

In 4-phase applications where two signals control gate voltage shaping for four CLK channels, the flicker clock for phases 1 and 3 should be connected to FLK1, the flicker clock for phases 2 and 4 connected to FLK2, and the unused pin FLK3 connected to GND. The unused pins IN 3 and IN6 should be connected to V_{LOGIC}. Alternatively, IN3 can be connected to IN2 and IN6 connected to IN5; this arrangement can simplify PCB layout. Typical schematics for each of the above cases are included in the *Applications* section of this data sheet.

Gate voltage shaping is started by the falling edge of the FLK signal(s), which must occur during a valid part of the clock waveform. For 6-phase systems, this means the last 60° of the clock waveform; for 4-phase systems, this means the last 90° of the clock waveform (see Figure 21 and Figure 22). Falling edges of the FLK signal(s) occurring outside the valid part of the clock waveform are ignored. The rising edge of the FLK signal(s) has no effect, regardless of when it occurs.

Note that gate voltage shaping is disabled when the voltage applied to the VSENSE pin is less than V_{REF}.

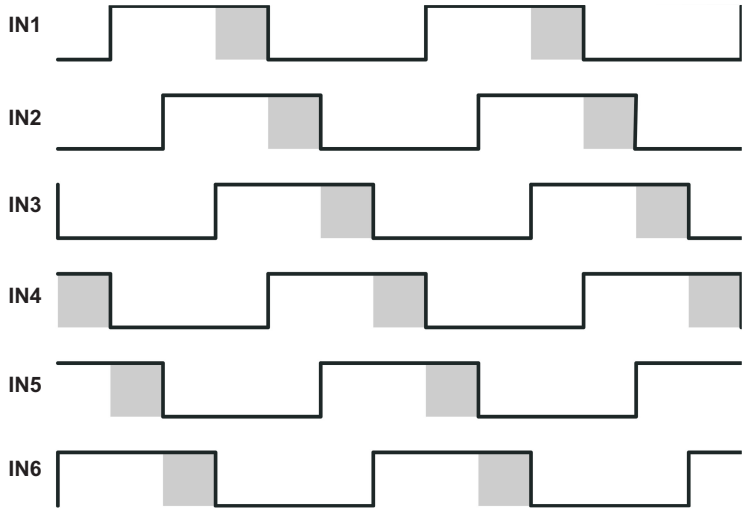


Figure 21. FLK Falling Edge Validity, 6-Phase Applications

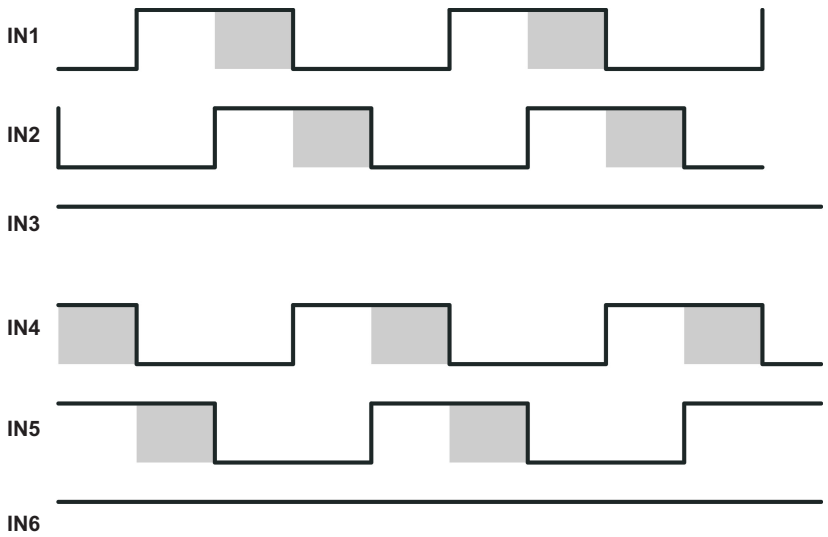


Figure 22. FLK Falling Edge Validity, 4-Phase Applications

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LEVEL SHIFTERS WITHOUT GATE VOLTAGE SHAPING

Channels 7 through 9 do not support gate voltage shaping and are controlled only by the logic level applied to their IN_X pin. Figure 23 contains a block diagram of a channel that does not support gate voltage shaping.

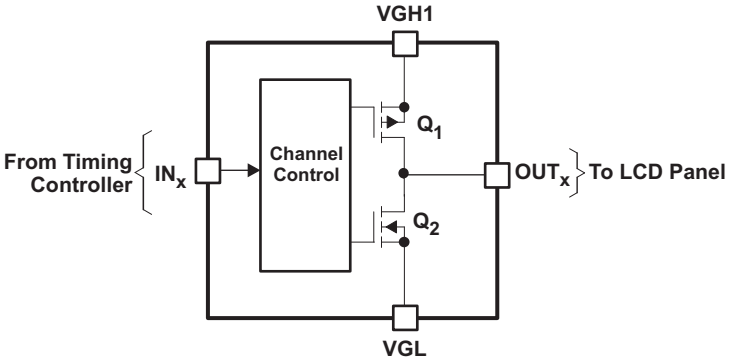


Figure 23. Block Diagram of Level Shifter Without Gate Voltage Shaping

PANEL DISCHARGE

The TPS65192 contains a function for discharging the display panel during power-down. The discharge function comprises a comparator and a level shifter (see Figure 24). During normal operation, the voltage applied to the VSENSE pin is greater than V_{REF}, the output of the level shifter is low, and the DISCHARGE signal is at V_{GL}. During power-down, when the voltage applied to the VSENSE pin falls below V_{REF}, the level shifter output goes high and the DISCHARGE signal tracks V_{GH1} as it discharges (see Figure 16 and Figure 17). Note that gate voltage shaping is disabled when the voltage applied to the VSENSE pin is less than V_{REF}.

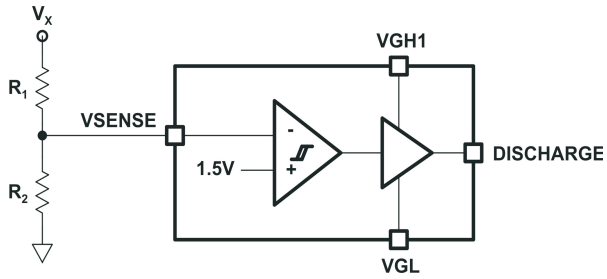


Figure 24. Panel Discharge Function Block Diagram

Suitable values for resistors R1 and R2 in Figure 24 can be calculated as follows:

$$R_1 = R_2 \times \left(\frac{V_X}{V_{REF}} - 1 \right) = R_2 \times \left(\frac{V_X}{1.5\ V} - 1 \right) \quad (2)$$

Where V_x is the voltage used to activate/deactivate the discharge function.

For most applications, a value between 1kΩ and 10kΩ for R_2 can be used (R_1 depends on the value of R_2 and the value of V_x).

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APPLICATION INFORMATION

Power Supply Decoupling

For proper performance, it is recommended that each power supply rail be decoupled with high quality ceramic decoupling capacitors placed as close to the IC supply pins as possible. The exact values used should be optimized for each application, but a parallel combination of 10µF and 100nF is a good place to start.

PCB LAYOUT

The output stages of the TPS65192 are capable of sinking and sourcing high peak currents – greater than 500mA in typical applications – and care must be taken during PCB layout to ensure that this performance can be achieved in practice. In particular, the high rates of change of current occurring at the rising and falling edges of each output require stray inductance to be minimized. This is most easily achieved by routing the output signals using short, wide PCB tracks (as far as this is possible) and using a low impedance ground plane on the other side of the board to conduct return currents. Tracks between the decoupling capacitors and the corresponding power supply pins should also be kept short and wide as possible.

PCB layout must also be adequate from a thermal as well as electrical point of view. The TPS65192 is supplied in a 28-pin QFN package designed to eliminate the need for heat sinks to dissipate the power generated in the IC. The package, shown in Figure 25, is designed so that the lead-frame die pad is exposed on the bottom of the IC, thereby providing an extremely low thermal resistance path between the die and the exterior of the package ($R_{\theta JC}$).

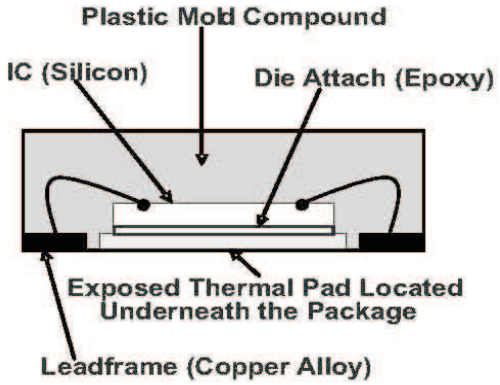


Figure 25. Section View of a QFN Package

Copper areas in and on a PCB act as heat sinks for the QFN device; however, signal routing typically restricts access to the power pad on the top layer of the PCB. In typical applications, therefore, the main copper area used to conduct heat away from the IC is on the bottom layer.

TI recommends placing thermal vias in the solder mask defined thermal pad to transfer heat from the top layer of the PCB to the inner or bottom layer used for heat sinking. The recommended via diameter is 0.3mm or less, and via spacing 1mm (see Figure 26). For the 5 × 5 mm QFN package used for the TPS65192, five thermal vias are typically used.

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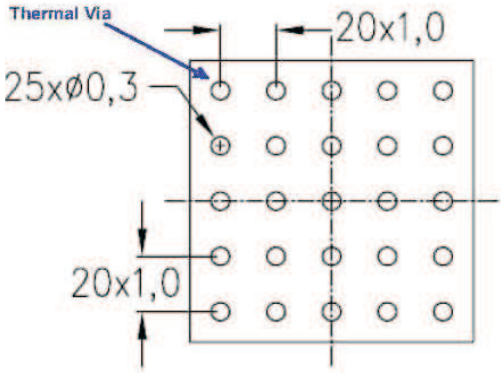


Figure 26. Recommended Thermal Via Spacing

The thermal vias should make their connection to the bottom (or internal) copper plane with a complete connection around the entire circumference of the plated through hole, and a ring of exposed copper (0.05mm wide) around the vias at the bottom of the copper plane. It is not recommended to cover the vias with solder mask as this can cause excessive voiding, and nor is it recommended to use a thermal relief web or spoke connection as this impedes the conduction path to the other layers (see Figure 27).



Figure 27. Thermal Via Connection at the Bottom Layer

In any design, the copper areas used as heat sinks should be made as large as possible.

The power pad of the TPS65192 is electrically connected to VGL and therefore must not be connected to the PCB's ground plane.

For more detailed information concerning the thermal performance of QFN packages and recommendations about how to mount the ICs on a PCB, refer to the following application reports:

SLOA122	*QFN Layout Guidelines*
SLUA271A	*QFN/SON PCB Attachment*

APPLICATION CIRCUITS

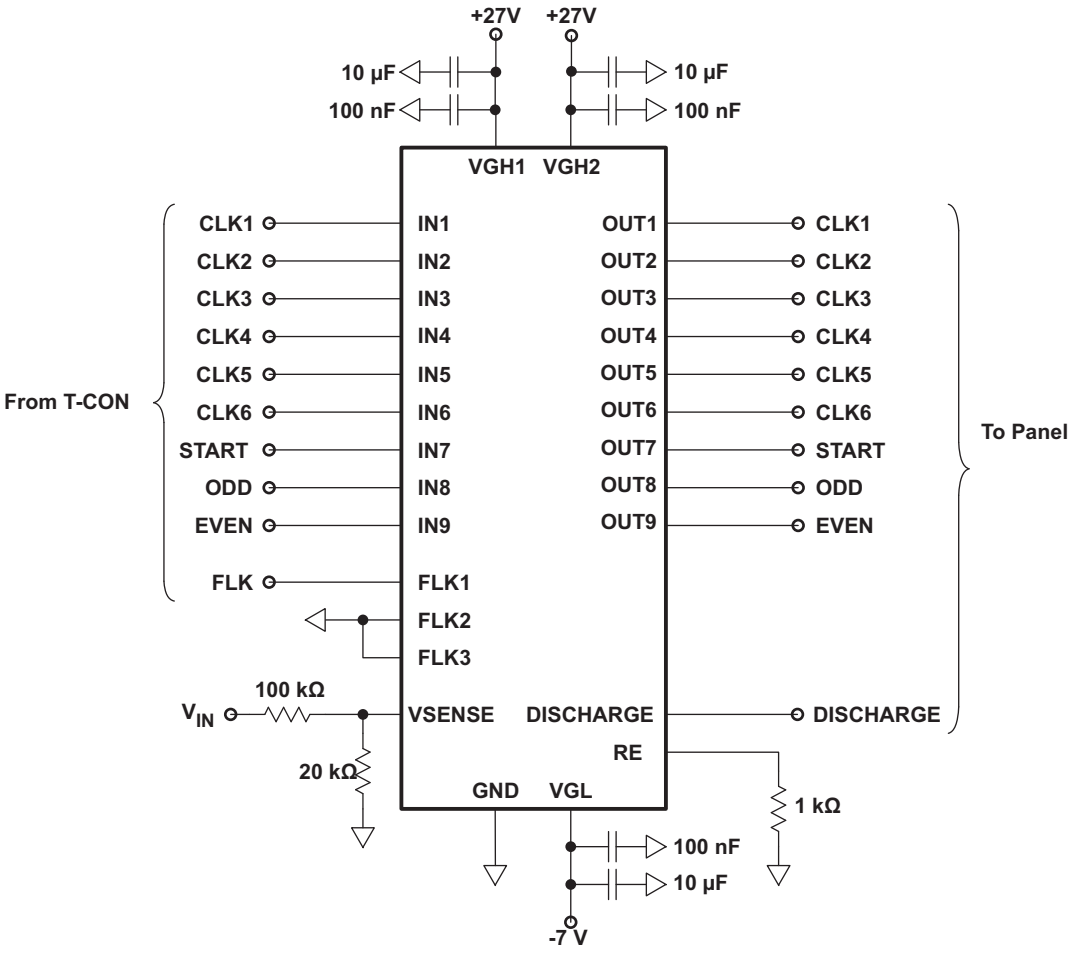


Figure 28. Typical 6-Phase HD TV Application with One Flicker Clock

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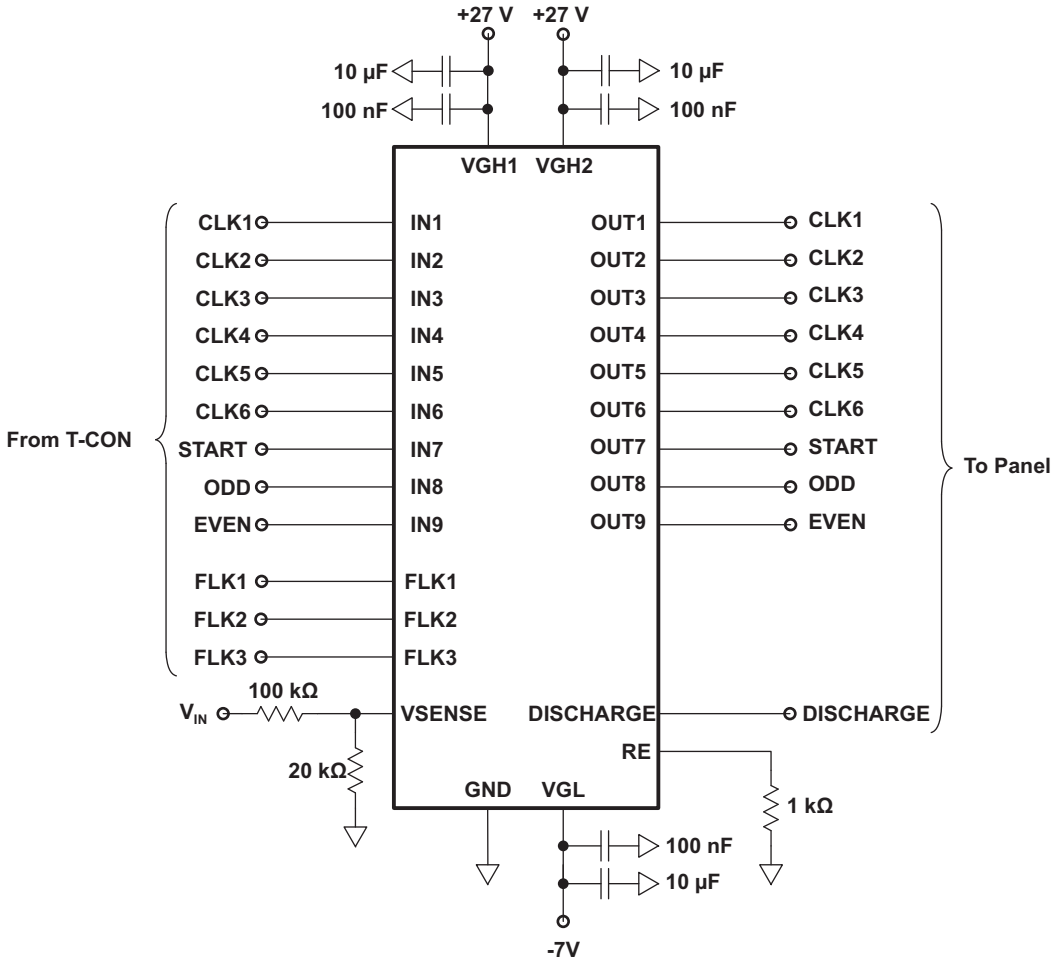


Figure 29. Typical 6-Phase F-HD TV Application with Three Flicker Clocks

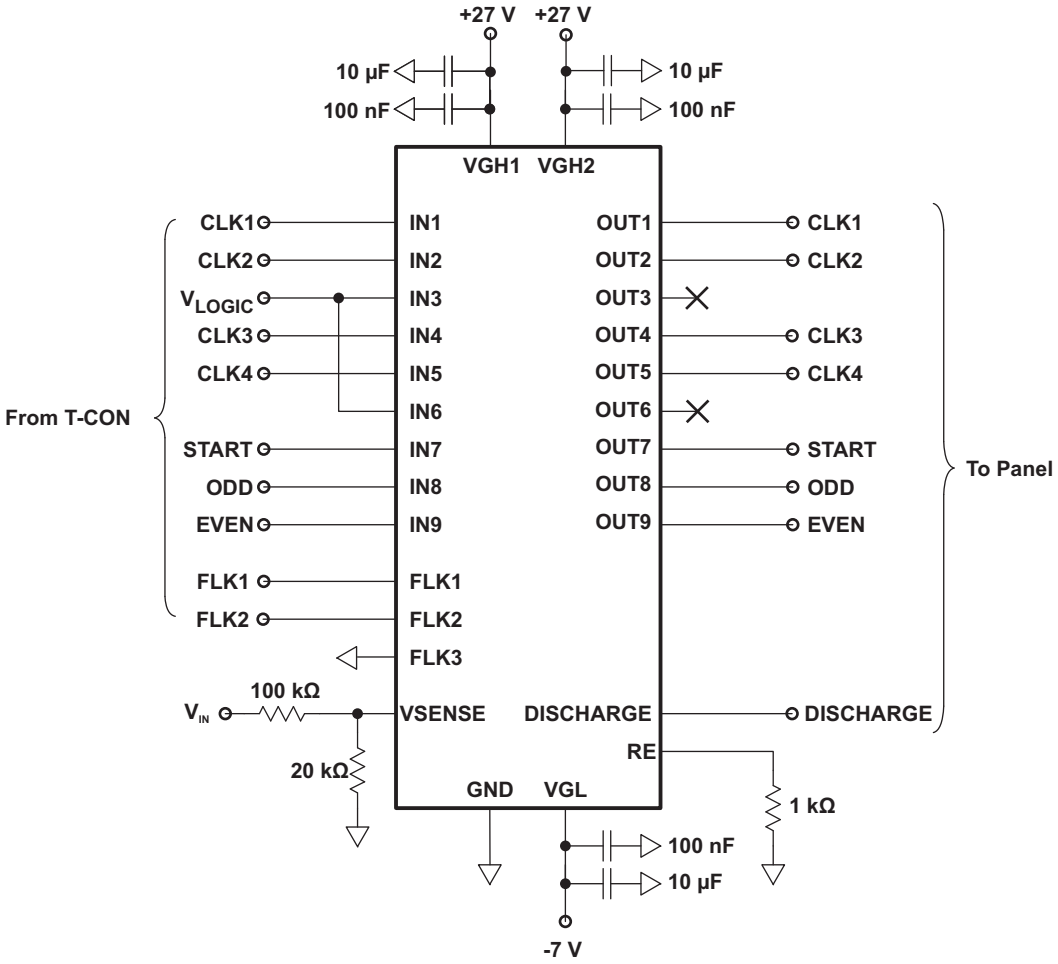


Figure 30. Typical 4-Phase Monitor Application with Two Flicker Clocks

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PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TPS65192RHDR	ACTIVE	VQFN	RHD	28	3000	Green (RoHS & no Sb/Br)	NIPDAU	Level-2-260C-1 YEAR	-40 to 85	TPS 65192	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

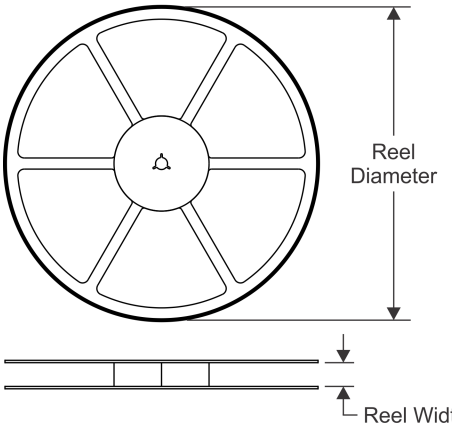
(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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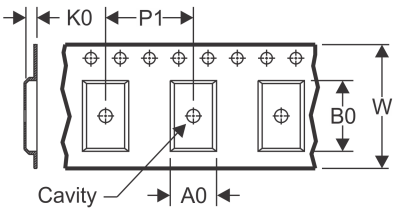
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TAPE AND REEL INFORMATION

REEL DIMENSIONS

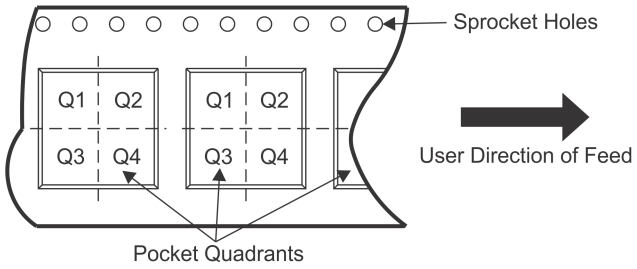


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

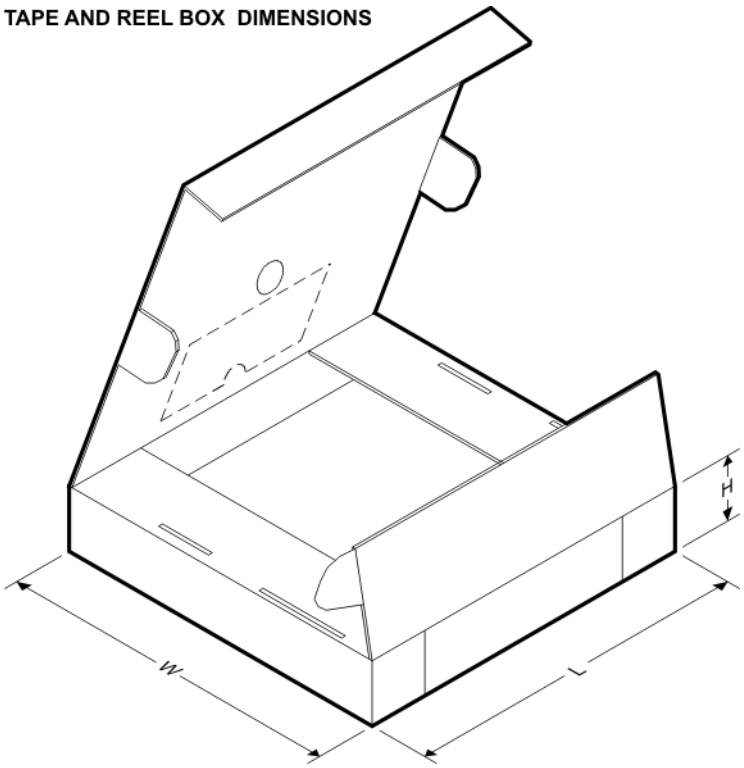
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TPS65192RHDR	VQFN	RHD	28	3000	330.0	12.4	5.3	5.3	1.1	8.0	12.0	Q2
TPS65192RHDR	VQFN	RHD	28	3000	330.0	12.4	5.3	5.3	1.5	8.0	12.0	Q2

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TPS65192RHDR	VQFN	RHD	28	3000	367.0	367.0	35.0
TPS65192RHDR	VQFN	RHD	28	3000	367.0	367.0	35.0

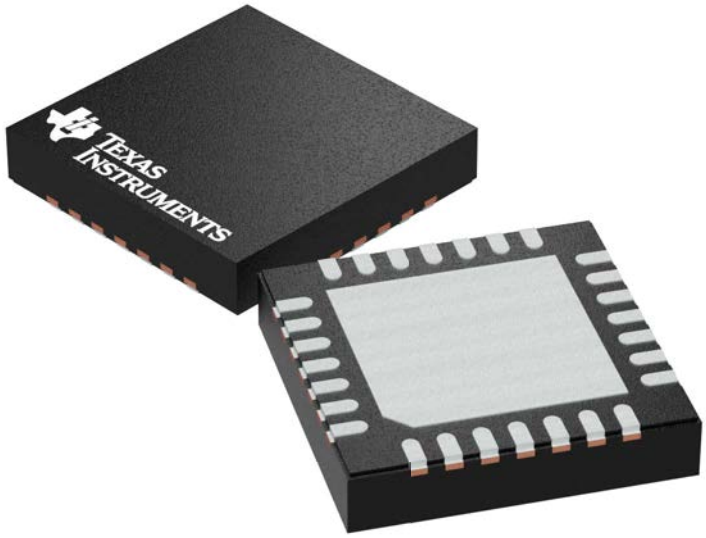
GENERIC PACKAGE VIEW

RHD 28

VQFN - 1 mm max height

5 x 5 mm, 0.5 mm pitch

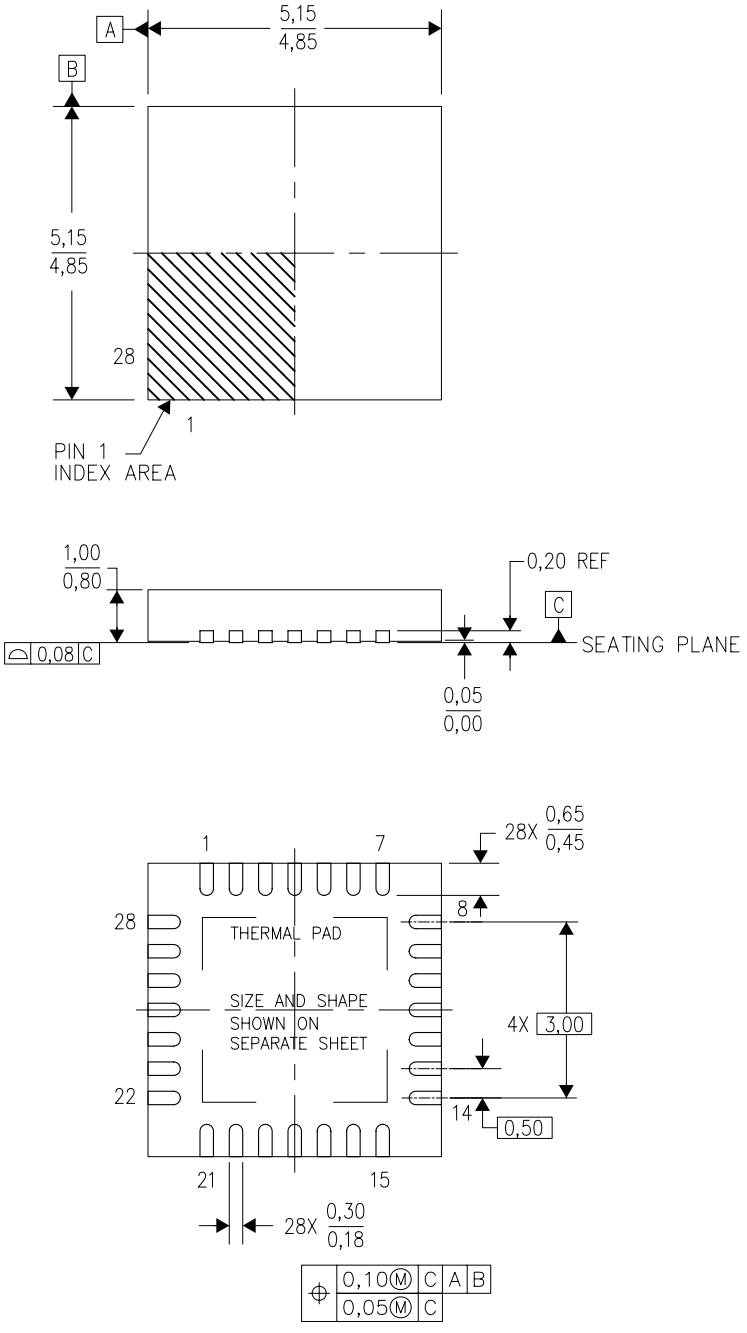
PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.
Refer to the product data sheet for package details.

4204400/G

RHD (S–PVQFN–N28) PLASTIC QUAD FLATPACK NO–LEAD



4204400/F 09/11

NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. QFN (Quad Flatpack No–Lead) Package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
F. Falls within JEDEC MO–220.

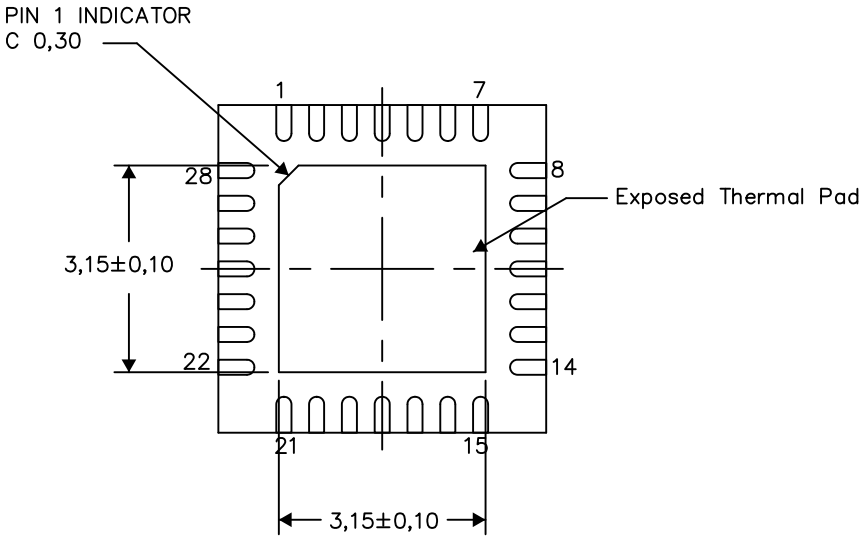
RHD (S–PVQFN–N28) PLASTIC QUAD FLATPACK NO–LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No–Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.



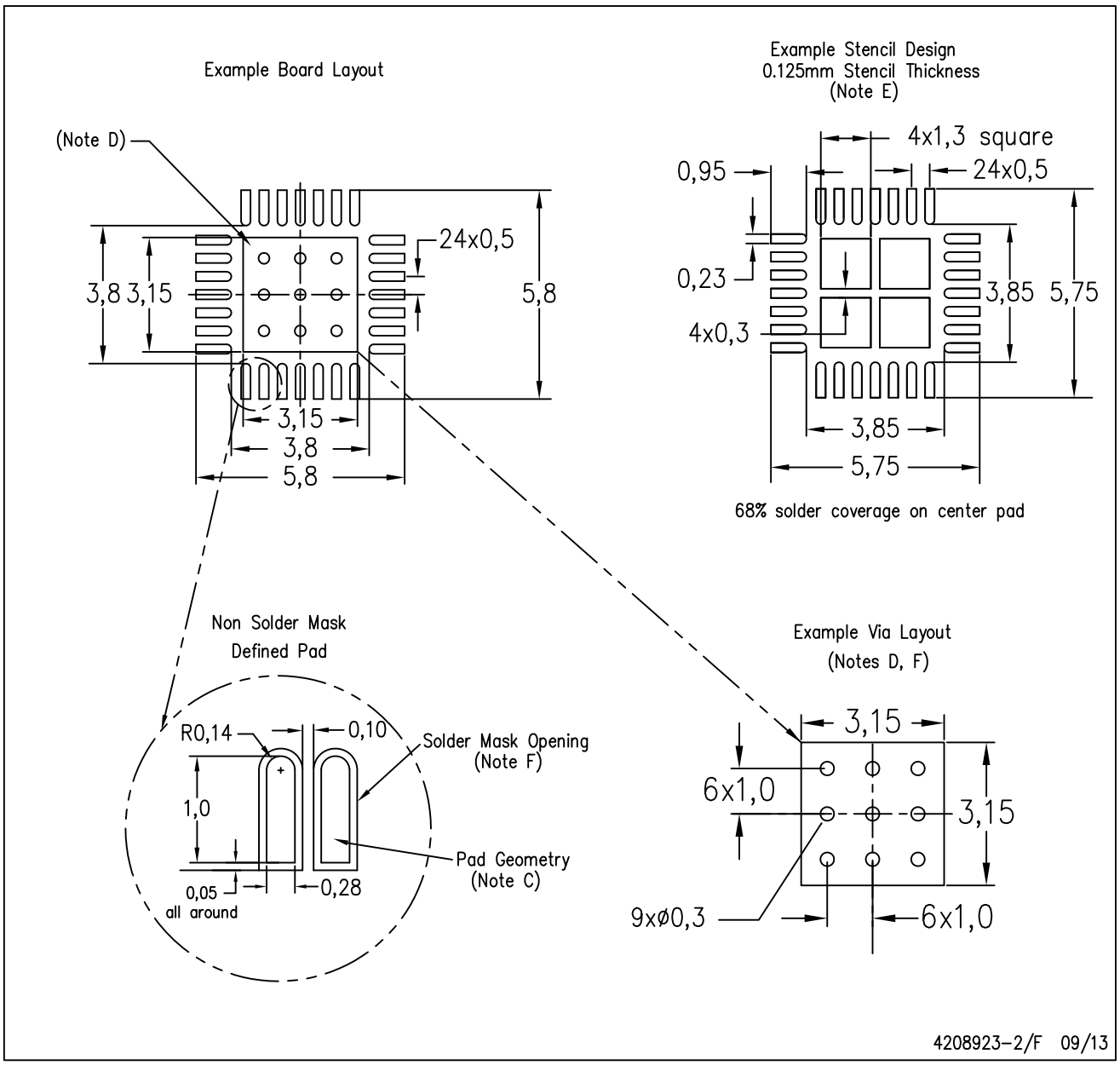
Bottom View

Exposed Thermal Pad Dimensions

4206358–2/L 05/15

NOTE: All linear dimensions are in millimeters

RHD (S–PVQFN–N28) PLASTIC QUAD FLATPACK NO–LEAD



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat–Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http://www.ti.com>.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
F. Customers should contact their board fabrication site for recommended solder mask tolerances and via tenting recommendations for vias placed in thermal pad.

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