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# FAN6240

## Secondary-Side Synchronous Rectifier Controller for Flyback Converters

### Features

- Works in Discontinuous Conduction Mode (DCM).
- Adaptive Turn-off Trigger Blanking Time for easier use
- Turn-on Trigger Blanking Time (Minimum-OFF Time) for Improved Noise Immunity
- Supports High-Frequency Applications up to 200 kHz
- Minimum Turn-on Delay (20 ns)
- Adaptive Turn-off Threshold Control for Minimized SR MOSFET Body Diode Conduction (Dead-Time is independent of SR MOSFET)
- Wide Voltage Range for LDO Input up to 30 V
- Small Footprint: SOT-23 6 Pin Package

### Description

The FAN6240M6X is a secondary-side synchronous rectifier (SR) controller for an isolated flyback converter operating in Discontinuous Conduction Mode (DCM). The adaptive dead-time control algorithm minimizes the body diode conduction of SR MOSFET while guaranteeing stable and robust SR operation against noise and disturbance caused by the circuit parasitic. 30 V rated input voltage LDO and Low VDD Under-Voltage Lockout (UVLO) voltage allow FAN6240M6X to be used for wide ranges of switched mode power supply output voltage without additional circuit.

### Applications

- Battery Chargers for Smart Phones, Feature Phones, and Tablet PCs
- AC-DC Adapters for Portable Devices that Require CV/CC Control

### Ordering Information

Part Number	Operating Temperature Range	Package	Packing Method
FAN6240M6X	-40°C to +125°C	6-Lead, SOT23, JEDEC MO-178 Variation AB, 1.6 mm Wide	Tape & Reel

## Application Diagram

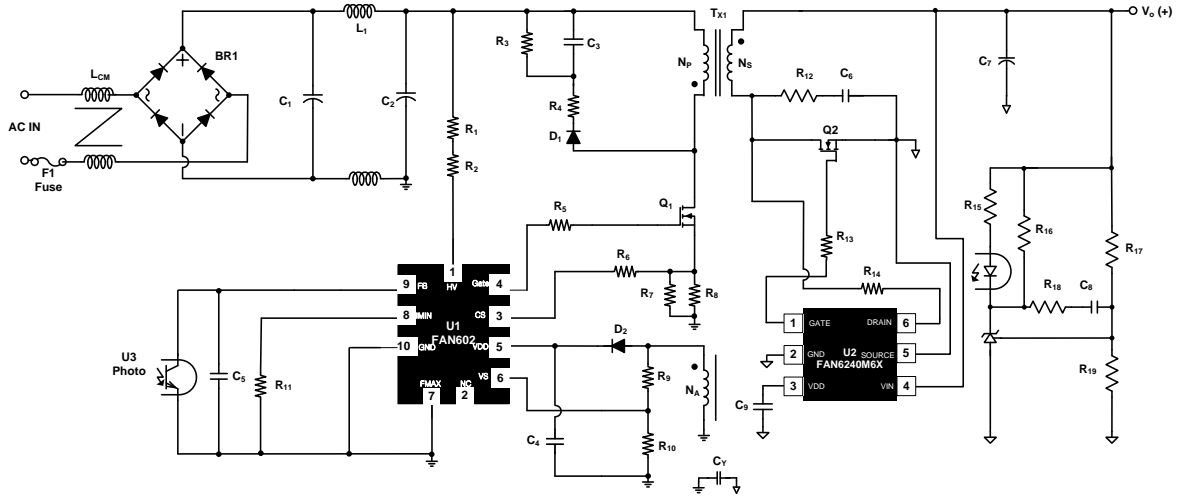


Figure 1. Typical Application

## Internal Block Diagram

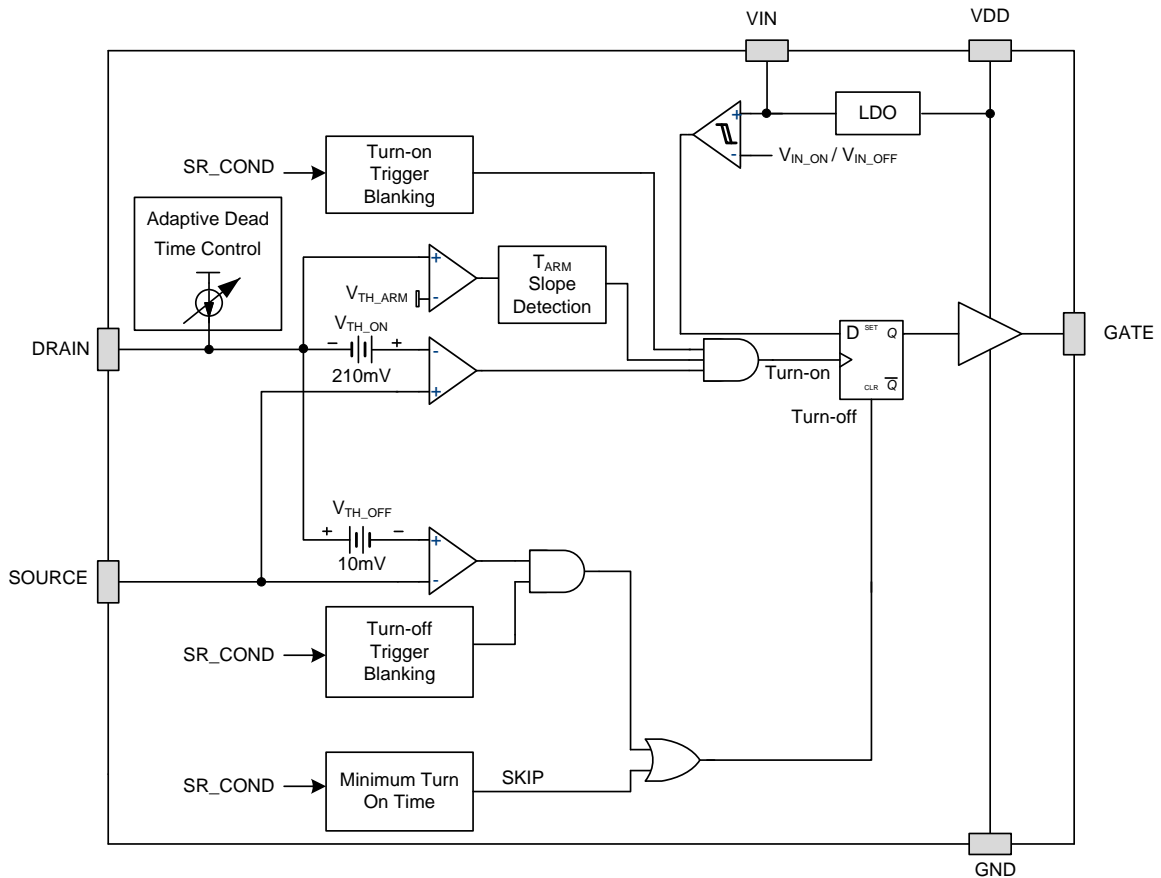


Figure 2. Function Block Diagram

## Marking Information

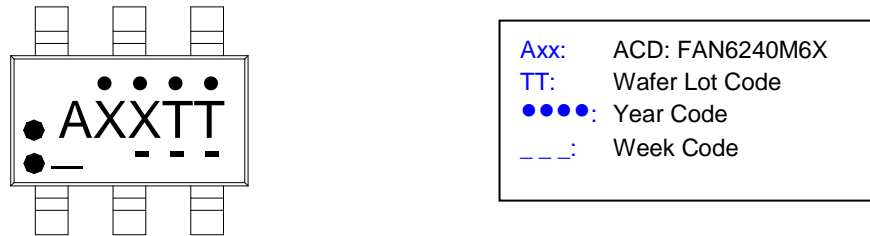


Figure 3. Top Mark

## Pin Configuration

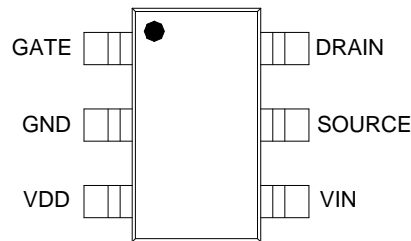


Figure 4. Pin Configuration

## Pin Definitions

Pin #	Name	Description
1	GATE	Gate drive output
2	GND	Ground
3	VDD	Internal regulator 5 V output and gate drive power supply rail. Bypass with 1uF capacitor to GND.
4	VIN	LDO input, supports up to 30 V operation. An integrated 5 V LDO generates the internal VDD power supply rail for the low-voltage control circuitry.
5	SOURCE	Synchronous rectifier source sense input.
6	DRAIN	Synchronous rectifier drain sense input.

## Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

Symbol	Parameter	Min.	Max.	Unit
V <sub>IN</sub>	Power Supply Input Pin Voltage	-0.3	30	V
V <sub>DD</sub>	Internal Regulator Output Pin Voltage	-0.3	6.5	V
V <sub>DRAIN</sub>	Drain Sense Input Pin Voltage	-1	100	V
V <sub>GATE</sub>	Gate Drive Output Pin Voltage	-0.3	6.5	V
V <sub>SOURCE</sub>	Source Sense Input Pin Voltage	-1	1	V
P <sub>D</sub>	Power Dissipation (T <sub>A</sub> =25°C)		23	mW
Θ <sub>JA</sub>	Thermal Resistance (Junction-to-Ambient Thermal)		235	°C/W
T <sub>J</sub>	Operating Junction Temperature	-40	150	°C
T <sub>STG</sub>	Storage Temperature Range	-60	150	°C
T <sub>L</sub>	Lead Temperature (Soldering) 10 Seconds		260	°C
ESD	Electrostatic Discharge Capability	Human Body Model, ANSI / ESDA / JEDEC JS-001-2012		kV
		Charged Device Model, JESD22-C101		

### Notes:

1. Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device.
2. All voltage values are with respect to the GND pin.

## Recommended Operating Conditions

The Recommended Operating Conditions table defines the conditions for actual device operation. Recommended operating conditions are specified to ensure optimal performance. Fairchild does not recommend exceeding them or designing to Absolute Maximum Ratings.

Symbol	Parameter	Min.	Typ.	Max.	Unit
V <sub>IN</sub>	Power Supply Input Pin Voltage	2.8		20	V
V <sub>DD</sub>	Internal Regulator Output Pin Voltage	2.8		6	V
V <sub>DRAIN</sub>	Drain Sense Input Pin Voltage	-0.3		100	V
V <sub>GATE</sub>	Gate Drive Output Pin Voltage	-0.3		6	V
V <sub>SOURCE</sub>	Source Sense Input Pin Voltage	-0.3		1	V

## Electrical Characteristics

$V_{IN} = 12\text{ V}$  and  $T_J = -40^\circ\text{C}$  to  $125^\circ\text{C}$  unless otherwise specified.

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
<b>Input Voltage</b>						
$V_{IN\_ON}$	Turn-On Threshold	$V_{IN}$ Rising	3.1	3.4	3.7	V
$V_{IN\_OFF}$	Turn-Off Threshold	$V_{IN}$ Falling	2.8	2.9	3.0	V
$I_{IN\_OP}$	Operating Current	$f_{SW} = 100\text{ kHz}$ , $C_{GATE} = 3.3\text{ nF}$ , $V_{IN} = 5\text{ V}$		2	3.5	mA
<b>Power Supply Section</b>						
$V_{DD}$	Internal LDO Output Voltage	$V_{IN} = 20\text{ V}$	5.00	5.25	5.50	V
<b>Drain Voltage Sensing Section</b>						
$I_{OFFSET}$		Maximum of adaptive offset current (15 steps, 6 $\mu\text{A}$ resolution)	75	90	105	$\mu\text{A}$
$V_{TH\_ON}$	Turn-On Threshold	$R_{DRAIN} = 0\ \Omega$ (includes comparator input offset voltage)	-235	-210	-185	mV
$T_{ON\_DLY}^{(3)}$	Turn-On Delay			20		ns
$V_{TH\_OFF}^{(3)}$	Turn-Off Threshold			10		mV
$T_{OFF\_DLY}^{(3)}$	Turn-Off Delay			20		ns
$V_{TH\_ARM}$	Gate Re-arming Threshold	$V_{IN} = 5\text{ V}$ , (Typically $0.7 \cdot V_{DD}$ )	3.3	3.5	3.7	V
$T_{ARM}^{(3)}$	Gate Re-arming Time for Slope Detection			85		ns
$V_{TH\_HGH}^{(3)}$	SR OFF Detection Threshold			0.5		V
<b>Minimum On-Time and Minimum Off-Time</b>						
$K_{TON}^{(3)}$	Adaptive Minimum On-Time Ratio	Ratio between minimum on time and SR conduction of previous switching cycle		50		%
$t_{ON\_MIN\_LL}$	Minimum On-Time Lower Limit		300	400	500	ns
$t_{ON\_MIN\_UL}^{(3)}$	Minimum On-Time Upper Limit			2		$\mu\text{s}$
$t_{OFF\_MIN}$	Minimum Off-Time	Default Option for Medium Frequency	1.0	1.2	1.4	$\mu\text{s}$
<b>Output Driver Section</b>						
$V_{OL}$	Output Voltage Low	$V_{IN} = 6\text{ V}$			0.25	V
$V_{OH}$	Output Voltage High	$V_{IN} = 6\text{ V}$	5.0			V
$t_R$	Rise Time	$V_{IN} = 6\text{ V}$ , $C_L = 3300\text{ pF}$ , $GATE = 1\text{ V} \sim 4\text{ V}$			10	ns
$t_F$	Fall Time	$V_{IN} = 6\text{ V}$ , $C_L = 3300\text{ pF}$ , $GATE = 4\text{ V} \sim 1\text{ V}$			10	ns
<b>Adaptive Dead-Time Control</b>						
$t_{DEAD}^{(3)}$	Dead-Time Self-Tuning Target	From GATE OFF to $V_{DRAIN}$ rising above $V_{TH\_HGH}$		290		ns

**Note:**

3. Not tested and guaranteed by design.

## Functional Description

### Theory of SR Control Operation

For an ideal circuit operation, the SR control algorithm of FAN6240 is very straightforward. FAN6240 controls the SR MOSFET based on the instantaneous drain-to-source voltage as illustrated in Figure 5. When the body diode starts conducting, the drain-to-source voltage drops below the turn-on threshold ( $V_{TH\_ON}$ ) which triggers the turn-on of the gate. Then the drain-to-source voltage is determined by the product of  $R_{DS(ON)}$  and instantaneous SR current. When the drain-to-source voltage reaches the turn-off threshold ( $V_{TH\_OFF}$ ) as SR MOSFET current decreases to near zero, FAN6240 turns off the gate. If the turn off threshold ( $V_{TH\_OFF}$ ) is very close to zero, the turn off dead time can be minimized.

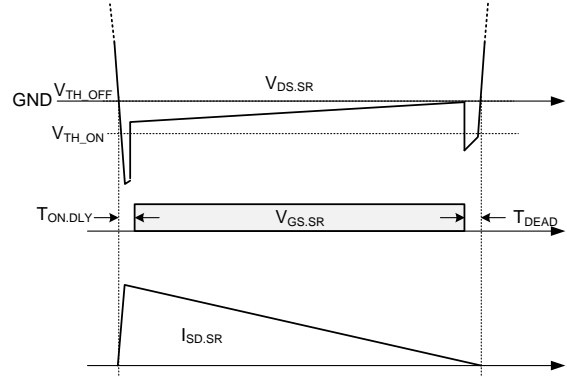


Figure 5. SR MOSFET Operation Waveforms (Ideal Case)

### SR Turn-On Algorithm

As the diagram shown in Figure 6, the turn-on of SR GATE is triggered by the three input signals of AND gate. The first input signal is TURN\_ON\_ALLOW signal, which is given after  $t_{OFF\_MIN}$  from the falling edge of  $V_{GS,SR}$  signal. The second input is the TURN\_ON\_TRG signal, which is enabled after DRAIN pin voltage drops below  $V_{TH\_ON}$ . The third signal is  $T_{ARM}$  which allows turn-on trigger only when SR drain voltage drops fast with a large slope, preventing SR from triggering by the drain resonance voltage in DCM operation.

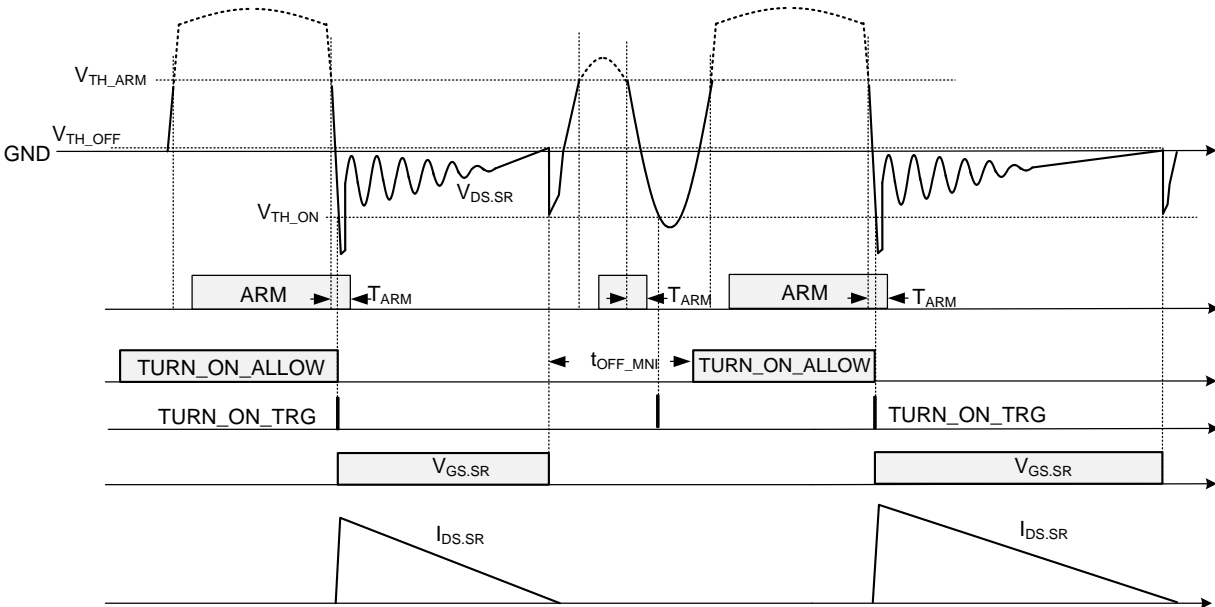


Figure 6. SR Turn-On Algorithm

### SR Turn-Off Algorithm

As diagram shown in Figure 7, the turn-off of SR GATE is triggered by the two input signals of AND gate. The first input signal is turn off signal, which is enabled when  $V_{DS,SR} > V_{TH,OFF}$ . The second input is TURN\_OFF\_ALLOW signal given from the adaptive turn-off blanking. The blanking time is adaptively determined as half of SR conduction time (SR\_COND) of the previous switching cycle for better noise immunity.

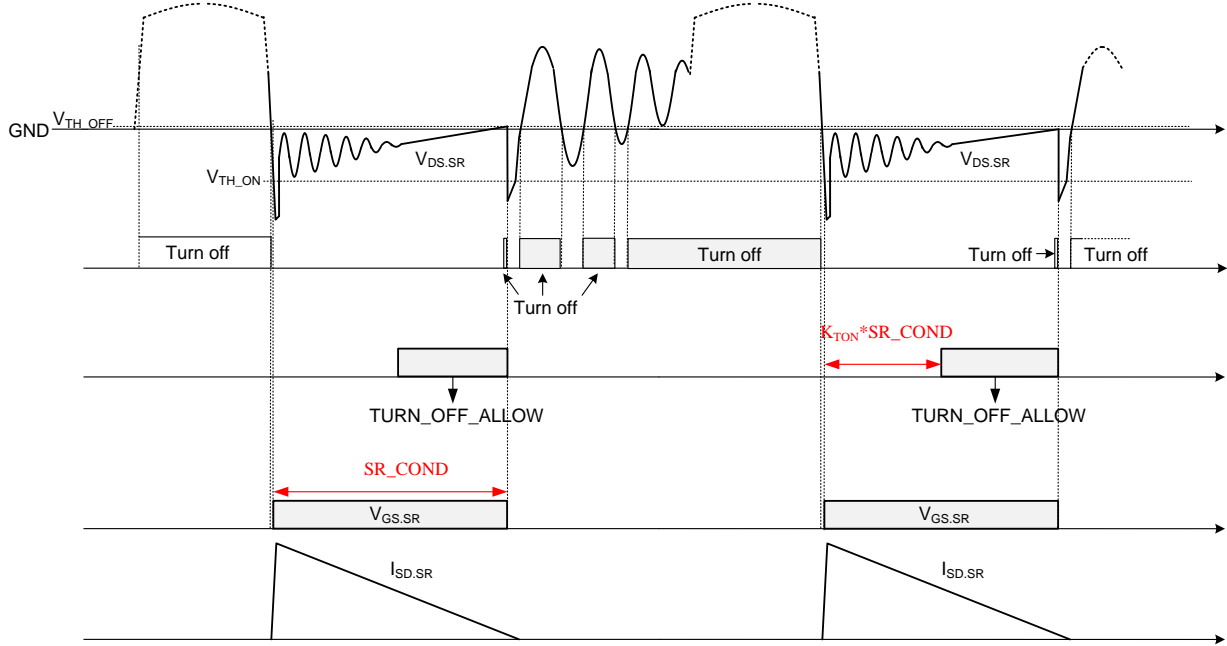


Figure 7. SR Turn-Off Algorithm

### SR Skipping Mode Algorithm

As diagram shown in Figure 8, FAN6240 disables SR gate signal (SR skipping) at next cycle when previous cycle SR conduction time  $V_{GS,SR}$  signal is smaller than the minimum ON time  $t_{ON,MIN,LL}$  in order reduce power consumption. This operation occurs only when the burst mode entry level of the primary side PWM controller is extremely low.

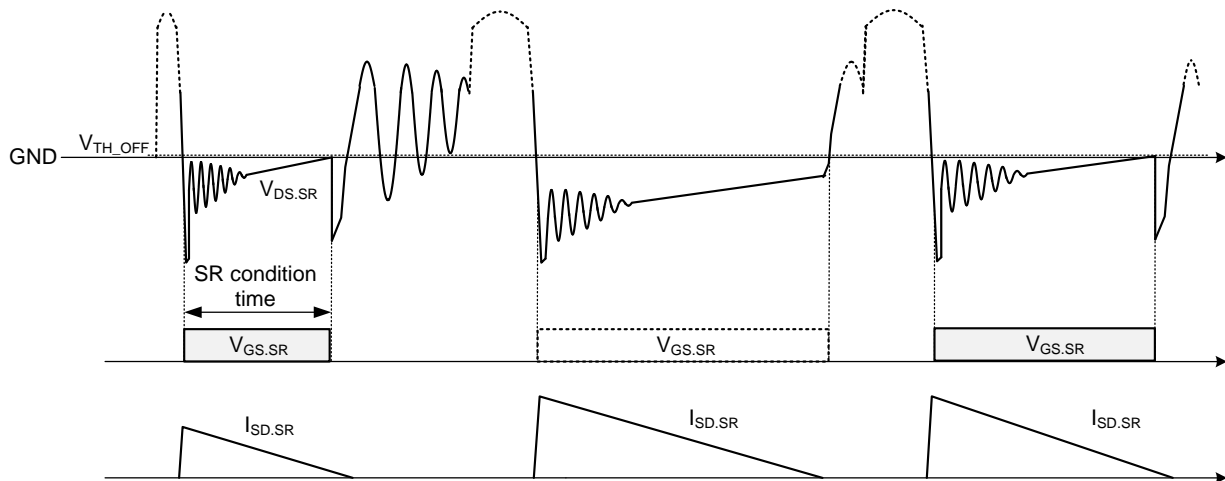
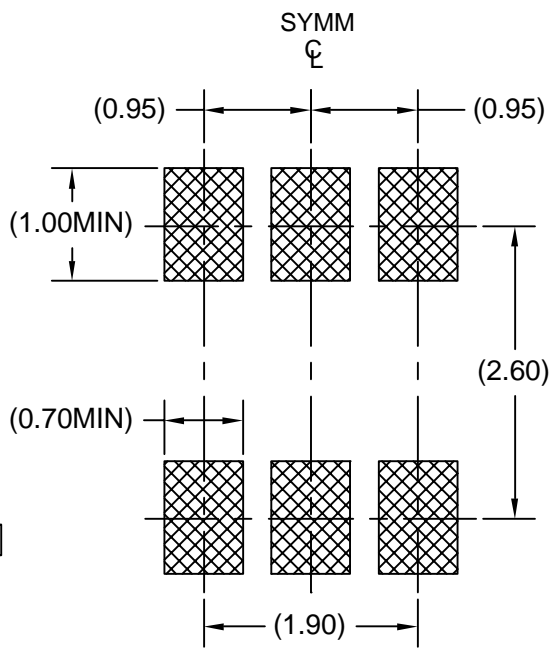
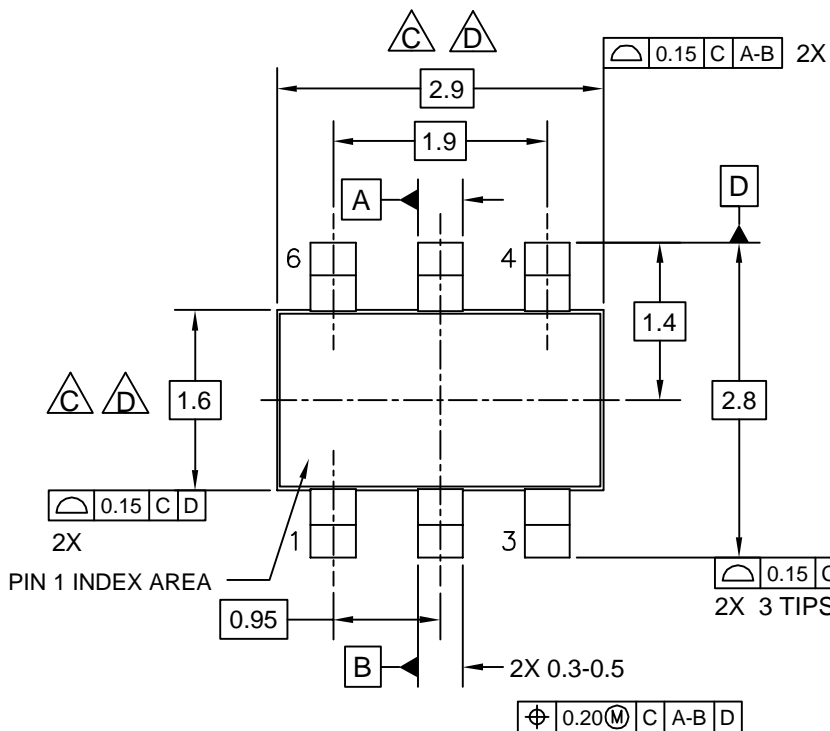


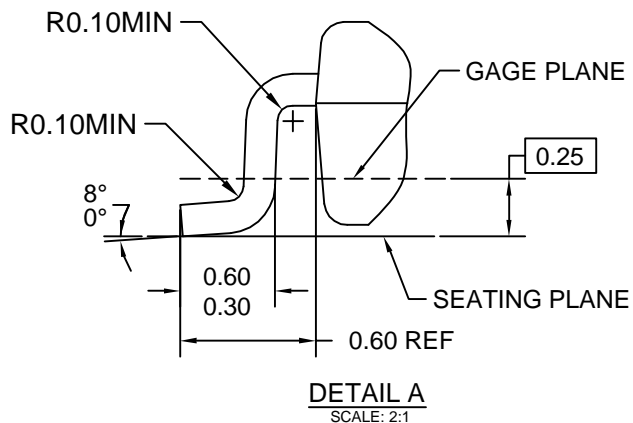
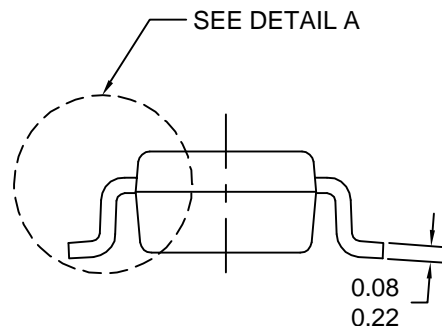
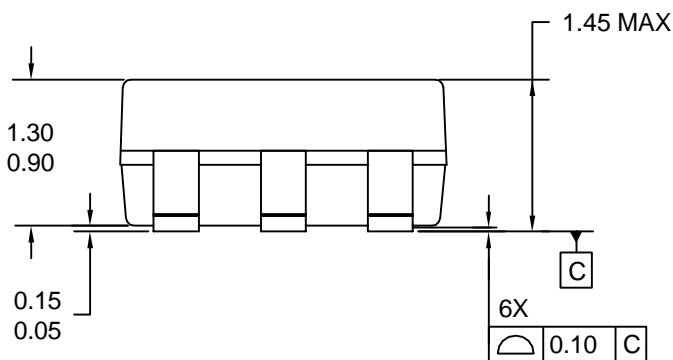
Figure 8. SR Skipping Diagram



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