Push-Button Circuit

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ABSTRACT

This application report details a push-button circuit that can be used in tandem with a power management integrated circuit (PMIC) to turn on and turn off the processor. The SN74LVC1G175 device is a D-type flip-flop with an asynchronous clear. The circuit differentiates between short presses (to turn on the PMIC) and long presses (to turn off the PMIC).

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1 Introduction

This push-button circuit can be used with a wide variety of PMICs. For example, this circuit can be used to drive a control pin, which enables and disables the buck converters, for the TPS65086 device. This application report describes the required components and a detailed description on how the circuit operates. The typical operating range for this circuit is from 1.65 V to 5.5 V. The input voltage can come from the same source powering the PMIC, or from the PMIC itself. The input voltage for the SN74LVC1G175 device must not exceed the maximum voltage of the control pins on the target device. If the input voltage does exceed the maximum voltage, then a level shift is required to match the operating voltage of the control pins.

The SN74LVC1G175 device, which has an asynchronous clear, is the D-type flip-flop chosen for this circuit. Using the asynchronous clear, the SN74LVC1G175 device can set the output low regardless of the clock. This functionality allows the circuit to differentiate between a short and long press.

2 Schematic

Figure 1 shows a schematic of the push-button circuit.

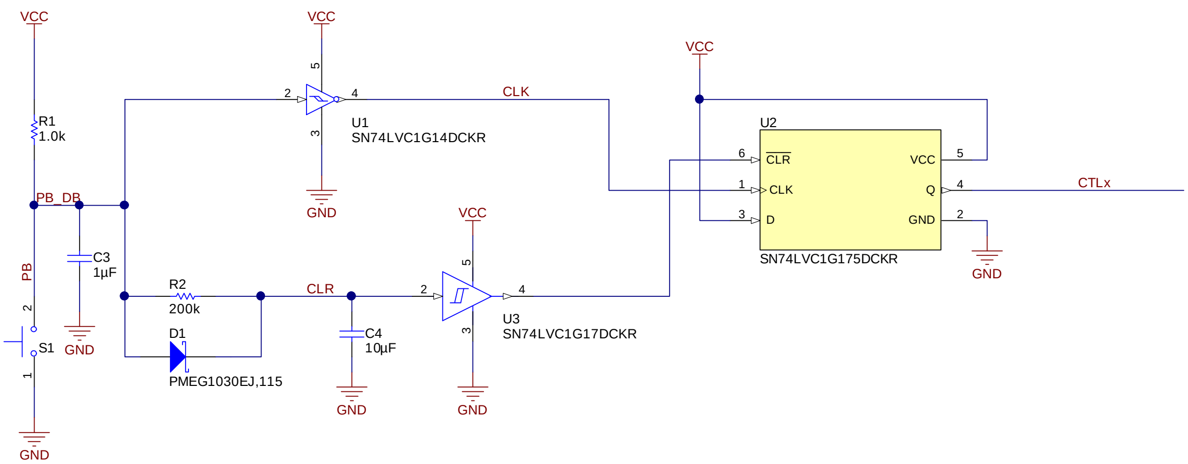

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Figure 1. Push-Button Schematic

2.1 *Power-On Process*

The initial state of the circuit has the CLR signal set to high (H). Table 1 shows this setting, where the CLR signal must be set to high for a write to occur at the rising edge of the clock.

Table 1. D-Type Flip-Flop Function Table

INPUTS			OUTPUT
$\overline{CLR}$	CLK	D	Q
H	↑	L	L
H	↑	H	H
H	H or L	X	Q0
L	X	X	L

To set the CTLx signal high, press the button which forces the debounced push-button signal (PB_DB) to go low and the CLK signal to go high. The CLR signal starts to go low but because the R2 resistor and C4 capacitor create an RC delay which causes the CLR signal to decay slowly. With a short button press, the CLR signal does not go low, which allows for the CTLx signal to go high when the button is pressed. The CTLx signal remains high even if the button is pressed again after the initial press.

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2.2 Power-Off Process

The power-off process starts by holding the button down for a longer time. The button must be held longer than the RC delay defined by R2 and C4. When the button is held long enough, the CLR signal goes low enough to fit the conditions for the asynchronous clear to occur, which sets the CTLx signal to low. If necessary, a quick turnaround time can occur from the time the processor turns off to the time it can be turn on again because of diode D1.

3 Selecting Delay Time

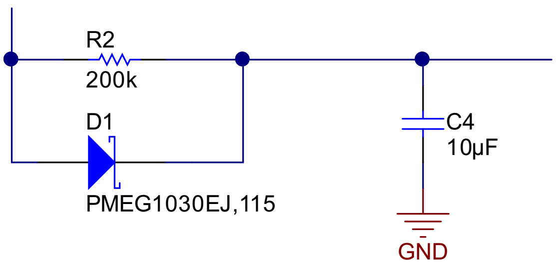

Figure 2. RC Delay

For the power-off process the button must be held down for a short period of time, and this time is dictated by the RC delay of R2 and C4 (see Figure 2). The simple formula, τ = RC, gives a good estimate as to what the turnoff time will be. However, the number calculated is greater than the actual turnoff time because the capacitor does not need to fully discharge for the D-type flip-flop to detect the CLR signal as low. Typically, the RC delay is the time for a capacitor to get to about 36.8% of a fully charged capacitor, but in the far right column of Table 2 all the percentages are greater the 36.8%. Therefore the τ = RC equation is a good estimate of the turnoff time; however, the actual turnoff time is less than the RC time constant. Use Equation 1 to determine the turnoff voltage based on the turnoff time acquired through testing and the RC constant.

When choosing the capacitor value, do not choose a capacitor that is too small. A small capacitor makes the delay so small that both the CLR and CLK signals go low during the time used to release the button which allows the CTLx signal to go high for a brief moment before going low shortly thereafter.

$$V(t) = V_0 e^{-t/\tau}$$

where

- V_0 = voltage at time zero (VCC)
- t = time
- τ = RC time constant (1)

Table 2. Capacitor Size Effect Regarding Turnoff Time

Capacitor (µF)	Measured Turnoff Time (ms)	RC Constant (ms) R = 200 kΩ	Turnoff Voltage (V)	Remaining Charge Percentage (V/V_0)
2.2	412	440	1.29	39.21%
3.3	600	660	1.33	40.29%
4.7	764	940	1.46	44.36%
10	1420	2000	1.62	49.16%
22	3260	4400	1.57	47.67%
33	4500	6600	1.67	50.57%
47	6600	9400	1.64	49.55%
100	14000	20000	1.64	49.66%

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4 Waveforms

In Figure 3, the initial press sets the CLK signal to high. This press also turns on the output CTLx signal. The CLR signal remains high and only dips slightly because the RC delay that is present in the circuit. Another observation is that while the CTLx signal is high, any short presses after the initial turnon does not effect the output.

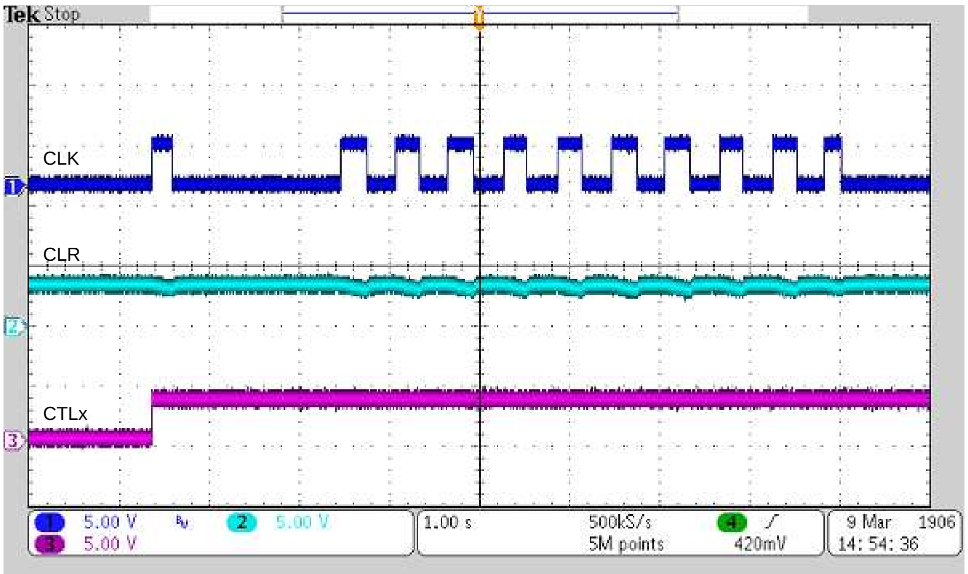

Figure 3. Turnon With Button Press

In Figure 4, the button is held long enough for the CLR signal to decay enough that the D-type flip-flop now detects the CLR signal as low. When the CLR signal goes low, it also forces the CTLx signal to go low and turns off whatever it is connected to (for example, a PMIC).

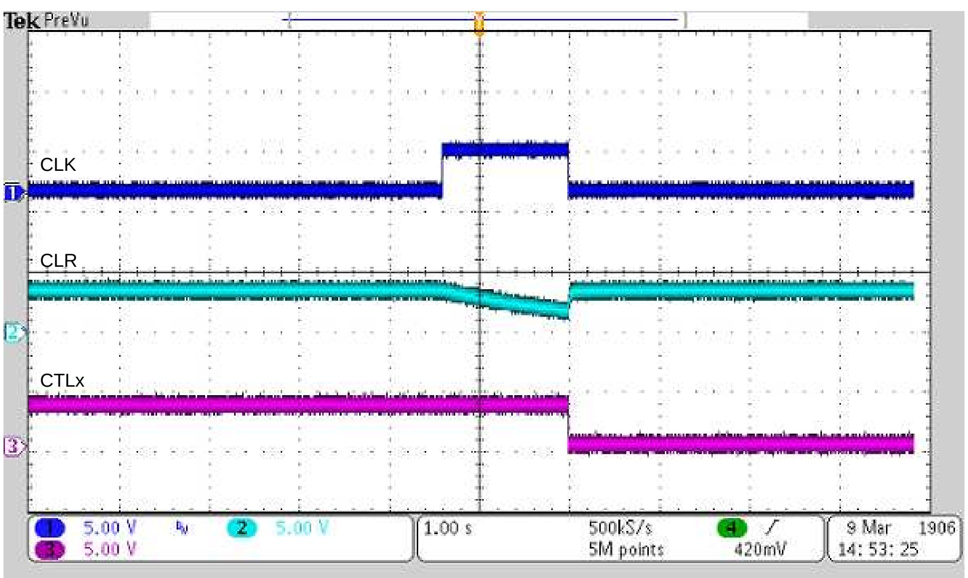

Figure 4. Turnoff With Button Hold

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In Figure 5, the CTLx signal is turned off and then turned on shortly afterward. This action is partly because of the diode in place with the RC circuit, which allows the short time between turnoff and turnon and between turnon and turnoff.

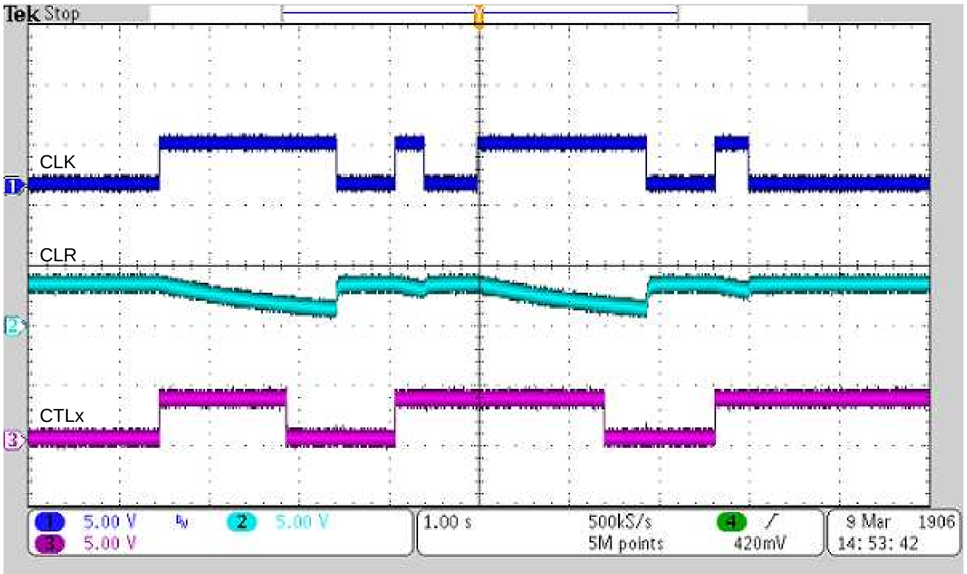

Figure 5. Quick Turnaround Between On and Off

5 Bill of Materials

Table 3 lists the bill of materials (BOM).

Table 3. BOM

Count	Reference Designator	Value	Description	Size	Part Number	MFR
3	C1 – C3	1 µF	Capacitor, Ceramic, 6.3 V, X5R, 20%	0201	GRM033R60J105MEA2D	Murata
1	C4	10 µF	Capacitor, Ceramic, 6.3 V, X5R, 20%	0402	C1005X5R0J106M050BC	TDK
1	D1	10 V	Diode, Schottky, 10 V, 3 A	SOD-323F	PMEG1030EJ,115	NXP
1	R1	1 kΩ	RES, Chip, 5%, 0.063W	0402	CRCW04021K00JNED	Vishay
1	R2	200 kΩ	RES, Chip, 5%, 0.063W	0402	CRCW0402200KJNED	Vishay
1	S1	—	Switch, Push-Button, SMD	—	SKRKAEE010	ALPS
1	U1	—	Single Schmitt-Trigger Inverter	—	SN74VC1G14DCKR	TI
1	U2	—	Single D-Type Flip-Flop with Asynchronous Clear	—	SN74VC1G175DCKR	TI
1	U3	—	Single Schmitt-Trigger Buffer	—	SN74LVC1G17DCKR	TI

6 Conclusion

The push-button circuit is a simple circuit that allows for a system to turn on with a short button press and turn off when the button is held down. As mentioned previously, this circuit pairs well with PMICs, because the PMIC can provide input voltage or both the push-button circuit and the PMIC can be powered from the same source. In conclusion, the push-button circuit is a simple addition to a PMIC circuit that requires few parts with a small footprint on the board.

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7 Related Documentation

1. Texas Instruments, *SN74LVC1G175 Single D-Type Flip-Flop with Asynchronous Clear* data sheet
2. Texas Instruments, *SN74LVC1G14 Single Schmitt-Trigger Inverter* data sheet
3. Texas Instruments, *SN74LVC1G17 Single Schmitt-Trigger Buffer* data sheet
4. Texas Instruments, *TPS65086 Configurable Multirail PMU for Multicore Processors* data sheet

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from A Revision (July 2017) to B Revision **Page**

- Changed the *Push-Button Schematic* 2

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