Product Overview

Transitioning to TPUL Family Monostable Multivibrators

Overview

The TPUL family of monostable multivibrators is designed to be fully compatible with existing legacy monostable multivibrator offerings across multiple logic families from Texas Instruments. These new devices offer improved power consumption and accuracy while maintaining the same functionality, packages, and pinouts as the legacy devices.

Due to the unique output pulse timing non-linearity of each legacy device, which is influenced by process, voltage, temperature, and RC timing component variations, it is not possible to create a new device using a new technology node that perfectly matches any legacy device. Instead, the TPUL pulse generators target timing similarity with the majority of legacy devices. In most cases, replacing the timing resistor allows matching of the legacy device timing.

Device Comparison

The TPUL logic family is based on the latest technology from Texas Instruments, providing improvements to many existing families. The devices were designed to match or exceed performance for existing devices to provide the best transition from legacy devices to new devices in the majority of use cases.

Table 1 provides a quick reference table for replacing legacy devices with new TPUL function devices. Table 1 includes the expected pulse width error for a typical application if the external timing components are not modified, as well as the replacement resistor value to eliminate the error. These values are based on specific conditions: V_{CC} = 5V, R_{ext} = 10kΩ, and C_{ext} = 0.1µF. The following sections provide more detailed explanations for designing the new TPUL devices into an existing system.

Table 1. Quick reference for device conversion

Legacy Device	TPUL	Legacy Output Pulse Width (t_{wo})	New Output Pulse Width (t_{wo})	% Change	$R_{new} = R_{old} \times K_{old}/K_{new}$ (nearest 1% value) Ω
CD74HC123	2G123	450µs	886µs	+98%	5062 (5.05k)
SN74LV123A	2G123	1ms	886µs	-11%	11249 (11.3k)
SN74LV123A-Q1	2G123-Q1	1ms	886µs	-11%	11249 (11.3k)
SN74AHC123A	2G123	1ms	886µs	-11%	11249 (11.3k)
SN74AHCT123A	2T123	1ms	886µs	-11%	11249 (11.3k)
CD74HCT123	2T123	1ms	886µs	-11%	11249 (11.3k)
CD74HC423	2G122	450µs	886µs	+98%	5062 (5.05k)
CD74HCT423	2T122	450µs	886µs	+98%	5062 (5.05k)
CD14538	2G122A	995µs	886µs	-11%	11192 (11.1k)
CD74HC4538	2G122A	700µs	886µs	+27%	7874 (7.87k)
CD74HC4538-Q1	2G122A-Q1	700µs	886µs	+27%	7874 (7.87k)
CD74HCT4538	2T122A	700µs	886µs	+27%	7874 (7.87k)
CD74HC221	2G223	700µs	886µs	+27%	7874 (7.87k)
SN74LV221A	2G223	1ms	886µs	-11%	11249 (11.3k)
SN74LV221A-Q1	2G223-Q1	1ms	886µs	-11%	11249 (11.3k)
CD74HCT221	2T223	700µs	886µs	+27%	7874 (7.87k)

Table 1. Quick reference for device conversion (continued)

Legacy Device	TPUL	Legacy Output Pulse Width (t_{wo})	New Output Pulse Width (t_{wo})	% Change	$R_{new} = R_{old} \times K_{old}/K_{new}$ (nearest 1% value) Ω
SN74123	2G123	250µs	886µs	+256%	2812 (2.8k)
SN74LS123	2G123	250µs	886µs	+256%	2812 (2.8k)

Table 2 provides a quick reference for comparing different logic family performance characteristics.

Table 2. Specification Comparison for Common Monostable Multivibrator Logic Families

	Family						
Specification	**HC**	**HCT**	**LV-A**	**LS**	**TTL (7400)**	**CD4000**	**TPUL2G123**
Supply voltage range	2V - 6V	4.5V - 5.5V	2V - 5.5V	4.75V - 5.75V	4.75V - 5.75V	3V - 18V	1.5V - 5.5V
Output drive current (5V)	4mA	4mA	12mA	8mA	16mA	1mA	12mA
Static supply current (max)	160µA	160µA	20µA	20mA	66mA	100µA	2µA
Active supply current (max)	-	-	975µA	20mA	66mA	-	195µA

Modifying an Existing Design for Drop-In Replacement

The vast majority of designs only require a resistor value change to use the new TPUL family of logic. Some designs do not require any external component changes. The equation to change only a resistor is shown in Equation 1.

$$R_{new} = \frac{K_{old}}{K_{new}} R_{old} \tag{1}$$

The K variable in Equation 1 comes from the monostable multivibrator pulse width equation, Equation 2. The K factor value can be found in the data sheet for each individual device and is dependent on multiple variables.

$$t_{wo} = K R_{ext} C_{ext} \tag{2}$$

Steps to transition from legacy to TPUL:

1. Identify the operational pulse width of the legacy device.
   a. Best practice is to measure in the existing system.
   b. Alternatively, refer to the legacy data sheet to determine the expected pulse width based on the timing component values.
2. Identify the existing timing component values (R_{ext}, C_{ext}).
3. Find the new expected pulse width using the original timing components and new TPUL device.
   a. The easiest method is to use the provided Excel-based calculator to get the expected pulse width. Example product folder: TPUL2G123
   b. The data sheet Application and Implementation section provides a method for calculating the expected pulse with without the provided calculator.
4. If the expected pulse width from (3) is within the operational requirements of the system, a direct replacement is recommended. **Stop here.**
5. Adjust timing components to match the desired pulse width.
   - The easiest method is to use the provided Excel-based calculator to get the required resistor and capacitor values to replace the existing components.
   - The alternate method is to adjust only the resistor using Equation 1.

Using the Provided Excel-Based Calculator

The Excel-based calculator is linked in each product folder under the *Design & development* section. This calculator provides three input methods.

The first method, shown in Figure 1, takes the supply voltage, timing resistor, and timing capacitor values and tolerances as inputs, and outputs the expected K Factor, nominal output pulse width, total pulse width range, and total error percentage. These values provide the system designer with important limitations of the accuracy of the TPUL device so that the designer can make informed decisions about the timing component selection. This view is particularly useful when timing components have been selected to provide a detailed look at the expected behavior in a system, especially when manufacturing at volume where tolerances play an important role in system requirements.

Input Supply and RC values, get K factor and pulse width						
		Component Tolerance				
Supply Voltage:		0.0%	3.3	V		
Timing Resistor:		1.0%	10.0E+3	Ω		
Timing Capacitor:		20.0%	100.0E-9	F		
	K Factor	t_w (s)	Tolerance error range[1]		$t_{w(min)}$ (s)	$t_{w(max)}$ (s)
	0.907	906.557E-6	-27.28%	28.15%	659.240E-6	1.162E-3

Figure 1. Calculator Example for Inputting Voltage and Component Values

The second method, shown in Figure 2, takes the supply voltage and desired output pulse width as inputs, and outputs the best options for the timing component values. If the R_{ext} entry is blank, this means that the calculated value was outside the recommended range for the device. In particular, this view is helpful for selecting a resistor value to tune the timing for a particular application.

Input Supply & Pulse width, get suggested RC combinations

SUPPLY VOLTAGE:	3.3	V
DESIRED PULSE WIDTH:	100.0E-6	s

V_{CC}	C_{ext} (F)	R_{ext} (Ω)	t_w (s)	t_w Error(2)
3.3	10.0E-12			
3.3	50.0E-12			
3.3	100.0E-12	859355	100.00E-6	0.0007%
3.3	1.0E-9	99957	100.01E-6	0.0102%
3.3	10.0E-9	10715	100.00E-6	-0.0003%
3.3	100.0E-9			
3.3	1.0E-6			

Figure 2. Calculator Example for Inputting Voltage and Desired Pulse Width Values

The third method, shown in Figure 3, takes the timing resistor and capacitor values as inputs, and outputs the expected K Factor and pulse widths for each common voltage node between 1.5V and 5V. This view is particularly useful in observing variations in pulse width due to supply changes.

Input RC, get pulse width for all supply values

Timing Resistor:	10.0E+3	Ω
Timing Capacitor:	10.0E-9	F

V_{CC}	C_{ext} (F)	R_{ext} (Ω)	K Factor	t_w (s)
1.5	10.0E-9	10000	0.945	94.50E-6
1.8	10.0E-9	10000	0.944	94.40E-6
2.5	10.0E-9	10000	0.939	93.90E-6
3.3	10.0E-9	10000	0.934	93.40E-6
5	10.0E-9	10000	0.913	91.30E-6
5.5	10.0E-9	10000	0.902	90.20E-6

Figure 3. Calculator Example for Inputting Resistor and Capacitor Values

These three methods are provided in the same Excel spreadsheet to give maximum flexibility to the system designer. In many cases, starting with method 2 allows a quick selection of the appropriate timing component values. Then, method 1 can be used to input industry standard component values and tolerances to get the best estimate of performance in the final system design.

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