Voltage Detector (Reset IC) Series

Calculation Method for Delay Time t_{PLH}

For a Reset IC of the adjustable delay time type (free delay time setting), the rise delay time t_{PLH} can be adjusted with the capacitance of a capacitor that is connected to the CT terminal.

This application note explains methods to estimate the rise delay time from the capacitance of the CT capacitor, the ambient temperature, and the voltage conditions.

Calculation formula for delay time t_{PLH}

Among the Reset ICs of the adjustable delay time type, the calculation formula for BD52xx-2C and BD53xx-2C is different from that for other models (BD52xx, BD53xx, BU42xx, and BU43xx). Since BD52xx-2C and BD53xx-2C are automotive grade models, the “delay coefficient” is specified based on the temperature and variations.

For other models, the calculation is executed by substituting values that reflect factors such as the internal resistance of the CT terminal (R_{CT}), the variations in the release voltage, and the temperature into the formula.

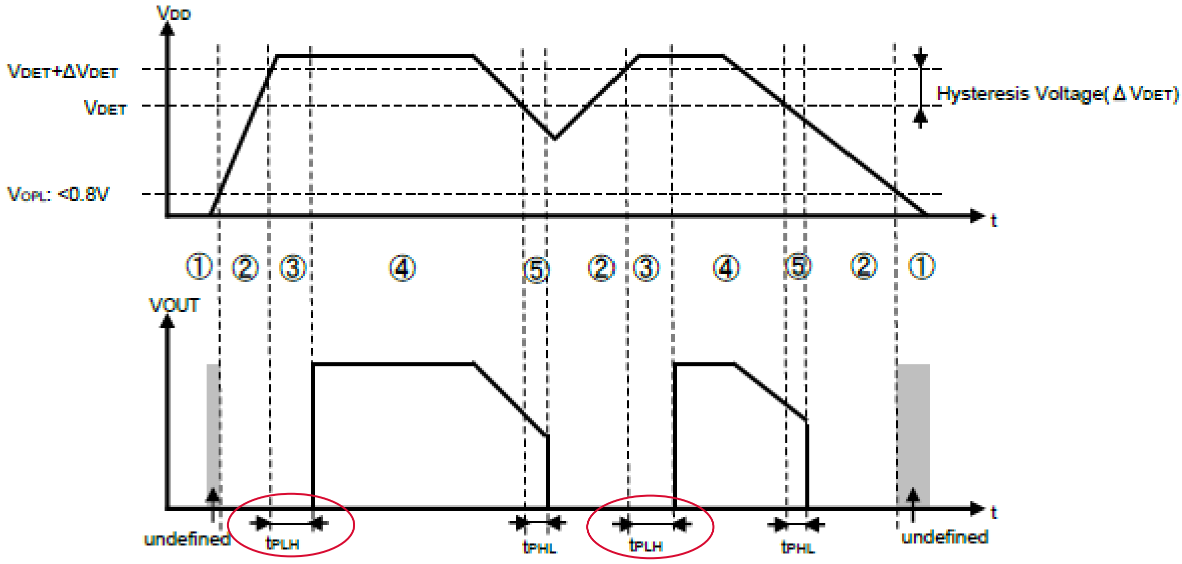

Figure 1. Relation of power supply rising and falling waveform and delay time t_{PLH}

The delay time t_{PLH} represents the time after V_{DD} exceeds the release voltage V_{DET} + ΔV_{DET} until the reset output V_{OUT} rises (more precisely, until V_{OUT} reaches half of its final voltage).

◆ Calculation formula (BD52xx/BD53xx/BU42xx/BU43xx)

Series	Calculation formula for delay time
BD52xx/BD53xx BD52Exx/BD53Exx BD52Exx/BD53Exx-M BU42xx/BU43xx	$t_{PLH}=-1\times C_{CT}\times R_{CT}\times \ln((V_{DD}-V_{CTH})/V_{DD})$

◆ Calculation formula (BD52xx-C/53xx-2C)

Series※	Calculation formula for delay time
BD52xx/BD53xx-2C	$t_{PLH}=C_{CT}\times$ Delay coefficient $+t_{CTO}$

Example of t_{PLH} calculation (BD52xx/BD53xx)

Series	Calculation formula for delay time
BD52xx/BD53xx BD52Exx/BD53Exx BD52Exx/BD53Exx-M BU42xx/BU43xx	$t_{PLH}=-1\times C_{CT}\times R_{CT}\times \ln((V_{DD}-V_{CTH})/V_{DD})$

Take the operating power supply voltage as V_{DD} of $(V_{DD} - V_{CTH})/V_{DD}$ in the formula. For the calculation of the delay time, an arbitrary value of V_{DD} gives the same result.

Example: $(V_{DD} - 0.5V_{DD})/V_{DD} = (1 - 0.5)/1 = 0.5$

Calculation example models BD5230/BD5330 (V_{DET} = 3.0 [V])

Operating conditions C_{CT} = 1,000 [pF], Ta = 25 [°C], V_{DD} = 3 [V]

◆ Parameters R_{CT}, V_{CTH}

Series	Ta Range [℃]	Ta[℃]	R_{CT} [MΩ]*	
			Typ	Min/Max
BD52xx/BD53xx BD52Exx/BD53Exx BD52Exx/BD53Exx-M	-40～105	105	5.70	±50%
		85	6.50	±50%
		25	9.00	±39%
		-40	12.0	±50%

*The values are not guaranteed.

Series	V_{CTH} [V]			
	VDET Range	Min	Typ	Max
BD52xx/BD53xx BD52Exx/BD53Exx BD52Exx/BD53Exx-M	2.3～2.6V	0.30VDD	0.40VDD	0.60VDD
	2.7～4.2V	0.30VDD	0.45VDD	0.60VDD
	4.3～5.2V	0.35VDD	0.50VDD	0.60VDD
	5.3～6.0V	0.40VDD	0.50VDD	0.60VDD

From the parameters above

$V_{CTH}(Min)=V_{DD}\times 0.30$, $V_{CTH}(Typ)=V_{DD}\times 0.45$, $V_{CTH}(Max)=V_{DD}\times 0.60$

$R_{CT}(Min)=5.70\times 0.5=2.85$[MΩ] (105[℃])

$R_{CT}(Typ)=9.00\times 1.0=9.00$[MΩ] (25[℃])

$R_{CT}(Max)=12.0\times 1.5=18.0$[MΩ] (-40[℃])

$t_{PLH}(Min)$, $t_{PLH}(Typ)$, $t_{PLH}(Max)$ in all temperature

$t_{PLH}(Min) =-1\times C_{CT}\times R_{CT}(Min)\times \ln\{(V_{DD}-V_{CTH}(Min))/V_{DD}\}$

$=-1\times(1000E-12)\times(2.85E+6)\times \ln\{(V_{DD}-0.30V_{DD})/V_{DD}\}$

$=-1\times(1000E-12)\times(2.85E+6)\times \ln\{0.7\}$

$=(-0.00285)\times(-0.356)=1.02E-3=1.02$[ms]

$t_{PLH}(Typ) =-1\times C_{CT}\times R_{CT}(Typ)\times \ln\{(V_{DD}-V_{CTH}(Typ)/V_{DD}\}$

$=-1\times(1000E-12)\times(9E+6)\times \ln\{(V_{DD}-0.45V_{DD})/V_{DD}\}$

$=-1\times(1000E-12)\times(9E+6)\times \ln\{0.55\}$

$=(-0.009)\times(-0.598)=5.38E-3=5.38$[ms]

$t_{PLH}(Max) =-1\times C_{CT}\times R_{CT}(Max)\times \ln\{(V_{DD}-V_{CTH}(Max))/V_{DD}\}$

$=-1\times(1000E-12)\times(18E+6)\times \ln\{(V_{DD}-0.60V_{DD})/V_{DD}\}$

$=-1\times(1000E-12)\times(18E+6)\times \ln\{0.4\}$

$=(-0.018)\times(-0.916)=16.49E-3=16.5$[ms]

Example of t_{PLH} calculation (BU42xx/BU43xx)

Series	Calculation formula for delay time
BD52xx/BD53xx BD52Exx/BD53Exx BD52Exx/BD53Exx-M BU42xx/BU43xx	$t_{PLH}=-1\times C_{CT}\times R_{CT}\times \ln((V_{DD}-V_{CTH})/V_{DD})$

Take the operating power supply voltage as V_{DD} of $(V_{DD} - V_{CTH})/V_{DD}$ in the formula. For the calculation of the delay time, an arbitrary value of V_{DD} gives the same result.

Example: $(V_{DD} - 0.5V_{DD})/V_{DD} = (1 - 0.5)/1 = 0.5$

Calculation example models BU4230/BU4330 (V_{DET} = 3.0 [V])

Operating conditions C_{CT} = 1,000 [pF], Ta = 25 [°C], V_{DD} = 3 [V]

◆ Parameters R_{CT}, V_{CTH}

Series	Ta Range [℃]	Ta[℃]	R_{CT} [MΩ]*	
			Typ	Min/Max
BU42xx/BU43xx	-40～125	125	6.80	±20%
		105	7.40	±20%
		85	8.10	±20%
		25	10.0	±10%
		-40	13.5	±20%

*The values are not guaranteed.

Series	V_{CTH} [V]			
	VDET Range	Min	Typ	Max
BU42xx/BU43xx	0.9～2.5V	0.35VDD	0.45VDD	0.55VDD
	2.6～4.8V	0.40VDD	0.50VDD	0.60VDD

From the parameters above

$V_{CTH}(Min)=V_{DD}\times 0.40$, $V_{CTH}(Typ)=V_{DD}\times 0.50$, $V_{CTH}(Max)=V_{DD}\times 0.60$

$R_{CT}(Min)=6.80\times 0.8=5.44$[MΩ] (125[℃])

$R_{CT}(Typ)=10.0\times 1.0=10.0$[MΩ] (25[℃])

$R_{CT}(Max)=13.5\times 1.2=16.2$[MΩ] (-40[℃])

$t_{PLH}(Min)$, $t_{PLH}(Typ)$, $t_{PLH}(Max)$ in all temperature

$t_{PLH}(Min) =-1\times C_{CT}\times R_{CT}(Min)\times \ln\{(V_{DD}-V_{CTH}(Min))/V_{DD}\}$

$=-1\times(1000E-12)\times(5.44E+6)\times \ln\{ (V_{DD}-0.40V_{DD})/V_{DD}\}$

$=-1\times(1000E-12)\times(5.44E+6)\times \ln\{0.60\}$

$=(-0.00544)\times(-0.511)=2.78E-3=2.78$[ms]

$t_{PLH}(Typ) =-1\times C_{CT}\times R_{CT}(Typ)\times \ln\{(V_{DD}-V_{CTH}(Typ)/V_{DD}\}$

$=-1\times(1000E-12)\times(10E+6)\times \ln\{ (V_{DD}-0.50V_{DD})/V_{DD}\}$

$=-1\times(1000E-12)\times(10E+6)\times \ln\{0.50\}$

$=(-0.01)\times(-0.693)=6.93E-3=6.93$[ms]

$t_{PLH}(Max) =-1\times C_{CT}\times R_{CT}(Max)\times \ln\{(V_{DD}-V_{CTH}(Max))/V_{DD}\}$

$=-1\times(1000E-12)\times(16.2E+6)\times \ln\{ (V_{DD}-0.60V_{DD})/V_{DD}\}$

$=-1\times(1000E-12)\times(16.2E+6)\times \ln\{0.40\}$

$=(-0.0162)\times(-0.916)=14.8E-3=14.8$[ms]

Example of t_{PLH} calculation (BD52xx-2C/BD53xx-2C)

Series	Calculation formula for delay time
BD52xx/BD53xx-2C	$t_{PLH}=C_{CT}\times$ Delay coefficient $+t_{CTO}$

A “delay coefficient” that reflects the temperature and variations is used for BD52xx/53xx-2C.

Min and Max are ±50% of Typ.

◆ Parameters: delay coefficient, t_{CTO}

Ta[℃]=-40～125	Min	Typ	Max
Delay coefficient	(5.55E+06)×0.5	(5.55E+06)×1	(5.55E+06)×1.5
Internal delay t_{CTO} [s]*	15E-06	50E-06	150E-06

When the value of the CT capacitor is 1,000 pF or larger, t_{CTO} can be ignored.

Applicable models BD5230-2C/BD5330-2C

Operating conditions C_{CT} = 100 [pF]

t_{PLH}(Min) = C_{CT} × Delay coefficient + t_{CTO} = 100E-12 × 5.55E + 6 × 0.5 + 15E-6 = 292 [µs]

t_{PLH}(Typ) = C_{CT} × Delay coefficient + t_{CTO} = 100E-12 × 5.55E + 6 × 1.0 + 50E-6 = 605 [µs]

t_{PLH}(Max) = C_{CT} × Delay coefficient + t_{CTO} = 100E-12 × 5.55E + 6 × 1.5 + 150E-6 = 983 [µs]

Operating conditions C_{CT} = 1,000 [pF]

t_{PLH}(Min) = C_{CT} × Delay coefficient + t_{CTO} = 1000E-12 × 5.55E + 6 × 0.5 = 2.78 [ms]

t_{PLH}(Typ) = C_{CT} × Delay coefficient + t_{CTO} = 1000E-12 × 5.55E + 6 × 1.0 = 5.55 [ms]

t_{PLH}(Max) = C_{CT} × Delay coefficient + t_{CTO} = 1000E-12 × 5.55E + 6 × 1.5 = 8.33 [ms]

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