

USB Hi-Speed Switch with Fault Protection

Features

- Operating Range: 2.7V to 5.5V
- USB Hi-Speed Dual SPDT Switch
- >1GHz -3db Bandwidth
- Low 3.8Ω Switch On-Resistance
- Typical 2.0pF Switch On-Capacitance
- Overvoltage Protection Up to +20V
- Surge Protection Up to +25V
- $\overline{\text{FLAG}}$ open drain output overvoltage indicator
- $\overline{\text{EN}}$ to disable switch output
- WLCSP34-12 package (1.17mm x 1.57mm)
- -40°C to +85°C Temperature Range

Brief Description

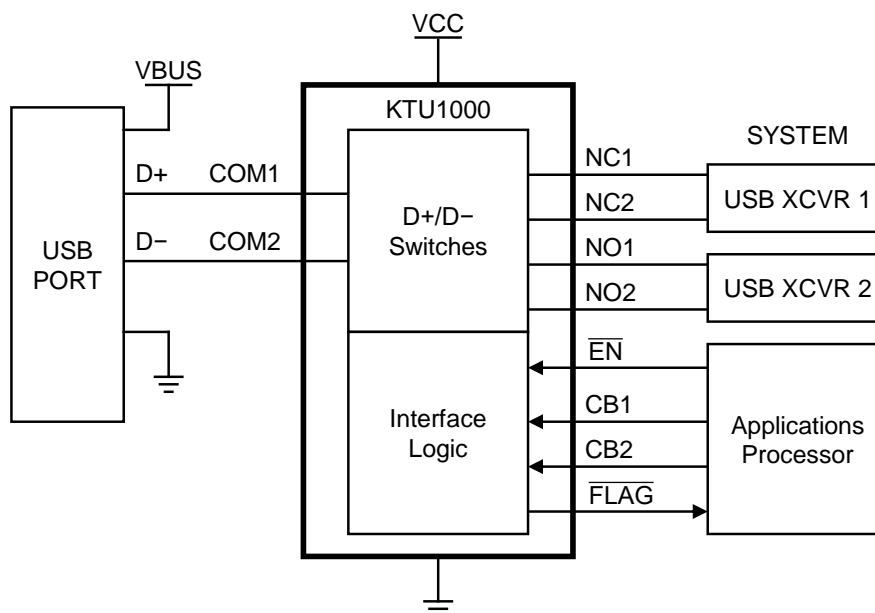
The KTU1000 is a Hi-Speed USB dual SPDT (single-pole/double-throw) switch with overvoltage protection. This device operates over a 2.7V to 5.5V input supply range with over voltage fault protection up to 20V. USB Type-C features high voltage charging where the KTU1000 protects USB data lines from short circuit and surge events that can permanently damage the mobile system. The device features independent control bits for each switch pair and an on/off enable ($\overline{\text{EN}}$) for shutdown mode. Additional features include low switch on resistance and capacitance along with a fault flag ($\overline{\text{FLAG}}$) to alert the system processor to overvoltage fault events.

The KTU1000 has low power consumption and is available in an ultra-small 12-Bump 1.17mm x 1.57mm WLCSP package making it an ideal solution for USB interface switching and protection in mobile applications.

Applications

- Smartphones
- USB Type-C
- Mobile Internet Devices
- Tablet Computers
- Peripherals

Typical Application

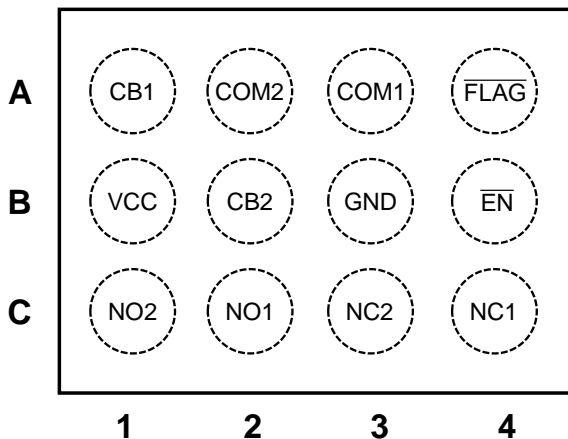


Pin Descriptions

Pin #	Name	Function
A1	CB1	Digital Control Input 1
A2	COM2	Common Terminal for I/O Switch 1 (Connect to D+ or D-)
A3	COM1	Common Terminal for I/O Switch 2 (Connect to D- or D+)
A4	FLAG	Active low fault flag output signal to alert fault event
B1	VCC	Input Supply Voltage input pin
B2	CB2	Digital Control Input 2
B3	GND	Ground. Connect this pin to system ground.
B4	EN	Active low enable input. Drive EN to a logic high level to disable the device and place switches to a high impedance state.
C1	NO2	Normally Open Terminal for USB I/O Switch 2
C2	NO1	Normally Open Terminal for USB I/O Switch 1
C3	NC2	Normally Closed Terminal for USB I/O Switch 2
C4	NC1	Normally Closed Terminal for USB I/O Switch 1

WLCSP34-12

TOP VIEW



TOP VIEW



12-Bump 1.17mm x 1.57mm x 0.62mm
WLCSP Package

Top Mark

WW = Device ID Code,
XX = Date Code, YY = Assembly Code,
ZZZZ = Serial Number

Absolute Maximum Ratings¹

(T_A = 25°C unless otherwise noted)

Symbol	Description	Value	Units
VCC	Input voltage	-0.3 to 8	V
CB1, CB2, EN, FLAG	CB1, CB2, EN, FLAG	-0.3 to 6	V
COM1, COM2	I/O Voltage (2.7V < V _{CC} < 5.5V)	-2 to 20	V
	Surge IEC61000-4-5	25	
NO1, NO2, NC1, NC2	I/O Voltage	-0.3 to 6	V
T _s	Storage Temperature Range	-65 to 150	°C
T _{LEAD}	Maximum Soldering Temperature (at leads, 10 sec)	260	°C
I _{SW}	Switch I/O Current (Continuous)	25	mA
T _s	Storage Temperature Range	-65 to 150	°C
T _{LEAD}	Maximum Soldering Temperature (at leads, 10 sec)	260	°C

Thermal Capabilities

Symbol	Description	Value	Units
θ _{JA}	Thermal Resistance – Junction to Ambient ²	74	°C/W
P _D	Maximum Power Dissipation at T _A ≤ 25°C	1697	mW

Ordering Information

Part Number	Marking	Operating Temperature	Package
KTU1000EUX-TR	KYXXYYZZZZ ³	-40°C to +85°C	WLCSP-12

1. Stresses above those listed in Absolute Maximum Ratings may cause permanent damage to the device. Functional operation at conditions other than the operating conditions specified is not implied. Only one Absolute Maximum rating should be applied at any one time.
2. Junction to Ambient thermal resistance is highly dependent on PCB layout. Values are based on thermal properties of the device when soldered to an EV board.
3. XX = Date Code, YY = Assembly Code, ZZZZ = Serial Number.

Electrical Characteristics⁴

Unless otherwise noted, the *Min* and *Max* specs are applied over the full operation temperature range of -40°C to $+85^{\circ}\text{C}$, while *Typical* values are specified at room temperature (25°C). $V_{CC} = 2.7\text{V}$ to 5.5V .

Symbol	Description	Conditions	Min	Typ	Max	Units
General Operating Conditions						
V_{CC}	Input operating range		2.7		5.5	V
V_{SW}	Analog V_{IO} Signal Range	$V_{CC} = 2.7\text{V}$ to 5.5V	-0.5		V_{FP}	V
V_{UVLO}	Under Voltage Lockout Threshold			2.0	2.5	V
I_{CC}	Supply Current	$V_{CC} = 3.0\text{V}$, $V_{EN} = V_{CC}$		0.1	1	μA
		$V_{CC} = 3.0\text{V}$, $V_{CB} = V_{CC}$, $V_{EN} = 0\text{V}$		25	40	μA
V_{FP}	COM Overvoltage Detect Threshold	$V_{CC} = 3.0\text{V}$, V_{IN} rising	4.5	4.8	5.1	V
		$V_{CC} = 3.0\text{V}$, V_{IN} falling		4.3		V
t_{FP}	Fault Protection Response Time	$V_{COM} = 1\text{V}$ to 10V step, $V_{CC} = 3.0\text{V}$; Figure 1			100	ns
t_{FPR}	Fault Protection Recovery Time	$V_{COM} = 10\text{V}$ to 1V step, $V_{CC} = 3.0\text{V}$; Figure 1		26		μs
R_{ON}	On-Resistance	$V_{COM} = 0\text{V}$ to V_{CC} , $I_{COM_} = 10\text{mA}$		3.8	8	Ω
$R_{ON[MATCH]}$	On-Resistance Match between channels	$V_{COM} = 0\text{V}$ to V_{CC} , $I_{COM_} = 10\text{mA}$			0.2	Ω
$R_{ON[FLAT]}$	On-Resistance Flatness	$V_{COM} = 0\text{V}$ to V_{CC} , $I_{COM_} = 10\text{mA}$			0.3	Ω
$I_{COM_}(OFF)$	COM_ Off Leakage Current	$V_{CC} = V_{EN} = 3.0\text{V}$, $V_{COM} = 3.0\text{V}$, $V_{NC} = 0\text{V}$	0	5	10	μA
$I_{NC_}(OFF)$	NC_ Off Leakage Current	$V_{CC} = V_{COM} = 3.0\text{V}$, $V_{NC} = 0\text{V}$		0.1	1	μA
Timing – Figures 2 and 3						
$t_{ON[WAKEUP]}$	IC Wake-Up Turn On Time	$V_{CC} = 3.0\text{V}$, $V_{COM} = 1.5\text{V}$, $R_L = 50\Omega$, $V_{EN} = 0\text{V}$, $V_{CB} = 0\text{V}$ to V_{CC} , Figure 3		14		μs
$t_{ON[SW]}$	SW Transition Turn On Time	$V_{CC} = 3.0\text{V}$, $V_{COM} = 1.5\text{V}$, $R_L = 50\Omega$, $V_{EN} = 0\text{V}$, $V_{CB} = 0\text{V}$ to V_{CC} , Figure 2a		28		μs
$t_{OFF[SW]}$	SW Transition Turn Off Time	$V_{CC} = 3.0\text{V}$, $V_{COM} = 1.5\text{V}$, $R_L = 50\Omega$, $V_{EN} = 0\text{V}$, $V_{CB} = 0\text{V}$ to V_{CC} , Figure 2a		1		μs
t_D	Break-Before-Make Time Delay	$R_L = 50\Omega$		28		μs
$C_{COM}(OFF)$	Off Capacitance	$V_{COM} = 0.5\text{V}_{p-p}$, DC bias = 0V , $f = 1\text{MHz}$		1.5		pF
$C_{COM}(ON)$	On Capacitance	$V_{COM} = 0.5\text{V}_{p-p}$, DC bias = 0V , $f = 1\text{MHz}$		2.0		pF
AC Performance						
BW	-3dB Bandwidth	$R_S = R_L = 50\Omega$, $V_{COM} = 0\text{dBm}$		>1		GHz
V_{ISO}	Off Isolation	$f = 100\text{kHz}$, $V_{COM} = 0.5\text{V}_{p-p}$, $R_S = R_L = 50\Omega$		-70		dB
V_{CT}	Crosstalk	$f = 100\text{kHz}$, $V_{COM} = 0.5\text{V}_{p-p}$, $R_S = R_L = 50\Omega$		-80		dB
Logic Input, Enable, CB1, CB2						
V_{IH}	Input Logic High		1.2			V
V_{IL}	Input Logic Low				0.4	V
I_{LK_IN}	Input Leakage Current	$\overline{EN} = CB_ = 0\text{V}$ or V_{CC}	-1		1	μA
Fault Flag						
V_{OL}	\overline{FLAG} Output Voltage Low	$V_{IO} = 3.3\text{V}$, $I_{SINK} = 1\text{mA}$		0.1	0.4	V
I_{LK_OUT}	\overline{FLAG} Output Leakage Current	$V_{IO} = 3.3\text{V}$, \overline{FLAG} de-asserted	-1		1	μA

4. KTU1000 is guaranteed to meet performance specifications over the -40°C to $+85^{\circ}\text{C}$ operating temperature range by design, characterization and correlation with statistical process controls.

Timing Diagrams

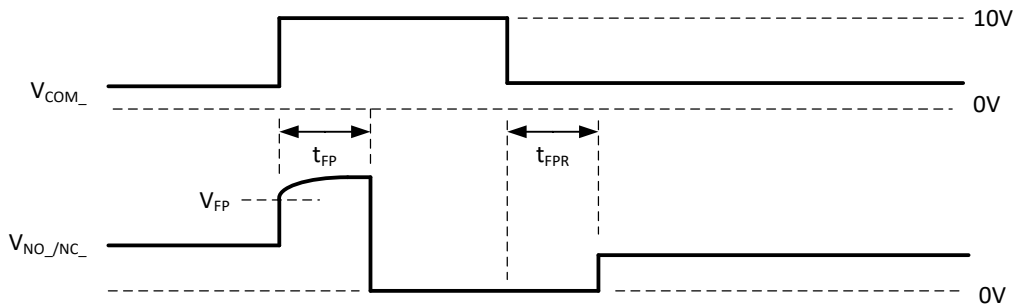


Figure 1. Fault Protection Timing Diagram

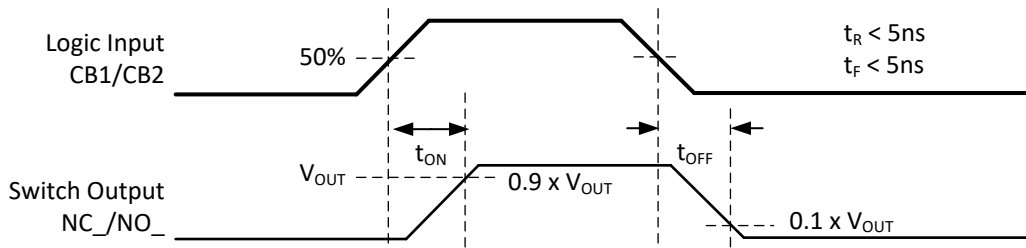


Figure 2a. USB COM1/2 On - Off Switch Control Timing Diagram

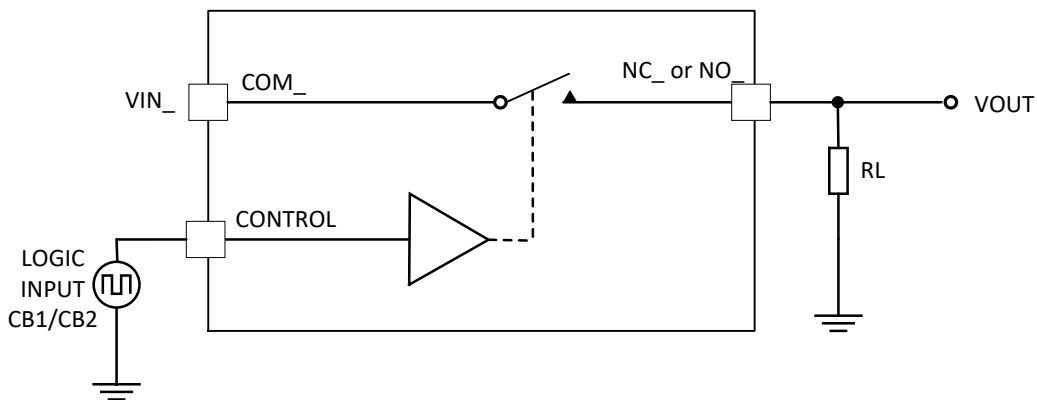


Figure 2b. Switch Timing Test Circuit

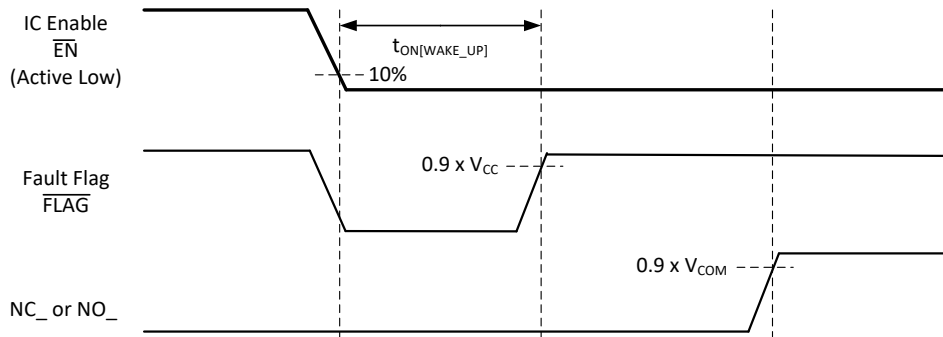


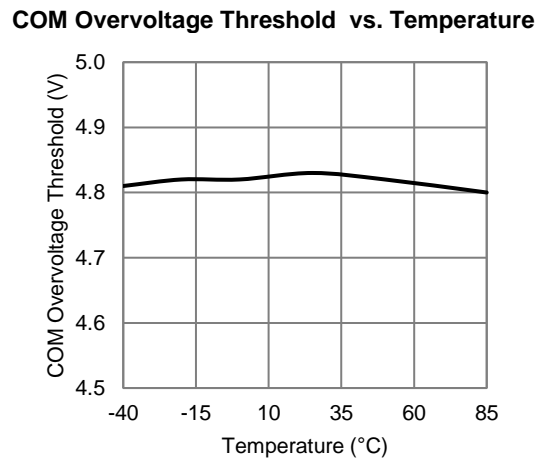
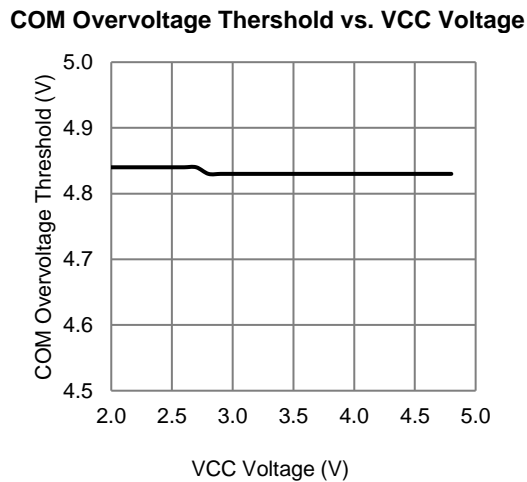
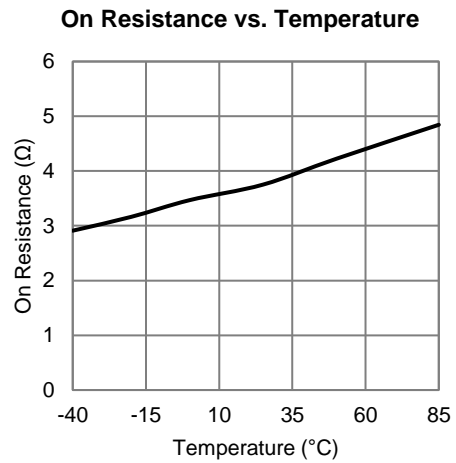
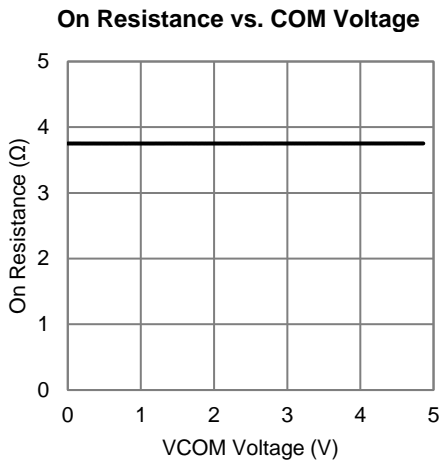
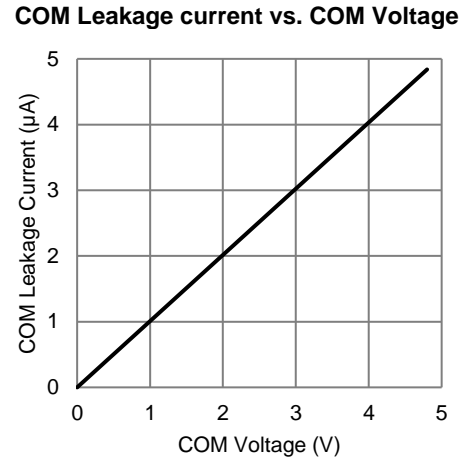
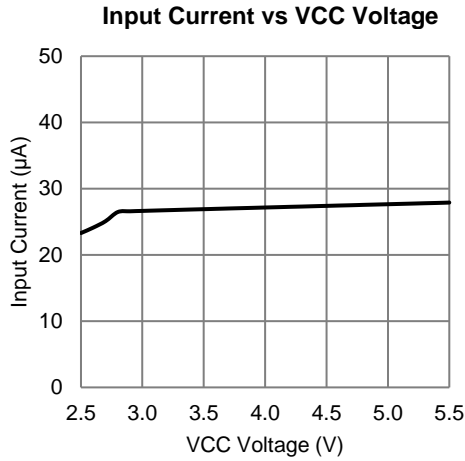
Figure 3. IC Wake-Up Timing Diagram

Enable and Control Input Truth Table

Control Logic Inputs			Switch Status	
EN	CB1	CB2	COM1	COM2
0	0	0	NC1	NC2
0	0	1	NC1	NO2
0	1	0	NO1	NC2
0	1	1	NO1	NO2
1	X	X	OPEN	OPEN

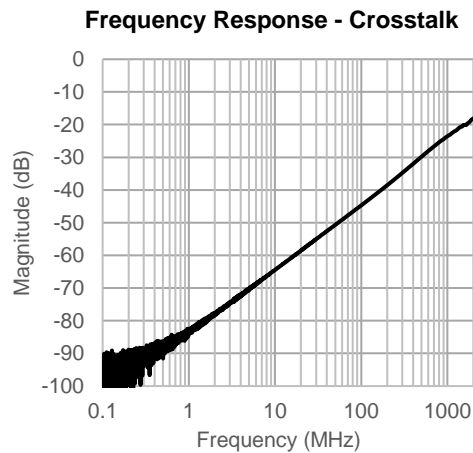
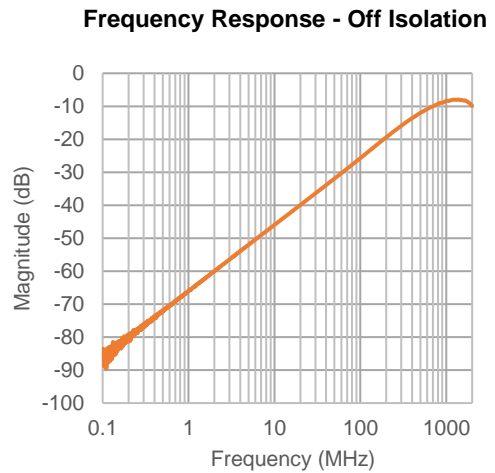
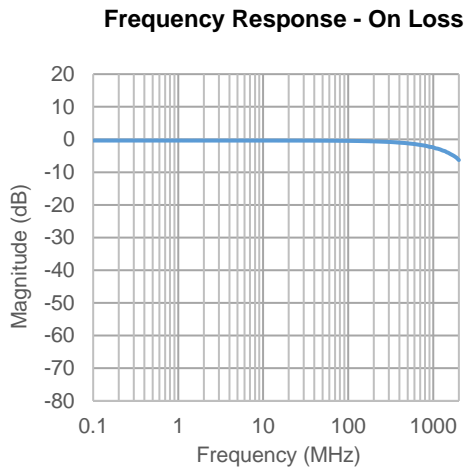
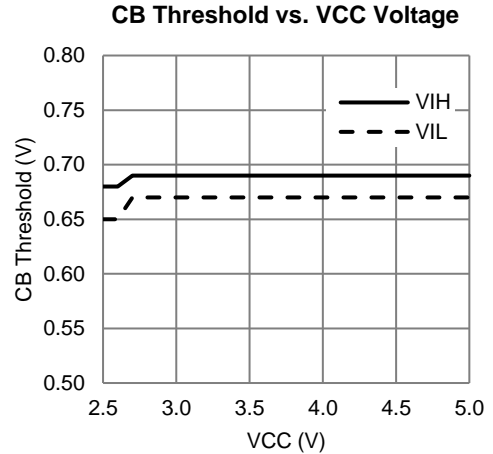
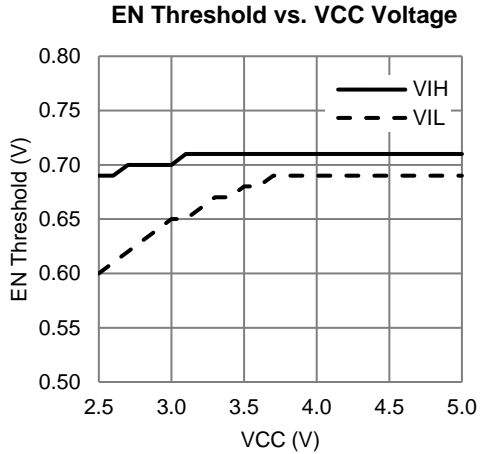
Typical Characteristics

VCC = 3V, C_{VCC} = 1μF, T_{AMB} = 25°C unless otherwise specified.

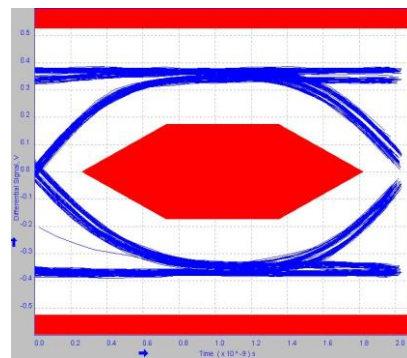


Typical Characteristics (continued)

VCC = 3V, C_{VCC} = 1μF, T_{AMB} = 25°C unless otherwise specified.



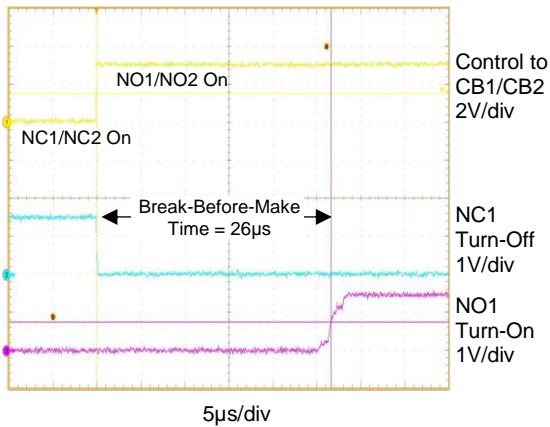
Eye Diagram USB 2.0 High-Speed



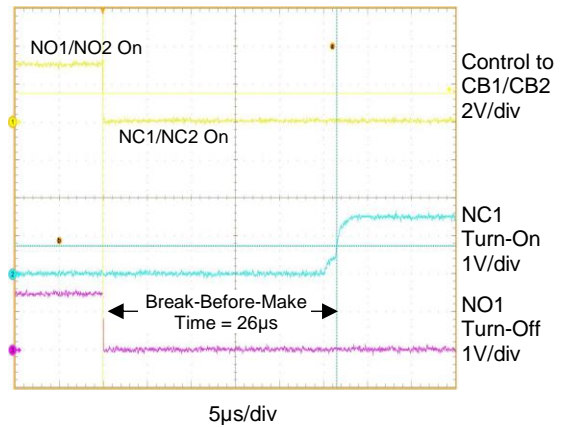
Typical Characteristics (continued)

VCC = 3V, C_{VCC} = 1μF, T_{AMB} = 25°C unless otherwise specified.

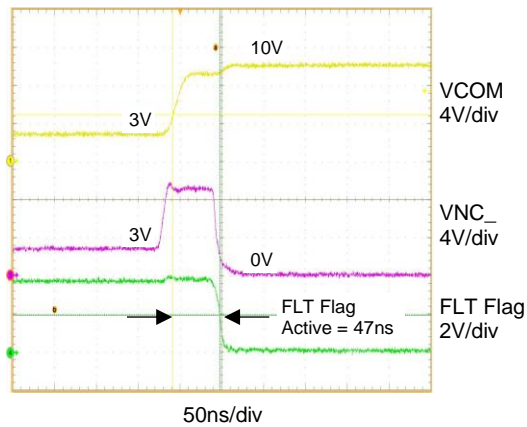
NC1 to NO1 Switch Break-Before-Make Timing



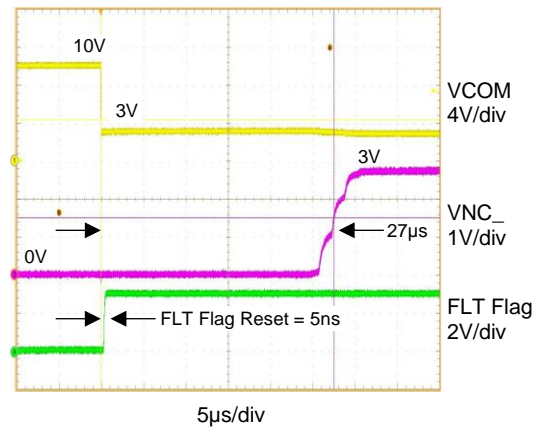
NO1 to NC1 Switch Break-Before-Make Timing



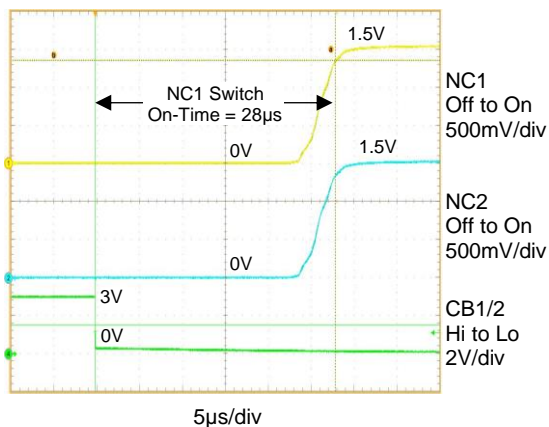
COM Input OVP to NC Output Shutdown Fault Flag Reporting Time



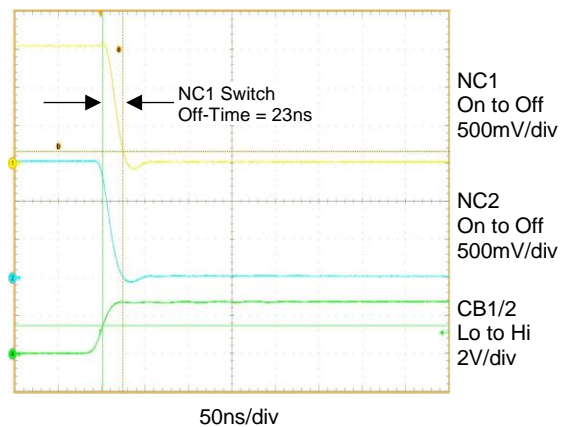
COM Input OVP to NC Output Recovery Time



Switch On-Time for NC1



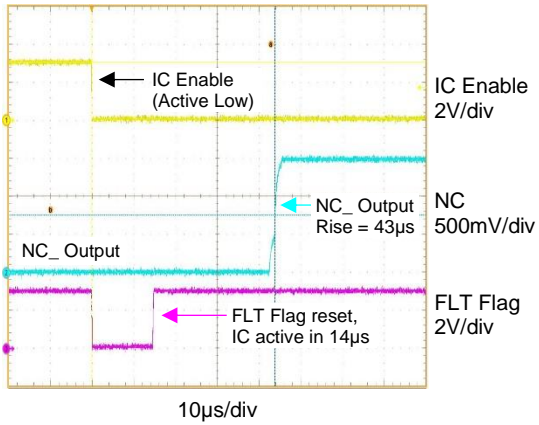
Switch Off-Time for NC1

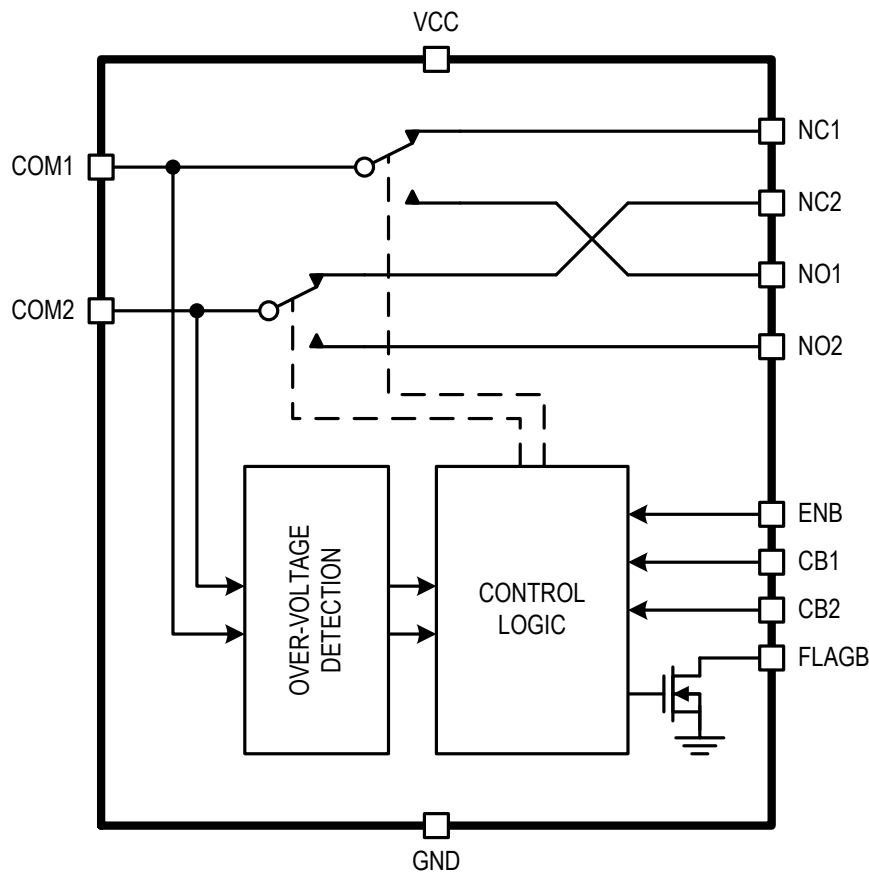


Typical Characteristics (continued)

VCC = 3V, C_{VCC} = 1μF, T_{AMB} = 25°C unless otherwise specified.

IC Turn-On Time From Enable



Functional Block Diagram

Figure 4. Functional Block Diagram
Functional Description

The KTU1000 is a SPDT analog switch intended for 2:1 MUX operation for USB 2.0 Low (LS), Full (FS) and High Speed (HS) applications up to 480Mbps. This device is specified to operate over a 2.7V to 5.5V input supply range. An active logic low enable pin (\overline{EN}) along with two switch state control pins (CB1 and CB2) provide full control of IC functions. When the device is disabled, the quiescent current consumption drops to less than 1 μ A. Upon IC enable, supply quiescent current increases to a typical 25 μ A to save power in battery powered portable products. The default enable SPDT switch state is normally closed between the COM1/2 pins and the NC1/2 pins unless otherwise programmed via the CB1/2 pins. Refer to the IC control truth table for all programming logic states.

The NC_ and NO_ switch pairs utilize break-before-make switching to assure the COM1/2 inputs are only passed to one switch output pair at any given time. When switch pairs are toggled to the opposite output via the CB1/2 control pins, the on-switch will open with a typical 28 μ s delay before the off-switches close.

The USB switch inputs COM1 and COM2 are over voltage protected with fixed typical OVP threshold level at 4.8V regardless of the applied Vcc supply voltage. Should a voltage level greater than the OVP threshold be applied to either COM1 or COM2, the IC will disable the switches to NC_ or NO_ and place them in a high impedance state to protect the device and down stream USB controller from damage. An active-low fault flag output (FLAG) is provided to alert the system controller to the fault condition.

Application Information

Analog Switch Applications

The KTU1000 is intended for use as a USB 2:1 data mux for USB 2.0 Low, Full and Hi-Speed applications up to 480Mbps and has an analog bandwidth up to 1GHz. KTU1000 switches may be used for other AC coupled analog signal switching applications as long as applied signal levels are within the minimum to maximum V_{sw} operating limits as defined in the electrical characteristics specification for this device. Due to the high frequency nature of USB and similar data signals, unused switch inputs or output should be terminated with 50Ω to ground to prevent unwanted signal-line reflections.

Non-Reverse-Blocking Switches

The switches in the KTU1000 are non-reverse-blocking for lowest on resistance and capacitance. Therefore, each switch has a body-diode that when forward-biased conducts current from NO1, NO2, NC1, or NC2 to COM1 or COM2. For this reason, USB transceivers or any other I/O devices connected in the system must be in high-Z mode or pulled to ground with logic 0 whenever data is routed through the KTU1000 to another device.

For a pin-to-pin compatible device with reverse-blocking, consult the factory.

Input Supply Bypass Capacitor

The KTU1000 may be operated with no additional external components. To maximize Hi-Speed data performance in systems with voltage supply noise or ripple, adding a V_{cc} input bypass capacitor in the range of 0.1 μ F or 1 μ F from V_{cc} to GND is recommended. Ceramic capacitors with minimum voltage rating of 6.3V and X5R or X7R dielectric should be used.

PCB Layout Guidelines

To achieve adequate bandwidth in USB 2.0 Hi-Speed data applications, careful PCB layout is critical for the signal traces to the COM1, COM2, NC1, NC2, NO1, and NO2 pins. The following guidelines are recommended for best system performance:

1. Multi-layer printed circuits boards are recommended for hi-speed data communication applications. Best USB signal quality is realized with 4 layer or greater PCB assemblies. A multilayer board minimizes the board material thickness between the signal trace layer and adjacent ground plane layer, which aids in maintaining consistent trace impedance for high-frequency signals.
2. Input and Output data signals should utilize matched width and length traces and be made as short as possible. As a general guide, USB 2.0 Hi-Speed signals, traces should be equal in lengths, maintain a 6 mil width with 8 mil spacing between traces and have 30 mil or greater isolation to adjacent signal traces.
3. The use of data trace vias should be minimized or ideally avoided altogether as they introduce impedance discontinuities at high frequencies and compromise signal quality.
4. If signal traces require turns or bends, do not use 90° turns. To maintain good high frequency performance, trace turns should use rounded arcs or bend at 45° angles at a maximum.
5. All signal traces should be routed directly over ground planes placed on the next PCB layer. To maintain best PCB trace impedance characteristic and minimize electro-magnetic interference (EMI), the ground plane layer should have no breaks under the signal trace layer. The ground plane layer should be referenced back to the system power source ground at one single point to avoid stray current paths through the ground plane.