UB20M High-Voltage, Low-Threshold, Ultra-Low Power Voltage Detector for Energy Harvesting, RF Power Transfer, and Event-Driven Sensing

Brief description

The voltage detector is an ultra-low power, input-powered device, that does not require connection to a power rail. When the input voltage rises to a typical threshold of 0.65 V, the voltage detector triggers an open-drain output. The detector is suitable for input signals with input voltage gradients from 0 to 10V/ms. At gradients higher than 10V/ms, the threshold increases. Detection hysteresis prevents output oscillations. The permitted input range of the detector is 0 to 20V.

The extremely low quiescent current of 5.4pA (at 1V, typ.) ensures that the loading of the voltage source is minimal and makes the voltage detector suitable for applications with very high-impedance sources, e.g. voltage-generating sensors. The leakage current of the open-drain output is below 100pA which minimises the energy storage discharge in power-gating applications.

Both input and output terminals have internal protection circuits against overcurrent, overvoltage and electrostatic discharge.

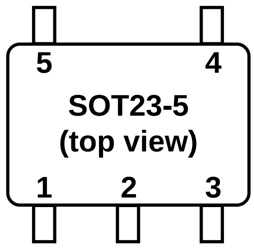
Features

- Ultra-low power consumption: 5.4pA at 1V
- Low threshold voltage: 650mV
- High input voltage capability: up to 20V
- Low off-state output leakage: below 100pA

Typical Applications

- Perpetual sensing
- Event-driven sensing
- RF wireless power transfer
- Energy harvesting
- Battery management
- Zero standby-power designs for wearable electronics, medical sensors and Internet-of-Things devices

Device Package



Pinout

Pin	Name	Description
1	IN	Input
2	GND	Ground
3	NC	Not connected
4	VBB	Output transistor body bias
5	OUT	Open drain output

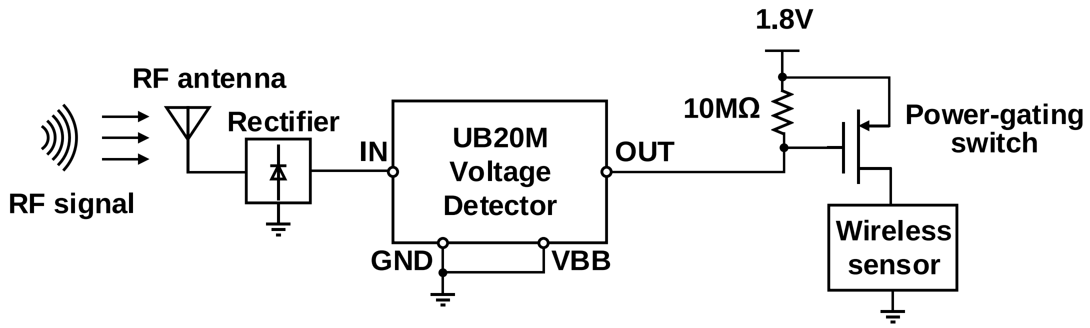


Figure 1 Example application - RF signal detection and power-gating

Absolute maximum ratings

Operation beyond the specified absolute maximum ranges can result in permanent damage or degradation of the voltage detector.

Symbol	Parameter	Min	Max	Unit
V_{IN}	Input voltage	0	20	V
V_{OUT}	Output voltage	0	5.5	V
I_{OUT}	Output current	–	7	mA
T_{amb}	Ambient temperature	-40	85	°C

Recommended operating conditions

Symbol	Parameter	Min	Max	Unit
V_{IN}	Input voltage	0	18	V
dV_{IN}/dt	Input voltage gradient	0	100	V/ms
V_{OUT}	Output voltage	0	5V	V
T_{amb}	Ambient temperature	0	40	°C

Electrical characteristic

All measurements performed at ambient temperature 20°C, output voltage V_{OUT} = 1.8V, and input voltage gradient dV_{IN}/dt = 1V/ms unless otherwise stated.

Symbol	Parameter	Conditions	Min	Nom	Max	Unit
I_{INst}	Static input current	V_{IN} = 0.2V	–	2.5	–	pA
		V_{IN} = 1V	–	5.4	–	
		V_{IN} = 4.2V	–	133	–	
I_{OUT}	Output leakage current	V_{IN} = 0V	–	76	–	pA
R_{OUTon}	Output on-state resistance	V_{IN} = 1V	–	786	–	Ω
V_{THf}^{*}	Falling input voltage threshold	0.1 V/ms	–	445	–	mV
		10 V/ms	–	615	–	
V_{THr}^{*}	Rising input voltage threshold	0.1 V/ms	–	650	–	mV
		10 V/ms	–	631	–	
ΔV_{HISTmn}^{*}	Minimum hysteresis		–	16	–	mV
t_{ON}^{**}	Turn-on delay		–	0.25	–	µs
t_{OFF}^{**}	Turn-off delay	R_{LOAD} = 100MΩ	–	180	–	µs
		R_{LOAD} = 20MΩ	–	40	–	
		R_{LOAD} = 5MΩ	–	8	–	

* Values are based on post-layout simulation.

** Delays are defined in Figure 12.

Description of operation

The voltage detector monitors time-varying voltages at the input pin (IN) and triggers an open-drain output (OUT) when the voltage has risen to the detection threshold voltage. The voltage detector is designed to operate in active-low mode, meaning that initially when V_{IN} is below the threshold V_{THr} the output is in high-impedance state; when V_{IN} becomes higher than the V_{THr} the output is pulled to ground (GND). The output is kept low until V_{IN} drops below V_{THf} at which point it is switched back to high-impedance state. The thresholds V_{THr} and V_{THf} depend on the slope of the input voltage dV_{IN}/dt (Figure 10) and at a typical slope of 1V/ms these equal 650mV and 520mV.

The VBB pin is typically tied to ground. It provides the option to reduce the output on-state resistance by lowering the threshold of the output transistor. This is useful for applications where the input voltage rises or drops only slightly above the threshold. In this case, if the VBB pin is tied to a potential that is higher than zero, the output transistor is turned on harder, and the on-state resistance is lower.

The low output leakage current (Figure 4) makes the voltage detector suitable for power-gating battery-powered devices. In this configuration a pull-up resistor is required. In order to minimise the on-state leakage current, the size of the resistor should be as large as possible; however larger resistors will increase the discharge time of the input capacitance of the power gating switch (Figure 9). Therefore, selection of the pull-up resistor is a compromise between leakage and speed, and should be determined considering the specific requirements of the application.

Typical measured performance characteristics

All measurements are performed at 20°C unless otherwise stated. The measurement setup is shown in Figure 11.

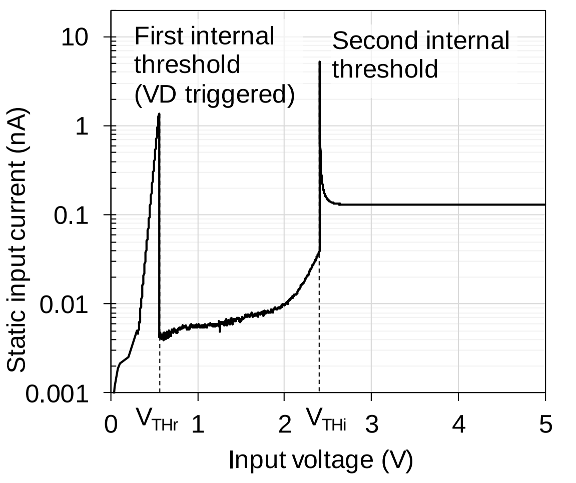


Figure 2 Static input current at V_{IN} swept From 0V to 5V

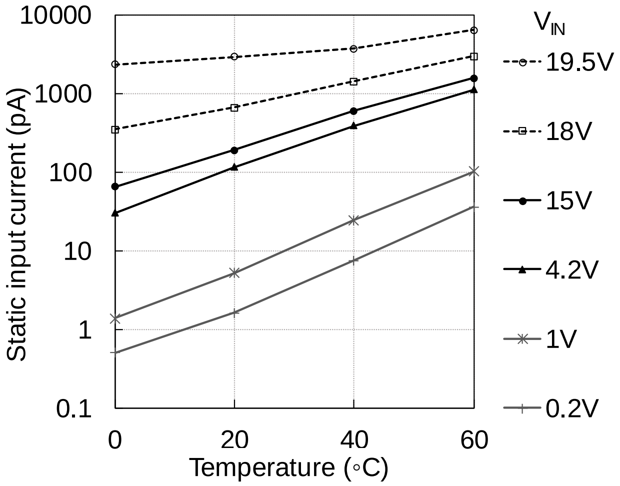


Figure 3 Static input current vs Temperature

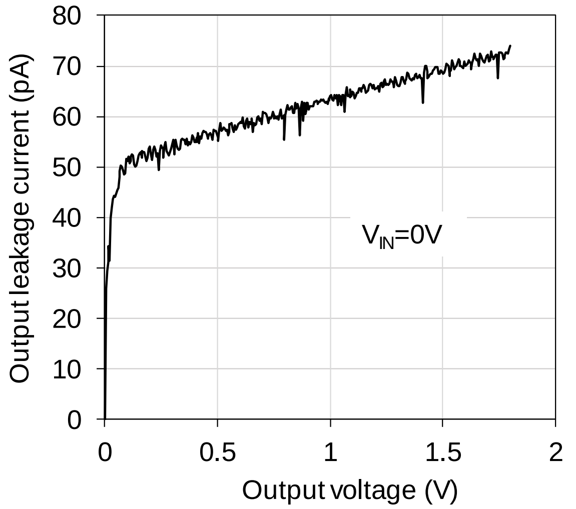


Figure 4 Output leakage current in OFF state

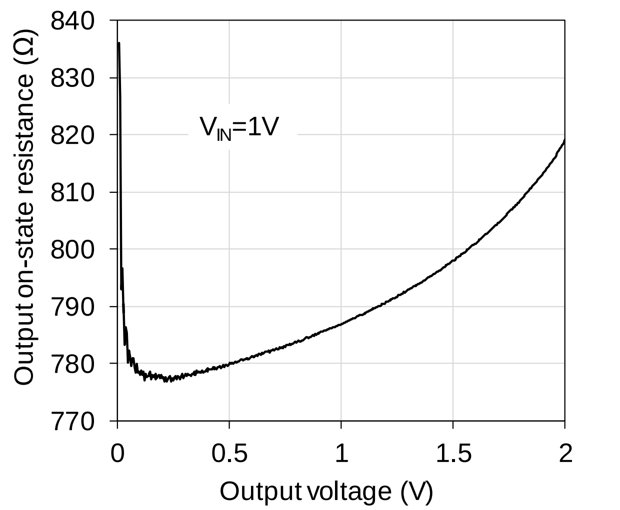


Figure 5 Output resistance in ON state

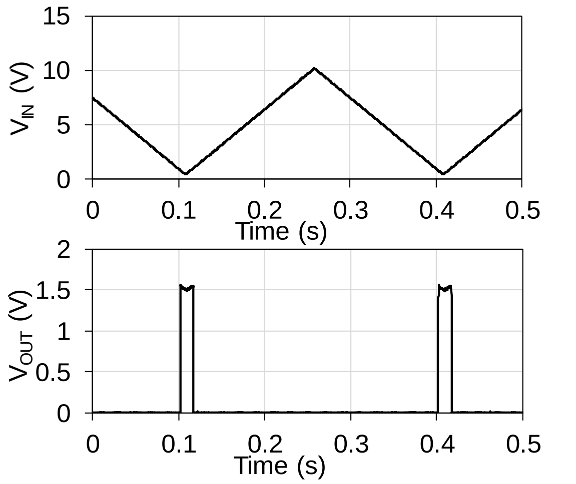


Figure 6 Waveforms of the input and output voltages with triangular waveform applied to input

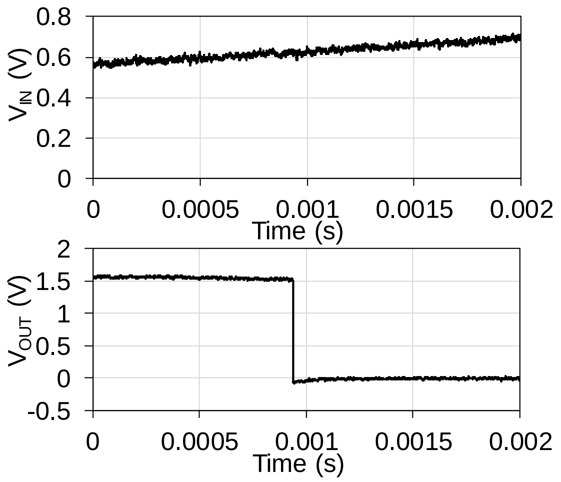


Figure 7 Waveforms of the input and output voltages at the turn-on instant

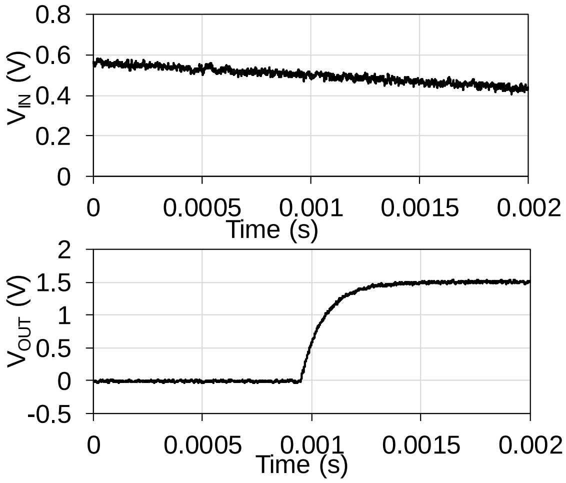


Figure 8 Waveforms of the input and output voltages at the turn-off instant

Simulated post-layout characteristics

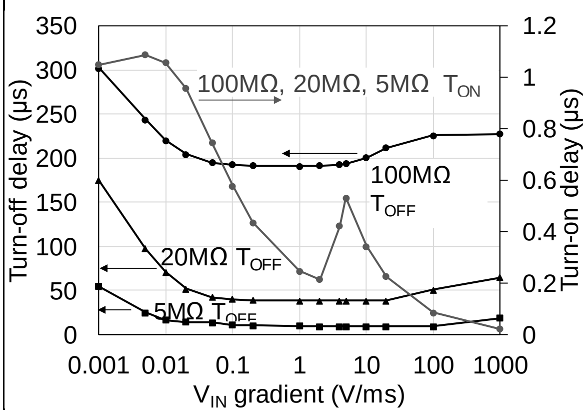


*Figure 9 Turn-on and turn-off delays (post-layout simulation)**

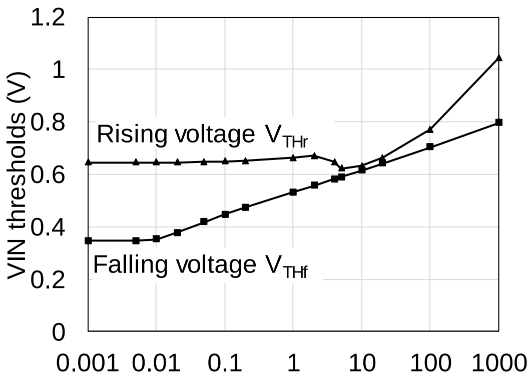


Figure 10 Threshold levels as a function of input voltage gradient (post-layout simulation)

*Turn-on and turn-off delays are defined in Figure 12.

Measurement setup

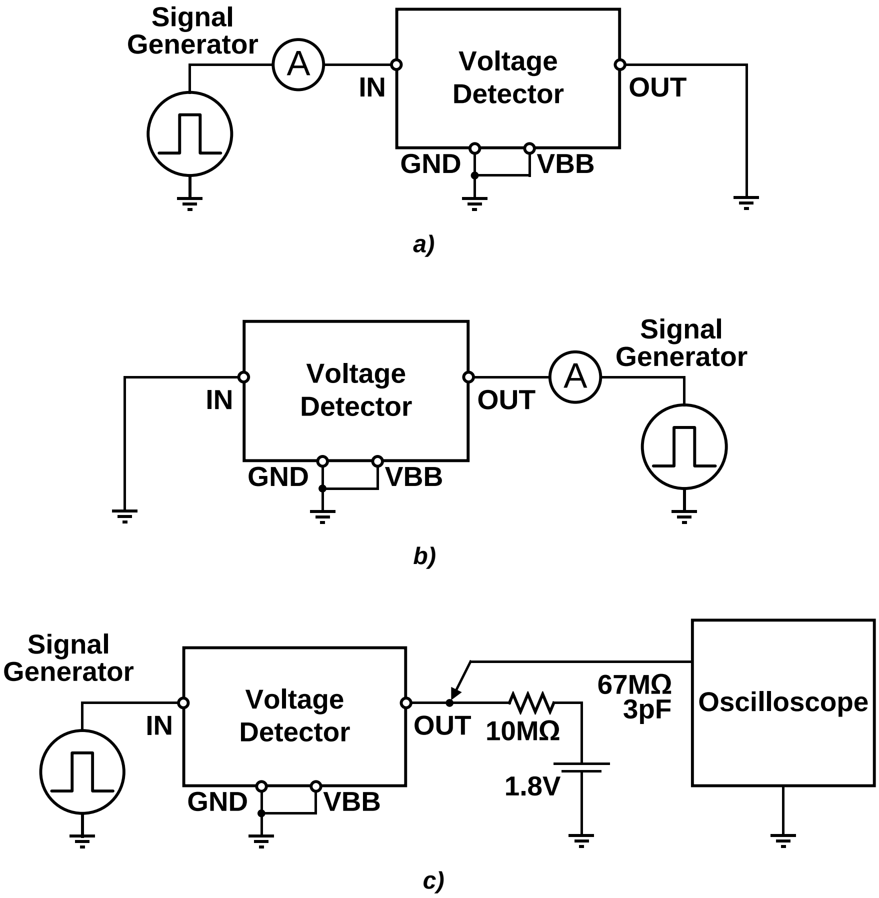


Figure 11 Measurement setup for the characteristics in: a) Figure 2 and Figure 3; b) Figure 4 and Figure 5; c) Figure 6, Figure 7, and Figure 8.

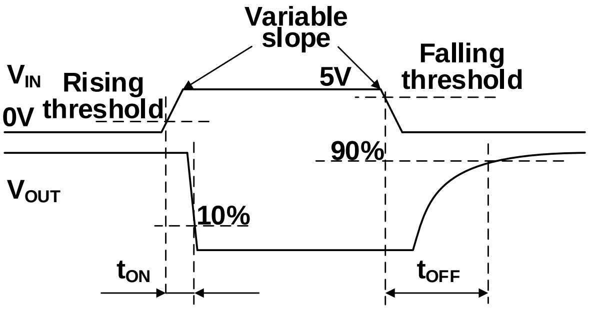
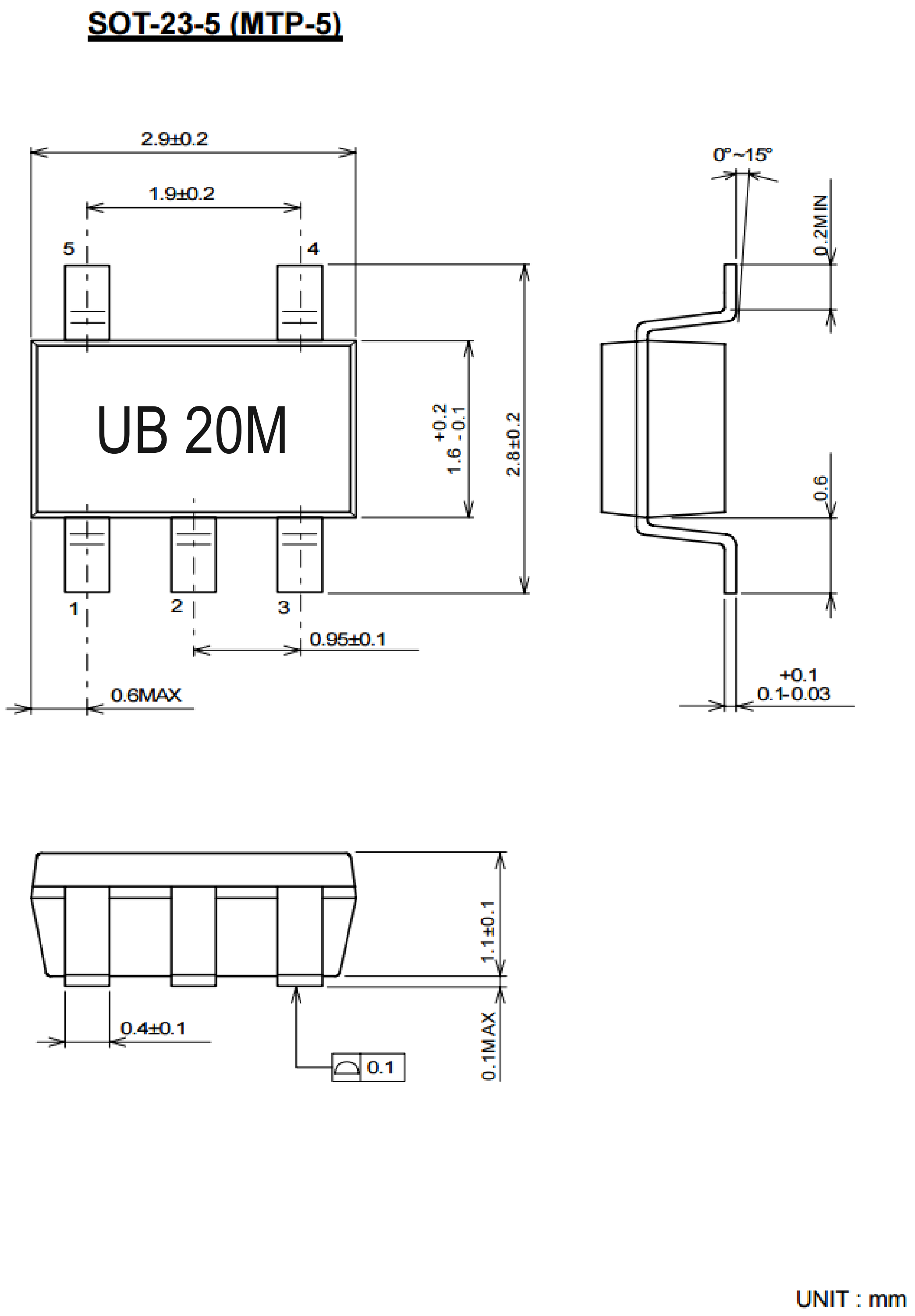


Figure 12 Definition of turn-on (t_{ON}) and turn-off (t_{OFF}) delays

Package dimensions



Variants

Two other variants of the voltage detector that have different output and input characteristics are available.

UB20L

Key specifications:

Parameter	Conditions	Value	Unit
Maximum input voltage	–	20	V
Maximum output voltage	–	1.98	V
Maximum output current	–	2.5	mA
Ambient temperature	–	85	°C
Static Input current at dV_{IN}/dt = 1V/ms	V_{IN}=0.2V	41	pA
	V_{IN}=1V	100	
	V_{IN}=4.2V	183	
Rising input voltage threshold	dV_{IN}/dt=1V/ms	460	mV
Falling input voltage threshold	dV_{IN}/dt=1V/ms	260	mV
Typical output leakage current	V_{IN}=0V	222	pA

For more detailed specification please refer to the UB20M datasheet.

UB05M

Key specifications:

Parameter	Conditions	Value	Unit
Maximum input voltage	–	5.5	V
Maximum output voltage	–	5.5	V
Maximum output current	–	7	mA
Ambient temperature	–	85	°C
Static Input current at dV_{IN}/dt = 1V/ms	V_{IN}=0.2V	2.5	pA
	V_{IN}=1V	5.4	
	V_{IN}=4.2V	13.5	
Rising input voltage threshold	dV_{IN}/dt=0.1V/ms	650	mV
Falling input voltage threshold	dV_{IN}/dt=0.1V/ms	450	mV
Typical output leakage current	V_{IN}=0V	76	pA

For more detailed specification please refer to the UB05L datasheet.

Supporting material

UB20M datasheet:
http://bristol.ac.uk/voltage-detector

UB05L datasheet: Available upon request.

UB20L datasheet: Available upon request.

UB20M breakout board datasheet:
http://bristol.ac.uk/voltage-detector

Contact and sample requests:

http://bristol.ac.uk/voltage-detector

Application videos:

Bristol Energy YouTube channel
https://www.youtube.com/channel/UCvh4MNL1kIq-tqw_YQSJWGg

The UB20M device is currently a pre-production prototype. Volume supply of commercial product is scheduled to commence in 2018.