cleverscope
plug & play instruments
oscilloscopes

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# CS1133 $V_{SAT}$ Probe

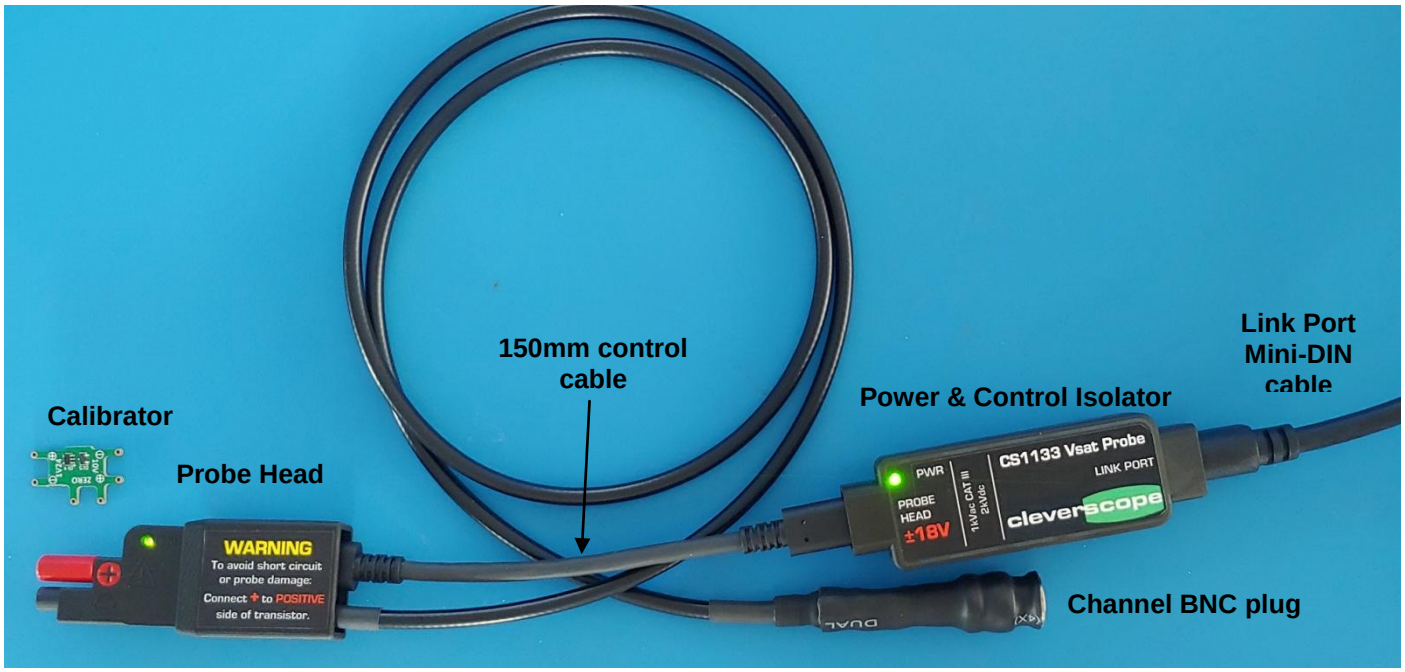
## Summary

The CS1133 $V_{SAT}$ probe is used to measure the saturation voltage of a switching transistor. It uses a 30mA high compliance current source to measure the transistor forward voltage while the voltage across the device is less than the clip level. The clip level can be set to 3 ranges; approximately 15V, 1.5V and 150mV. Above the clip level the $V_{SAT}$ probe is disconnected from the Unit Under Test (UUT). It is expected that the UUT will have a good deal more than 30mA flowing through it so this small additional current will not significantly change the saturation voltage. The CS1133 is designed to work into a 50 ohm load. The CS1133 is rated for operation over the input voltage range of 0V to +3.3kV. It can also withstand negative overshoot on the UUT down to -100V for short term transients.

The CS1133 is powered by +5V sourced by the CS448 LINK PORT (pin 1) and 0V (pin 2) via an 8 pin Mini Din Connector. It also includes two controls to select clip level; IN1 (pin 8) & IN2 (pin 5). The power and control signals are isolated via a low capacitance isolated power supply and optical isolators housed in a separate unit. The isolation withstand voltage is 1kVAC CAT III or 2kVDC. In addition the active portion of the CS1133 is shielded to ensure it can be used to measure the high side transistor while it is switching.

### Connections

The CS1133 is made up of two units; the Probe Head containing the measuring electronics and the Power & Control Isolator. The Probe Head connects to the Isolator with a 150mm long Type-C USB cable.



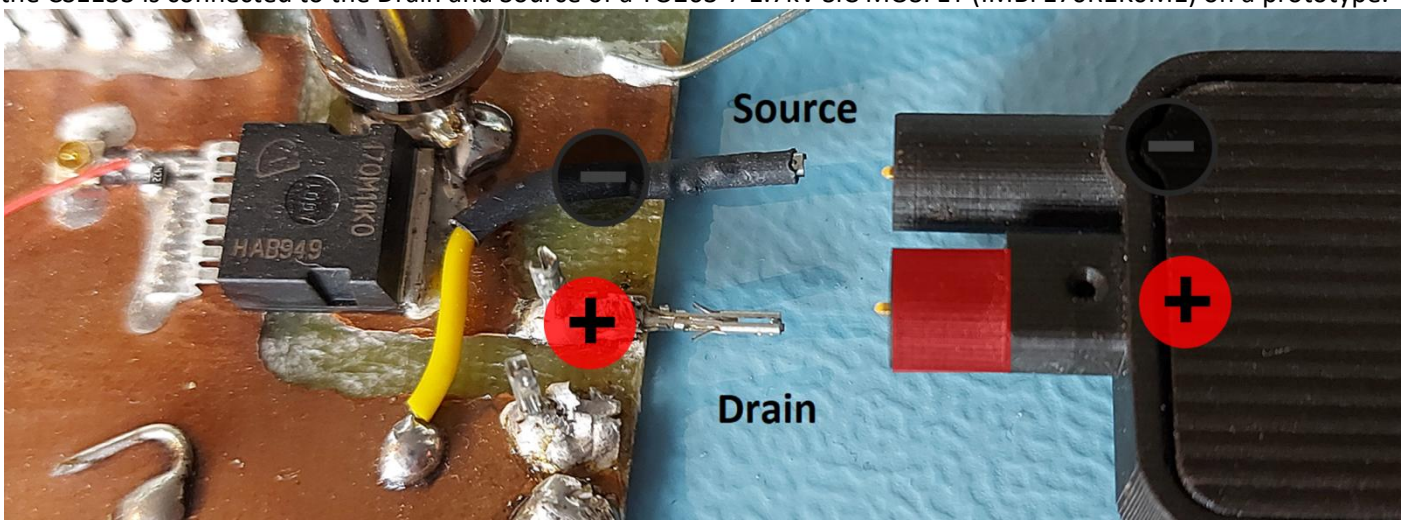

**WARNING** The Power/Control connectors on the Probe Head & Isolator do not use standard USB pin-out or signals, and include +/-18V power supplies. DO NOT connect these to a charger, computer, or phone, etc.

To connect the Probe Head slide the protective sheath towards the input pins and then screw on the SMA coax and plug in the power/control cable. Slide the protective sheath back into position.

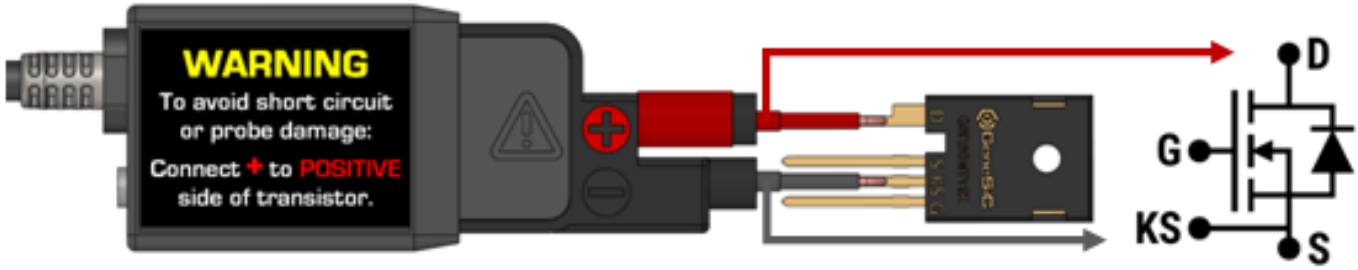

Connect the other end of the power/control cable to the Isolator. Connect the 8 pin Mini Din cable to the CS448 LINK PORT and the internally terminated (50ohm ) and insulated coax cable to a CS448 channel input.

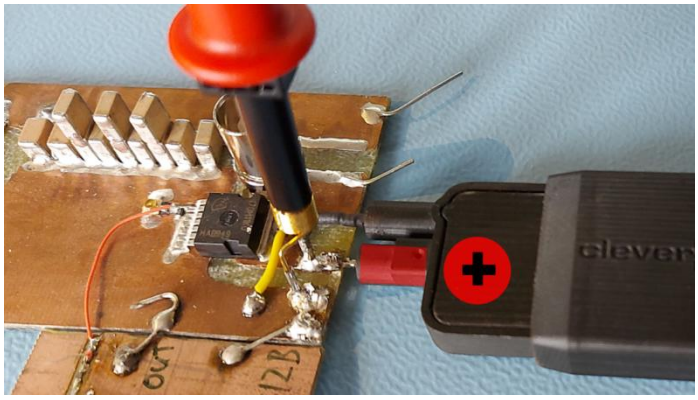
## Connection to UUT

The CS1133 has two 0.64mm square input pins which enable close connection to the UUT. This minimises the loop area to keep the input inductance low and achieve a fast response. To connect the CS1133 to the UUT solder some 0.64mm square sockets with short wires to the Drain & Source (or Collector & Emitter). In the example shown here the CS1133 is connected to the Drain and Source of a TO263-7 1.7kV SiC MOSFET (IMBF170R1K0M1) on a prototype.




**WARNING Ensure that the CS1133 + terminal is connected to the UUT positive terminal (eg Drain or Collector). Reverse connection will damage the CS1133, and require repair.**



Here 0.64mm square sockets have also been used to simultaneously measure $V_{DS}$ with a x200 probe

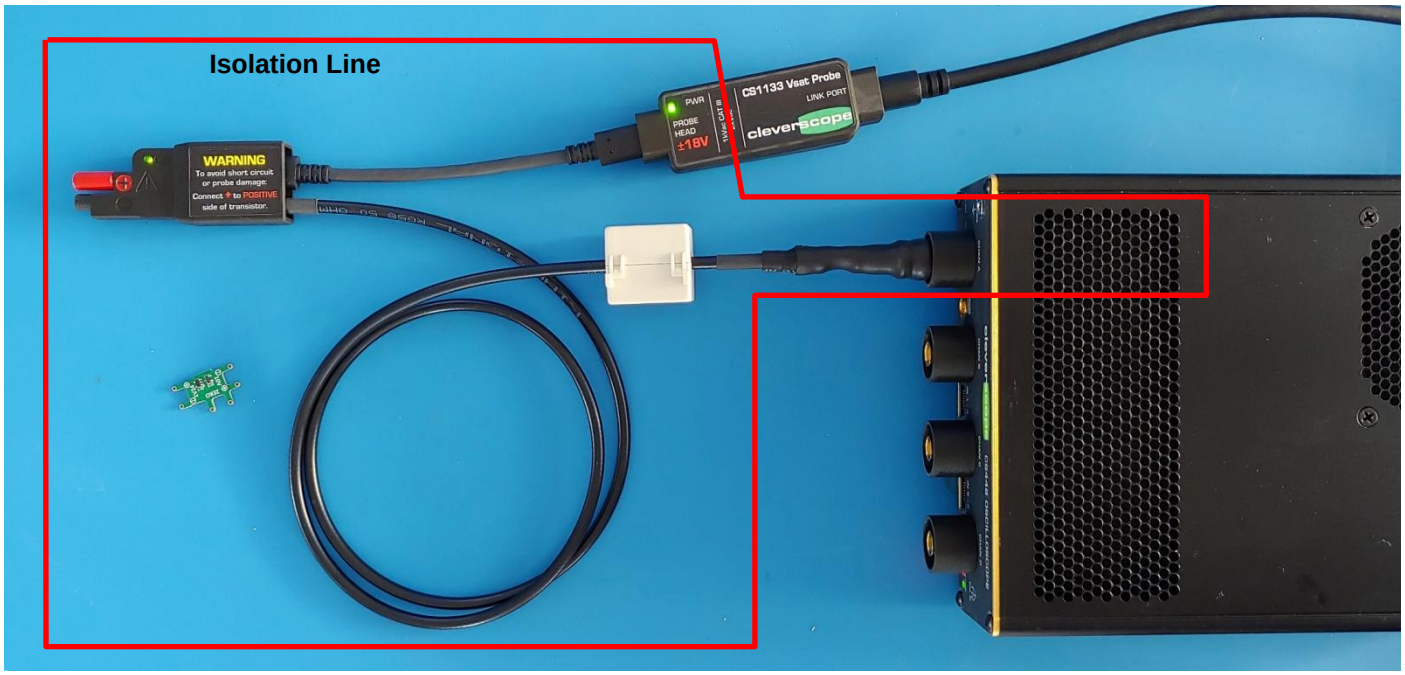
Note the CS1133 can only withstand short duration transient reverse voltages, max -100V.

## Indicators

The CS1133 has two power indicator LEDs. One on the Power and Control module shows isolated power is on. One on the Probe Head shows the Probe Head power is on. Always operate the CS1133 with both LEDs visible.


## System Isolation

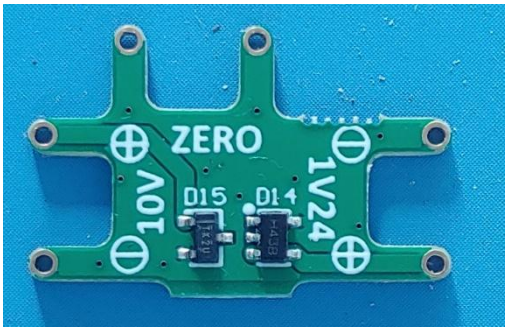
When used with the input channel isolation of the CS448 the CS1133 can be used to measure $V_{SAT}$ of a high side or floating transistor. This diagram shows where the isolation occurs




All items within the isolation line (Channel A, Probe Head, Coax cable and output of Isolator) have a common reference connection which will be connected to the UUT Source (or Emitter). If the Source is a high side transistor in a half bridge this whole isolation island will move with the switching edges of the half bridge. A common mode choke (as supplied with the CS448) may be required on the coax cable to suppress common mode induced spikes and ringing.

**WARNING** All items within the isolation line above will be at the same potential as the UUT Source. **DO NOT touch**.

## Calibrator

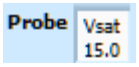



The Calibrator will be used by the updated Cleverscope 4 application to precision calibrate the CS1133. Accuracy is already pretty good (1%), but the calibrator will increase accuracy to about 0.1%. A calibrator is included with each CS1133.

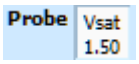
Calibration results are stored in an Eeprom in the probe.

## Ranges

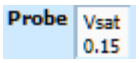
There are 3 ranges:

- 

15V is useful for de-saturation measurements where the transistor $V_{SAT}$ voltage increases during overload conditions.

- 

1V5 range is used for normal $V_{SAT}$ measurements of an IGBT or MOSFET

- 

150mV range is useful for very low RDS-ON transistors where the saturation voltage is below approx 100mV.

Range selection is via the input signals IN1 & IN2 on the LINK PORT and controlled by the CS448 application using the Probe settings. The link Port supplies power to the CS1133.

For increased accuracy when using the 1V5 and 150mV ranges, you can lock the CS448 channel into the low range by clicking on the Low Range Lock button (yellow when locked):


**Low Range Lock**

Note: If you leave the button locked, the CS448 will clip signals greater than the low range maximum value (probe dependant). If this happens, unlock the range.

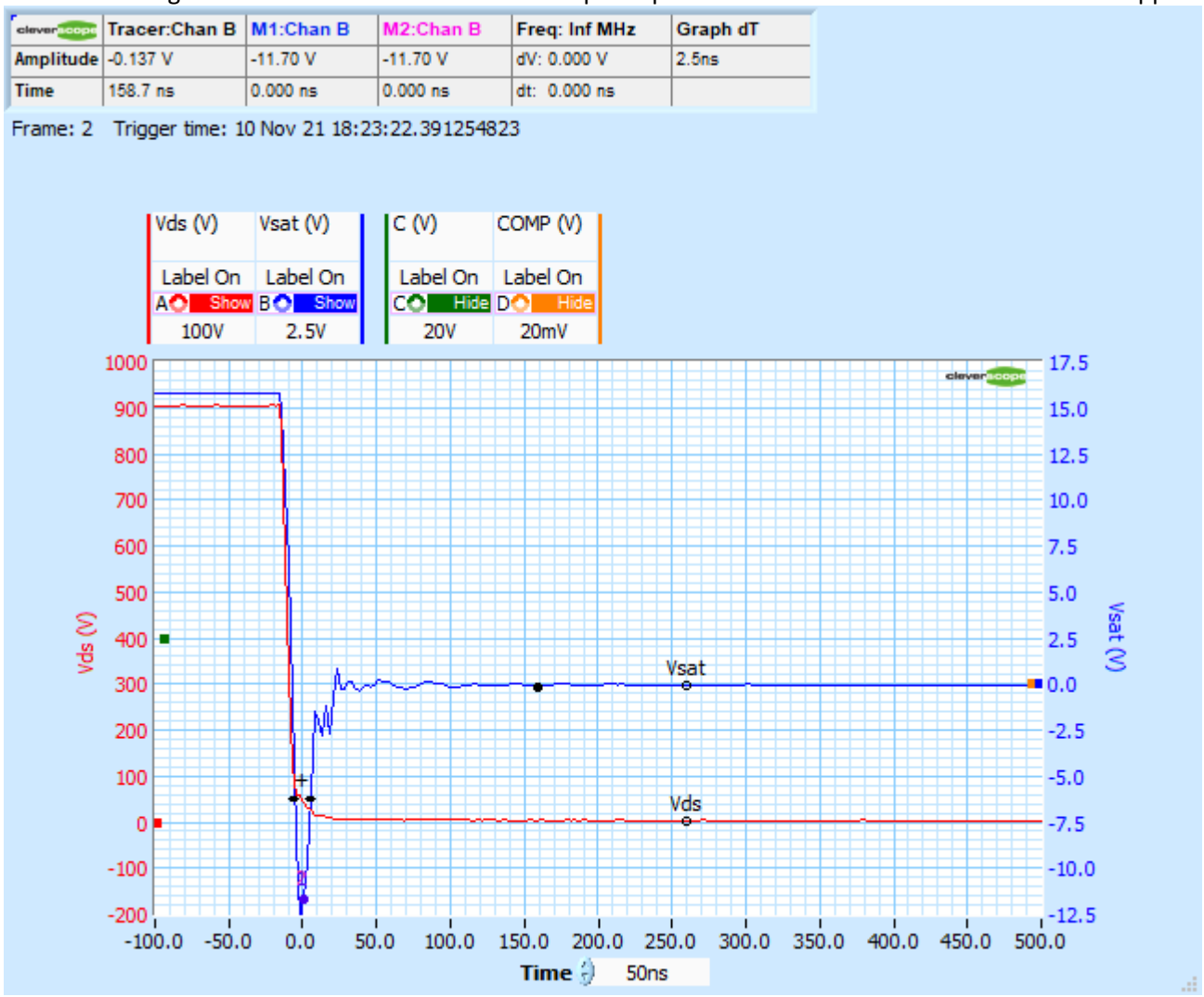
## Specifications

| Parameter | Value (typical) | Comment |
|---|---|---|
| Supply Voltage | 5V | From CS448 LINK PORT |
| Supply Current | 300mA | UUT Input open |
| Supply Current | 380mA | UUT Input shorted |
| Current source output | 30mA | |
| Input Voltage Range | 0-3300V | **Do Not reverse connect** |
| Max Negative Overshoot | -100V | Duration < 1ms, max 10% duty cycle |
| Isolation Working Voltage | 1kVAC CAT III or 2kVDC | |
| Clip Levels: | | |
| 15V range | 15V ± 1V | Set CS448 input to x20 & IN1,2=0,0 |
| 1V5 range | 1.5V ± 100mV | Set CS448 input to x2 & IN1,2=0,1 |
| 150mV range | 150mV ± 50mV | Set CS448 input to x2 & IN1,2=1,1 |
| Gain accuracy | < ± 1% | |
| Rise and Fall Times | <10ns | |
| Recovery after falling edge | 50ns on 15V range<br>100ns on 1V5 range | Approx. Depends on edge.<br>With 1000V 10ns falling edge |
| Probe Head Size | 70x30x12mm | |
| Isolator Size | 94x30x20mm | |
| Supplied with | SMA-BNC cable with 50ohm termination, 1m<br>LINK PORT cable, Mini DIN8, 1m<br>Probe Head – Isolator cable, 150mm (USB-C)<br>0.64mm square sockets, 10pcs, Calibrator | |

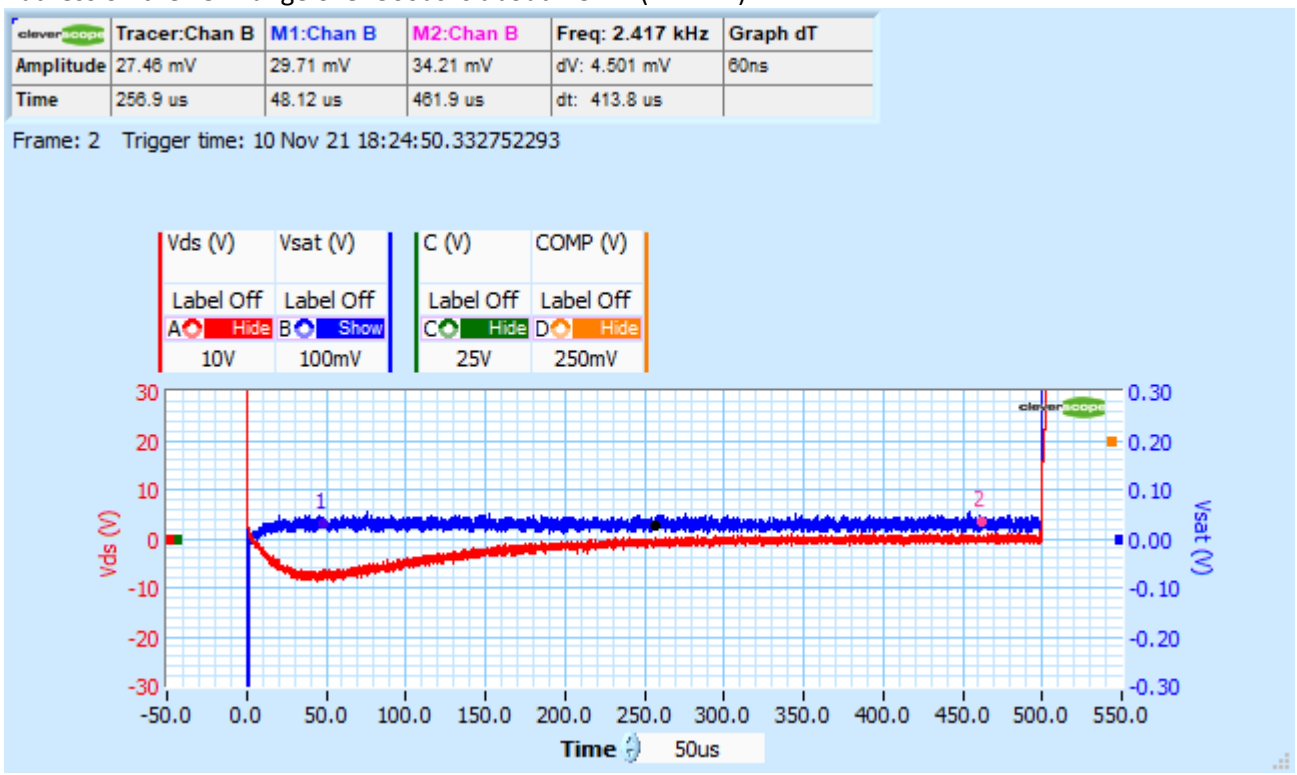
## Measurements

The CS1133 is used to measure $V_{DS}$ of a 1.7kV SiC MOSFET (IMBF170R1K0M1) with a 1M pullup to 1kV. Falling edge is approx 10ns, 100V/ns.

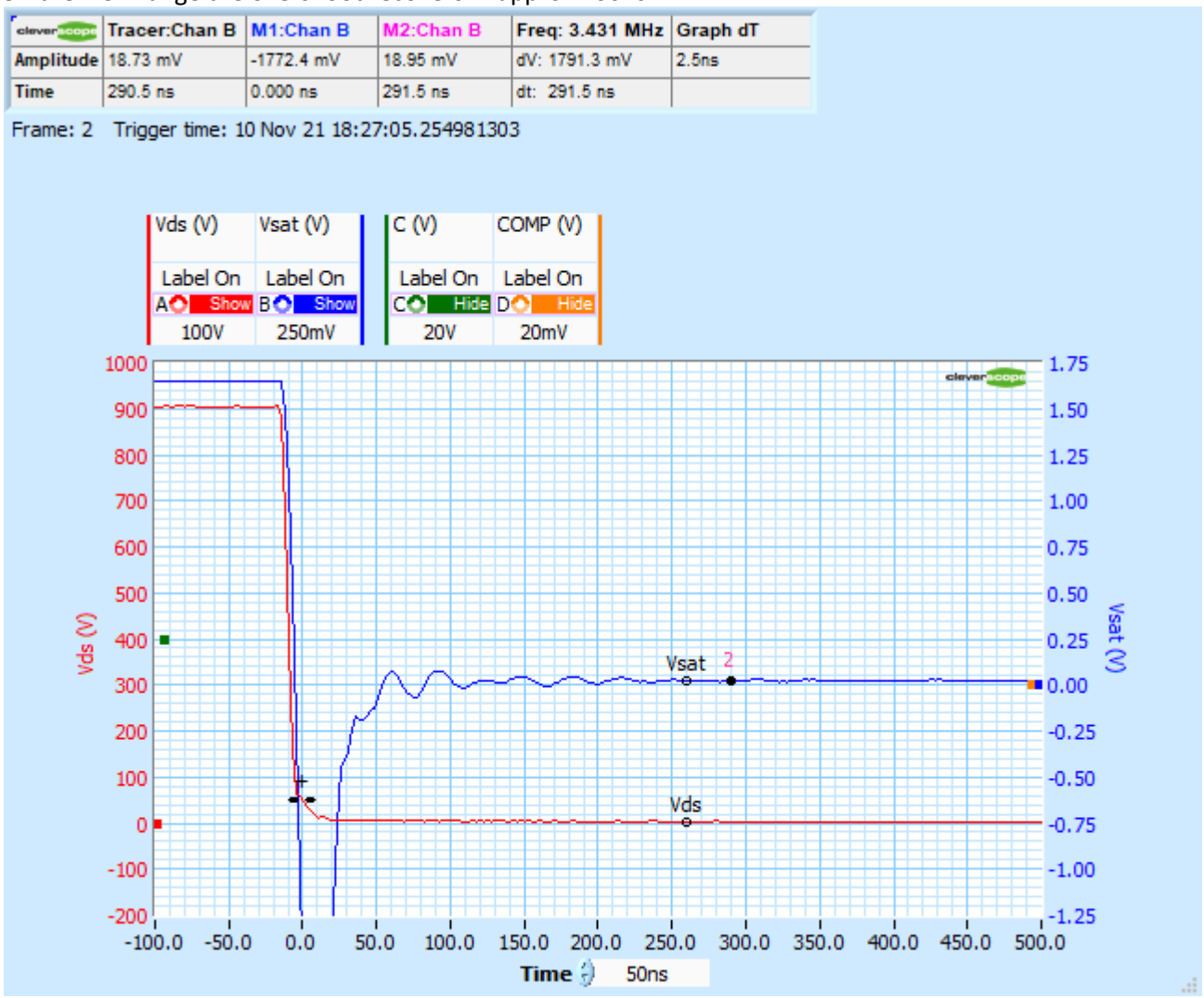
On the 15V range there is an overshoot due to the input capacitance of the CS1133 which recovers in approx 50ns:



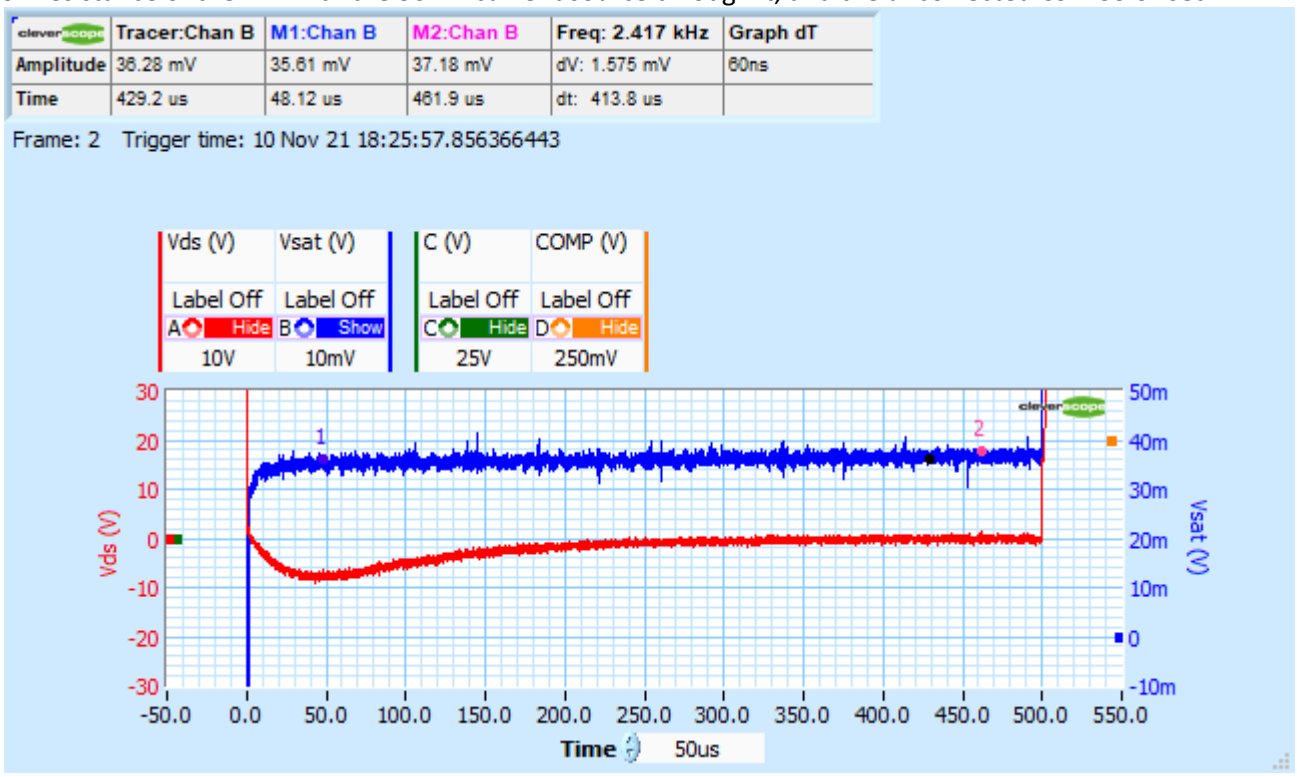

Flatness on the 15V range over 500us is about 4.5mV (M1-M2):



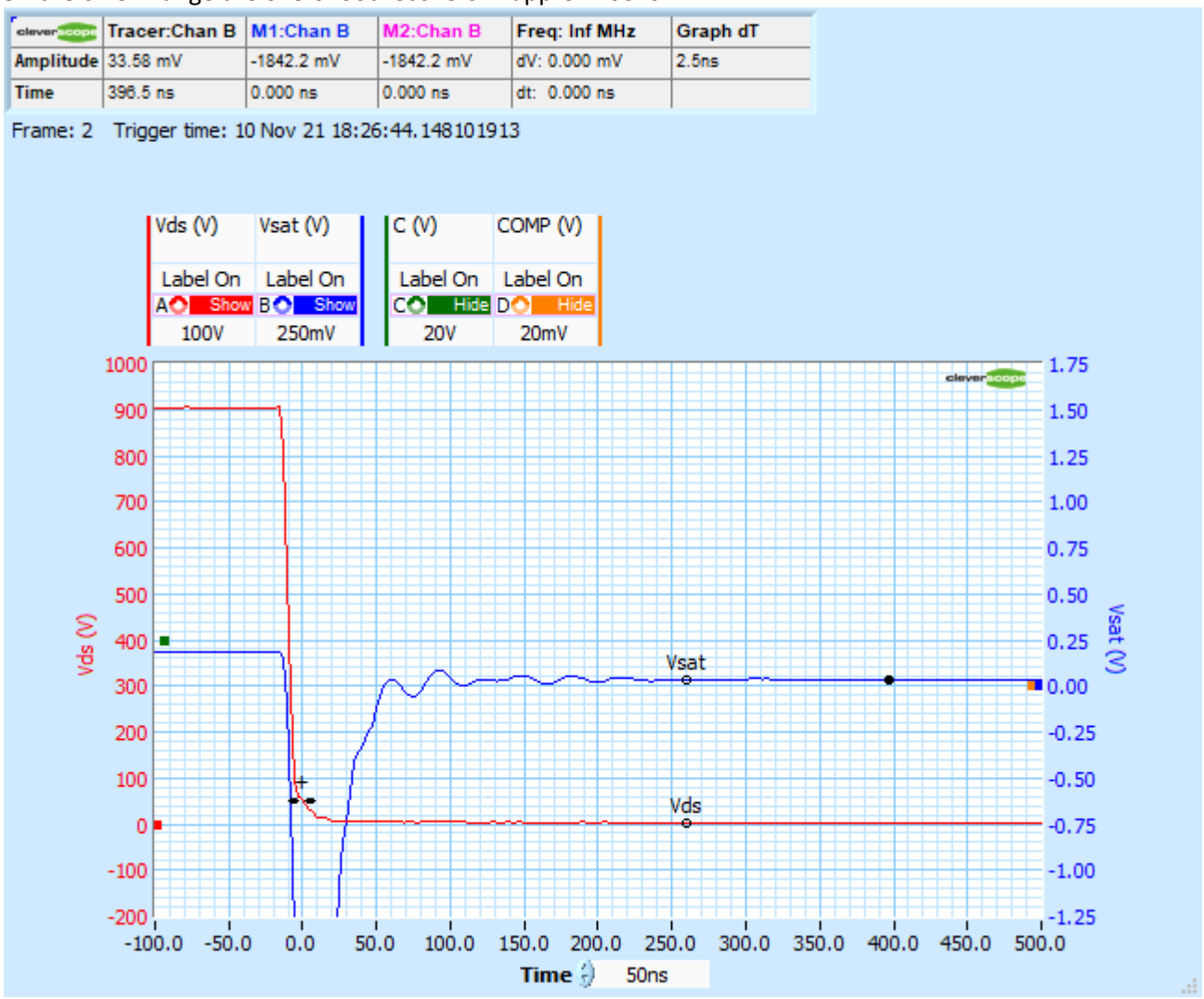
On the 1.5V range the overshoot recovers in approx 100ns:




Flatness on the 1.5V range over 500us is about 1.6 mV (M1-M2). The 37mV voltage drop is due to the approx 1 Ohm on resistance of the FET with the 30mA current source through it, and the uncorrected CS1133 offset:



On the 0.15V range the overshoot recovers in approx 100ns:




Flatness on the 0.15V range over 500us is in the noise (0mV displayed, M1-M2):