Cleverscope Ltd
Mob +64 21 1777 367
Email support@cleverscope.com
35 Charlotte St, Eden Terrace
Auckland 1021
New Zealand

5 March 24 v1.1

CS1202 Loss Probe and Digitizer Overview

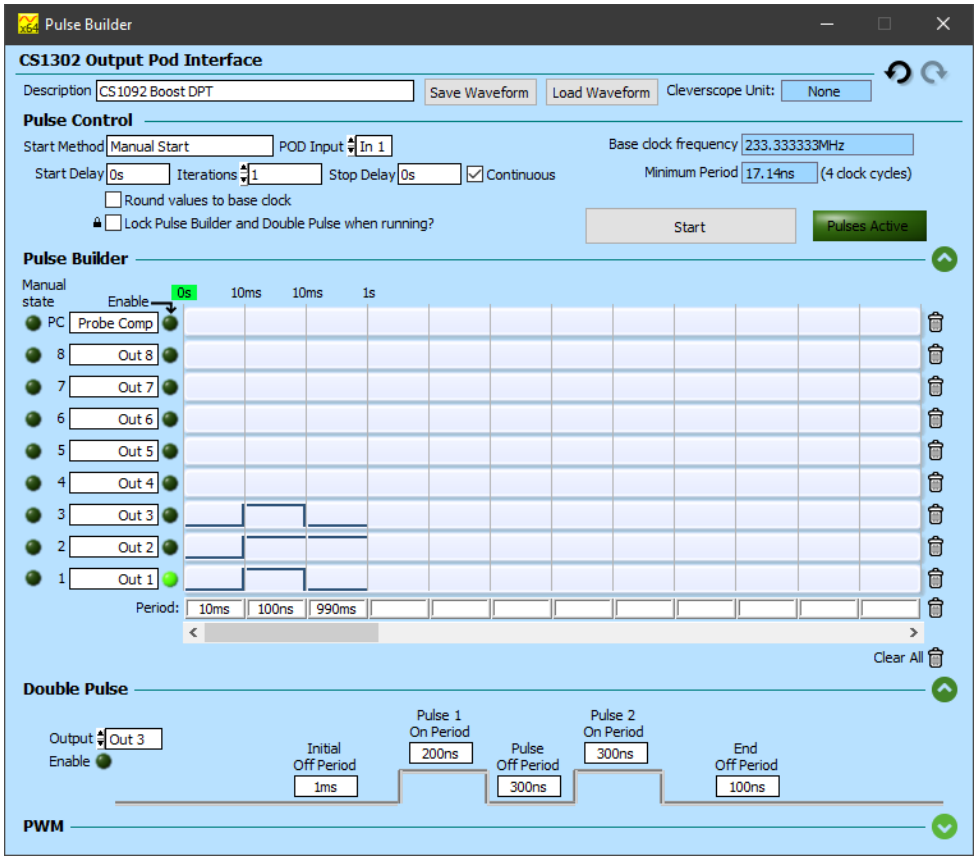
Summary

At APEC 2024, Cleverscope demonstrated a prototype CS1202 Loss Probe and Digitizer used to measure I_S, V_{DS}, V_{SAT}, P_{SW} (switching edge power) and E_{SW} (switching edge energy). The bandwidth of the P_{SW} and E_{SW} measurement is 1 GHz.

We used our CS1096 low side GaN switch board with 42A high side resistive load to demonstrate the high side measurement of current and voltage. Current was measured using our CS1501 shunt resistor (1 mΩ, 40 pH insertion inductance, 50A rated with compensation in the CS1202 to yield 1 GHz band width).

We delivered a presentation at the Industry and Exhibitor Sessions discussing the prototype, and sketched out the way forward. The first section of this overview documents the measurements we made, while the second looks at the way forward. Our goal is to have a production CS1202 Loss Digitizer in Q3 2024.

We used our CS1302 Output Pod and Pulse Builder to generate control pulses.
Out 1 controlled the Gan Fet Gate:



Other outputs were used for other setups.

At the same time we showed posters of the prototype operating. The posters we showed follow.

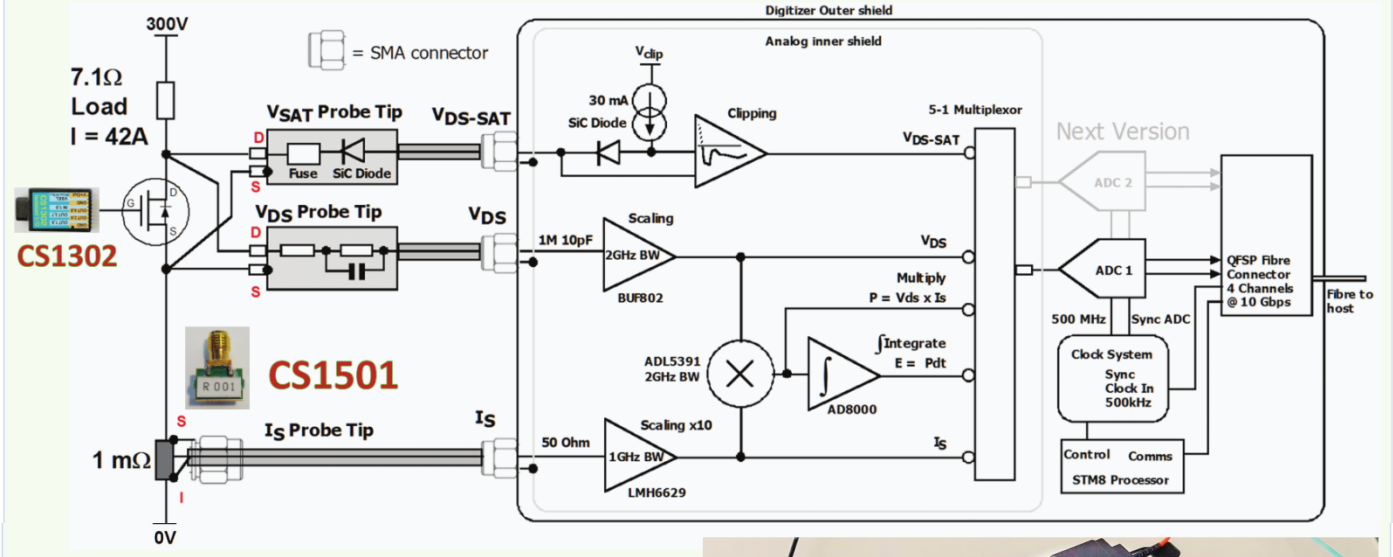
Step 1: Functions that work

CS1202 Power Probe

Fibre Isolated power probe prototype

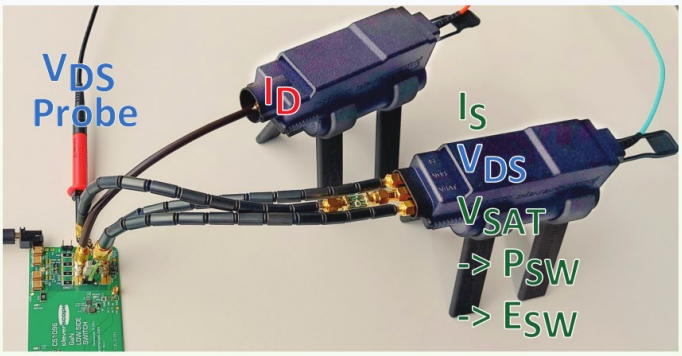
Measure:
- V_{DS}
- VSAT
- ID
- PSW
- ESW

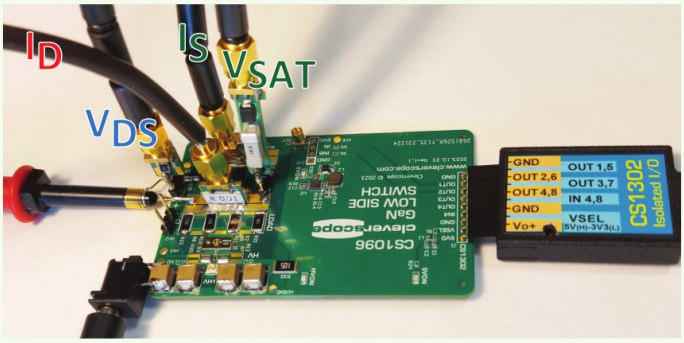
Switching loss measurement with 1 GHz BW HW multiplier and Integrator



What it does:
The CS1202 uses 1 GHz BW op-amps driving a 1 GHz BW HW multiplier and integrator to measure switching edge power and energy. The CS1501 is compensated to have 1 GHz BW.

Using a Vsat function and I_S we measured the conduction power and energy using the PC application. Vsat has mV resolution.

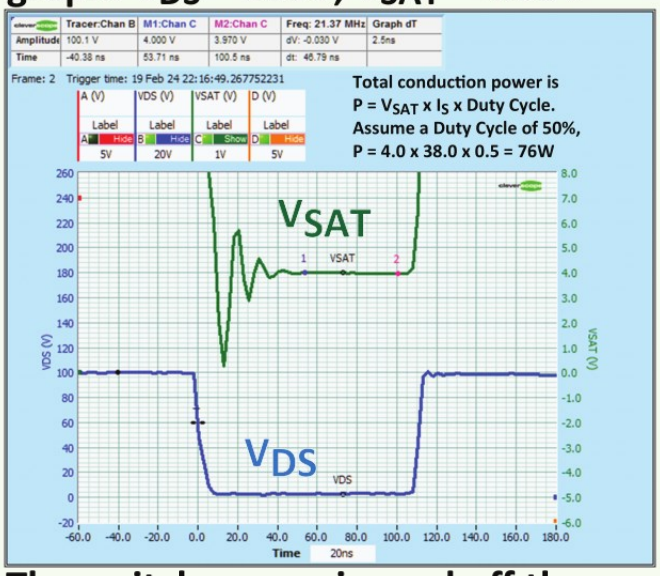




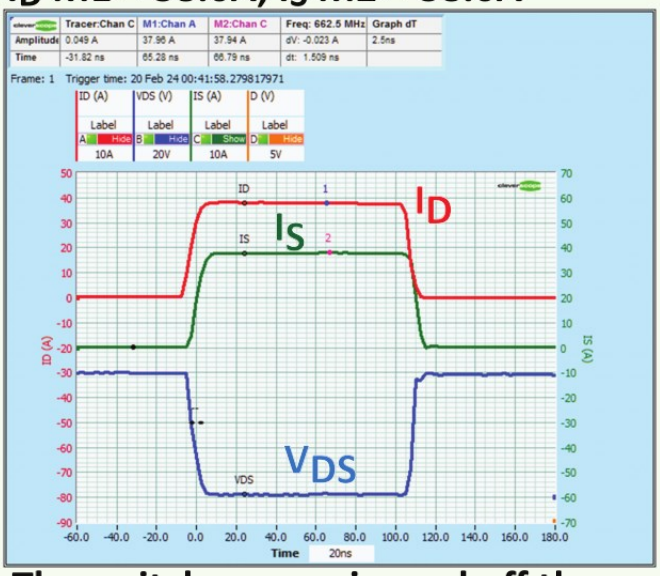
As an interim step we plan to release the CS1201 current sensing digitizer while we finish off the CS1202 loss probe and digitizer. The CS1201 will look pretty much the same as the upper probe digitizer in the picture above.

Measurements

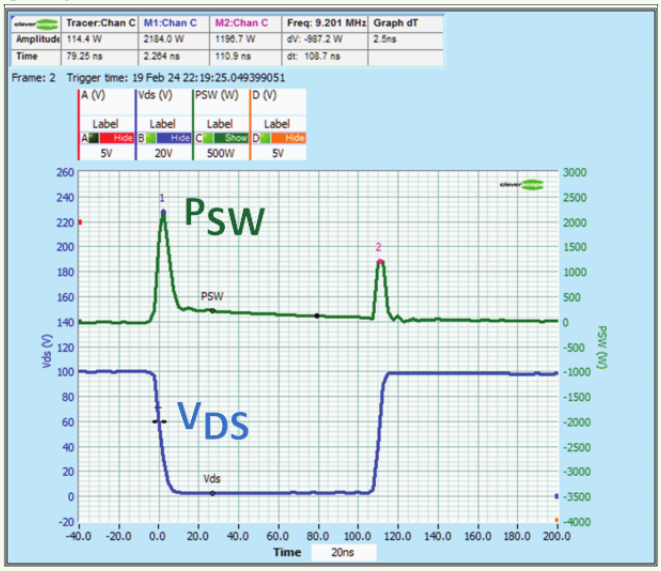
V_{DS} and V_{SAT} are read off the graph: V_{DS} = 100V, V_{SAT} = 4.00V



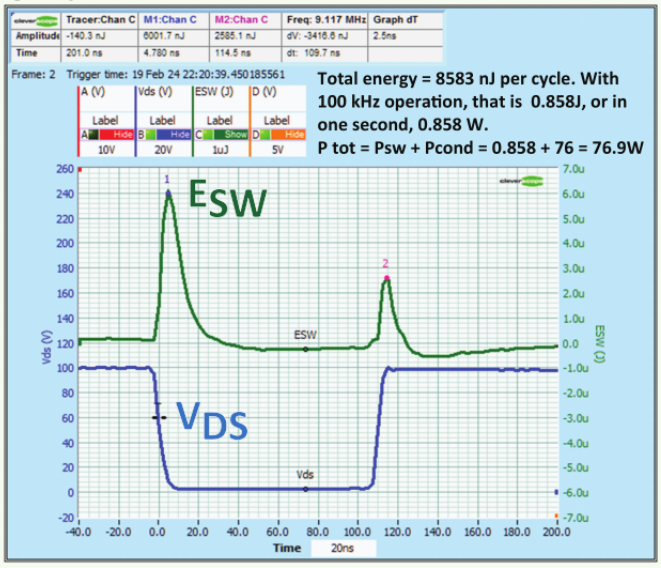
I_D and I_S are read off the graph: I_D M1 = 38.0A, I_S M2 = 38.0A



The switch power is read off the graph: M1 = 2184W, M2 = 1197W



The switch energy is read off the graph: M1 = 6002nJ, M2 = 2581nJ



Note that the measured pulse is about 100ns wide. Vsat is oscillatory while the reverse diode capacitive charge dissipates.

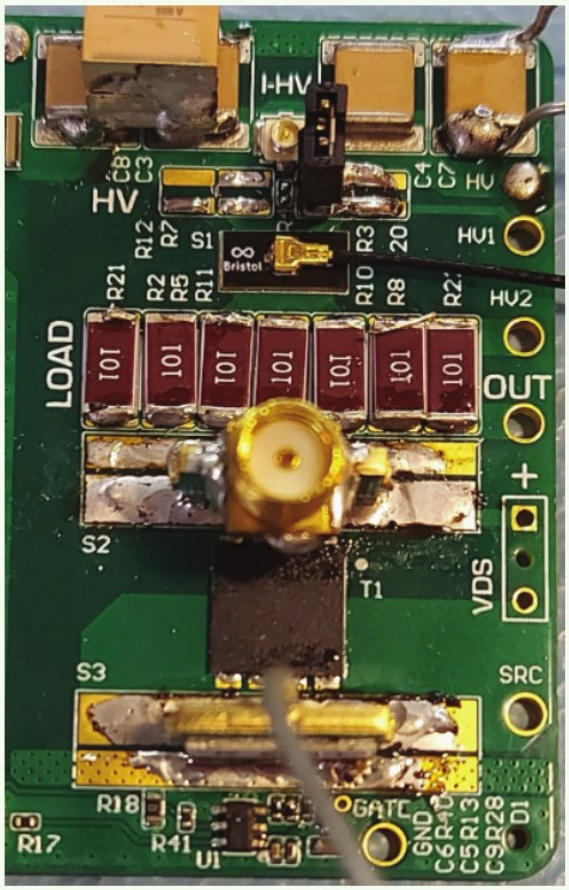
I_D is measured on high side and is subject to the full switching edge change in Common Mode voltage, but there are no common mode artifacts in the waveform because of the CS1202's exceptional CMRR.

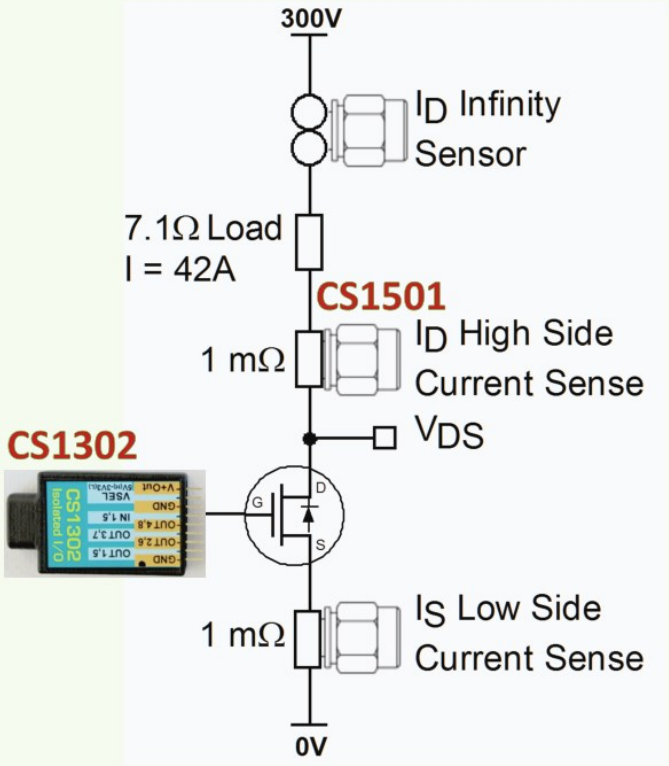
Current Sensing

Measuring a CS1096 42A
GAN switch on the high side.

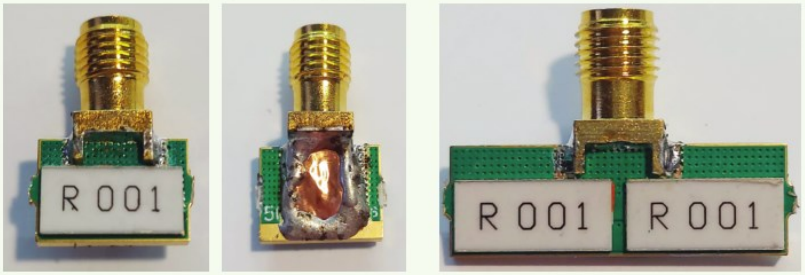
Turn on time = 3.8 ns
Vsupply = 300V (for safety)

CS1096





CS1501 1 mΩ 50A **CS1502 500 uΩ 100A**



Shielded current sensor

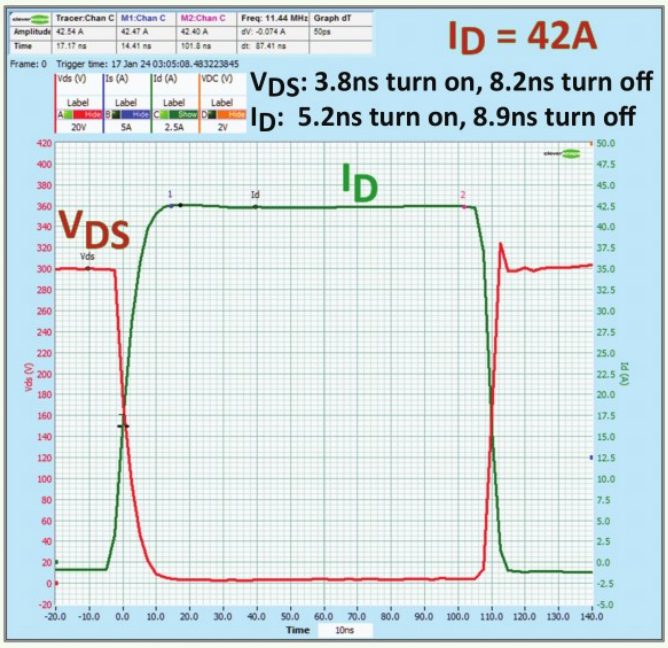
solder vertically onto curent sense tracks

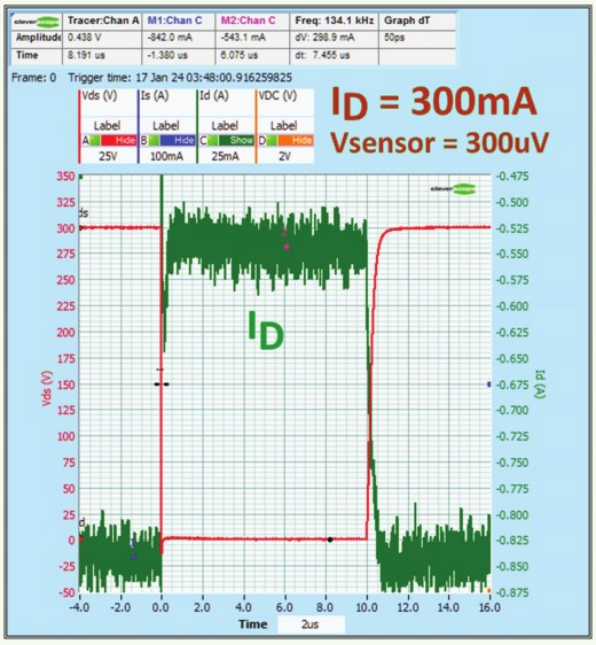
The sensors are based on Ohmite FCSL110 1mOhm metal foil resistors, which are 11mm wide x 5mm high. The active surface is downwards to minimize inductance. The CS1501 sensor is rated at 50 A, with a maximum inrush current of 240A, and the CS1502 is rated at 100A.

The vertical mounting allows us to control the insertion inductance to about 40 pH.

Measurements

The High side current sensor measurements:

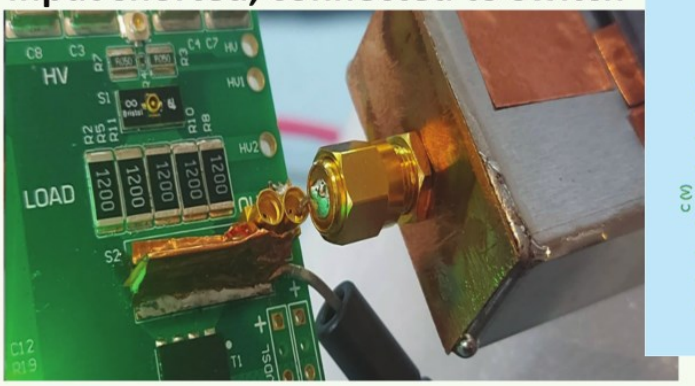




CMRR = 146.5 dB

11.3uv on a 240V 8ns edge

Input shorted, connected to switch



We want to achieve 1 part in 1000 for reading the current, or 50mA on 50A. The 300 mA capture graph shows the current could have been at 50 mA (50uV at the sensor), and can still be resolved. The next version of the current sensor will be a bit quieter, as we learnt some lessons.

Step 2 - Add Vgs, gate drive, and high bandwidth transient capture

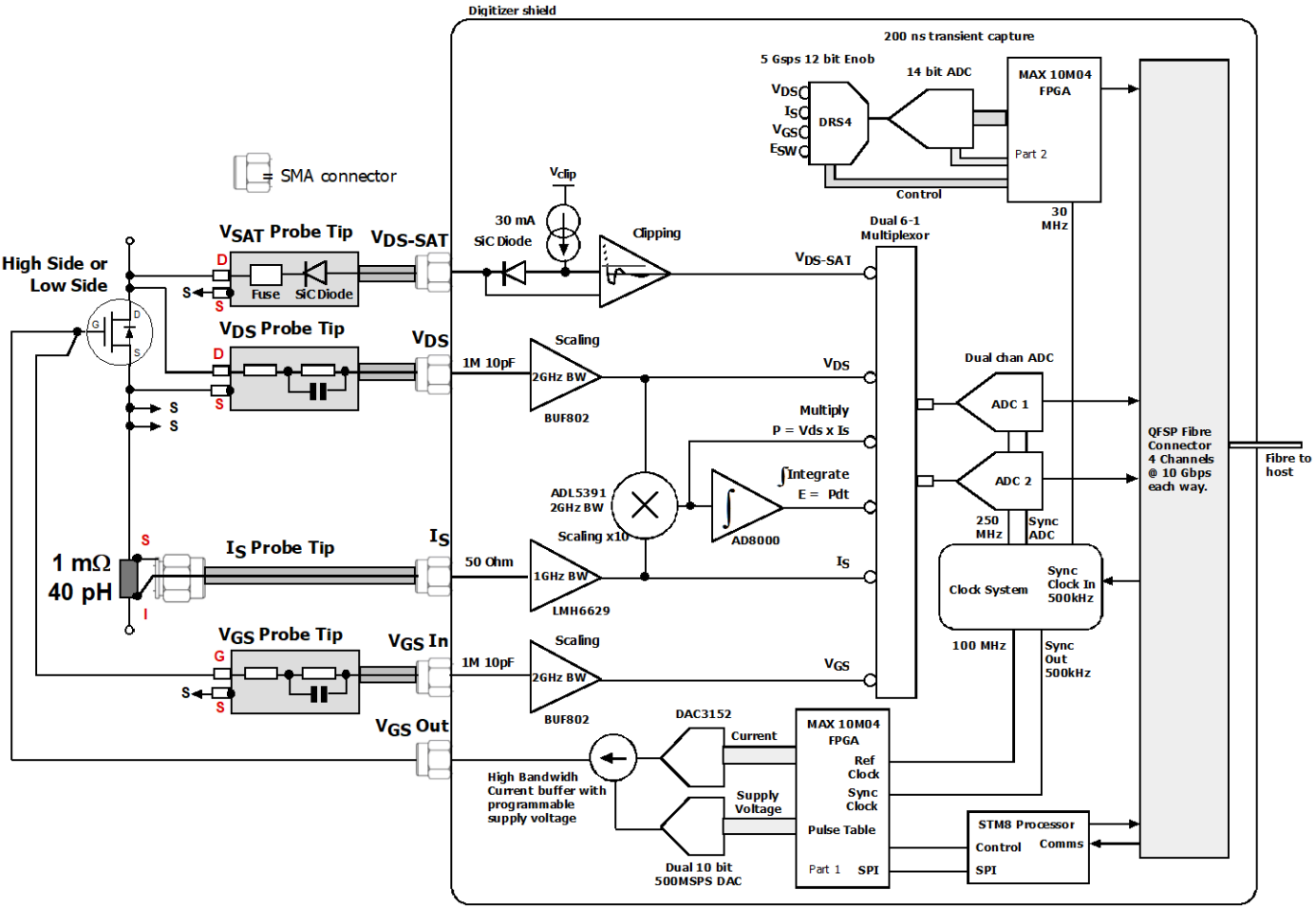
We'll be spending the next few months adding these functions:

- V_{GS} measurement. This is very similar to V_{DS} measurement, but with a different probe tip.
- I_{GS} stimulation. We plan a 500 MSPS table based gate pulse profile with programmable current (ie charge), and programmable voltage headroom. Our goal is +20/-5V gate voltage, 500nC gate charge and 50A maximum current. The current source recharge time will be about 5us.
- Switch transient capture. We'll be using a DRS4 to capture a 200ns time window located about the switch edge transient. We will combine the capture with our up converted 250 MSPS captured waveform to present the full waveform with 200ps resolution (nearly 1 GHz BW), with very good time (200ps) and amplitude resolution (12 ENOB) around the switch edge.

System Block Diagram

The two new blocks are:

- 200ns transient capture
- V_{GS} In + V_{GS} Out.



We are introducing a two channel ADC, so we can measure any two parameters at the same time. The 5GSPS DRS4 digitizes V_{DS}, I_S, V_{GS} and E_{SW} all at the same time, and all are returned to the CS548.

The Loss digitizer can be used on either the high side or the low side with connections as shown.

Some users!


TESLA
JAGUAR
WILLIAMS RACING
NASA
KEYSIGHT
MICROCHIP
SIEMENS
dyson
Stanford University
HARVARD UNIVERSITY
ABB
BAE SYSTEMS
BorgWarner
logitech
B/S/H/
ASML
TOSHIBA
KEMPPI
ADVANTICS
infineon
MAGNA
FORVIA
HELLA
CSIRO
ZEBRA
KONGSBERG
adcos
etelligent
Valeo SIEMENS eAutomotive
solantro SEMICONDUCTOR CORP.
Currawong ENGINEERING
smartpowersolutions
inmotion
SILVER ATENA
eia
UNSW SYDNEY
ABITIBI GEOPHYSICS
DELTA
NEXUS TECHNOLOGY
THE UNIVERSITY OF SYDNEY
BLIXT
Nidec DRIVE SYSTEMS
TUM
Young & Franklin
HM
ENRX
UNIVERSITY OF ALBERTA
der Bundeswehr München
Ben-Gurion University of the Negev
MACQUARIE University SYDNEY·AUSTRALIA
UNIVERSITY OF ALBERTA
UNIVERSITY OF AUCKLAND Waipapa Taumata Rau NEW ZEALAND
PENTRONIC Advanced Automatic Fire Detection Design and Manufacture
UC UNIVERSITY OF CANTERBURY Te Whare Wānanga o Waitaha CHRISTCHURCH NEW ZEALAND
Kearfott