FOUNDED IN 2002

ANALOG POWER

10+ YEARS OF GROWTH

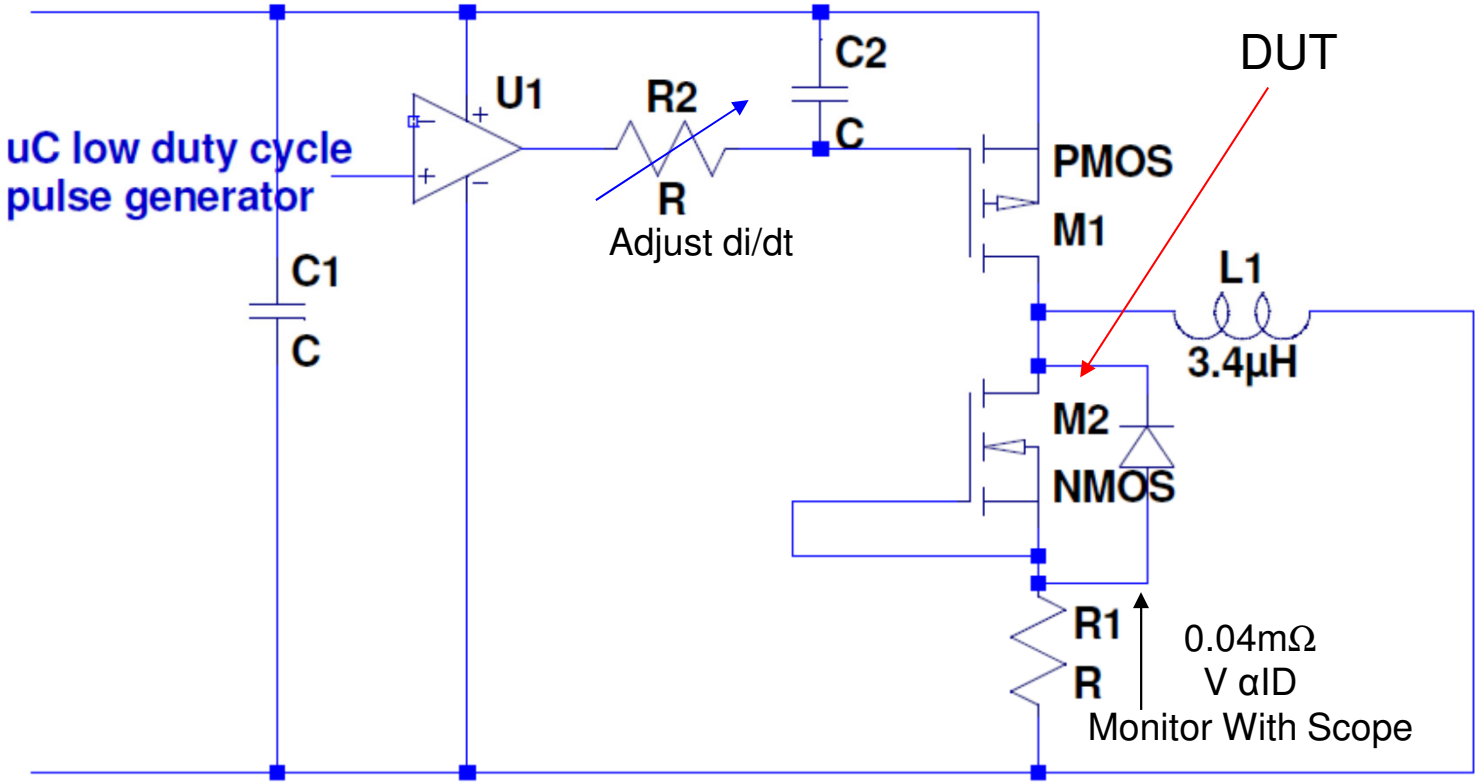
trr Measurements at High di/dt

Preliminary Discussion

Discussion

- An attempt was made to determine how MOSFETs' diodes behave at high di/dt such as found in a synchronous buck circuit
- This is an attempt to myth-bust statements such as:
  - Schottkies have extremely low trr and should be used in parallel with MOSFETs to reduce lossses
  - Qrr is constant, Irr x trr = constant
  - trr losses are not significant

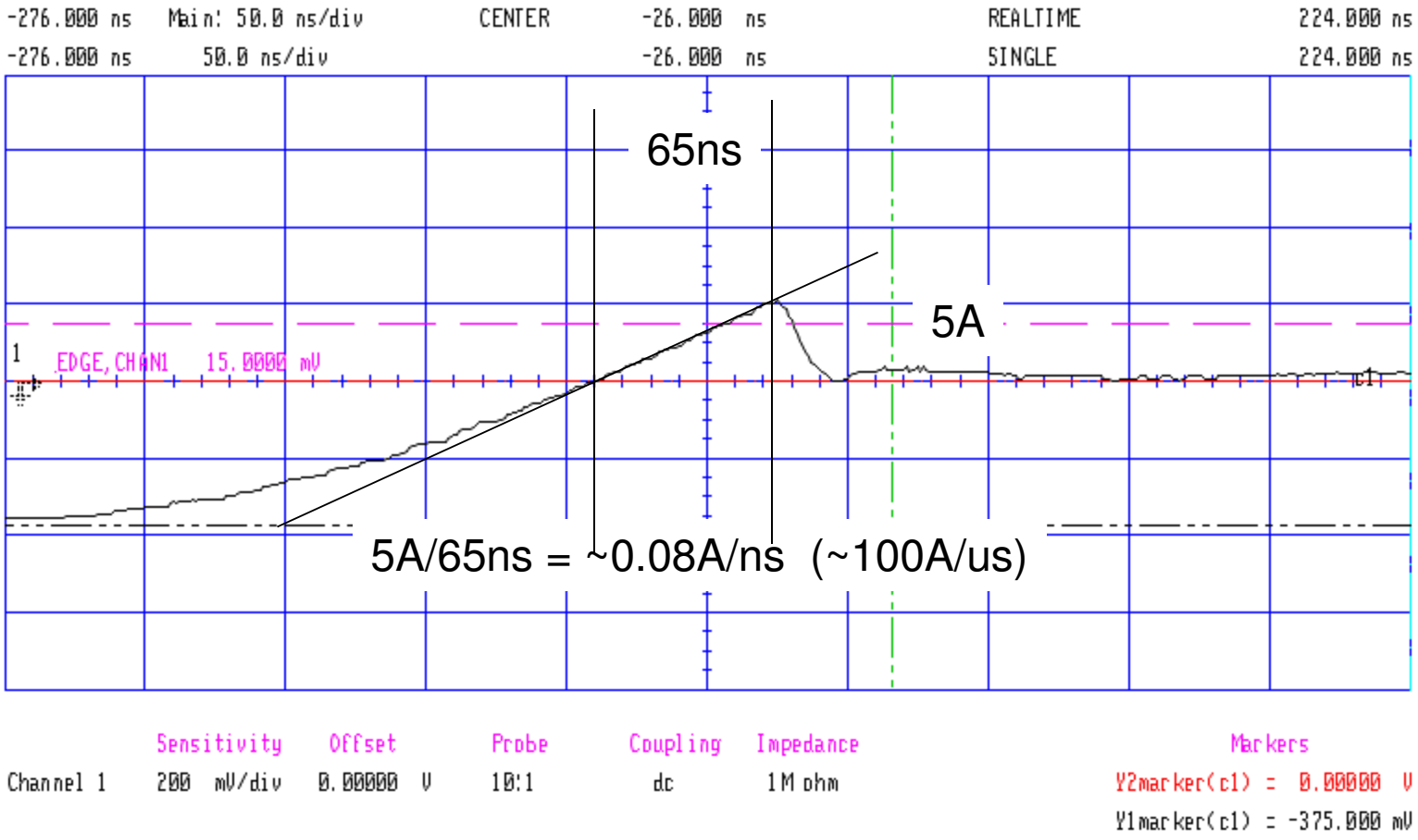
Tester Schematic



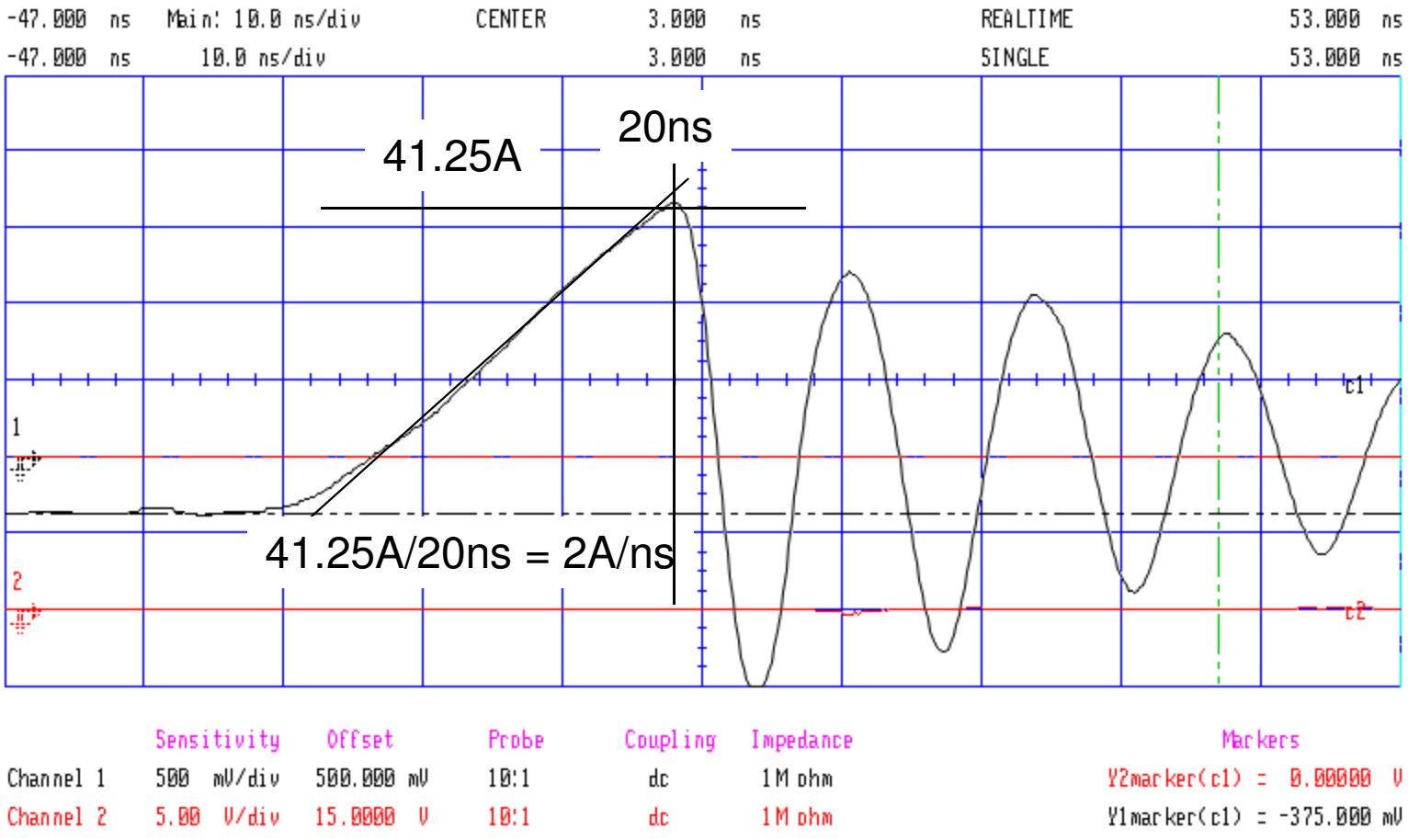
Testing Conditions

- AM7436N MOSFET
- VIN = 12V
- IF = 10A
- Sense resistor = 40m Ohm
- All time measurements are for ta only, ignore tb
  - ta>>tb
  - Losses for tb ~0 as VDS of diode has ramped up

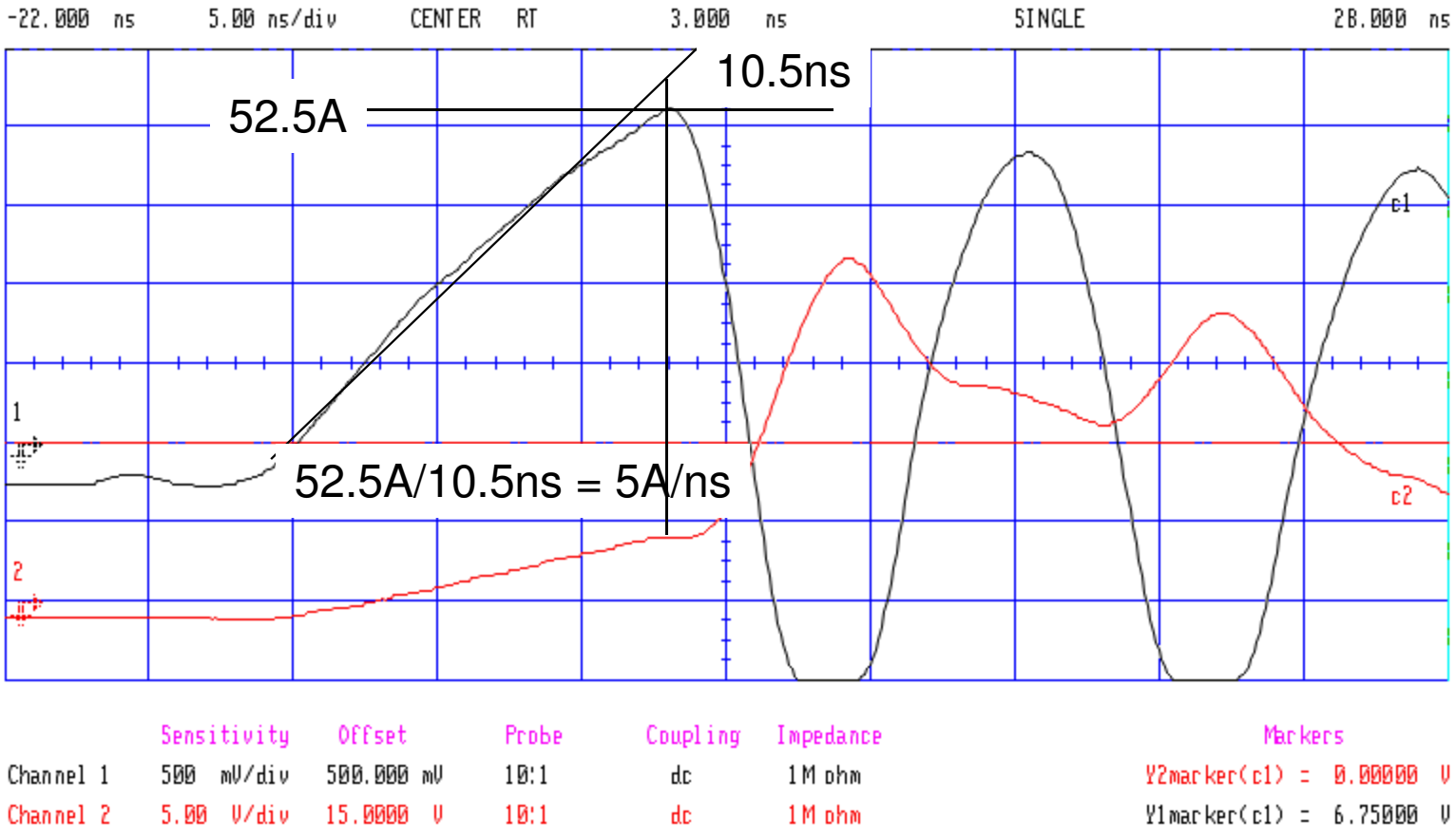
Traditional Conditions: 100A/us



2A/ns


-47.000 ns Main: 10.0 ns/div CENTER 3.000 ns REALTIME 53.000 ns
-47.000 ns 10.0 ns/div 3.000 ns SINGLE 53.000 ns
41.25A
20ns
41.25A/20ns = 2A/ns
c1
c2
1
2
Sensitivity Offset Probe Coupling Impedance Markers
Channel 1 500 mV/div 500.000 mV 10:1 dc 1M ohm Y2marker(c1) = 0.00000 V
Channel 2 5.00 V/div 15.0000 V 10:1 dc 1M ohm Y1marker(c1) = -375.000 mV

5A/ns


-22.000 ns
5.00 ns/div
CENTER RT
3.000 ns
SINGLE
28.000 ns
10.5ns
52.5A
52.5A/10.5ns = 5A/ns
c1
c2
1
2
Sensitivity
Offset
Probe
Coupling
Impedance
Markers
Channel 1 500 mV/div 500.000 mV 10:1 dc 1M ohm
Channel 2 5.00 V/div 15.0000 V 10:1 dc 1M ohm
Y2marker(c1) = 0.00000 V
Y1marker(c1) = 6.75000 V

Results

Di/Dt A/ns	Irr peak A	trr ns	trr * di/dt	Qrr nC
0.1	5	65		160
2	41	20	40	410
5	52	10.5	50	275

Conclusions

This data needs verification, however we make the following assumptions:

- Qrr at >1A/ns >> at di/dt = 100A/us. The reason for the increase is probably natural recombination over time at slower di/dt
- The data show Qrr decreasing from 2A/ns to 5A/ns, this is not likely the case for a perfect circuit. We think IRR is being capped by other parts of the circuit, i.e. parasitics and circuit resistance play, but this is how a real circuit will behave and di/dt of >5A/ns is quite possible so maybe at high di/dt trr is less important and parasitics play a part
- trr x di/dt = ~constant at high di/dt
- The data actually shows significant +ve VDS during ta. This was a surprise, but some +ve VDS is likely due to substrate and package resistance at these high currents.
- We will design new board and see if data makes any more sense, more data points are needed.
  - More: see next page

Other Conclusions/Findings

- Schottkies have finite trr too. Many Schottkies are no better than PN diodes
  - MOSFETs with schottkies have quite long trr
  - Conditions for some Schottky trr are unreasonably low current as at higher currents PN junction comes into play
- This experiment would suggest trr losses are a significant cause of losses in the top FET, but maybe not quite as much as expected due to:
  - +VE VDS during recovery (although this may be losses in the bottom FET)
  - Irr being limited by other circuit components
  - Very high di/dt does reduce losses and trr < 10ns is possible