

SW12400 - Double Pulse Switching Test Introduction

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SW12400
(Switching test box)

+



STT-700X tester

1. Double Pulse Test Theory

The double pulse switching test is done with an inductive load and a power supply. The inductor is used to replicate circuit conditions in a converter design.

The figure 1 shows the current flow within the different stages of the test for a Double Pulse Test with MOSFETs.

Remark: The TRR and Isc test use similar test circuit.

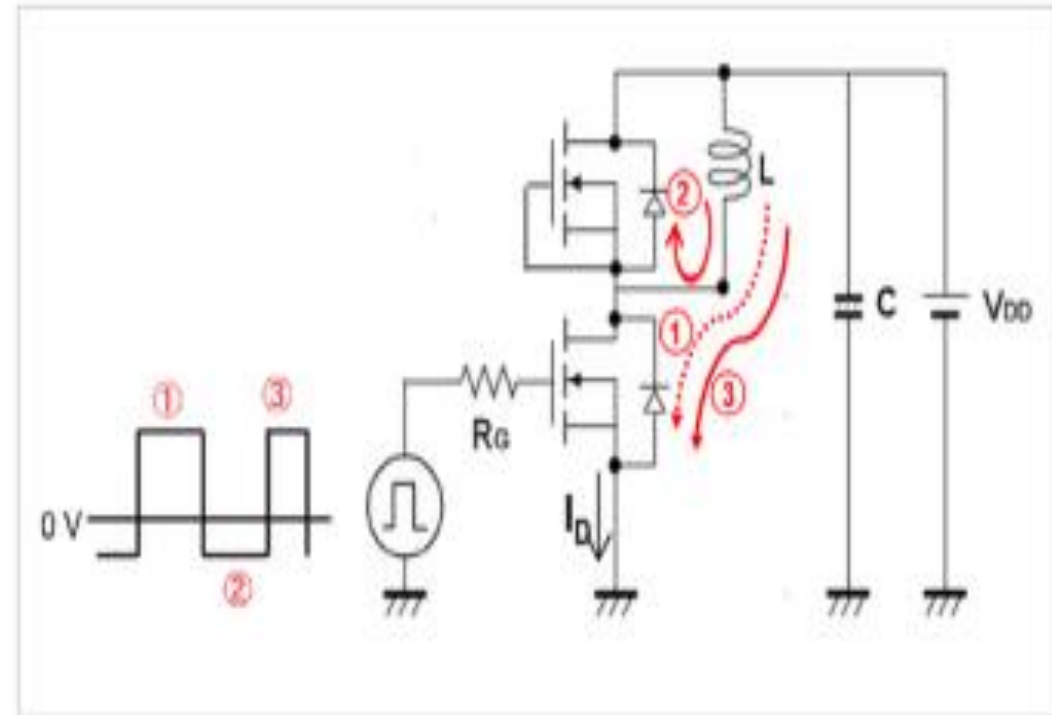


Figure 1

2. Double Pulse Switching Test Specifications:

Test Item	Parameter	Range	Accuracy	Test Condition
Double pulse switching test (with Inductive load)	Tdon	5~10000ns	Vds: $\pm 2\%$ Ids: $\pm 4\%$ Vgs: $\pm 1.5\%$ L-Load: 20uH、50uH、100uH、 200uH、500uH、1mH Stability: $\pm 3\%$ ^[1]	Vdc: 50~1200V Ids(Ice): 5~400A L-Load: 20uH、50uH、100uH、200uH、 500uH、1mH Vge(Vgs) ON : 0~20V Vge(Vgs) OFF: -20~0V Rg ON: 0~255ohm, step 1ohm, accuracy 1% Rg OFF: 0~255ohm, step 1ohm, accuracy 1% 1st on time: 1~1000 μ s, step 0.1 μ s 1st off time: 1~100 μ s, step 0.1 μ s 2nd on time: 1~100 μ s, step 0.1 μ s
	Tr	5~10000ns		
	Ton	5~10000ns		
	Imax	400A		
	Eon	1~1000000 μ J		
	Di/Dton	0.01~100KA/ μ s		
	Dv/Dton	0.01~100KA/ μ s		
	Vmax1	50~1200V		
	Vmax2	50~1200V		
	Tdoff	5~10000ns		
	Tf	5~10000ns		
	Toff	5~10000ns		
	Eoff	1~1000000 μ J		
	Di/Dtoff	0.01~100KA/ μ s		
Dv/Dtoff	0.01~100KA/ μ s			

[1] With good contact and HDO6054B Oscilloscope in Lab

3. TRR Test Specifications:

Test Item	parameter	range	accuracy	Test condition
TRR test	Irr	400A	Vds: $\pm 2\%$ Ids: $\pm 4\%$ Vgs: $\pm 1.5\%$ L-Load: 20uH、50uH、100uH、 200uH、500uH、1mH Stability: $\pm 3\%$ [1]	Vdc: 50~1200V Ids(Ice): 5~400A L-Load: 20uH、50uH、100uH、200uH、 500uH、1mH Vge(Vgs) ON : 0~20V Vge(Vgs) OFF: -20~0V Rg ON: 0~255ohm, step 1ohm, accuracy 1% Rg OFF: 0~255ohm, step 1ohm, accuracy 1% 1st on time: 1~1000 μ s, step 0.1 μ s 1st off time: 1~100 μ s, step 0.1 μ s 2nd on time: 1~100 μ s, step 0.1 μ s
	Trr	5~10000ns		
	Qrr	0.001~100 μ C		
	Erec	1~1000000 μ J		
	IFM	400A		

[1] With good contact and HDO6054B Oscilloscope in Lab

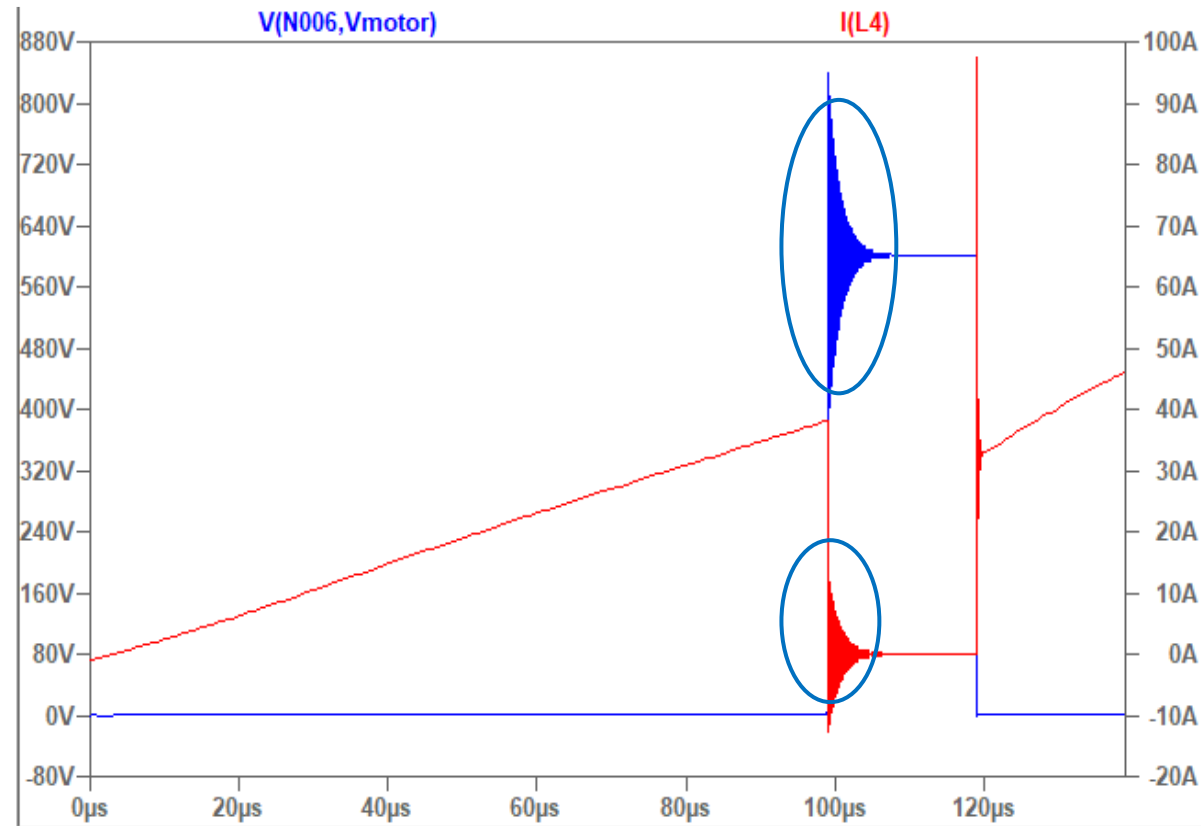
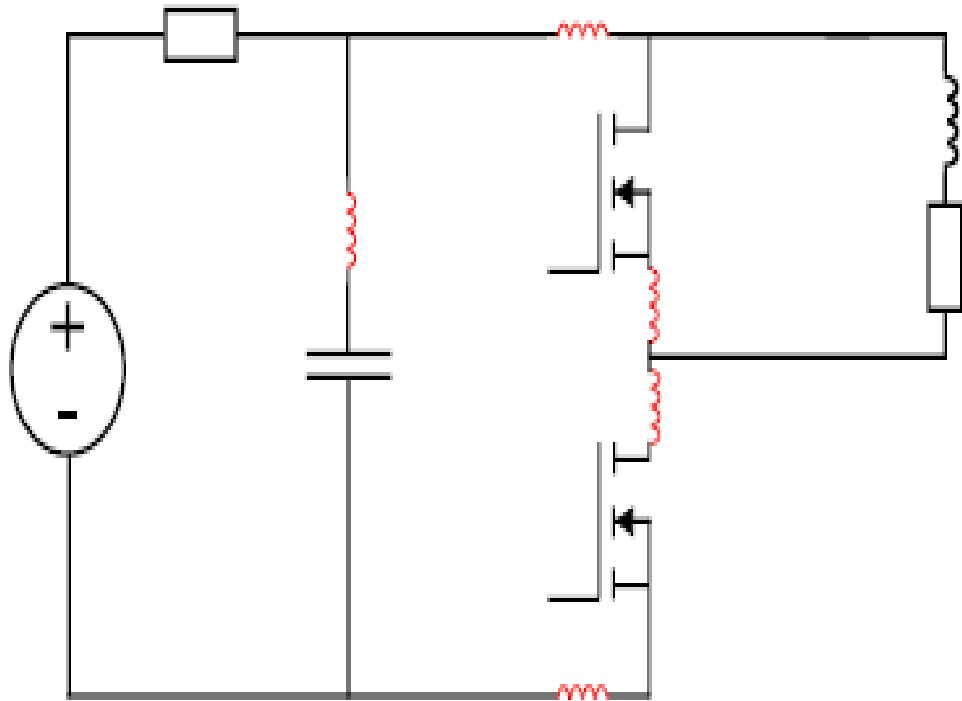
4. Isc Test Specifications:

Test Item	Parameters	Range	Accuracy	Test Condition
Isc test	I _{max}	1000A	V _{ds} : ±2% I _{ds} : ±4% V _{gs} : ±1.5% Stability: ±3% ^[1]	V _{dc} : 50~1200V I _{ds(Ice)} : Max 1000A V _{ge(Vgs)} ON: 0~20V V _{ge(Vgs)} OFF: -20~0V R _g ON: 0~255ohm, step 1ohm, accuracy 1% R _g OFF: 0~255R, step 1ohm, accuracy 1% 1st on time: 1~10μs, step 0.1μs
	V _{max}	50~1200V		
	T _{sc}	1~10us		

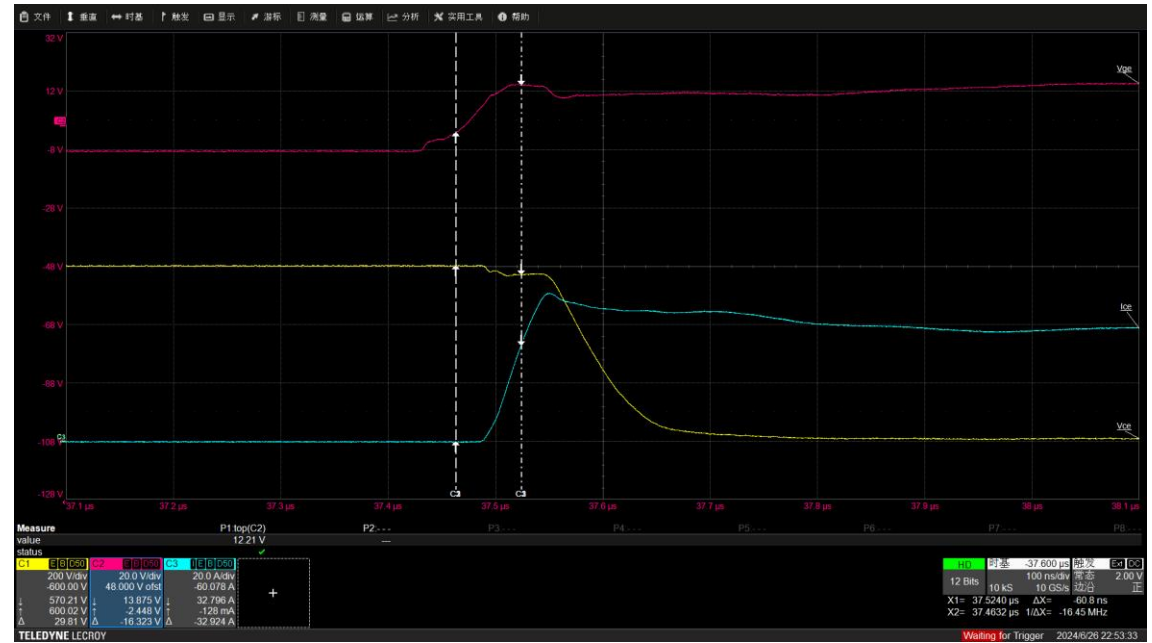
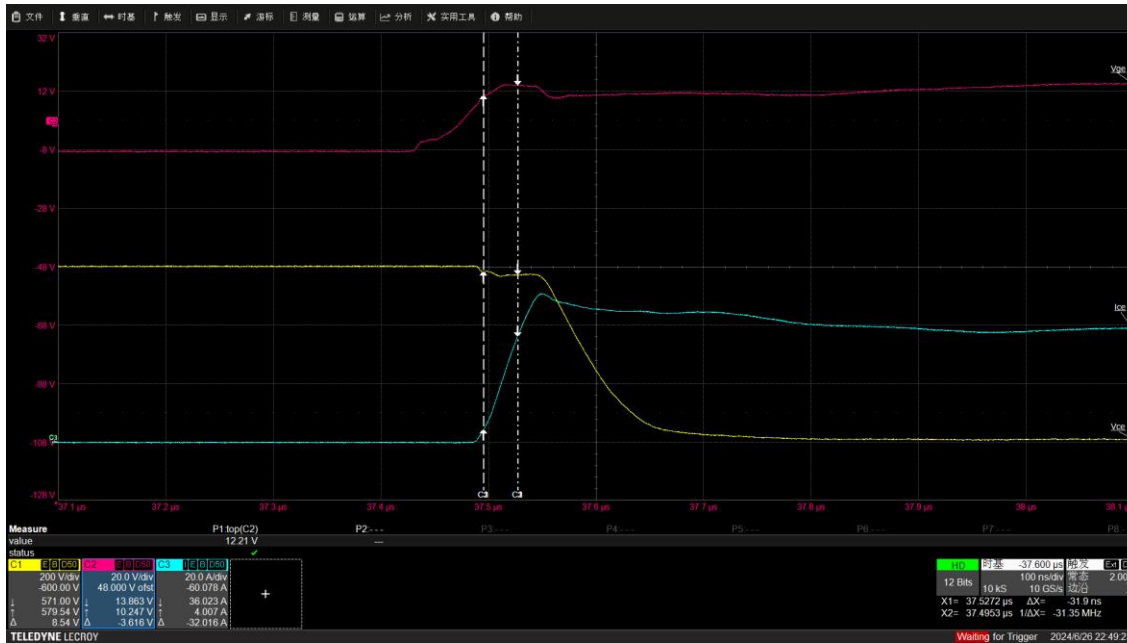
[1] With good contact and HDO6054B Oscilloscope in Lab

Parasitic inductance affect the test accuracy

Due to the parasitic effect in the test circuit, there is overshoot and ringing etc., to affect the switching test accuracy.



Parasitic inductance in our test circuit



From the waveform and calculation, the parasitic inductance in our test circuit is **29.81nH**.

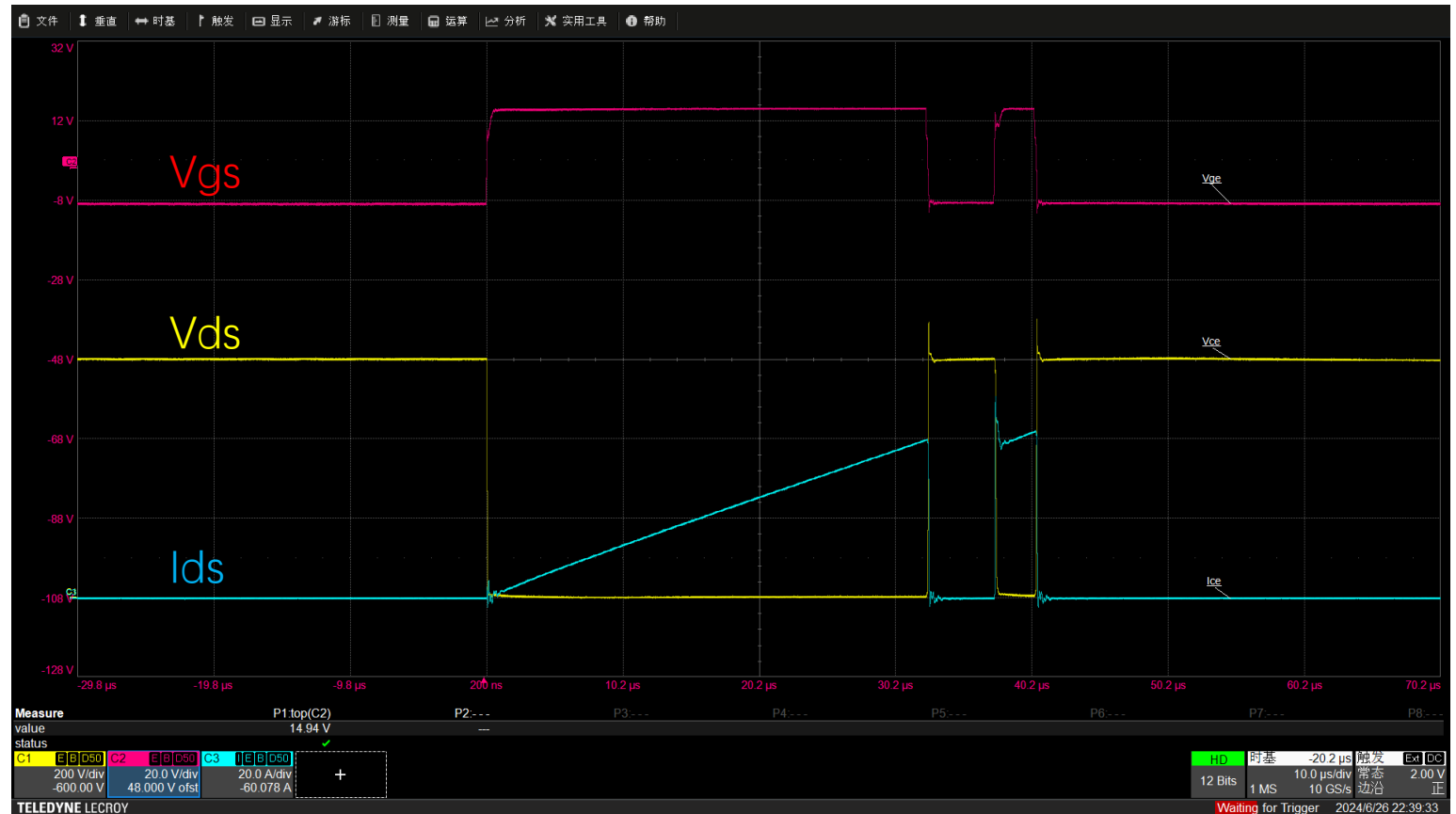
5. Case Study: IGBT(IKW40N120H3FKSA1) Switching Test Waveform and result

Double pulse test waveform of the IGBT device:

Red line: V_{gs}

Yellow line: V_{ds}

Blue line: I_{ds}



Switching Test of IGBT (IKW40N120H3FKSA1)

Test condition and test result.



The screenshot shows the 'Double Pulse Test' software window. It includes a 'Device' section with 'Bus Voltage' and 'Current' input fields, a 'Start Discharge' button, and a dropdown menu set to 'IGBT'. Below this are tabs for 'Switch Test', 'Diode Test', and 'Short-Circuit Test'. The 'Param' section contains various test parameters with input fields and spinners. The 'Result' section displays a grid of measured values with checkboxes. At the bottom, there is a 'START' button and a 'Run Time: 504.0 ms' indicator.

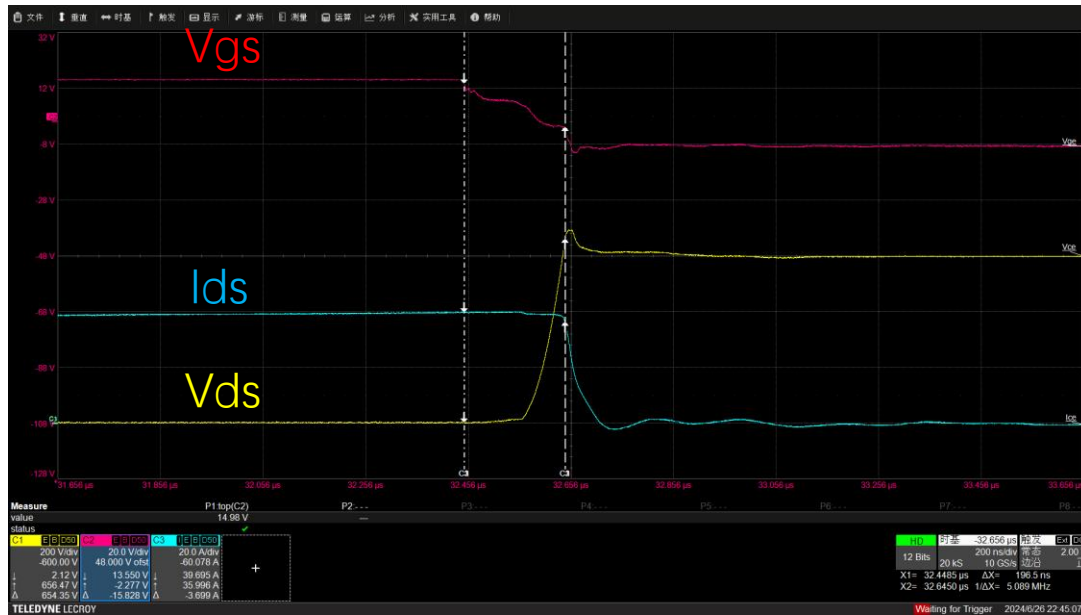
Param	
Gate Pulse High	15.0V
Gate Pulse Low	-9.0V
1st OnTime	33.3us
1st Off Time	5.0us
2nd OnTime	3.0us
Rg_OFF	12R
Rg_ON	12R
Vds / Vce OFF	600V
Ids / Ice ON	40.0A
Load-L	500uH

Result	
<input checked="" type="checkbox"/> Tdon	19.6ns
<input checked="" type="checkbox"/> Ton	51.5ns
<input checked="" type="checkbox"/> Eon	2331.1uJ
<input checked="" type="checkbox"/> dv/dt(on)	5.3V/ns
<input checked="" type="checkbox"/> di/dt(on)	1.0A/ns
<input checked="" type="checkbox"/> Tr	31.9ns
<input checked="" type="checkbox"/> Tdoff	196.1ns
<input checked="" type="checkbox"/> Toff	249.7ns
<input checked="" type="checkbox"/> Eoff	1189.8uJ
<input checked="" type="checkbox"/> dv/dt(off)	11.3V/ns
<input checked="" type="checkbox"/> di/dt(off)	0.6A/ns
<input checked="" type="checkbox"/> Tf	53.6ns
<input checked="" type="checkbox"/> Vce.ds_peck	701.2V
<input checked="" type="checkbox"/> Ice.ds_peck	50.8A

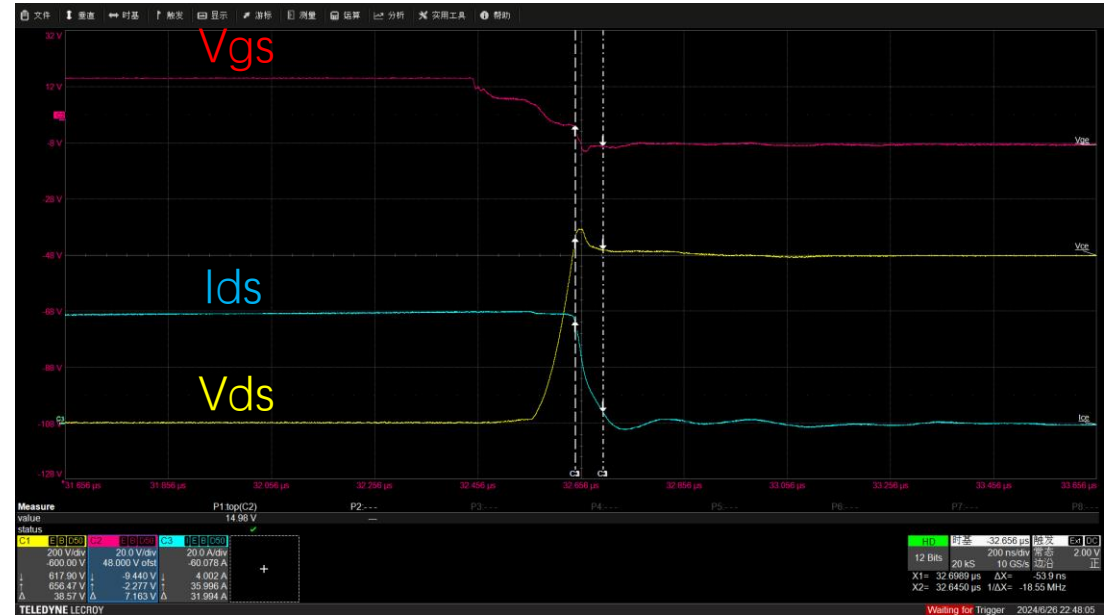
Waveform of Tdoff and Tf of IGBT (IKW40N120H3FKSA1)

Tdoff

Tf



First off waveform, Tdoff=196.5ns.

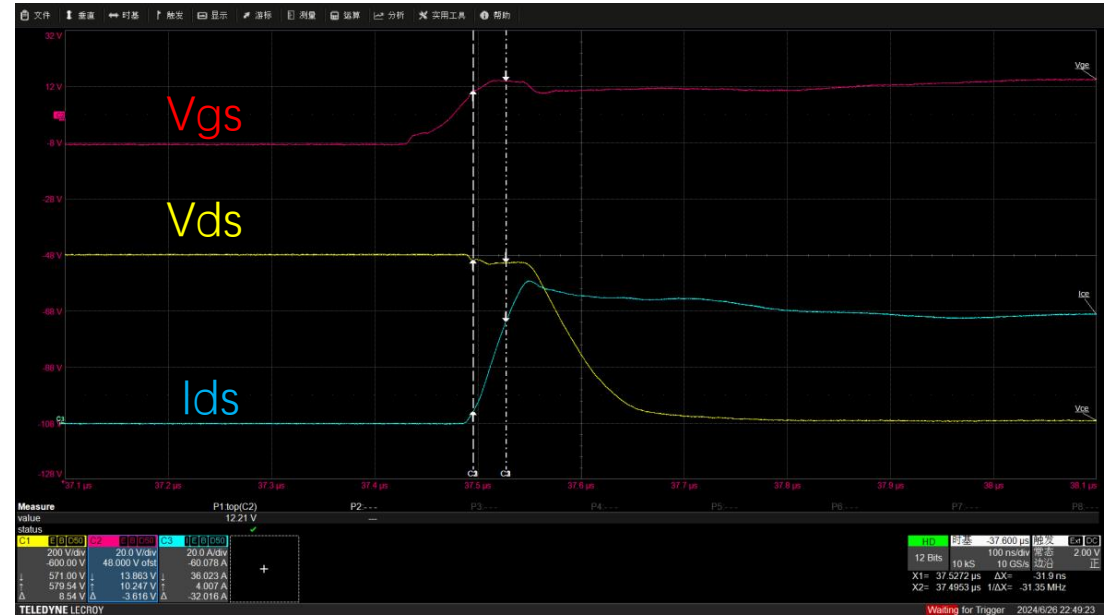
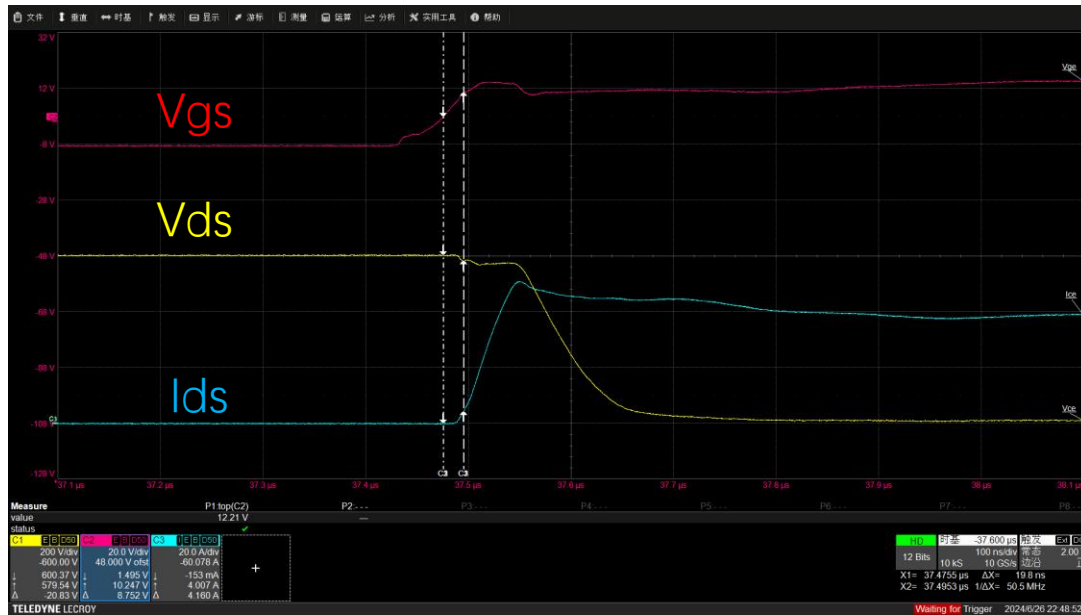


First off waveform, Tf=196.5ns.

Waveform of Tdon and Tr of IGBT(IKW40N120H3FKSA1)

Tdon

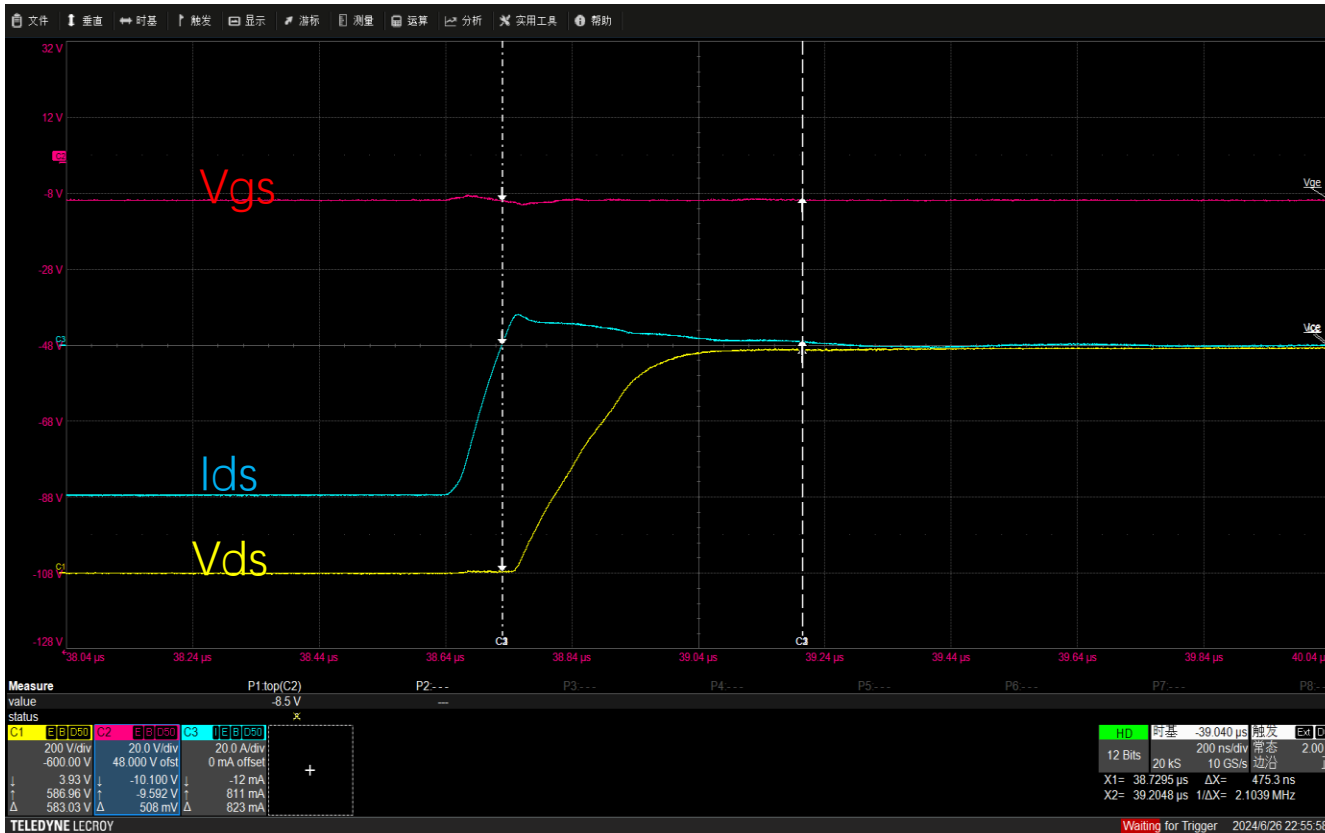
Tr



Second on waveform, Tdon=19.8ns.

Second on waveform, Tr=31.9ns.

Waveform of IGBT (IKW40N120H3FKSA1) Trr Test



$T_{rr}=393.5\text{ns}$

Double Pulse Test

File Option

Device: IGBT

Bus Voltage: Start Discharge

Current:

Switch Test | Diode Test | Short-Circuit Test

Param

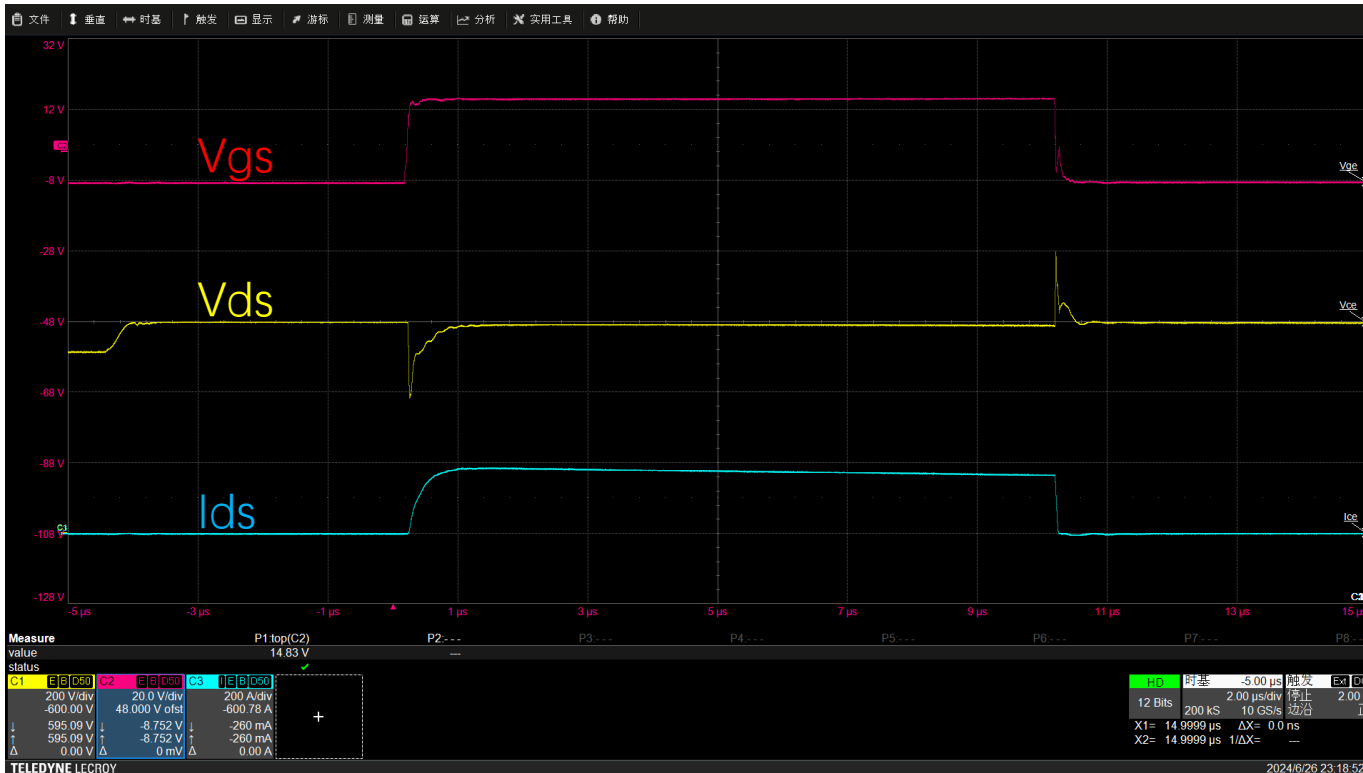
Gate Pulse High	15.0V	Voff	600V	
Gate Pulse Low	-9.0V	Ion	40.0A	
1st OnTime	33.3us	0.0us	Load-L	500uH
1st Off Time	5.0us			
2nd OnTime	5.0us			
Rg_OFF	10R			
Rg_ON	30R			

Result

<input type="checkbox"/> Trr_JESD24		<input type="checkbox"/> Erec_JESD24	
<input checked="" type="checkbox"/> Trr_IEC60747	393.5ns	<input checked="" type="checkbox"/> Erec_IEC60747	535.8uJ
<input type="checkbox"/> Qrr_JESD24		<input checked="" type="checkbox"/> Irr	8.1A
<input checked="" type="checkbox"/> Qrr_IEC60747	1600.0nC	<input checked="" type="checkbox"/> di / dt	0.5A/ns

START

Waveform of IGBT (IKW40N120H3FKSA1) Isc Test



Isc=187.0A

Double Pulse Test

File Option

Device

Bus Voltage

Current

Start Discharge

IGBT

Switch Test | Diode Test | Short-Circuit Test

Param

Gate Pulse High

Gate Pulse Low

1st OnTime

Rg_OFF

Rg_ON

Vds / Vce OFF

Max Short Current

Result

Vmax

Isc

Tsc

Esc

START

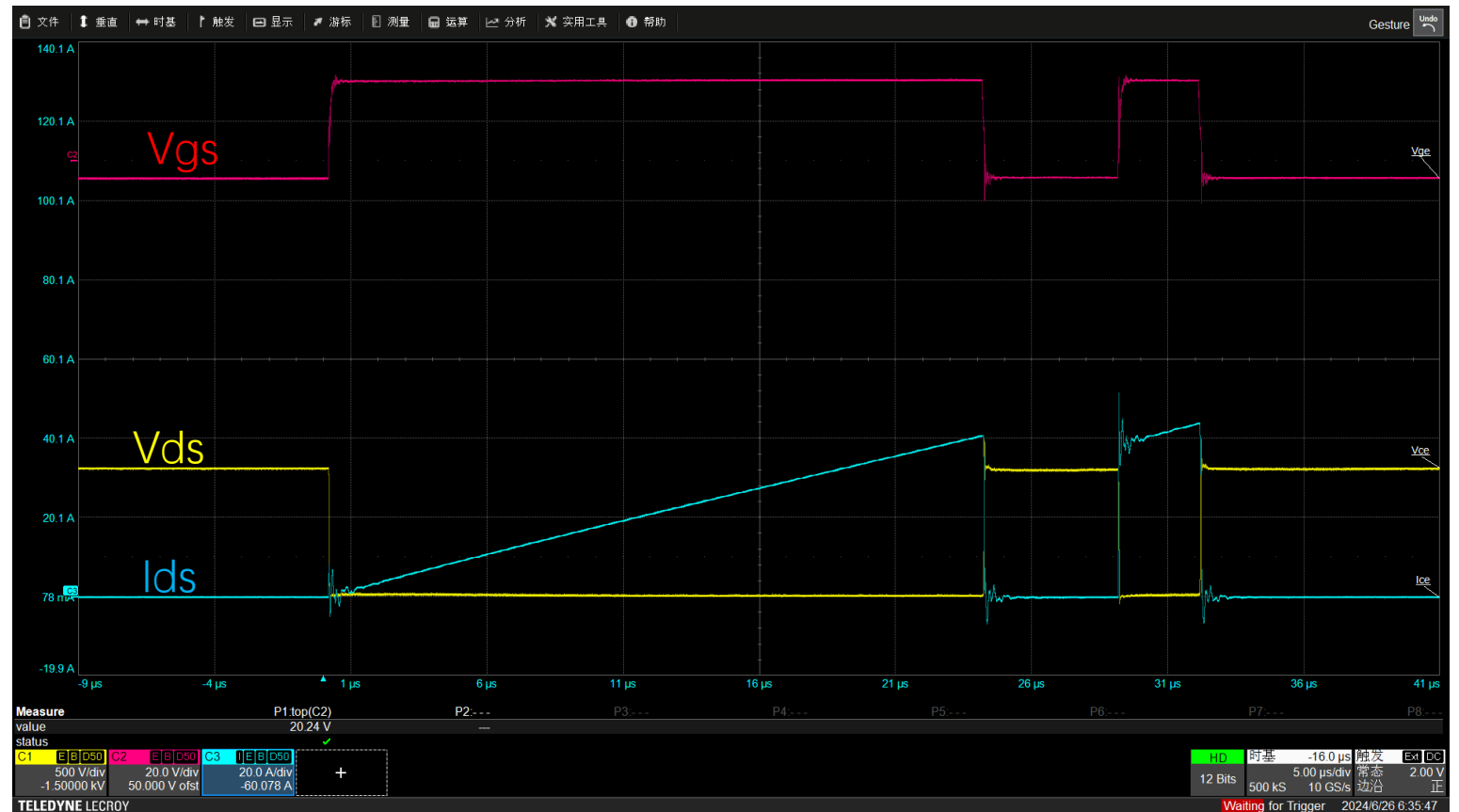
6. Case Study: SiC Mosfet(C160N120SM) Switching Test Waveform and Result

Double pulse test waveform of the SiC Mosfet device

Red line: V_{gs}

Yellow line: V_{ds}

Blue line: I_{ds}



Switching Test of SIC Mosfet (C160N120SM)

Test condition and test result.



The screenshot shows the 'Double Pulse Test' software window. It includes a 'Device' section with 'Bus Voltage' and 'Current' input fields, a 'Start Discharge' button, and a 'MOSFET' dropdown menu. Below this are tabs for 'Switch Test', 'Diode Test', and 'Short-Circuit Test'. The 'Param' section contains various test parameters with spinners, and the 'Result' section displays a grid of measured values.

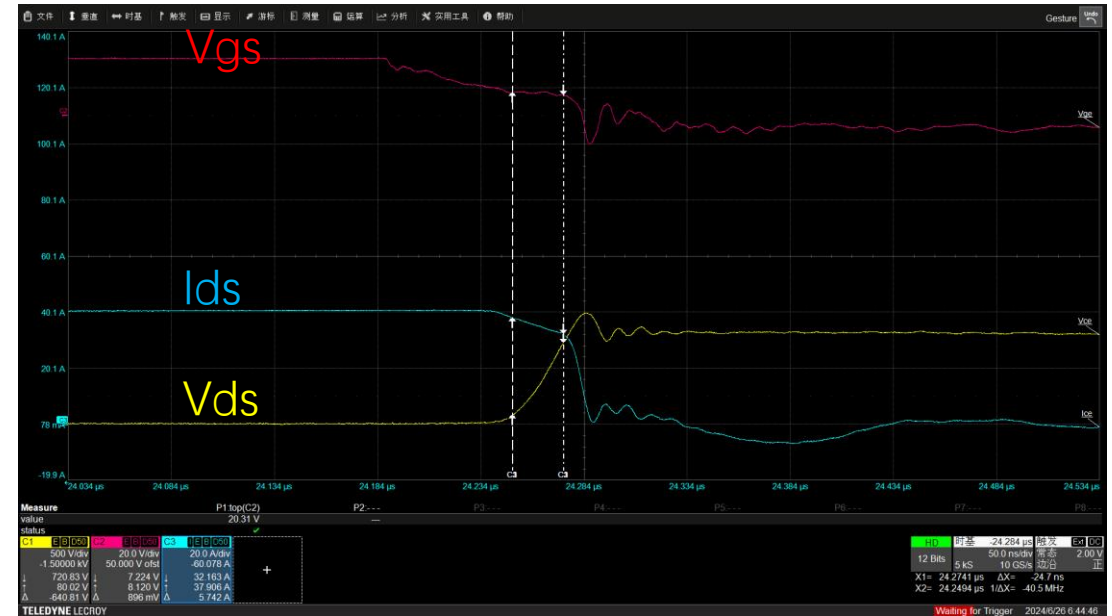
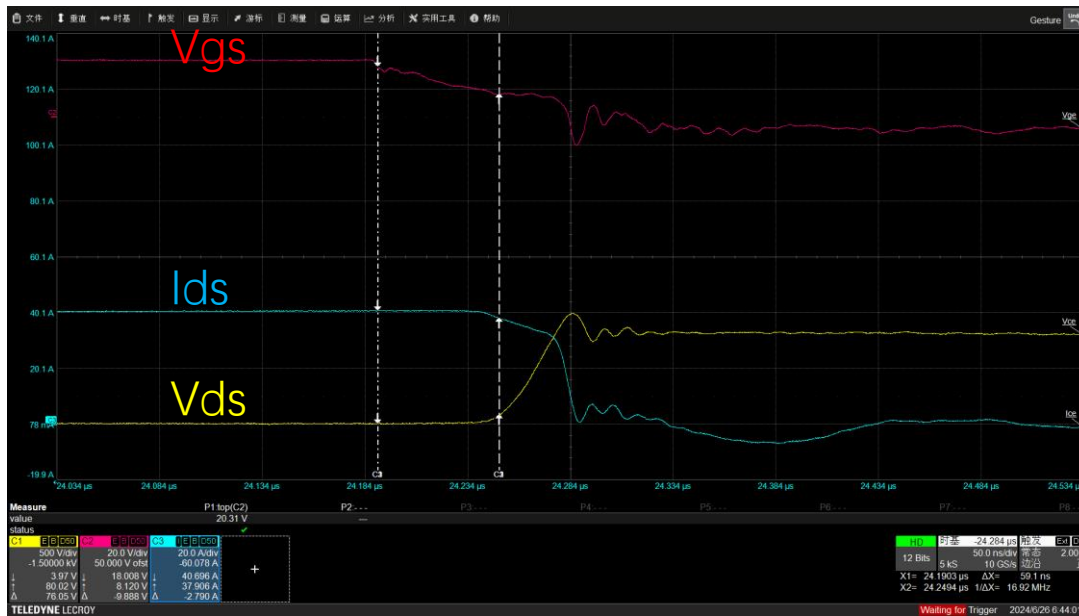
Param		Result	
Gate Pulse High	20.0V	Tdon	20.7ns
Gate Pulse Low	-5.0V	Ton	58.9ns
1st OnTime	25.0us	Eon	931.1uJ
1st Off Time	5.0us	dv/dt(on)	16.8V/ns
2nd OnTime	3.0us	di/dt(on)	2.3A/ns
Rg_OFF	10R	Tr	38.2ns
Rg_ON	10R	Tdoff	58.7ns
Vds / Vce OFF	800V	Toff	83.7ns
Ids / Ice ON	40.0A	Eoff	527.4uJ
Load-L	500uH	dv/dt(off)	87.5V/ns
		di/dt(off)	1.1A/ns
		Tf	25.0ns
		Vce,ds_peck	995.4V
		Ice,ds_peck	51.5A

START Run Time:828.3 ms

Waveform of Tdoff and Tf of SIC Mosfet (C160N120SM)

Tdoff

Tf



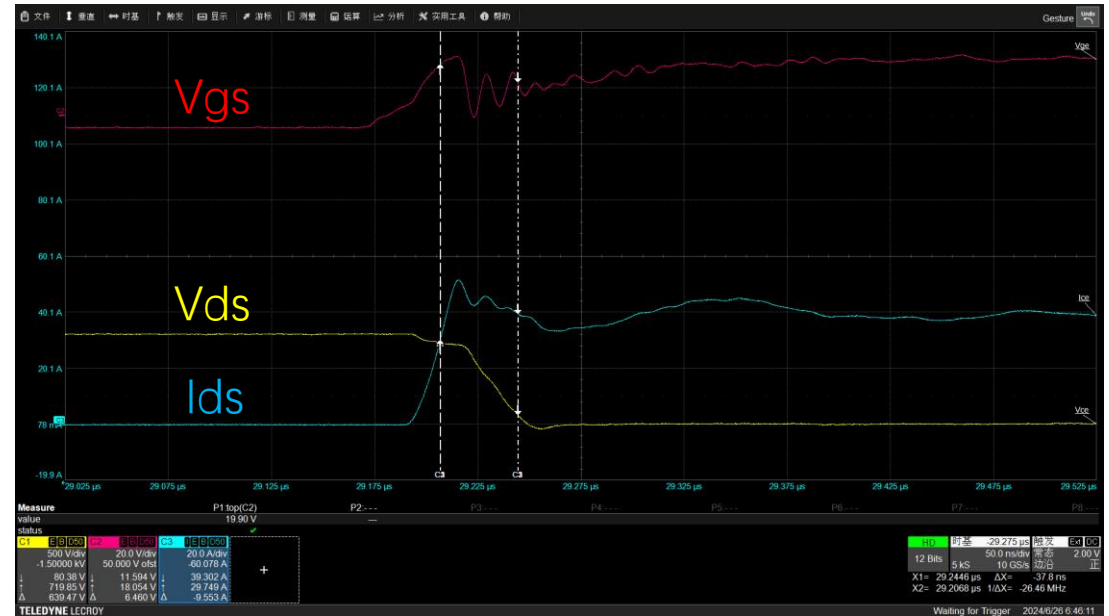
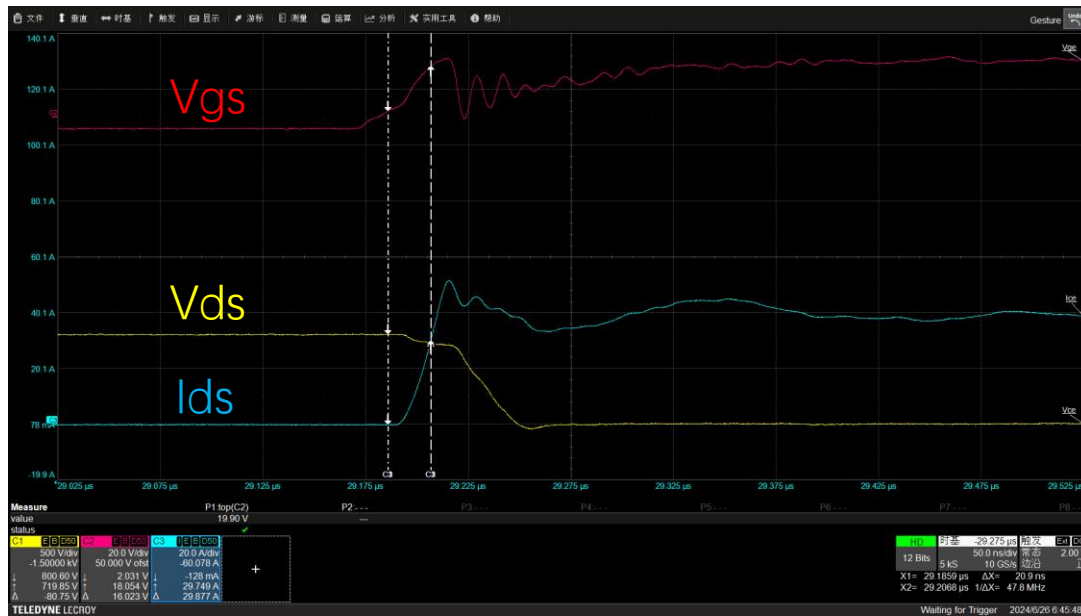
First off waveform, Tdoff=59.1ns.

First off waveform, Tf=24.7ns.

Waveform of Tdon and Tr of SIC Mosfet (C160N120SM)

Tdon

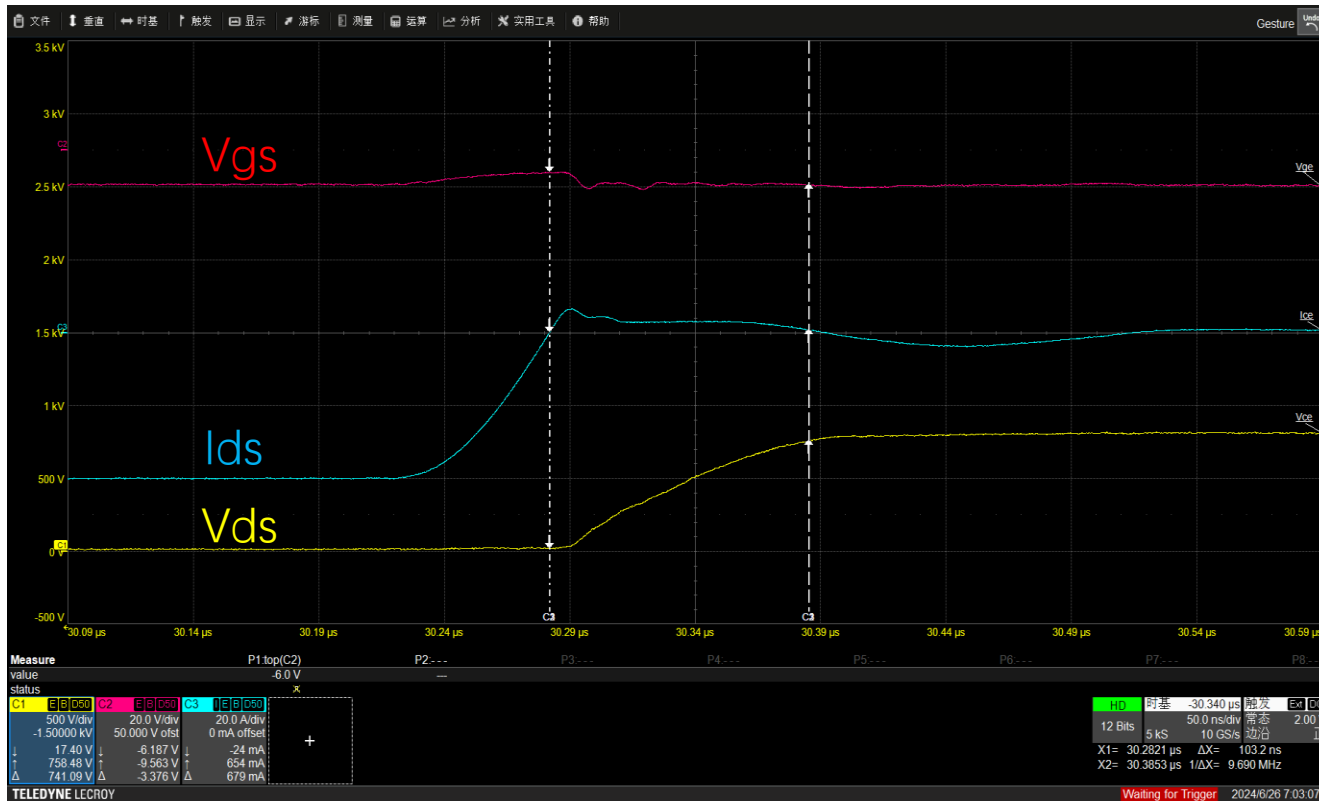
Tr



DUT Second on waveform, Tdon=20.9ns。

DUT Second on waveform, Tr=37.8ns。

Waveform of SIC Mosfet (C160N120SM) Trr Test

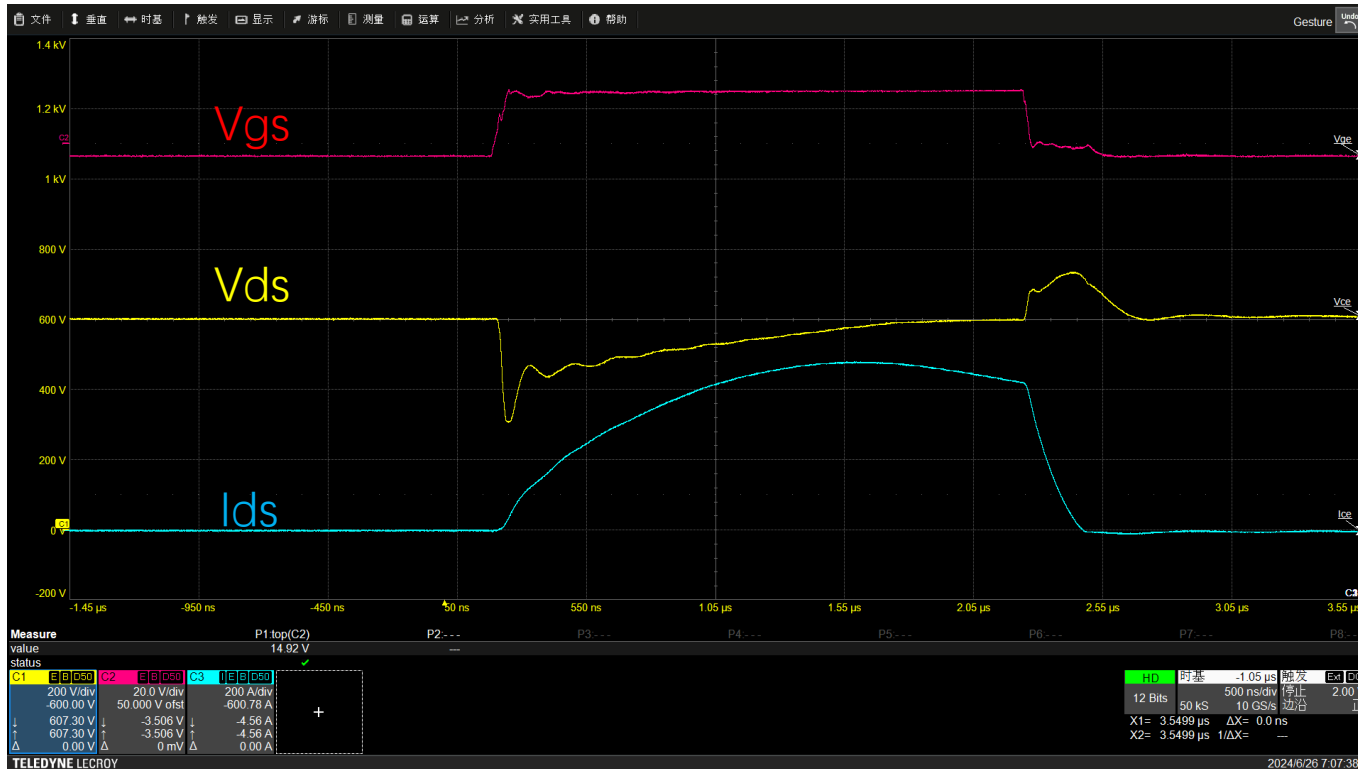


Trr=122.8ns

The screenshot shows the Double Pulse Test software interface. The Device is set to MOSFET. The Gate Pulse High is 20.0V and Gate Pulse Low is -5.0V. The 1st On Time is 25.0us and 1st Off Time is 5.0us. The 2nd On Time is 5.0us. The Rg_OFF is 10R and Rg_ON is 37R. The Voff is 800V and Ion is 40.0A. The Load-L is 500uH. The Result section shows Trr_JESD24 as 122.8ns, Erec_JESD24 as 104.2uJ, Qrr_JESD24 as 300.0nC, Irr as 6.4A, and di/dt as 1.0A/ns.

Parameter	Value
Gate Pulse High	20.0V
Gate Pulse Low	-5.0V
1st On Time	25.0us
1st Off Time	5.0us
2nd On Time	5.0us
Rg_OFF	10R
Rg_ON	37R
Voff	800V
Ion	40.0A
Load-L	500uH
Trr_JESD24	122.8ns
Erec_JESD24	104.2uJ
Qrr_JESD24	300.0nC
Irr	6.4A
di/dt	1.0A/ns

Waveform of SIC Mosfet(CI60N120SM) Isc Test



Isc=479.1A

Double Pulse Test

File Option

Device: MOSFET

Bus Voltage: Start Discharge

Current:

Switch Test | Diode Test | Short-Circuit Test

Param

Gate Pulse High	<input type="text" value="20.0V"/>	Vds / Vce OFF	<input type="text" value="600V"/>
Gate Pulse Low	<input type="text" value="-5.0V"/>	Max Short Current	<input type="text" value="600.0A"/>
1st OnTime	<input type="text" value="2.1us"/>		
Rg_OFF	<input type="text" value="10R"/>		
Rg_ON	<input type="text" value="10R"/>		

Result

Vmax Isc Tsc

Esc

START