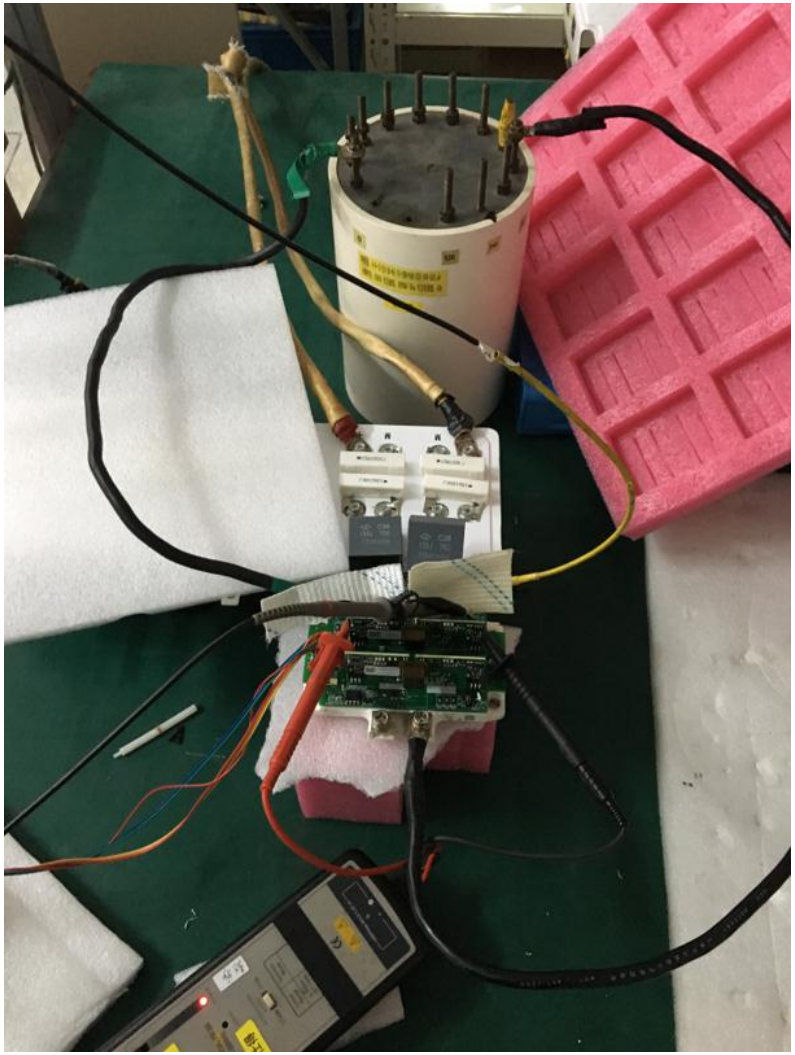
F3L300R07PE4双脉冲测试报告

强电测试大纲

- 关断尖峰（T1-T4）
- 开关特性（T1-T4）
- 短路测试（T1-T4）
- 结论

测试安装图



关断尖峰测试

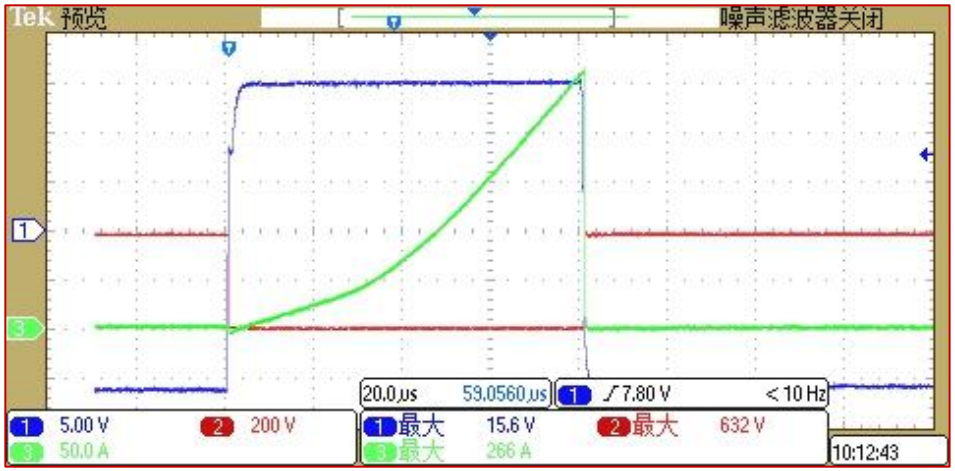
测试条件:

1. V_{DC}=750V@I_C=270A；
2. R_{Gon}=6.0Ω R_{Goff}=4.0Ω
3. IGBT: F3L300R07PE4
4. 1.5uF吸收电容
5. 有源钳位阈值:520V
6. 驱动核：C-Core

T1—关断尖峰

CH1：V_{GE-T1}
CH2：V_{CE-T1}
CH3：I_C

实验条件：V_{DC}=750V；I_C=270A；

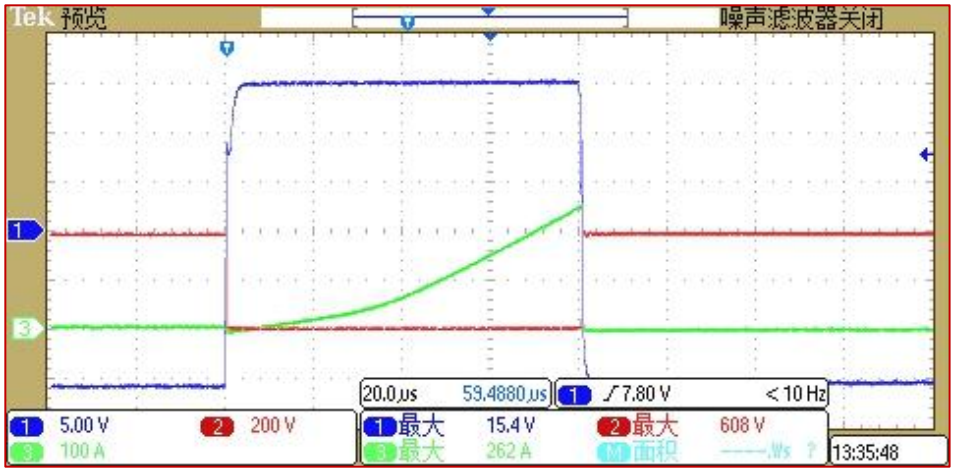


V_{ce_max}=632V

T2—关断尖峰

CH1：V_{GE-T2}
CH2：V_{CE-T2}
CH3：I_C

实验条件：V_{DC}=750V；I_C=270A；

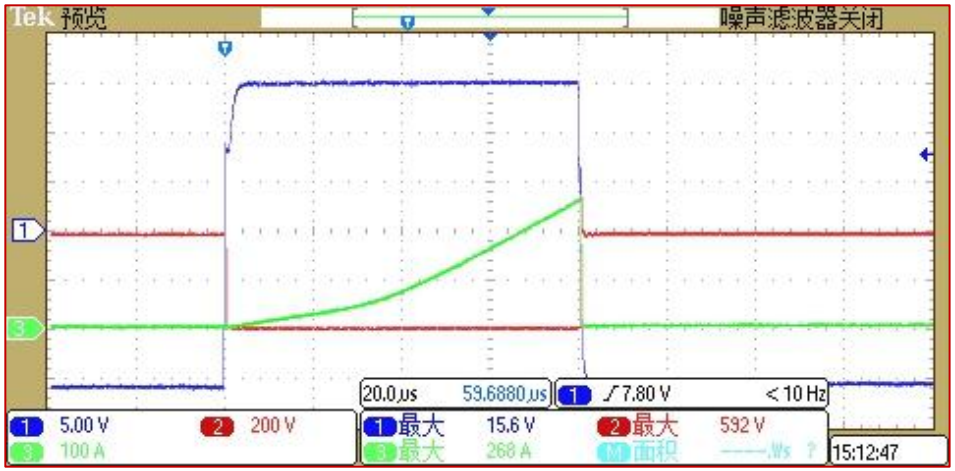


V_{ce_max}=608V

T3—关断尖峰

CH1：V_{GE-T2}
CH2：V_{CE-T2}
CH3：I_C

实验条件：V_{DC}=750V；I_C=270A；

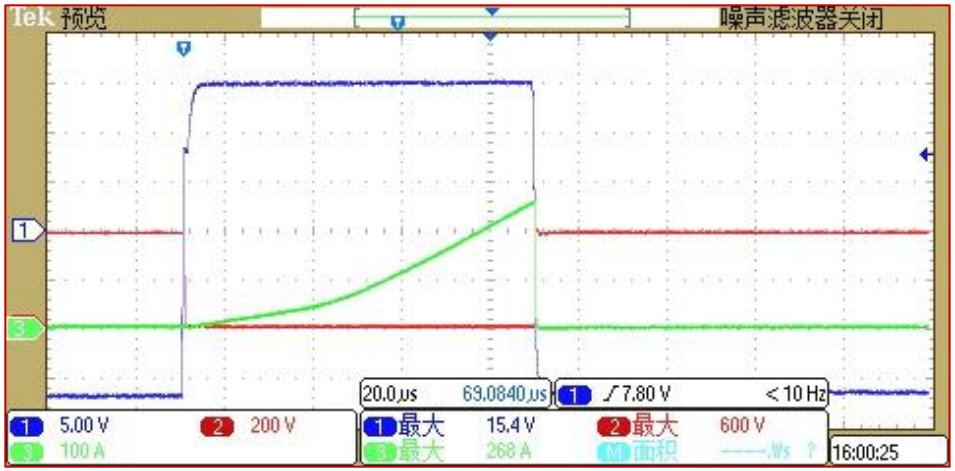


V_{ce_max}=592V

T4—关断尖峰

CH1：V_{GE-T2}
CH2：V_{CE-T2}
CH3：I_C

实验条件：V_{DC}=750V；I_C=270A；



V_{ce_max}=600V

数据汇总—V_{DC}=750V@I_C=270A

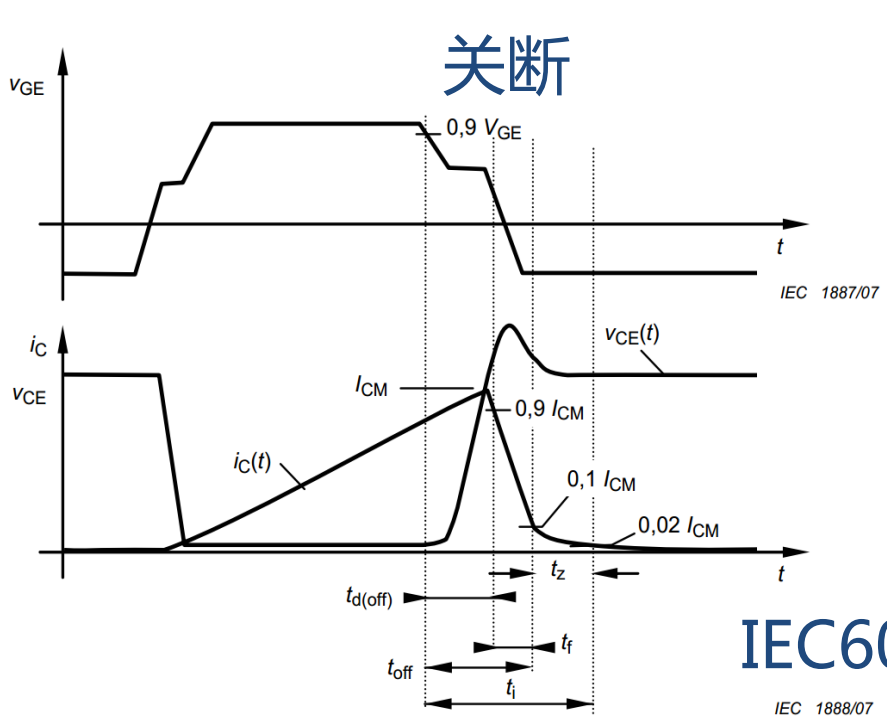
参数	T1	T2	T3	T4
V_{ce_max}（V）	632	608	592	600

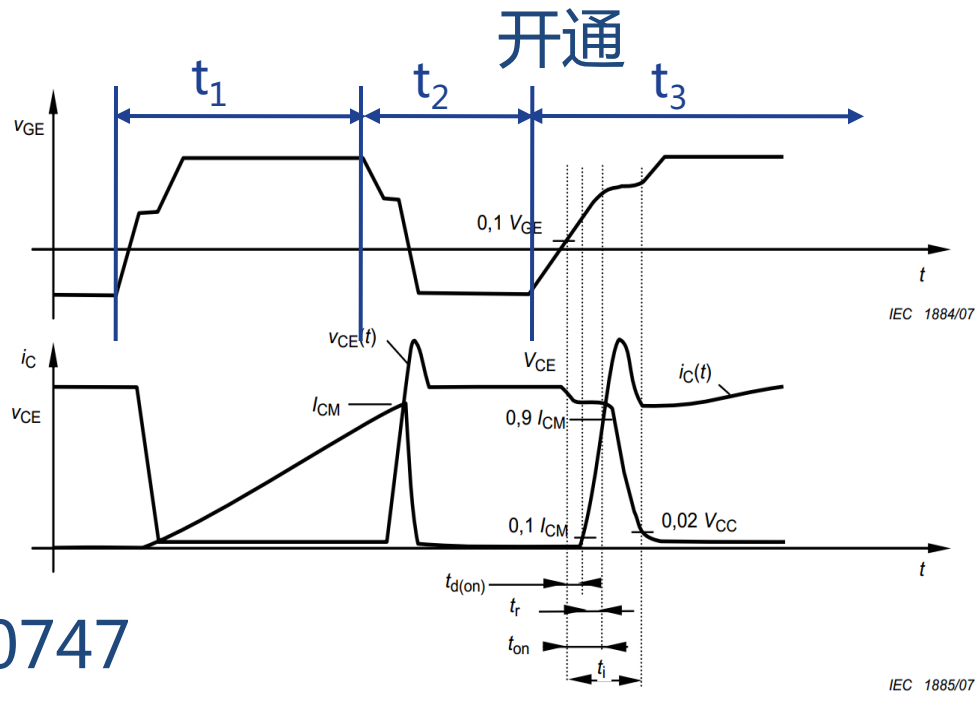
双脉冲测试

测试条件:

1. V_{DC}=750V@I_C=210A；
2. R_{Gon}=6.0Ω R_{Goff}=4.0Ω
3. IGBT: F3L300R07PE4
4. 1.5uF吸收电容
5. 有源钳位阈值:520V
6. 驱动核：C-Core

IGBT开关特性测试方法





IEC60747

IEC 1888/07

$t_{d(off)}$:关断延时

t_f: 下降时间

$t_{off}=t_{d(off)}+t_f$ ：关断时间

t_i：积分时间，用于计算关断损耗

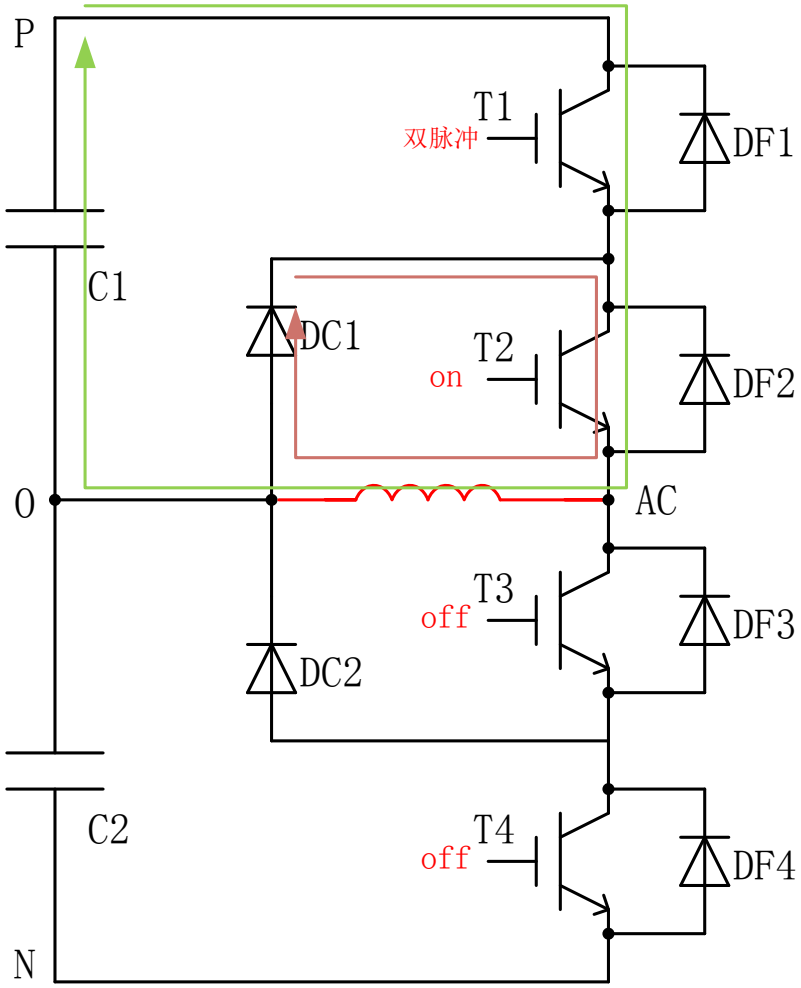
$t_{d(on)}$:开通延时

t_r: 上升时间

$t_{on}=t_{d(on)}+t_r$ ：开通时间

t_i：积分时间，用于计算开通损耗

T1管双脉冲原理示意图

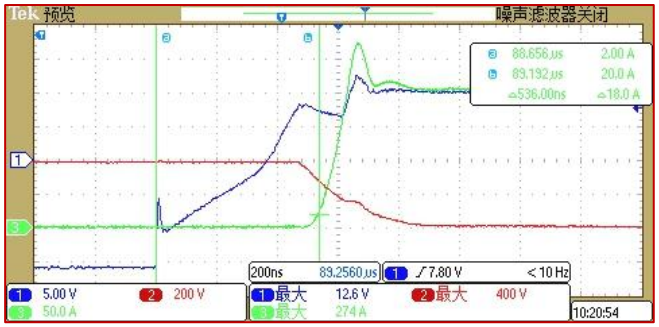


- ✓O与AC接345uH电感
- ✓T2常开，T3、T4常关，T1双脉冲
- ✓测试T1开关特性及DC1反向恢复特性

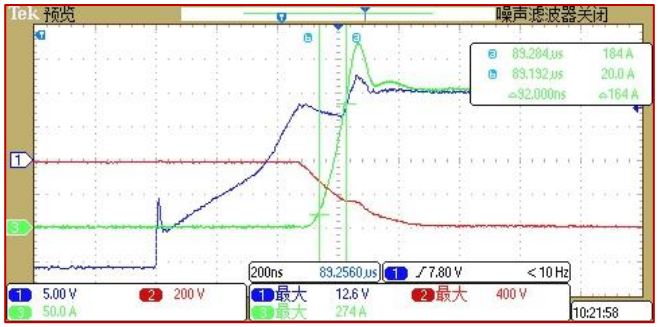
T1—双脉冲测试t_{on}

CH1：V_{GE-T1}
CH2：V_{CE-T1}
CH4：I_C
P：损耗

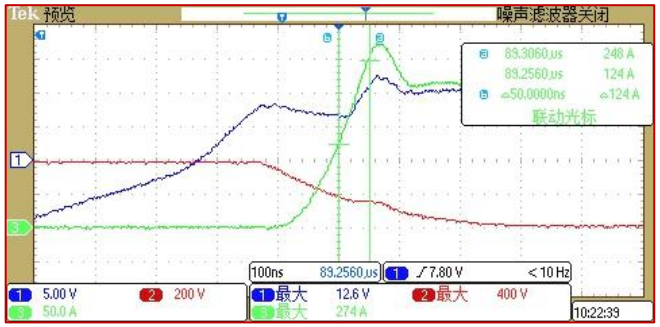
实验条件：V_{DC}=750V；I_C=210A;



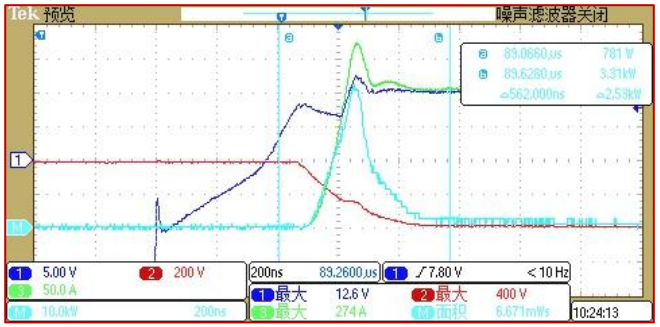
t_{don}=536ns



t_r=92ns



di/dt=2480A/us

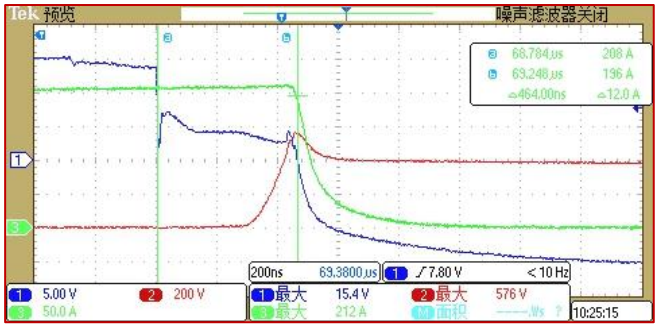


Eon=6.7mJ

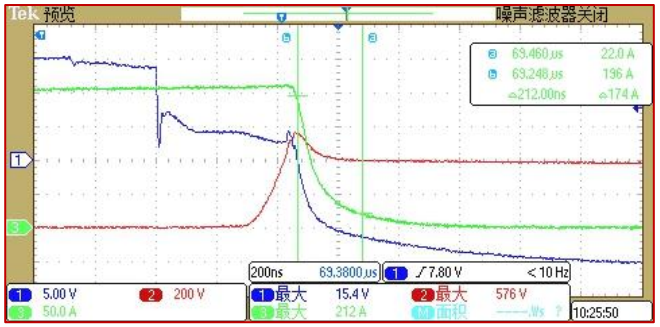
T1—双脉冲测试t_{off}

CH1：V_{GE-T1}
CH2：V_{CE-T1}
CH4：I_C
P：损耗

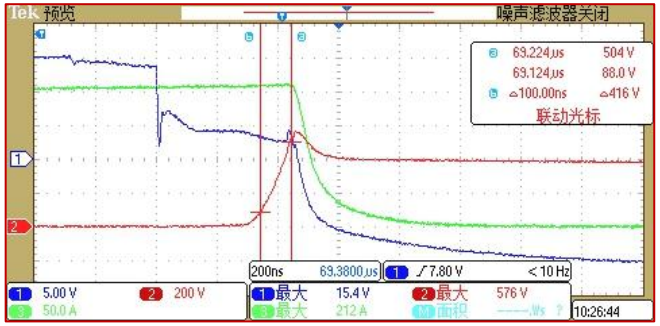
实验条件：V_{DC}=750V；I_C=210A;



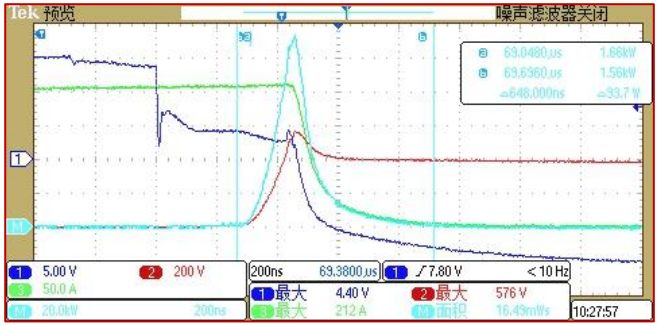
t_{doff}=464ns



t_f=212ns



dv/dt=4160V/us

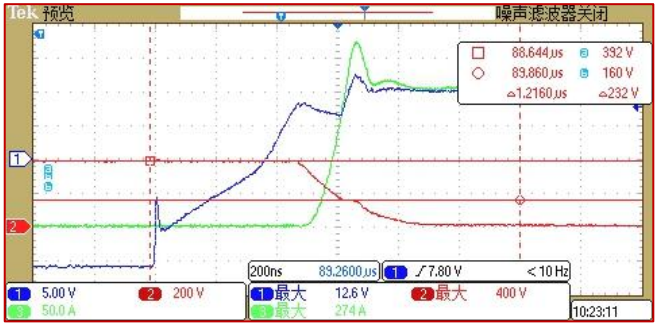


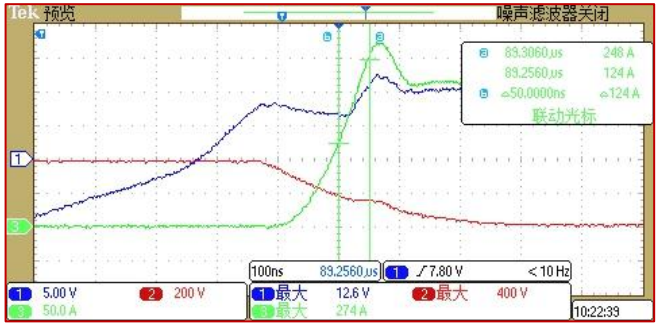
Eoff=16.5mJ

T1—杂散电感

CH1：V_{GE-T1}
CH2：V_{CE-T1}
CH4：I_C

实验条件：V_{DC}=750V；I_C=210A;



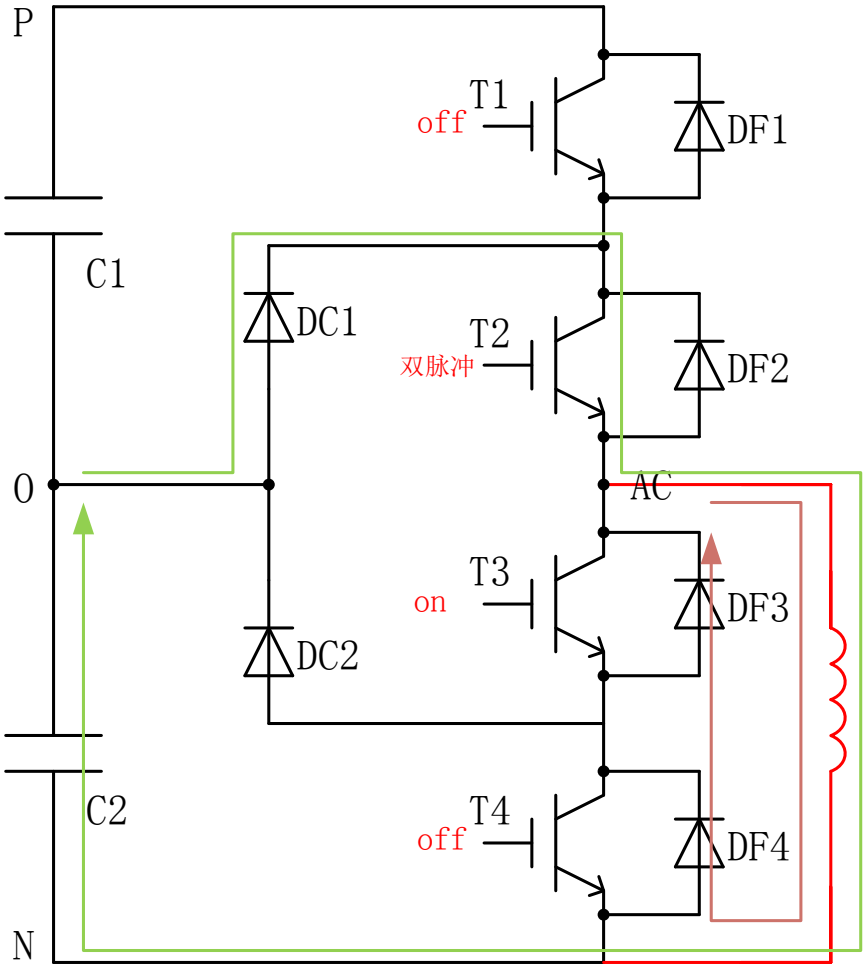


△V=232V

di/dt=2480A/us

L=94nH

T2管双脉冲原理示意图

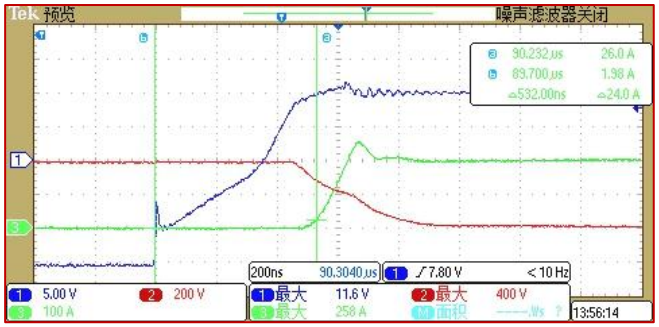


- ✓N与AC接345uH电感
- ✓T3常开，T1、T4常关，T2双脉冲
- ✓测试T2开关特性及DF4反向恢复特性

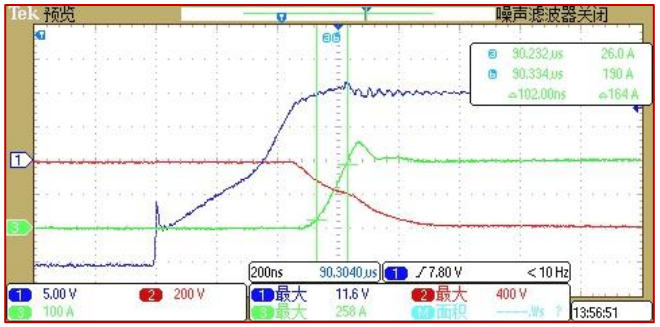
T2—双脉冲测试t_{on}

CH1：V_{GE-T2}
CH2：V_{CE-T2}
CH4：I_C
P：损耗

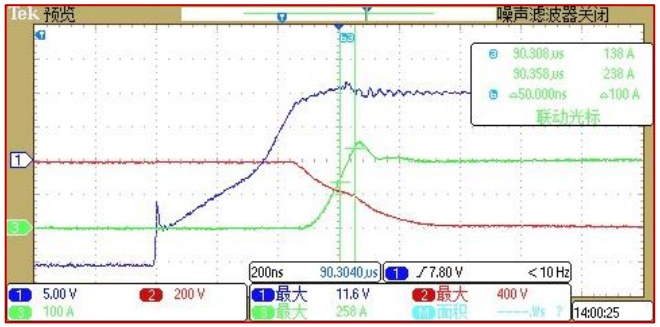
实验条件：V_{DC}=750V；I_C=210A;



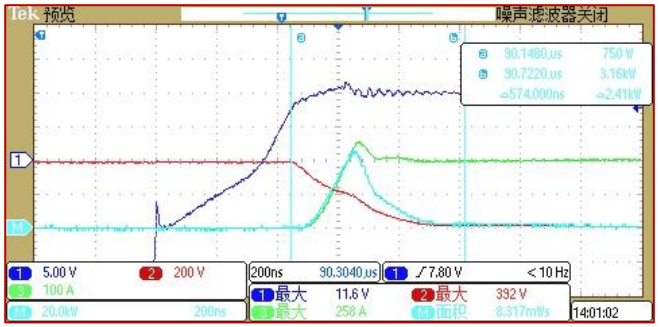
t_{don}=532ns



t_r=102ns



di/dt=2000A/us

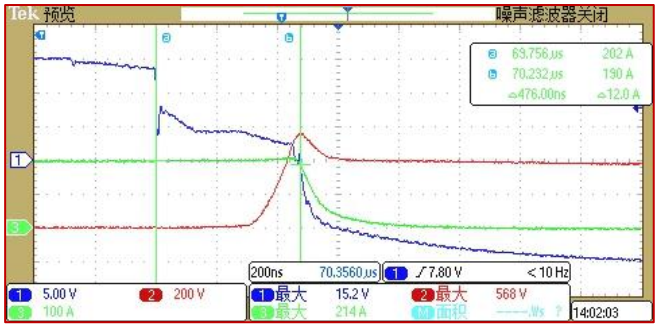


Eon=8.3mJ

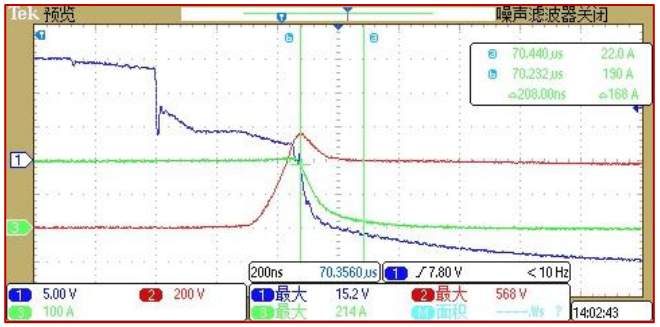
T2—双脉冲测试t_{off}

CH1：V_{GE-T2}
CH2：V_{CE-T2}
CH4：I_C
P：损耗

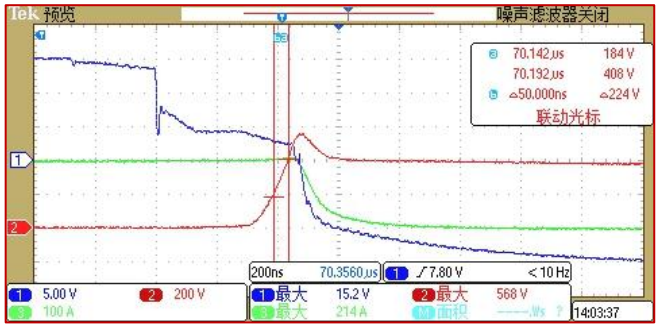
实验条件：V_{DC}=750V；I_C=210A;



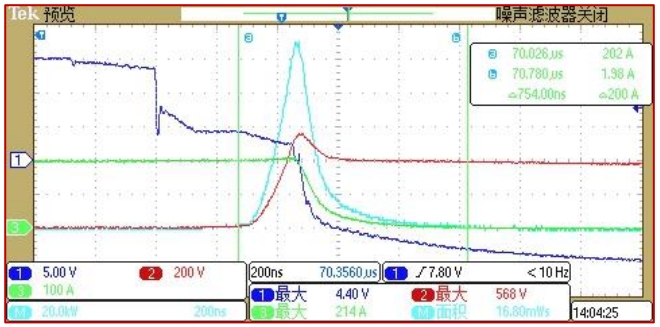
t_{doff}=476ns



t_f=208ns



dv/dt=4480V/us

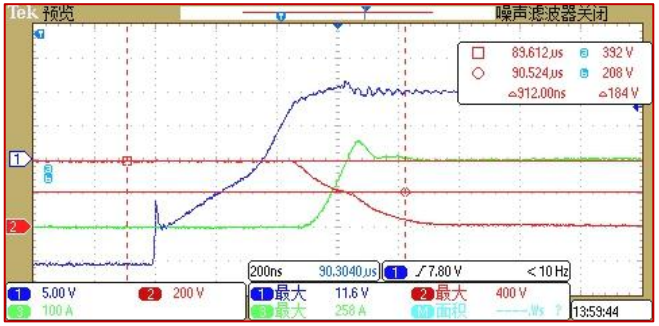


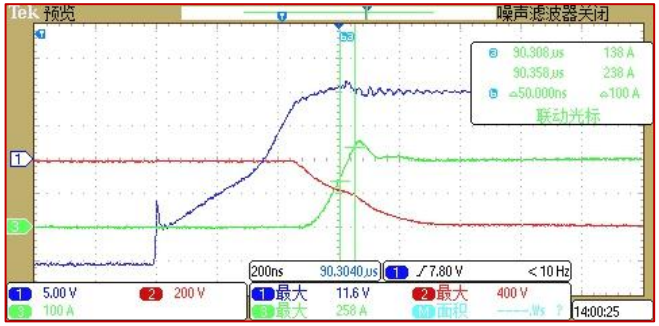
Eoff=16.8mJ

T2—杂散电感

CH1：V_{GE-T2}
CH2：V_{CE-T2}
CH4：I_C

实验条件：V_{DC}=750V；I_C=210A;



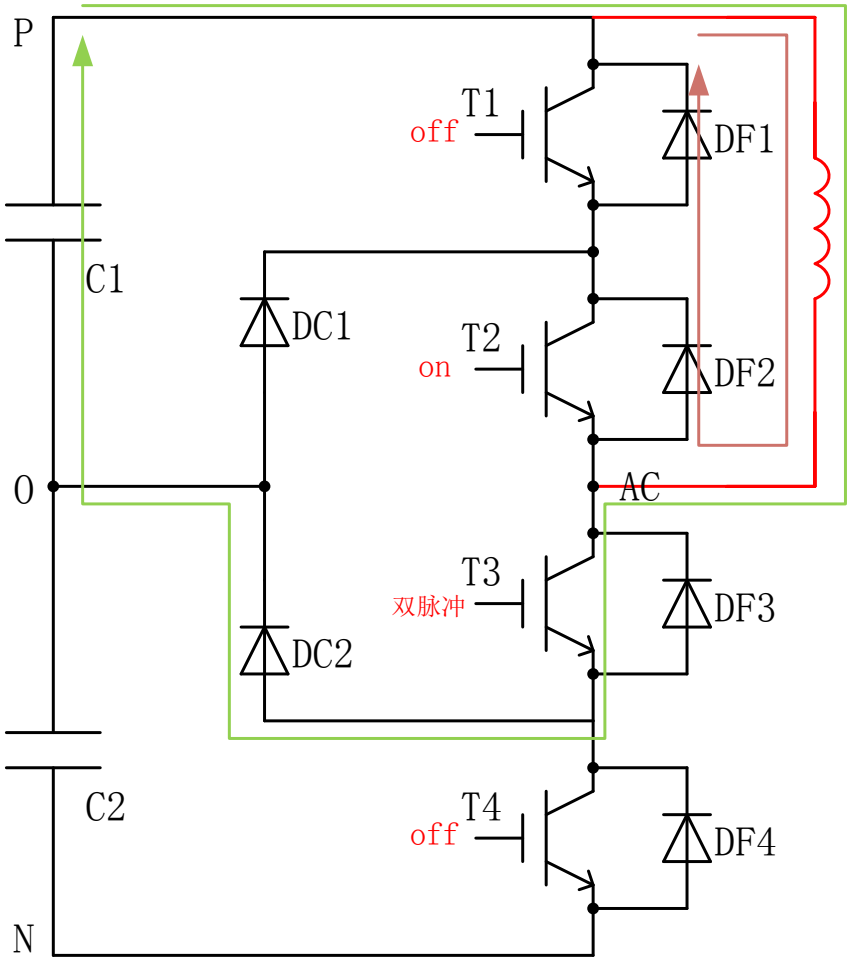


△V=184V

di/dt=2000A/us

L=92nH

T3管双脉冲原理示意图

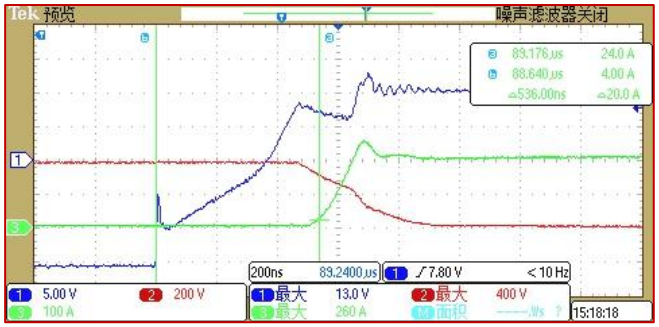


- ✓P与AC接345uH电感
- ✓T2常开，T1、T4常关，T3双脉冲
- ✓测试T3开关特性及DF1反向恢复特性

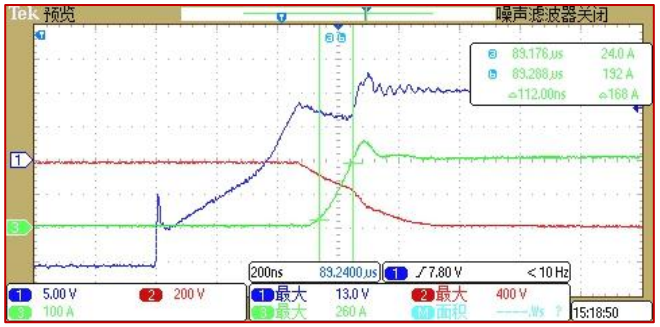
T3—双脉冲测试t_{on}

CH1：V_{GE-T3}
CH2：V_{CE-T3}
CH4：I_C
P：损耗

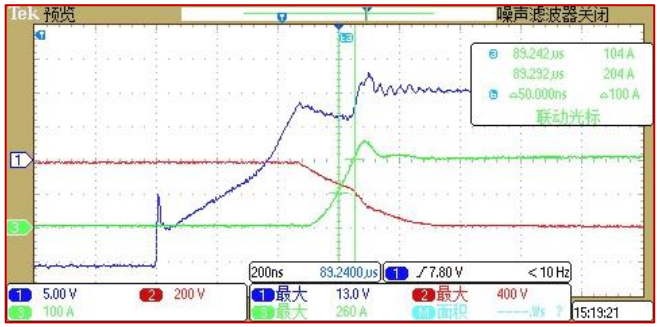
实验条件：V_{DC}=750V；I_C=210A;



t_{don}=536ns



t_r=112ns



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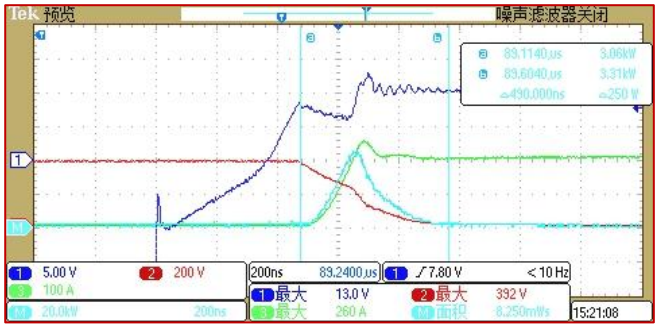
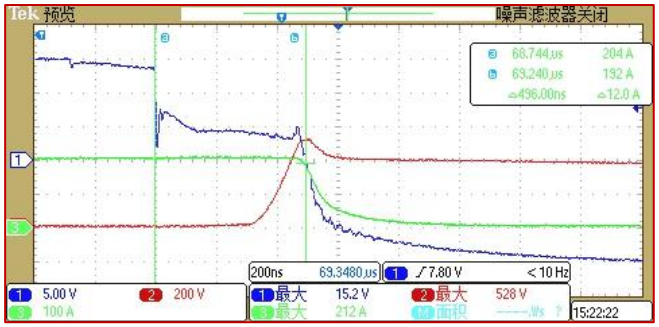


Eon=8.3mJ

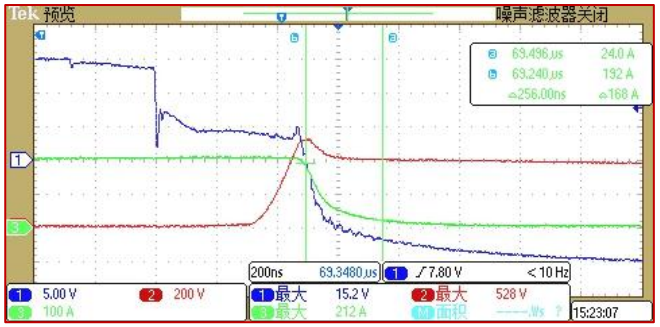
T3—双脉冲测试t_{off}

CH1：V_{GE-T3}
CH2：V_{CE-T3}
CH4：I_C
P：损耗

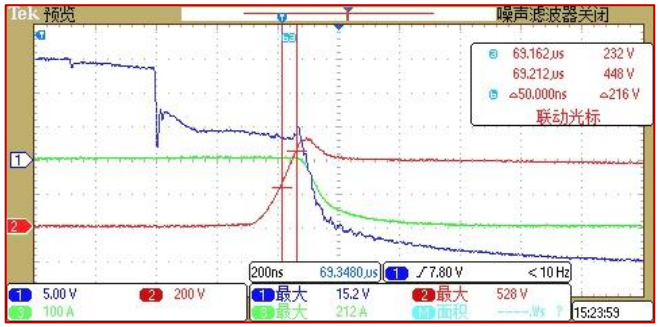
实验条件：V_{DC}=750V；I_C=210A;



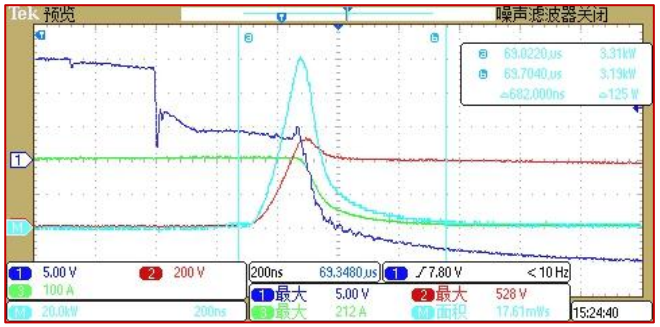
t_{doff}=496ns



t_f=256ns



dv/dt=4320V/us

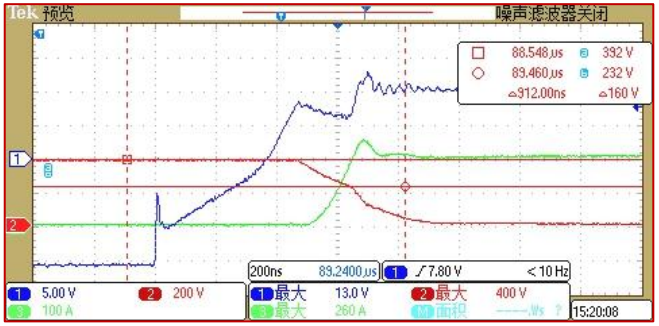


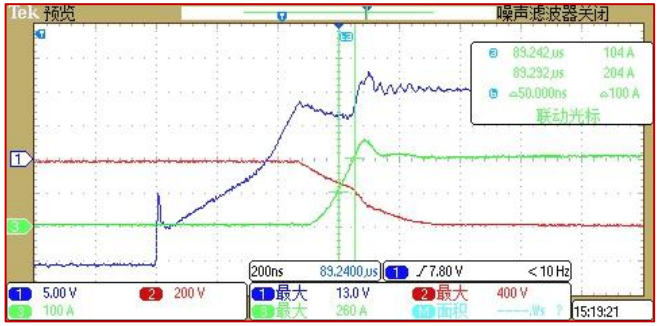
Eoff=17.6mJ

T3—杂散电感

CH1：V_{GE-T3}
CH2：V_{CE-T3}
CH4：I_C

实验条件：V_{DC}=750V；I_C=210A;



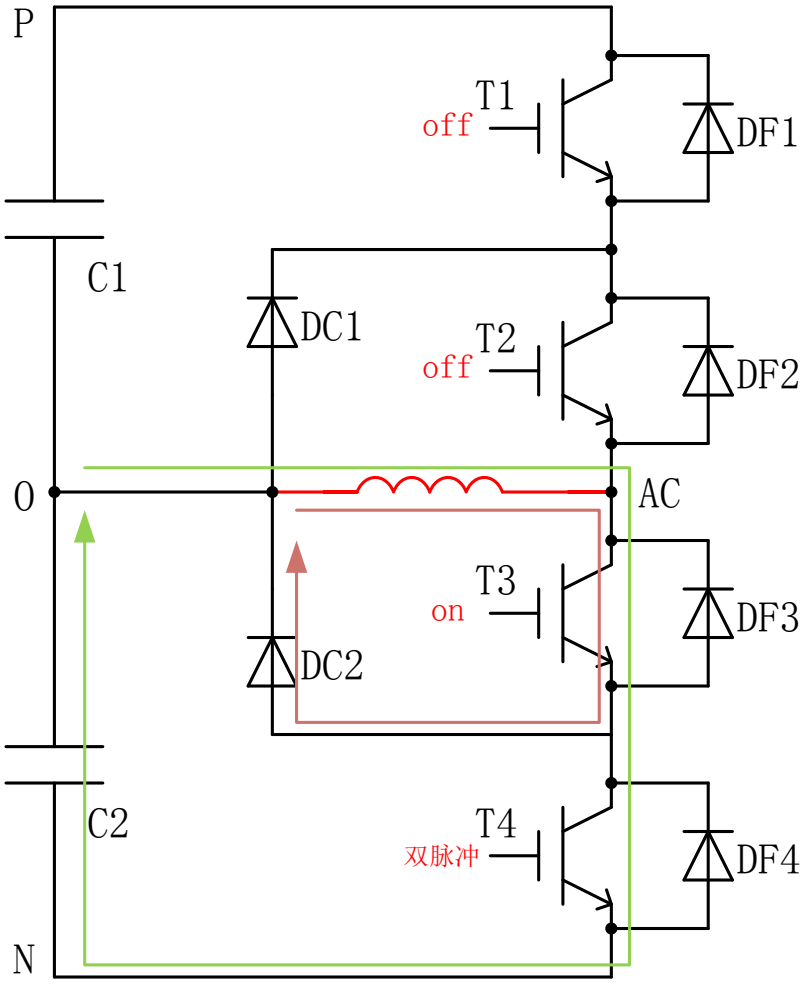


△V=160V

di/dt=2000A/us

L=80nH

T4管双脉冲原理示意图

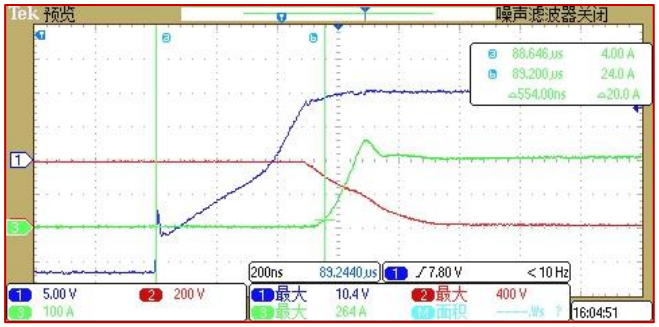


- ✓O与AC接345uH电感
- ✓T3常开，T1、T2常关，T4双脉冲
- ✓测试T4开关特性及DC2反向恢复特性

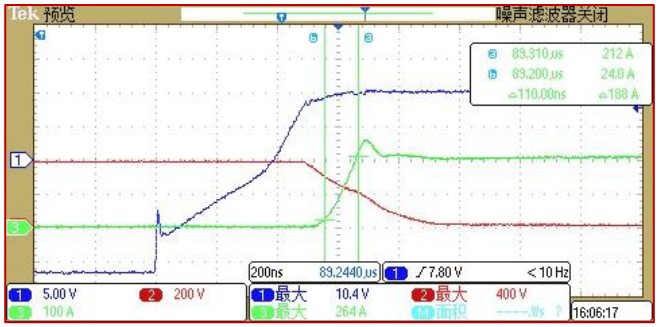
T4—双脉冲测试t_{on}

CH1：V_{GE-T4}
CH2：V_{CE-T4}
CH4：I_C
P：损耗

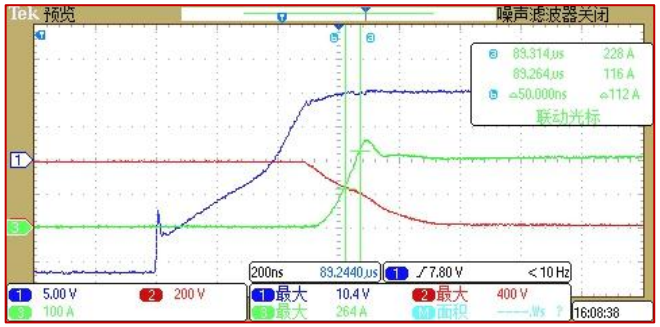
实验条件：V_{DC}=750V；I_C=210A;



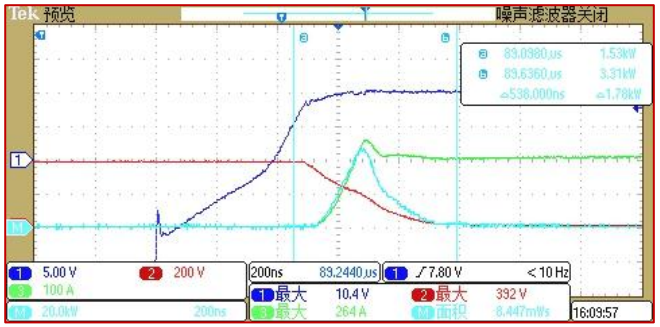
t_{don}=554ns



t_r=110ns



di/dt=2240A/us

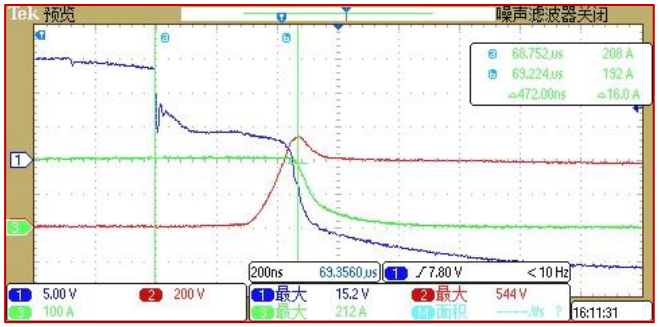


Eon=8.4mJ

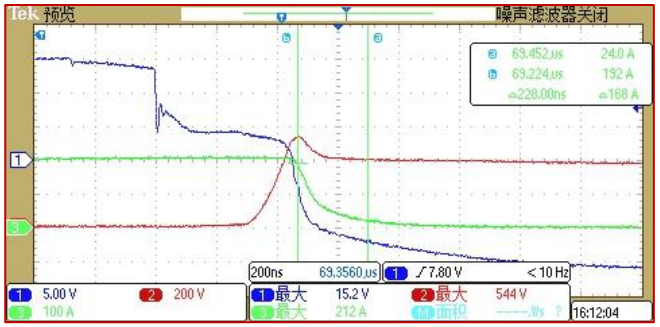
T4—双脉冲测试t_{off}

CH1：V_{GE-T4}
CH2：V_{CE-T4}
CH4：I_C
P：损耗

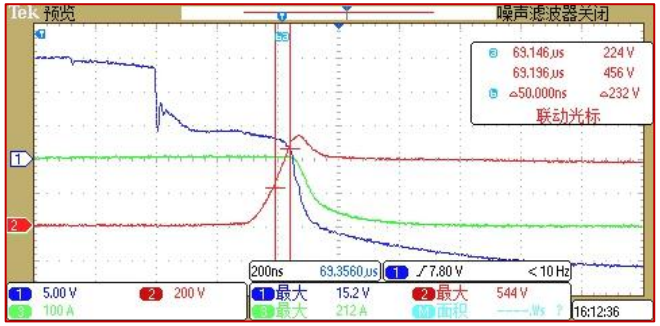
实验条件：V_{DC}=750V；I_C=210A;



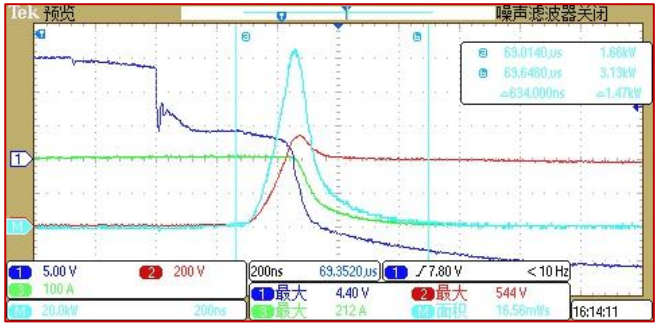
t_{doff}=472ns



t_f=228ns



dv/dt=4640V/us

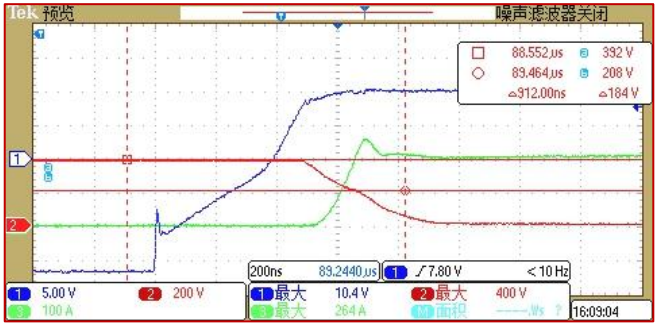


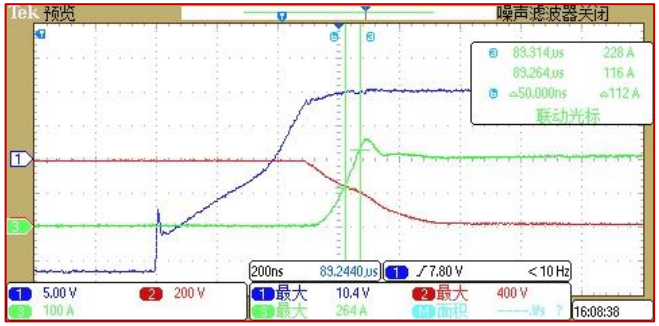
Eoff=16.6mJ

T4—杂散电感

CH1：V_{GE-T4}
CH2：V_{CE-T4}
CH4：I_C

实验条件：V_{DC}=750V；I_C=210A;





△V=184V

di/dt=2240A/us

L=82nH

双脉冲数据汇总

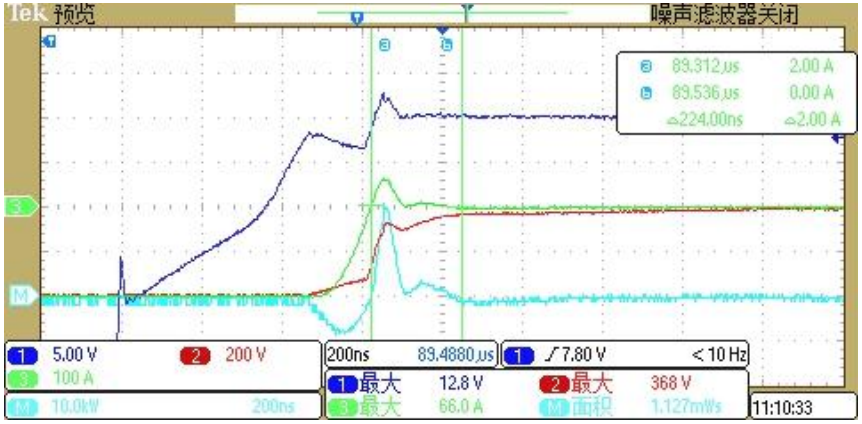
实验条件：V_{DC}=750V；I_C=210A；

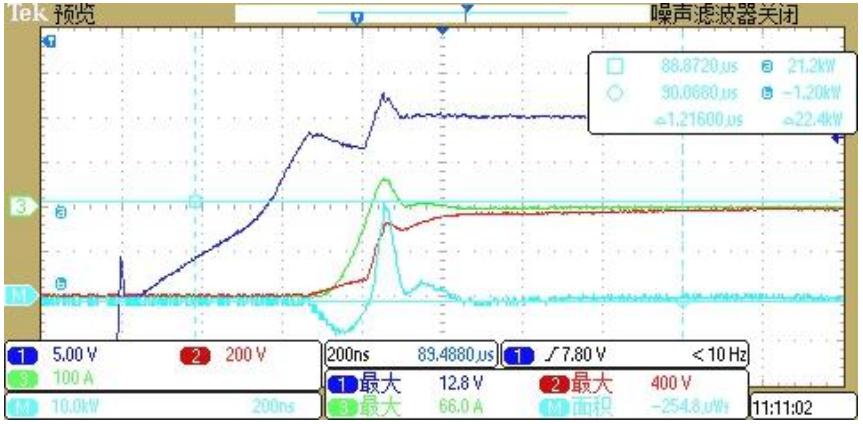
Parameter	T1	T2	T3	T4
t_{don}(ns)	536	532	536	554
t_{doff}(ns)	464	476	496	472
t_r (ns)	92	102	112	110
t_f (ns)	212	208	256	228
E_{on}(mJ)	6.7	8.3	8.3	8.4
E_{off} (mJ)	16.5	16.8	17.6	16.6
di/dt(A/us)	2480	2000	2000	2240
dv/dt(V/us)	4160	4480	4320	4640
E_{on}+E_{off} (mJ)	23.2	25.1	25.9	25.0
L (nH)	94	92	80	82

二极管特性测试

Diode——DC1

CH1：V_{GE-T1}
CH2：V_{CE-DC1}
CH4：I_C
P：损耗

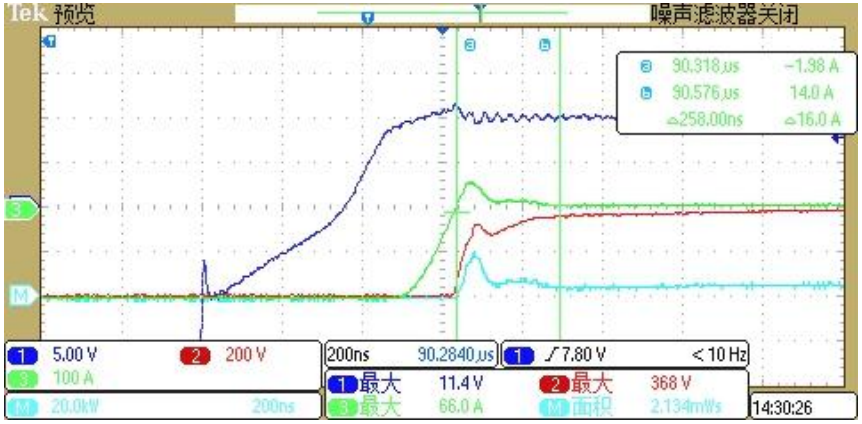


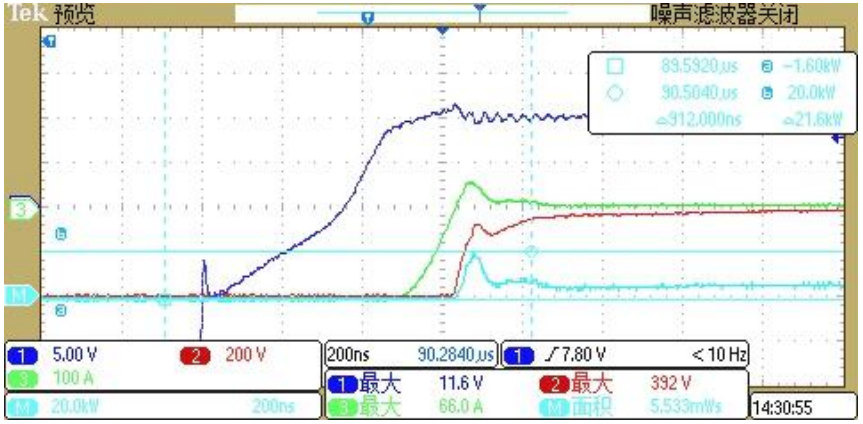


I_{rr_max}=66A
E_{rec}=1.13mJ
P_{rec}=21.2kW

Diode——DF4

CH1：V_{GE-T2}
CH2：V_{CE-DF4}
CH4：I_C
P：损耗

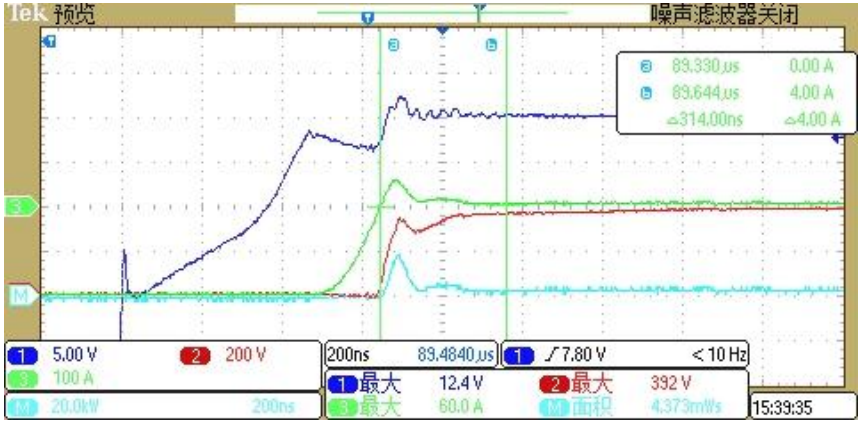


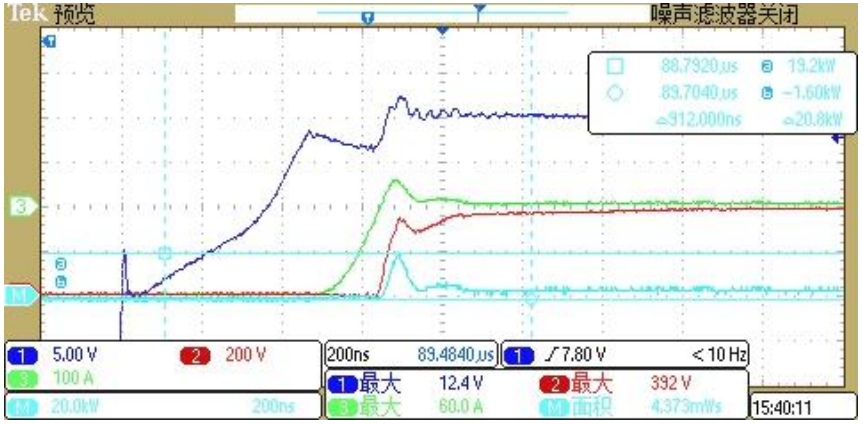


I_{rr_max}=66A
E_{rec}=2.13mJ
P_{rec}=20.0kW

Diode——DF1

CH1：V_{GE-T3}
CH2：V_{CE-DF1}
CH4：I_C
P：损耗

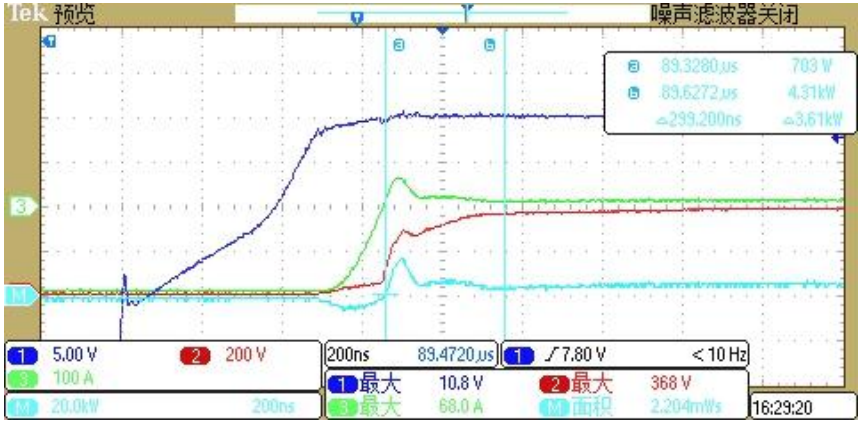


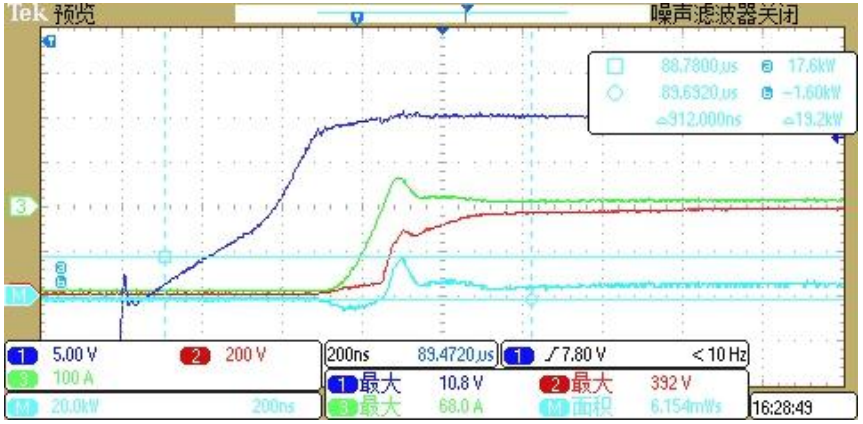


I_{rr_max}=60A
E_{rec}=4.37mJ
P_{rec}=19.2kW

Diode——DC2

CH1：V_{GE-T4}
CH2：V_{CE-DC2}
CH4：I_C
P：损耗





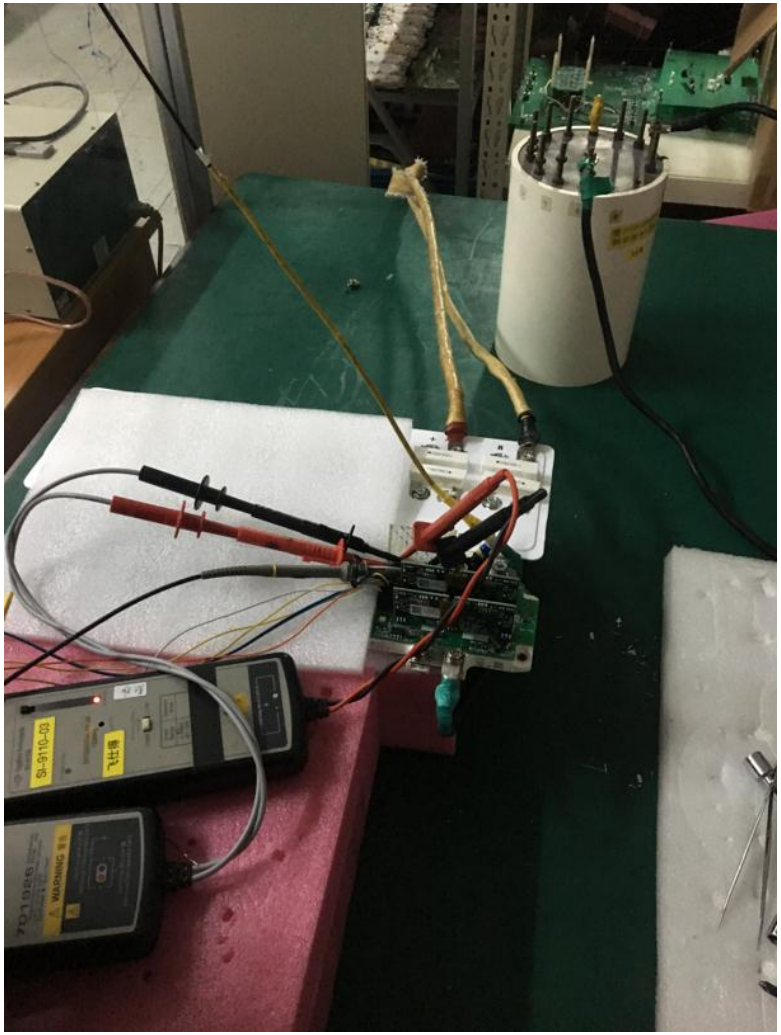
I_{rr_max}=68A
E_{rec}=2.20mJ
P_{rec}=17.6kW

二极管特性数据汇总

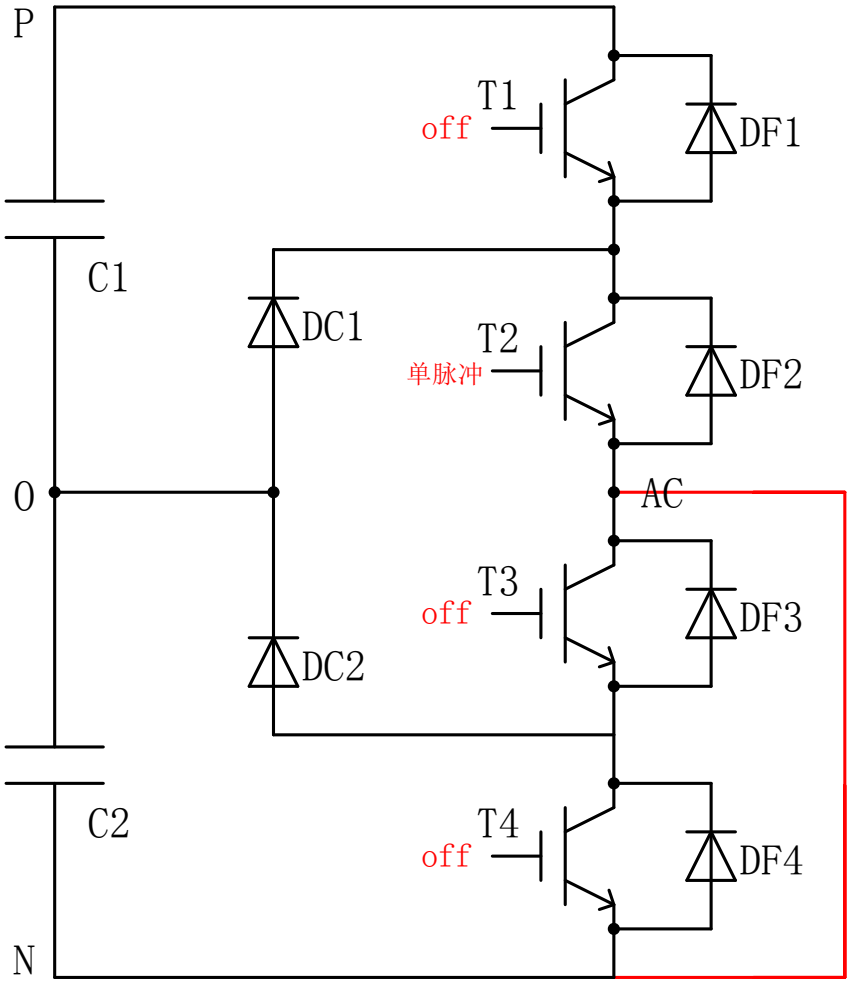
Parameter	DC1	DF4	DF1	DC2
I_{rr_max}(A)	66	66	60	68
E_{rec} (mJ)	1.13	2.13	4.37	2.20
P_{rec} (kW)	21.2	20.0	19.2	17.6

短路测试

测试安装图



T2管短路原理示意图



- ✓N与AC短接
- ✓T2单脉冲，T1、T3、T4常关
- ✓测试T2管的短路保护功能

短路测试

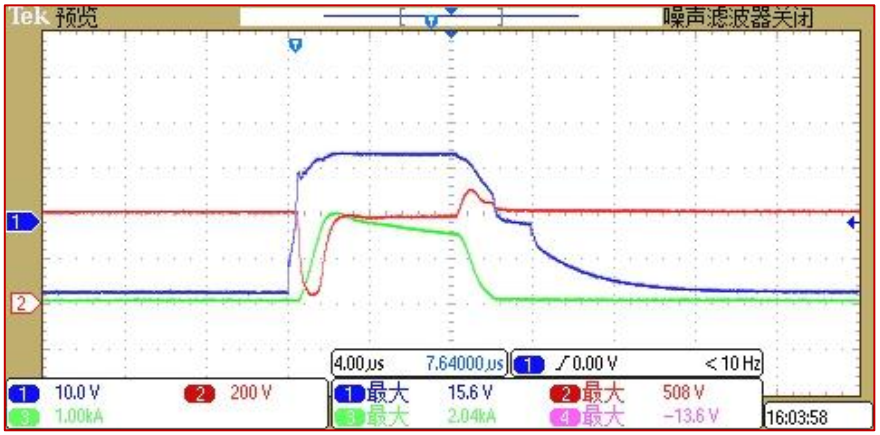
测试条件:

1. $1/2V_{DC}$=400V；
2. R_{Gon}=6.0Ω R_{Goff}=4.0Ω R_{SSD}=25.5Ω；
3. IGBT: F3L300R07PE4
4. 有源钳位阈值:520V
5. 驱动核：C-Core

T2—短路测试

CH1：V_{GE-T2}
CH2：V_{CE-T2}
CH3：I_{SC}

实验条件：$1/2V_{DC}$=400V ；R_{gon}=6.0Ω；R_{goff}=4.0Ω；R_{ssd}=25.5Ω

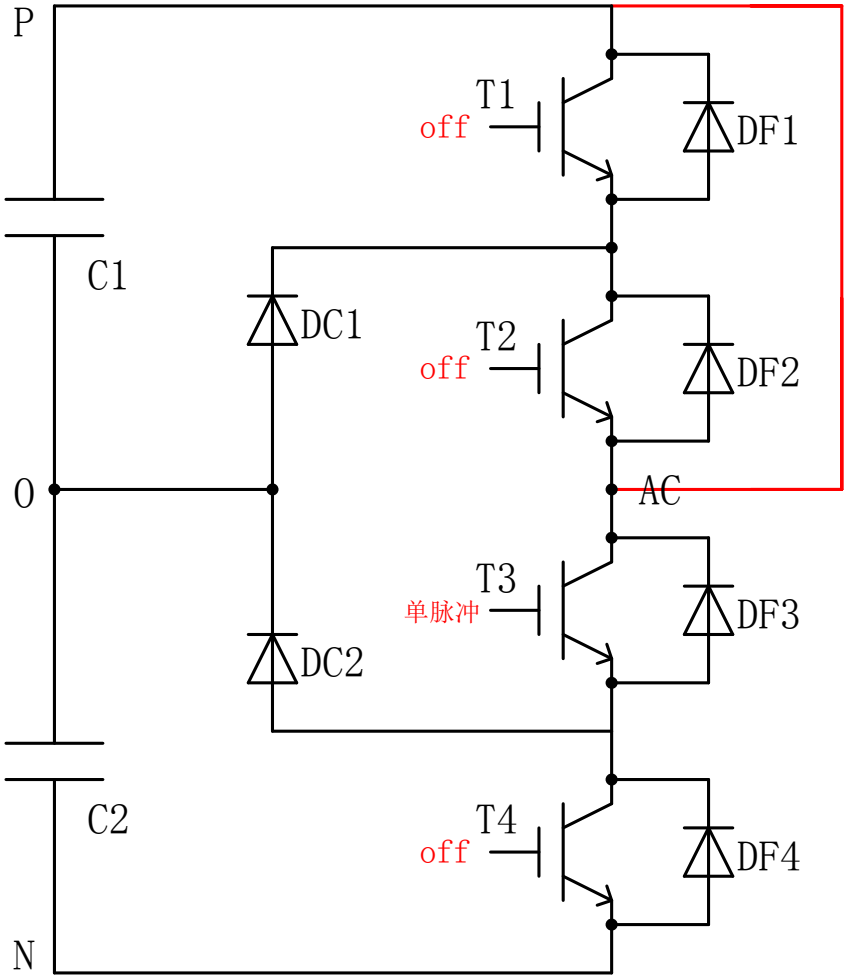


V_{GE}=15.6V

V_{ce_max}=508V

Isc=2040A=6.8*Inom

T3管短路原理示意图



- ✓P与AC短接
- ✓T3单脉冲，T1、T2、T4常关
- ✓测试T3管的短路保护功能

短路测试

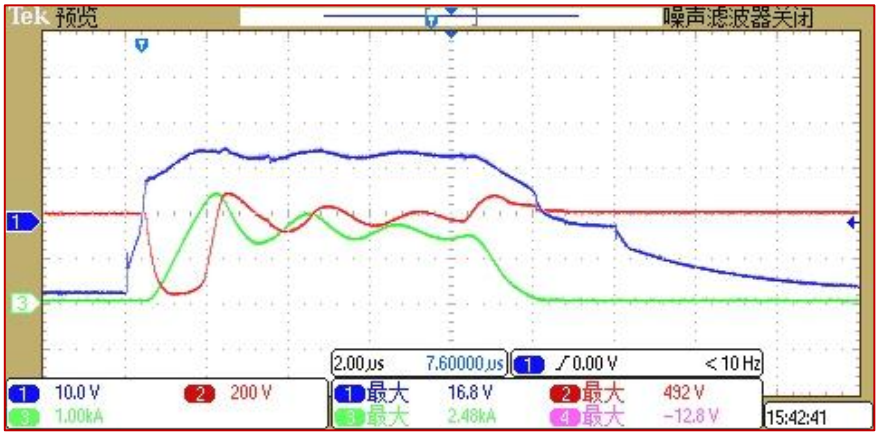
测试条件:

1. $1/2V_{DC}$=400V；
2. R_{Gon}=6.0Ω R_{Goff}=4.0Ω R_{SSD}=25.5Ω；
3. IGBT: F3L300R07PE4
4. 有源钳位阈值:520V
5. 驱动核：C-Core

T3—短路测试

CH1：V_{GE-T3}
CH2：V_{CE-T3}
CH3：I_{SC}

实验条件：$1/2V_{DC}$=400V ；R_{gon}=6.0Ω；R_{goff}=4.0Ω；R_{ssd}=25.5Ω

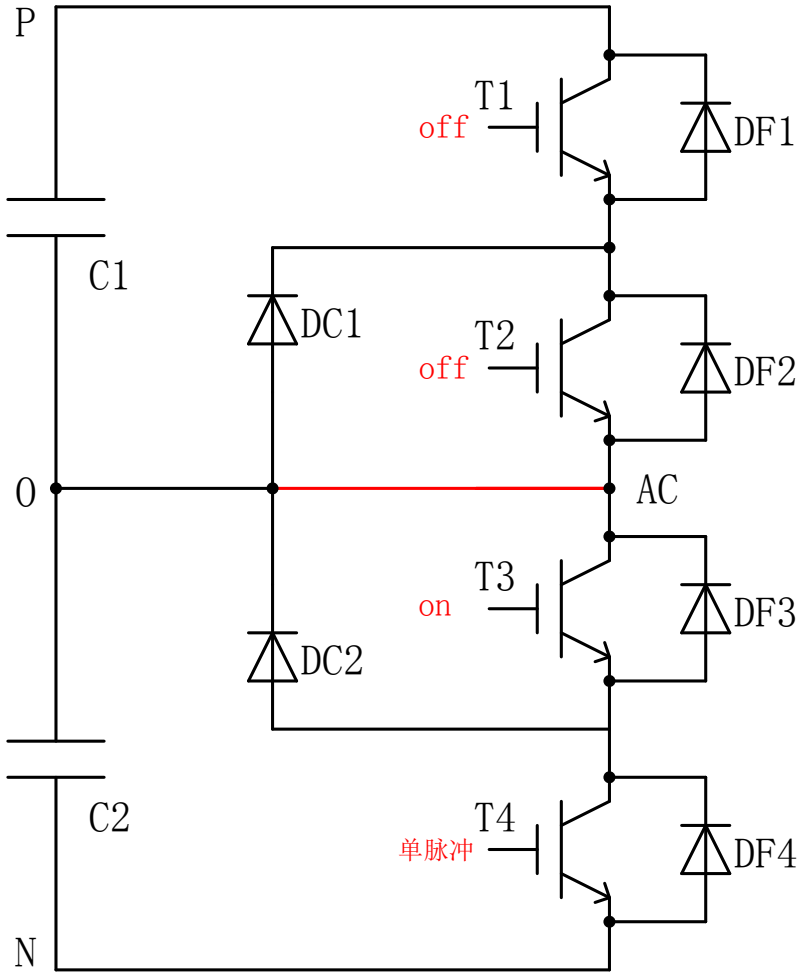


V_{GE}=16.8V

V_{ce_max}=492V

Isc=2480A=8.3*Inom

T4管短路原理示意图



- ✓O与AC短接
- ✓T3常开，T1、T2常关，T4单脉冲
- ✓测试T4管的短路保护功能

短路测试

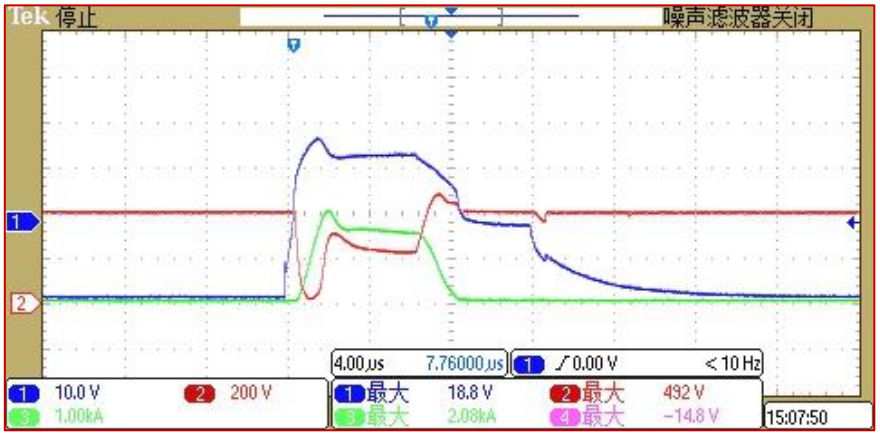
测试条件:

1. $1/2V_{DC}$=400V；
2. R_{Gon}=6.0Ω R_{Goff}=4.0Ω R_{SSD}=25.5Ω；
3. IGBT: F3L300R07PE4
4. 有源钳位阈值:520V
5. 驱动核：C-Core

T4—短路测试

CH1：V_{GE-T4}
CH2：V_{CE-T4}
CH3：I_{SC}

实验条件：$1/2V_{DC}$=400V ；R_{gon}=6.0Ω；R_{goff}=4.0Ω；R_{ssd}=25.5Ω



V_{GE}=18.8V

V_{ce_max}=492V

Isc=2080A=6.9*Inom

短路测试数据汇总

实验条件：$1/2V_{DC}$=400V ；R_{gon}=6.0Ω；R_{goff}=4.0Ω；R_{ssd}=25.5Ω

Parameter	T1	T2	T3	T4
V_{GE}(V)	/	15.6	16.8	18.8
V_{CEMAX}(V)	/	508	492	492
Isc（A）	/	2040	2480	2080

结论

- 1，采用本文驱动参数，在V_{DC}=750V下，系统的最大关断电流为270A，客户实际系统的硬件过流点需≤270A。
- 2，该模块内部杂散电感较大，实际需要加至少1.5uF吸收电容。
- 4，短路测试可以通过。