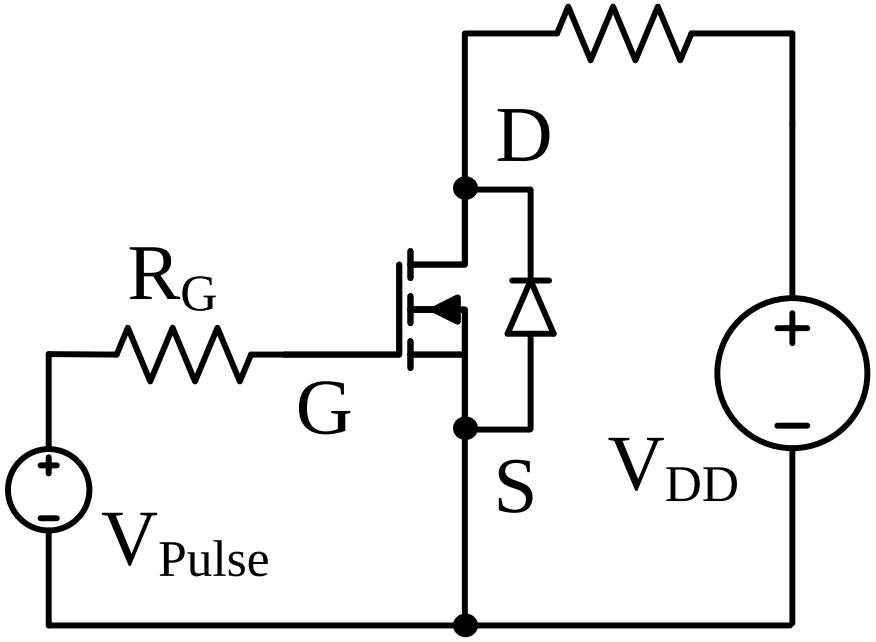
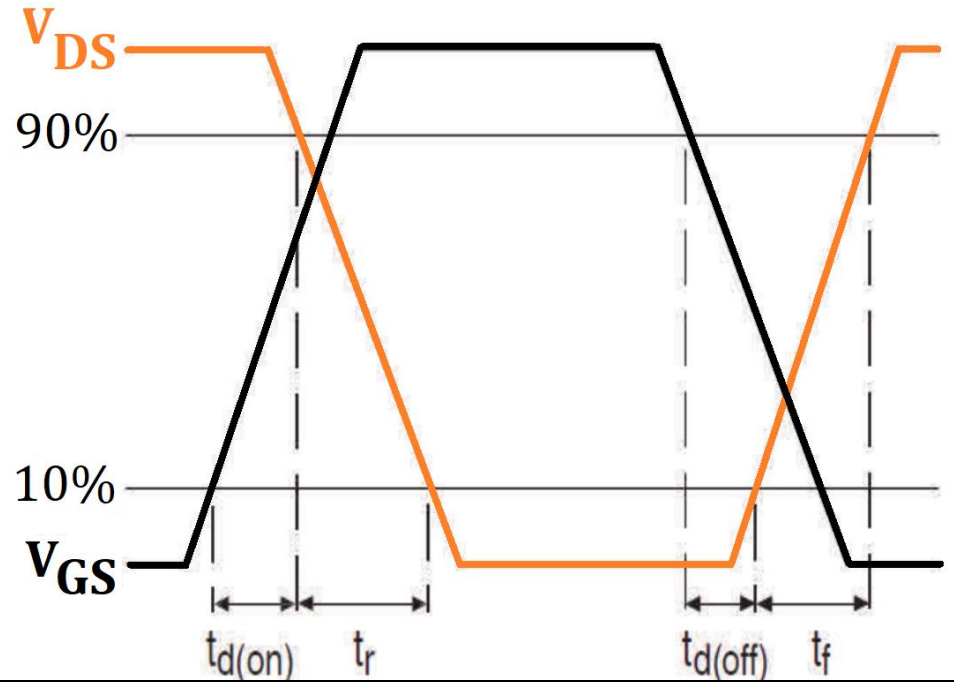
Dynamic Electrical Characteristics @ T_J = 25°C (unless otherwise specified)

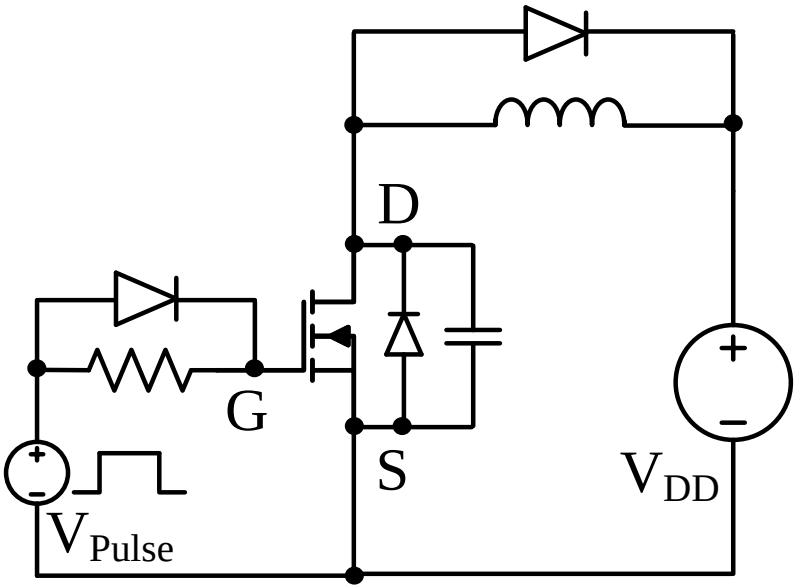
Symbol	Parameter	Min.	Typ.	Max.	Units	Conditions
gfs	Forward Transconductance	264	—	—	S	V_{DS} = 10V, I_D = 100A
Q_g	Total Gate Charge	—	205	307	nC	I_D = 100A
Q_{gs}	Gate-to-Source Charge	—	57	—		V_{DS} = 20V
Q_{gd}	Gate-to-Drain Charge	—	104	—		V_{GS} = 4.5V⑤
Q_{sync}	Total Gate Charge Sync. (Qg– Qgd)	—	101	—		
$t_{d(on)}$	Turn-On Delay Time	—	67	—	ns	V_{DD} = 20V
t_r	Rise Time	—	210	—		I_D = 30A
$t_{d(off)}$	Turn-Off Delay Time	—	222	—		R_G= 2.7Ω
t_f	Fall Time	—	176	—		V_{GS} = 4.5V⑤



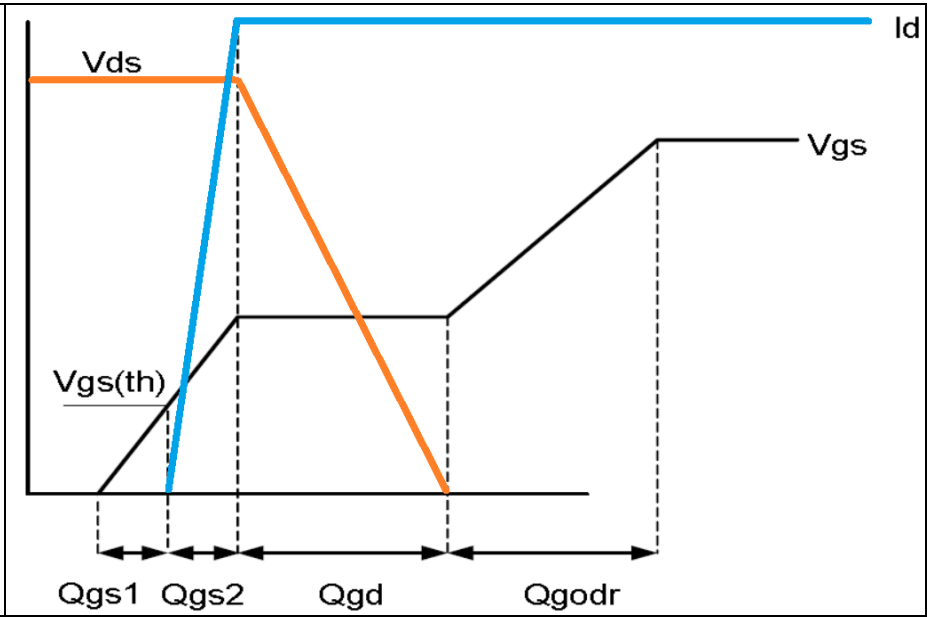
Switching Time Test Circuit



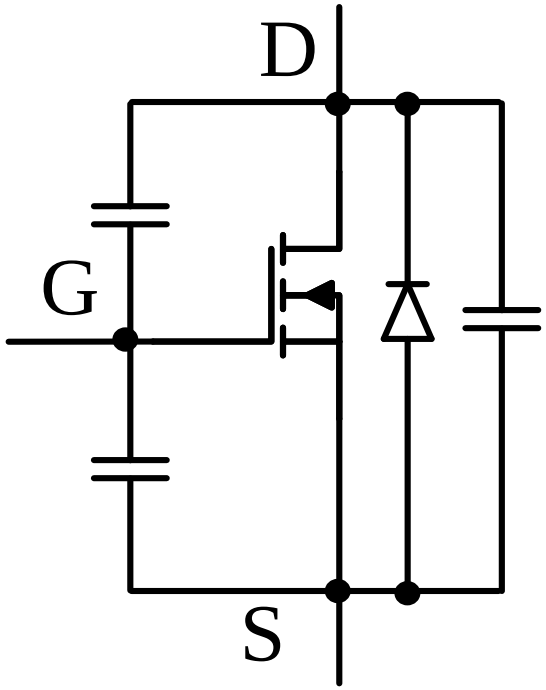
Switching Time Waveforms

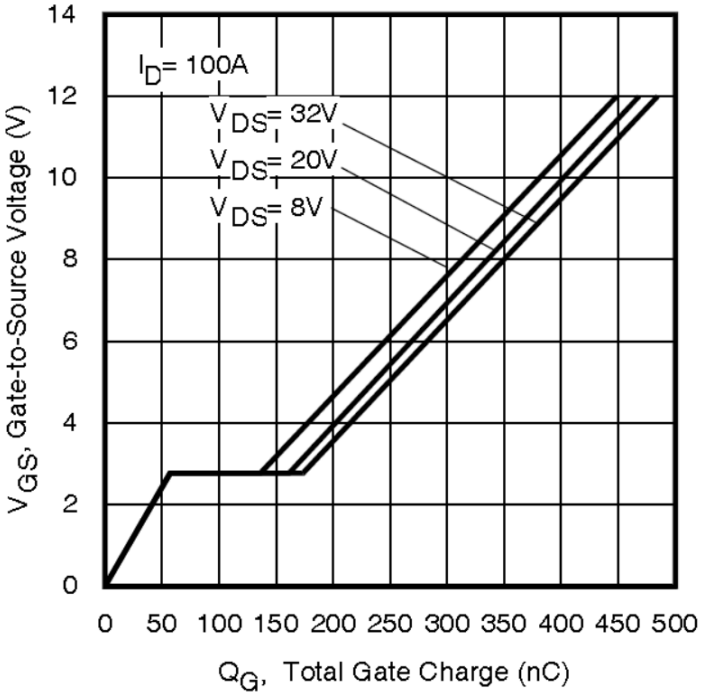


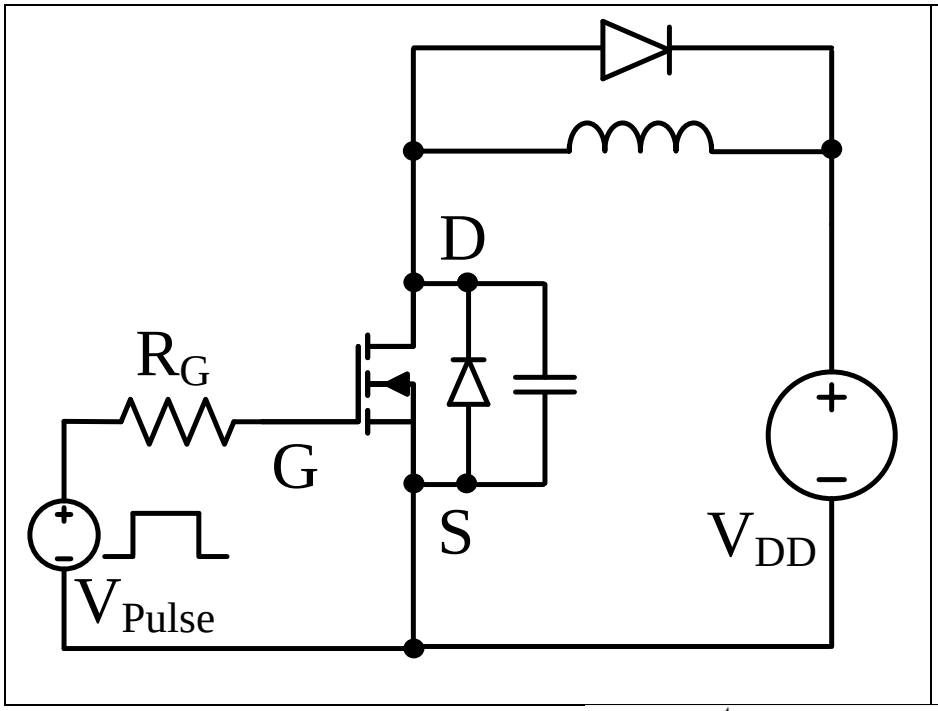
Gate Charge Test Circuit

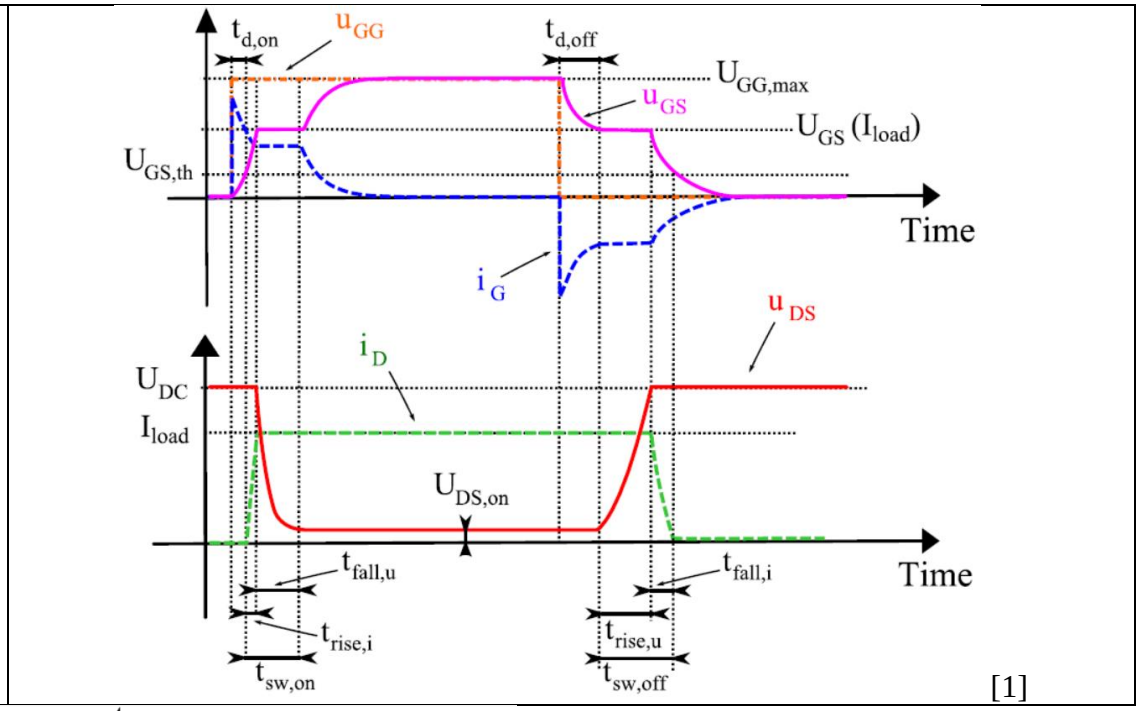


Gate Charge Waveforms

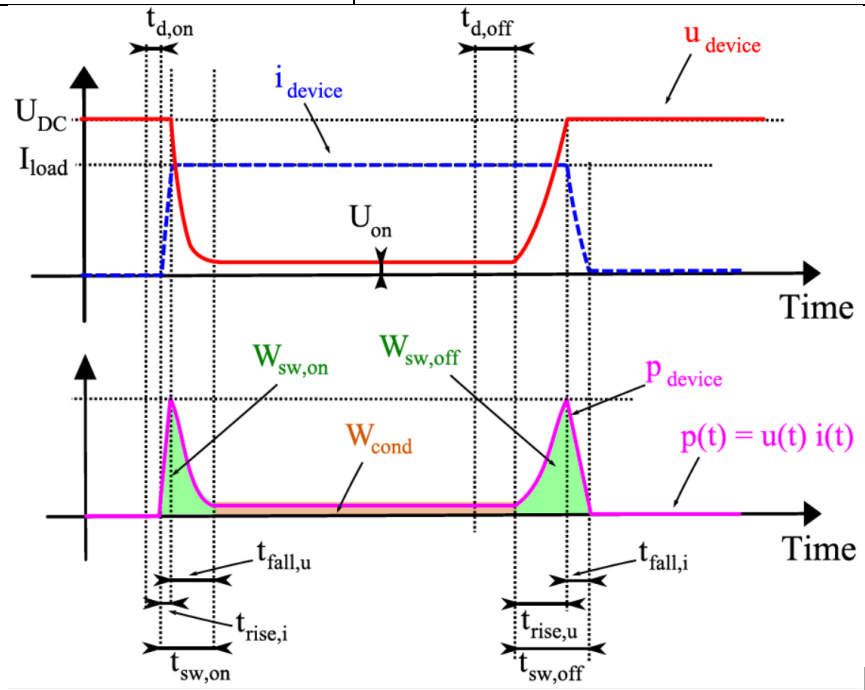





D
R_G
G
S
V_{DD}
V_{Pulse}

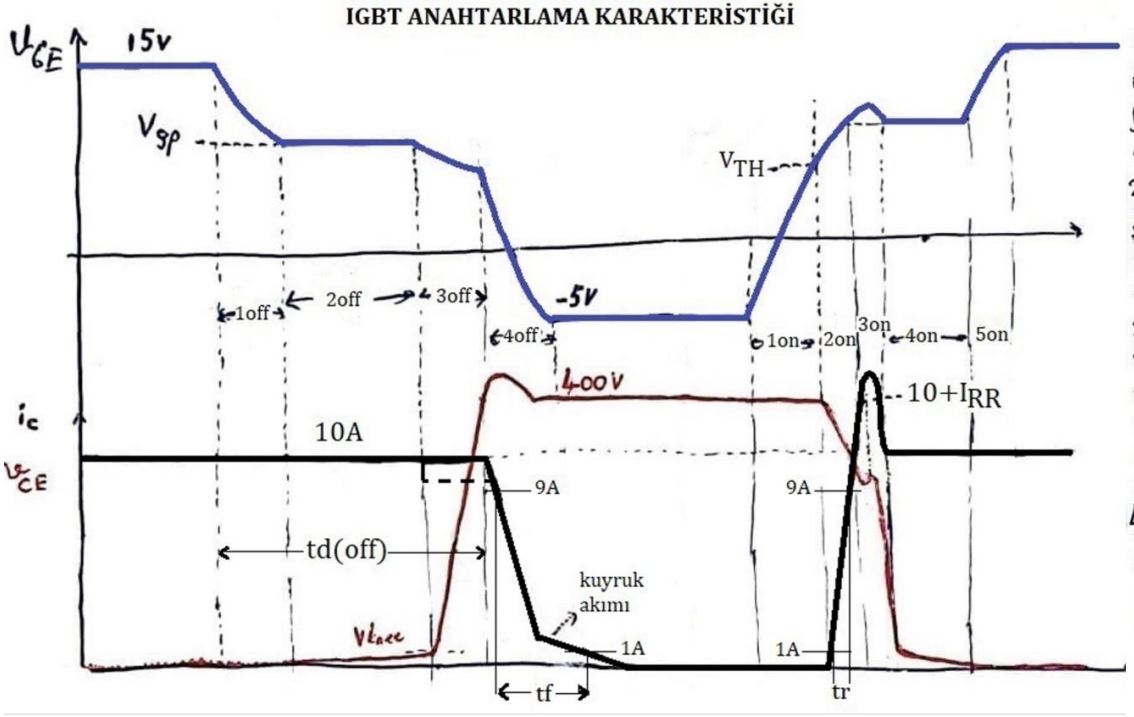

$t_{d,on}$
u_{GG}
$t_{d,off}$
$U_{GG,max}$
u_{GS}
U_{GS} (I_{load})
$U_{GS,th}$
Time
i_G
u_{DS}
i_D
U_{DC}
I_{load}
$U_{DS,on}$
Time
$t_{fall,u}$
$t_{fall,i}$
$t_{rise,u}$
$t_{rise,i}$
$t_{sw,on}$
$t_{sw,off}$

[1]


$t_{d,on}$
$t_{d,off}$
u_{device}
i_{device}
U_{DC}
I_{load}
U_{on}
Time
$W_{sw,on}$
$W_{sw,off}$
p_{device}
W_{cond}
p(t) = u(t) i(t)
Time
$t_{fall,u}$
$t_{fall,i}$
$t_{rise,u}$
$t_{rise,i}$
$t_{sw,on}$
$t_{sw,off}$

[1]

IGBT ANAHTARLAMA KARAKTERİSTİĞİ

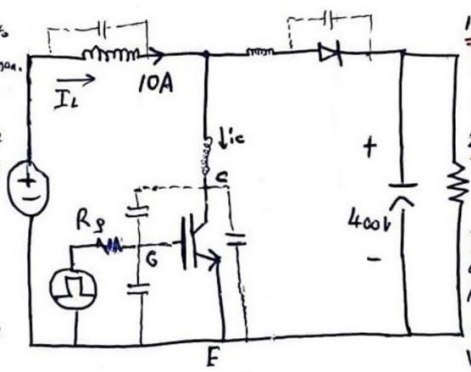


1off ⇒ GE cap. Rg üzerinden Miller platosu gerilimine kadar eksponansiyel deşarj oluyor.

2off ⇒ ic sabit. Gate şarjı azalıyor. Azaldıkça VCE, VKnee'ye kadar artıyor

3off ⇒ VCE artıyor. VGE tekrar düşmeye devam ediyor. CG akımı Rg üzerinden peşmeli GE'yi şarj etmemeli. (PCB ve Gate Driver tasarımı ⚠!)

4off ⇒ VCE = 400V olunca diyot iletime girer. IGBT akımı azalmaya başlar. Endüktans. tordan dolayı VCE 400V'u aşar



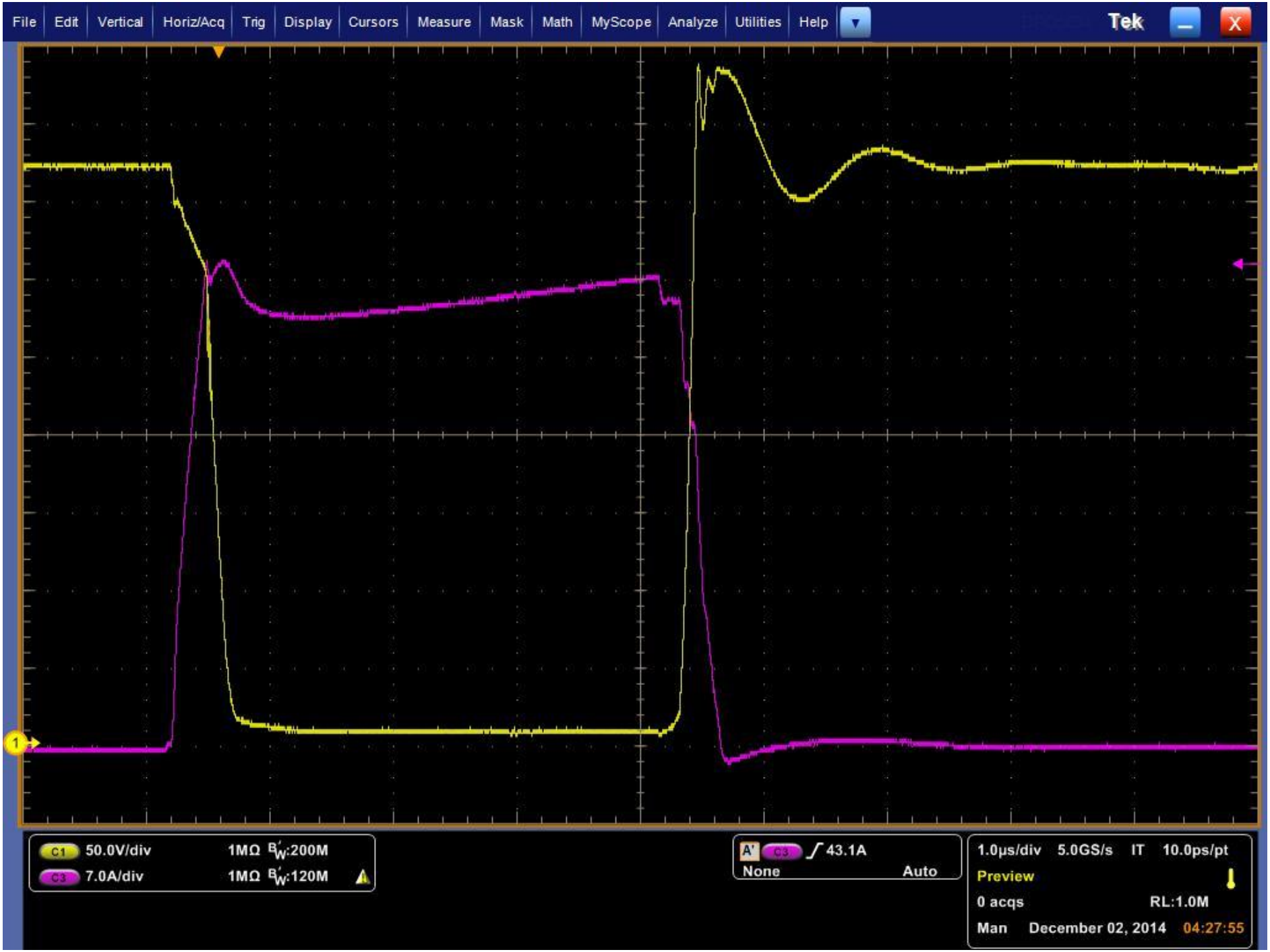
5on ⇒ VCE düşük. Rg akımı GE'yi ve GC'yi şarj ediyor. Bu süreçte de kısa olması gerekir

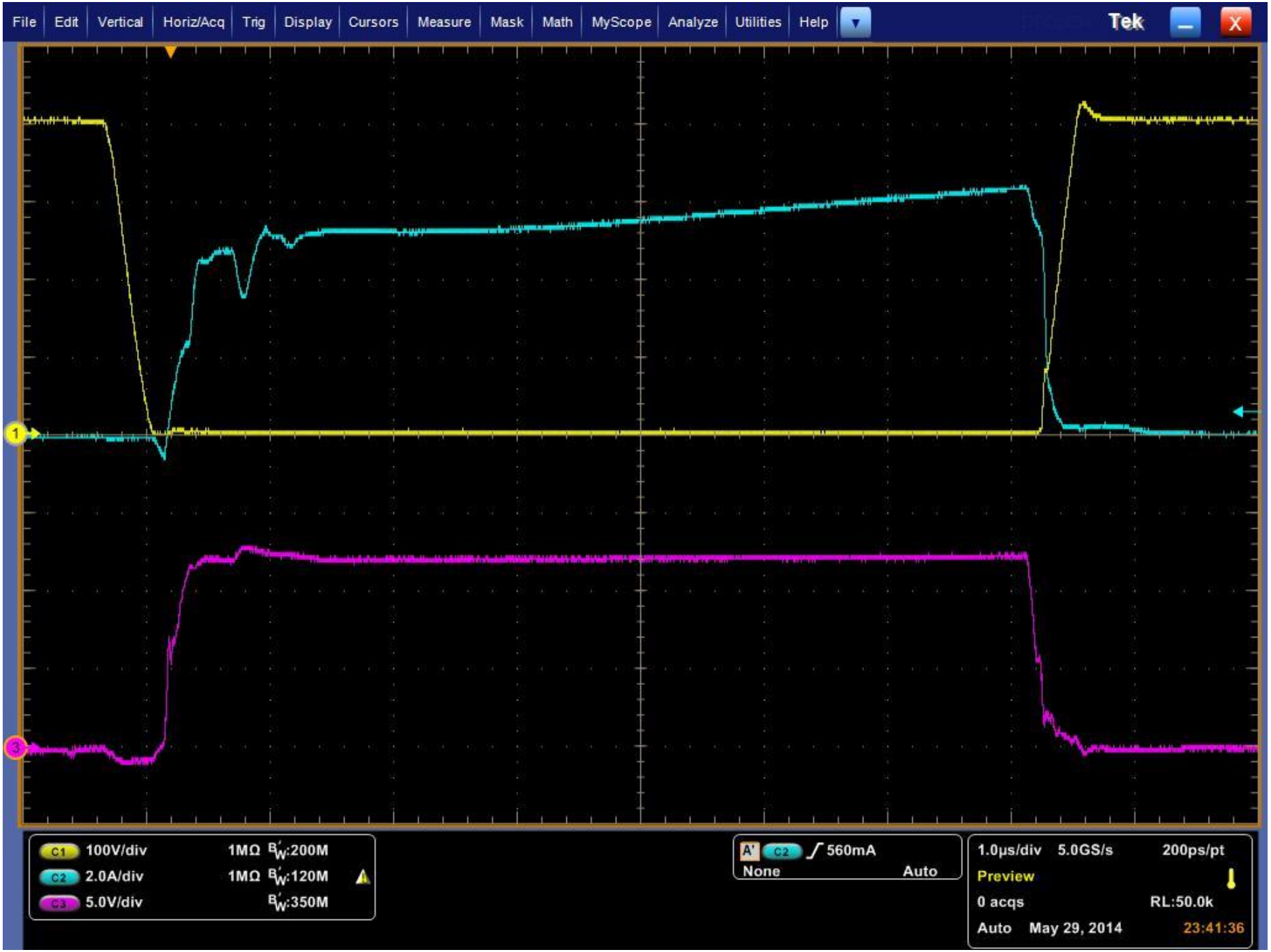
1on ⇒ GE cap. Rg üzerinden VTH'a kadar eksponansiyel şarj olur.

2on ⇒ VTH gerilimi geçtikçe ic artar. Endüktanstan dolayı, VCE biraz düşer.

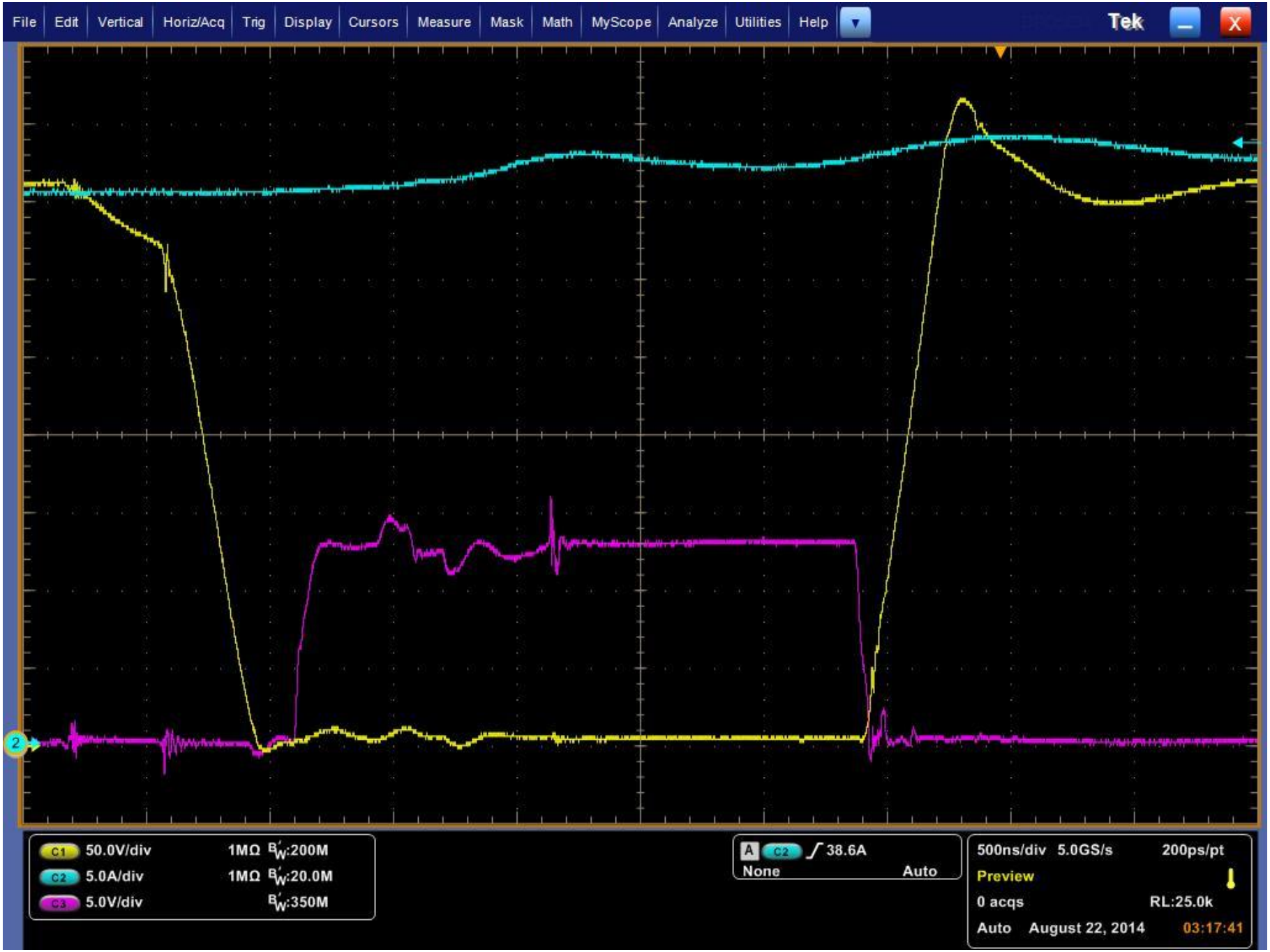
3on ⇒ Diyot ters toparlanma akımı da IGBT üzerinden geçer. Ayrıca, LC rezonans akımı da IGBT üzerinden geçer. VCE gerilimi düşer, VGE gerilimi VGP'ye ulaşır. VGP'yi IL belirler.

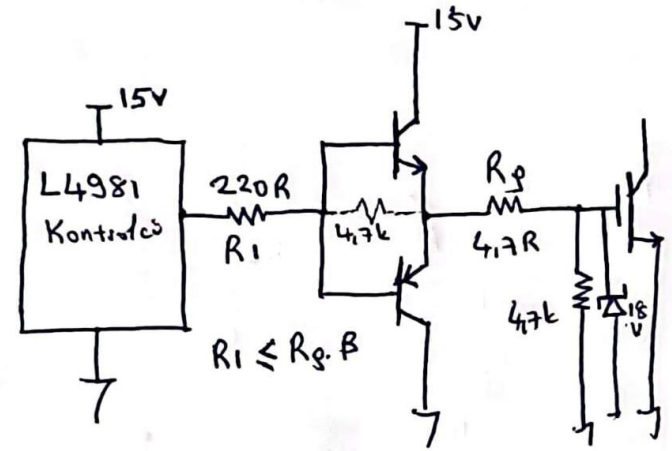
4on ⇒ Miller platosu. VGE sabit. VCE düşmeye devam eder. VGC artar. Gate akımı (Rg'den geçen akım) VGC'yi arttırır. VGE=VGC+VCE Gate şarjı artıyor. Artıkça, VCE düşüyor


File
Edit
Vertical
Horiz/Acq
Trig
Display
Cursors
Measure
Mask
Math
MyScope
Analyze
Utilities
Help
Tek
C1 50.0V/div 1MΩ BW:200M
C3 7.0A/div 1MΩ BW:120M
A' C3 43.1A
None Auto
1.0µs/div 5.0GS/s IT 10.0ps/pt
Preview
0 acqs RL:1.0M
Man December 02, 2014 04:27:55

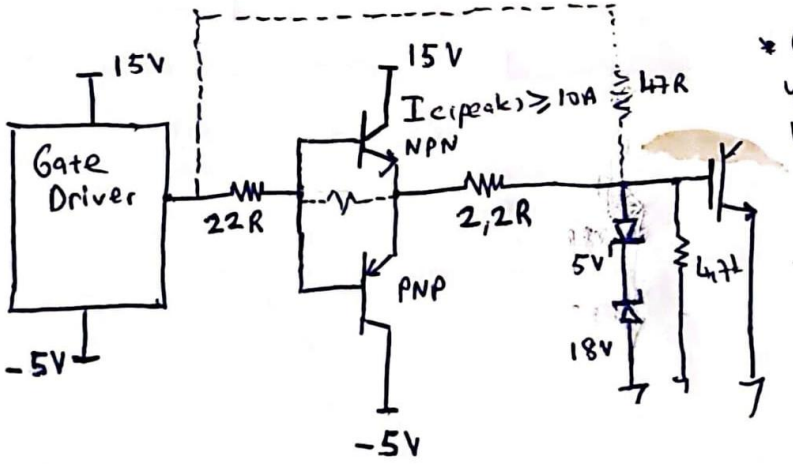

File
Edit
Vertical
Horiz/Acq
Trig
Display
Cursors
Measure
Mask
Math
MyScope
Analyze
Utilities
Help
Tek
C1 100V/div
C2 2.0A/div
C3 5.0V/div
1MΩ BW:200M
1MΩ BW:120M
BW:350M
A' C2 560mA
None
Auto
1.0µs/div 5.0GS/s 200ps/pt
Preview
0 acqs
RL:50.0k
Auto May 29, 2014
23:41:36


File
Edit
Vertical
Horiz/Acq
Trig
Display
Cursors
Measure
Mask
Math
MyScope
Analyze
Utilities
Help
Tek
C1 100V/div 1MΩ BW:200M
C2 2.0A/div 1MΩ BW:120M
C3 5.0V/div 1MΩ BW:200M
A C2 7.84A
None Auto
2.0µs/div 2.5GS/s 400ps/pt
Stopped
670 acqs RL:50.0k
Auto February 17, 2014 22:32:34


File
Edit
Vertical
Horiz/Acq
Trig
Display
Cursors
Measure
Mask
Math
MyScope
Analyze
Utilities
Help
Tek
C1 50.0V/div 1MΩ BW:200M
C2 5.0A/div 1MΩ BW:20.0M
C3 5.0V/div BW:350M
A C2 38.6A
None Auto
500ns/div 5.0GS/s 200ps/pt
Preview
0 acqs RL:25.0k
Auto August 22, 2014 03:17:41



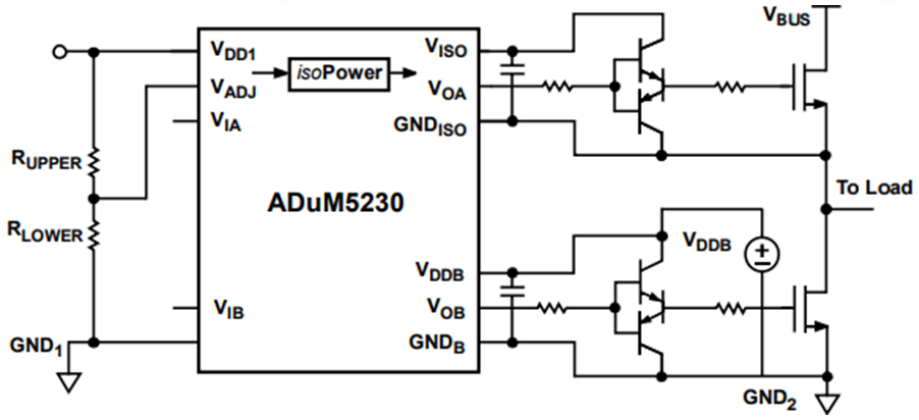
* Kontrolcü sıkışını zorlamamak için kullanılır

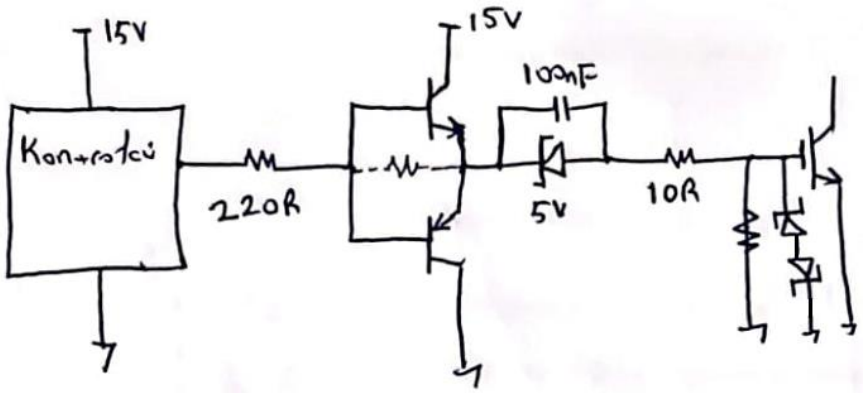


* Gate Driver sıkış akımını yükseltmek için kullanılabilir

Totem Pole Dezavantajları

- Kontrol gerilimi yüksek olmalı
- Tam sıfır ve Vcc'ye çekemez.
- Komponent sayısı

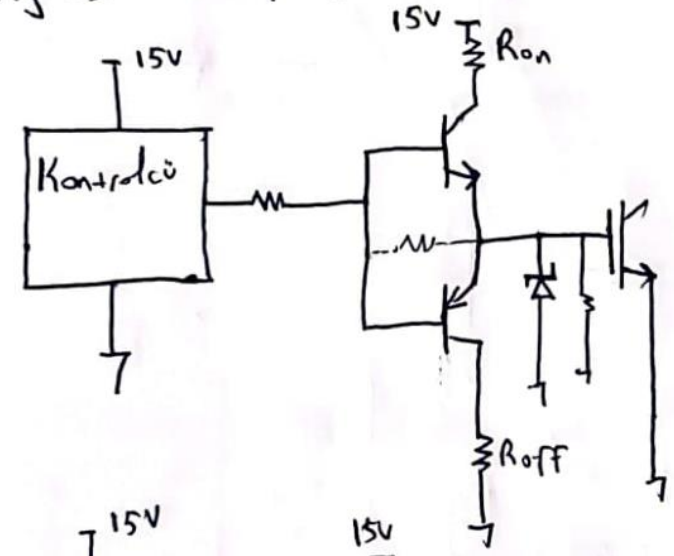


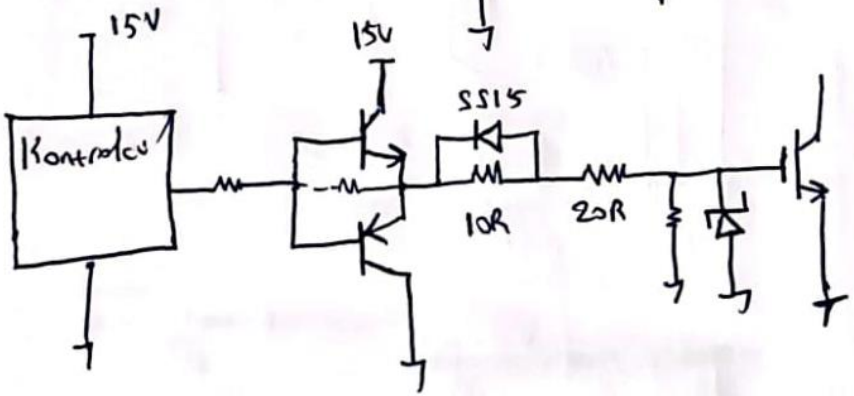


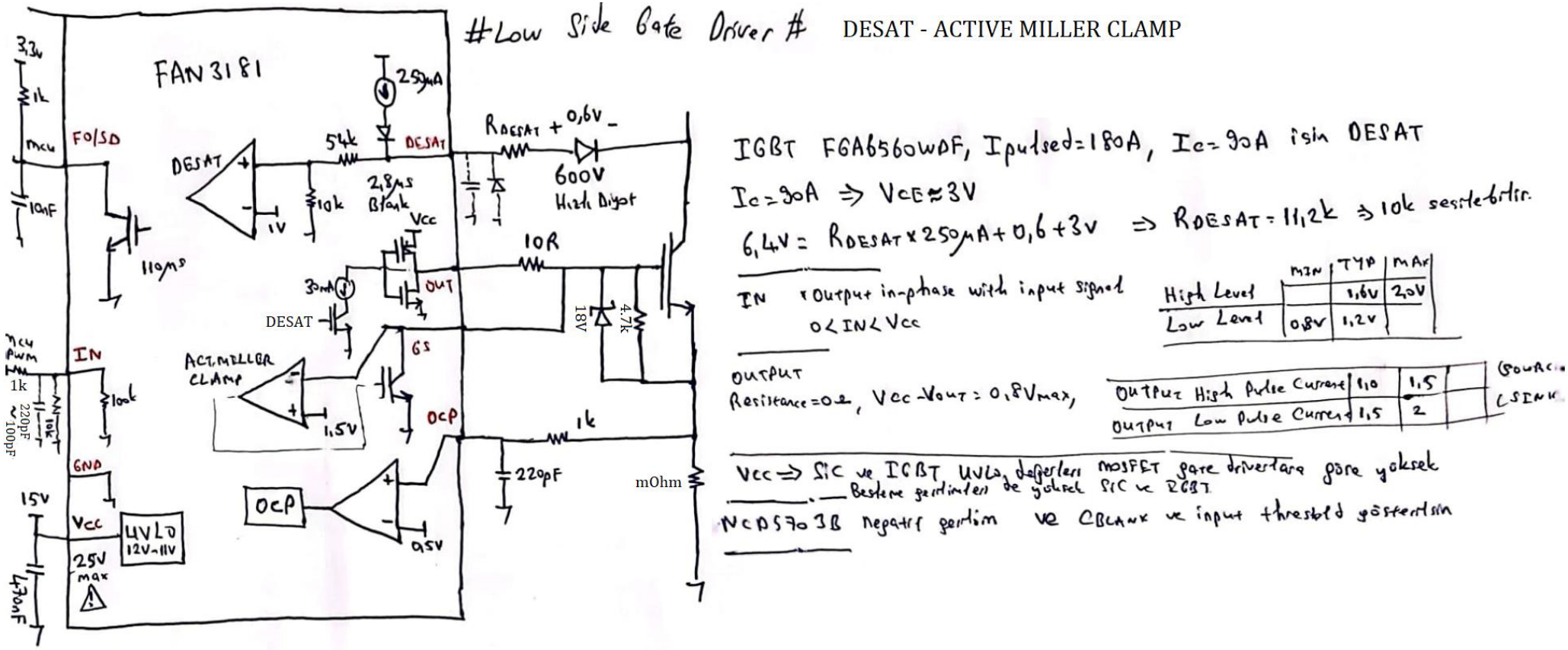
$V_{GE} \approx -5 < V_{GE} < 10V$

Duty'e bağlı değişebilir

R_g ⇒ Karbon film, SMD, metal film, ~~wire wound~~, ~~tel direnç~~



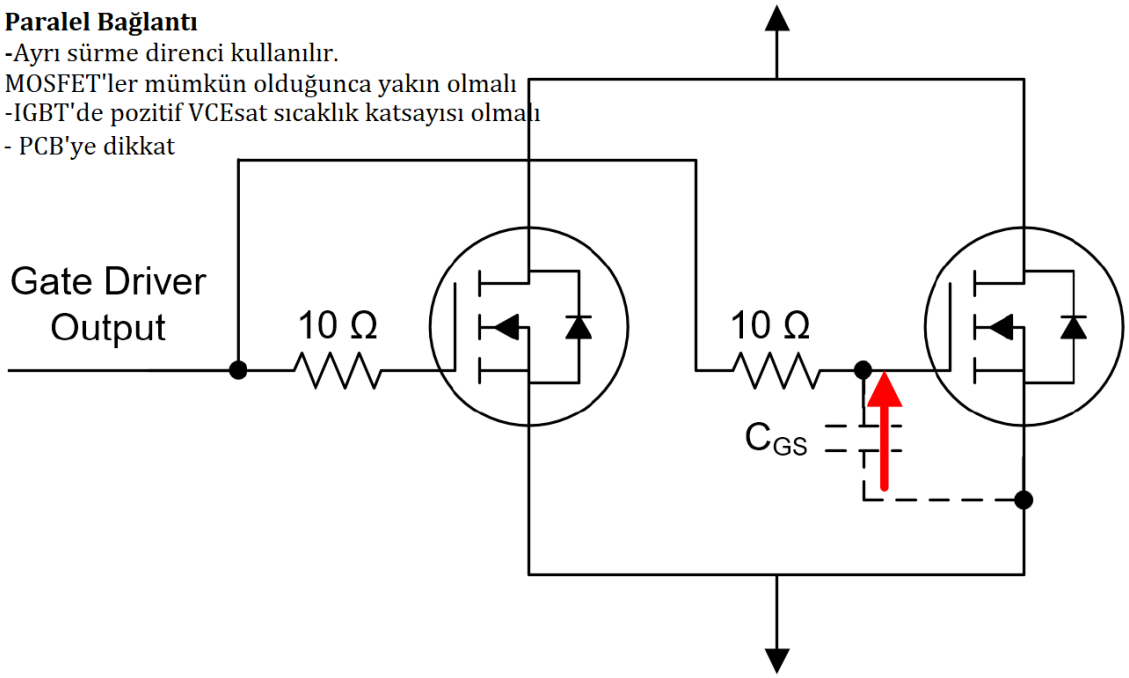


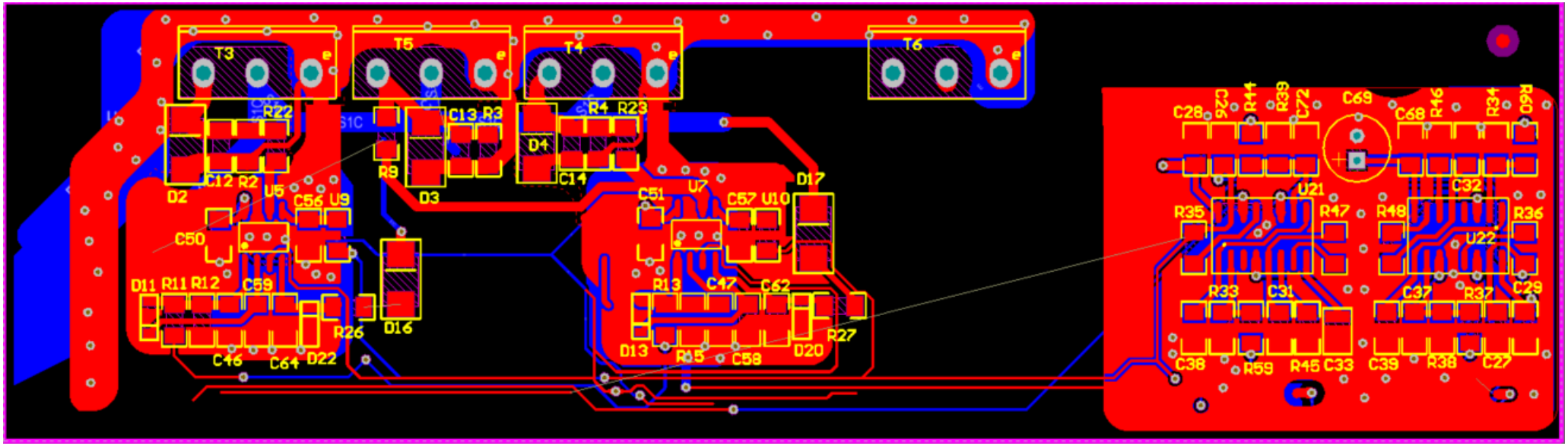


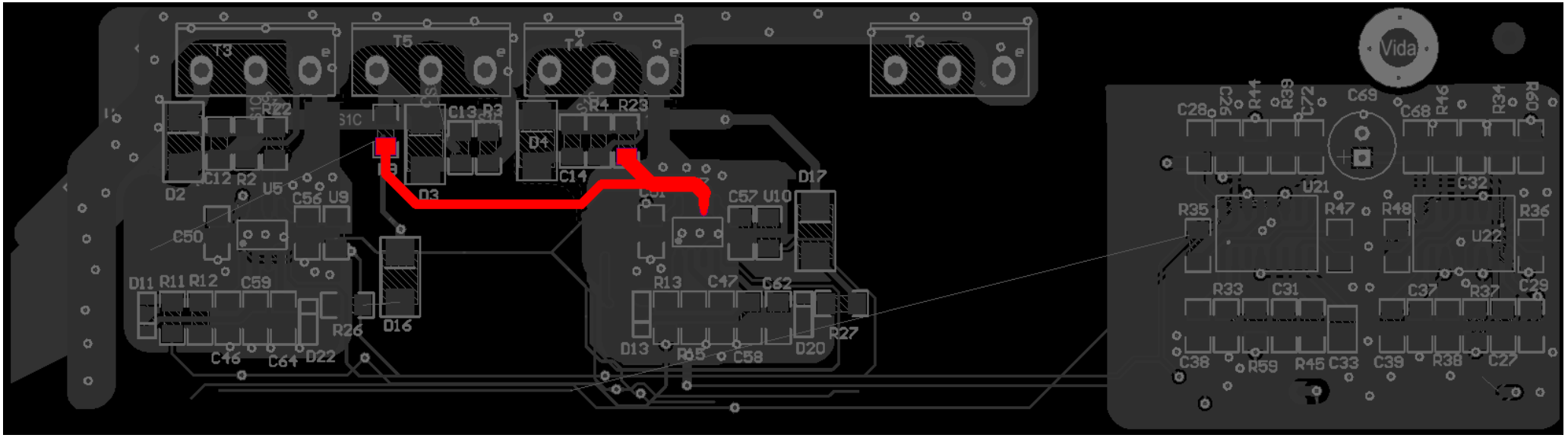
NCD5703B input threshold gerilimleri gösterilsin.

Paralel Bağlantı

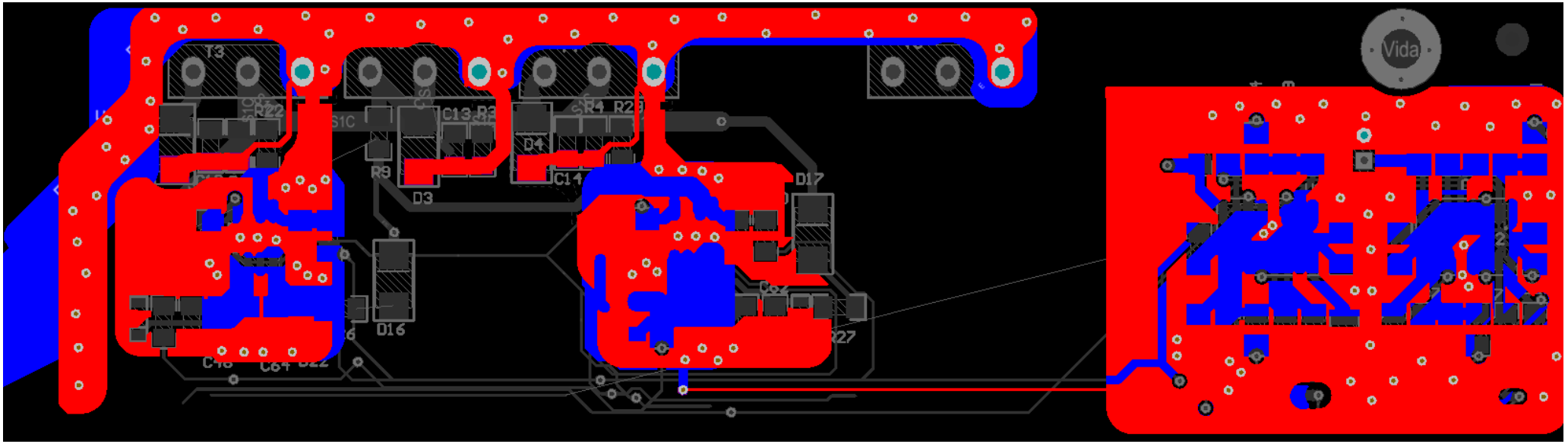
-Ayrı sürme direnci kullanılır.
MOSFET'ler mümkün olduğunca yakın olmalı
-IGBT'de pozitif VCEsat sıcaklık katsayısı olmalı
- PCB'ye dikkat





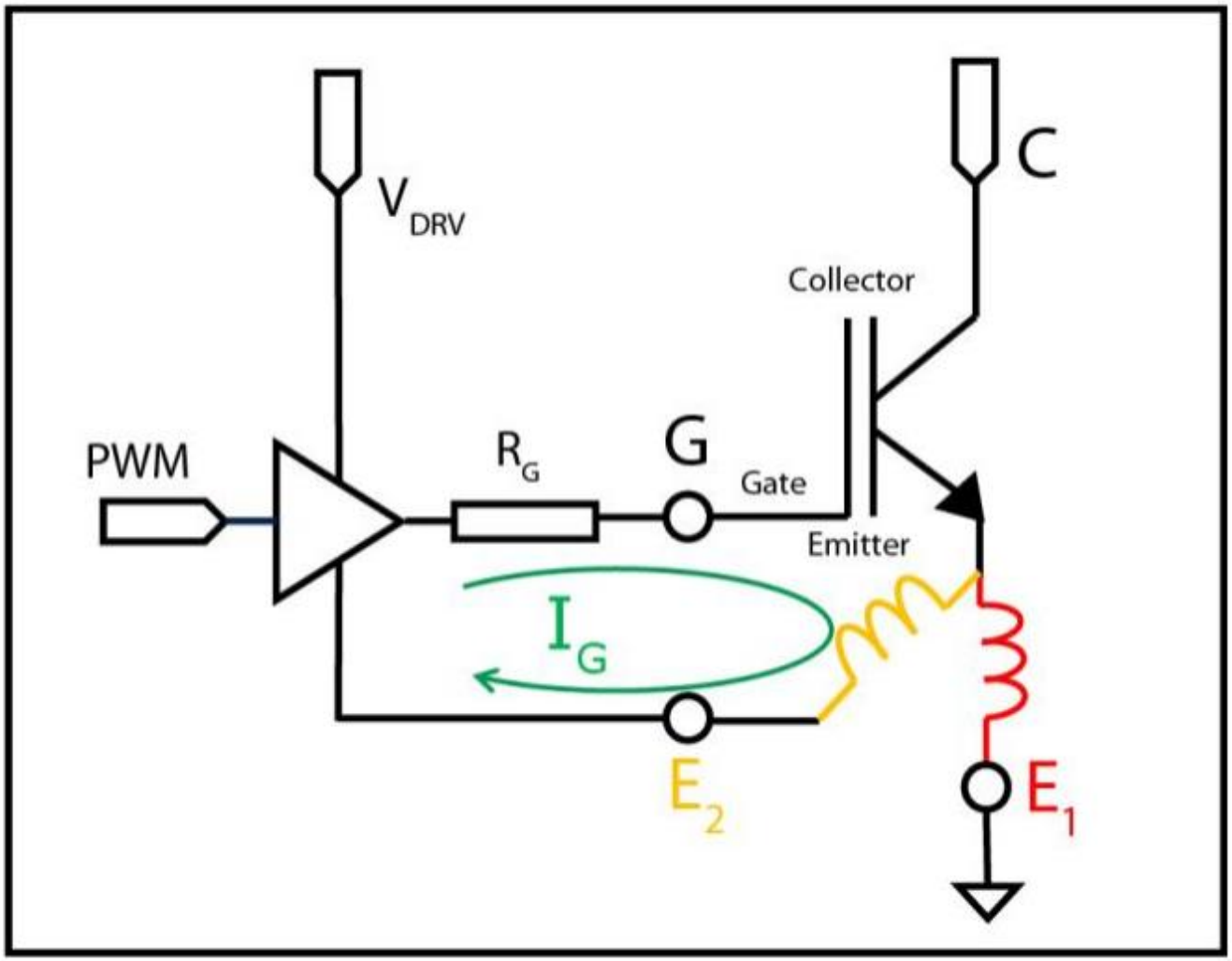


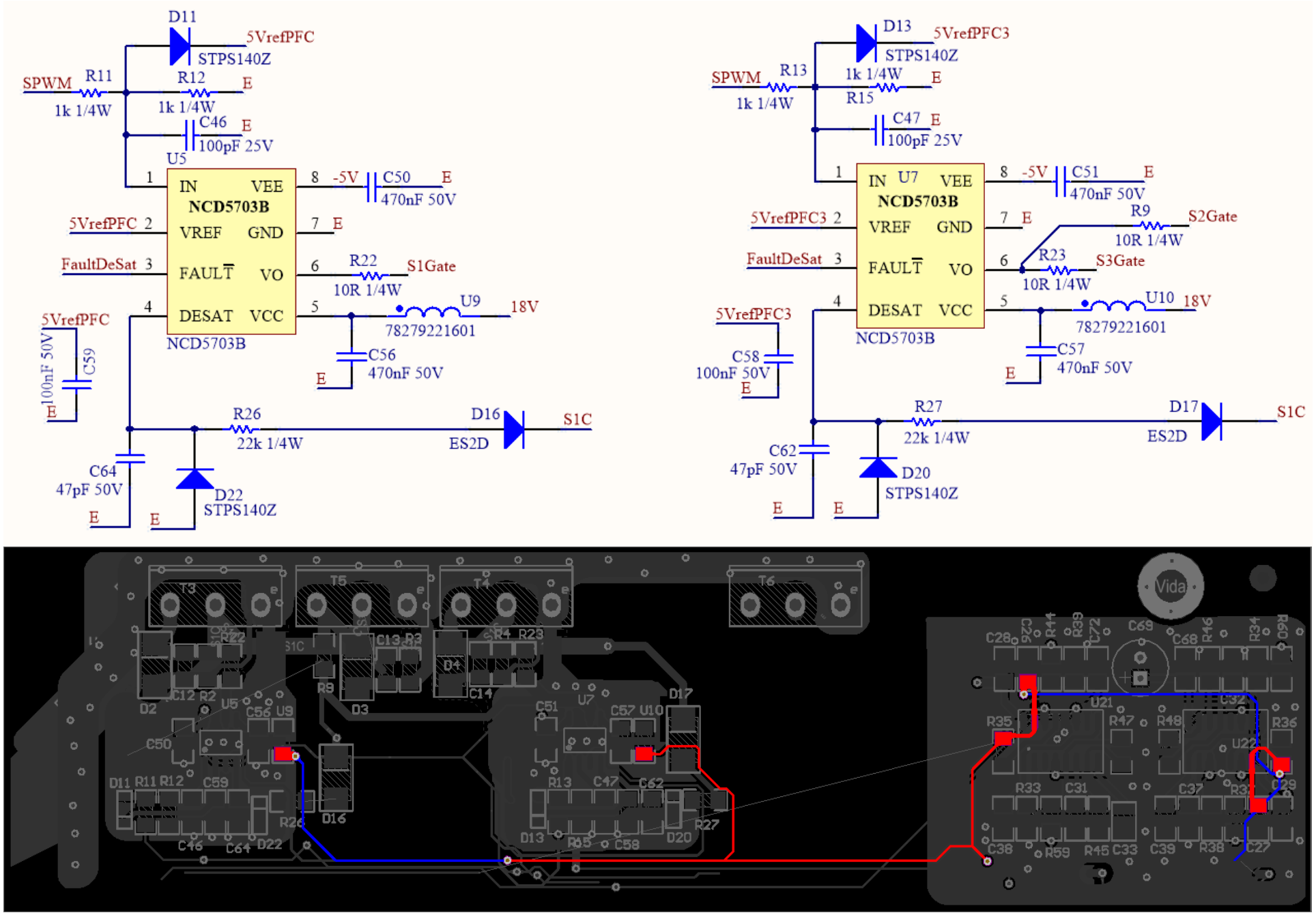
Gate Direnci



E

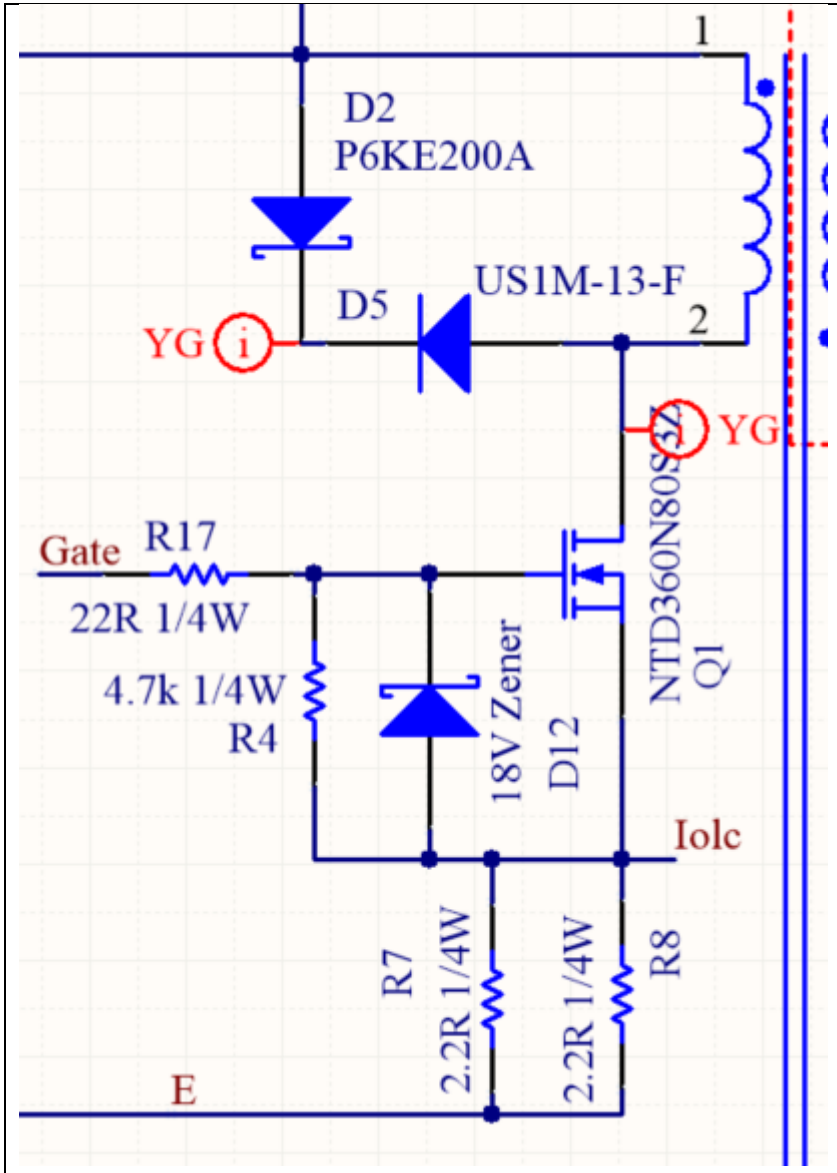

Infineon
TO-247 4pin
C
E1
E2
G

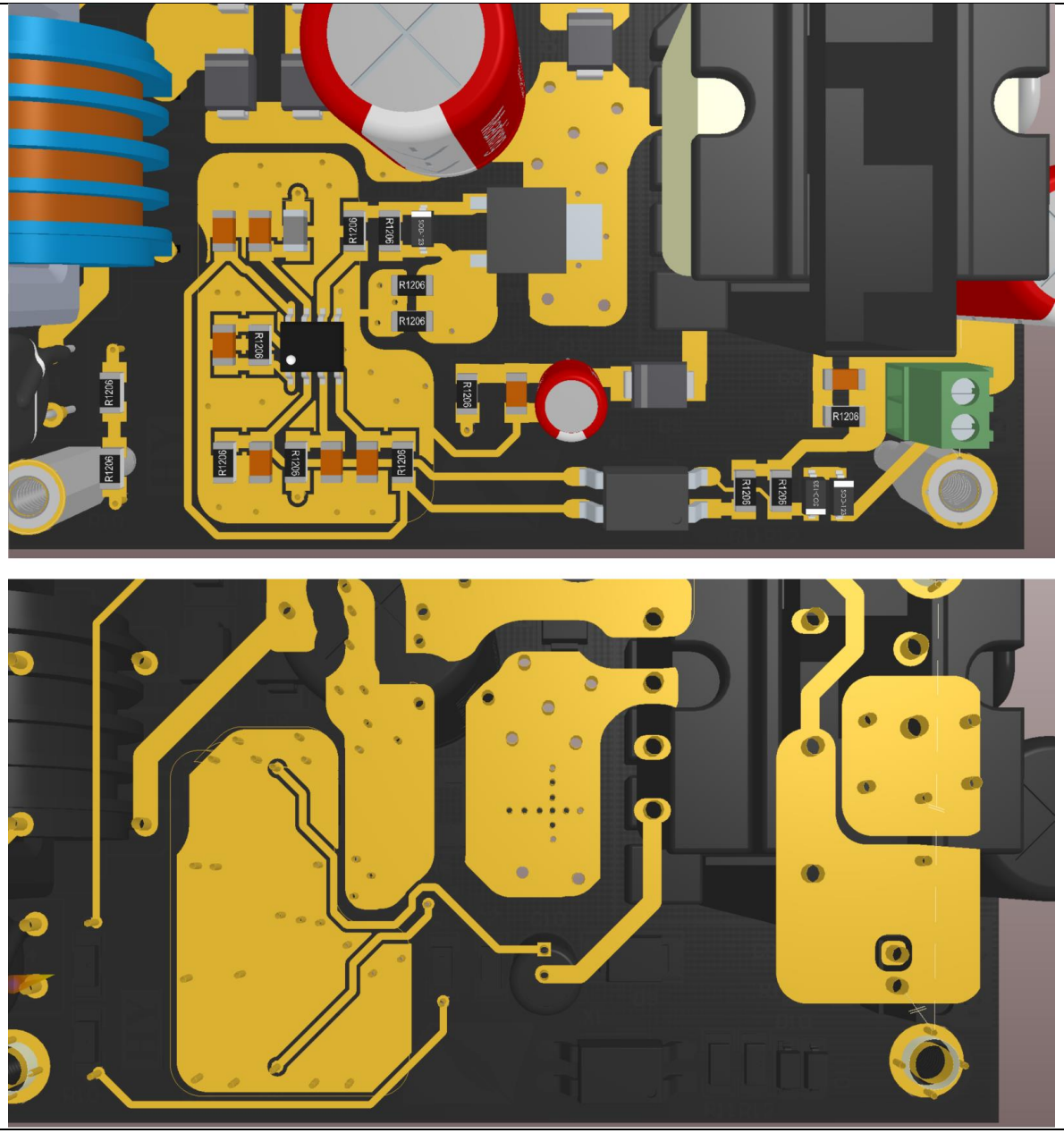

V DRV
C
Collector
PWM
R G
G
Gate
Emitter
I G
E2
E1


D11
5VrefPFC
STPS140Z
SPWM
R11
1k 1/4W
R12
1k 1/4W
E
C46
100pF 25V
U5
IN
VEE
NCD5703B
VREF
GND
FAULT
VO
DESAT
VCC
NCD5703B
-5V
C50
470nF 50V
5VrefPFC
FaultDeSat
R22
10R 1/4W
S1Gate
U9
18V
78279221601
C56
470nF 50V
C59
100nF 50V
R26
22k 1/4W
D16
ES2D
S1C
C64
47pF 50V
D22
STPS140Z
D13
5VrefPFC3
STPS140Z
R13
R15
C47
100pF 25V
U7
C51
470nF 50V
R9
S2Gate
10R 1/4W
R23
S3Gate
10R 1/4W
U10
78279221601
C57
470nF 50V
C58
100nF 50V
R27
22k 1/4W
D17
ES2D
C62
47pF 50V
D20
STPS140Z

18V Besleme

Sense Direnci Olduğu Durum





Kaynaklar

[1] Electric Drives with Permanent Magnet Synchronous Machines Connected to Internal Combustion Engines, Mattia Morandin

Onsemi Conductor Datasheet FAN3181

Infineon Datasheet IRL40SC228
Application Note TRENCHSTOP 5 Discrete IGBT in TO-247 4pin Package

Texas Instruments slvaf39a