Power MOSFET Module

SHD4101

Data Sheet

Description

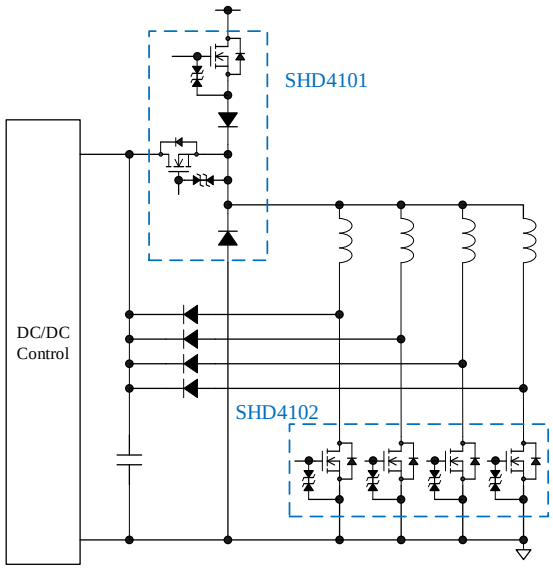
The SHD4101 includes four elements (two each of single and dual fast recovery diodes, two N-channel power MOSFETs) in its small HSON package. The internal power MOSFETs have Zener diodes between gates and sources, thus requiring no externally clamped circuit for an injection coil drive circuit. Supplied in a low thermal resistance package, the product achieves high performance in heat dissipation.

Features

- Suitable for High Reliability Applications
- Complies with Automotive Quality Requirements
- AEC-Q101 Qualified
- Bare Lead Frame: Pb-free (RoHS Compliant)
- Built-in Zener Diodes between Gates and Sources
- Specifications
  Element 1: Single Fast Recovery Diode (200 V, 5 A)
  Element 2: Dual Fast Recovery Diodes (200 V, 3 A)
  Element 3: N-channel Power MOSFET (100 V, 10 A)
  Element 4: N-channel Power MOSFET (40 V, 10 A)

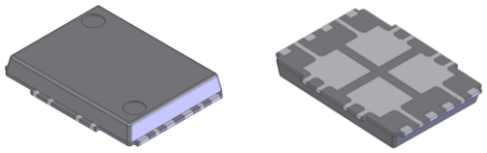
Typical Application

- **Solenoid Injection System**



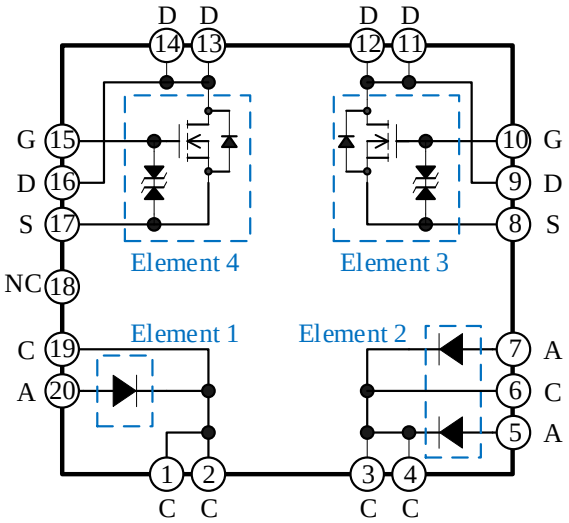
Package

- HSON-20



Not to scale

Internal Schematic Diagram



A: Diode Anode
C: Diode Cathode
D: Power MOSFET Drain
S: Power MOSFET Source
G: Power MOSFET Gate
NC: No Connection

Applications

- Injection Coil Driver Circuits

Contents

1. Absolute Maximum Ratings (All Elements Common)

Parameter	Symbol	Conditions	Rating	Unit
Power Dissipation	P_D	T_C = 25 °C, all elements operating; mounted on an FR4 board (26 mm × 36 mm × 1.66 mm)	1.7	W
		T_C = 25 °C, all elements operating; with an infinite heatsink	80	W
Junction Temperature	T_J		150	°C
Storage Temperature	T_{STG}		−55 to 150	°C

2. Thermal Characteristics

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Thermal Resistance (Junction-to-Case)	$R_{\theta JC}$	T_C = 25 °C, all elements operating; with an infinite heatsink	—	—	6.25	°C/W

3. Absolute Maximum Ratings and Electrical Characteristics

3.1. Element 1 (200 V, 5 A Fast Recovery Diode)

3.1.1. Absolute Maximum Ratings

Unless otherwise specified, T_A = 25 °C.

Parameter	Symbol	Conditions	Rating	Unit
Peak Repetitive Reverse Voltage	V_{RSM}		200	V
Repetitive Reverse Voltage	V_{RM}		200	V
Average Forward Current	$I_{F(AV)}$		5	A
Surge Forward Current	I_{FSM}	Half cycle sine wave, positive side, 10 ms, 1 shot	30	A
I^2t Limiting Value	I^2t	t ≤ 30 µs, duty cycle ≤ 1%	4.5	A^2s

3.1.2. Electrical Characteristics

Unless otherwise specified, T_A = 25 °C.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Forward Voltage Drop	V_F	T_J = 25 °C, I_F = 5 A	—	—	1	V
Reverse Leakage Current	I_R	$V_R = V_{RM}$	—	—	50	µA
Reverse Leakage Current under High Temperature	H·I_R	$V_R = V_{RM}$, T_J = 150 °C	—	—	300	µA
Reverse Recovery Time	t_{rr}	$I_F = I_{RP}$ = 100 mA, 90% recovery point, T_J = 25 °C	—	—	50	ns

3.1.3. Characteristic Curves

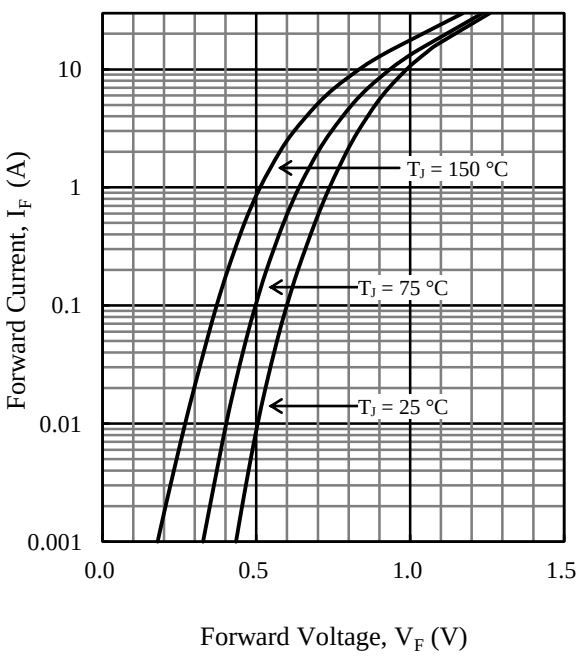


Figure 3-1. Element 1 Typical Characteristics: V_F vs. I_F

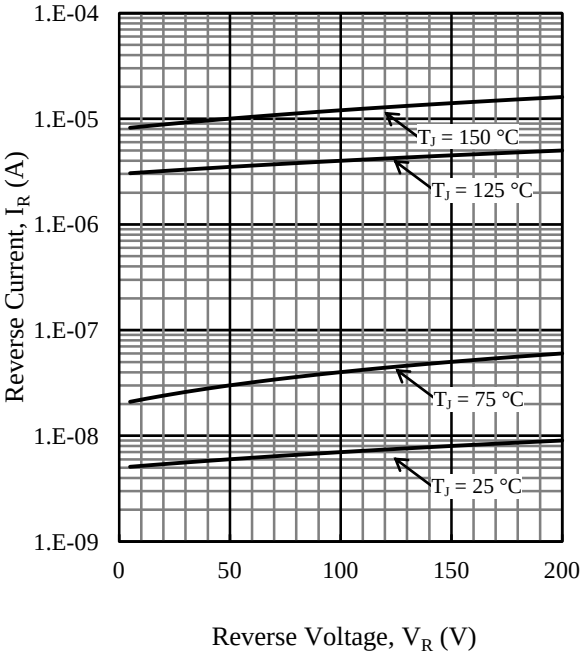


Figure 3-2. Element 1 Typical Characteristics: V_R vs. I_R

3.2. Element 2 (200 V, 3 A Fast Recovery Diode)

3.2.1. Absolute Maximum Ratings

Unless otherwise specified, T_A = 25 °C.

Parameter	Symbol	Conditions	Rating	Unit
Peak Repetitive Reverse Voltage	V_{RSM}		200	V
Repetitive Reverse Voltage	V_{RM}		200	V
Average Forward Current	$I_{F(AV)}$		3	A
Surge Forward Current	I_{FSM}	Half cycle sine wave, positive side, 10 ms, 1 shot	30	A
I^2t Limiting Value	I^2t	t ≤ 30 µs, duty cycle ≤ 1%	4.5	A^2s

3.2.2. Electrical Characteristics

Unless otherwise specified, T_A = 25 °C.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Forward Voltage Drop	V_F	T_J = 25 °C, I_F = 3 A	—	—	1	V
Reverse Leakage Current	I_R	$V_R = V_{RM}$	—	—	50	µA
Reverse Leakage Current under High Temperature	H·I_R	$V_R = V_{RM}$, T_J = 150 °C	—	—	300	µA
Reverse Recovery Time	t_{rr}	$I_F = I_{RP}$ = 100 mA, 90% recovery point, T_J = 25 °C	—	—	50	ns

3.2.3. Characteristic Curves

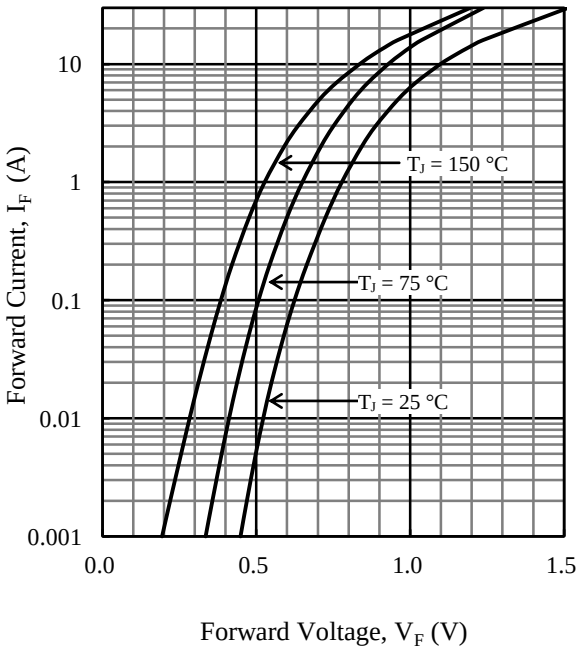


Figure 3-3. Element 2 Typical Characteristics: V_F vs. I_F

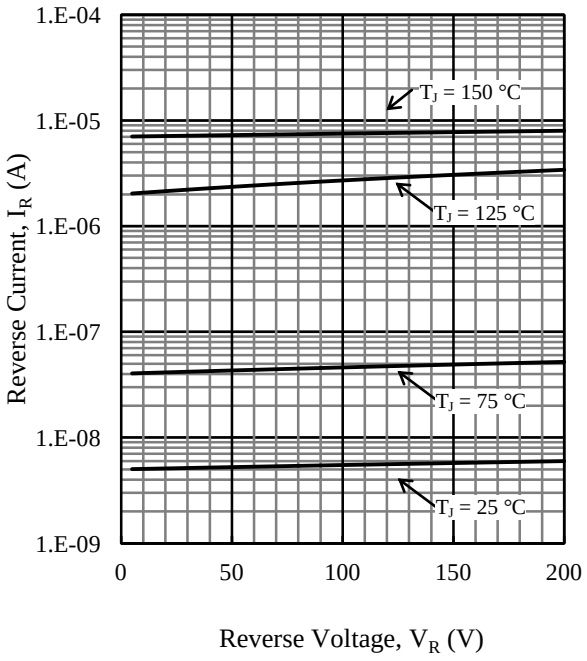


Figure 3-4. Element 2 Typical Characteristics: V_R vs. I_R

3.3. Element 3 (100 V, 10 A Power MOSFET)

3.3.1. Absolute Maximum Ratings

Unless otherwise specified, T_A = 25 °C.

Parameter	Symbol	Conditions	Rating	Unit
Drain-to-Source Voltage	V_{DS}		100	V
Gate-to-Source Voltage	V_{GS}		±20	V
Continuous Drain Current	I_D	T_C = 25 °C	10	A
Pulsed Drain Current	I_{DM}	t ≤ 30 µs, duty cycle ≤ 1 %	30	A
Single Pulse Avalanche Energy	E_{AS}	V_{DD} = 14 V, L = 1.08 mH, I_D = 10 A, unclamped, R_G = 50 Ω; see Figure 3-35	62.5	mJ
Avalanche Current	I_{AS}		10	A
Drain-to-Source dv/dt 1	dv/dt 1	See Figure 3-35	0.6	V/ns
Peak Diode Recovery dv/dt 2	dv/dt 2	See Figure 3-36	5	V/ns
Peak Diode Recovery di/dt	di/dt	See Figure 3-36	100	A/µs

3.3.2. Electrical Characteristics

Unless otherwise specified, T_A = 25 °C.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Drain-to-Source Breakdown Voltage	$V_{(BR)DSS}$	I_D = 100 µA, V_{GS} = 0 V	100	—	—	V
Drain-to-Source Leakage Current	I_{DSS}	V_{DS} = 100 V, V_{GS} = 0 V	—	—	100	µA
Gate-to-Source Leakage Current	I_{GSS}	V_{GS} = ± 15 V	—	—	± 10	µA
Gate Threshold Voltage	$V_{GS(th)}$	V_{DS} = 10 V, I_D = 1 mA	1.5	2.0	2.5	V
Forward Transconductance	g_{fs}	V_{DS} = 10 V, I_D = 5 A	9	—	—	S
Static Drain-to-Source On-resistance	$R_{DS(ON)}$	I_D = 5 A, V_{GS} = 10 V	—	38	50	mΩ
Input Capacitance	C_{iss}	V_{DS} = 10 V, V_{GS} = 0 V, f = 1 MHz	—	2200	—	pF
Output Capacitance	C_{oss}		—	210	—	
Reverse Transfer Capacitance	C_{rss}		—	110	—	
Total Gate Charge	Q_g	V_{DD} = 50 V, I_D = 5 A, V_{GS} = 10 V, R_L = 10 Ω	—	45	—	nC
Gate-to-Source Charge	Q_{gs}		—	6	—	
Gate-to-Drain Charge	Q_{gd}		—	10	—	
Turn-on Delay Time	$t_{d(on)}$	V_{DD} = 50 V, I_D = 5 A, V_{GS} = 10 V, R_G = 20 Ω, R_L = 10 Ω; see Figure 3-37	—	30	—	ns
Rise Time	t_r		—	40	—	
Turn-off Delay Time	$t_{d(off)}$		—	160	—	
Fall Time	t_f		—	80	—	
Source-to-Drain Diode Forward Voltage	V_{SD}	I_S = 10 A, V_{GS} = 0 V	—	—	1.2	V
Source-to-Drain Diode Reverse Recovery Time	t_{rr}	I_F = 10 A, di/dt = 100 A/µs; see Figure 3-36	—	50	—	ns

3.3.3. Rating and Characteristic Curves

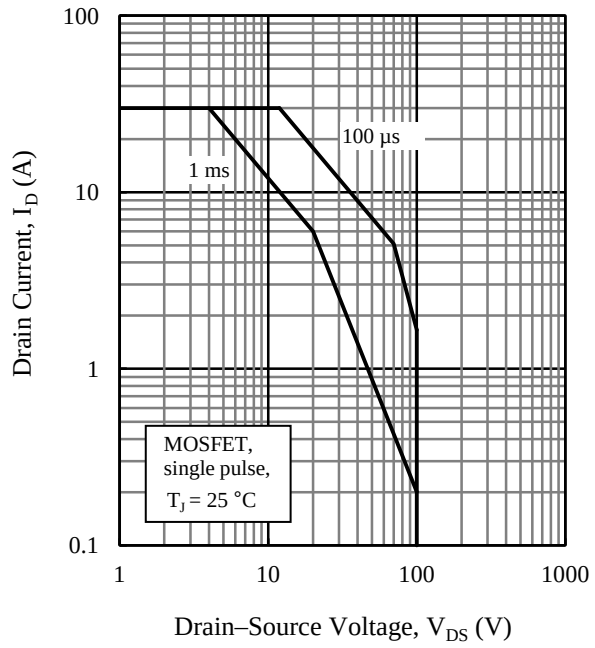


Figure 3-5. Element 3: Safe Operating Area

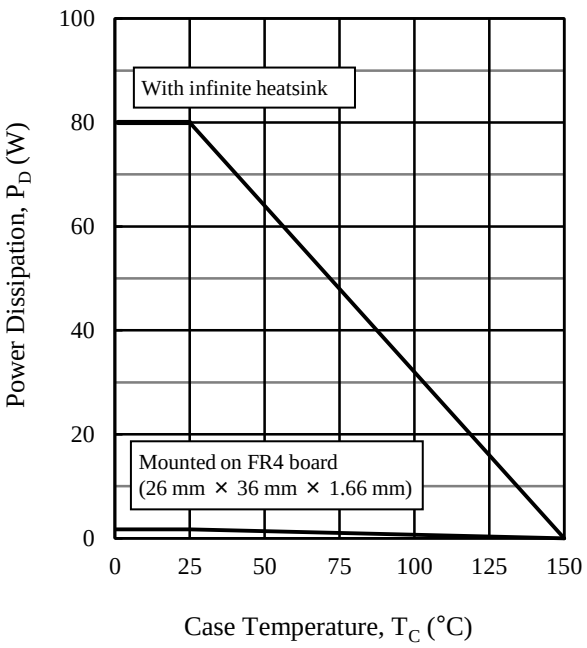


Figure 3-6. Element 3: Power Dissipation vs. Case Temperature

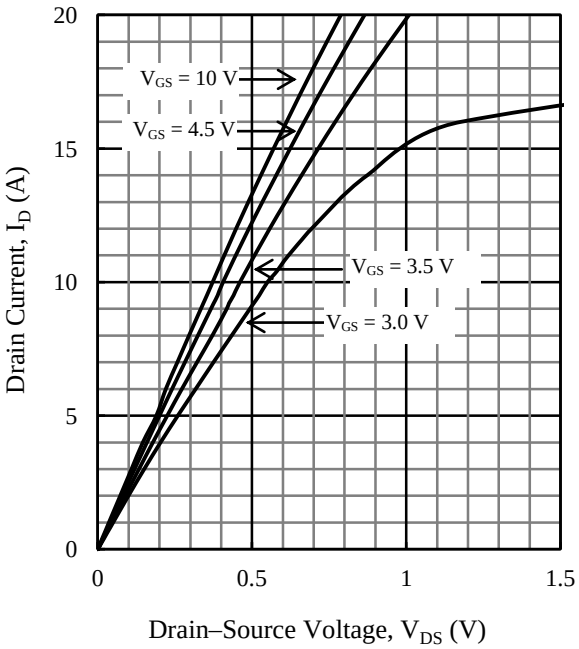


Figure 3-7. Element 3: Output Characteristics (T_J = 25 °C)

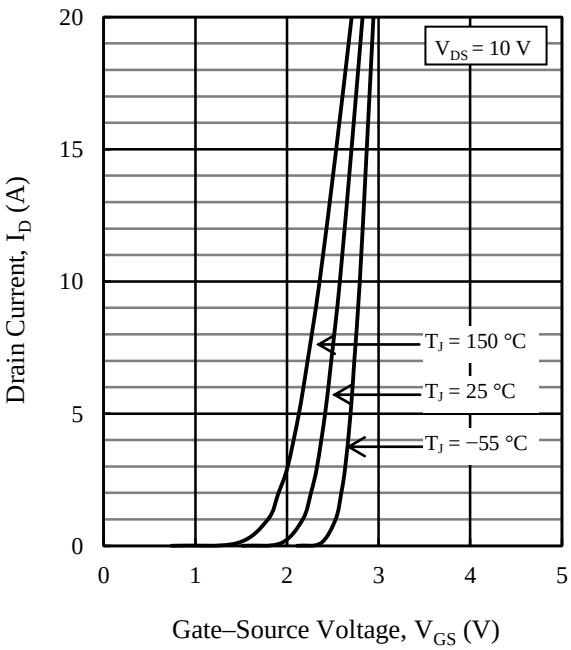


Figure 3-8. Element 3: Transfer Characteristics

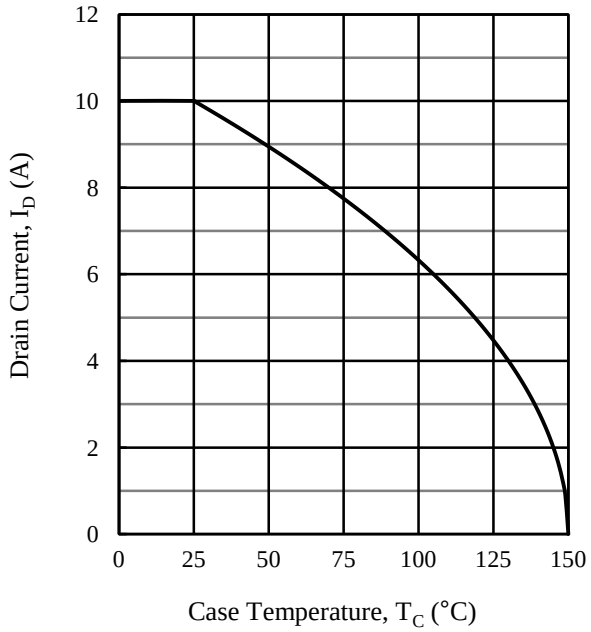


Figure 3-9. Element 3: Drain Current vs. Case Temperature

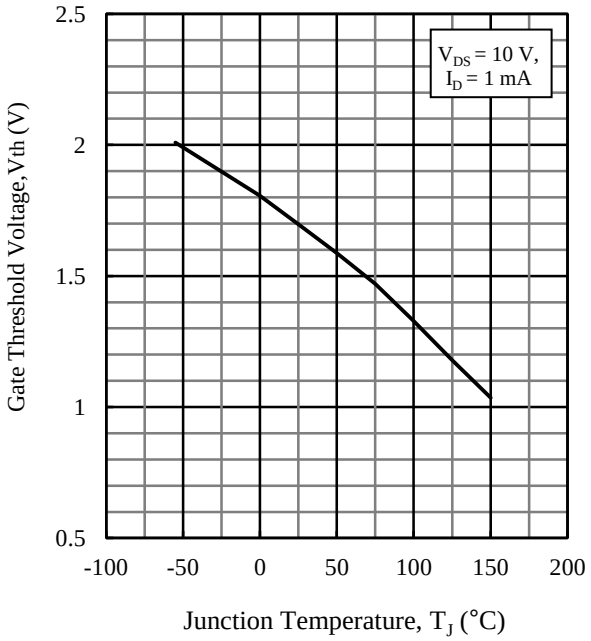


Figure 3-10. Element 3: Gate Threshold Voltage vs. Junction Temperature

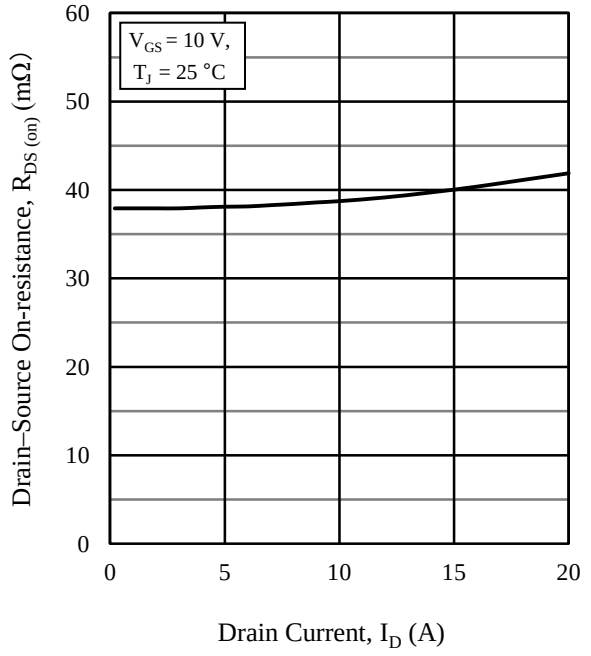


Figure 3-11. Element 3: Drain–Source On-resistance vs. Drain Current

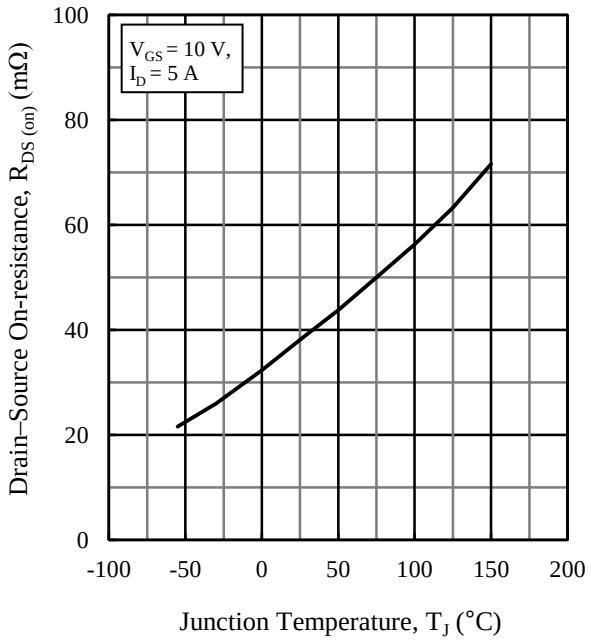


Figure 3-12. Element 3: Drain–Source On-resistance vs. Junction Temperature

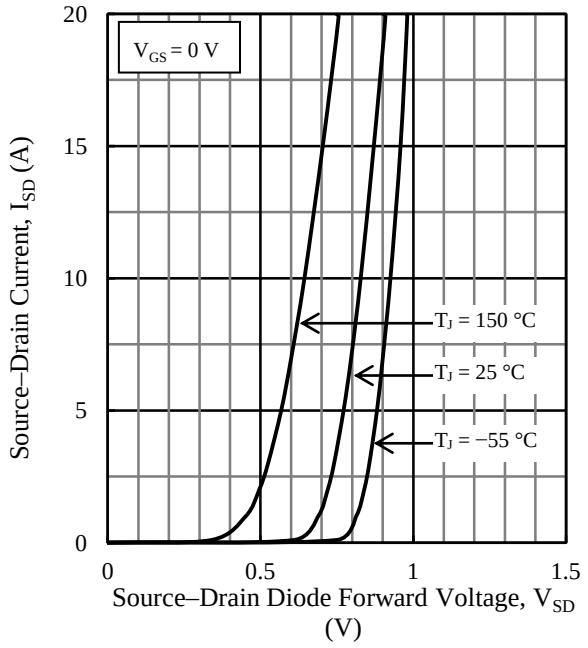


Figure 3-13. Element 3: Forward Diode Characteristics

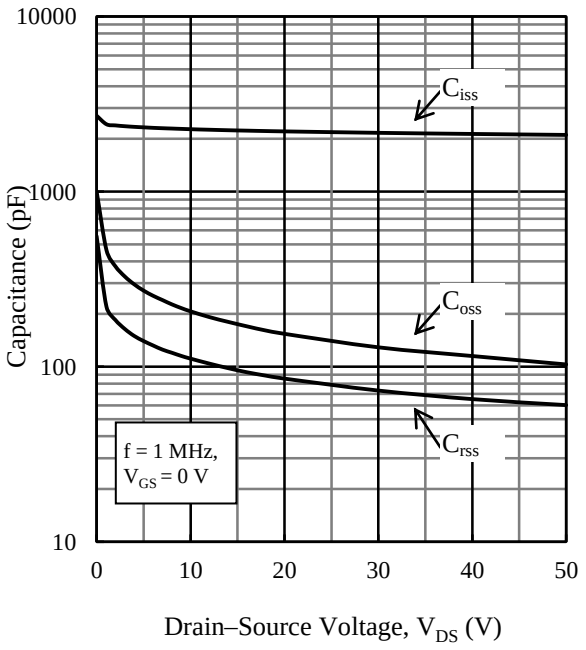


Figure 3-14. Element 3: Capacitance Characteristics

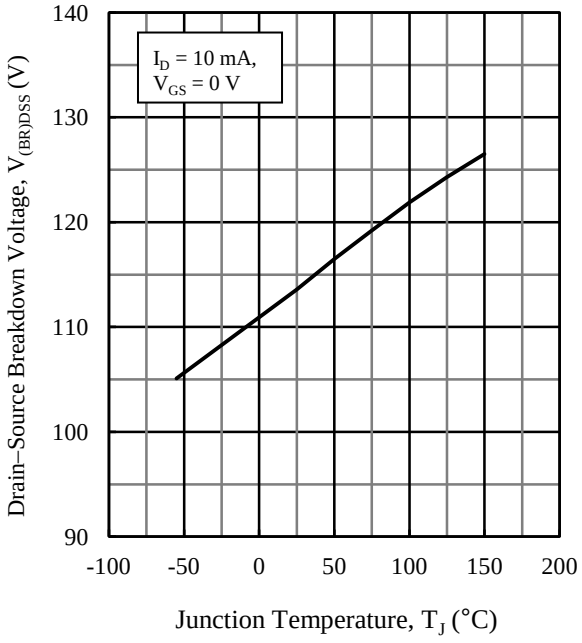


Figure 3-15. Element 3: Drain–Source Breakdown Voltage vs. Junction Temperature

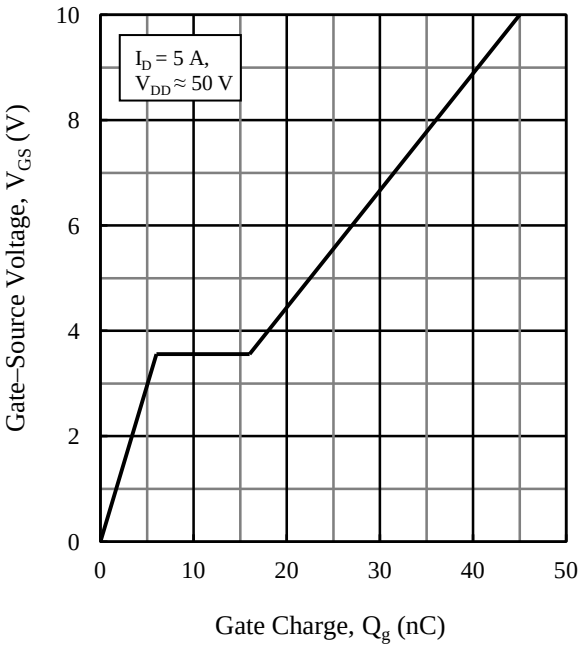


Figure 3-16. Element 3: Typical Gate Charge

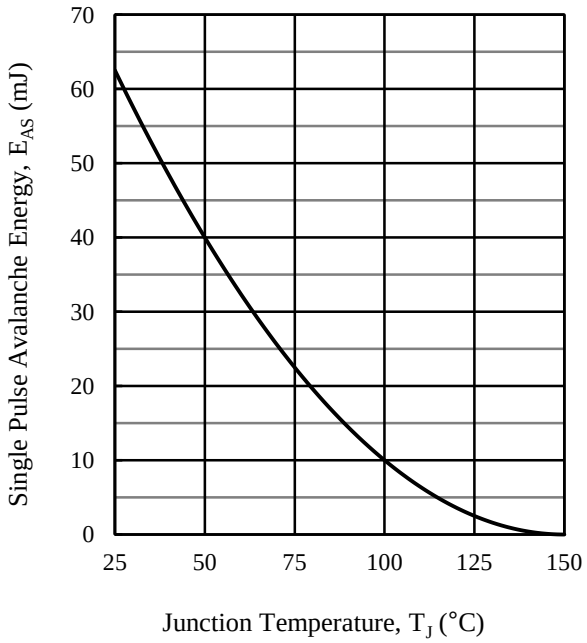


Figure 3-17. Element 3: Typical Avalanche Energy

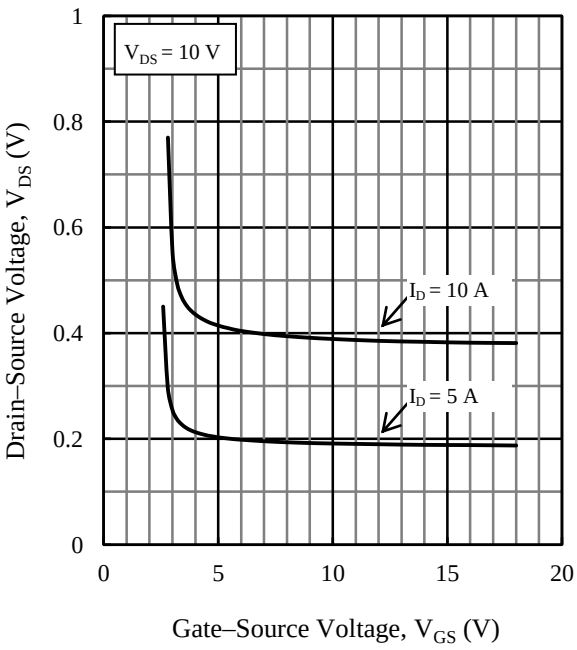


Figure 3-18. Element 3: Transfer Characteristics

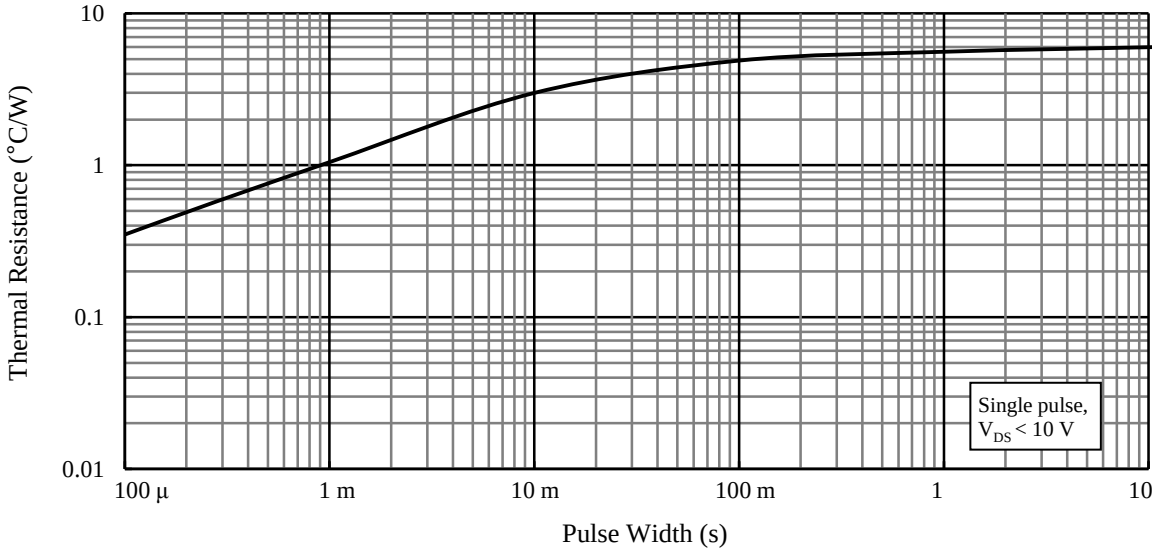


Figure 3-19. Element 3: Transient Thermal Resistance

3.4. Element 4 (40 V, 10 A Power MOSFET)

3.4.1. Absolute Maximum Ratings

Unless otherwise specified, T_A = 25 °C.

Parameter	Symbol	Conditions	Rating	Unit
Drain-to-Source Voltage	V_{DS}		40	V
Gate-to-Source Voltage	V_{GS}		±20	V
Continuous Drain Current	I_D	T_C = 25 °C	10	A
Pulsed Drain Current	I_{DM}	t ≤ 30 µs, duty cycle ≤ 1 %	30	A
Single Pulse Avalanche Energy	E_{AS}	V_{DD} = 14 V, L = 0.4 mH, I_D = 10 A, unclamped, R_G = 50 Ω; see Figure 3-35	30.5	mJ
Avalanche Current	I_{AS}		10	A
Drain-to-Source dv/dt 1	dv/dt 1	See Figure 3-35	0.2	V/ns
Peak Diode Recovery dv/dt 2	dv/dt 2	See Figure 3-36	2	V/ns
Peak Diode Recovery di/dt	di/dt	See Figure 3-36	100	A/µs

3.4.2. Electrical Characteristics

Unless otherwise specified, T_A = 25 °C.

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Drain-to-Source Breakdown Voltage	$V_{(BR)DSS}$	I_D = 100 µA, V_{GS} = 0 V	40	—	—	V
Drain-to-Source Leakage Current	I_{DSS}	V_{DS} = 40V, V_{GS} = 0 V	—	—	100	µA
Gate-to-Source Leakage Current	I_{GSS}	V_{GS} = ± 15 V	—	—	± 10	µA
Gate Threshold Voltage	$V_{GS(th)}$	V_{DS} = 10 V, I_D = 1 mA	1.5	2.0	2.5	V
Forward Transconductance	g_{fs}	V_{DS} = 10 V, I_D = 5 A	5	—	—	S
Static Drain to Source On-resistance	$R_{DS(ON)}$	I_D = 5 A, V_{GS} = 10 V	—	15	21	mΩ
Input Capacitance	C_{iss}	V_{DS} = 10 V, V_{GS} = 0 V, f = 1 MHz	—	1200	—	pF
Output Capacitance	C_{oss}		—	310	—	
Reverse Transfer Capacitance	C_{rss}		—	170	—	
Total Gate Charge	Q_g	V_{DD} = 20 V, I_D = 5 A, V_{GS} = 10 V, R_L = 4 Ω	—	25	—	nC
Gate-to-Source Charge	Q_{gs}		—	3	—	
Gate-to-Drain Charge	Q_{gd}		—	6	—	
Turn-on Delay Time	$t_{d(on)}$	V_{DD} = 20 V, I_D = 5 A, V_{GS} = 10 V, R_G = 20 Ω, R_L = 4 Ω; see Figure 3-37	—	15	—	ns
Rise Time	t_r		—	35	—	
Turn-off Delay Time	$t_{d(off)}$		—	100	—	
Fall Time	t_f		—	50	—	
Source-to-Drain Diode Forward Voltage	V_{SD}	I_S = 10 A, V_{GS} = 0 V	—	—	1.2	V
Source-to-Drain Diode Reverse Recovery Time	t_{rr}	I_F = 10 A, di/dt = 100 A/µs; see Figure 3-36	—	50	—	ns

3.4.3. Rating and Characteristic Curves

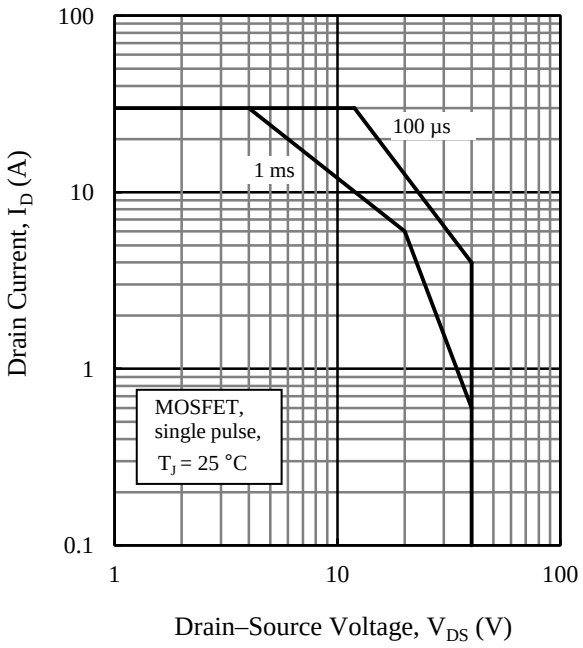


Figure 3-20. Element 4: Safe Operating Area

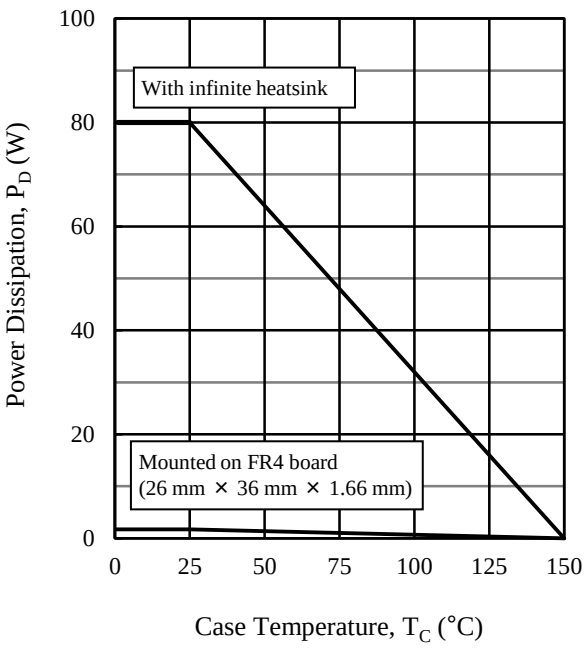


Figure 3-21. Element 4: Power Dissipation vs. Case Temperature

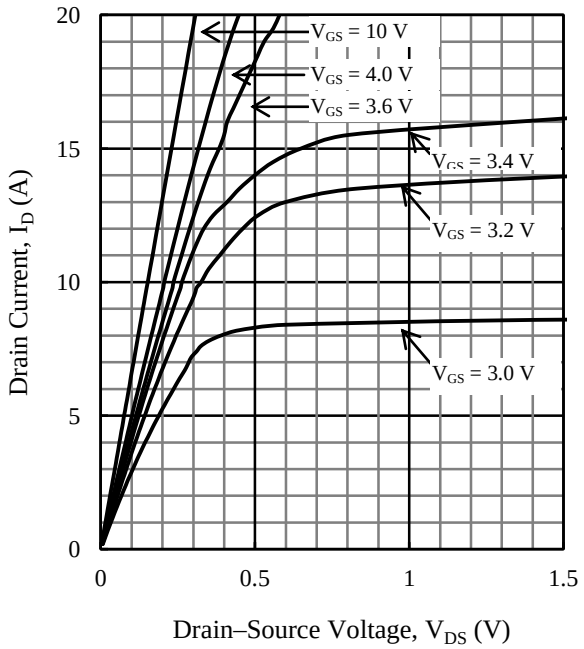


Figure 3-22. Element 4: Output Characteristics (T_J = 25 °C)

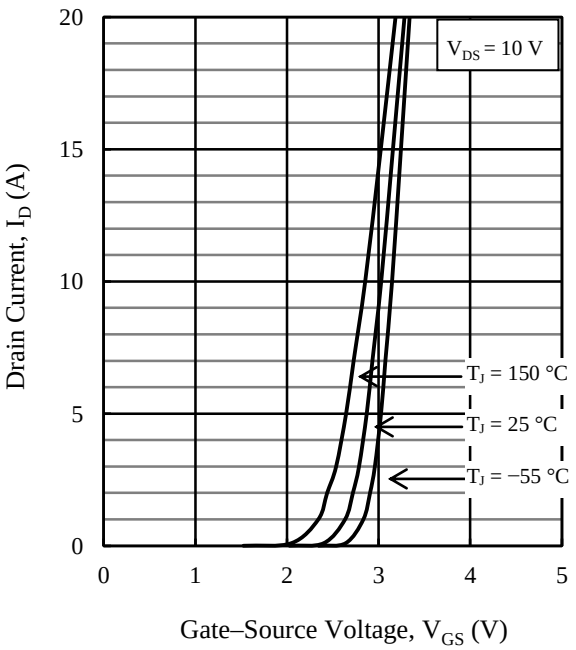


Figure 3-23. Element 4: Transfer Characteristics

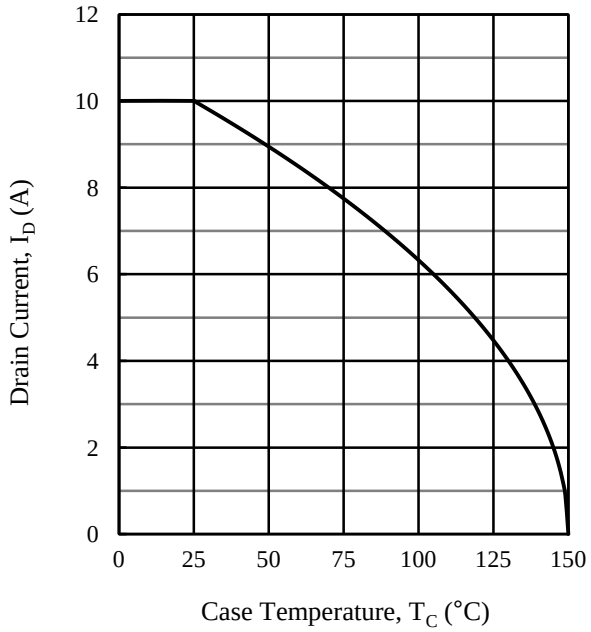


Figure 3-24. Element 4: Drain Current vs. Case Temperature

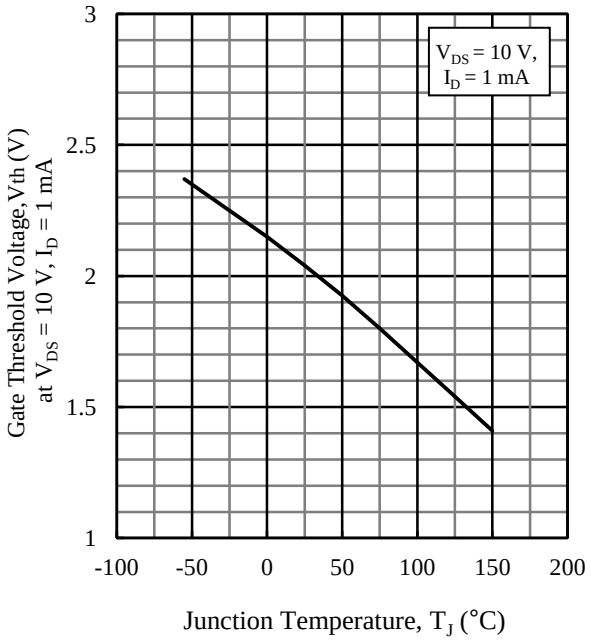


Figure 3-25. Element 4: Gate Threshold Voltage vs. Junction Temperature

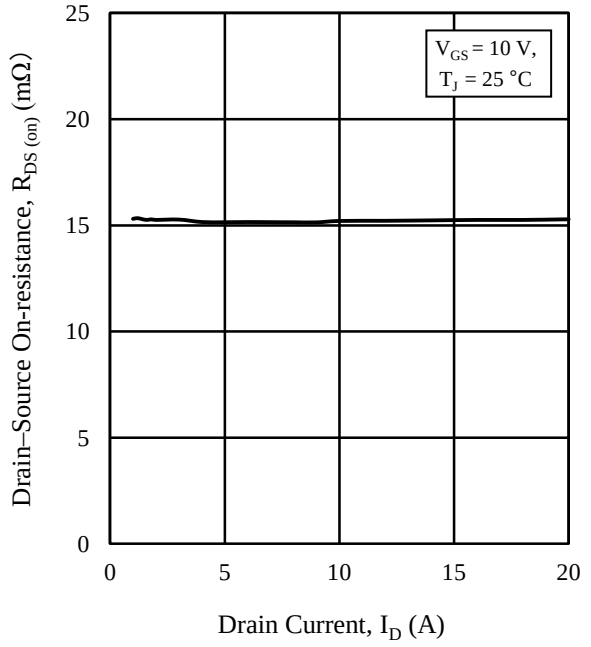


Figure 3-26. Element 4: Drain–Source On-resistance vs. Drain Current

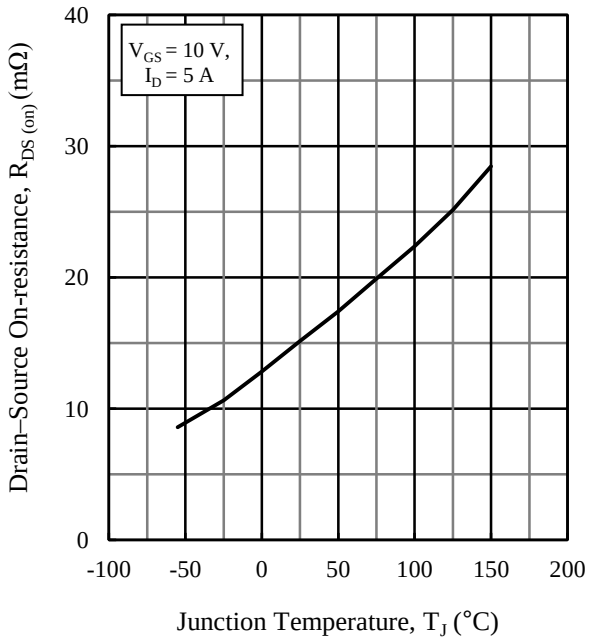


Figure 3-27. Element 4: Drain–Source On-resistance vs. Junction Temperature

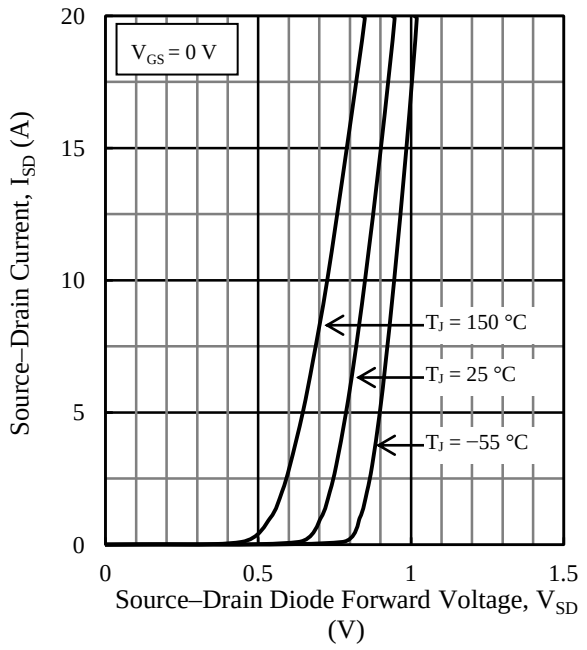


Figure 3-28. Element 4: Forward Diode Characteristics

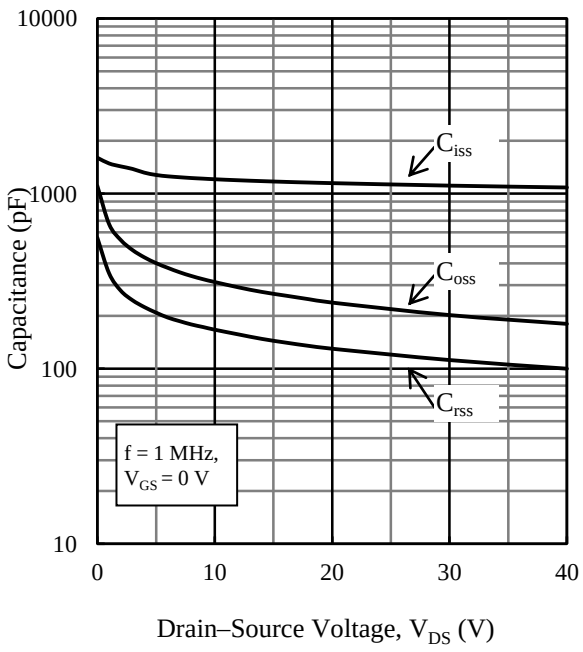


Figure 3-29. Element 4: Capacitance Characteristics

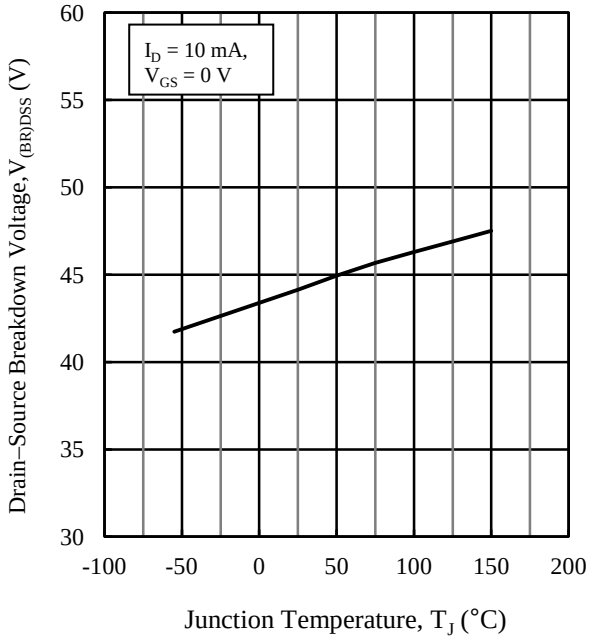


Figure 3-30. Element 4: Drain–Source Breakdown Voltage vs. Junction Temperature

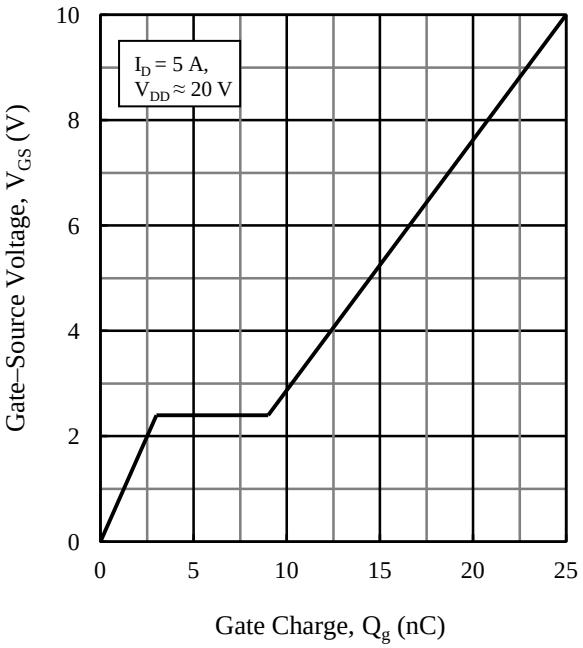


Figure 3-31. Element 4: Typical Gate Charge

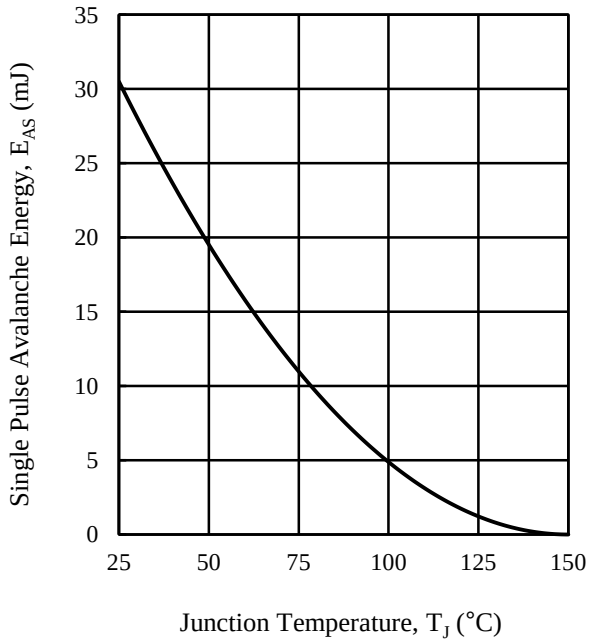


Figure 3-32. Element 4: Typical Avalanche Energy

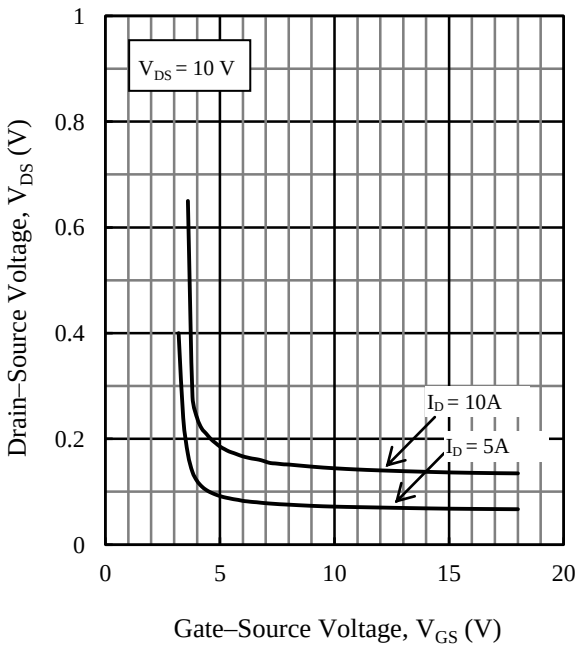


Figure 3-33. Element 4: Transfer Characteristics

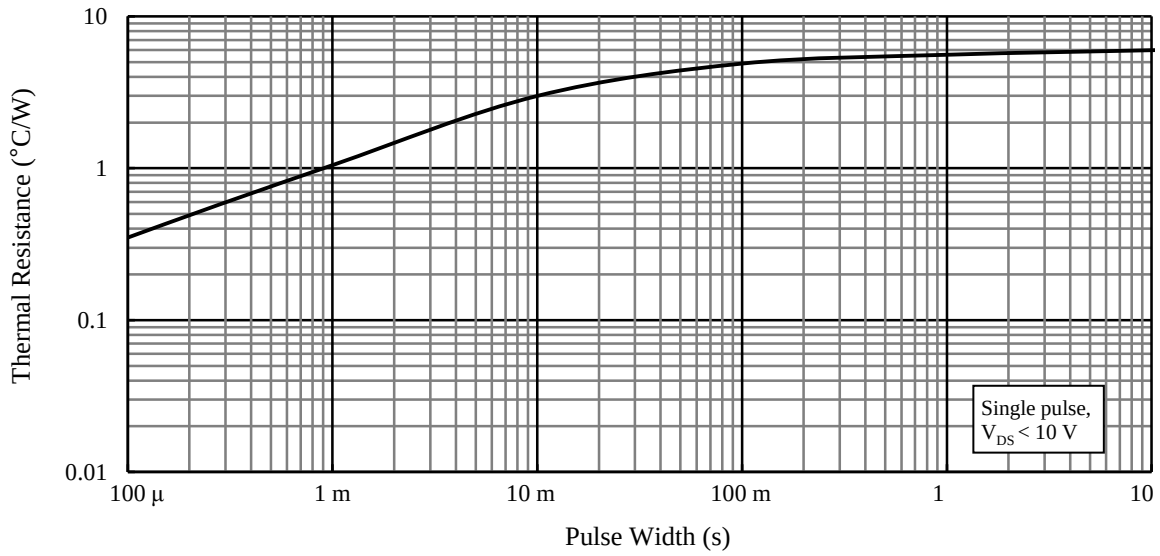
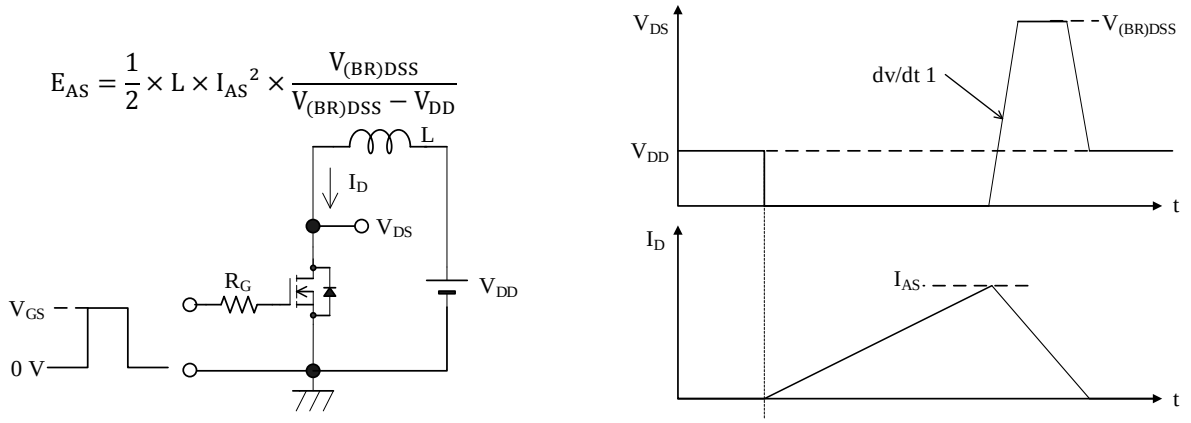


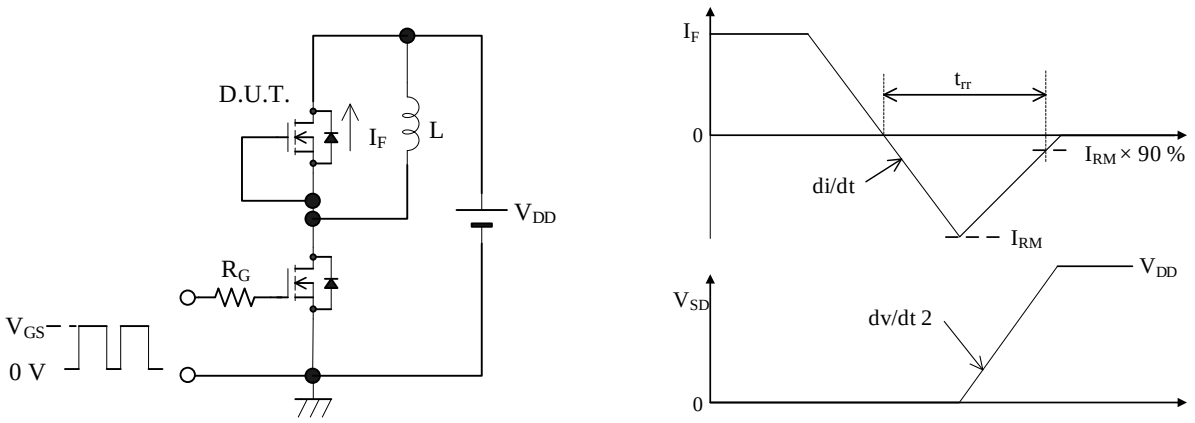
Figure 3-34. Element 4: Transient Thermal Resistance

3.5. Test Circuits and Waveforms



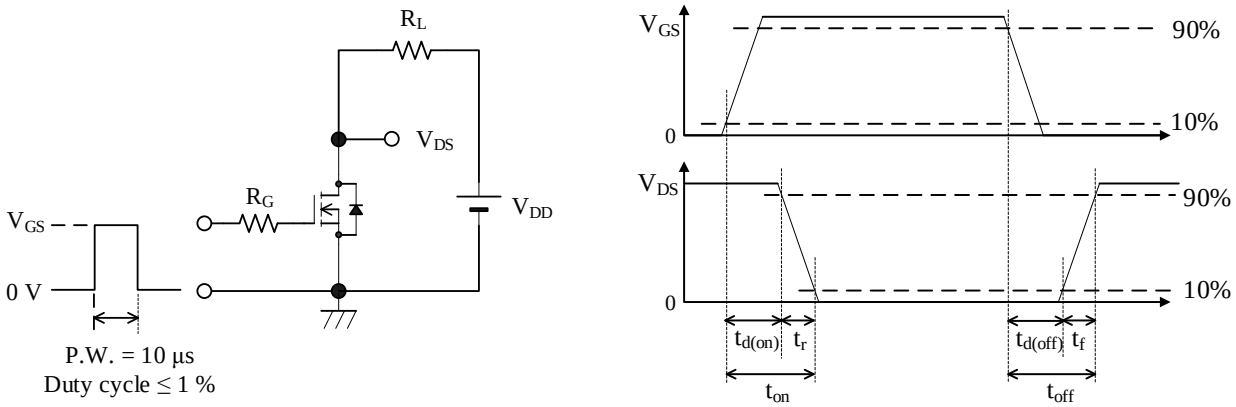
(a) Test Circuit (b) Waveforms

Figure 3-35. Unclamped Inductive Test Circuit and Switching Time Waveforms



(a) Test Circuit (b) Waveforms

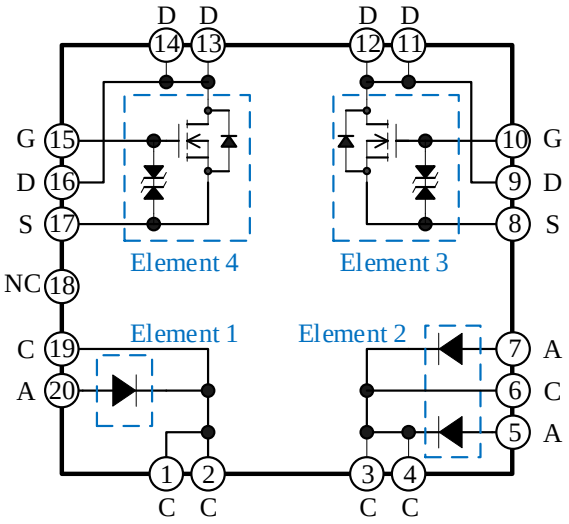
Figure 3-36. Diode Reverse Recovery Time



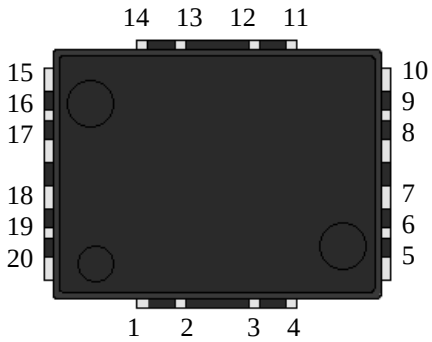
(a) Test Circuit (b) Waveforms

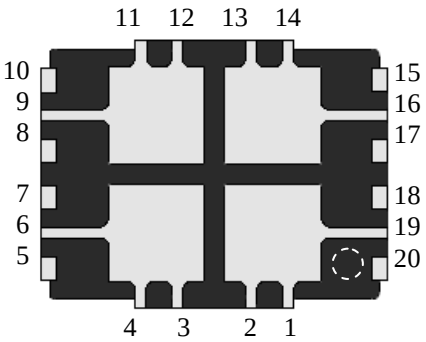
Figure 3-37. Resistive Load Test Circuit and Switching Time Waveforms

4. Internal Schematic Diagram



5. Pin Configuration Definitions

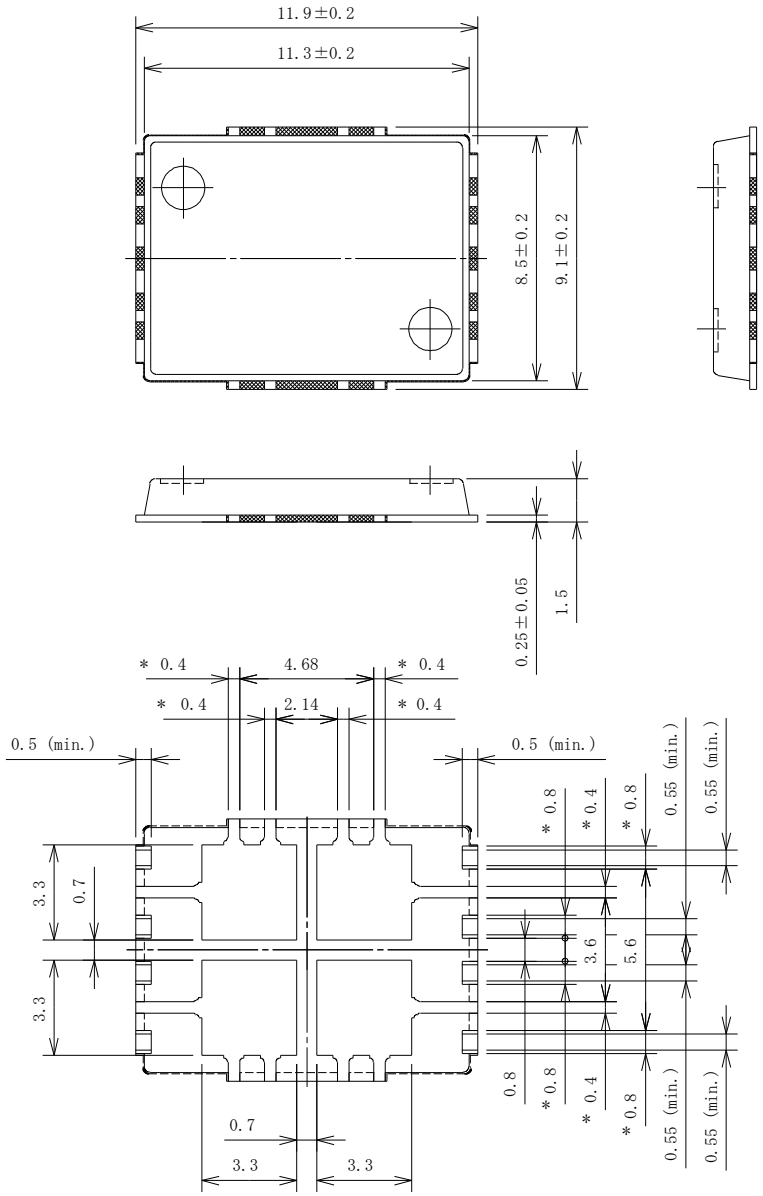




Pin Number	Description	Pin Number	Description
1	Element 1 cathode	11	Element 3 drain
2	Element 1 cathode	12	Element 3 drain
3	Element 2 cathode	13	Element 4 drain
4	Element 2 cathode	14	Element 4 drain
5	Element 2 anode	15	Element 4 gate
6	Element 2 cathode	16	Element 4 drain
7	Element 2 anode	17	Element 4 source
8	Element 3 source	18	No connection
9	Element 3 drain	19	Element 1 cathode
10	Element 3 gate	20	Element 1 anode

6. Physical Dimensions

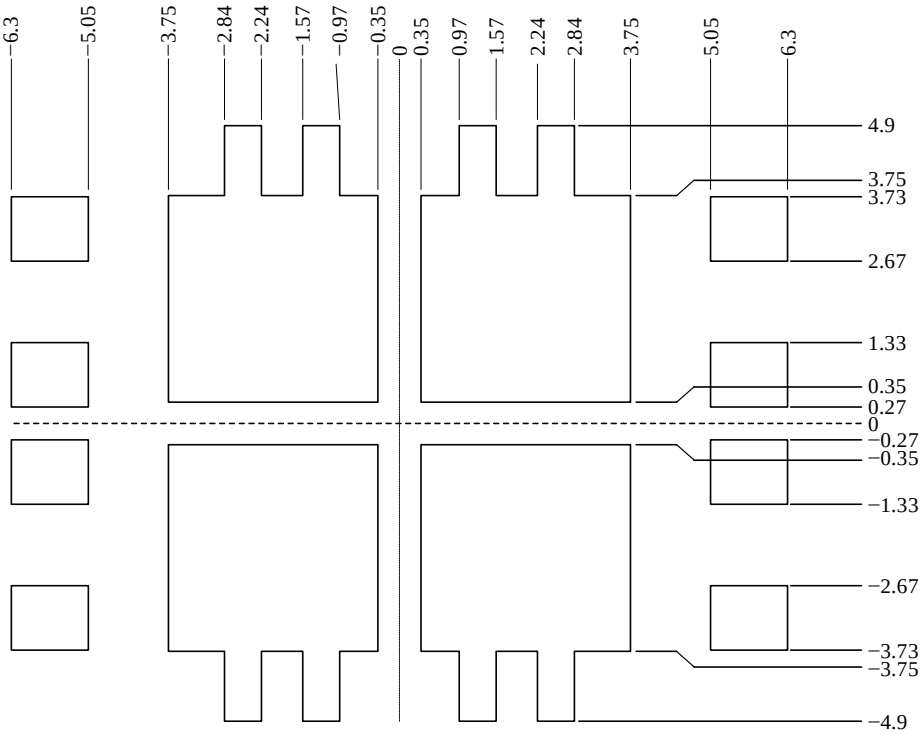
6.1. HSON-20 Package



NOTES:

- Dimensions in millimeters
- Bare lead frame: Pb-free (RoHS compliant)
- Dimensions with the asterisks do not include any mold flash.
- ▨ depicts the area where one or more mold flashes similar in thickness to that of the frame may exist.
- Dimensions without tolerances have a tolerance of ±0.1.
- When soldering the products, it is required to minimize the working time within the following limits:
  Reflow
  Preheat: 180 °C / 90 ± 30 s
  Solder heating: 250 °C / 10 ± 1s, 2 times (260 °C peak)
  Soldering iron: 380 ± 10 °C / 3.5 ± 0.5 s, 1 time
- The following pins are not guaranteed to be connected by soldering: 6, 9, 16, and 19.

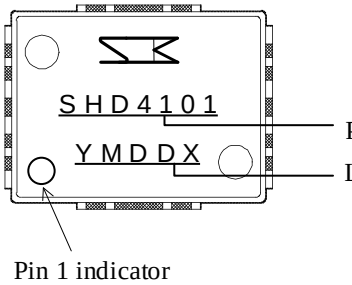
6.2. HSON-20 Land Pattern Example



NOTE:

- Dimensions in millimeters

7. Marking Diagram



Part Number

Lot Number:

Y is the last digit of the year of manufacture (0 to 9)
M is the month of the year (1 to 9, O, N, or D)
DD is the day of the month (01 to 31)
X is the control number

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