Version 1.0 , Aug 13, 2001

Modeling Note

MN-PSM-1

SIGBT / EMCON-Fast DuoPacks

Author: Peter Türkes

Published by Infineon Technologies AG
www.infineon.com/simulate

Support: simulate@infineon.com

Power Management & Supply

Never stop thinking

Devices covered by this Modeling Note:

1200 V S-IGBT/EMCON-fast Duopacks:

- SKP02N120
- SKW07N120
- SKW15N120
- SKW25N120

600V S-IGBT/EMCON-fast DuoPacks :

- SKP02N60 = SKB02N60
- SKP04N60 = SKB04N60
- SKP06N60 = SKB06N60
- SKP10N60 = SKB10N60 = SKW10N60
- SKP15N60 = SKB15N60
- SKW15N60
- SKW20N60
- SKW30N60

Model Description:

Overview:

DuoPacks feature a fast S-IGBT in NPT-technology with soft, fast recovery anti-parallel EmCon diode. This system can be easily used in motor drive, inverter, and switch-mode power supply applications.

The base model of the DuoPack includes the base models of the NPT IGBT and the EMCON-fast diode. The PSPICE compact models of the NPT-IGBT and the EMCON-fast devices are based on the device-physics-based models described in detail in [3].

The special features of the 600V and 1200V S-IGBT/EMCON-diode combinations are the fast switching times and the low reverse charge at turn-off. The PSPICE parameters related to these features are developed from the known device geometry and doping levels.

Implementation of Temperature Influence:

The electrical characteristics of the S-IGBT and EMCON diodes are dependent on the device temperature. Of particular importance for the PSPICE implementation of the temperature-dependent equations are the bipolar device regions. The approach chosen for the implementation of the temperature dependencies is determined by the capabilities of PSPICE.

Based on the temperature dependencies of the pn-junction currents (diode and IGBT) and MOSFET currents (IGBT), the temperature-dependent excess currents are modeled by auxiliary current sources in parallel to the MOS-channel and the pn-junctions, respectively. In case of level-2 models, the device temperature is represented by a local parameter. For level-3 models, it is modeled by an auxiliary network feeding the device's dissipated power into a thermal network.

Figure 1 shows the models that can be generally used in order to model the thermal path of semiconductor devices. The physical-correct T-type network has the advantage that it can be easily extended with additional heat-sink models [1,2].

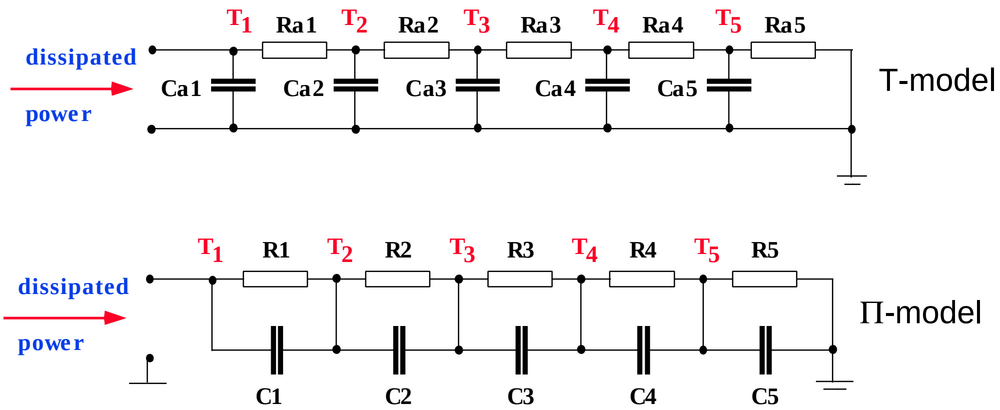

Figure 1: Types of thermal models for calculation of dynamic temperature behavior during PSPICE simulations

It should be noted that the use of the level-3 transient-temperature models requires more simulation time than the use of lower-level models.

Typical Model Tests:

Static Characteristics

The performance and quality of the compact models are tested in standard-device characterization circuits. Of particular importance is the temperature-dependent behavior of the devices.

The PSPICE schematic for the dc-simulation of an IGBT is shown in Figure 2. It can be used in order to determine the device's transfer and output characteristics. Latter requires a shorted IGBT gate emitter. The device temperature parameter **TJ** is local to the device and can be used as a 'vary' variable.

The simulation results for temperature-dependent 600V-IGBT transfer and output characteristics are shown in Figure 3. The respective diode output curves are depicted in Figure 4.

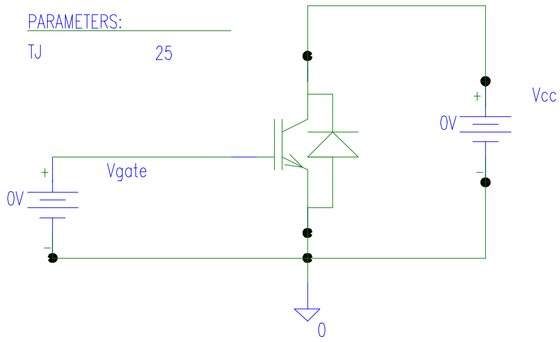

Figure 2: PSPICE schematic for determination of IGBT DC characteristics

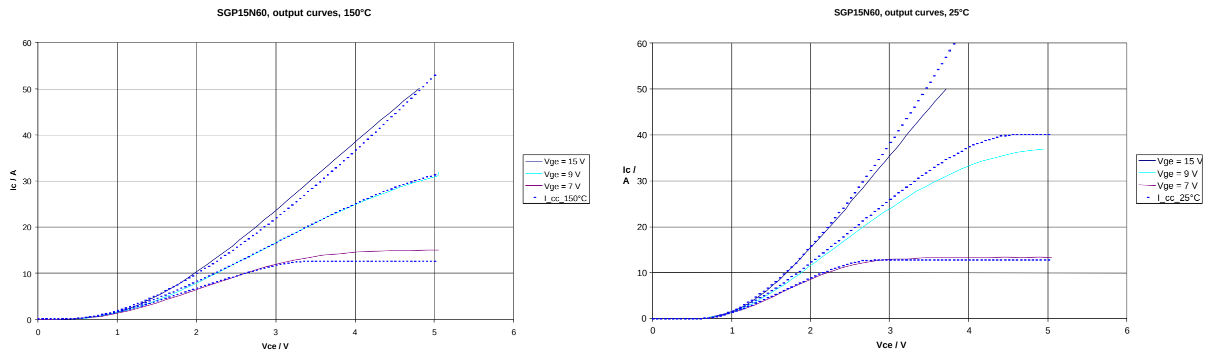

Figure 3: Temperature-dependent 15A/600V DuoPack output characteristics (Vge = 7V/9V/15V) (simulation / measurements). Left graph: at 150°C; Right graph: at room temperature.

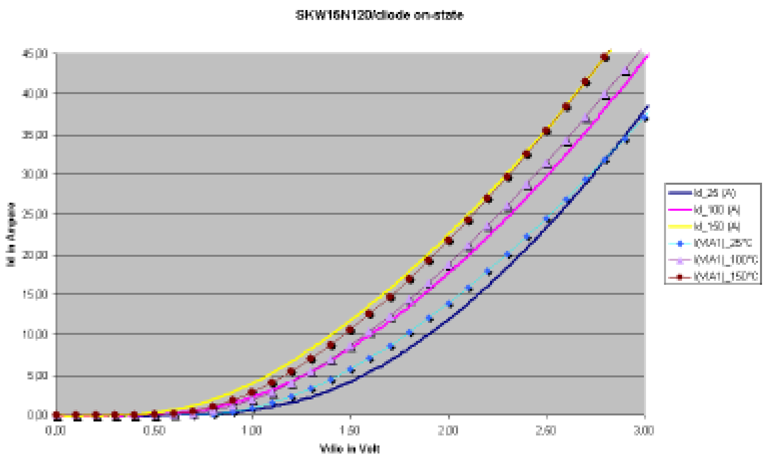

Figure 4: Temperature-dependent 15A/1200 EMCON-fast output characteristics (simulation / measurement)

Dynamic Characteristics

The switching behavior of the devices is mainly influenced by the intrinsic capacitances that result from the MOS cell structure, by the internal gate resistance, and the inherent pn-junctions. It is further affected by the diode charge and the commutation speed during switching. These multi-dimensional effects are tested and compared to measurements (see Figure 5).

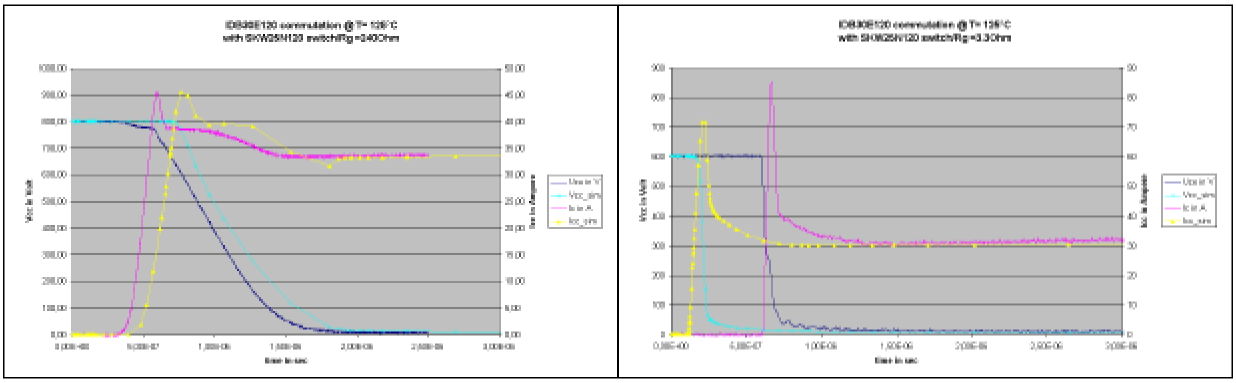

Figure 5: Comparison 1200V-DuoPack half-bridge turn-off commutations (at 125°C; with two different external gate resistors) (simulated / measured; measured and simulated curves shifted in time)

Summary

Simulation and measurement results show an excellent agreement for the static and dynamic case. The simulation of the device's dynamic behavior impressively demonstrates the reliability of the models when used for the simulation of application circuits.

PSPICE Settings for Power Electronic Simulations:

The standard version of PSPICE is optimized for the simulation of small-signal applications. For the simulation of power electronic devices and applications the PSPICE settings need to be modified.

Power device models utilize auxiliary circuits in order to calculate internal system parameters such as the internal free-carrier concentration. This requires a larger number of iterations for convergence. Furthermore, currents and voltages in power electronic applications are far higher than those in small-signal applications. As a consequence, it is necessary to modify the PSPICE settings for the absolute accuracy limits of currents and voltages, and for the relative error-limit. In some cases, the absolute accuracy limit for charges needs to be adjusted as well.

The PSPICE settings can be changed in the schematic-editor menu “Analysis/Setup/Options”. They can be also modified directly by changing the values in the .OPTIONS section of the “.cir” PSPICE file. The settings depend on the particular case to be simulated. However, as a rough estimate, the following numbers can be used as a first guess:

OPTION name	Description	default	Change to: In power electronic simulation
ABSTOL	best accuracy of currents amp	1.0 pA	1uA
VNTOL	best accuracy of voltages volt	1.0 uV	10uV
CHGTOL	best accuracy of charges coulomb	0.01 pC	
ITL1	DC and bias point blind repeating limit	150.0	300
ITL2	DC and bias point educated guess repeating limit	20.0	250
ITL4	the limit at any repeating point in transient analysis	10.0	100 (higher when large number of stray inductances)
RELTOL	relative accuracy of V and I	0.001	0.005

Infineon Simulation Support:

For further information please contact us through our local sales offices, email to simulate@infineon.com, or check out our simulation web site: http://www.infineon.com/simulate.

Bibliography:

[1] H. Müller, *Beziehungen zwischen dem praktisch verwendeten und dem physikalisch sinnvollen Wärmeersatzschaltbild von Dioden und Thyristoren,* Archiv für Elektrotechnik 54, p. 170 ff (1971)

[2] P. Türkes, *Thermal Network Calculation for Level-3 Compact Models*, Infineon Application Note, AN-PSM-12 (2001)

[3] R. Kraus, P. Türkes, J. Sigg, *Physics-based Models Of Power Semiconductor Devices For The Circuit Simulator Spice*, Power Electronics Specialists Conference, 1998. PESC 98 Record.

Information

For information on simulation-related issues, please check out the INFINEON simulation web page: www.infineon.com/simulate or email to: simulate@infineon.com. For information on technology, delivery terms and conditions and prices of INFINEON devices please contact your nearest Infineon Technologies Office in Germany or our Infineon Technologies Representatives worldwide (see address list).

Warnings

Due to technical requirements components may contain dangerous substances. For information on the types in question please contact your nearest Infineon Technologies Office.

Infineon Technologies Components may only be used in life-support devices or systems with the express written approval of Infineon Technologies, if a failure of such components can reasonably be expected to cause the failure of that life-support device or system, or to affect the safety or effectiveness of that device or system. Life support devices or systems are intended to be implanted in the human body, or to support and/or maintain and sustain and/or protect human life. If they fail, it is reasonable to assume that the health of the user or other persons may be endangered.

Infineon Technologies AG sales offices worldwide – partly represented by Siemens AG

A
Siemens AG Österreich
Erdberger Lände 26
A-1031 Wien
T (+43)1-17 07-3 56 11
Fax (+43)1-17 07-5 59 73

AUS
Siemens Ltd.
885 Mountain Highway
Bayswater,Victoria 3153
T (+61)3-97 21 21 11
Fax (+61)3-97 21 72 75

B
Siemens Electronic Components
Benelux
Charleroisesteenweg 116/
Chaussée de Charleroi 116
B-1060 Brussel/Bruxelles
T (+32)2-5 36 69 05
Fax (+32)2-5 36 28 57
Email:components@siemens.nl

BR
Siemens Ltda.
Semiconductores
Avenida Mutinga,3800-Pirituba
05110-901 São Paulo-SP
T (+55)11-39 08 25 64
Fax (+55)11-39 08 27 28

CDN
Infineon Technologies Corporation
320 March Road,Suite 604
Canada,Ontario K2K 2E2
T (+1)6 13-5 91 63 86
Fax (+1)6 13-5 91 63 89

CH
Siemens Schweiz AG
Bauelemente
Freilagerstrasse 40
CH-8047 Zürich
T (+41)1-4 953065
Fax (+41)1-4 955050

D
Infineon Technologies AG
Völklinger Str.2
D-40219 Düsseldorf
T (+49)2 11-3 99 29 30
Fax (+49)2 11-3 99 14 81
Infineon Technologies AG
Werner-von-Siemens-Platz 1
D-30880 Laatzen (Hannover)
T (+49)5 11-8 77 22 22
Fax (+49)5 11-8 77 15 20
Infineon Technologies AG
Von-der-Tann-Straße 30
D-90439 Nürnberg
T (+49)9 11-6 54 76 99
Fax (+49)9 11-6 54 76 24
Infineon Technologies AG
Weissacher Straße 11
D-70499 Stuttgart
T (+49)7 11-1 37 33 14
Fax (+49)7 11-1 37 24 48

D
Infineon Technologies AG
Halbleiter Distribution
Richard-Strauss-Straße 76
D-81679 München
T (+49)89-92 21 40 86
Fax (+49)89-92 21 20 71

DK
Siemens A/S
Borupvang 3
DK-2750 Ballerup
T (+45)44 77-44 77
Fax (+45)44 77-40 17

E
Siemens S.A.
Dpto.Componentes
Ronda de Europa,5
E-28760 Tres Cantos-Madrid
T (+34)91-5 14 71 51
Fax (+34)91-5 14 70 13

F
Infineon Technologies France,
39/47,Bd.Ornano
F-93527 Saint-Denis CEDEX2
T (+33)1-49 22 31 00
Fax (+33)1-49 22 28 01

FIN
Siemens Components
Scandinavia
P.O .Bo x 6 0
FIN-02601 Espoo (Helsinki)
T (+3 58)10-5 11 51 51
Fax (+3 58)10-5 11 24 95
Email:
scs@components.siemens.se

GB
Infineon Technologies
Siemens House
Oldbury
GB-Bracknell,Berkshire
RG12 8FZ
T (+44)13 44-39 66 18
Fax (+44)13 44-39 66 32

H
Simacomp Kft.
Lajos u.103
H-1036 Budapest
T (+36)1-4 57 16 90
Fax (+36)1-4 57 16 92

HK
Infineon Technologies
Hong Kong Ltd.
Suite 302,Level 3,
Festival Walk,
80 Tat Chee Avenue,
Yam Yat Tsuen,
Kowloon Tong
Hong Kong
T (+8 52)28 32 05 00
Fax (+8 52)28 27 97 62

I
Siemens S..A.
Semiconductor Sales
Via Piero e Alberto Pirelli,10
I-20126 Milano
T (+39)02-66 76 -1
Fax (+39)02-66 76 43 95

IND
Siemens Ltd.
Components Division
No.84 Keonics Electronic City
Hosur Road
Bangalore 561 229
T (+91)80-8 52 11 22
Fax (+91)80-8 52 11 80
Siemens Ltd.
CMP Div,5th Floor
4A Ring Road,IP Estate
New Delhi 110 002
T (+91)11-3 31 99 12
Fax (+91)11-3 31 96 04
Siemens Ltd.
CMP Div,4th Floor
130,Pandurang Budhkar Marg,
Worli
Mumbai 400 018
T (+91)22-4 96 21 99
Fax (+91)22-4 96 22 01

IRL
Siemens Ltd.
Electronic Components Division
8,Raglan Road
IRL-Dublin 4
T (+3 53)1-2 16 23 42
Fax (+3 53)1-2 16 23 49

IL
Nisko Ltd.
2A,Habarzel St.
P.O.Box 58151
61580 Tel Aviv –Isreal
T (+9 72)3 -7 65 73 00
Fax (+9 72)3 -7 65 73 33

J
Siemens Components K.K.
Talanawa Park Tower 12F &17F
3-20-14,Higashi-Gotanda,
Shinagawa-ku
Tokyo
T (+81)3-54 49 64 11
Fax (+81)3 -54 49 64 01

MAL
Infineon Technologies AG
Sdn Bhd
Bayan Lepas Free Industrial Zone1
11900 Penang
T (+60)4 -6 44 99 75
Fax (+60)4 -6 41 48 72

N
Siemens Components
Scandinavia
Østre Aker vei 24
Postboks 10,Veitvet
N-0518 Oslo
T (+47)22-63 30 00
Fax (+47)22-68 49 13
Email:
scs@components.siemens.se

NL
Siemens Electronic Components
Benelux
Postbus 16068
NL-2500 BB Den Haag
T (+31)70-3 33 20 65
Fax (+31)70-3 33 28 15
Email:components@siemens.nl

NZ
Siemens Auckland
300 Great South Road
Greenland
Auckland
T (+64)9-5 20 30 33
Fax (+64)9-5 20 15 56

P
Siemens S.A.
an Componentes Electronicos
R.Irmaos Siemens,1
Alfragide
P-2720-093 Amadora
T (+351)1-4 17 85 90
Fax (+351)1-4 17 80 83

PK
Siemens Pakistan Engineering
Co.Ltd.
PO Box 1129,Islamabad 44000
23 West Jinnah Ave
Islamabad
T (+92)51-21 22 00
Fax (+92)51-21 16 10

PL
Siemens SP.z.o.o.
ul.Zupnicza 11
PL-03-821 Warszawa
T (+48)22-8 70 91 50
Fax (+48)22-8 70 91 59

ROK
Siemens Ltd.
Asia Tower,10th Floor
726 Yeoksam-dong,Kang-nam Ku
CPO Box 3001
Seoul 135-080
T (+82)2-5 27 77 00
Fax (+82)2-5 27 77 79

RUS
INTECH electronics
ul.Smolnaya,24/1203
RUS-125 445 Moskva
T (+7)0 95 -4 51 97 37
Fax (+7)0 95 -4 51 86 08

S
Siemens Components Scandinavia
Österögatan 1,Box 46
S-164 93 Kista
T (+46)8-7 03 35 00
Fax (+46)8-7 03 35 01
Email:
scs@components.siemens.se

RC
Infineon Technologies
Asia Pacific Pte.Ltd.
Taiwan Branch
10F,No.136 Nan King East Road
Section 23,Taipei
T (+8 86)2-27 73 66 06
Fax (+8 86)2-27 71 20 76

SGP
Infineon Technologies Asia
Pacific,Pte.Ltd.
168 Kallang Way
Singapore 349 253
T (+65)8 40 06 10
Fax (+65)7 42 62 39

USA
Infineon Technologies Corporation
1730 North First Street
San Jose,CA 95112
T (+1)4 08-5 01 60 00
Fax (+1)4 08-5 01 24 24
Siemens Components,Inc.
Optoelectronics Division
19000 Homestead Road
Cupertino,CA 95014
T (+1)4 08-2 57 79 10
Fax (+1)4 08-7 25 34 39
Siemens Components,Inc.
Special Products Division
186 Wood Avenue South
Iselin,NJ 08830-2770
T (+1)7 32-9 06 43 00
Fax (+1)7 32-6 32 28 30

VRC
Infineon Technologies
Hong Kong Ltd.
Beijing Office
Room 2106,Building A
Vantone New World Plaza
No.2 Fu Cheng Men Wai Da Jie
Jie
100037 Beijing
T (+86)10 -68 57 90 -06,-07
Fax (+86)10 -68 57 90 08
Infineon Technologies
Hong Kong Ltd.
Chengdu Office
Room14J1,Jinyang Mansion
58 Tidu Street
Chengdu,
Sichuan Province 610 016
T (+86)28-6 61 54 46 /79 51
Fax (+86)28 -6 61 01 59
Infineon Technologies
Hong Kong Ltd.
Shanghai Office
Room1101,Lucky Target Square
No.500 Chengdu Road North
Shanghai 200003
T (+86)21-63 6126 18 /19
Fax (+86)21-63 61 11 67
Infineon Technologies
Hong Kong Ltd.
Shenzhen Office
Room 1502,Block A
Tian An International Building
Renim South Road
Shenzhen 518 005
T (+86)7 55 -2 28 91 04
Fax (+86)7 55-2 28 02 17

ZA
Siemens Ltd.
Components Division
P.O.B.3438
Halfway House 1685
T (+27)11-6 52 -27 02
Fax (+27)11-6 52 20 42