## Features
- Neutral-point-Clamped inverter
- High power flow2 housing
- High Speed IGBT3 in Buck
- Low Inductance Layout

## Target Applications
- UPS
- Solar inverters

## Types
- F206NIA200SG

## Maximum Ratings

*Tj=25°C, unless otherwise specified*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Condition</th>
<th>Value</th>
<th>Unit</th>
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<td>V</td>
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<td>IC</td>
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### Buck FWD

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### Maximum Ratings

**Tj=25°C, unless otherwise specified**

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#### Thermal Properties

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#### Insulation Properties

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### Characteristic Values

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### Characteristic Values

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<td>B-value</td>
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**F206NIA200SG-M105F25 datasheet**

copyright Vincotech
**Buck**

**Figure 1**
Typical output characteristics
\[ I_C = f(V_{CE}) \]

**Figure 2**
Typical output characteristics
\[ I_C = f(V_{CE}) \]

At
- \( t_p = 250 \mu s \)
- \( T_j = 25 \degree C \)
- \( V_{CE} \) from 6 V to 16 V in steps of 1 V

**Figure 3**
Typical transfer characteristics
\[ I_C = f(V_{GE}) \]

**Figure 4**
Typical diode forward current as a function of forward voltage
\[ I_F = f(V_F) \]

At
- \( t_p = 250 \mu s \)
- \( V_{CE} = 10 \) V
- \( T_j = 25 \degree C \)
- \( T_j = T_{jmax} - 25 \degree C \)
**Typical switching energy losses**

E = f(I_c)

**With an inductive load at**

\[ \begin{align*}
T_j &= 25/125 \degree C \\
V_{CE} &= 350 \text{ V} \\
V_{GE} &= \pm 15 \text{ V} \\
R_{FS(on)} &= 4 \text{ } \Omega \\
R_{FS(off)} &= 4 \text{ } \Omega
\end{align*} \]

**Diode**

**Typical reverse recovery energy loss**

E_{rec} = f(I_c)

**With an inductive load at**

\[ \begin{align*}
T_j &= 25/125 \degree C \\
V_{CE} &= 350 \text{ V} \\
V_{GE} &= \pm 15 \text{ V} \\
R_{FS(on)} &= 4 \text{ } \Omega
\end{align*} \]
Typical switching times as a function of collector current

\[ t = f(I_C) \]

With an inductive load at

- \( T_j = 125 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( R_{gon} = 4 \, \Omega \)
- \( R_{goff} = 4 \, \Omega \)

Typical reverse recovery time as a function of collector current

\[ t_{rr} = f(I_C) \]

At

- \( T_j = 25/125 \, ^\circ C \)
- \( V_{CE} = 350 \, V \)
- \( V_{GE} = \pm 15 \, V \)
- \( R_{gon} = 4 \, \Omega \)
Buck

**Figure 13**
Typical reverse recovery charge as a function of collector current

\[ Q_{rr} = f(I_C) \]

![Graph showing typical reverse recovery charge as a function of collector current](image1)

**Figure 14**
Typical reverse recovery charge as a function of IGBT turn on gate resistor

\[ Q_{rr} = f(R_{gon}) \]

![Graph showing typical reverse recovery charge as a function of IGBT turn on gate resistor](image2)

**Figure 15**
Typical reverse recovery current as a function of collector current

\[ I_{RRM} = f(I_C) \]

![Graph showing typical reverse recovery current as a function of collector current](image3)

**Figure 16**
Typical reverse recovery current as a function of IGBT turn on gate resistor

\[ I_{RRM} = f(R_{gon}) \]

![Graph showing typical reverse recovery current as a function of IGBT turn on gate resistor](image4)

**At**

- \( T_J = 25/125 \) °C
- \( V_{GE} = 350 \) V
- \( V_{GSS} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω

---

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Typical rate of fall of forward and reverse recovery current as a function of collector current
\[ \frac{dI_0}{dt}, \frac{dI_{rec}}{dt} = f(I_c) \]

At
\[ T_j = 25/125 \degree C \]
\[ V_{GE} = 350 \ V \]
\[ V_{GE} = \pm 15 \ V \]
\[ R_{gon} = 4 \ \Omega \]

IGBT transient thermal impedance as a function of pulse width
\[ Z_{thJH} = f(t_p) \]

At
\[ D = \frac{t_p}{T} \]
\[ R_{thJH} = 0.33 \ \text{KW} \]

IGBT thermal model values

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<th>R (C/W)</th>
<th>Tau (s)</th>
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Diode transient thermal impedance as a function of pulse width
\[ Z_{thJH} = f(t_p) \]

At
\[ D = \frac{t_p}{T} \]
\[ R_{thJH} = 0.67 \ \text{KW} \]

Diode thermal model values

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Power dissipation as a function of heatsink temperature

\[ P_{tot} = f(T_h) \]

At
\[ T_j = 175 \degree C \]

Collector current as a function of heatsink temperature

\[ I_C = f(T_h) \]

At
\[ T_j = 175 \degree C \]
\[ V_{GE} = 15 \text{ V} \]

Power dissipation as a forward current as a function of heatsink temperature

\[ P_{tot} = f(T_h) \]

At
\[ T_j = 175 \degree C \]

Forward current as a function of heatsink temperature

\[ I_F = f(T_h) \]

At
\[ T_j = 175 \degree C \]
Figure 25
Safe operating area as a function of collector-emitter voltage

\[ I_C = f(V_{CE}) \]

Figure 26
Gate voltage vs Gate charge

\[ V_{GE} = f(Q_g) \]

At
\[ D = \text{single pulse} \]
\[ T_h = 80 \degree C \]
\[ V_{GE} = \pm 15 \text{ V} \]
\[ T_J = T_{\text{max}} \text{ °C} \]

At
\[ I_C = 200 \text{ A} \]
Figure 1
IGBT
Typical output characteristics
$I_C = f(V_{CE})$

At
$\tau_p = 250 \ \mu s$
$T_j = 25 \ ^\circ C$
$V_{CE}$ from 7 V to 17 V in steps of 1 V

Figure 2
IGBT
Typical output characteristics
$I_C = f(V_{CE})$

At
$\tau_p = 250 \ \mu s$
$T_j = 125 \ ^\circ C$
$V_{CE}$ from 7 V to 17 V in steps of 1 V

Figure 3
IGBT
Typical transfer characteristics
$I_C = f(V_{GE})$

At
$\tau_p = 250 \ \mu s$
$V_{CE} = 10 \ V$

Figure 4
Diode
Typical diode forward current as a function of forward voltage
$I_F = f(V_F)$

At
$\tau_p = 250 \ \mu s$
Typical switching energy losses as a function of collector current
\[ E = f(I_C) \]

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω
- \( R_{goff} = 4 \) Ω

Typical reverse recovery energy loss as a function of collector current
\[ E_{rec} = f(I_C) \]

With an inductive load at
- \( T_j = 25/125 \) °C
- \( V_{CE} = 350 \) V
- \( V_{GE} = \pm 15 \) V
- \( R_{gon} = 4 \) Ω
- \( I_C = 200 \) A
Boost

**Figure 9**
Typical switching times as a function of collector current

$t = f(I_C)$

With an inductive load at

$T_J = 125 \, ^\circ C$

$V_{CE} = 350 \, V$

$V_{GE} = \pm 15 \, V$

$R_{gon} = 4 \, \Omega$

$R_{goff} = 4 \, \Omega$

**Figure 10**
Typical switching times as a function of gate resistor

$t = f(R_G)$

With an inductive load at

$T_J = 125 \, ^\circ C$

$V_{CE} = 350 \, V$

$V_{GE} = \pm 15 \, V$

$I_C = 200 \, A$

**Figure 11**
Typical reverse recovery time as a function of collector current

$t_{rr} = f(I_C)$

At

$T_J = 25/125 \, ^\circ C$

$V_{CE} = 350 \, V$

$V_{GE} = \pm 15 \, V$

$R_{gon} = 4 \, \Omega$

**Figure 12**
Typical reverse recovery time as a function of IGBT turn on gate resistor

$t_{rr} = f(R_{gon})$

At

$T_J = 25/125 \, ^\circ C$

$V_{CE} = 350 \, V$

$I_F = 200 \, A$

$V_{GE} = \pm 15 \, V$
Figure 13
Typical reverse recovery charge as a function of collector current
\[ Q_{rr} = f(I_C) \]

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_{CE} = 350 \, V \]
\[ V_{GE} = \pm 15 \, V \]
\[ R_{gon} = 4 \, \Omega \]

Figure 14
Typical reverse recovery charge as a function of IGBT turn on gate resistor
\[ Q_{rr} = f(R_{gon}) \]

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_B = 350 \, V \]
\[ I_B = 200 \, A \]
\[ V_{GE} = \pm 15 \, V \]

Figure 15
Typical reverse recovery current as a function of collector current
\[ I_{RRM} = f(I_C) \]

Figure 16
Typical reverse recovery current as a function of IGBT turn on gate resistor
\[ I_{RRM} = f(R_{gon}) \]

At
\[ T_j = 25/125 \, ^\circ C \]
\[ V_B = 350 \, V \]
\[ I_B = 200 \, A \]
\[ V_{GE} = \pm 15 \, V \]
**Figure 17**
Typical rate of fall of forward and reverse recovery current as a function of collector current

\[
dI_0/dt, dI_{rec}/dt = f(I_c)
\]

- **At**
  - \( T_j = 25/125 \) °C
  - \( V_{CE} = 350 \) V
  - \( V_{GE} = \pm 15 \) V
  - \( R_{gon} = 4 \) Ω

**Figure 18**
Typical rate of fall of forward and reverse recovery current as a function of IGBT turn on gate resistor

\[
dI_0/dt, dI_{rec}/dt = f(R_{gon})
\]

- **At**
  - \( T_j = 25/125 \) °C
  - \( V_{CE} = 350 \) V
  - \( I_F = 200 \) A
  - \( V_{GE} = \pm 15 \) V

**Figure 19**
IGBT transient thermal impedance as a function of pulse width

\[
Z_{thJH} = f(t_p)
\]

- **At**
  - \( D = \frac{t_p}{T} \)
  - \( R_{thJH} = 0.39 \) KW

IGBT thermal model values

- \( R \) (C/W) | \( \tau \) (s)
  - 0.02 | 1.2E+01
  - 0.10 | 2.6E+00
  - 0.07 | 4.8E-01
  - 0.11 | 5.9E-02
  - 0.05 | 1.3E-02
  - 0.02 | 4.9E-04

**Figure 20**
Diode transient thermal impedance as a function of pulse width

\[
Z_{thJH} = f(t_p)
\]

- **At**
  - \( D = \frac{t_p}{T} \)
  - \( R_{thJH} = 0.49 \) KW

Diode thermal model values

- \( R \) (C/W) | \( \tau \) (s)
  - 0.04 | 9.5E+00
  - 0.09 | 1.8E+00
  - 0.08 | 2.9E-01
  - 0.18 | 3.6E-02
  - 0.06 | 8.5E-03
  - 0.03 | 4.7E-04

Figure 21
Power dissipation as a function of heatsink temperature
\( P_{\text{tot}} = f(T_h) \)

At
\( T_j = 175 \, ^\circ C \)

Figure 22
Collector current as a function of heatsink temperature
\( I_C = f(T_h) \)

At
\( T_j = 175 \, ^\circ C \)

Figure 23
Power dissipation as a function of heatsink temperature
\( P_{\text{tot}} = f(T_h) \)

At
\( T_j = 175 \, ^\circ C \)

Figure 24
Forward current as a function of heatsink temperature
\( I_F = f(T_h) \)

At
\( T_j = 175 \, ^\circ C \)
Figure 25

**Boost Inverse Diode**

Typical diode forward current as a function of forward voltage

\[ I_F = f(V_F) \]

Diode transient thermal impedance as a function of pulse width

\[ Z_{thJH} = f(t_p) \]

**At**

\[ t_p = 250 \ \mu s \]

Figure 26

**Boost Inverse Diode**

Power dissipation as a function of heatsink temperature

\[ P_{tot} = f(T_h) \]

Forward current as a function of heatsink temperature

\[ I_F = f(T_j) \]

**At**

\[ T_j = 175 \ \degree C \]

Figure 27

**Boost Inverse Diode**

**Figure 28**

**Boost Inverse Diode**
Figure 1
Thermistor

Typical NTC characteristic
as a function of temperature

\[ R_T = f(T) \]
Switching Definitions BUCK MOSFET

General conditions

\[
\begin{align*}
T_I &= 125 \, ^\circ C \\
R_{\text{on}} &= 4 \, \Omega \\
R_{\text{off}} &= 4 \, \Omega
\end{align*}
\]

Turn-off Switching Waveforms & definition of \(t_{\text{doff}}, t_{\text{Eoff}}\)

- \(V_{\text{GE}}(0\%) = -15 \, V\)
- \(V_{\text{GE}}(100\%) = 15 \, V\)
- \(V_{\text{C}}(100\%) = 350 \, V\)
- \(I_{\text{C}}(100\%) = 200 \, A\)
- \(t_{\text{doff}} = 0.27 \, \mu s\)
- \(t_{\text{Eoff}} = 0.28 \, \mu s\)

Turn-on Switching Waveforms & definition of \(t_{\text{don}}, t_{\text{Eon}}\)

- \(I_{\text{C}} = 200 \, A\)
- \(V_{\text{C}}(100\%) = 350 \, V\)
- \(t_{\text{don}} = 0.20 \, \mu s\)
- \(t_{\text{Eon}} = 0.38 \, \mu s\)

Turn-off Switching Waveforms & definition of \(t_{r}\)

- \(V_{\text{C}}(100\%) = 350 \, V\)
- \(I_{\text{C}}(100\%) = 200 \, A\)
- \(t_{r} = 0.02 \, \mu s\)
Switching Definitions BUCK MOSFET

**Figure 5**
Output inverter IGBT

Turn-off Switching Waveforms & definition of $t_{Eoff}$

![Graph showing turn-off switching waveforms](image)

\[ P_{off}(100\%) = 69.97 \text{ kW} \]
\[ E_{off}(100\%) = 3.38 \text{ mJ} \]
\[ t_{Eoff} = 0.28 \text{ µs} \]

**Figure 6**
Output inverter IGBT

Turn-on Switching Waveforms & definition of $t_{Eon}$

![Graph showing turn-on switching waveforms](image)

\[ P_{on}(100\%) = 69.97 \text{ kW} \]
\[ E_{on}(100\%) = 3.48 \text{ mJ} \]
\[ t_{Eon} = 0.38 \text{ µs} \]

**Figure 7**
Output inverter IGBT

Gate voltage vs Gate charge (measured)

![Graph showing gate voltage vs gate charge](image)

\[ V_{GEoff} = -15 \text{ V} \]
\[ V_{GEon} = 15 \text{ V} \]
\[ V_{C}(100\%) = 350 \text{ V} \]
\[ I_{d}(100\%) = 200 \text{ A} \]
\[ Q_{g} = 2037.49 \text{ nC} \]

**Figure 8**
Output inverter IGBT

Turn-off Switching Waveforms & definition of $t_{r}$

![Graph showing turn-off switching waveforms](image)

\[ V_{d}(100\%) = 350 \text{ V} \]
\[ I_{d}(100\%) = 200 \text{ A} \]
\[ I_{max}(100\%) = -154 \text{ A} \]
\[ t_{r} = 0.11 \text{ µs} \]
Switching Definitions BUCK MOSFET

Figure 9
Turn-on Switching Waveforms & definition of $t_{Qrr}$
($t_{Qrr}$ = integrating time for $Q_{rr}$)

![Diagram](image1)

- $I_d(100\%) = 200$ A
- $Q_{rr}(100\%) = 7.28$ μC
- $t_{Qrr} = 0.23$ μs

Figure 10
Turn-on Switching Waveforms & definition of $t_{Erec}$
($t_{Erec}$ = integrating time for $E_{rec}$)

![Diagram](image2)

- $P_{rec}(100\%) = 69.97$ kW
- $E_{rec}(100\%) = 1.54$ mJ
- $t_{Erec} = 0.23$ μs

Measurement circuits

Figure 11
BUCK stage switching measurement circuit

![Diagram](image3)

Figure 12
BOOST stage switching measurement circuit

![Diagram](image4)
Ordering Code and Marking - Outline - Pinout

Ordering Code & Marking

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15 Feb. 2019 / Revision 4
PRODUCT STATUS DEFINITIONS

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