BRY39
Programmable unijunction transistor/
Silicon controlled switch

Product specification
Supersedes data of September 1994
File under Discrete Semiconductors, SC04

1997 Jul 24
Philips Semiconductors

Programmable unijunction transistor/
Silicon controlled switch

**BRY39**

**FEATURES**
- Silicon controlled switch
- Programmable unijunction transistor.

**APPLICATIONS**
- Switching applications such as:
  - Motor control
  - Oscillators
  - Relay replacement
  - Timers
  - Pulse shapers, etc.

**DESCRIPTION**
Silicon planar PNPN switch or trigger device in a TO-72 metal package. It is an integrated PNP/NPN transistor pair with all electrodes accessible.

**QUICK REFERENCE DATA**

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MAX.</th>
<th>UNIT</th>
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<tbody>
<tr>
<td></td>
<td><strong>PNP TRANSISTOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{EBO}$ emitter-base voltage</td>
<td>open collector</td>
<td>$-70$</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td><strong>NPN TRANSISTOR</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$V_{CBO}$ collector-base voltage</td>
<td>open emitter</td>
<td>$70$</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$I_{ERM}$ repetitive peak emitter current</td>
<td>$T_{amb} \leq 25 ^\circ C$</td>
<td>$-2.5$</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>$P_{tot}$ total power dissipation</td>
<td></td>
<td>$275$</td>
<td>mW</td>
</tr>
<tr>
<td></td>
<td>$T_j$ junction temperature</td>
<td></td>
<td>$150$</td>
<td>^\circ C</td>
</tr>
<tr>
<td></td>
<td>$V_{AK}$ forward on-state voltage</td>
<td>$I_A = 50 mA; I_{AG} = 0; R_{KG-K} = 10 k\Omega$</td>
<td>$1.4$</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$I_H$ holding current</td>
<td>$I_{AG} = 10 mA; V_{BB} = -2 V; R_{KG-K} = 10 k\Omega$</td>
<td>$1$</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>$t_{on}$ turn-on time</td>
<td></td>
<td>$0.25$</td>
<td>\mu s</td>
</tr>
<tr>
<td></td>
<td>$t_{off}$ turn-off time</td>
<td></td>
<td>$15$</td>
<td>\mu s</td>
</tr>
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Programmable unijunction transistor

<table>
<thead>
<tr>
<th>SYMBOL</th>
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<th>CONDITIONS</th>
<th>MAX.</th>
<th>UNIT</th>
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<tr>
<td></td>
<td>$V_{GA}$ gate-anode voltage</td>
<td></td>
<td>$70$</td>
<td>V</td>
</tr>
<tr>
<td></td>
<td>$I_A$ anode current (DC)</td>
<td>$T_{amb} \leq 25 ^\circ C$</td>
<td>$175$</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td>$T_j$ junction temperature</td>
<td></td>
<td>$150$</td>
<td>^\circ C</td>
</tr>
<tr>
<td></td>
<td>$I_p$ peak point current</td>
<td>$V_S = 10 V; R_G = 10 k\Omega$</td>
<td>$0.2$</td>
<td>\mu A</td>
</tr>
</tbody>
</table>

**PINNING**

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<thead>
<tr>
<th>PIN</th>
<th>DESCRIPTION</th>
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<tr>
<td>1</td>
<td>cathode</td>
</tr>
<tr>
<td>2</td>
<td>cathode gate</td>
</tr>
<tr>
<td>3</td>
<td>anode gate (connected to case)</td>
</tr>
<tr>
<td>4</td>
<td>anode</td>
</tr>
</tbody>
</table>
Programmable unijunction transistor/  
Silicon controlled switch  

**LIMITING VALUES**  
In accordance with the Absolute Maximum Rating System (IEC 134).

<table>
<thead>
<tr>
<th>SYMBOL</th>
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<th>CONDITIONS</th>
<th>MIN.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{tot}$</td>
<td>total power dissipation</td>
<td>$T_{amb} \leq 25 , ^\circ C$</td>
<td>–</td>
<td>275</td>
<td>mW</td>
</tr>
<tr>
<td>$T_{stg}$</td>
<td>storage temperature</td>
<td>–65</td>
<td>+200</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>$T_j$</td>
<td>junction temperature</td>
<td>–</td>
<td>150</td>
<td>°C</td>
<td></td>
</tr>
<tr>
<td>$T_{amb}$</td>
<td>operating ambient temperature</td>
<td>–65</td>
<td>+150</td>
<td>°C</td>
<td></td>
</tr>
</tbody>
</table>

**Silicon controlled switch**

- **$V_{CBO}$** collector-base voltage  
  - PNP: –70 V  
  - NPN: 70 V
- **$V_{CER}$** collector-emitter voltage  
  - PNP: $R_{BE} = 10 \, k\Omega$  
  - NPN: –70 V
- **$V_{CEO}$** collector-emitter voltage  
  - PNP: –70 V  
  - NPN: –5 V
- **$V_{EBO}$** emitter-base voltage  
  - PNP: –70 V  
  - NPN: –5 V
- **$I_C$** collector current (DC)  
  - PNP: – mA  
  - NPN: 175 mA
- **$I_{CM}$** peak collector current  
  - PNP: – mA  
  - NPN: 175 mA
- **$I_E$** emitter current (DC)  
  - PNP: –175 mA  
  - NPN: –175 mA
- **$I_{ERM}$** repetitive peak emitter current  
  - PNP: $t_p = 10 \, \mu s; \delta = 0.01$  
  - NPN: –2.5 A

**Programmable unijunction transistor**

- **$V_{GA}$** gate-anode voltage | – | 70 | V |
- **$I_A$** anode current (AV)  
  - $T_{amb} \leq 25 \, ^\circ C$ | – | 175 | mA |
## Programmable unijunction transistor/ Silicon controlled switch BRY39

### Notes

1. Provided the $I_E$ rating is not exceeded.
2. During switching on, the device can withstand the discharge of a capacitor of a maximum value of 500 pF. This capacitor is charged when the transistor is in cut-off condition, with a collector supply voltage of 160 V and a series resistance of 100 kΩ.

### THERMAL CHARACTERISTICS

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>VALUE</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_{th,j-a}$</td>
<td>thermal resistance from junction to ambient</td>
<td>in free air</td>
<td>450</td>
<td>K/W</td>
</tr>
</tbody>
</table>

### CHARACTERISTICS

$T_{amb} = 25 ^\circ C$ unless otherwise specified.

<table>
<thead>
<tr>
<th>SYMBOL</th>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{CEO}$</td>
<td>collector cut-off current</td>
<td>$I_B = 0; V_{CE} = -70 V; T_j = 150 ^\circ C$</td>
<td>–</td>
<td>–10</td>
<td>µA</td>
</tr>
<tr>
<td>$I_{EBO}$</td>
<td>emitter cut-off current</td>
<td>$I_C = 0; V_{EB} = -70 V; T_j = 150 ^\circ C$</td>
<td>–</td>
<td>–10</td>
<td>µA</td>
</tr>
<tr>
<td>$h_{FE}$</td>
<td>DC current gain</td>
<td>$I_E = 1 mA; V_{CE} = -5 V$</td>
<td>3</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>$I_{CER}$</td>
<td>collector cut-off current</td>
<td>$V_{CE} = 70 V; R_{BE} = 10 k\Omega$</td>
<td>–</td>
<td>100</td>
<td>nA</td>
</tr>
<tr>
<td>$I_{EBO}$</td>
<td>emitter cut-off current</td>
<td>$I_C = 0; V_{EB} = 5 V; T_j = 150 ^\circ C$</td>
<td>–</td>
<td>10</td>
<td>µA</td>
</tr>
<tr>
<td>$V_{CEsat}$</td>
<td>collector-emitter saturation voltage</td>
<td>$I_C = 10 mA; I_B = 1 mA$</td>
<td>–</td>
<td>0.5</td>
<td>V</td>
</tr>
<tr>
<td>$V_{BESat}$</td>
<td>base-emitter saturation voltage</td>
<td>$I_C = 10 mA; I_B = 1 mA$</td>
<td>–</td>
<td>0.9</td>
<td>V</td>
</tr>
<tr>
<td>$h_{FE}$</td>
<td>DC current gain</td>
<td>$I_C = 10 mA; V_{CE} = 2 V$</td>
<td>50</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>$C_c$</td>
<td>collector capacitance</td>
<td>$I_E = I_A = 0; V_{CB} = 20 V$</td>
<td>–</td>
<td>5</td>
<td>pF</td>
</tr>
<tr>
<td>$C_e$</td>
<td>emitter capacitance</td>
<td>$I_C = I_c = 0; V_{EB} = 1 V; f = 1 MHz$</td>
<td>–</td>
<td>25</td>
<td>pF</td>
</tr>
<tr>
<td>$f_T$</td>
<td>transition frequency</td>
<td>$I_C = 10 mA; V_{CE} = 2 V; f = 100 MHz$</td>
<td>100</td>
<td>–</td>
<td>MHz</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>CONDITIONS</th>
<th>MIN.</th>
<th>MAX.</th>
<th>UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$V_{AK}$</td>
<td>forward on-state voltage</td>
<td>$R_{KG-K} = 10 k\Omega$</td>
<td>$I_A = 50 mA; I_{AG} = 0$</td>
<td>–</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$I_A = 50 mA; I_{AG} = 0; T_j = -55 ^\circ C$</td>
<td>–</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$I_A = 1 mA; I_{AG} = 10 mA$</td>
<td>–</td>
<td>1.2</td>
</tr>
<tr>
<td>$I_H$</td>
<td>holding current</td>
<td>$V_{BB} = -2 V; I_{AG} = 10 mA; R_{KG-K} = 10 k\Omega$</td>
<td>see Fig.14</td>
<td>–</td>
<td>1</td>
</tr>
</tbody>
</table>

1997 Jul 24
**Programmable unijunction transistor**

**Silicon controlled switch**

**BRY39**

### SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT
--- | --- | --- | --- | --- | ---

#### SWITCHING TIMES

| t<sub>on</sub> | turn-on time | \( V_{KG-K} = -0.5 \text{ to } 4.5 \text{ V}; \ R_{KG-K} = 1 \text{ kΩ}; \) see Figs 15 and 16 | − | 0.25 | µs
| t<sub>off</sub> | turn-off time | \( V_{KG-K} = -0.5 \text{ to } 0.5 \text{ V}; \ R_{KG-K} = 1 \text{ kΩ}; \) see Figs 17 and 18 | − | 1.5 | µs

### Programmable unijunction transistor

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
</table>
| \( I_p \) | peak point current | \( V_S = 10 \text{ V}; \ R_G = 10 \text{ kΩ}; \) see Figs 3 and 8 | − | 0.2 | µA
| \( I_v \) | valley point current | \( V_S = 10 \text{ V}; \ R_G = 10 \text{ kΩ}; \) see Figs 3 and 8 | − | 0.06 | µA
| \( V_{offset} \) | offset voltage | typical curve; \( I_A = 0; \) for \( V_P \) and \( V_S \) see Fig.8 | − | − | V
| \( I_{GAO} \) | gate-anode leakage current | \( I_K = 0; \ V_{GA} = 70 \text{ V} \) | − | 10 | nA
| \( I_{GKS} \) | gate-cathode leakage current | \( V_{AK} = 0; \ V_{KG} = 70 \text{ V} \) | − | 100 | nA
| \( V_{AK} \) | anode-cathode voltage | \( I_A = 100 \text{ mA} \) | − | 1.4 | V
| \( V_{OM} \) | peak output voltage | \( V_{AA} = 20 \text{ V}; \ C = 10 \text{ nF}; \) see Figs 9 and 11 | 6 | − | V
| \( t_r \) | rise time | \( V_{AA} = 20 \text{ V}; \ C = 10 \text{ nF}; \) see Fig.11 | 80 | − | ns

**Explanation of symbols**

For application of the BRY39 as a programmable unijunction transistor, only the anode gate is used. To simplify the symbols, the term gate instead of anode gate will be used (see Fig.2).

![Fig.2 Programmable unijunction transistor explanation of symbols.](image_url)
Programmable unijunction transistor/
Silicon controlled switch

Fig. 3 Programmable unijunction transistor test circuit for peak and valley points.

Fig. 4 Programmable unijunction transistor with 'program' resistors R1 and R2.

Fig. 5 Programmable unijunction transistor equivalent test circuit for characteristics testing.

Fig. 6 Programmable unijunction transistor equivalent test circuit for gate-anode leakage current.
Programmable unijunction transistor/
Silicon controlled switch

Fig. 7 Programmable unijunction transistor equivalent test circuit for gate-cathode leakage current.

Fig. 8 Programmable unijunction transistor offset voltage.

Fig. 9 Programmable unijunction transistor test circuit for peak output voltage.

Fig. 10 Programmable unijunction transistor peak output voltage.
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Silicon controlled switch

Fig.11 Silicon controlled switch two transistor equivalent circuit.

Fig.12 PNPN silicon controlled switch structure.

Fig.13 Silicon controlled switch symbol.

Fig.14 Silicon controlled switch equivalent test circuit for holding current.
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Silicon controlled switch

Fig.15  Silicon controlled switch test circuit for turn-on time.

Fig.16  Silicon controlled switch pulse duration increased until dashed curve disappears.

Fig.17  Silicon controlled switch test circuit for turn-on time.

Fig.18  Silicon controlled switch capacitance increased until $C = C_{\text{opt}}$ dashed curve disappears.
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Silicon controlled switch

**Fig. 19** Silicon controlled switch normalized DC current gain as a function of anode gate current.

\[ X = \text{value of } h_{FE} \text{ at } I_C = 10 \text{ mA; } V_{AG,K} = 2 \text{ V; } T_{amb} = 25 \text{ °C}. \]

**Fig. 20** Silicon controlled switch normalized DC current gain as a function of ambient temperature.

\[ X = \text{value of } h_{FE} \text{ at } I_{AG} = 10 \text{ mA; } V_{AG,K} = 2 \text{ V; } T_{amb} = 25 \text{ °C}. \]

**Fig. 21** Silicon controlled switch normalized anode-cathode voltage as a function of ambient temperature.

\[ X = \text{value of } V_{AK} \text{ at } I_A = 1 \text{ mA; } I_{AG} = 10 \text{ mA; } V_{BB} = -2 \text{ V; } R_{KG,K} = 10 \text{ kΩ; } T_{amb} = 25 \text{ °C}. \]

**Fig. 22** Silicon controlled switch normalized holding current as a function of ambient temperature.

\[ X = \text{value of } I_H \text{ at } I_{AG} = 10 \text{ mA; } V_{BB} = -2 \text{ V; } R_{KG,K} = 10 \text{ kΩ; } T_{amb} = 25 \text{ °C}. \]
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**Fig. 23** Silicon controlled switch power derating curve.

**Fig. 24** Silicon controlled switch thermal impedance as a function of pulse duration.
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Fig.25 Silicon controlled switch anode current as a function of pulse duration. $T_{\text{amb}} = 25 \, ^\circ\text{C}$.  

Fig.26 Silicon controlled switch anode current as a function of pulse duration. $T_{\text{amb}} = 70 \, ^\circ\text{C}$. 
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Programmable unijunction transistor/
Silicon controlled switch

BRY39

PACKAGE OUTLINE

Metal-can cylindrical single-ended package; 4 leads

DIMENSIONS (millimetre dimensions are derived from the original inch dimensions)

<table>
<thead>
<tr>
<th>UNIT</th>
<th>A</th>
<th>a</th>
<th>b</th>
<th>D</th>
<th>D1</th>
<th>j</th>
<th>k</th>
<th>L</th>
<th>w</th>
<th>α</th>
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<tr>
<td>mm</td>
<td>5.31</td>
<td>4.74</td>
<td>2.54</td>
<td>0.46</td>
<td>5.50</td>
<td>5.50</td>
<td>1.05</td>
<td>1.05</td>
<td>14.5</td>
<td>0.36</td>
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OUTLINE VERSION

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<th>REFERENCES</th>
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<th>ISSUE DATE</th>
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<td>IEC</td>
<td>JEDEC</td>
<td>EIAJ</td>
</tr>
<tr>
<td>SOT18/9</td>
<td>B12/C7 type 3</td>
<td>TO-72</td>
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DEFINITIONS

Data sheet status

<table>
<thead>
<tr>
<th>Status</th>
<th>Description</th>
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<tbody>
<tr>
<td>Objective specification</td>
<td>This data sheet contains target or goal specifications for product development.</td>
</tr>
<tr>
<td>Preliminary specification</td>
<td>This data sheet contains preliminary data; supplementary data may be published later.</td>
</tr>
<tr>
<td>Product specification</td>
<td>This data sheet contains final product specifications.</td>
</tr>
</tbody>
</table>

Limiting values

Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability.

Application information

Where application information is given, it is advisory and does not form part of the specification.

LIFE SUPPORT APPLICATIONS

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NOTES
Philips Semiconductors – a worldwide company

Argentina: see South America
Australia: 34 Waterloo Road, NORTH RYDE, NSW 2113, Tel. +61 2 9805 4455, Fax. +61 2 9805 4466
Austria: Computerstr. 6, A-1101 WIEN, P.O. Box 213, Tel. +43 160 1010, Fax. +43 160 101 1210
Belarus: Hotel Minsk Business Center, Bld. 3, r. 1211, Volodarski Str. 6, 220050 MINSK, Tel. +375 172 200 733, Fax. +375 172 200 773
Belgium: see The Netherlands
Brazil: see South America
Bulgaria: Philips Bulgaria Ltd., Energojekt, 15th floor, 51 James Bourchier Blvd., 1407 SOFIA, Tel. +359 2 689 211, Fax. +359 2 689 102
Canada: PHILIPS SEMICONDUCTORS/COMPONENTS, 51 James Bourchier Blvd., 1407 SOFIA, Tel. +359 1 7640 000, Fax. +359 1 7640 200
China: Philips Semiconductor, Marketing & Sales Communications, Building BE-p, P.O. Box 218, 5600 MD EINDHOVEN, The Netherlands, Fax. +31 40 27 28785, Tel. +31 40 27 88399
Colombia: see South America
Colombia: 254-D, Dr. Annie Besant Road, Worli, MUMBAI 400 025, Tel. +353 1 203 7000
Costa Rica: see Switzerland
Czech Republic: see Austria
Denmark: Prags Boulevard 80, PB 1919, DK-2300 COPENHAGEN S, Tel. +34 3 301 6312, Fax. +34 3 301 4107
Dominican Republic: see South America
Dubai: Philips Semiconductors, Marketing & Sales Communications, Building BE-p, P.O. Box 218, 5600 MD EINDHOVEN, The Netherlands, Fax. +31 40 27 28785, Tel. +31 40 27 88399
Ecuador: see South America
Egypt: Philips Russia, Ul. Usatcheva 35A, 119048 MOSCOW, Tel. +7 095 755 6918, Fax. +7 095 755 6919
Finland: Sinikalliontie 3, FIN-02630 ESPOO, Tel. +358 9 6158 000, Fax. +358 9 6158 0920
France: 4 Rue du Port-aux-Vins, BP317, 92156 SURESNES Cedex, Tel. +359 2 689 211, Fax. +359 2 689 102
Germany: Hammerbrookstraße 69, D-20097 HAMBURG, Tel. +43 1 203 7000
Greece: No. 15, 25th March Street, GR 17778 TAVROS/ATHENS, Tel. +49 40 23 53 60, Fax. +49 40 23 536 300
Guatemala: see South America
Haiti: see South America
Haïti: see South America
Honduras: see South America
Hong Kong: 254-D, Dr. Annie Besant Road, Worli, MUMBAI 400 025, Tel. +353 1 203 7000
Hungary: Tel. +30 1 4894 339/239, Fax. +30 1 4814 240
Iceland: see South America
Indonesia: see Singapore
India: Philips INDIA Ltd., Band Box Building, 2nd floor, 254-D, Dr. Annie Besant Road, Worli, MUMBAI 400 025, Tel. +9 11 625 344, Fax. +9 11 635 777
Indonesia: see Singapore
Iran: PHILIPS SEMICONDUCTORS, Piazza IV Novembre 3, 20922 Sanpavud-Bangna Road Prakanong, BANGKOK 10260, Tel. +66 2 745 6090, Fax. +66 2 398 0793
Iraq: see South America
Ireland: Newsbeat, Clonskeagh, DUBLIN 14, Tel. +353 1 764 000, Fax. +353 1 7640 200
Israel: RAPAC Electronics, 7 Kehilat Saloniki St, PO Box 18053, TEL AVIV 61180, Tel. +972 3 645 0444, Fax. +972 3 649 1007
Italy: PHILIPS SEMICONDUCTORS, Piazza IV Novembre 3, 20124 MILANO, Tel. +39 2 6752 2531, Fax. +39 2 6752 2557
Jamaica: see South America
Japan: Philips Bldg 13-37, Kohnan 2-chome, MINATO-ku, TOKYO 108, Tel. +81 3 3740 5130, Fax. +81 3 3740 5077
Jordan: see South America
Korea, South: Philips Bulgaria Ltd., Energoproject, 15th floor, 51 James Bourchier Blvd., 1407 SOFIA, Tel. +359 2 689 211, Fax. +359 2 689 102
Kosovo: see South America
Kuwait: see South America
Laos: see South America
Latvia: see South America
Lithuania: see South America
Luxembourg: see South America
Macedonia: see South America
Malaysia: No. 76 Jalan Universiti, 46200 PETALING JAYA, SELANGOR, Tel. +60 3 750 5214, Fax. +60 3 757 4880
Malta: see Italy
Mauritius: see South America
Mexico: 5900 Gateway East, Suite 200, EL PASO, TEXAS 79905, Tel. +1 800 234 7381
Middle East: see Italy
Moldova: see South America
Monaco: see South America
Montenegro: see South America
Netherlands: Postbus 90050, 5600 PB EINDHOVEN, Bldg. VB, Tel. +31 40 27 82785, Fax. +31 40 27 88399
New Zealand: 2 Wagener Place, C.P.O. Box 1041, AUCKLAND, Tel. +64 9 849 4160, Fax. +64 9 849 7811
Norway: Box 1, Mangelur 0612, OSLO, Tel. +47 22 74 8000, Fax. +47 22 74 8341
Philippines: see South America
Philippines: Philips Semiconductors, Marketing & Sales Communications, Building BE-p, P.O. Box 218, 5600 MD EINDHOVEN, The Netherlands, Fax. +31 40 27 28785, Tel. +31 40 27 88399
Poland: see South America
Portugal: see Spain
Portugal: see South America
Post Office Box 223, Bldg. VA, 110000 LISBOA, Tel. +351 2 745 4090, Fax. +351 2 398 0793
Puerto Rico: see South America
Qatar: see South America
Qatar: see South America
Rwanda: see South America
Russia: see South America
Singapore: see South America
Slovakia: see Austria
Slovenia: see Austria
South Africa: Philips Bldg 13-37, Kohnan 2-chome, MINATO-ku, TOKYO 108, Tel. +81 3 3740 5130, Fax. +81 3 3740 5077
Spain: PHILIPS ELECTRONICS (THAILAND) Ltd., 51 James Bourchier Blvd., 1407 SOFIA, Tel. +353 1 203 7000
Sweden: Kottbygatan 80, PB 1919, DK-2300 COPENHAGEN S, Tel. +358 9 6158 000, Fax. +358 9 6158 0920
Syria: see South America
Thailand: PHILIPS SEMICONDUCTORS, Piazza IV Novembre 3, 20124 MILANO, Tel. +39 2 6752 2531, Fax. +39 2 6752 2557
Turkey: see South America
United Kingdom: see South America
United States: 5900 Gateway East, Suite 200, EL PASO, TEXAS 79905, Tel. +1 800 234 7381
Uruguay: see South America
Vietnam: see South America
Yugoslavia: see South America
Zimbabwe: see South America