

Philips Components - a worldwide company

Australia: Philips Components Pty Ltd., HOMEBUSH,
Tel. +61 2 9704 8141, Fax. +61 2 9704 8139

Austria: Österreichische Philips Industrie GmbH, WIEN,
Tel. +43 1 60 101 12 41, Fax. +43 1 60 101 12 11

Belarus: Philips Office Belarus, MINSK,
Tel. +375 172 200 924/733, Fax. +375 172 200 773

Benelux: Philips Components B.V., EINDHOVEN, NL,
Tel. +31 40 25 90 772, Fax. +31 40 25 90 777

Brazil: Philips Components, SÃO PAULO,
Tel. +55 11 821 2333, Fax. +55 11 829 1849

Canada: Philips Electronics Ltd., SCARBOROUGH,
Tel. +1 416 292 5161, Fax. +1 416 754 6248

China: Philips Company, SHANGHAI,
Tel. +86 21 6354 1088, Fax. +86 21 6354 1060

Denmark: Philips Components A/S, COPENHAGEN V,
Tel. +45 3329 3333, Fax. +45 3329 3905

Finland: Philips Components, ESPOO,
Tel. +358 9 615 800, Fax. +358 9 615 80510

France: Philips Composants, SURESNES,
Tel. +33 1 4099 6161, Fax. +33 1 4099 6493

Germany: Philips Components GmbH, HAMBURG,
Tel. +49 40 2489-0, Fax. +49 40 2489 1400

Hong Kong: Philips Hong Kong, KOWLOON,
Tel. +852 2784 3000, Fax. +852 2784 3003

India: Philips India Ltd., MUMBAI,
Tel. +91 22 4930 311, Fax. +91 22 4930 966/4950 304

Indonesia: P.T. Philips Development Corp., JAKARTA,
Tel. +62 21 794 0040, Fax. +62 21 794 0080

Ireland: Philips Electronics (Ireland) Ltd., DUBLIN,
Tel. +353 1 7640 203, Fax. +353 1 7640 210

Israel: Rapac Electronics Ltd., TEL AVIV,
Tel. +972 3 6450 444, Fax. +972 3 6491 007

Italy: Philips Components S.r.l., MILANO,
Tel. +39 2 6752 2531, Fax. +39 2 6752 2557

Japan: Philips Japan Ltd., TOKYO,
Tel. +81 3 3740 5135, Fax. +81 3 3740 5035

Korea (Republic of): Philips Electronics (Korea) Ltd., SEOUL,
Tel. +82 2 709 1472, Fax. +82 2 709 1480

Malaysia: Philips Malaysia SDN Berhad,
Components Division, PULAU PINANG,
Tel. +60 3 750 5213, Fax. +60 3 757 4880

Mexico: Philips Components, EL PASO, U.S.A.,
Tel. +52 915 772 4020, Fax. +52 915 772 4332

New Zealand: Philips New Zealand Ltd., AUCKLAND,
Tel. +64 9 815 4000, Fax. +64 9 849 7811

Norway: Philips Components, STOCKHOLM,
Tel. +46 8 5985 2000, Fax. +46 8 5985 2745

Pakistan: Philips Electrical Industries of Pakistan Ltd., KARACHI,
Tel. +92 21 587 4641-49, Fax. +92 21 577 035/+92 21 587 4546

Philippines: Philips Semiconductors Philippines Inc.,
METRO MANILA, Tel. +63 2 816 6345, Fax. +63 2 817 3474

Poland: Philips Poland Sp. z o.o., WARSZAWA,
Tel. +48 22 5710 000, Fax. +48 22 5710 001

Portugal: Philips Portuguesa S.A.,
Philips Components: LINDA-A-VELHA,
Tel. +351 1 416 3160/416 3333, Fax. +351 1 416 3174/416 3366

Russia: Philips Russia, MOSCOW,
Tel. +7 95 755 6918, Fax. +7 95 755 6919

Singapore: Philips Singapore Pte Ltd., SINGAPORE,
Tel. +65 350 2000, Fax. +65 355 1758

South Africa: S.A. Philips Pty Ltd., JOHANNESBURG,
Tel. +27 11 470 5911, Fax. +27 11 470 5494

Spain: Philips Components, BARCELONA,
Tel. +34 93 301 63 12, Fax. +34 93 301 42 43

Sweden: Philips Components, STOCKHOLM,
Tel. +46 8 5985 2000, Fax. +46 8 5985 2745

Switzerland: Philips Components AG, ZÜRICH,
Tel. +41 1 488 22 11, Fax. +41 1 481 7730

Taiwan: Philips Taiwan Ltd., TAIPEI,
Tel. +886 2 2134 2900, Fax. +886 2 2134 2929

Turkey: Türk Philips Ticaret A.S., UMRANIYE/ISTANBUL,
Tel. +90 216 522 18 00, Fax. +90 216 522 18 14

United Kingdom: Philips Components Ltd., DORKING,
Tel. +44 1306 512 000, Fax. +44 1306 512 345

United States:

- Philips Components, SAN JOSE, CA,
Tel. +1 408 570 5600, Fax. +1 408 570 5700
- Philips Display Components, ANN ARBOR, MI,
Tel. +1 734 996 9400, Fax. +1 734 761 2776
- Philips Discrete Ceramics, CHARLOTTE, NC,
Tel. +1 915 860 3267, Fax. +1 915 860 3270
- Philips Ferrite Ceramics, ROSWELL, GA,
Tel. +1 877 433 77483, Fax. +1 770 992 0725

Yugoslavia (Federal Republic of): Philips Components, BELGRADE,
Tel. +381 11 625 344 / +381 11 3341 299, Fax. +381 11 635 777

- Internet:**
- Discrete and Ferrite Ceramics: www.acm.components.philips.com
 - Display Components: www.philipsdisplay.com

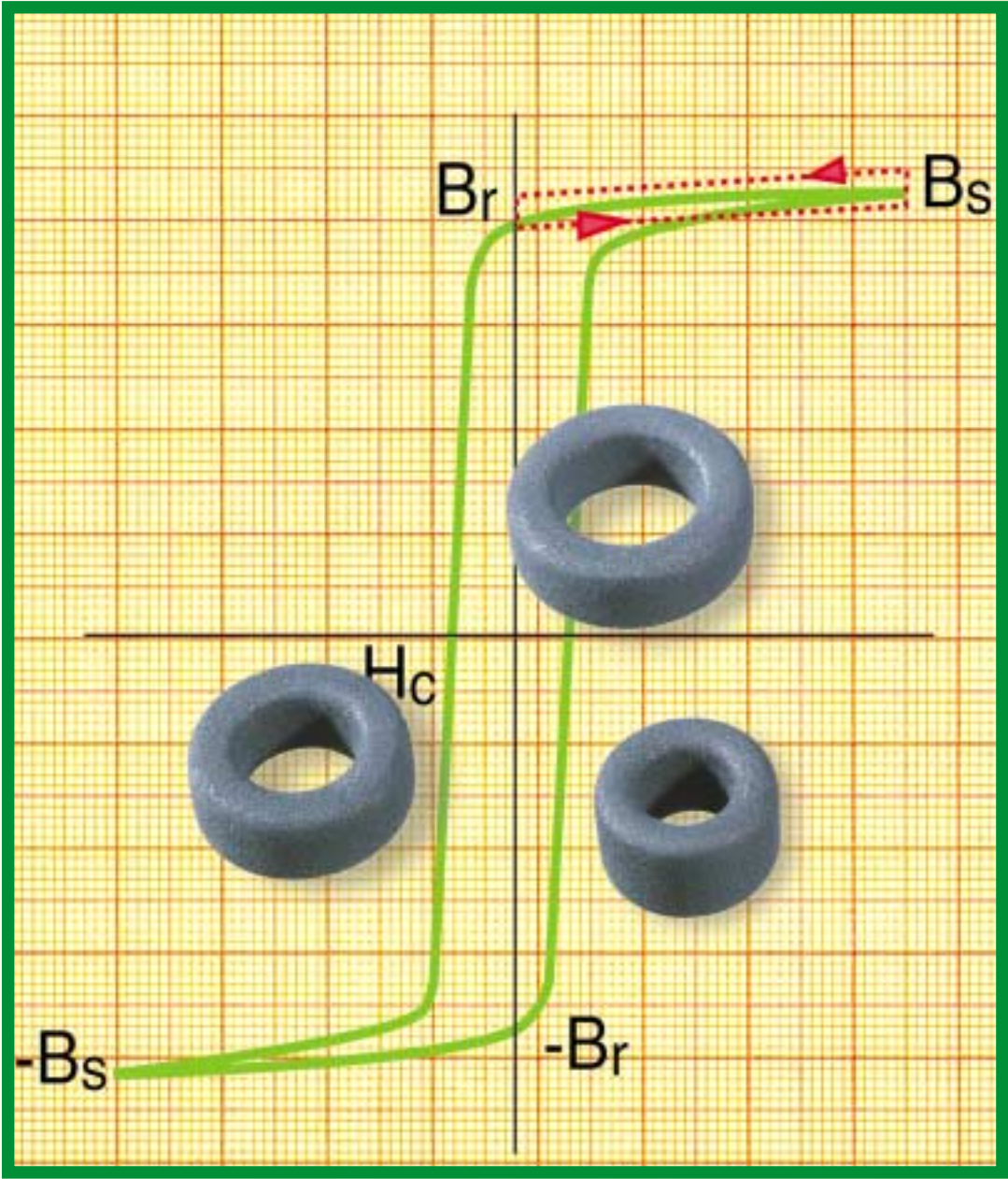
For all other countries apply to:
Philips Components, Building BAE-1, P.O. Box 218, 5600 MD EINDHOVEN,
The Netherlands, Fax. +31 40 27 22 599

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Square Loop Ferrite Toroids
for Magnetic Amplifiers



Philips Components
Ferrite Ceramics



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Let's make things better.



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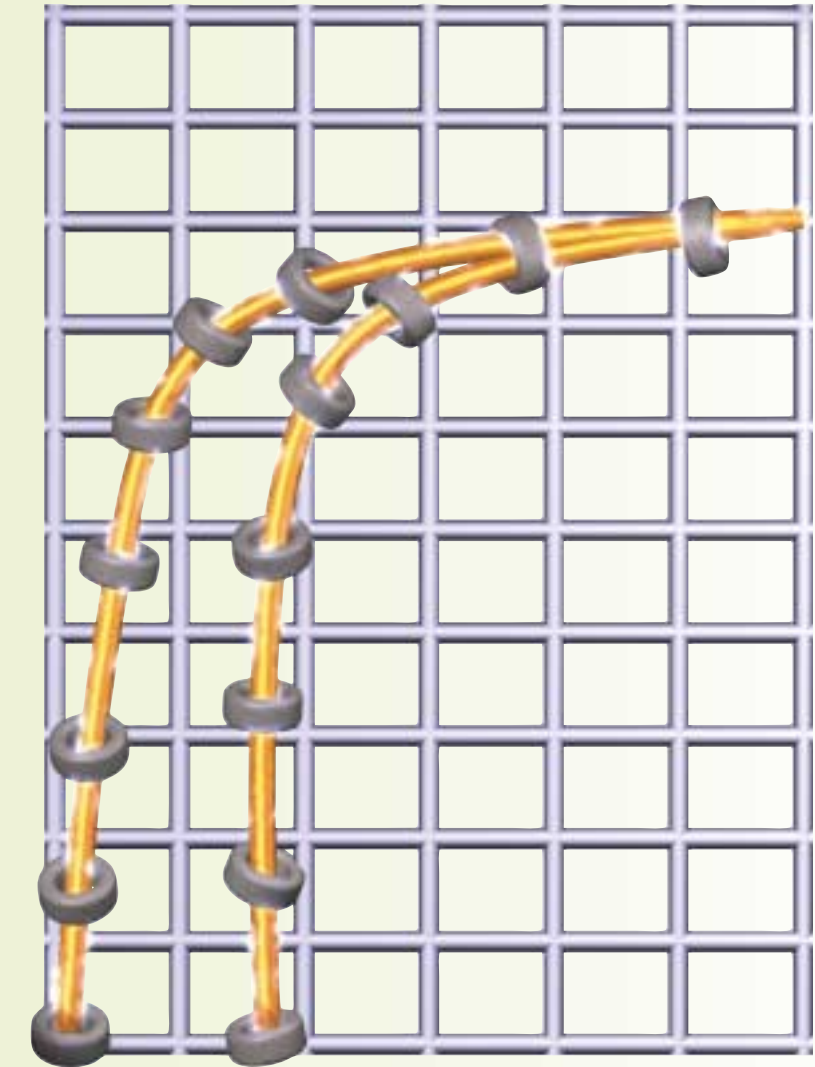
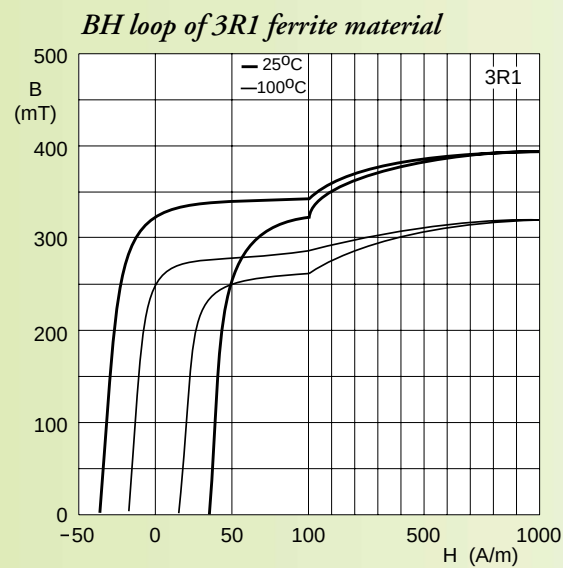
Square Loop Ferrite Toroids for Magnetic Amplifiers

In recent years, square loop ferrite toroids have continuously gained market share and more and more designers have learnt to appreciate them as an economic replacement for amorphous metal cores in magnetic amplifiers.

Continuous research, the use of improved raw materials and well controlled process conditions have led to a robust and stable ferrite material, 3R1.

These developments have resulted in a range of 3R1 toroids, featuring a very good squareness ratio, a low H_c and an excellent performance under high loading current conditions.

As an alternative to the normal toroids, the Integrated Inductive Component (IIC) is offered for SMD only designs.

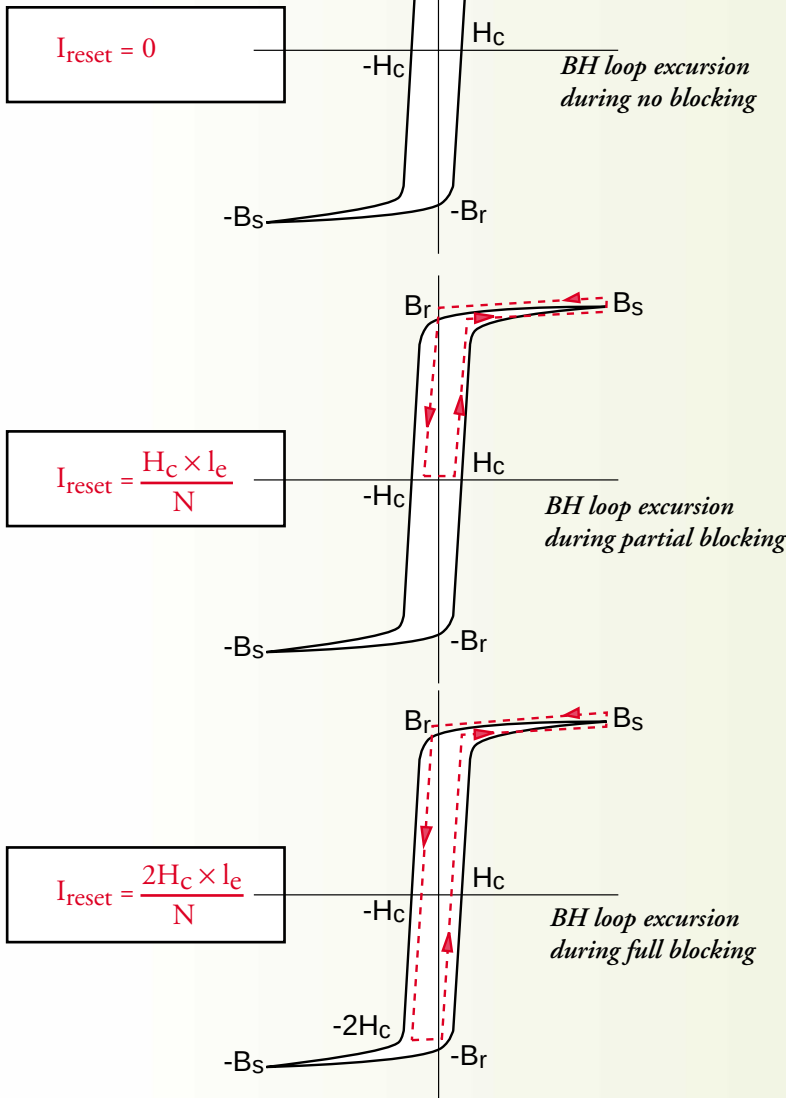


Features

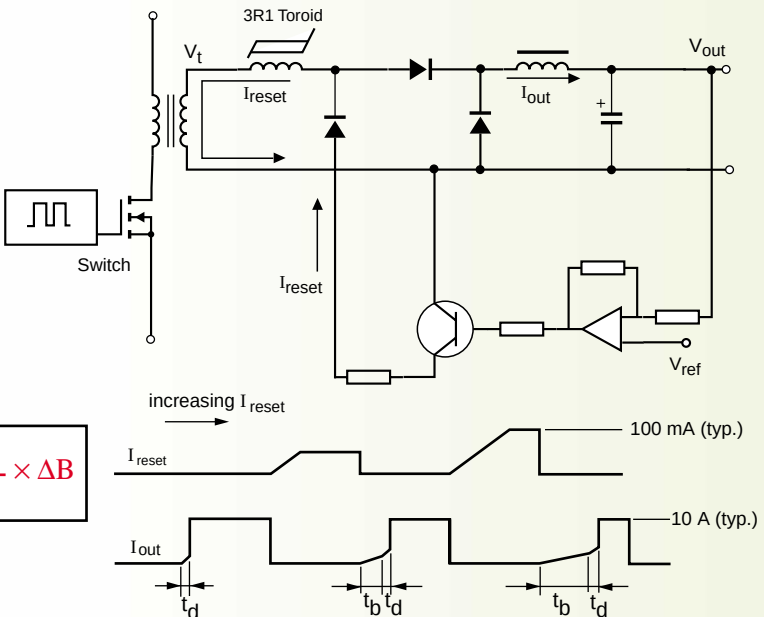
- Squareness ratio of 85 to 90% at 100 kHz, 100 °C depending on applied field strength
- Excellent load handling
- Low H_c

Current product range

TN9/6/3-3R1 IIC10-14/4-3R1
TN10/6/6-3R1
TN13/7.5/5-3R1
TN14/9/5-3R1
TN17/11/11-3R1
TN23/14/7-3R1
TN36/23/15-3R1



$$I_{reset} = \frac{H_c \times l_e}{B_r \times N} \times \Delta B$$



Basic circuit

3R1 Toroids in Magnetic Regulators

Saturable inductors can be used to regulate several independent outputs of an SMPS by blocking varying amounts of energy from the secondary of the transformer. The rectangular BH loop of our 3R1 ferrite toroids makes them ideal for magnetic regulators with reset control. The circuits required are both simple and economic and can be easily integrated.

Operating principles

When the main switch is ON (t_{on}) the current (I_{out}) flows through the winding of the saturable inductor to the output inductor and from there to the load.

During OFF time this current falls to zero and so does the magnetic field H . Because the saturable inductor has a rectangular B-H loop, the flux remains at the high level B_r even when the driving field H has fallen to zero.

When no reset current is applied, the flux in the toroid remains at the level of B_r until the next ON time starts after a complete cycle time T ($=1/f$). There is only a short delay (t_d) because the flux rises from B_r to B_s . After that, the current sharply rises to its maximum value, limited only by the load impedance. The output voltage has its maximum value, given by:

$$V_{out} = V_t \times (t_{on} - t_d) / T$$

When V_{out} is higher than V_{ref} a reset current flows during OFF time, regulated by the transistor. This current can only flow through the winding of the saturable inductor. Because this current induces a magnetic field in reverse direction it will move the ferrite away from saturation. Resetting to $-H_c$, for instance, causes some extra delay (t_b) because of the larger flux swing. Full reset causes a flux swing of almost $2 \times B_s$, resulting in a maximum delay ($t_d + t_b$) and the blocking of a major part of the energy flowing from the transformer to the load. The output voltage is regulated to the required level and is given by:

$$V_{out} = V_t \times (t_{on} - t_d - t_b) / T$$

In this way a reset current in the order of 100 mA can regulate load currents of 10 A or more, depending on the layout of the saturable inductor. For this reason the described circuit is called a magnetic regulator or magnetic amplifier.

The performance of the material 3R1 is comparable to that of amorphous metal, making it an excellent choice for use in magnetic regulators. However, since the value of H_c is higher for the ferrite than for most amorphous metal compositions, a simple replacement will often fail to deliver the expected results. A dedicated design or a slight redesign of the regulating circuit is then required, for which we will be glad to give you advice.

