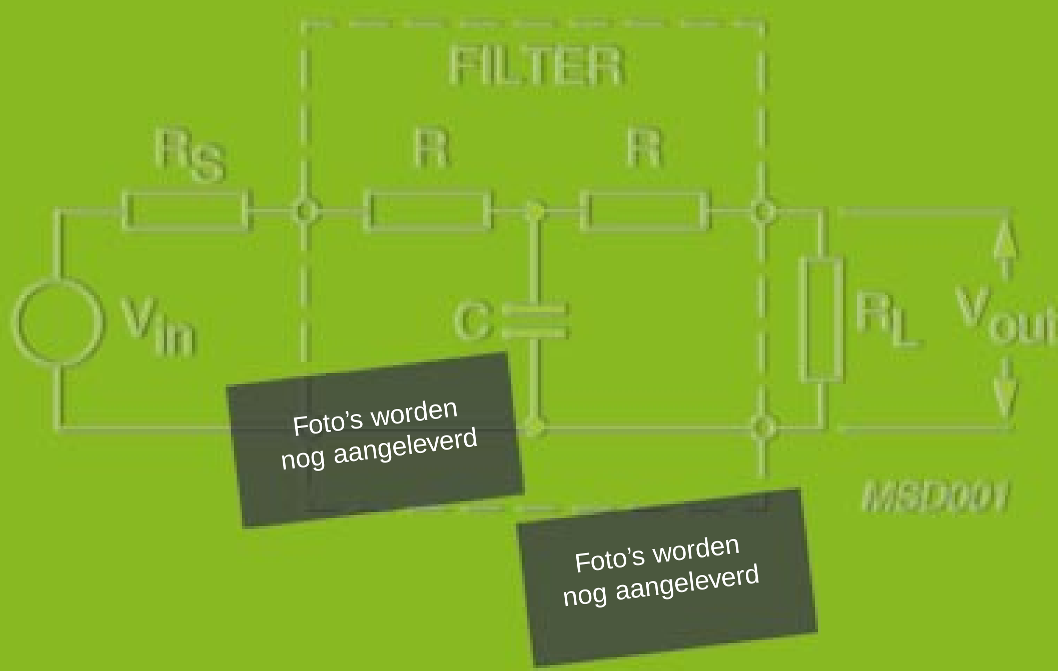
Application Note

Integrated RC filters for EMI/RFI suppression



PHILIPS

Let's make things better.

Integrated RC filters for EMI/RFI suppression

SUMMARY

Philips offers a variety of integrated passive RC filters in thin film-on-silicon technology in both T-Filter and Half-T Filter configurations. T-type filters provide bi-directional filtering for applications in which signals are passed in both directions on the same line. Half-T filters are useful for achieving the greatest amount of one-way filtering given a maximum resistance value. RC filters also offer the benefit of attenuating reflections from the end of high-speed transmission lines, thereby improving pulse fidelity.

Integrated RC filters for EMI/RFI suppression

EMI/RFI low pass filters are used in computers, telecommunications and wireless communication systems to suppress noise and interfering signals at frequencies higher than the signal frequency entering or exiting the electronic equipment. Because of their small size and ability to achieve low cut-off frequencies and high attenuation to over 1 GHz, an RC-type filter is the filter of choice in many applications.

Filter design considerations

The cut-off frequency, f_c of a low-pass filter, shown in Fig.1, is defined as the frequency at which the filter passes one-half the power it receives at its input terminal. The cut-off frequency, also known as the "-3dB" frequency, is determined by the filter's resistance (R) and capacitance (C) values.

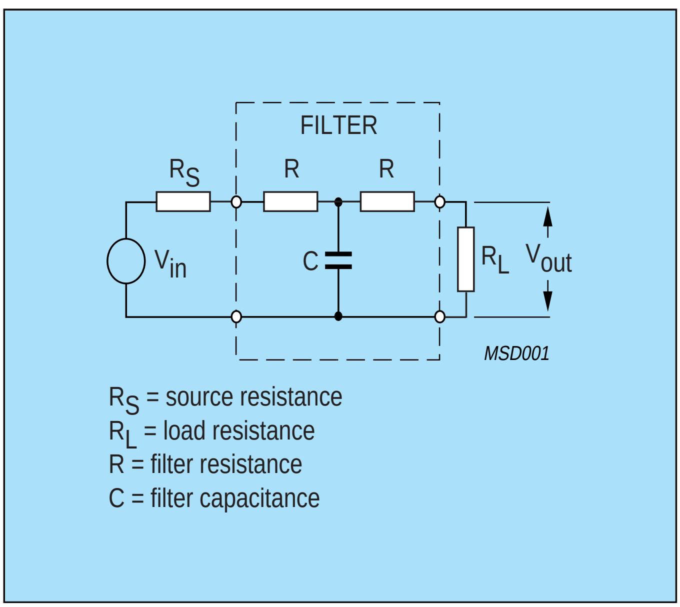


Fig.1 RC filter

The selection of the R and C values depends upon conditions involving the unwanted signal frequency, system response time performance and source/load impedance. The following method provides the approximate values of R and C. Actual R and C values for a real filter may differ somewhat due to the effects of parasitic capacitance and ground inductance. Careful modeling of the filter, including the PC-board layout and source/load impedance, will help ensure that the performance of an actual filter closely matches that of one predicted.

The cut-off frequency should be selected to pass the signal frequency with minimal distortion, while providing rejection of the undesired signals. The transfer function for the filter shown in Fig.1 is:

$$\frac{V_{out}}{V_{in}} = \frac{R_L}{j\omega C(R + R_s)(R + R_L) + (R_s + R_L + 2R)}$$

By setting the real part of the denominator of the transfer function equal to the imaginary part, one can determine the filter cut-off frequency:

$$f_c = \frac{R_s + R_L + 2R}{2\pi C(R + R_s)(R + R_L)}$$

For pulsed digital signals, the cut-off frequency of an RC filter should be selected to result in minimal impact on the rise time of the digital input pulse's amplitude. For a RC low-pass filter the 10-90% rise time of the waveform amplitude can be calculated in terms of the circuit's RC time constant by the relationship:

$$T_{10-90} = 2.2R_{th}C$$

where R_{th} is the Thévenin equivalent resistance as seen by the capacitor.

The rise time of the filter of Fig.1 can therefore be calculated:

$$T_{10-90} = 2.2C\frac{(R + R_s)(R + R_L)}{R_s + R_L + 2R}$$

To ensure that under all conditions an RC filter will not signifcantly degrade the rise time of the digital input signal, select a filter rise time at least twice as fast as that of the signal.

Philips' integrated passive RC filters

Philips offers a variety of integrated passive RC filters, implemented in thin film-on-silicon technology, in both T-filter and half-T filter configurations as shown in Fig.2. T-type filters provide bi-directional filtering for applications in which signals are passed in both directions on the same line. Half-T filters are useful for achieving the greatest amount of one-way filtering given a maximum resistance value. RC filters also offer the benefit of attenuating reflections from the end of high-speed transmission lines, thereby improving pulse fidelity.

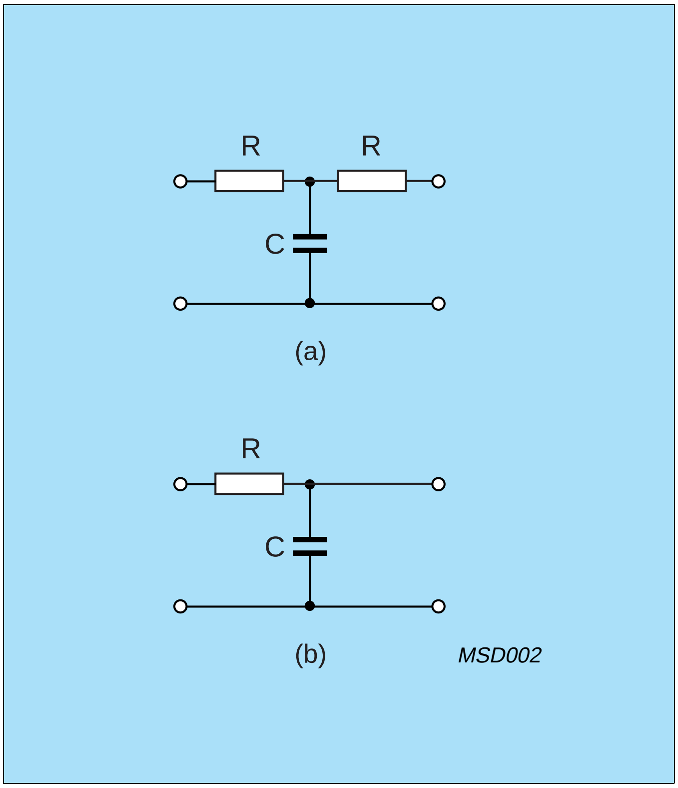


Fig.2 RC filters (a) T-filter (b) half T-filter

ESD Protection

Philips' EMI/RFI filters include built-in electrostatic discharge (ESD) protection which also serves to provide system-level protection to vulnerable components. Discrete diodes or varistors commonly used for this purpose can therefore be eliminated, resulting in significant cost and PC board space savings. An added benefit of the integrated ESD protection Philips' EMI/RFI filters offer is the suppression of logic undershoot conditions due to the voltage clamping action of the ESD diodes. Typical applications where ESD protection along with low-pass filtering is used include input/output lines on laptop and desktop computers, workstations, peripherals and mobile phones. Philips offers two levels of ESD protection in its EMI/RFI filters in accordance with the IEC 61000-4-2 specification:

Level 1, which specifies a 2 kV contact rating, adequate for most applications, and

Level 4, which specifies a 8 kV contact and 15 kV air discharge rating.

Level 4 protection is generally specified where the ultimate in ESD protection is desired, the I/Os of external connectors, for example.

Philips' standard products

The following table lists a sample of the EMI/RFI filters available. Philips also can develop a fully customized solution for your specific requirements. Contact your local Philips representative for more information.

Philips P/N	Filter type	Package	R (Ω)	C (pF)	ESD protection
IP2000CY20-03	Octal Half-T	20 Pin QSOP	27	15	2 kV
IP2000CY20-06	Octal Half-T	20 Pin QSOP	33	220	2 kV
IP2050CY20-05	Octal Half-T	20 Pin QSOP	33	47	8 kV
IP2050CY20-07	Octal Half-T	20 Pin QSOP	47	33	8 kV
IP2100CY20-03	Octal T	20 Pin QSOP	25	200	2 kV
IP2100CV20-03	Octal T	20 Pin SOIC	25	200	2 kV
IP2150CY20-04	Octal T	20 Pin QSOP	33	15	8 kV
IP2150CV20-04	Octal T	20 Pin SOIC	33	15	8 kV

Philips Components - a worldwide company

Australia: Philips Components Pty Ltd., NORTH RYDE,
Tel. +61 2 9805 4455, Fax. +61 2 9805 4466

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 Nederland B.V., EINDHOVEN, NL,
Tel. +31 40 2783 749, Fax. +31 40 2788 399

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: Norsk A/S Philips, OSLO,
Tel. +47 22 74 8000, Fax. +47 22 74 8341

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 22 612 2594, Fax. +48 22 612 2327

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 AB, 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., GÜLTEPE/ISTANBUL,
Tel. +90 212 279 2770, Fax. +90 212 282 6707

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

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

Internet:

- Advanced Ceramics & Modules: www.acm.components.philips.com
- Display Components: www.dc.comp.philips.com

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

Printed in The Netherlands 9398 084 01011 Date of release: 04/99

PHILIPS

Let's make things better.