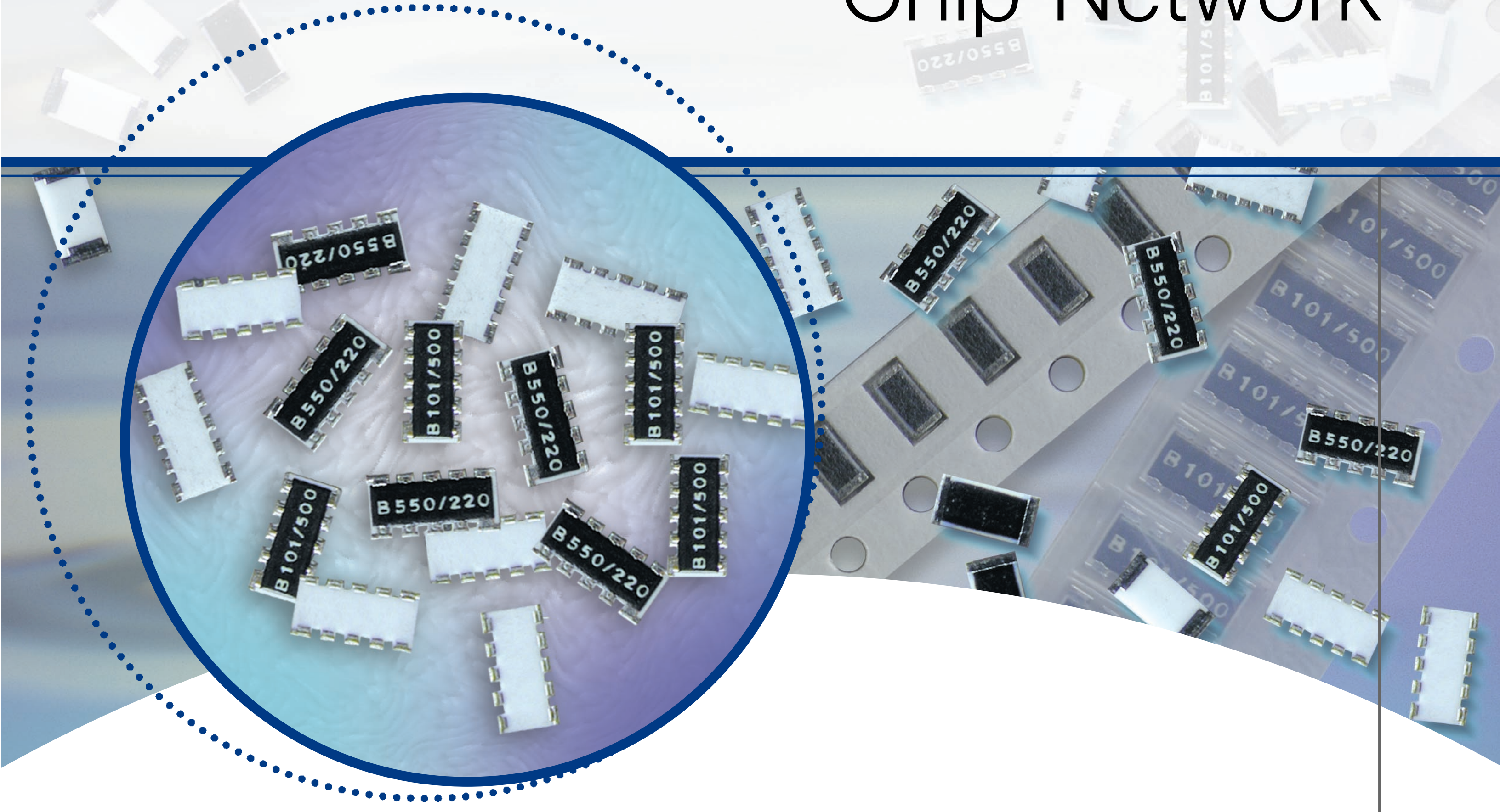
Resistor Capacitor Chip Network



An Integrated Passive Device Solution

- High speed AC line termination
- EMI / RFI filtering
- Enhanced parallel port (IEEE1284)
- Thick film on ceramic
- Low profile, suitable for PCMCIA
- Low inductance, leadless design

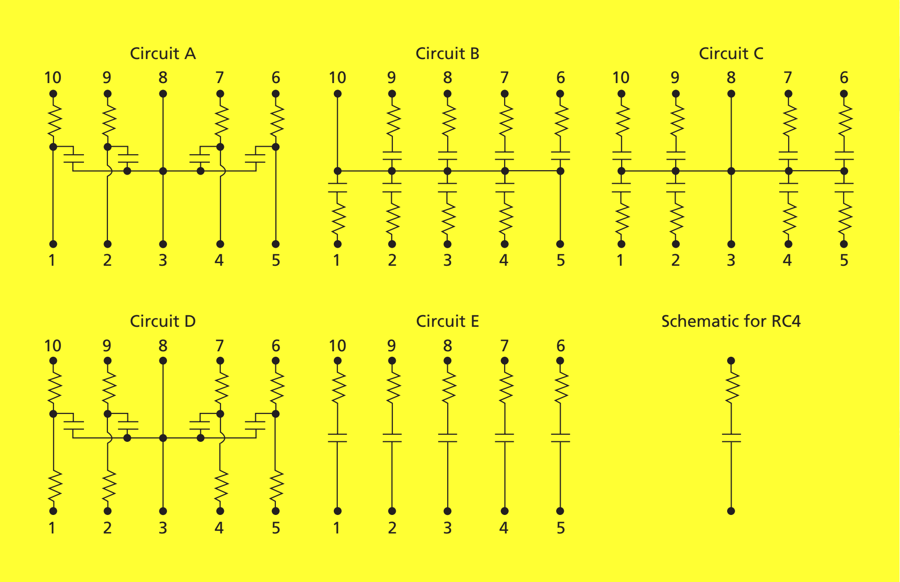
BI technologies

A subsidiary of TT electronics plc

TT electronics

BI Technologies

The RC series is available as a single RC chip in 1206 size and in five different circuit configurations in a ten terminal 2512 size array, as shown below.



	RC4	RC6A	RC6B	RC6C	RC6D	RC6E
Capacitance pF max	200	220	68	68	220	180
Capacitance tolerance	± 20 %					
Dielectric	X7R					
Resistance range	20 Ohms to 1 M Ohm					
Tolerance	± 20% (Optional 10%, 5%)					
Power rating, mW	63mW per resistor, 250mW per package					
Temperature coefficient of resistance	± 200 ppm/°C (Optional ± 100ppm/°C)					
Size	1206	2512				

Why Use BI Technologies RC Chip Networks?

- Improve reliability and increase board yields by reducing number of solder joints and traces on PCB.
- Real estate savings of 50% over discrete components.
- Minimise PCB trace inductance.
- Savings on pick and place costs - place one RC6B instead of 16 discrete components.
- RC chips permit placement close to active devices.
- Reduce component count in inventory and bill of material.
- Not susceptible to ESD unlike thin film.
- Does not require diode protection.
- Reduce PCB trace routing problems.
- Manufactured in ISO9001 / QS9000 approved facility.

Markets

- Lap Top Computers
- Workstations
- Multimedia Applications
- Automotive electronics
- Computer Peripherals
- Medical Electronics
- Notebook Computers
- Set Top Boxes

1. Line Terminations

With increased operating frequencies printed circuit board traces connecting components behave more like transmission lines which if uncompensated result in a degradation of signal integrity and an increase in radiated EMI. Signal integrity degradation or distortion is due to signal reflections in the PCB traces at the receiving end and takes the form of signal under/over shoot and ringing resulting in random triggering on clock lines and invalid bits on data, address and control lines. The point at which a signal line is considered to be a transmission line depends upon the amount of acceptable distortion. As a rule of thumb it is generally agreed to be when the transition time of the signal is less that two times its propagation delay or $t_r / \tau \geq 2$, a more conservative estimate is to consider it as less that eight times the propagation delay or $t_r / \tau \geq 8$. Generally the larger the transition time in relation to the propagation delay of the signal line, the cleaner the signal. Using this equation it is possible to calculate the maximum feasible PCB trace length without experiencing distortion due to reflections. The table shows a number of logic families and the maximum trace lengths beyond which transmission line effects are considered to be detrimental. The calculated trace lengths assume a PCB of FR4 material with a dielectric constant ε_r of 4.1.

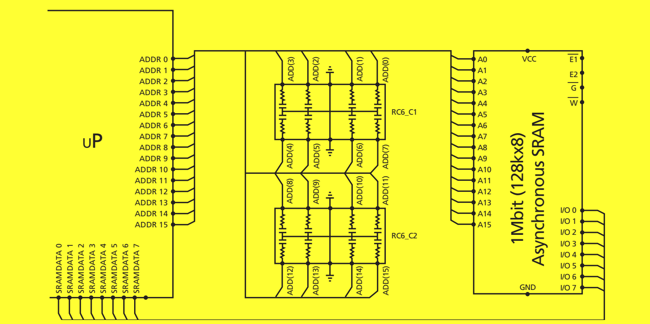
Logic Family	Typical Signal Rise Time	Line Length (mm)
TTL	2 ns	74
CMOS	1.5 ns	55
GTL	1 ns	37
LVDS	400 ps	15
ECL	100 ps	3.7
GaAs	40 ps	1.5

Logic families V's Max trace length

Signal reflections are caused by an impedance mismatch between the signal source and load. The impedance mismatch means that the transmitted signal is not fully absorbed by the load and is reflected back to the source, this process continues until all of the energy is absorbed. An impedance mismatch can be overcome by matching the source and load impedance using line terminations. A number of different techniques can be employed one of which is the AC line termination The AC termination, also known as an RC termination, requires a series resistor and capacitor connected at the load with a resistance equal to the characteristic impedance of the transmission line. The capacitance should be selected such that the RC time constant is equal to twice the signal propagation delay. Too small a capacitance will result in signal under/over shoots while too high a value will result in excessive power dissipation. The AC termination is dependent upon the termination trace length and is thus unsuitable for multiple source topologies however since AC termination consume less power than other termination techniques they are often used for applications where power economy is important such as battery operated systems.

RC Line Terminations

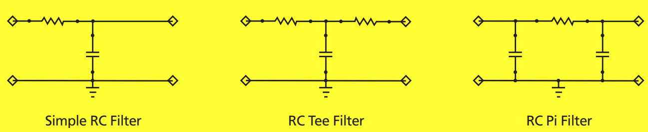
With increased operating frequencies printed circuit board traces behave like transmission lines This can result in degradation of signal integrity and an increase in radiated EMI. Signal integrity degradation or distortion results from signal reflections in the PCB traces at the receiving end and takes the form of signal under/over shoot and ringing resulting in random triggering on clock lines and invalid bits on data, address and control lines. A carefully selected AC or RC termination comprising of a series resistor and capacitor connected at the load with a resistance equal to the characteristic impedance of the transmission line will eliminate these effects.



uP / SRAM interface showing line terminations (16-bit address bus, 8-bit data bus)

2. EMI Filters

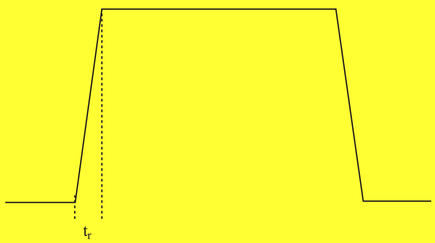
Along with the demand for faster processing speeds comes a rise in high frequency noise. Electromagnetic compatibility is a major concern for all electronic designs and new products must be capable of functioning without becoming effected by or adversely effecting the operation of neighbouring devices. Most high-speed circuits and systems suffer interference from internal "unwanted" transmitters and receivers intrinsic to the design and this interference can radiate to other systems. I/O interfaces connecting



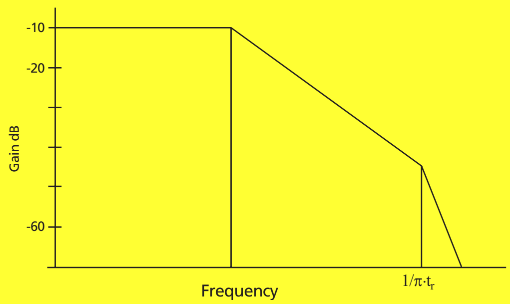
Passive RC filter configurations

these systems can be a major source and entry point for both conducted and radiated electromagnetic interference (EMI). Effective high-frequency filters are required to ensure correct circuit operation and meet EMC regulations.

There are several filter design choices available to attenuate noise on I/O ports and signal lines, this application note discusses passive RC filter configuration. Unidirectional low pass filtering can be achieved using a basic RC filter while bi-directional signals can be effectively filtered using Pi and Tee filters, these filter configurations are first order with a frequency attenuation roll-off of



Square wave pulse – Trapezoid

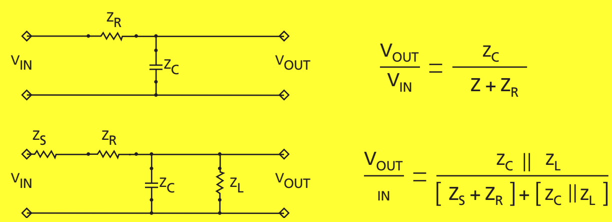


Trapezoid harmonic content

–20dB/decade. Ideally each EMI filter in a multiple channel application would be optimised however in reality identical filters are chosen to limit the number of components used in a design. The RC6 integrated resistor-capacitor networks allow design engineers to implement multiple channel EMI filters without the need for discrete components which may have poor attenuation characteristics due to parasitic impedance between components that will amplify frequencies above the 3dB point. The RC6 attenuates noise to signal ground most effectively when located in close proximity to the I/O port requiring filtering. For external interface I/O connectors it is more effective to shun the noise signal to chassis ground where possible.

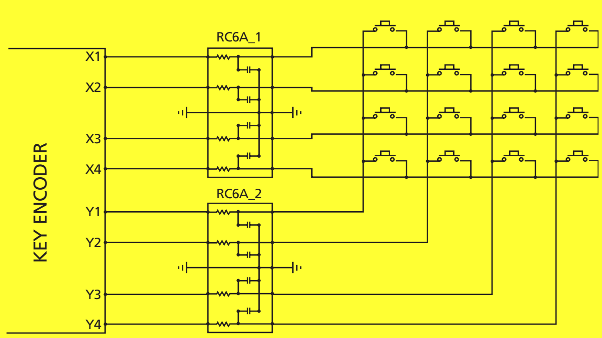
In order to select an appropriate low pass filter for an application it is first necessary to determine the signal bandwidth. Most digital signals are high frequency trapezoids. The harmonic content of this signal, observed using a spectrum analyser is shown, notice that the slope of the envelope is 20 dB/decade up to a frequency at which the slope increases to 40 dB/decade. The frequency at which the slope changes from 20 to 40 dB/decade is governed by the rise and fall times of the waveform. For an ideal waveform it is possible to calculate the slope-change point as the reciprocal of rise/fall time multiplied by π, or $1/\pi \cdot t_r$. In general harmonic content above this frequency can be ignored.

For analogue signals this is chosen as the filter corner frequency or 3dB point. For digital signals the 3dB point will be set less than or greater than this frequency since sometimes it is necessary to control the rate of rise of the signal to reduce radiated emissions. After selecting the desired filter 3dB point an adjustment is necessary to account for any variance in component tolerance and temperature coefficients by calculating the root sum square (RSS) of the errors where $\Delta f = \sqrt{} (\Sigma R\_Tol)^2 + (\Sigma R\_Temp)^2 + (\Sigma C\_Tol)^2 + (\Sigma C\_Temp)^2$. Now since the frequency response of a filter is dependent on the impedance of the signal source and its load, any shift in 3dB point must be accounted for by adjusting the filter component values. The required values can be calculated using AC circuit analysis or running a SPICE simulation.



Effect of source and load impedance on transfer function

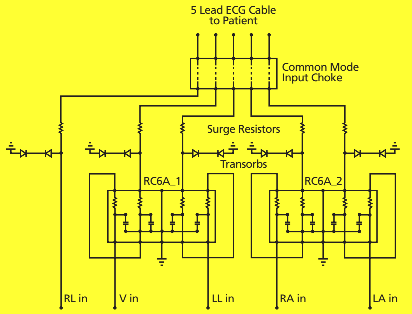
Keypad Filter



Keypad encoder with EMI filters

Almost all embedded systems allow a degree of user interaction facilitated by using a keypad. A keypad encoder IC is designed to interface the keypad with a microprocessor. The scanning keypad encoder detects and encodes contact closures in the keypad X-Y switch matrix. An external oscillator sets the scan frequency and the encoder converts then transmits the closure as a corresponding binary code. Scanning the keypad generates EMI noise that is radiated from the connecting wires and traces. EMI filters are often required to reduce radiated emissions as inadequate filtering can lead to difficulties during emissions testing.

ECG Input Filter

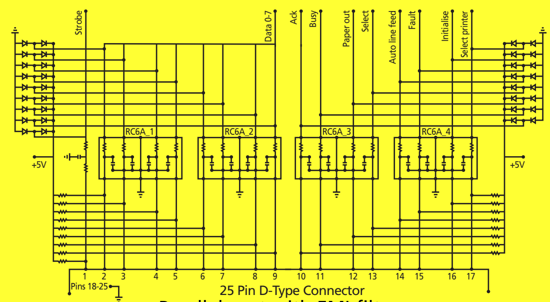


ECG input with EMI filters

An electrocardiogram (ECG) records the changing potential generated by electrical activity from the heart. To obtain an overall view of the heart's electrical activity, three or five electrodes attached to lead wires detect electrical impulses from the patient's heart to the skin. The monitor calculates the difference in electrical force between two of the electrodes. The ECG unit then uses a differential amplifier to extract surface ECG activity from the pair of electrodes. A common mode choke, surge resistor and a transient voltage suppresor protected the amplifier input from high energy defibrillator pulses that may be applied to a patient with the ECG electrodes connected. Passive low-pass filtering attenuates these transients and noise from electrosurgical devices to acceptable levels.

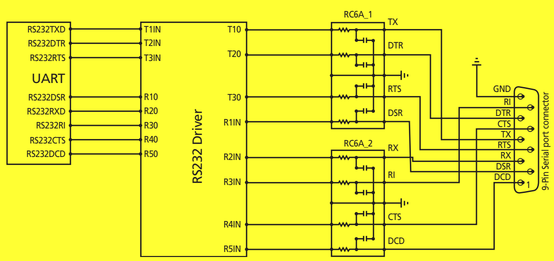
Parallel Port Filter

The parallel port was originally designed for connecting your PC to a parallel printer. Now the port is used for interfacing lots of different peripherals such as scanners, Zip-drives and network adapters. The parallel port operates by simultaneously sending 8 bits as ground-referenced TTL. Once the sender has issued the data a strobe pulse is generated. The receiver acknowledges the data by sending an "Acknowledge" pulse, confirming readiness to receive new data. With rising clock frequencies and additional EMI sources, such as Bluetooth, 802.11 wireless LAN and USB 2.0, that can couple on to the parallel port, there is a need for effective high frequency EMI filtering to meet regulatory requirements.



Parallel port with EMI filters

Serial Port Filter

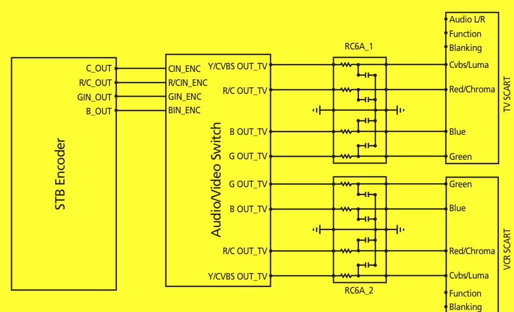


Serial port with EMI filters

The original RS-232C standard specified the maximum speed for the serial port as 19.2 kbit/s however today serial ports are operated at 115.2 kbit/s and faster. For serial data transfer the individual bits are sent one after the other over a single line asynchronously this means that clock information is not included with the transmission, so frequent re-synchronisation using start/stop bits is required. The maximum communications cable length specified by RS-232 is 50 feet. Cables act like antennae through which RF noise can radiate EMI filters placed close to the port helps to reduce radiated emissions.

SCART Port Filter

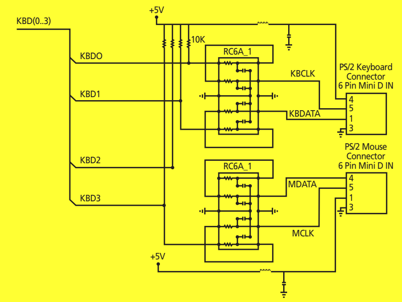
In Europe, the external connections to TVs, set-top boxes, VCRs and other video peripherals are provided by a SCART, or Peritel, connector. Its pin-out is specified in EN50049. Depending on the SCART connector's use (TV SCART, AUX SCART, or VCR SCART) the connector is an input, an output, or both. The SCART is a twenty-one pin connector plug found most consumer audio-visual equipment. SCART supports stereo audio, composite video, S-video, RGB and some control signals. The addition of S-VHS complicated this interface by requiring the RED and Cvbs pins to be shared with the Chroma (C) and Luma (Y) pins. EMI filters close to the output connectors attenuates high frequency noise generated inside the unit and lowers the level of externally radiated EMI.



SCART ports with EMI filters

Keyboard and Mouse Filter

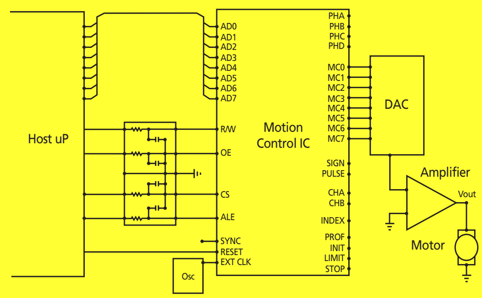
Traditional PC keyboards connect to a PS/2 keyboard interface (6-pin mini DIN connector) on the PC motherboard. The keyboard uses four wires and sends scan codes to the computer. The scan codes tell the keyboard Bios the keys that are pressed or released. A keyboard interface control IC handles communication between keyboard and motherboard. The first mouse connected to PC serial port and used 1200 bps serial communication. The most common type of mouse today is the PS/2 mouse that was introduced by IBM on their PS/2 range of computers. Most PC manufacturers adopted this mouse port type on their motherboards. The PS/2 mouse uses same protocol and connector type as PS/2 keyboard. EMI filters placed close to these ports reduce radiated emissions.



Keyboard and mouse ports with EMI filters

Control and Data Line Filters

Filters are used to reduce the susceptibility of IC inputs when operating in noisy environments. This example shows a precision DC motor control system that could be a FAX machine, a printer, a medical instrument or industrial automation equipment. The noise may originate from many sources within the system from the DC motor or the switching power supply to high-speed data signals. The control signals can be particularly susceptible to noise and if it coupled onto these inputs would result in intermittent read and write errors as well as potential crashing of the host processor. Low pass filters should be placed as close as possible to the protected input to minimise the amount of noise coupled onto the signal traces after the filters. Data lines can also be susceptible to noise and may be filtered.



Control signal EMI filters

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