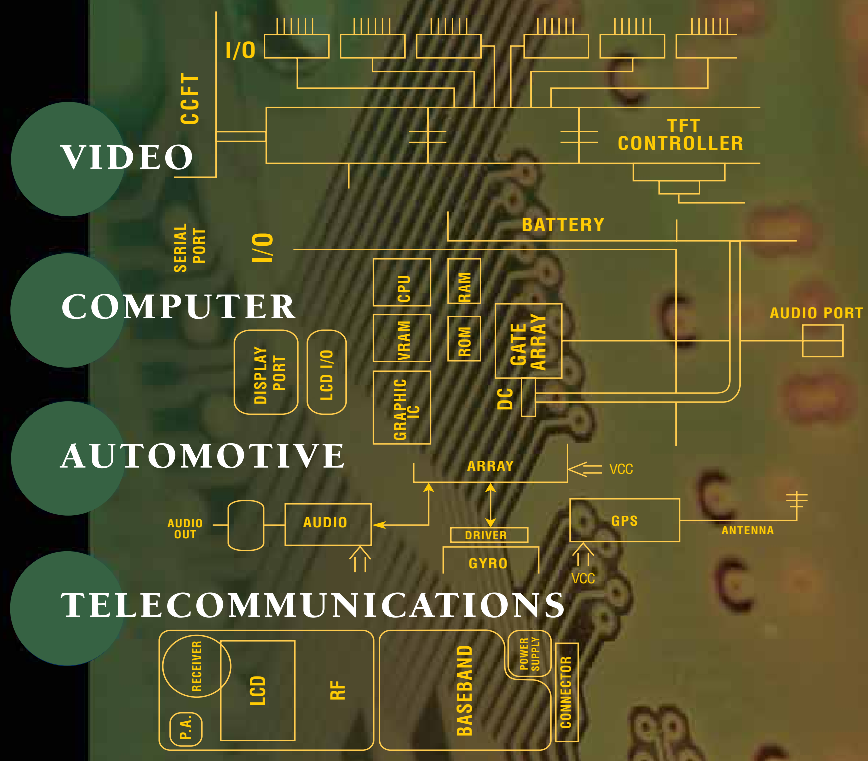
VISHAY

VISHAY INTERTECHNOLOGY, INC.

EMI/RFI SOLUTIONS

Electro-Magnetic Compatibility



ENGINEERING SOLUTIONS

Electro-Magnetic Interference (EMI) and Radio Frequency Interference (RFI) is noise at radio frequencies generated by today's sophisticated electronic equipment's microprocessors, oscillators, and switching power supplies. Radio Frequency (RF) noise is often of sufficient strength as to interfere with, or even disable, operation of both consumer and vital communication services (i.e., police, fire, emergency medical and military). To reduce or eliminate EMI/RFI most countries have instituted regulations and practices for the design, building and testing of new electronic equipment so it does not create (or become susceptible to) EMI/RFI. This area of engineering is often referred to as Electro-Magnetic Compatibility (EMC). The following information is designed to assist the EMC engineers and technicians in the proper selection of passive components to reduce EMI/RFI.

Components designed for electromagnetic interference filtering (EMI) or radio frequency interference suppression (RFI) can be classified into five main categories: **L–Reflection** (inductors, common-mode chokes, and transformers), **Z–Absorption** (ferrite beads), **C–Bypass** (ceramic capacitors, film capacitors, varistors), **R–Attenuation** (resistors-attenuators), and **C+R–Multifunction** (thick film capacitor and resistor combinations and terminations). The choice of component depends on how and where noise is being generated, and how and where the application circuit will be operated in the customer's end product.

L REFLECTION

INDUCTORS

The first and most common type of electromagnetic filter is the inductor or choke. Inductors are used for both line filtering and energy storage. If a circuit is suspected of generating EMI, a well-chosen inductor often can help eliminate the problem. For radiated interference, a toroidal inductor is often called for. Whether in surface-mount or leaded packaging, a toroidal inductor can virtually eliminate radiated fields thanks to its unique ability to contain the magnetic flux within its core. The toroid configuration is also less susceptible to induced noise from other components since the applied magnetic field tends to create equal and opposite currents inside the toroid, thus canceling out the effect of interference.

COMMON-MODE CHOKES

Common-mode or differential-mode chokes are used to eliminate noise on a pair of conductors. Noise is "common mode" when it is present or "common" to both conductors. It is usually induced by the antenna effect of a conductor or printed circuit board (pcb) trace. Common-mode noise is typically "in phase" in the conductors. Differential noise is present on only one conductor or present in opposite phase in both conductors. Common-mode chokes use the properties of two closely coupled magnetic fields to eliminate the interference problem by canceling the noise within the magnetic fields. They are best employed to eliminate noise or EMI on cables or signal tracks.

The choke should be located as close as possible to the driver or receiver circuit, or at the signal entry point to the circuit board. Careful selection of an inductance value helps in matching line impedance and in providing bandwidth filter for the circuit. Chokes can be configured in the common mode or differential mode depending on the application.

TRANSFORMERS

A transformer provides an isolation barrier between a signal line and the signal processing circuit, particularly where the signal line exits the board or system. Whether the signal is being driven or received, isolating the line reduces common-mode noise and eliminates ground potential (or signal return) differences between systems.

High noise immunity is especially important in thyristor/triac driving circuits, where the transformer provides an isolation between the driven load and a logic-based controller. An isolating pulse transformer provides much better noise immunity than an insulated gate bipolar transistor (IGBT) due to its inherently lower coupling capacitance, which is usually measured in tens of picofarads as opposed to nanofarads for a power IGBT. The lower coupling capacitance improves the circuit's immunity from noise generated by the mains or by power switching devices, and many different configurations are available to meet the needs of specific designs.

Z ABSORPTION

SURFACE-MOUNT FERRITE BEADS

Ferrite chip beads, also known as chip impeders, remove RF energy from pcb traces. In this task, they function as high-frequency resistors that allow DC to pass while absorbing the RF energy and dissipating that energy in the form of heat. Compared with alternative solutions, surface-mount ferrite beads are small, lightweight, and inexpensive. Their high impedance values

INTRODUCTION TO EMC COMPONENTS

remove a broad range of RF energy while a closed magnetic circuit design eliminates crosstalk. Because of the bead's resistance characteristics at RF frequencies, spurious circuit oscillations or resonances are reduced.

To select the best bead for the application, the designer needs to know how much signal attenuation is required, the range of unwanted frequencies, the source of the electromagnetic energy, and the environmental and electrical conditions under which the circuit will operate.

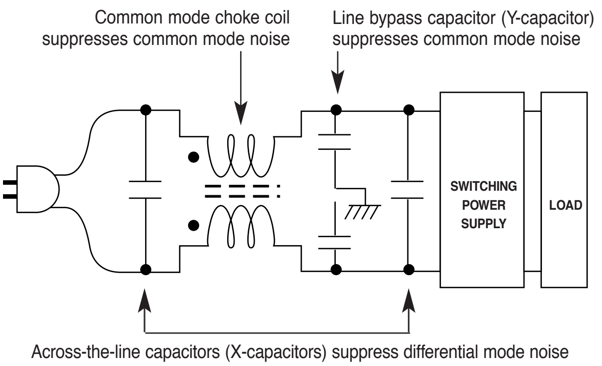
Selection of the right bead for a particular frequency is not always a simple process, since beads are only rated for impedance at 100 MHz and thus may or may not be optimal for circuits operating at higher or lower frequencies. DC bias will also lower the effective impedance of the device. Formerly, the selection process would have involved the study of several different graphs. Today there are available automated design tools like Vishay's *Surface Mount Ferrite Bead Designers Kit* (pictured on page 3) to assist designers in making the correct choice.

C BYPASS CAPACITORS/VARISTORS

CERAMIC CAPACITORS

Ceramic capacitors are often used to reduce EMI by shunting the unwanted signals to ground. Ceramic capacitors are available in many different configurations and sizes; choosing the right capacitor for the application depends on the electrical characteristics of the noise and the associated electrical circuit. Peak circuit voltage, frequency spectrum of both the wanted and unwanted signals, and energy content of the unwanted signal all play an important part in selecting the correct ceramic capacitor for EMI filtering. It is important when using capacitors as EMI filters to insure that the circuit has a stable ground. The impedance of circuits using ceramic capacitors as EMI filters are characterized by high impedance.

NOISE SUPPRESSION ON AC POWER LINE



TYPE X AND Y RFI CAPACITORS

RFI Capacitors are used to reduce interference that is conducted on the AC line either in common mode or in differential mode. Differential-mode interference can be envisioned as a noise source connected between the main and neutral wires. A properly applied type X (or "line-to-line") capacitor is an effective solution for this case. Common-mode interference is represented by a source between either main or neutral and chassis ground, and the appropriate solution is a type Y (or "line-to-ground") capacitor to provide filtering.

X capacitor values are determined by the frequency spectrum of the offending noise sources and therefore can be any available value, although they typically range from 0.1µF to 1.0µF, and are metallized film construction. Improved pcb layout practices can allow these values to be reduced. Two smaller value X capacitors are usually a better solution than one larger value X capacitor, especially when used in a pie filter configuration with a choke. Y capacitors are normally ceramic and have values that are restricted typically to values around 4700pF to reduce to a minimum 50/60Hz leakage current to ground. The diagram (below left) of a noise suppression solution on an AC Power line shows the normal use of both X and Y type capacitors.

X Capacitor Applications. X Capacitors are suitable only for applications where there is no danger of a short-circuit resulting in an electric shock. X type capacitors are divided into subclasses corresponding to the peak voltages to which they are subjected in addition to the power line voltage. All three classes are described in order of their popularity in the table below.

MAIN X TYPE CAPACITORS

Subclass	Peak pulse voltage $\sqrt{p}$ in operation	Application	Peak values of surge voltage V_p (before endurance test)
X1	2,5 kV < V_p ≤ 4,0 kV	Use for high peak voltages	For C ≤ 1,0 µF: V_p = 4,0kV For C > 1,0 µF: $V_p = \frac{4,0}{\sqrt{CN}}$ kV¹)
X2	V_p ≤ 2,5 kV	General purpose	For C ≤ 1,0 µF: V_p = 2,5kV For C > 1,0 µF: $V_p = \frac{2,5}{\sqrt{CN}}$ kV¹)

MAIN Y TYPE CAPACITORS

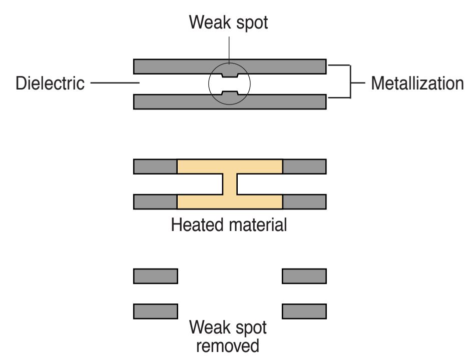
Subclass	Type of bridged insulation	Rated AC voltage	Peak values of surge voltage V_p (before endurance test)
Y1	Double or reinforced	V_R ≤ 250V	8,0kV
Y2	Basic or supplementary	150V ≤ V_R ≤ 250V	5,0kV

Y Capacitor Applications. Capacitors connected between power lines and ground (Y capacitors) have the potential upon a loss of earth ground to pass current from the device ground (metal case) by means of capacitive leakage current. Y capacitors are designed to limit the leakage current so that no dangerous voltages or currents can occur on exposed metal parts resulting in personal injury or death. This leakage current is even more restricted in medical type equipment. In ordinary data processing equipment, class Y2 is generally required when bridging the AC primary to ground. Some applications such as bridging the DC side of the primary to ground may require a Y1 type.

RFI CAPACITOR CONSTRUCTION

There are two types of RFI capacitors commonly in use on the AC line. These are metallized film and ceramic. The ceramic capacitor was described above. The metallized film are categorized as "self healing" while ceramic is not. The property of self healing, properly designed into a capacitor, can extend its life while maintaining a small size and safe operation.

THE PROCESS OF SELF HEALING



VARISTORS

A varistor is used to protect sensitive circuits from excessive voltage excursions or spikes that could damage components. The diagram to the right shows typical characteristics of voltage transients by peak voltage and transient duration in microseconds. A varistor acts as a short to voltage excursions or spikes that exceed the specified voltage of the varistor. By allowing voltage transients to be bypassed to ground a varistor can prevent circuit damage and reduce EMI problems.

R ATTENUATION

A resistor is used to attenuate signals or to maintain signal integrity while reducing power consumption through the conversion of the signal's electrical energy into heat. Excess noise is often generated in circuits because of impedance mismatches between circuits that result in overdriving of components that can lead to the production of unwanted harmonics (noise). Matching circuit impedance and attenuating signals between circuits is often done using a complex network of independent resistors. This same goal can be accomplished using a signal chip that is designed to duplicate the resistor network on a single chip. Every resistor is performing similar because of the usage of the same substrate and batch. This type of device is referred to as a chip attenuator and can help prevent EMI.

MULTIFUNCTION

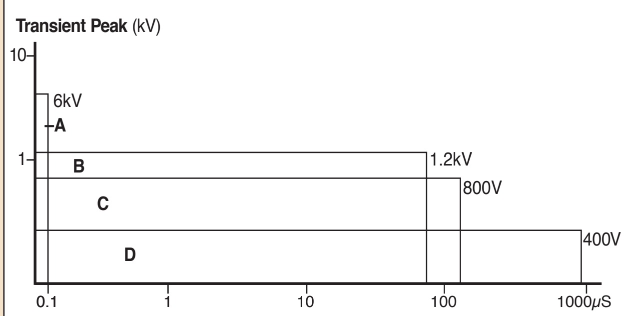
C+R A resistor and capacitor combination is often the simplest, most compact and inexpensive way to provide the filtering function. With thick film or thin film technology, a resistor/capacitor filter can be built for either a low-pass or high-pass response depending on the schematic chosen. Values can be adjusted to filter a wide range of frequencies found in RF designs. These R/C filters can take the form of a single chip, or an array can be used where multiple signal lines need a particular frequency response. R/C filters are used for lines with no resistive termination. Thin film resistor/capacitor networks provide substantial space savings with exceptional performance.

EMI/EMC COMPONENT SELECTION

Once the designer knows which circuit paths and circuit areas are likely to conduct noise—and which circuit areas are likely to act as antennas and radiate noise—the most appropriate location for the components chosen can be determined. The choice of components will depend on the frequency and signal level of the noise to be eliminated. Naturally consideration must also be given to the frequencies that should be left intact.

Another consideration is the circuit impedance. The diagram to the right shows the relationship between impedance and the type of filter to be used.

TYPES OF TRANSIENTS FOUND ON THE LINE

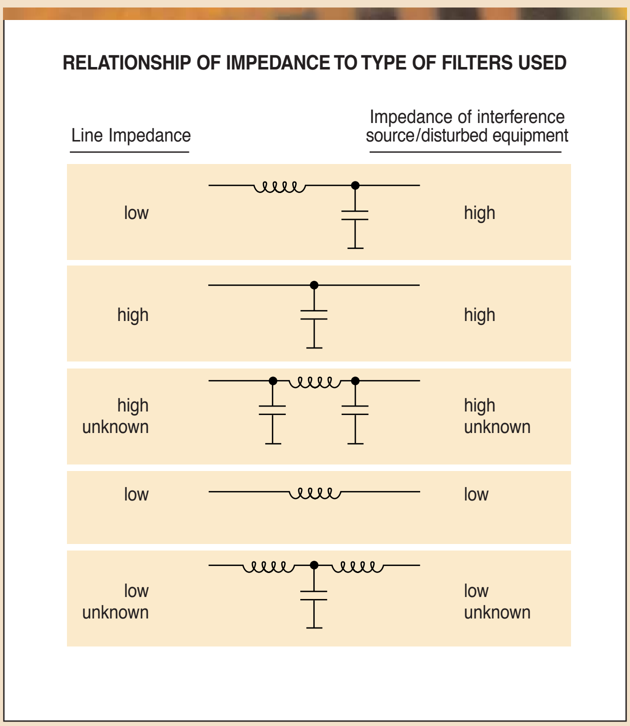


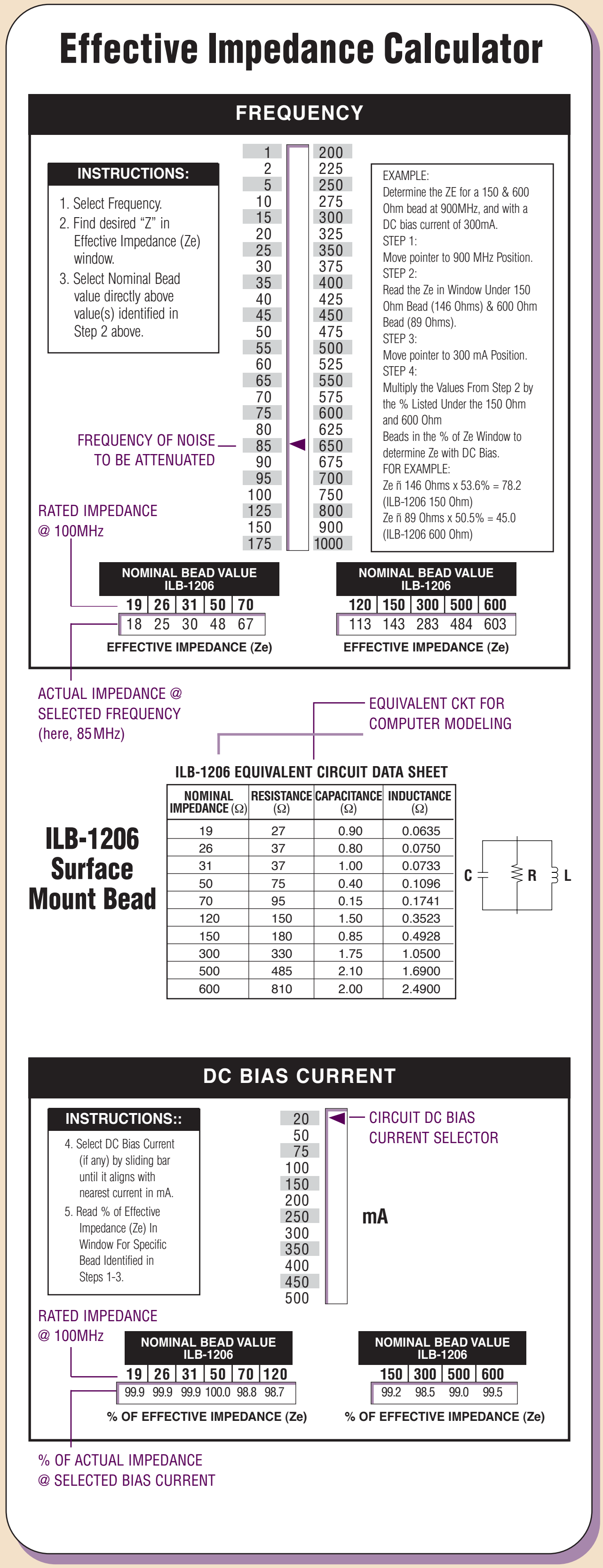
A = 0.1μS/6kV Atmospheric interference such as lightning.
B = 60μS/1.2kV Failure in the network or in nearby equipment, such as flashovers and fuse breakings.
C = 200μS/800V On/off operation of equipment such as motors, air conditioning units, etc.
D = 1000μS/400V Pulses from equipment such as welders, thyristors, triacs, etc.

In high-speed signal circuits, the easiest choice is a pure resistor termination followed by R/C filter terminations. The best choice is a complex filter consisting of inductive and capacitive components. In lower-speed circuits, grounding stability must be determined first. Capacitive EMI components are an excellent choice when a stable ground is available, but if the circuit has an unstable ground, designers should consider using inductive components that can provide sufficient impedance to the noise to reduce it below the acceptable threshold for EMI or RFI.

Oftentimes it will be possible to measure the overall radiation level from a given piece of equipment only at the end of the design process, so choosing the wrong component can have adverse consequences downstream. Although some measure of trial and error may always be necessary, designers can minimize wasted time by observing the following rules:

- Always place EMI/EMC components as close as possible to the noise source.
- Select EMI/EMC components that match the impedance of the noise conduction path, whether or not this is the same as the circuit path. Remember that common-mode noise tends to travel in a different path from circuit current.
- Always begin the design process with EMI/EMC components that offer more than sufficient performance to meet emission standards. There is always time to work on reducing component costs once a working design is developed.

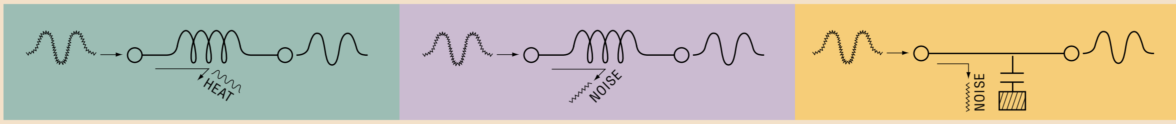




ILB-1206 EQUIVALENT CIRCUIT DATA SHEET

NOMINAL IMPEDANCE (Ω)	RESISTANCE (Ω)	CAPACITANCE (Ω)	INDUCTANCE (Ω)
19	27	0.90	0.0635
26	37	0.80	0.0750
31	37	1.00	0.0733
50	75	0.40	0.1096
70	95	0.15	0.1741
120	150	1.50	0.3523
150	180	0.85	0.4928
300	330	1.75	1.0500
500	485	2.10	1.6900
600	810	2.00	2.4900

Above is a representation of the calculator included in Vishay's *Surface Mount Ferrite Bead Designers Kit.* The kit is available upon request.

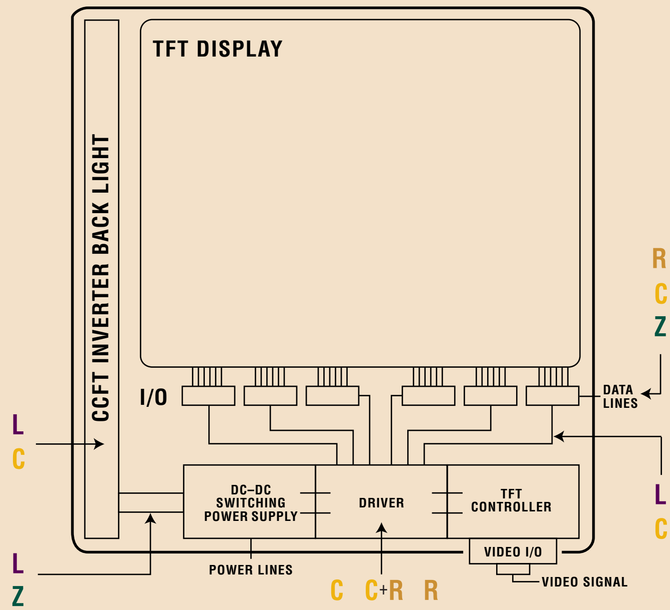


Z ABSORPTION   L REFLECTION   C BYPASS

VIDEO DISPLAY

CRT, **LCD SCREEN**, HDTV, TV

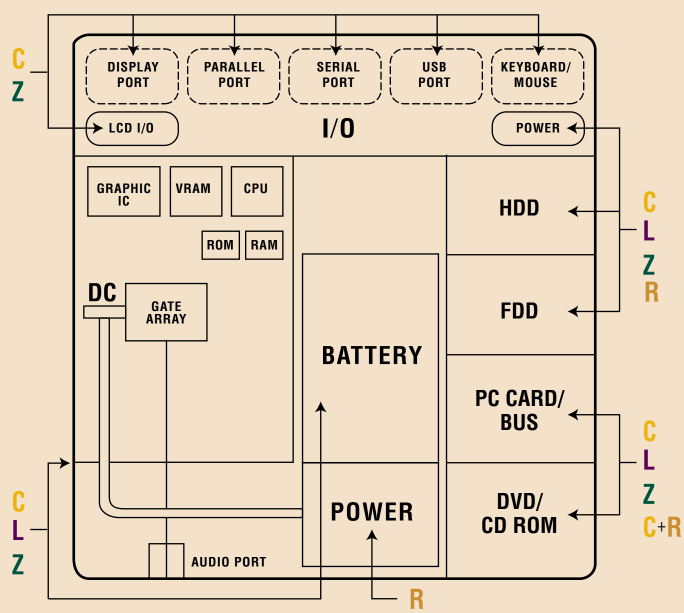
APPLICATION GOAL	VISHAY COMPONENTS	
Suppress Noise from Signal Lines	• Capacitor/Resistor Filter • Ceramic Capacitor • Ferrite Chip Bead • Inductor • Common Mode Choke Coil • Chip Array	C+R C Z L L R
Suppress Noise from AC Power Lines	• Varistor	C
Suppress Noise from DC Power Lines	• Ferrite Chip Bead • Common Mode Choke Coil	Z L
Suppress Noise from I/O Cables	• Ferrite Chip Bead	Z

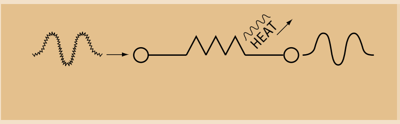


PERSONAL COMPUTER

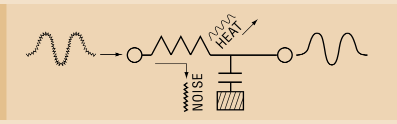
SERVERS/PC, PDA, MODEM, **NOTEBOOK**

APPLICATION GOAL	VISHAY COMPONENTS	
Suppress High Speed Digital Signal Line Noise	• Capacitor/Resistor Filter • Ceramic Capacitor • Ferrite Chip Bead • Inductor • Chip Array	C+R C Z L R
Suppress High Frequency Digital Noise on DC Power Line	• Ceramic Disc Capacitor • Chip Capacitor • Feed through Capacitor • Ferrite Bead • Inductor • Common Mode Choke Coil	C C C Z L L
Suppress High Frequency Digital Noise on AC Power Line	• Safety Capacitor • Chip Array	C R
Suppress High Frequency Digital Noise I/O Cables	• Ferrite Clamps & Cores • Chip Array	Z R





R ATTENUATION



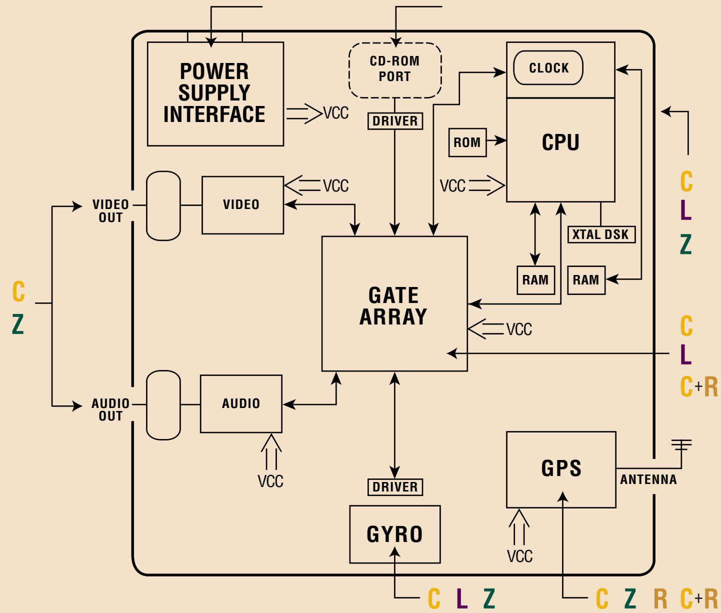
C+R MULTIFUNCTION

EMC APPLICATIONS

AUTOMOTIVE

NAVIGATION, ENGINE CONTROL, STEERING, AUDIO, SUSPENSION

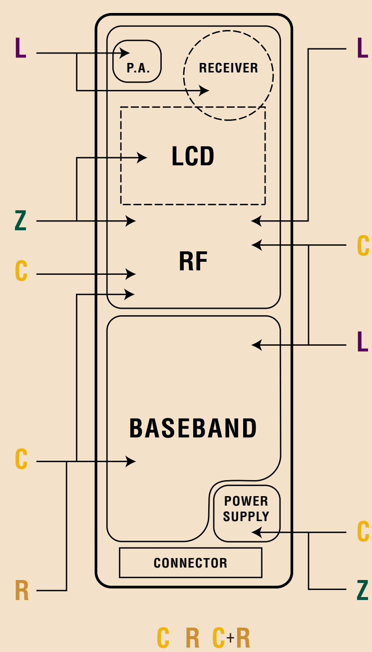
APPLICATION GOAL	VISHAY COMPONENTS	
Suppress High Frequency Noise on DC Power Line	• Varistor • Ferrite Bead • Common Mode Choke Coil • Choke Coil	C Z L L
Suppress High Frequency Noise on Signal Lines	• Capacitor/Resistor Filter • Ceramic Capacitor • Varistor • Inductor • Ferrite Bead • Chip Array	C+R C C L Z R
Suppress Noise from Voltage & Current Surges	• Ceramic Capacitor • Varistor • Inductor • Ferrite Bead	C C L Z
Suppress High Frequency Noise from Motors, Solienoids & Electronic Switches	• Choke Coil • Varistor • Inductor	L C L

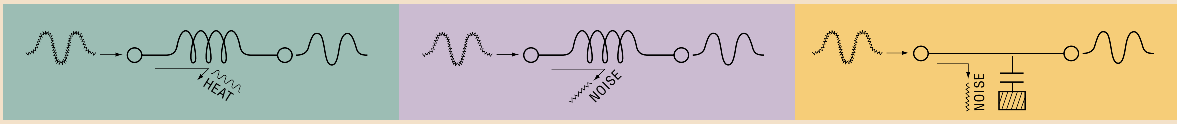


TELECOMMUNICATION

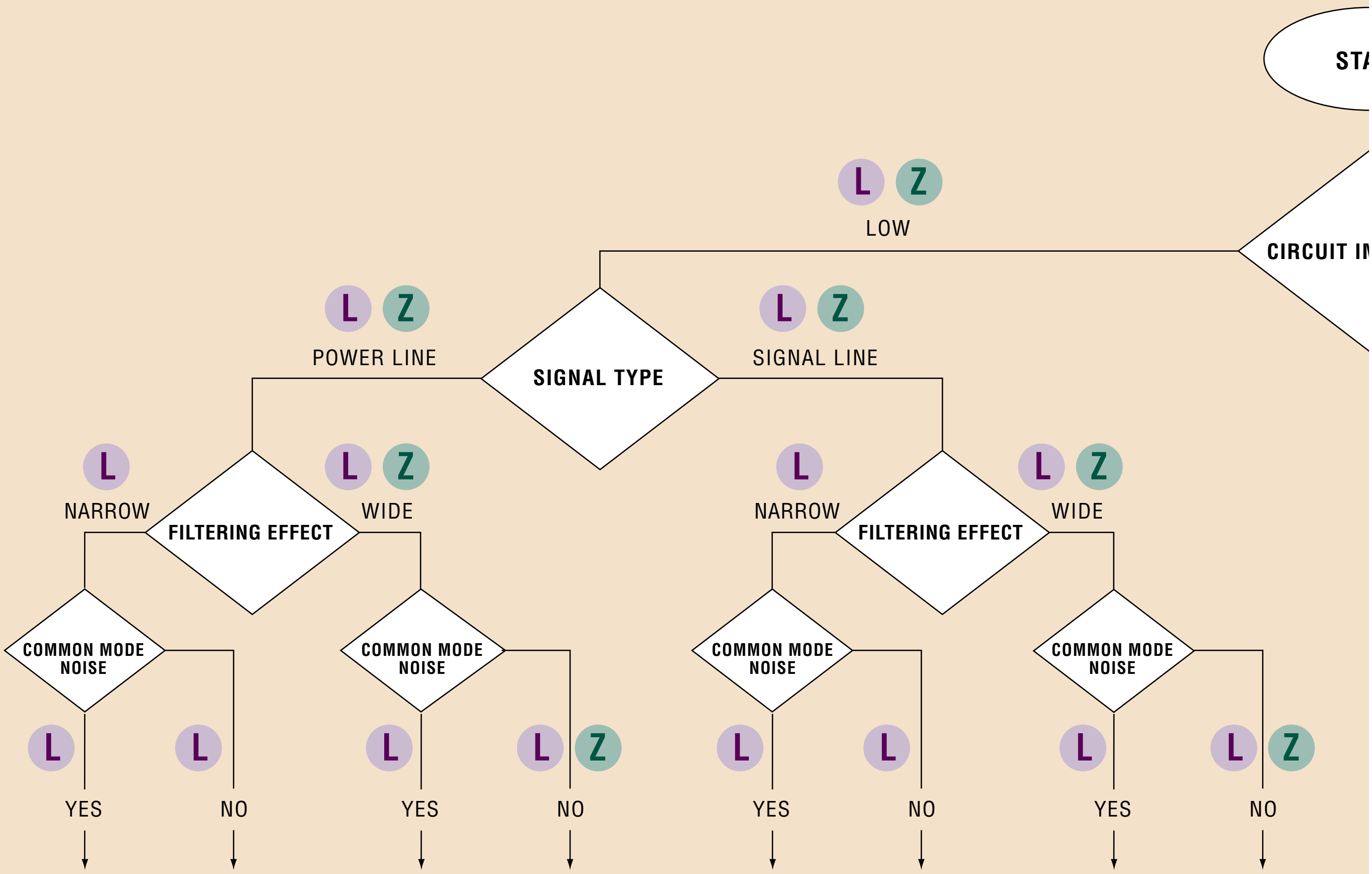
TELEPHONE, FAX, **CELLULAR**, xDSL, SATELLITE

APPLICATION GOAL	VISHAY COMPONENTS	
Suppress Line Noise from AM/FM, CB, TV/VCR	• Ceramic Capacitor • Ferrite Inductor • Common Mode Choke Coil	C Z L
Suppress Transmitter Noise (Low & High)	• Capacitor/Resistor Filter • Ceramic Capacitor • Chip Capacitor • Attenuator	C+R C C R
Suppress High Frequency Digital Signal Noise	• Line Filter • Feed Through Capacitor • Ferrite Chip Beads • Chip Array	C C Z R
Suppress Line & Power Supply Noise from Surges of Voltage and/or Current	• Varistor • Chip Capacitor • Disc Capacitor • Common Mode Choke Coil	C C C L
Suppress Static Discharge Noise	• Capacitor	C





Z ABSORPTION L REFLECTION C BYPASS



COMMON MODE FILTER:

SMD
LPT-4545
LPT-3535

Leaded
TJ3
TJ4
TJ5
TJ6
TJ7
TJ8
TJ9

CHOKE:

SMD
LPT-4545
LPT-3535
IHSM-3825
IHSM-4825
IHSM-5832
IHSM-7832

IDCP-1813
IDCP-2218
IDCP-3020
IDCP-3114
IDCP-3722
IDCP-3916
IDC-2512
IDC-5020
IDC-7328
IDCS-2512
IDCS-5020
IDCS-7328

Leaded
IHD-1
IHD-3

TJ3
TJ4
TJ5
TJ6
TJ7
TJ8
TJ9

TE3 through 5
TD3 through 5

COMMON MODE FILTER:

SMD
LPT-4545
LPT-3535

Leaded
TJ3
TJ4
TJ5
TJ6
TJ7
TJ8
TJ9

BEAD or CHOKE:

SMD bead
ILHB-0603
ILHB-0805
ILHB-1206
ILHB-1806
ILHB-1812

SMD choke
LPT-4545
LPT-3535
IHSM-3825
IHSM-4825
IHSM-5832
IHSM-7832

IDCP-1813
IDCP-2218
IDCP-3020
IDCP-3114
IDCP-3722
IDCP-3916
IDC-2512
IDC-5020
IDC-7328
IDCS-2512
IDCS-5020
IDCS-7328

Leaded
IHD-1
IHD-3

TJ3 through 9

TE3 through 5
TD3 through 5

COMMON MODE FILTER:

SMD
LPT-4545
LPT-3535

Leaded
IHD-1
IHD-3

TJ3
TJ4
TJ5
TJ6
TJ7
TJ8
TJ9

CHOKE:

SMD
ILSB-0603
ILSB-0805
ILSB-1206

IMC-1210
IMC-1812

ISC-1210
ISC-1812 (shielded)

Leaded
IM-1
IM-2
IM-6
IM-8
IM-9
IM-10

IMS-2
IMS-5

IHD-1
IHD-3

TJ3
TJ4
TJ5
TJ6
TJ7
TJ8
TJ9

TE3 through 5
TD3 through 5

COMMON MODE FILTER:

SMD
LPT-4545
LPT-3535

Leaded
TJ3
TJ4
TJ5
TJ6
TJ7
TJ8
TJ9

BEAD or VARISTOR:

SMD bead
ILBB-0402
ILBB-0603
ILBB-0805
ILB-1206
ILBB-1210
ILBB-1806
ILBB-1812

ILAS-1206 (array)

SMD varistor
ILSB-0603
ILSB-0805
ILSB-1206

IMC-1210
IMC-1812

ISC-1210 (shielded)
ISC-1812 (shielded)

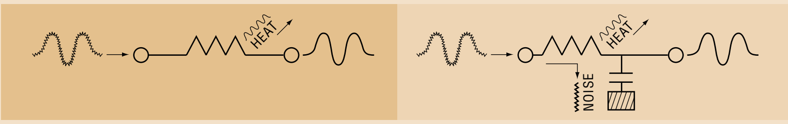
Leaded
IM-1
IM-2
IM-6
IM-8
IM-9
IM-10

IMS-2
IMS-5

TJ3 through 9

TE3 through 5
TD3 through 5

(Custom designs and variations of standards available upon request)

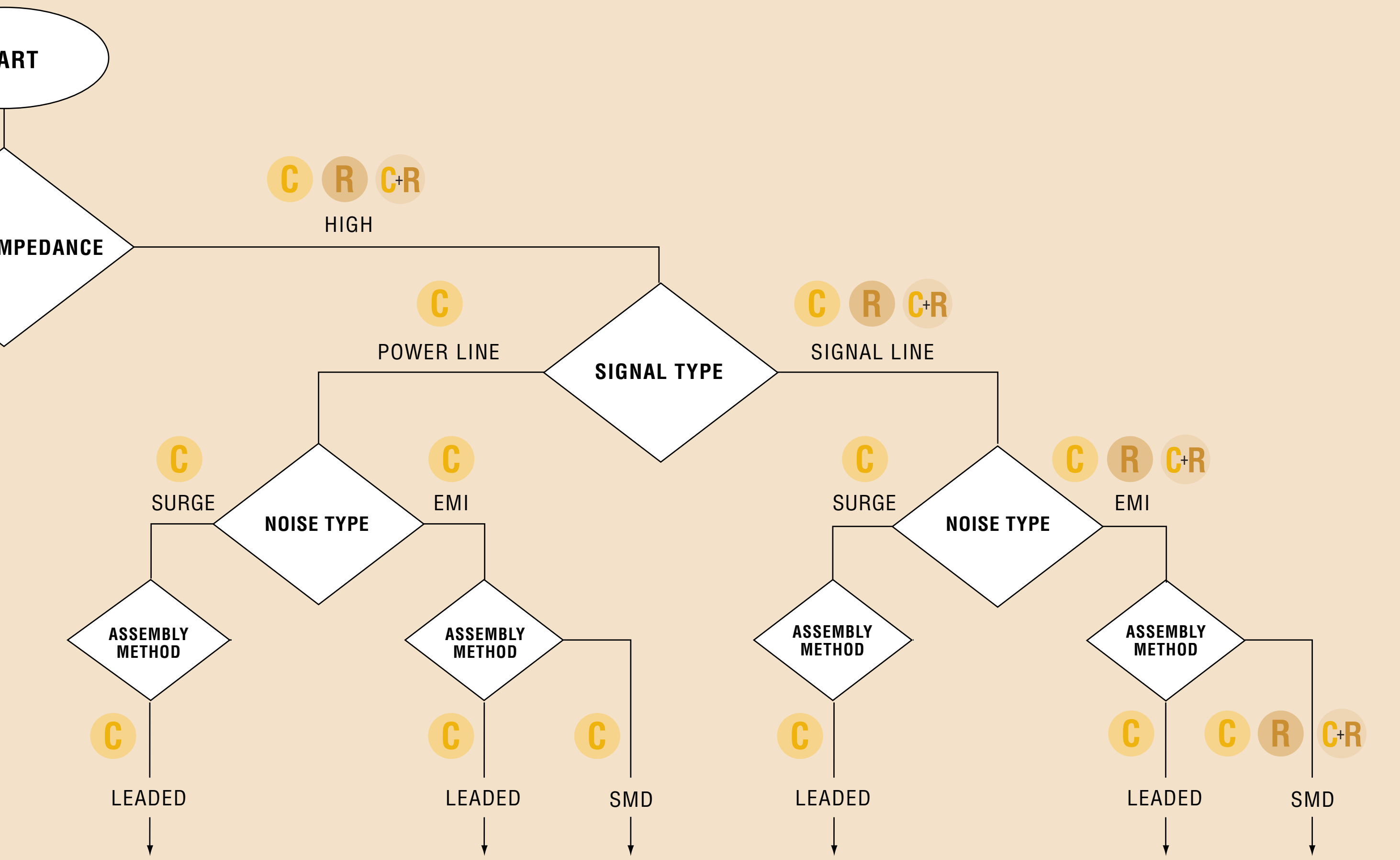


R ATTENUATION

C+R MULTIFUNCTION

EMC FILTER SELECTION GUIDE

LOW IMPEDANCE & HIGH IMPEDANCE



VARISTOR:

RMV05
RMV07
RMV10
RMV14
RMV18

EMI FILTER:

F1710-Y2
F1712-Y2
F1772-X2
F1773-X2
F1774-X2

F1722-X1
F1724-X2

F1778-X2
F1779-X2
WYO-Y2
WKO-Y2
WKP-Y1

VKO-X1/Y2
VKP-X1/Y1

EMI FILTER:

VJ0402Y
VJ0603Y
VJ0612Y

VJ0805Y
VJ1206Y
VJ1210Y

VJ1812Y
VJ1825Y
VJ2220Y
VJ2225Y

VJ0402A
VJ0603A
VJ0805A
VJ1206A
VJ1210A
VJ1812A
VJ1825A
VJ2220A
VJ2225A

VARISTOR:

RMV05
RMV07
RMV10
RMV14
RMV18

EMI FILTER:

VP31
VP32
VP40
VP41
VP43
VP44
VP52

VP31
VP32
VP40
VP41
VP43
VP44
VP52

EMI FILTER:

CZA

CRCA12E
or S / X7R or Y5U

CRCC1206
X7R or Y5U

VJ0603Q
VJ0805Q
VJ1206Q
VJ1210Q

VM3033Y-3033
VM3640Y-3640
VM4756Y-4759
VSSRC20-AB
VTSRC20-AB
VSORC20-AB
VSORC-20AC
VTSRC20-AC
VSORC20-AC
VRAC

T-Filter

VSSRC20-AA
VTSRC20-AA
VSORC20-AA
VSSRC20-AD
VTSRC20-AD
VSORC20-AD
VRAA
VRAD

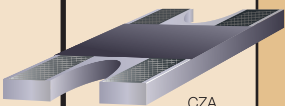
EMC Surface Mount Devices

POWER LINE AND SIGNAL LINE USE

R ATTENUATION

Resistors attenuate all frequencies by converting the RMS current into heat.

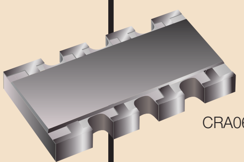
SIGNAL LINE



CZA

THICK FILM CHIP ATTENUATOR

Type / (LxW)	Attenuation	Impedance
CZA / .063 in x .059 in	1–6db	50–75 Ohms



CRA06

THICK FILM ARRAY

Type–Dimension	Value	Tolerance
CRA06	10 - 1M Ω	5%

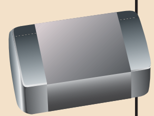
THIN FILM ARRAY

Type–Dimension	Value	Tolerance
TRAO6E	10-330K Ω	1-5%

Z ABSORPTION (FERRITE BEADS)

Ferrite bead absorbers block noise in the signal and convert it into heat.

POWER LINE

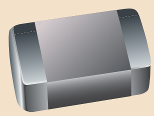


ILHB–0603

MULTILAYER FERRITE CHIP BEAD
MEDIUM–HIGH CURRENT

Type–Dimension	IMP / DC Current
ILHB–0603	60 – 120Ω / 2000mA
ILHB–0805	30 – 600Ω/ 2000 – 6000mA
ILHB–1206	500 – 600Ω/ 2500 – 6000mA
ILHB–1806	60Ω/ 6000mA
ILHB–1812	120 – 1300Ω/ 3000 – 6000mA

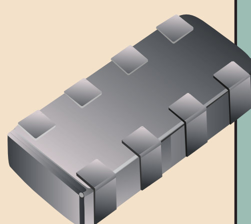
SIGNAL LINE



ILBB–0603

MULTILAYER FERRITE CHIP BEAD

Type–Dimension	IMP
ILBB–0402	20 – 600Ω
ILBB–0603	10 – 2000Ω
ILBB–0805	7 – 2200Ω
ILB–1206	19 – 2000Ω
ILBB–1210	31 – 90Ω
ILBB–1806	80 – 150Ω
ILBB–1812	70 – 120Ω



ILAS–1206

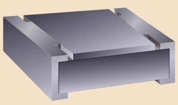
MULTILAYER FERRITE CHIP BEAD ARRAY

Type–Dimension	IMP
ILAS–1206 (0603 x 4)	60 – 1000Ω (STANDARD SPEED)

C+R MULTIFUNCTION

Combines two or more noise attenuation methods

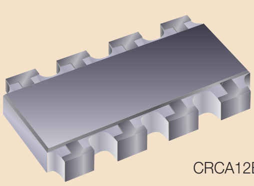
SIGNAL LINE



CRCC1206

THICK FILM RESISTOR / CAPACITOR CHIP

Type–Dimension / Dielectric	Capacitance / Resistance
CRCC1206 / X7R	10– 270pF / 10–1 MΩ
CRCC1206 / Y5U	270–1800pF / 10–1 MΩ



CRCA12E

THICK FILM RESISTOR / CAPACITOR ARRAY

Type / Die (LxW)	Terminals	Capacitance / Resistance
5.1 x 3.1 mm /Y5U	**8**	10–270pF 10–1 MΩ 270–1800pF 10–1 MΩ
CRCA12E or S/XYR	**10**	
6.4 x 3.1 mm /Y5U	**10**	10–270pF 10–1 MΩ 2700–1800pF 10–1 MΩ

"E" = scalloped edge "S" = square edge

THICK FILM RESISTOR / CAPACITOR ARRAY

Type / Terminator Network	Capacitance / Resistance
VSSRC20-AB	10-250pF / 10-750Ω
VTSRC20-AB	10-250pF / 10-750Ω
VSORC20-AB	10-250pF / 10-750Ω
VSSRC20-AC	10-250pF / 10-250Ω
VTSRC20-AC	10-250pF / 10-750Ω
VSORC20-AC	10-250pF / 10-750Ω
VSORC20-AC	10-250pF / 10-750Ω
VRAC	47pF / 33Ω
Filter	
VSSRC20-AA	10-250pF / 10-750Ω
VTSRC20-AA	10-250pF / 10-750Ω
VSORC20-AA	10-250pF / 10-750Ω
VRAA	47pF / 47Ω
VSSRC20-AD	10-250pF / 10-750Ω
VTSRC20-AD	10-250pF / 10-750Ω
VSORC20-AD	10-250pF / 10-750Ω
VRAD	50pF / 75Ω

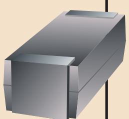
Note: Case sizes are listed in EIA standard sizes. Unless stated otherwise, case sizes use inches: e.g., 0805 equal .08 in long by .05 in wide.

L REFLECTION

Inductors reflect noise back to the source. Very effective for low impedence lines.

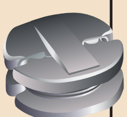
NORMAL MODE

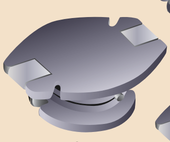
POWER LINE

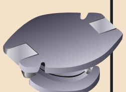

IHSM–5832

HIGH CURRENT MOLDED INDUCTOR

Type–Dimension	Inductance / Current
IHSM–3825	1–1000μH / 5.1–.16A
IHSM–4825	1–1000μH / 8.6–.24A
IHSM–5832	1–4700μH / 9–.14A
IHSM–7832	1–18000μH / 9–.11A


IDCP–1813


IDC–5020

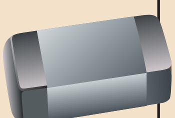

IDCS–5020

HIGH CURRENT DRUM CORDS INDUCTOR

Type–Dimension (LxH)	Inductance / Rated Current
IDCP–1813	1 – 68μH / 3.8–.46A
IDCP–2218	3.3 – 220μH / 2–.35A
IDCP–3020	10 – 470μH / 2.2–.34A
IDCP–3114	10 – 330μH / 1.14–.28A
IDCP–3722	10 – 820μH / 2.6–.24A
IDC–5020	1–100μH / 6.8–.3A
IDCS–5020	1–390μH / 5–33A
IDCP–3916	
IDC–2512	
IDC–5020	
IDC–7328	
IDCS2512	
IDCS–5020	
IDCS–7328	

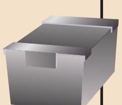
NORMAL MODE

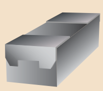
SIGNAL LINE

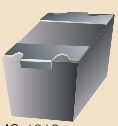

ILSB–1206

MULTILAYER FERRITE CHIP IN INDUCTOR

Type–Dimension	Inductance
ILSB–0603	.047 – 4.7μH
ILSB–0805	.047 – 27μH
ILSB–1206	.047 – 33μH


ISC-1210


IMC-1210

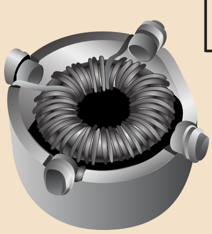

IMC-1812

WIREWOUND CHIP INDUCTOR
(SHIELDED AND UNSHIELDED)

Type–Dimension	Inductance
IMC–1210	.01 – 220μH
IMC–1812	.01 – 1000μH
ISC–1210 (SHIELDED)	.01 – 100μH
ISC–1812 (SHIELDED)	.1 – 1000μH

COMMON MODE

POWER & SIGNAL LINE


LPT-4545

LOW PROFILE TOROIDAL INDUCTOR

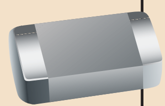
Type–Dimension	IMP
LPT–4545	Custom
LPT–3535	Custom

(Kool-MU, Powdered Iron, MMP Cores available)

C BYPASS

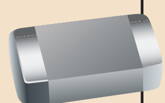
Noise elements in the signals are shunted to ground and prevented from entering the load. Very effective for high impedence lines.

POWER LINE


VJ0603Y

MULTILAYER CERAMIC CHIP CAP
HIGH VOLTAGE & SURGE SUPPRESSION

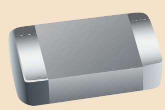
Type–Dimension	Capacity /VDC
VJ0603Y	220 pF–4700pF / 200V
VJ0805Y	220pF–.027uF / 200V
VJ1206Y	680 pF–.068uF / 200,500V
VJ1210Y	1000pF–.15uF / 200, 500V
VJ1808Y	470pF–.1uF / 200, 500V, 1000V
VJ1812Y	1000pF–.33uF / 200, 500V, 1000V
VJ1825Y	.015uF–.68uF / 200, 500V, 1000V
VJ2220Y	.015uF–.47uF / 200, 500V
VJ2225Y	.033uF–1.2uF / 200, 500V, 1000V
VJ0603A	1pF–270pF / 200V
VJ0805A	1pF–820pF / 200V, 500V
VJ1206A	1pF–3300pF / 200V, 500V
VJ1210A	10pF–5600pF / 200V, 500V
VJ1808A	120pF–6800pF / 200V, 500V, 1000V
VJ1812A	10pF–.012uF / 200V, 500V, 1000V
VJ1825A	100pF–.027uF / 200V, 500V
VJ2220A	2200pF–.012uF / 200V, 500V, 1000V
VJ2225A	1000pF–.039uF / 200V, 500V


VV0603Z

MULTILAYER CERAMIC CHIP VARISTOR
METAL OXIDE

Type–Dimension	VDC Surge 1
VV0603Z	5.5 – 18V / 30A
VV0805Z	5.5 – 18V / 150A
VV1206Z	5.5 – 65V / 150 – 200A
VV1210Z	5.5 – 65V / 150 – 400A
VV1812Z	5.5 – 65V / 250 – 600A
VV2220Z	5.5 – 65V / 300 – 1000A

SIGNAL LINE


VJ0603Q

MULTILAYER CERAMIC CHIP CAP
HIGH Q

Type–Dimension	Capacitance /VDC
VJ0603Q	1pF–100pF/ 50V, 100V
VJ0805Q	1pF–220pF/ 50V, 100V, 200V
VJ1206Q	1pF–330pF/ 50V, 100V, 200V
VJ1210Q	180pF–680pF/ 50V, 100V, 200V

MULTILAYER CERAMIC CHIP CAP
X7R (NORMAL)

Type–Dimension	Capacitance/ VDC
VJ0402Y	100–10,000pF / 25–100V
VJ0603Y	100–100,000pF / 16–100V
VJ0805Y	100–330,000pF / 16–100V
VJ1206Y	100–1,000,000pF / 16–100V
VJ1210Y	27,000–1,000,000pF / 25–100V
VJ1812Y	100,000–1,500,000pF / 25–100V
VJ2220Y	270,000–1,500,000pF / 50–100V
VJ2225Y	180,000–4,700,000pF / 50–100V

X7R (LOW INDUCTANCE)

VJ2225Y	8200–220,000pF / 25–50V

X7R (MULTI-CHIP ASSEMBLED)

VM3033Y – 3033	150–1200pF / 50–500V
VM3640Y – 3640	390–1800pF / 50–500V
VM4756Y – 4759	680–27000 / 50–500V

Ⓛ REFLECTION

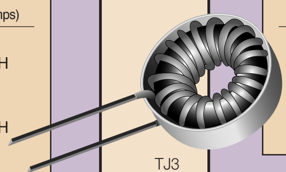
Inductors reflect noise back to the source. Very effective for low impedance lines.

POWER LINE

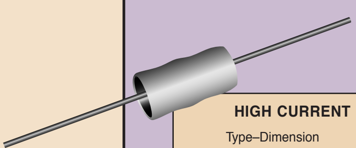
TOROIDAL INDUCTORS

Type-Dimension (DxH)	Inductance / IDC (amps)
TJ3–1U/2U	
16.5 x 7.6 mm(V)	1.2 – 1500µH
16.8 x 8.1 mm(H)	10 – .5A
TJ4–1U/2U	
22.4 x 10.2 mm(V)	1.2 – 1500µH
22.4 x 10.2 mm(H)	10.7 – .9A
TJ5–1U/2U	
25.4 x 11.4 mm(V)	1.2 – 1500µH
25.4 x 11.4 mm(H)	10.1 – 1.3A
TJ6–1U/2U	
35.1 x 21.1 mm(V)	1.2 – 2700µH
35.1 x 21.1 mm(H)	16 – 2A
TJ7–1U/2U	
41.9 x 19.1 mm(V)	1.2 – 2700µH
41.9 x 19.1 mm(H)	16 – 27.A
TJ8–1U/2U	
48.8 x 25.4 mm(V)	1.5 – 3900µH
49.3 x 25.4 mm(H)	18.5 – 3.2A
TJ9–1U/2U	
67.6 x 36.1 mm(V)	1.5 – 5600µH
69.1 x 36.1 mm(H)	20 – 5A

1U = Vertical Mount 2U = Horizontal Mount



TJ3



IHD-1

HIGH CURRENT INDUCTORS

Type–Dimension	Inductance / IDC
IHD–1	1 – 18,000µH
6.8 x 17.8 mm	5.3 – .08A
IHD–3	3.9 – 100,000µH
11.7 x 22.3 mm	4 – .07A

SIGNAL LINE

TOROIDAL INDUCTORS

Type–Dimension (DxH)	Inductance / IDC (amps)

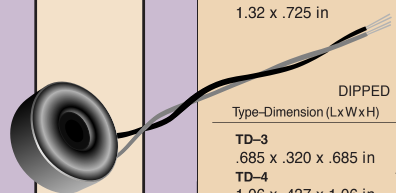
TJ/TD3 through TJ/TD9

(Toroidal inductors for signal line use are identical to those for power line use. Refer to data at left.)

TOROIDAL FILTER INDUCTORS

ENCAPSULATED

Type–Dimension (L x H)	Inductance
TE–3	50µH – 4H
.685 x .385 in	
TE–4	150µH – 2H
1.06 x .500 in	
TE–5	1mH – 2H
1.32 x .725 in	

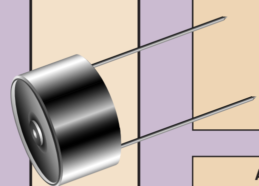


TE

DIPPED

Type–Dimension (LxWxH)	Inductance
TD–3	50µH – 4H
.685 x .320 x .685 in	
TD–4	150µH – 2H
1.06 x .437 x 1.06 in	
TD–5	1mH – 2H
1.32 x .688 x 1.32 in	

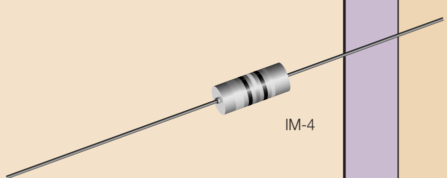
Core Materials:
Q0 = highest DCR
Q1 = low DCR
Q4 = lowest DCR



TD

AXIAL MOLDED INDUCTORS

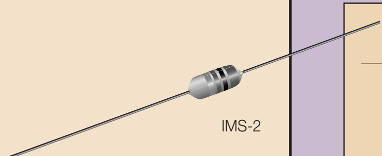
Type–Dimension	Inductance
IM–1	
2 x 5 mm	.1 – 100µH
IM–2	
2.4 x 6.4 mm	.022 – 1000 µH
IM–4	
3.9 x 9.4 mm	.15 – 1800µH
IM–6	
4.8 x 11.2 mm	.1 – 1000µH
IM–8	
5.4 x 14.2 mm	1100 – 3600µH
IM–9	
6.3 x 14.2 mm	68 – 150µH
IM–10	
6.1 x 18.7 mm	3900 – 10,000µH



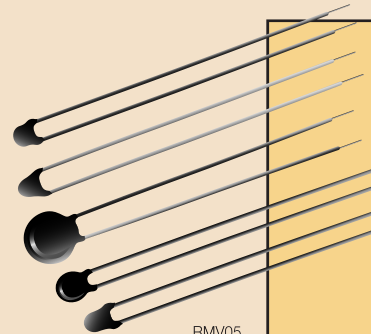
IM-4

SHIELDED MOLDED INDUCTORS

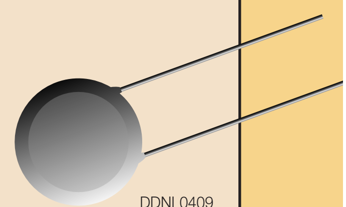
Type–Dimension	Inductance
IMS–2	
2.5 x 6.4 mm	.1 – 560µH
IMS–5	
4.1 x 10.4 mm	.1 – 100,000 µH



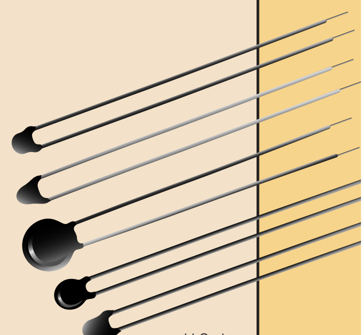
IMS-2



RMV05



DDNL0409



H Series

EMC LEADED DEVICES

POWER LINE AND SIGNAL LINE USE

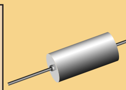
C BYPASS

Noise elements in the signals are shunted to ground and prevented from entering the load. Very effective for high impedance lines.

POWER LINE

LEADED VARISTOR

Type–Dimension (DxL)		AL (VRMS)
RMV05	7 x 5 mm	250 – 300V
RMVO7	9 x 5 mm	250 – 300V
RMV10	12.5 x 5.2 mm	250 – 300V
RMV14	16.5 x 6 mm	250 – 300V
RMV18	20.5 x 6 mm	250 – 300V



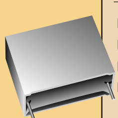
MKP1842

RFI CAP POLYPROPYLENE

Type	Capacitance / VDC
MKP1842	.01 – .68 / 400V
MKP1844	.01 – 1.0 / 400V
F1778–X2	.01 – 2.2 / 275V
F1779–X2	.01 – 2.2 / 305V
	.01 – 2.2 / 275V
	.01 – 2.2 / 305V

FEED THROUGH FILTERS

Type – Class	(DxL)	Capacitance / VDC
DDNL0409–2	4.3 x 9 mm	1600 / 400V
DDM20312–2	3 x 12 mm	5000pF / 200V
DDML04...	4.3 x 9–20 mm	1600–7000pF / 400V



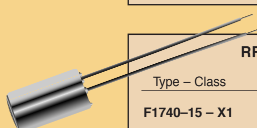
F1772

RFI CAP POLYESTER FILM

Type – Class	Capacitance / VDC
F1710 –Y2	.001 – .1 / 250V
F1710–X1Y2	.001 – .1 / 305V
F1712 –Y2	.001 – .1 / 250V
F1772 –X2	.01 – 2.2 / 275V
	.01 – 2.2 / 300V
F1773 –X2	.01 – 1.0 / 440V
F1774 –X2	.01 – 2.2 / 253V
	.01 – 2.2 / 275V
	.01 – 1.0 / 440V
F1722 –X1	.01 – .47 / 440V
F1724 –X1	.01 – .47 / 440V

HIGH VOLTAGE DISK CAPACITORS

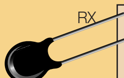
Type	Capacitance / VDC
HA	47pf – .022uf / 1KV
HB	56pf – .022uf / 2KV
HC	68pf – .015uf / 3KV
HD	33pf – 4700pf / 4KV
HF	56pf – 6800pf / 6KV
HG	100pf – 2200pf / 8KV
HH	100pf – 1200pf / 10KV
HI	100pf – 820pf / 15KV



F1740

RFI CAP PAPER

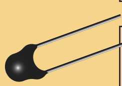
Type – Class	Capacitance / VDC
F1740–15 – X1	.0068 – .47uF / 275V
F1740–35 – X1Y2	.022 – .47μH / 275V +2X (2700pF – .027uF) / 275V
F1740–55 – X1Y2	.022 – .47 / 275V +2X (2400pF – .027uF) / 275V



RX

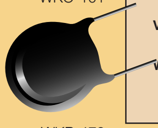
RFI CAP CERAMIC

Type – Class	Capacitance / VDC
W1X – X1	4700pF–.22uF / 275V



WYO-102

WKO-101

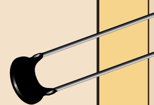


WKP-472

RFI CAP CERAMIC – SAFETY DISC

Type	Capacitance / VDC (Class)	
WYO	1000pF – .22uF / 250 (Y2)	
VKO	1000 – 4700pF	/ 440 (X1) / 250 (X2)
WKO	33 – 4700pF	/ 440 (X1) / 250 (Y2)
VKP	470 – 4700pF	/ 760 (X1) / 500 (Y1)
WKP	33 – 4700pF	/ 440 (X1) / 250 (Y1)

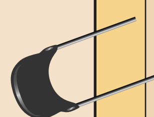
SIGNAL LINE



VP31

MULTILAYER CERAMIC RADIAL DIPPED
NPO CAPACITORS

Type	(HxW)	Lead Space	Capacitance/VDC
VP31	4 x 4 mm	2.54	1 – 1800 50 – 100VDC
VP32	5.1 x 5.1 mm	2.54	10 – 10000 50 – 100V
VP40	4 x 4 mm	5.08	1 – 1800 50 – 100V
VP41	5.1 x 5.1 mm	5.08	1 – 10000 50 – 100V
VP43	6.8 x 6.5 mm	5.08	680 – 18000 50 – 100V
VP44	7.6 x 7.6 mm	5.08	6800 – 56000 50 – 100V
VP52	5.1 x 6.8 mm	7.62	820 – 10000 50 – 100V



VP31

MULTILAYER CERAMIC RADIAL DIPPED
X7R CAPACITORS

Type	(HxW)	Lead Space	Capacitance/VDC
VP31	4 x 4 mm	2.54	100 – 150000 25 – 100V
VP32	5.1 x 5.1 mm	2.54	1000 – 820000 25 – 100V
VP40	4 x 4 mm	5.08	100 – 100000 25 – 100V
VP41	5.1 x 5.1 mm	5.08	100 – 820000 50 – 100V
VP43	6.5 x 6.8 mm	5.08	22000 – 1500000 50 – 100V
VP44	7.6 x 7.6 mm	5.08	220000 – 2000000 50 – 100V
VP52	5.1 x 6.8 mm	2.62	12000 – 220000 50 – 100V

Note: Case sizes are listed in EIA standard sizes. Unless stated otherwise, case sizes use inches: e.g., 0805 equals .08 in long by .05 in wide.

AF Audio Frequency. Components of signal or noise having frequencies in the 15Hz–20kHz range.

ANSI American National Standards Institute

ANSI/IEEE C95.1-1992 Recommendation for limits of maximum human exposure to radiated fields.

Case Size The physical size of a component. Vishay sizes are usually included in the part number. "0805" means the device is .08″ long and .05″ wide. The case size is usually followed by the parts value.

Capacitor A passive component whose reactance, $X_C = 1/2\pi f$, decreases with frequency at 20 dB/decade.

Capacitors, Feed Through Single-stage capacitors that are bulkhead mounted to provide low insertion inductance.

CCIR International Radio Consultative Committee

CE Mark CE European product compliance (conformity) mark

Certification (FCC) A procedure that requires submittal of a written application to the FCC that includes an application form 731, fee, complete technical description of the product and a measurement report showing compliance with the FCC technical standards.

Characteristic Impedance The equivalent circuit of a transmission line, Z_O, defining if lossy and reactive properties:

For ELF/VLF: $Z_O = \sqrt{R/G}$ ohms
For frequencies >10 kHz: $Z_O = \sqrt{L/C}$ ohms

Chip Bead A generic term for a ferrite component ("bead") that is produced in a surface mount package. A chip bead already has an internal conductor *inside*, so no additional parts are necessary to make the component work.

Common Mode When applied to two or more wires, all currents flowing therein which are in phase.

DC Current Rating The maximum amount of direct current that can safely pass through the component.

DC/DC Converters These devices are used in DC power-distribution, and convert DC voltage from one level to another DC level.

Differential Mode On a wire pair when the currents are of opposite polarity.

EMC Electro-Magnetic Compatibility. The practice of building electronic devices so that they do not create (or are susceptible to) EMI/RFI.

EMI When an electrical disturbance from natural phenomena or an electrical/electronics device or system causes an undesired response in another.

ESD An electrostatic discharge with a fast risetime, intensive discharges from humans, clothing, furniture and other charged dielectric sources.

FCC Federal Communications Commission. Mission: to manage the spectrum and provide leadership in order to create new opportunities for competitive technologies and services for the American public. Website: http://www.fcc.gov.com

Ferrites Powdered magnetic (permeable) material in the form of beads, rods and blocks used to absorb EMI on wires and cables. Ferrites convert the associated EMI magnetic-flux density into heat.

Ferrite Beads A ferrite core with a conductor passing through the ferrite (as opposed to wrapping the wire aroune the ferrite). These devices resemble a bead in a necklace. Ferrite beads are also available in a surface mount package.

Harmonic An integer multiple of the fundamental frequency.

HF High frequency: frequency ranging from 3 MHz to 30 MHz.

IEC International Electrotechnical Commission

IEEE Institute of Electrical and Electronic Engineers

IEEE/EMC The EMC Society (professional group) within the IEEE.

Impedance The vector sum of resistance and reactance at any specified frequency, where the reactance corresponds to that of an inductor or capacitor, as applicable.

Inductor A passive component whose reactance, $X_L = 1/2\pi f$, increases with frequency at 20 dB/decade.

Inductors and Coils Discrete devices used to pass low-frequency and reject high-frequency EMI. Often used in filters, safety-ground lines with ferrites and oscillator tank circuits.

I/O input/output (port or cable)

LF Low frequency: frequency ranging from 30 kHz to 300 kHz. This includes many navigation bands, including Loran.

Maximum DC Resistance The maximum value of resistance (how much opposition there is to current flow) that will be exhibited by the device.

MOV Metal-Oxide Varistor

Radio Frequency In the ANS/IEEE, Standard 1001984, the term is commonly used to cover the frequency range from 10 kHz to 1000 GHz.

RFI Radio Frequency Interference. Exists when either the transmitter or receiver has an antenna, causing undesired interference with other equipment or systems.

SMD Surface Mount Device. An electronic component without wire-type external leads; the solder terminals are built as an integral part of the component.

Surge A sudden voltage increase on the power mains.

Transformer A device for changing the voltage of electrical energy.

EMI REGULATIONS

	EQUIPMENT	INFORMATION	JAPAN	UNITED STATES	EUROPE
EMISSION	Generic Standard	IEC61000-6-3 IEC61000-6-4			EN50081-1 EN50081-2
	ITE (Information technology*)	CISPR Pub. 22	VCCI Electrical Appliance Regulation	FCC Part 15 Subpart B	EN55022
	ISM (microwaves)	CISPR Pub. 11	Electrical Appliance Regulation	ECC Part 18	EN55011
	Igniters (autos, motorboats)	CISPR Pub. 12	JASO	FCC Part 15 Subpart B	Automotive Directive
	Radio, TV, audio, VTR	CISPR Pub. 13	Electrical Appliance Regulation	FCC Part 15 Subpart B	EN55013
	Household electrical, portable tools	CISPR Pub. 14	Electrical Appliance Regulation		EN55014
	Fluorescent lamps, luminary	CISPR Pub. 15	Electrical Appliance Regulation		EN55015
	Transceiver	CCIR	Radio Act	FCC Part 15 Subpart C FCC Part 22	ETS300 Series
	Power supply higher harmonte	IEC555 IEC61000-3	Industry Voluntary Regulation		EN60555 EN61000-3
IMMUNITY	Basic Standard	IEC61000-4	(JIS regulation pending)		EN61000-4 Series
	Generic Standard	IEC61000-6-1 IEC61000-6-2	(JIS regulation pending)		EN50082-1 EN50082-2
	Industry process measurement & control	IEC801 series	Industry Voluntary Action		
	Radio, TV	CISPR Pub. 20	Industry Voluntary Action		EN55020
	ITE (Information technology)	CISPR Pub. 24	Industry Voluntary Action		EN55024

*printers, personal computers, word processors, displays

NOISE DETECTION

	CISPR PUB 22	VCCI		FCC PART 15		EN55022
ITEM MEASURED:	Radiated interference	Radiated interference	Mains interference voltage	Radiated interference	Mains interference voltage	Mains interference voltage
POLARIZATION & MEASURING POINT:	Horizontal Pol. / Vertical Pol.	Horizontal Pol. / Vertical Pol.	AC Mains Ports	Horizontal Pol. / Vertical Pol.	AC Mains Ports	AC Mains Ports
FREQUENCY (Hz):	30M to 1GHz	30M to 1GHz	150k to 30MHz*	30M to 1GHz	450k to 30MHz	150k to 30MHz
DETECTION:	Quasi-Peak	Quasi-Peak	Quasi-Peak, Mean	Quasi-Peak, Mean	Quasi-Peak	Quasi-Peak, Mean
MEASURING DEVICE:	Antenna	Dipole antenna	Artificial Mains Network	Antenna	Artificial Mains Network	Artificial Mains Network

*for 150kHz to 526.5kHz, design targets only at this time

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