

The Use of Ferrites in EMI Suppression

鐵氧磁體於抑制電磁波干擾的應用

Properties Of Ferrites 鐵氧磁體之特性

Introduction

簡介

Ferrites are a class of ceramic ferromagnetic materials that by definition can be magnetized to produce large magnetic flux densities in response to small applied magnetization forces. Originally referred to as "magnetic insulators," ferrites were first used as replacements for laminated and slug iron core materials in low loss inductors intended for use above 100 kilohertz (kHz). At these frequencies, laminated and slug iron are plagued by excessive eddy current losses whereas the high volume resistivity of ferrite cores limit power loss to a fraction of other core materials. Today, Tai-Tech ferrites are the core material of choice for modern high density switch mode power supply and pulse transformer design.

陶瓷鐵氧磁性材料可被一小的磁化力所磁化而產生很大的磁通密度,而鐵氧磁體便是其中之一種,其原意為 "磁性絕緣體",鐵氧磁體最初是用以取代應用在頻率100千赫茲以上之彈丸形鐵質鐵芯,作為低損耗之電感,在此頻帶,層壓的彈丸形鐵質鐵芯受制於過高之渦流損失,而具高阻抗係數的鐵氧磁體則可以將此能量損失降至只有其他材質的一小部份.現今,西北臺慶之鐵氧磁體為現代高密度切換式電源供應器設計及脈衝式變壓器設計之最佳鐵芯材質的選擇.

Fundamental Properties

基本特性

While frequently nicknamed "magic beads" in marketing literature, EMI Suppression ferrites are actually well understood magnetic components. Ferrites intended for EMI applications above 30 MHz are mixtures of iron, nickel and zinc oxides that are characterized by high volume resistivity (10^7 ohm-cm) and moderate initial permeability (100 to 1500).

常在行銷文獻上被暱稱為"魔術磁珠",作為抑制電磁波干擾的鐵氧磁體,實際上已是被充份瞭解的磁性元件.對頻率在30百萬赫茲以上電磁波應用之鐵氧磁體是由鐵、鎳及鋅之氧化混合物所組成,其具有高阻抗係數(10 歐姆-公分)及中等的初導磁率(100到1500)的特性.

Ferrites are most frequently used as two terminal circuit elements, or in groups of two terminal elements. The unique high frequency noise suppression performance of ferrites can be traced to their frequency dependent complex impedance, as shown in Figure 1 . At low frequencies (below ~ 10 MHz), a Tai-Tech type chip bead presents a small, predominately inductive impedance of less than 100 ohms, as shown in Figure 2. At higher frequencies, the impedance of the bead increases to over 600 ohms, and becomes essentially resistive above 100 MHz. When used as EMI filters, ferrites can thus provide resistive loss to attenuate and dissipate (as minute quantities of heat) high frequency noise while presenting negligible series impedance to lower frequency intended signal components. When properly selected and implemented, ferrites can thus provide significant EMI reduction while remaining "transparent" to normal circuit operation! For high frequency applications, ferrites should be viewed as frequency dependent resistors. Since they are magnetic components that exhibit significant (and useful) loss over a bandwidth of over 100 MHz, ferrites can be characterized as high frequency, current operated, low Q series loss elements. Whereas a purely reactive (i.e., composed only of inductors and capacitors) EMI filter may induce circuit resonances and thus establish additional EMI problem frequencies, lossy ferrites cannot. In fact, ferrites are often used in high frequency amplifier design and power supply design to prevent or significantly reduce unintended high frequency oscillations.

鐵氧磁體常被用作為雙電極電路元件或雙電極電路元件的群組.鐵氧磁體對高頻雜訊獨特的抑制表現,可由其與頻率相關的複合阻抗看出,如圖例一.在低頻帶(約低於10MHz),-西北臺慶的晶片磁珠具有一小於100歐姆的主要感應阻抗,如圖例二.在較高頻帶時,此磁珠的阻抗增加到600歐姆以上,而在100MHz以上其本質上成為純阻抗性.當作為一抑制電磁波干擾之濾波器,鐵氧磁體因此能產生阻抗的損失以減小或消除(以微量的熱能方式)高頻的雜訊而對低頻所欲之訊號具可忽略的串聯阻抗.當適當地選擇及植入,鐵氧磁體可有效抑止電磁波干擾而對一般正常電路操作則仍維持"透明".對高頻率的應用,鐵氧磁體可被視為是一個隨頻率改變的電阻器,因為他是在頻率100MHz以上能有顯著的(具有用的)損失的一種磁性元件,鐵氧磁體能被歸於是具有高頻,以電操作,低品質係數等特性的串聯損失元件.然而,對於一個純電抗(意即僅由電感及電容所組成)的電磁波干擾濾波器,有可能會使電路感應而形成共振,造成額外有電磁波干擾問題的頻帶.鐵氧磁體則不會如此.事實上,鐵氧磁體常被應用於高頻放大器的設計及電源供應器的設計以預防或顯著降低不致之高頻振盪.

The Use of Ferrites in EMI Suppression

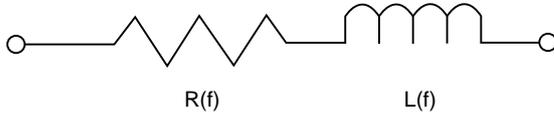


FIGURE 1: Simple equivalent circuit model of a two terminal ferrite bead
圖例一:雙電極鐵氧磁體磁珠的等效電路模型

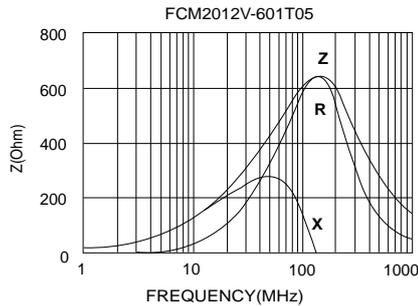


FIGURE 2: Typical impedance versus frequency characteristics of Tai-Tech high impedance chip bead
圖例二:西北臺慶高阻抗晶片磁珠一般的阻抗對頻率的特性曲線

A Closer Look At Ferrite Impedance

細說鐵氧磁體阻抗

The previously described complex impedance of ferrites can be analyzed further if the situation considered is limited to small applied magnetization forces (i.e., small forward current, few turns of conductor around through the core). In such cases, the application of incremental increases in magnetizing force H to a ferrite will result in a corresponding increase in magnetic flux density B in the core. This operation typically displayed graphically via a device's B-H curve, as shown in Figure 3.

如果考慮僅施予一小的磁化力(意即小電流,電感的線圈數少)的狀況下,前述之鐵氧磁體復合阻抗可以被進一步分析,在此情況下施以一逐漸增加的磁化力H於一鐵氧磁體上,會在鐵芯中產生一相對應增加的磁通量密度B,此過程通常藉一儀器以B-H曲線圖表示出來,如圖例三。

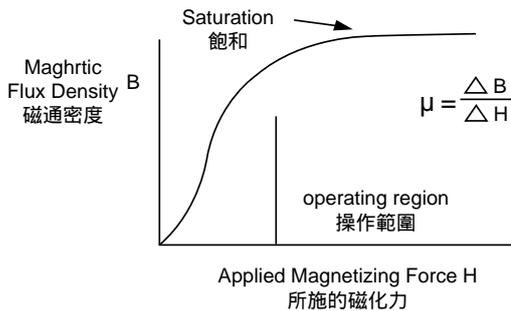


FIGURE 3: Virgin B-H curve for a typical ferrite
圖例三:典型的鐵氧磁體B-H曲線圖

With the previously mentioned restrictions, the impedance of a given ferrite bead or core can be expressed as:

在先前所提到的限制下,一鐵氧磁體磁珠或鐵芯的阻抗值可以下式表之:

$$Z = R(f) + j L(f)$$

The Use of Ferrites in EMI Suppression

The frequency dependent loss term arises from the loss of energy incurred as a result of oscillation of microscopic magnetic regions (called domains) within the ferrite. The loss and the ferrite impedance can be expressed in terms of a complex permeability as:

此與頻率相依的損失項是由鐵氧磁體中在微觀下磁性區域(稱為磁區)的震盪而招致的能量損失所產生。此損失與鐵氧磁體之阻抗可以以複合導磁率表示:

$$\begin{aligned} Z &= K \{ j \mu_o [(\mu'(f) - j\mu''(f))] \} \\ &= K \mu_o \mu'(f) + jK \mu_o \mu''(f) \\ &= R(f) + j L(f) \end{aligned}$$

Where:

$\mu'(f)$ = the real component of the frequency dependent series complex relative permeability
與頻率相依之串聯複合相對導磁率的實部

$\mu''(f)$ = the imaginary component of the frequency dependent series complex relative permeability
與頻率相依之串聯複合相對導磁率的虛部

K = a constant corresponding to the number of windings and the core dimensions
對應於線圈繞圈數及鐵芯尺寸的常數

μ_o = permeability of free space
真空之導磁率

ω = radian frequency = $2\pi f$
角頻率 = $2\pi f$

The loss tangent ($\tan d$) of a ferrite material can be defined as the ratio of the imaginary part to the real part of the material's relative permeability.

鐵氧磁體材料的損失正切($\tan d$)可定義為此材料相對導磁率之虛部對其實部之比值。

$$\tan d = \frac{\mu''(f)}{\mu'(f)}$$

Figure 4 gives a graphical representation of the loss tangent. As is true with the permeability, the loss tangent is frequency dependent. The loss tangent is an intrinsic property of a given ferrite material formulation. Choosing a particular ferrite material corresponds to choosing a particular loss tangent and an associated impedance versus frequency characteristic.

圖例四為損失正切的圖形表示式,如同導磁率,損失正切亦與頻率相關。損失正切為一鐵氧磁體一固有的特性。選擇一特定之鐵氧磁體材料,會對應到一特定的損失正切及與頻率相關的阻抗特性。

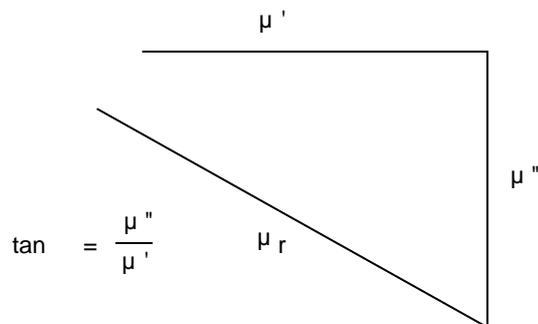


FIGURE 4: Graphical representation of the loss tangent

圖例四:損失正切的圖示

The Use of Ferrites in EMI Suppression

DC & Low Frequency AC Bias Effects And Saturation

直流電極低頻交流偏壓和飽和

The performance of any magnetic material will be degraded if it is operated under large DC or low frequency AC bias. Under "small" bias conditions, increasing the applied magnetomotive force E applied to a magnetic core device induces a corresponding increase in magnetic flux F in the core. At some value of E the magnetic flux F stops increasing; increasing E beyond this value results in a rapid decrease in the permeability of the part. For this condition magnetic theory terms the device's core saturated, as it is unable to support further increases in magnetic flux with increasing magnetomotive force input. To illustrate, saturation may occur if a ferrite core is placed around a single output wire of a DC power supply as shown in Figure 5. In this situation, the core will experience a large DC magnetizing force. If the current is sufficient, the core will operate in the saturation region of its B-H characteristic, as shown in Figure 3. Since the slope of the B-H curve is nearly flat ($=0$) in saturation, the instantaneous relative permeability (equal to the slope at the operating point) of the core will drop to a value of approximately 1, or that of free space. Since the desirable lossy characteristics of EMI suppression ferrites require core permeability $\gg 1$, the core will provide little noise attenuation if operated near or in saturation.

任何磁性材料,如果是在大的直流電流或低頻交流偏壓下運作,其性能都會衰減,在"小"的偏壓狀況下,施於磁性鐵芯增加的生磁力 E ,會使在鐵芯中感應之磁通量 F 相對應的增加。當 E 在某個值時磁通量 F 停止增加。此時再增加生磁力,會導致元件導磁率的快速下降。此狀況在磁學上稱此為元件之鐵芯達飽和,即他無法在隨輸入之生磁力的增加而增加其磁通量。舉例而言,當一鐵氧磁體鐵芯如圖例五所示置於一直流電源供應的其中一條輸出線時,飽和即可能發生在此狀況,此鐵芯會經歷一巨大的直流磁化力。如果此電流夠大,鐵芯將在如圖例三所示之B-H特性曲線上的飽和區域運作,因為在飽和時,B-H曲線的斜率接近水平($=0$),其即時的相對導磁率(等於在操作點時曲線的斜率)會降低近乎1,或者說是降至自由空間的導磁率,因為鐵氧磁體對抑制電磁波干擾的這種損失特性需要在鐵芯的導磁率遠大於1時才可,當其在或接近飽和時運作,僅能少許的減少雜訊。

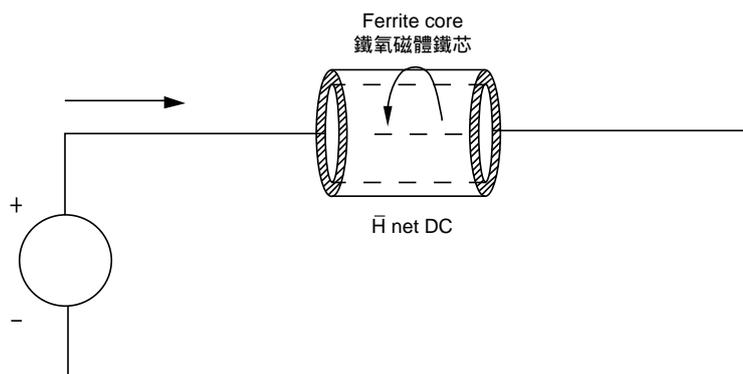


FIGURE 5: Ferrite core under DC Bias

圖例五: 直流偏壓下的鐵氧磁體鐵芯

When operated at DC bias currents greater than zero but less than the saturation bias value, EMI suppression ferrites will maintain a large lossy impedance. Since high frequency EMI filter applications depend on the lossy component of a ferrite's impedance, it is possible to use a ferrite effectively even with a significant net DC or low frequency magnetomotive force input. Many Tai-Tech EMI suppression ferrites maintain useful lossy impedance with forward bias currents in excess of 6000 milliamperes.

當鐵芯的直流偏壓電流在零及其飽和偏壓值之間運作時,用以抑制電磁波干擾之鐵氧磁體會維持在很高的損失阻抗,因為高頻電磁波干擾的濾波應用主要是利用鐵氧磁體阻抗的損失部份。在輸入一顯著的淨直流電或低頻生磁力之下,鐵氧磁體能仍可能有效的運作。很多西北臺慶作為抑制電磁波干擾的鐵氧磁體都具有很有用之損失阻抗,其偏壓電流可達6000毫安培。

The Use of Ferrites in EMI Suppression

DC & Low Frequency AC Bias Effects in a Board Level Application

一般等級應用之直流電及低頻交流偏壓效應

Tai-Tech ferrites deliver maximum series impedance under zero DC and low frequency AC bias; ie., when zero net flux is induced into the device by circuit bias currents. Since EMI suppression ferrites are frequently used to filter common mode EMI on conductors carrying DC or AC power, they should be applied so as to encircle pairs or groups of conductors that carry equal and opposite (balanced) low frequency (e.g., 60 Hz) alternating and direct currents. For example, suppose an EMC engineer wishes to reduce the high frequency noise on a DC power supply output cable. The engineer proposes two solutions. The first implementation, shown in Figure 6, employs two ferrite cores, one for the +5 volt conductors, and one for the "round" or power return conductors. In this case, each ferrite will be subject to a large net DC bias, which will result in a large reduction in the high frequency impedance of the ferrite, and a corresponding reduction in EMI suppression performance. In the second implementation, displayed in Figure 7, equal numbers of +5 volt and "ground" conductors are passed through a single ferrite. In this instance, the ferrite "sees" equal and opposite DC currents and thus zero net magnetic flux density. The ferrite will be able to provide maximum series impedance for high frequency common mode currents and remain unaffected by the DC operation of the encircled conductors. Some applications may not permit a ferrite to operate under zero bias. While ferrites can still function as lossy elements with non-zero DC and low frequency flux densities, the user must be aware that the impedance of the device will decrease under such bias. This drop in impedance can be easily compensated by increasing the mass of the part.

在沒有直流或低頻交流偏壓下,亦即在沒有因電路偏壓電流而感應出磁通時,西北臺慶的鐵氧磁體提供極高的串聯阻抗。因為抑制電磁波干擾之濾波器常被應用於承載直流或交流電源的導體所產生的一般模式電磁波干擾,故其應被用於環繞成對或成群承載相等且反向(平衡的)的低頻(如60赫茲)交流或直流電流的導體。舉例來說,假設一EMC工程師希望減低一直流電源輸出線的高頻雜訊。此工程師提出兩種解決方案,第一個方案,如圖例六所示,利用兩個鐵氧磁體鐵芯,一個置於+5伏特的導線,另一個置於"接地"或電源來回的導線上,在此狀況下,每個鐵氧磁體都會承受一很大之淨直流偏壓,而導致鐵氧磁體在高頻的阻抗會有很大的降低,進而降低抑制電磁波干擾的功能。第二個方案如圖例七所示,等數的+5伏特及"接地"之導線通過同一個鐵氧磁體。如此,鐵氧磁體"視"其為等量且反向之電流,因而其淨磁通密度為零,此時,鐵氧磁體便能對高頻一般模式電流提供最大之串聯阻抗,而本身不會受到所包覆之導體上的直流電流的影響,有些應用可能無法允許鐵氧磁體在無偏壓下運作。然而,鐵氧磁體仍是在非零直流及低頻磁通密度下作為一損失元件,使用者必需要注意到這樣的偏壓下,元件的阻抗會降低。如此的阻抗降低通常可以簡單地以增加元件的質量來補償。

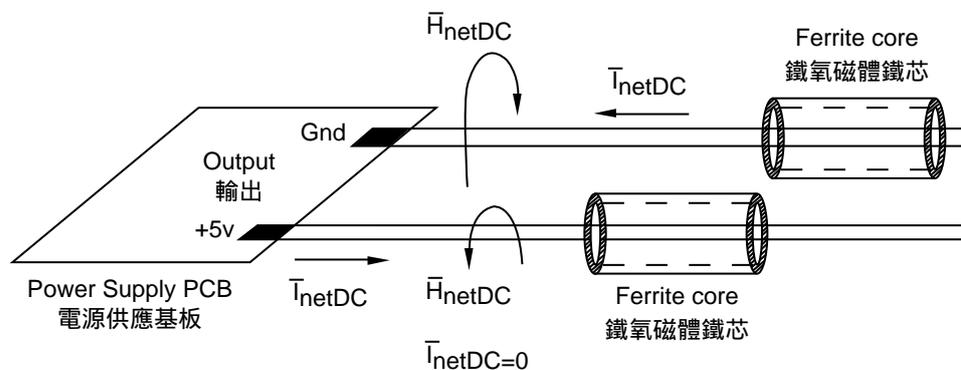


FIGURE 6: Incorrect usage of cable ferrites to filter conductors carrying large DC components

圖例六:不正確的使用鐵氧磁體來過濾承載高直流電流的導線

The Use of Ferrites in EMI Suppression

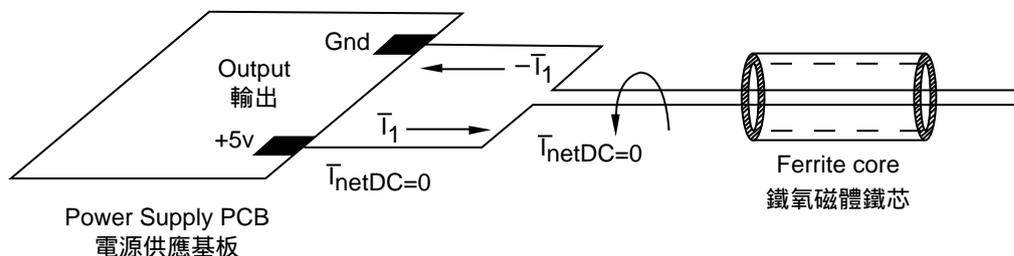


FIGURE7: Correct usage of cable ferrites on DC carrying conductors

圖例七:正確的使用鐵氧磁體與承載直流電流的導線

Ferrites for EMI Suppression on PCBs 應用於基板上作為抑制電磁波干擾的鐵氧磁體

Attacking EMI Problems At The Source

在電磁波源著手電磁波干擾問題

A fundamental EMC design principle requires that EMI be attenuated at its source on the PC board. This strategy confines noise to the small regions of a given PC board and reduces the possibility that high frequency noise will couple to other circuits (often called receptor or victim circuits) that may radiate the noise more efficiently through interconnecting wires or openings in a product's shielding. Attacking EMI at the source generally provides the most cost effective design approach, since filtering is targeted only to a few specific noise generating circuits, rather than to every single possible noise receptor in the entire product. Effective source filtering also helps limit overall EMC design costs by reducing the need for additional shielding that would otherwise be necessary to confine unfiltered high frequency noise components.

一個最基本的EMC設計原則是要能夠減低基板上電磁波源的電磁波干擾,這樣的策略使雜訊被局限在基板上的一小區域而且降低高頻雜訊與其他電路(通常被稱為感受電路或受害電路)耦合的機會,而將雜訊經由相接的導線或產品遮蔽的空隙有效地輻射出去,在電磁波源著手電磁波干擾通常是最有經濟效益的方法,因為此時濾波器只需針對幾處特定的雜訊產生電路而不是整個產品中的每一個可能的雜訊感受電路,有效的過濾電磁波源可藉由減少額外遮蔽的需求而降低整體EMC設計的成本,否則,對未過濾的高頻雜訊元件進行遮蔽將會是必要的。

Noise On the PC Board Power & Ground Distribution Network

在基板上的電源及接地分佈網路的雜訊

PC board generated EMI originates from the periodic switching of digital circuits. A simple noise model of a digital integrated circuit (IC) is shown in Figure8. Each time the IC output switches state, it causes high frequency current to flow from the PC board power distribution bus (Vcc and "ground"). This action will introduce a small differential noise voltage drop, or "sag" across the board's power bus. Since this process will repeat with each transition of the IC's output, the noise that is induced on the PC board power and "ground" will oscillate at a frequency equal to the operating frequency of the IC. Additional IC's that reside on the PC board will "see" this noise voltage and couple it to other areas of the system. Power supply and data cables that are connected to the PC board power and ground bus will also transport and radiate the IC switching noise throughout and outside of the system.

基板上產生電磁波干擾源於週期性的切換數位電路,一個簡單的數位積體電路(IC)的雜訊模型列於圖例八,每次當IC的輸出在切換狀態,會從基板上電源分佈匯流排(Vcc及"接地線"線)產生高頻的電流,此行為會在板上的電流匯流排上產生一小差別的雜訊電壓降,或稱"衰弱".因為此過程會隨IC輸出的每次傳輸而重複,所以在基板上的電源及"接地"上感應產生之雜訊會以與IC的操作頻率相同的頻率作振盪,在基板上額外的IC會"注意"到此雜訊電壓而與產生耦合並擴散至系統的其他區域,連接至基板上的電源及接地匯流排的電源供應及訊號線亦會傳導及輻射IC切換的雜訊至整個系統及至系統外。

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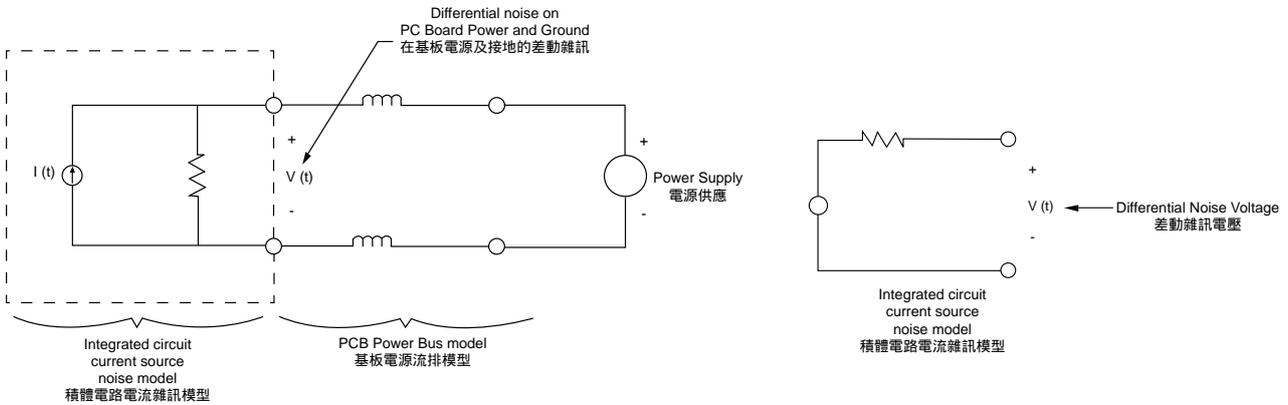


FIGURE 8: Noise voltage and current source models of an integrated circuit on a PC board

圖例八:基板上積體電路的雜訊電壓及電流源

We can generalize this power bus noise voltage problem by modeling the PC board power bus as a lumped impedance through which active devices (integrated circuits, for example) draw high frequency current. An ideal board impedance would have value of zero ohms. i.e., an active device could draw infinite switching current yet introduce no significant differential noise voltage to the PC board bus. This ideal situation is never achieved in practice. To reduce the magnitude of the board impedance, circuit designers add decoupling capacitors across the power and ground conductors of the PC board in an attempt to provide a "local" source of charge for each active device. This technique can also be viewed as placing a high frequency "short circuit" across the active device's power and ground pins, as shown in Figure 9.

我們對電源匯流排的雜訊電壓問題可以一模型來作歸納,就是基板的電源匯流排可視為一整體的阻抗,而主動元件(像是積體電路)由此獲得高頻電流。一理想的基板阻抗應為零,也就是說,一主動元件能獲得極大的切換電流而不會對基板的匯流排造成有明顯差距的雜訊電壓,此理想狀況在現實中是不可能的。要減低基板的阻抗,電路設計者會在基板電源及接地導線間加入抑制耦合的電容以提供每一個主動元件的電源及接地的接腳加上一個高頻的“短路電路”,如圖例九所示。

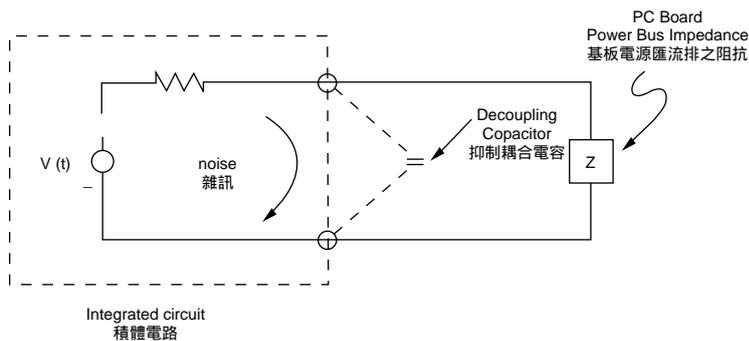


FIGURE 9: PC board noise model with board impedance, integrated circuit, and decoupling capacitors

圖例九:基板阻抗,積體電路及抑制耦合電容的基板雜訊模型

The Use of Ferrites in EMI Suppression

While decoupling capacitors may provide adequate noise filtering at frequencies up to 75 MHz, their performance at higher frequencies will be dramatically reduced by the presence of circuit resonances. These resonances arise from the interaction of the decoupling capacitors with device lead and interconnect inductance in essence, capacitors become functional inductors at higher frequencies. Many EMC engineers have observed and solved frustrating noise problems that arise unexpectedly from unique combinations of noise frequencies, PC board layouts and decoupling capacitors.

雖然抑制耦合電容能有效抑制75MHz以下的雜訊,但他在較高頻帶的表現,會因電路共振的出現而顯著地降低,這些共振導源於抑制耦合電容與元件導線及相互連接之電感的交互作用.本質上,電容在高頻時其作用如電感一般,很多的EMC工程師已觀察並解決很多由某些雜訊頻率的結合,基板電路配線及抑制耦合電容所產生之雜訊問題.

Filtering The Power Input Pins of Active Devices With EMI Suppression Ferrites

以抑制電磁波干擾的鐵氧磁體來過濾主動元件的電源輸入接腳

While the resonant behavior of decoupling capacitor arrangements limits their effectiveness at higher frequencies, the performance of Tai-Tech ferrites actually improves with increasing frequencies. Since Tai-Tech EMI suppression ferrites present an essentially resistive (lossy) impedance at high frequencies, they cannot by themselves introduce performance limiting circuit resonances. When used in conjunction with decoupling capacitors, ferrites can provide additional EMI source suppression by blocking and dissipating power bus noise generated by high speed logic devices. Note that a capacitor still must be used at the power input pin of the active device, since the ferrite by its nature will block the high speed switching current that the device requires to operate. Figure 10 shows an example of a ferrite bead and capacitor filter that is often used in personal computer clock oscillator circuits.

由於這種抑制耦合電容的方式在高頻產生的共振行為會限制其在高頻的效果,西北臺慶的鐵氧磁體可真正的提昇在高頻的表現.因西北臺慶用於抑制電磁波干擾的鐵氧磁體在高頻時其本質上具有一抵抗性的(損耗的)阻抗質,所以自身並不會有限制電路共振的表現.當與抑制耦合的電容併用時,鐵氧磁體能藉由阻止和吸收由高速邏輯元件產生之電源匯流排雜訊以提供對電磁波干擾源額外的抑制.需注意的是主動元件的電源輸出接腳上的電容仍是必需的,因鐵氧磁體在本質上會阻斷元件得以運作的高速切換電流.圖例10為一常用於個人電腦中計時振盪電路的鐵氧磁體磁珠及電容濾波器

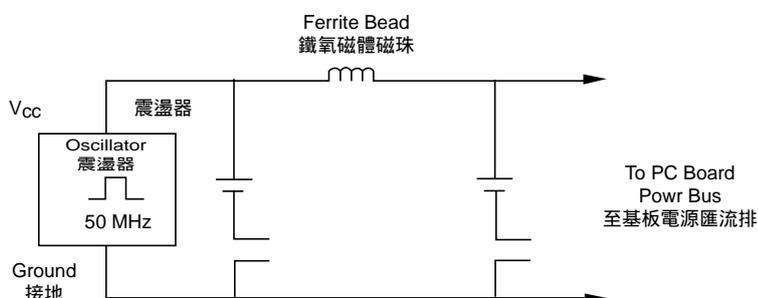


FIGURE 10: Ferrite and decoupling capacitors for high frequency DC power filtering

圖例十:高頻直流電源濾波器中的鐵氧磁體及抑制耦合電容.

Note that this application subjects the ferrite to a net DC bias current. As discussed in the previous section, the impedance and resulting noise attenuation of a ferrite drops with increasing net DC or low frequency AC bias current; therefore, the amount of attenuation obtained from a ferrite DC filter circuit will depend upon the current requirements of the active device and the impedance versus forward DC current characteristic of the ferrite.

需注意此應用令鐵氧磁體受到一淨直流偏壓電流,如前所討論,其阻抗及所造成雜訊減低能力會隨著淨直流或低頻交流偏壓電流而降低,因此一鐵氧磁體直流濾波電路對減低雜訊的大小會隨著主動元件所需的電流及鐵氧磁體的阻抗對直流電流的特性曲線而異.

The Use of Ferrites in EMI Suppression

Filtering DC Power To Multiple & Individual PC Boards

多重及單一基板的直流電源濾波器

Time-to-market design pressures have inspired a new generation of modular electronic products whose features can be easily upgraded with cost-effective interchangeable PC boards. For successful EMI control of such product architecture, EMC engineers must design in a type of "configuration independence" in which any possible combination of product features and hardware options will always pass mandatory Taiwan and international EMI requirements. Since high frequency noise is often produced on and conducted through a PC board's power distribution bus, the tendency of interchangeable circuit boards to create EMI problems can be substantially reduced by filtering the power input to each circuit board, as shown in Figure 11.

縮短上市時間的設計壓力,開啟了新一代模組化的電子產品.其具有可以簡易地以經濟且可互換的基板來作升級.為了成功地控制此種產品架構的電磁波干擾,EMC工程師必需設計一種與"組裝無關"而能使產品功能和選擇硬體的所有可能組合皆能通過台灣及國際的電磁波干擾要求,因為高頻雜訊通常由基板上的電源分佈匯流排產生併藉其傳導,此種因可交換的電路板而產生之電磁波干擾問題的趨勢,可藉由對各個電路板的電源輸入端作濾波而得到有效的降低,如圖例十一.

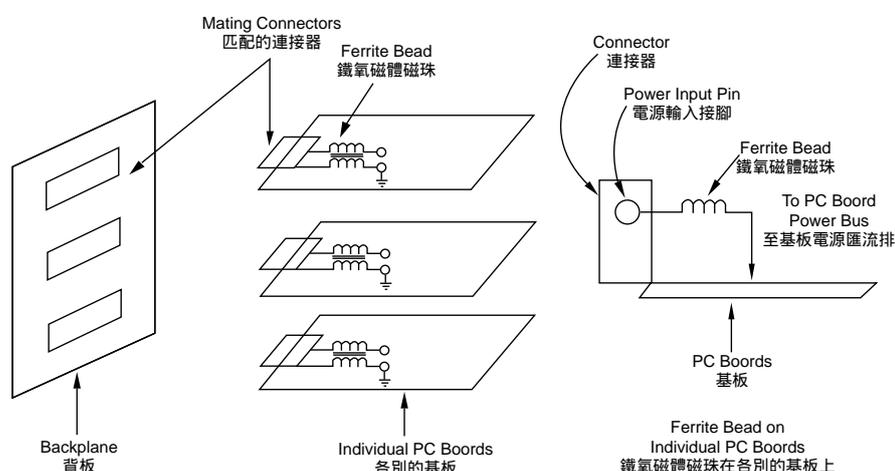


FIGURE 11: Using ferrites to filter the DC power input of interconnected PC boards

圖例十一:應用鐵氧磁體於過濾相互連結之基板的直流電源輸入

This design approach can also substantially reduce "common frequency" type problems where the noise output of multiple circuit boards with identical operating frequencies combine at one or more frequencies to create large radiated emission test failures. Examples of DC power filtering can be found in notebook computers, where external battery packs, AC adapters, and facsimile, printer, and other communication options must connect to an "EMI-noisy" main system module. Other applications include backplane/daughter board arrangements as found in low cost computer network hardware, where multiple PC boards receive power and data from a single high frequency backplane arrangement. Since the described DC filter applications will subject the ferrite components to DC bias current, the maximum in-circuit impedance (and hence maximum noise attenuation) achieved will be less than that obtained under zero bias conditions. In applications involving DC bias above 300 milliamperes, the greater cross-sectional area and higher zero bias impedance of these devices will provide better performance than smaller radial and surface mount devices.

此種設計方式亦可明顯的降低"共同頻率"型式問題,指數個電路板上的雜訊輸出與其相同的操作頻率在單一或數個頻率相結合而造成嚴重的幅射放射測試失效.直流電源濾波的例子可於筆記型電腦上發現,在其外接的電池組,交流整流器,傳真機,列表機及其他的可連接的通訊設備皆必需接連到一"電磁波干擾-雜訊"的主要系統模組.其他的應用,包括如在低價的電腦網路硬體中的背板/子板方式,其數個板由單一的高頻背板接收電源及資料,因此描述的直流濾波應用會使鐵氧磁體元件承受一直流偏壓電流,故最大之通電流阻抗(及可說是最大雜訊降低)會比在零偏壓狀況下來的小,對直流偏壓大於300毫安的應用,用較大截面積及高零偏壓阻抗的元件會比小的徑向且表面黏著的元件來的好.

The Use of Ferrites in EMI Suppression

Filtering Of Input/Output (I/O) Data Conductors

輸入/輸出訊號導線的率波

One of the most common and cost effective applications of ferrites is the filtering of conductors that must bring signals into and out of an EMI noisy environment such as the inside of a high speed personal computer enclosure. For example, energy radiated from a central processor (CPU) integrated circuit (IC) may couple into the "driver" IC that sends to and receives data from the system's external keyboard and mouse, as shown in Figure 12. The long external cables of these devices then radiate the noise that previously was confined to the shielded enclosure of the computer. Tai-Tech ferrites can be used between the driver IC and the key board and mouse connector to insert a large signal loss in series with the high frequency CPU noise on the data lines. Since the keyboard and mouse signals have essentially zero signal energy above 1 MHz, they will pass through the ferrite filter undisturbed.

鐵氧磁體一個最常見且最經濟效益的應用是在一個如高速得個人電腦內部一樣的電磁波干擾雜訊環境中對訊號得以輸入及輸出的導線作濾波,舉例來說,從一中央處理器(CPU)積體電路(IC)所輻射出的能量,會如圖例十二所示一樣,與用以從系統外接的鍵盤及滑鼠傳送及接收資料 " 驅動 " 積體電路產生耦合,使得原本被侷限載具遮蔽的電腦內部的雜訊,得以藉這些設備裸露在外的導線而產生輻射.西北臺慶的鐵氧磁體可安置於此驅動積體電路和鍵盤及滑鼠的連接器之間,用以對在訊號線中的高頻中央處理器雜訊插入一很大的串連訊號阻抗,因為鍵盤及滑鼠的訊號在1MHz以上,其本質具有零訊號能量,故可在不受干擾下通過鐵氧磁體

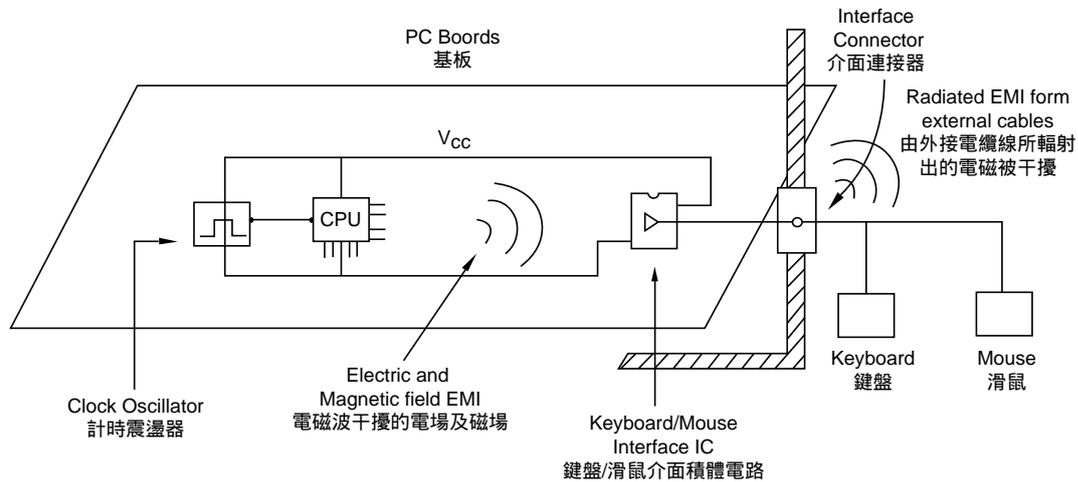


FIGURE 12: Noise coupling between high speed CPU IC and keyboard/mouse interface IC

圖例十二:高速的中央處理器積體電路與鍵盤/滑鼠界面積體電路間的耦合