Application Notes

Infotainment
and KEMET METCOM Inductors

1 ORIGIN AND EVOLUTION OF IVI

The word IVI - In-Vehicle Infotainment is a combination of the two words **information** and **entertainment**. It can be seen that the in-vehicle infotainment system is not a single-function system. It is a larger system composed of multiple different systems.

In order to better explain IVI, let us briefly review the development history of IVI. This article will divide the development of the vehicle infotainment system into several different stages for explanation. (Note: The following segmentation method is not an industry standard, but the author’s personal opinion).

In the earliest cars, meters indicating the car's speed, fuel level and other information, as well as radio functions were added to the car. In addition to providing entertainment, the most important thing about the radio is that it can provide real-time road information to the driver. The addition of these devices was the prototype of the IVI. Later, in order to increase the entertainment of passengers while driving, car manufacturers added music playback functions to cars. With the development of music (sound) playback technology, from the initial cassette tapes to CDs, DVDs, MP3s, etc., these audio playback devices were added to cars, which was the prototype of IVI. At this stage, the information system and entertainment system were independent, as illustrated in Figure 1.

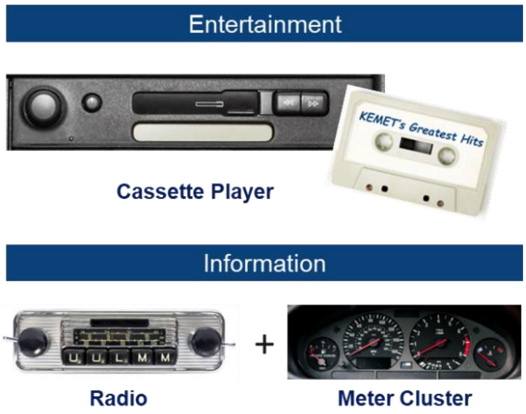


Figure 1 – Independence of Entertainment and Information Systems

1.1 IVI First Stage

Later, car manufacturers assembled the music playback and radio functions on the same device and the first product that could truly be called IVI came out. This was the first stage of the IVI. (But the concept and term IVI did not exist at that time) See Figure 2.

Figure 2 –The First Stage of IVI

1.2 IVI Second Stage

With the development of electronic technology, wireless communication functions have been added to music (sound) playing equipment. For example, you can connect to a mobile phone through Bluetooth to make or answer calls directly on the device. The equipment can communicate with a mobile phone through Bluetooth to play music, etc. Some products at this time can even insert a data card to play music. This is the second stage of IVI, see Figure 3.

Figure 3 –The Second Stage of IVI

1.3 IVI Third Stage

Later, the popularity of LCD touch screens provided greater opportunities for further integration of in-vehicle entertainment systems and in-vehicle information systems. At this stage, the biggest special feature of IVI is the addition of LCD touch screens, which can be controlled by tapping on the screen, reducing the need for physical buttons. And it can be directly connected to the mobile phone, tap on the LCD touch screen and directly use apps on the mobile phone (such as the navigation app, or the function of making calls, watching video, etc.). This is the third stage of the IVI. At this stage, the meters are still not integrated to the IVI, but at this stage many meters have changed from traditional mechanical indicator needle meters to LCD meters. See Figure 4.

Figure 4 – The Third Stage of IVI

1.4 IVI Fourth Stage

As the power source of automobiles gradually changed from fuel to electric, the control of various parts of the automobile changed from mechanical to electronic. This provided the opportunity for the in-vehicle infotainment system to participate in more automobile electronic control and monitoring. It provides the opportunity to connect and communicate with electronic controllers (ECUs) of other automotive systems through the connection with the Controller Area Network (CAN), such as Advanced Drive Assist System (ADAS), Battery Management Systems (BMS), Domain Control Unit (DCU), etc., and calculates and organizes various real-time data of the car and then displays it on the central control screen. For example, the remaining amount of fuel or battery, the health of the battery, the images around the car, to carry out vehicle monitoring. You can also click on the central control screen of the in-vehicle infotainment system to issue instructions to the automotive domain controller to control various electronic control parts of the body (windows, door locks, lights in the cabin, air conditioning, etc.). On the other hand, with the advancement of wireless communication technology, vehicle infotainment systems can connect to the Internet through Wi-Fi or LTE and can directly download and use mobile apps. They can also communicate online, watch movies, and even play online games. This is stage 4, as illustrated in Figure 5. IVI at this stage is the mainstream of new cars produced today.

Figure 5 – Infotainment System Components

1.5 Major Changes in IVI Stage 4

It can be seen from the figure that there are great changes from the third stage to the fourth stage. The biggest characteristics of this stage are:

・The introduction of the central control screen allows the driver to focus on one LCD screen and control many different parts of the car by issuing instructions to different systems or electronic controllers. This combines the IVI system with many originally independent systems to become a larger system.

・In terms of entertainment, in order to improve the user experience, more LCD screens are used. For example, LCD screens are added behind the seats to provide entertainment for passengers in the rear seats. Moreover, the size of the screen has increased, and the resolution has been further improved.

・IVI systems use more wireless technologies, allowing the system to connect to the Internet and obtain real-time external information.

・Integrate the functions of the assisted driving system (ADAS) into the IVI system, and the driver can confirm the information from ADAS on the dedicated LCD screen.

However, each automobile manufacturer's market strategy and product positioning are different, and the degree to which the functions are integrated into the IVI system is also different. Therefore, it is difficult to make a clear definition of which functions are to be included in the IVI system. But in general, the following functions are present in car infotainment systems produced today.

・Vehicle and environmental information display functions and their LCD screen. Such as central control, instrument, head-up display, streaming rearview mirror.

・Entertainment and browsing functions: local and online media playback, radio playback.

・Configuration, settings and control functions: vehicle/driving information settings.

・In-car monitoring: driver/passenger head, face, eye monitoring functions and health monitoring.

・Interactive functions: voice interaction, gesture control.

・Connection and navigation functions: Bluetooth/Wi-Fi, USB, 4G/5G, BeiDou, GPS.

・Assisted driving: surround view, rear view, night vision and other functions.

2 IVI POWER MANAGEMENT

Of course, this stage does not mean the end of the development of IVI systems. On the contrary, more functions are being considered to be combined to IVI systems. For example, further integration with other smart cockpit functions, or adding functions connected to the cloud. Through mutual communication with the entire transportation network and the use of the Internet of Things (IoT), higher SAE autonomous driving levels can be met, and partial or complete autonomous driving can be achieved. However, those topics are beyond the scope of this article. Therefore, the focus will remain on the most popular products today (the IVI fourth stage products in this article).

Figure 6 below is the system block diagram of today's mainstream products in vehicle infotainment systems. The most important part is the main control board equipped with the main chip MCU because the main control board needs to communicate with various other systems (such as LCD screens, HUD, ECU in vehicle, voice recognition system, wireless communication board, ADAS), process data and exchange information with them and achieve the purpose of monitoring and controlling. With the high speed and large flow of data processing a more powerful chipset such as MCU, is needed. On the other hand, image processing is also required to have higher resolution and more real-time experience. It also needs to interact with other systems using different protocols (i.e. different protocols for LCD image data, image data collected by the camera, etc.). MCUs with single functions can no longer meet these needs. So, more types of chips such as SoC, FPGA, CPLD, etc. will also be used in the system. In terms of hardware, these powerful and sophisticated chips further reduce their voltage demand. Against this background, the power management system needs to provide a lower voltage and high current power supply for these chips and some peripheral semiconductor components (such as DDR, SDRAM, etc.). Simply quoting the equation $P = VI$, if the output power remains unchanged and the operating voltage drops, it means that the operating current needs to be increased.

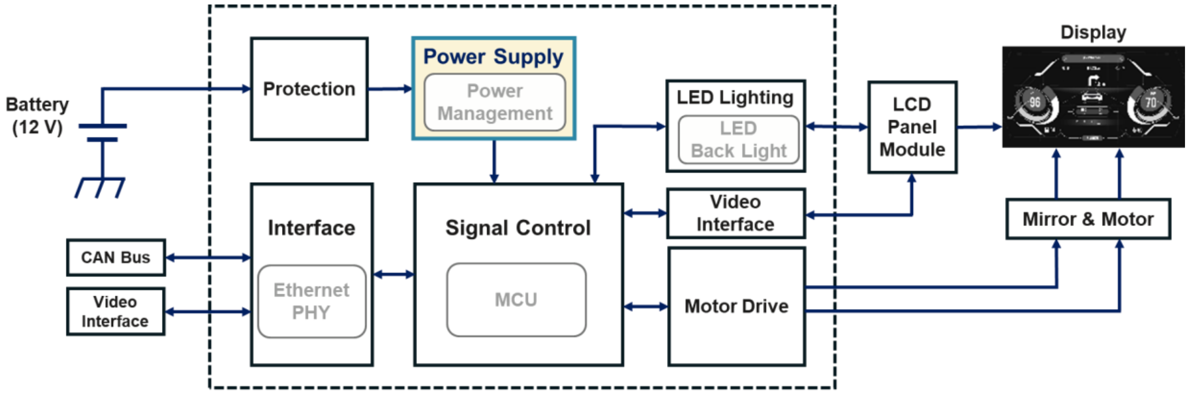


Figure 6 – Block Diagram of the IVI Fourth Stage

In terms of power management circuit design, the power supply circuits that were previously scattered in various MCUs tend to be centralized into the same larger power management circuit. This also makes the design of the power management circuit more compact in space. Undoubtedly the core component in the power management circuit of today's IVI products is the power management IC (including switching IC, regulator). Its function is to convert the input voltage into the required output voltage by adjusting the duty cycle according to different usage conditions. A power inductor is one of the most important electronic components during this voltage transformation process. Because its quality and characteristics directly affect the efficiency of the entire power circuit.

2.1 Power Management System Circuit Design for IVI

In the circuit design of IVI's power management system, in order to improve the efficiency of the power supply, a 2-stage or multi-stage step-down voltage circuit is generally used. Take a medium-sized IVI with 4-5 LCD screens as an example. This system requires simultaneous and independent control of the LCD screens in different areas, such as the rear seat passenger screen, main control screen, HDU, etc. The centralized power management system needs to adjust the power supply voltage provided from the car's low-voltage (typically 12 V or 48 V) battery to a lower volage power (such as 1.8 V, 2.5 V, 3.3 V…), in order to provide a suitable power voltage for some major semiconductor components, such as chips on the main control board and peripheral circuit chips and various memories or interfaces. Figure 7 shows an example of a power management system circuit design.

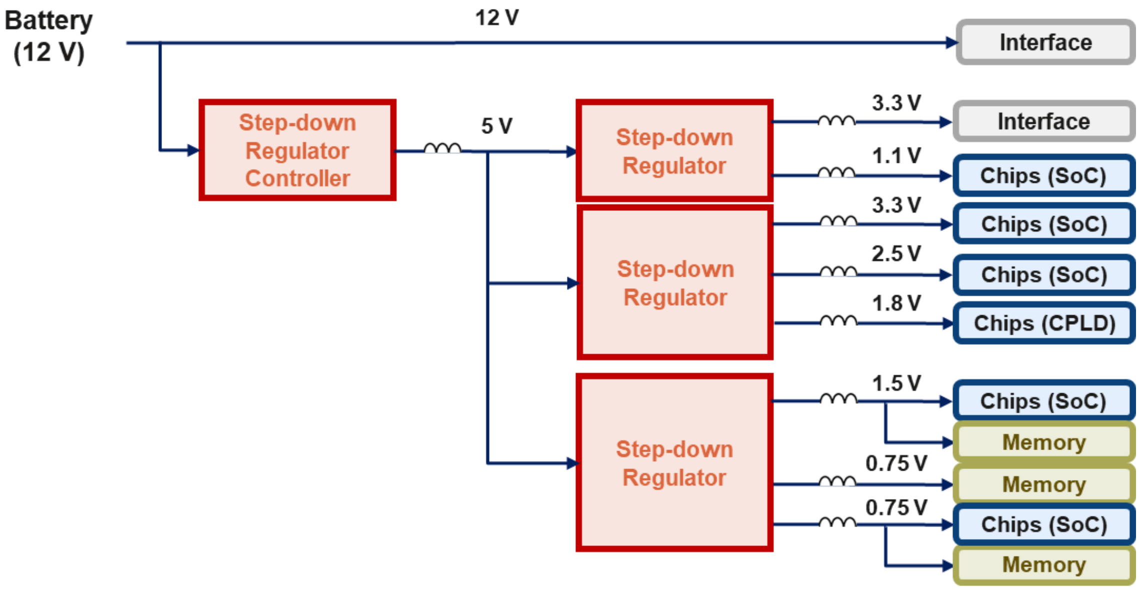


Figure 7 – Power Management System Circuit Design Example

2.2 Requirements Regarding Power Inductor Characteristics

It can be seen from the circuit that the power inductor is one of the most important passive components in the circuit because of the low voltage and high current power that is needed. The requirements for the parameters of the power inductor are also moving towards lower inductance and larger rated current. With this background, compared with traditional ferrite power inductors, the characteristics of metal composite power inductors (KEMET METCOM's product line) are more suitable. The difference in the characteristics of these two power inductors is mainly caused by the characteristics of core magnetic materials. Table 1 below details a comparison of the characteristics of ferrite and alloy powder inductor. It can be seen from there that METCOM inductors have lower inductance and higher magnetic saturation characteristics than ferrite inductors, so they are suitable for large saturation currents and lower voltage usage.

Material Type	Ferrite Inductor		Metal Inductor
	Ni-Zn	Mn-Zn	Fe Based
Inductance	Good	Excellent	Poor
Magnetic Saturation	Good	Poor	Excellent
Thermal Property	Good	Poor	Excellent
Efficiency	Good	Excellent	Good
Resistance of Core	Excellent	Poor	Good

Table 1 – Material Comparison

3 COMPARING FERRITE AND METCOM

Based on the different characteristics of the magnetic core materials, ferrite power inductors generally have higher inductance values than METCOM. The reason is that the ferrite material has higher magnetic permeability compared with metal composite material (a kind of alloy powder with binder) that is used for METCOM. However, METCOM can support higher rated currents. The reason is that the material used in METCOM has a higher magnetic saturation characteristic. Table 2 details the comparison of the characteristics of ferrite power inductors and METCOM with similar area sizes in different heights.

The inductance value range of ferrite power inductors is usually between 1 ~ 10,000 µH. While the range of METCOM is between 0.1 ~ 100 µH. It can be seen that the two kinds of power inductors can be selected if your required inductance is in a range between 1 ~ 100 µH. But from this comparison we can see that METCOM is volumetrically more efficient than ferrite power inductors.

For example, if you need to choose a 3.3 µH 6 A power inductor, when you choose a ferrite power inductor in the table below (**framed in red**), the size of the power inductor will be 7.4 x 7 x 4.5 mm and the volume is 233.1 mm^3. When you choose METCOM, you only need a power inductor with a size of 7 x 6.5 x 2.4 mm and a volume of 109.2 mm^3 (**framed in green**) to meet the requirements. This means that the volume is reduced by about 53%.

For the same requirement (3.3 µH 6 A), if we choose METCOM with similar size to replace the ferrite power inductor, we can get a power inductor with a larger rated current, 3.3 µH 8 A. Compared with the rated current 6 A of ferrite power inductor has increased by about 33% (**framed in orange**).

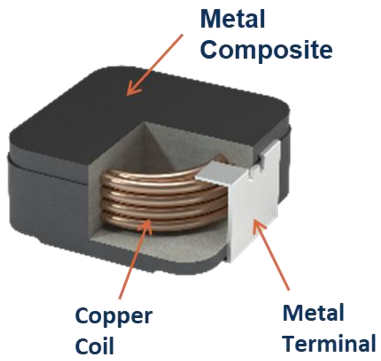
Therefore, if you switch from a circuit that is using ferrite power inductors to using METCOM instead, you can get the benefits of reducing the size or increasing the rated current.

	Industry Standard Ferrite Power Inductor	KEMET METCOM		
		MPXV1D0650	MPXV1D0630	MPXV1D0624
Dimension (mm)	7.4 x 7 x 4.5	7 x 6.5 x 5	7 x 6.5 x 3	7 x 6.5 1.2x 2.4
Volume (mm^3)	233.1	227.5	136.5	109.2
Inductance (µH)	**Rated current (A)**			
0.1			31.1	26.6
0.15			27.6	23.2
0.22			23.3	19.4
0.33			21.1	17.2
0.47			18.7	15.4
0.68		17	15.1	12.6
1	11	13	13.1	10.8
1.5	8.6	12	10.5	8.1
2.2	6.3	10	8.7	6.3
3.3	6	8	6.8	6
4.7	4.8	6.5	6.2	4.9
6.8	4.1	5.5	5.2	4.3
10	3.4	4.5	4.2	
15	2.8		3.3	
22	2.4		2.7	
33	1.9			
47	1.6			
68	1.3			
100	1.1			
150	0.89			
220	0.71			
330	0.6			
470	0.5			

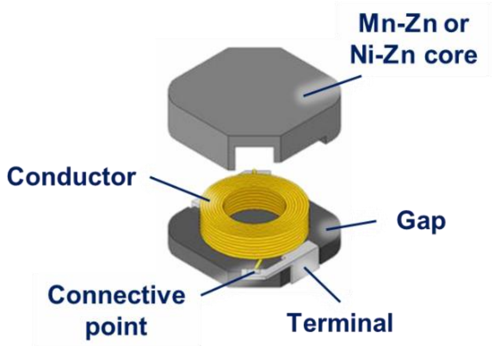
Table 2 – Characteristics Comparison

4 MAGNETIC FLUX LEAKAGE OF POWER INDUCTORS

In addition to the electronic characteristics of the power inductor, magnetic flux leakage is also a matter that needs attention. Because many wireless communication technologies are used in today's IVI systems, if the magnetic flux leakage of the power inductor is ignored, it may become the source of electromagnetic interference, which affects the quality of wireless communications. Of course, this interference can sometimes be solved by adding shielding cases/covers or EMI countermeasure components, strengthening grounding or changing circuit design. However, this will definitely increase the cost of R&D and production. Therefore, reducing the source of electromagnetic interference is the most effective method, such as using electronic components with better EMI characteristics. Therefore, in addition to choosing semiconductor components with better EMI characteristics, choosing power circuits with better EMI characteristics is also a very effective method. Compared with traditional ferrite power inductors, METCOM inductors have a lower magnetic leakage and thus have better EMI characteristics. This advantage is due to the molding method used to manufacture the parts and having a one-piece structure. Compared with ferrite inductors, where there must be an air gap between the core and the coil in the assembly production process, as detailed in Figure 8 below.



Metal Composite Inductor



Assembled Ferrite Inductor

Figure 8 – Inductor Structure Comparison

Although a ferrite magnetic shield case can be added to the outside to reduce magnetic flux leakage, it will only slightly improve flux leakage. This magnetic flux leakage may become a source of electromagnetic interference. Figure 9 shows the result of measuring these two types of power inductors with a near-field analyser while powered. It can be seen that it is an effective method to reduce electromagnetic interference by using METCOM to replace traditional ferrite power inductors from the beginning.

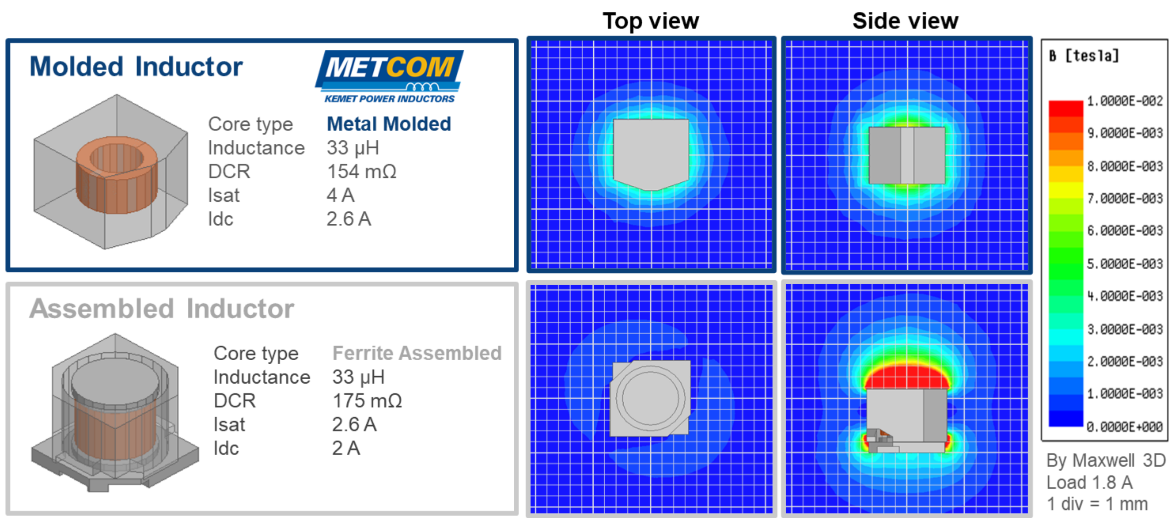


Figure 9 – Magnetic Flux Leaking Amount Comparison

5 NECESSITY TO REACH AEC-Q200 COMPLIANCY

Today's IVI's stage 4 has been connected to the ADAS system, and its functional capabilities have exceeded the scope of traditional information and entertainment. It has participated in assisted driving functions related to driving safety. If the IVI suddenly fails and loses its function temporarily or continuously, it is likely to cause a traffic accident. So, the reliability of the IVI is taken seriously. Although most of the electronic components used in the traditional IVI did not need to meet automotive grade testing in the past, the situation has changed, and most current IVI products require the use of automotive grade components that meet the AEC-Q standard. For passive components, such as power inductors, the AEC-Q200 standard needs to be met. And because the power inductor is an important part of IVI power management, some automotive manufacturers that have higher requirements for IVI reliability even require the use of power inductors with stricter standards than AEC-Q200, such as requiring temperature ratings to +155°C or above, or requiring a power inductor with vibration resistance of 20 G or above.

For the KEMET METCOM line up, in addition to the MPX series that meets general industrial specifications, KEMET can provide 3 other series that meet the AEC-Q200 standard, see Figure 10. They include sizes from 5 x 5 mm – 22 x 22 mm, corresponding to different products with rated current and inductance values. Among them, the MPXV series provides a wide range of sizes, rated currents, and inductance value choices. The MPEV series is characterized by providing a higher operating temperature range from -55°C to +180°C. The MPGV series can work in a vibration environment up to 50 G.

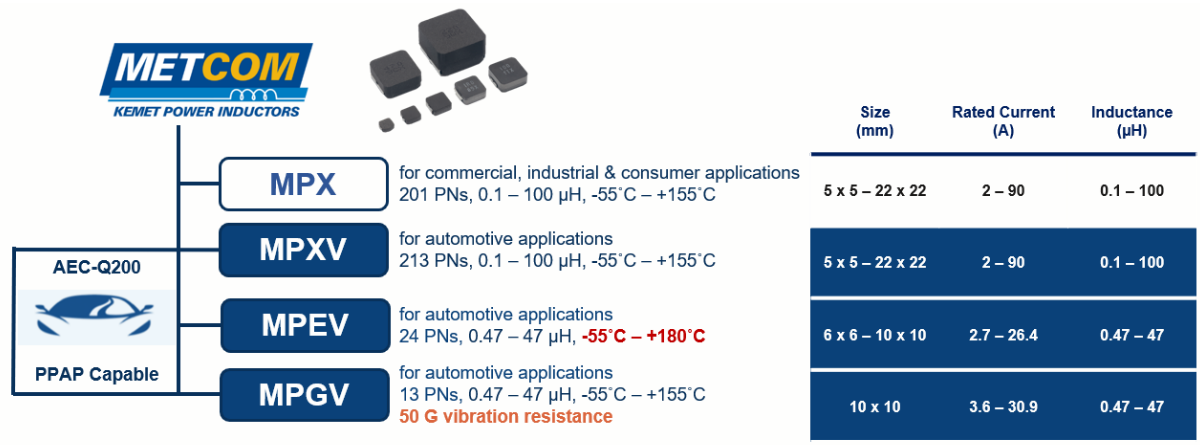


Figure 10 – METCOM Product Family

6 SUMMARY AND FUTURE OUTLOOK FOR IVI

From the evolutionary history of IVI, we can see that IVI initially only provided information and entertainment for drivers and passengers that had nothing to do with driving operations and judgments, but now it has developed to include ADAS or other safety related systems. The independent existing system is integrated into the IVI system to become a bigger system. And it has gone beyond the function of simply providing information and entertainment to the driver, and has even involved direct body control, providing important information or warnings that affect driving judgment, and assisting the driver in operating the vehicle, as well as important functions such as intervening in the driving operation of the vehicle in an emergency. Moreover, as IVI continues to develop and integrate with the automatic driving system, these functions will inevitably continue to be strengthened. Not only that, to achieve automatic driving of the car, it must be combined with the traffic network communication system so that the autonomous driving system can accurately grasp the real-time conditions on the road, including other vehicles, pedestrians or obstacles. Therefore, the function of connecting to IoT is further integrated into IVI, among which V2V, V2I, and V2X. The communication function of wireless communication will inevitably be further strengthened. This also means that in terms of the use of hardware, more powerful and larger numbers of chips and semiconductor components, as well as higher quality and larger quantities of sensors will be used. For wireless communication, technical requirements are also bound to develop towards higher speed and higher sensitivity communication systems that correspond to different communication protocols and have better EMC characteristics.

These factors simultaneously promote the output of IVI power systems with high current, the miniaturization of the design space of the base plate, and the requirements for circuits to generate lower electromagnetic interference.

Taking these factors together, we infer that METCOM will play a greater role, based on the advantages, in future IVI power systems and further replace traditional ferrite power inductors. Concept diagram of the next stage of IVI can be seen in Figure 11.

Figure 11 – The Future of IVI