Technical Report

Common Mode Filters for Automotive ECU Power Lines

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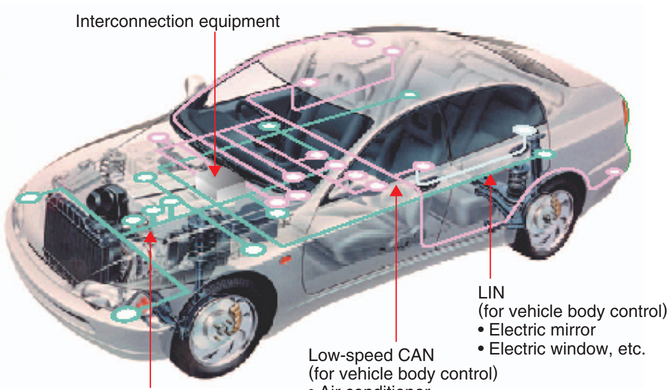
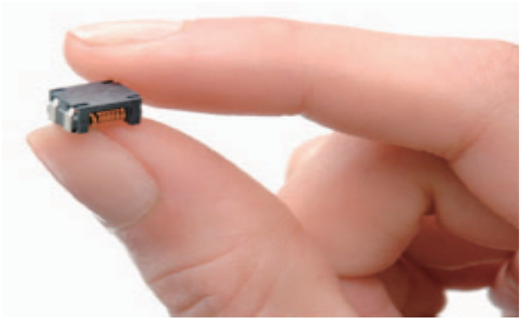
1. Introduction

As ever more automotive components are being computerized today, vehicles that employ automotive LAN networks, such as LINs (Local Interconnect Networks) and CANs (Controller Area-Networks), are rapidly increasing, causing the number of ECUs per vehicle to increase year by year. An example of an automotive network employed in a vehicle is illustrated in Figure 1. Corresponding to this trend, the demand for automotive electronic components, including EMC countermeasure components, is growing remarkably.

Figure 1 Automotive network in a vehicle



A conceptual diagram of electric power steering (EPS) noise reduction measures is shown in Figure 2. Due to the increase in the number of ECUs in vehicles, noise problems, such as noise interference between ECUs and noise intrusion from power lines, tend to occur more often. In addition, as today's automotive designs use brushless motors rather than conventional brush motors for the EPS and due to the introduction of PWM (Pulse Width Modulation) control for EPSs to meet the need for higher durability and output, the band and level of noise has been growing wider and higher. This also raises the need for a higher level of EMC countermeasures.



ACM90V-701-2PL
Common mode filter for automotive ECU power lines

In order to meet the need for EMC countermeasures for communication network lines, manufacturers are trying to extend the range of their automotive EMC countermeasure component portfolio. The common mode filters and other EMC countermeasure components of other manufacturers have been confirmed as being effective for reducing noise in communication network lines; however, there are not many EMC countermeasure components that can be used for automotive power lines.

In this report, an introduction will be given to a common mode filter for automotive ECU power lines, the ACM90V-701-2PL, which is designed to meet severe automotive use conditions. This is an ideal EMC countermeasure component for ECU power lines.

2. Product development and design

2-1 Basic specifications

The size of the ACM90V-701-2PL, a common mode filter for automotive ECU power lines (hereinafter called "this filter"), is 9.0(L)×7.0(W)×4.3(T)mm. It supports a rated current up to 5.0A and an operating temperature range up to 125°C. A shape diagram and its equivalent circuit schematics are shown in Figure 3, and the electrical characteristics of this filter are shown in Table 1.

The capability of supporting a rated current up to 5A enables this filter to be used in power lines of various ECUs, such as the EPS and airbags, as well as in power

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Figure 2 Conceptual diagram of EMC countermeasures for EPS

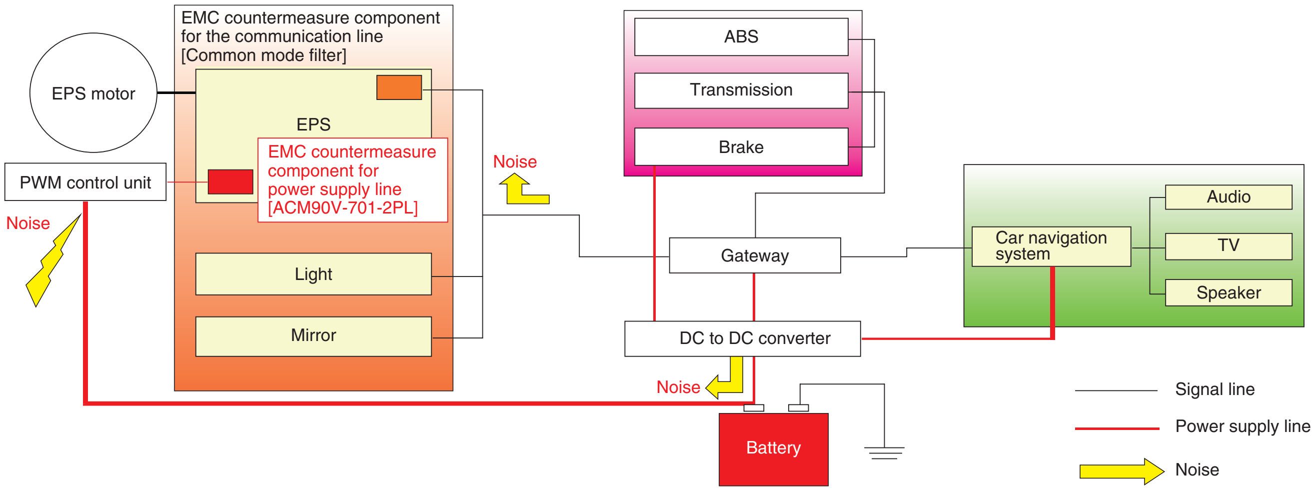


Table 1 Electrical characteristics

Part No.	Common mode impedance(Ω) [100MHz]	DC current (mΩ)max. [1 line]	Rated current DC(A)max.	Rated current DC(V)max.	Insulation resistance (MΩ) min.
ACM90V-701-2PL	500min. (700typ.)	10	5	80	10

Figure 3 Shapes and dimensions/equivalent circuit

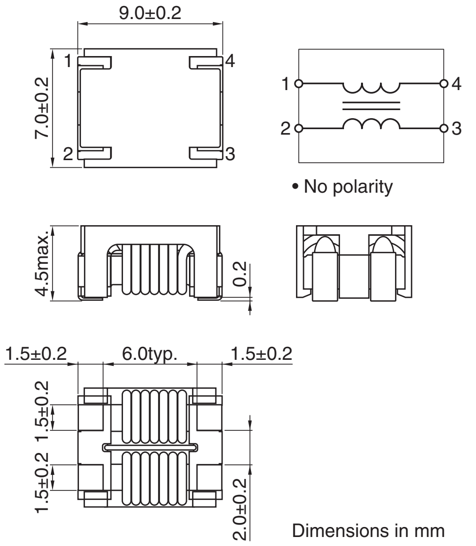
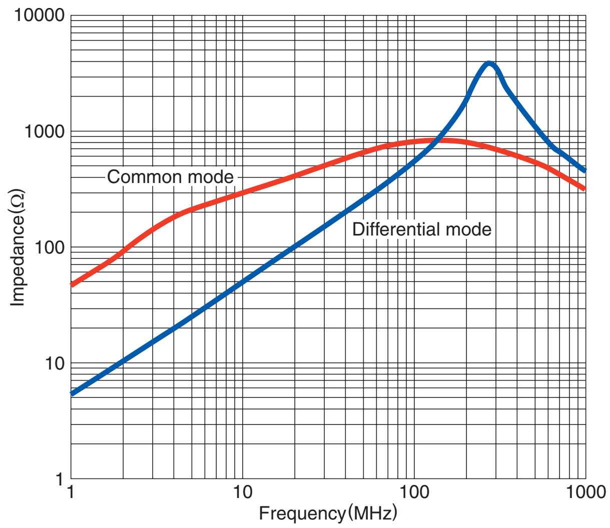


Figure 4 Impedance frequency characteristics



lines of automotive equipment, such as car navigation systems and air conditioners.

The power lines for these automotive devices require countermeasures against various noises ranging from low to high frequencies. This filter provides high impedance over a wide band ranging from low frequencies to frequencies as high as several hundred MHz, which makes this filter ideal for noise reduction.

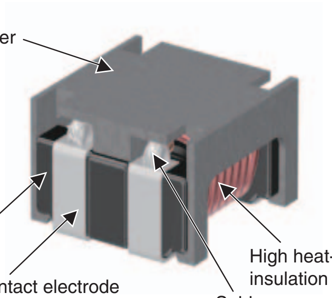
The impedance frequency characteristics of this filter in two modes, the common mode and differential mode, are shown in Figure 4.

2-2 Automotive application

Components for today's ECUs, including the EPS and airbags, must support an operating temperature range up to +125°C, while the operating range required for common mode filters used in IT devices (e.g. notebook PCs, digital camcorders, etc.) has typically been up to +85°C.

This filter provides the capability of supporting a wide range of operating temperatures, from –40 to +125°C, by (1) employing high heat-resistance insulation coated wire and (2) employing a metal contact structure. The basic structure of this filter is shown in Figure 5.

Figure 5 Basic configuration



(1) High heat-resistance insulation coated wire

The high heat-resistance insulation coated wire used for this filter features a high resistance to heat (UL heat resistance class: 200°C and above). When compared to the polyurethane insulation coating that is typically used for IT devices (UL heat resistance class: 150°C), it has a significantly-improved heat resistance.

Conventional coil-type filters in which the wound wiring sticks out of the filter enclosure bear the potential risk of short circuits (i.e. when mounting a coil-type filter on a PCB, a droplet of solder may adhere to the wound wire and damage the insulation coating, and a short circuit may consequently occur).

On the other hand, the high heat-resistance insulation coated wire used for this filter has a highly-improved resistance to solder heat, and thus prevents damage caused by soldering at the time of mounting.

(2) Metal contact structure

Conventional common mode filters used in the power lines of IT devices have a structure in which electrodes are directly attached to the filters themselves. If these types of filter are used under wide temperature ranges, they may be affected by cooling and heat stress from boards.

In particular, when the temperature conditions change greatly, from low to high or vise versa, the solder used to mount the components can expand or contract, causing stress to the components. Though the degree of damage caused by the cooling or heat stress depends on the operating temperature range, the size of the boards and components and several other conditions, in a worst-case situation, breakage of the solder fillet or cracking of the component contacts can result.

To reduce stress on the solder fillet and the ferritic core, this filter employs a metal contact structure for the electrode contacts. With this structure, the cooling and heat stress can be absorbed by the metal contacts.

In a heat shock test (under –40°C/+125°C conditions, 30 minutes at each temperature), this filter was confirmed to be reliable for over 1000 cycles. No damage to the solder fillet or ferrite core, such as cracking, was noticed during the test.

3. Summary

Considering the trend of introducing new automotive LANs, such as MOST or FlexRay, automotive systems are expected to become further computerized.

In addition, EMC problems are becoming more critical, and the priority of and need for EMC countermeasures will increase in the future. It is also expected that automotive common mode filters will need to be more reliable and highly heat-resistant.

TDK is planning to develop and propose high performance, highly reliable EMC countermeasure components, including common mode filters, by taking advantage of TDK's proprietary EMC evaluation technology and various analysis technologies.

• Please note that the articles from the October 5, 2006 Edition of the Dempa Shimbun contained in this chapter have been edited by our company.