High-Speed Op Amps Prevent Oscillation due to Load Capacitance “BD7750x Series”

ROHM expands its high noise immunity EMARMOUR™ lineup by a new high-speed CMOS type ideal for anomaly detection with adopts Nano Cap™ technology for extremely stable control

White Paper

Introduction

The proliferation of the Internet of Things (IoT) in recent years has led to a significant increase in the number of electronic components that carry out advanced control in a variety of applications. In this case, the number of cases requiring high-speed sensing technology is increasing, such as sensors that handle very small signals and anomaly detection systems used in measurement and control devices, together with high-speed op amps to reliably detect abnormal system signals. However, with conventional high-speed op amps, board design can be difficult due to the need to prevent oscillation caused by capacitance loads (i.e. wiring).

At the same time, the continuing electrification of vehicles is leading to a greater number of electronic components and devices that generate noise, worsening the noise environment. As a result, noise countermeasures that prevent malfunctions in small-signal devices have become a major challenge. However, it is extremely difficult to perform noise evaluation of the system alone, making it necessary to conduct testing after assembly. And at this time if the noise evaluation results in NG, the process of Design / Assembly / Evaluation must be repeated multiple times, increasing customer design resources considerably.

In response, ROHM developed the EMARMOUR™ lineup featuring superior noise immunity. The first products in this lineup, a series of bipolar op amps produced since 2017, has been well-received not only by our customers, but engineers in other fields as well. This time, ROHM is expanding its EMARMOUR™ lineup with the BD7750x series of high-speed CMOS op amps (BD77501G, BD77502FVM) that not only supports high-speed amplification required in anomaly detection and other systems, but also completely eliminates oscillation caused by load capacitance (i.e. wiring).

Key features of the BD7750x include:

- Breakthrough noise immunity that limits fluctuation to just ±20mV, 10x lower than the ±200mV of conventional products
- High-speed amplification (10V/us slew rate) along with industry-leading stability by adopting proprietary Nano Cap™ technology
- A CMOS configuration that reduces bias current and minimizes the effects on the sensor

Basic Analog ICs: Op Amps and Comparators

Comparators and op amps are essential electronic components used in virtually all analog circuits (Fig. 1). An op amp (operational amplifier) is placed downstream of sensors that detect information such as pressure, sound, heat, and weight in order to amplify and convert the sensor signals to a voltage level that can be processed by the AD converter. A comparator determines whether the sensor signal is above a threshold and outputs a digital signal (Fig. 2). In all applications, the MCU (Microcontroller Unit) acts as the brains, controlling the entire system using signals from the op amps and comparators.

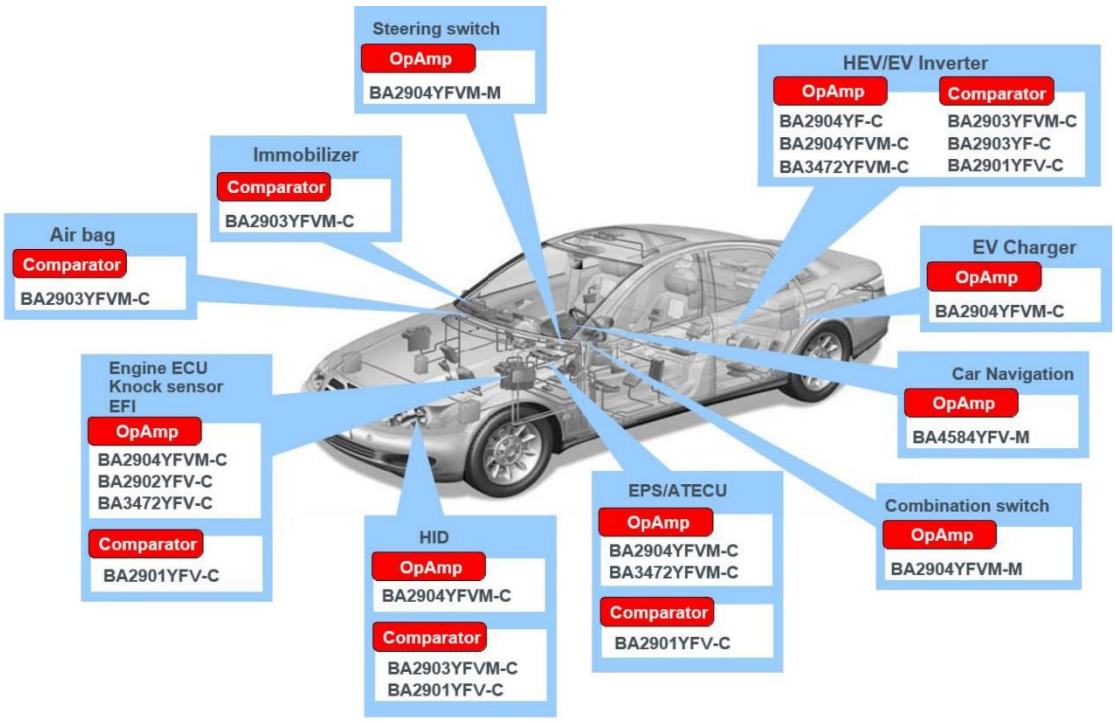

Figure 1. Application Examples of Op Amps and Comparators in Automotive Systems

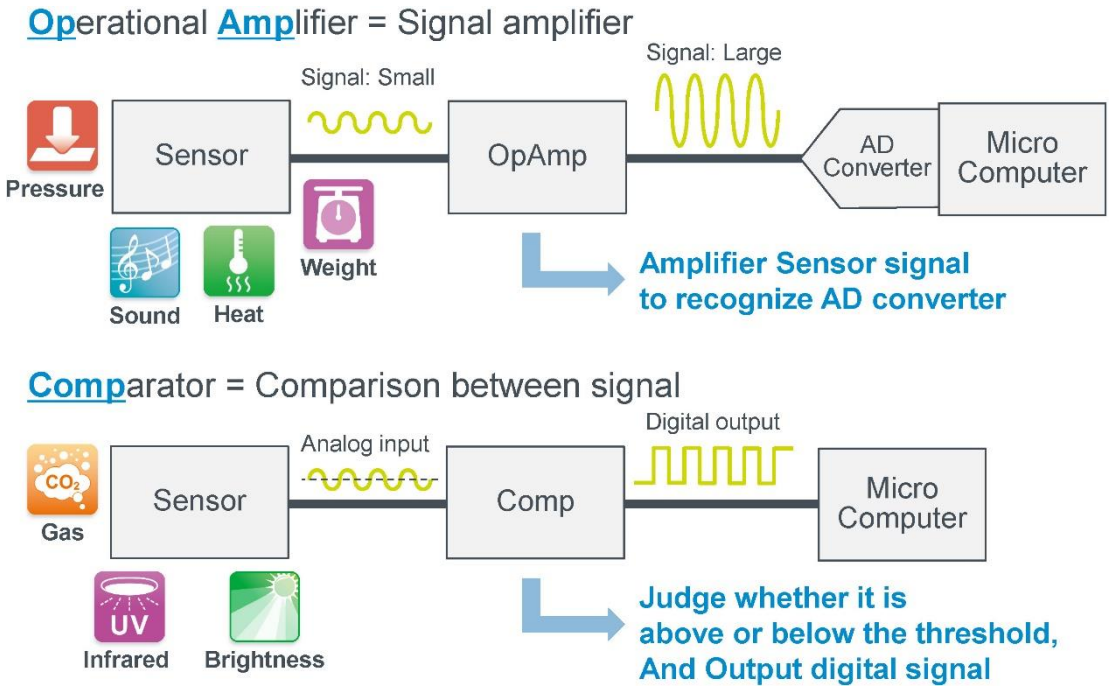

Figure 2. Conceptual Diagram of Op Amp / Comparator Operation

Relationship Between Op Amps and Noise Immunity

The primary consideration when amplifying voltage is noise tolerance of the op amp itself. External noise introduced into the sensor output signal or op amp will be amplified along with the sensor signal if the noise immunity of the op amp is low. This can lead to MCU and, subsequently system malfunction. On the other hand, a high noise immunity op amp is capable of removing noise and accurately amplifying the sensor signal before sending it to the MCU, ensuring normal system operation. For this reason, ECUs (Electronic Control Units) and inverters with a highly integrated design require electronic components with robust noise immunity.

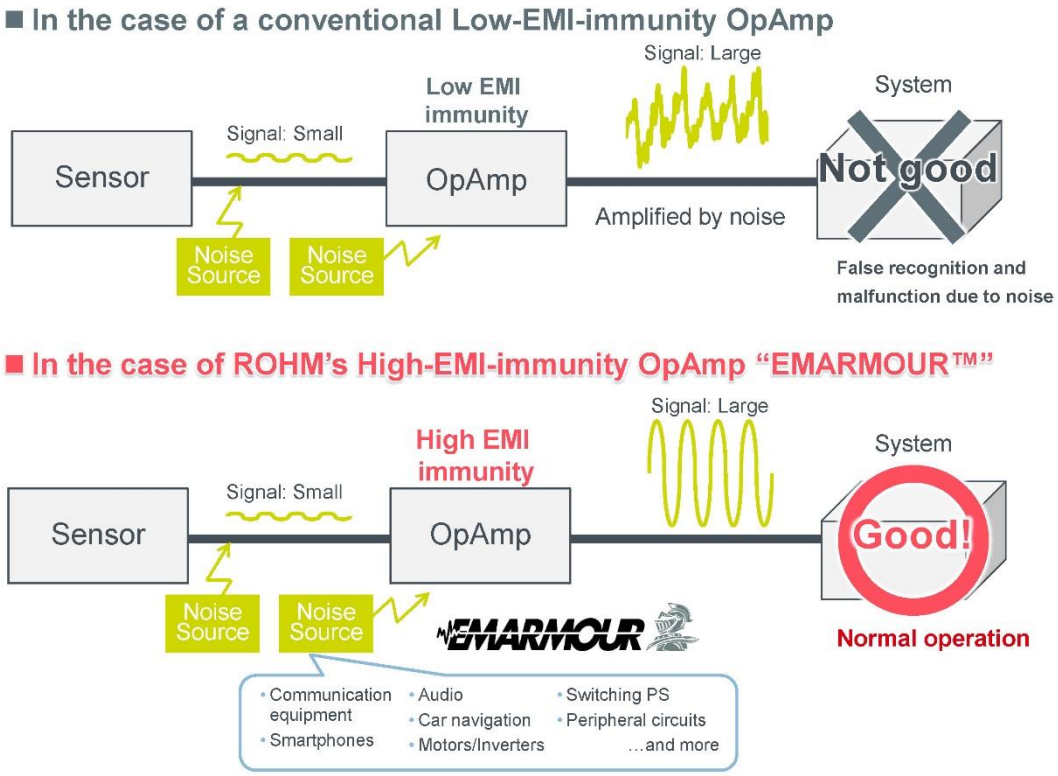

Figure 3. The Effects of Op Amp Noise Immunity on System Operation

For op amps in particular, when implementing noise countermeasures it is necessary to consider not only the op amp itself, but also all of the resistance, capacitance, and inductance components connected to the op amp, such as the supply and ground lines. Recently, however, although the development of high performance high frequency simulators is progressing, it is still not possible to cover detailed characteristics such as process-specific parasitic capacitance and inductance, leaving it up to the knowledge, intuition and experience of the designer to determine the strength of noise immunity. All of these factors contribute to the difficulty of noise design.

ROHM Adds New High-Speed CMOS Types to its EMARMOUR™ Lineup Featuring Breakthrough Noise Immunity

In response to the challenges in noise design, ROHM developed the EMARMOUR™ series. EMARMOUR™ is the brand name given to ROHM products leveraging proprietary technologies covering layout, processes, and circuit design to achieve ultra-high noise immunity across the entire noise frequency band during evaluation testing under the international ISO11452-2 standard.

As mentioned earlier, in 2017 ROHM began producing the first products under the EMARMOUR™ brand – bipolar op amps ideal for sensor-equipped automotive systems exposed to harsh environments, such as ECUs and powertrain.

This time, ROHM incorporated this technology into the BD7750x series (BD77501G, BD77502FVM) of CMOS op amps while also adopting original Nano Cap™ power supply IC technology to achieve extremely stable control.

BD7750x series of EMARMOUR™ op amps are the first in the industry to not only provide superior noise immunity, but eliminate oscillation caused by load capacitance (i.e. wiring) while also supporting high-speed amplification (high slew rate: 10V/us) required in anomaly detection and other systems (Fig. 4).

Part No.	No. of Circuits	Max. Operating Voltage (V)	Input Offset Voltage (mV) (Typ.)	Bias Current (nA)	Slew Rate (V/μs) (Typ.)	Circuit Current (mA) (Typ.)	Nano Cap™ Technology (Stable Output)	Package
New BD77501G	1ch	15	4	0.001	10.0	1.3	✓	SSOP5
New BD77502FVM	2ch					2.6	✓	MSOP8
BD87581YG-C	1ch	14	1		3.5	2.3	–	SSOP5
BD87582YFVM-C	2ch					5.0	–	MSOP8

Figure 4. ROHM's EMARMOUR™ CMOS Op Amp Lineup

To achieve high noise immunity, the BD7750x series integrates an EMI filter circuit that cuts noise over a wide frequency band and adopts an optimized layout (i.e. element + power supply/ground line configuration) along with a new chipset layout and processes strong against noise (Fig. 5).

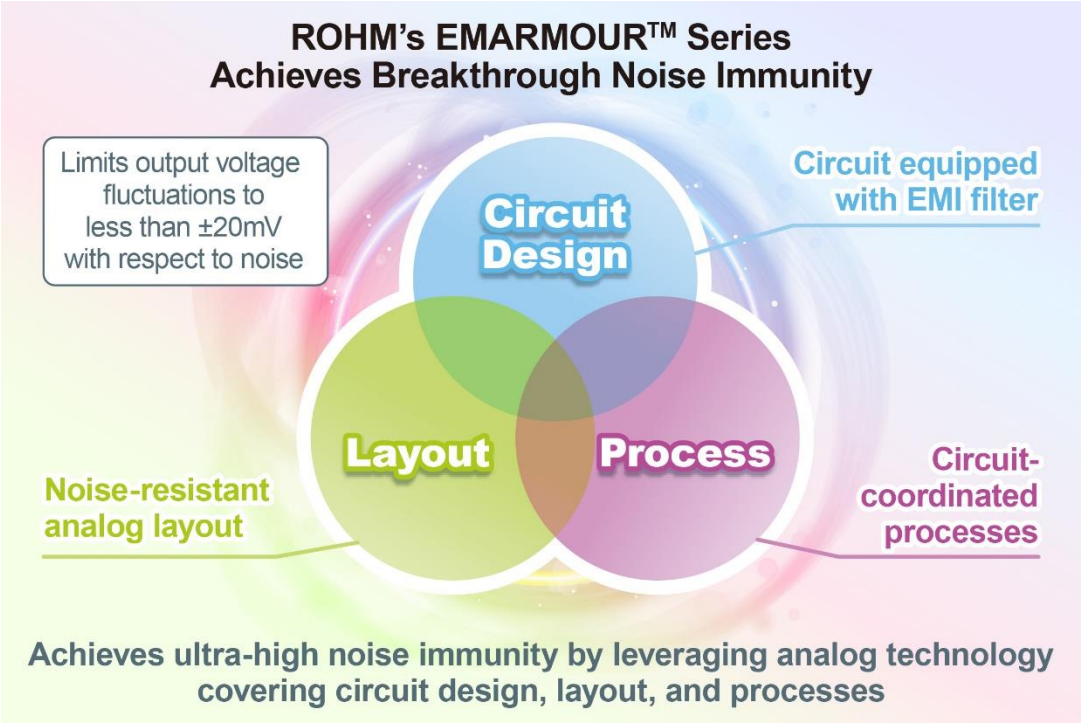

Figure 5. ROHM Utilizes Proprietary Analog Technologies to Achieve High Noise Immunity

As a result, unlike standard products whose output voltage fluctuation can exceed ±200mV, the BD7750x series has been proven to suppress noise to less than ±20mV across the entire frequency range (200MHz to 1GHz) during evaluation testing under the automotive ISO11452-2 standard (Fig. 6).

Conventionally, to compensate for op amp noise tolerance and prevent system malfunction, it was necessary to utilize an external filter for attenuating the specific frequency band susceptible to noise along with shielding (metal plates). However, all of these measures can be eliminated by EMARMOUR™'s providing ultra-high noise immunity. This allows designers to significantly decrease the time and costs required for noise countermeasures, reducing noise design resources considerably.

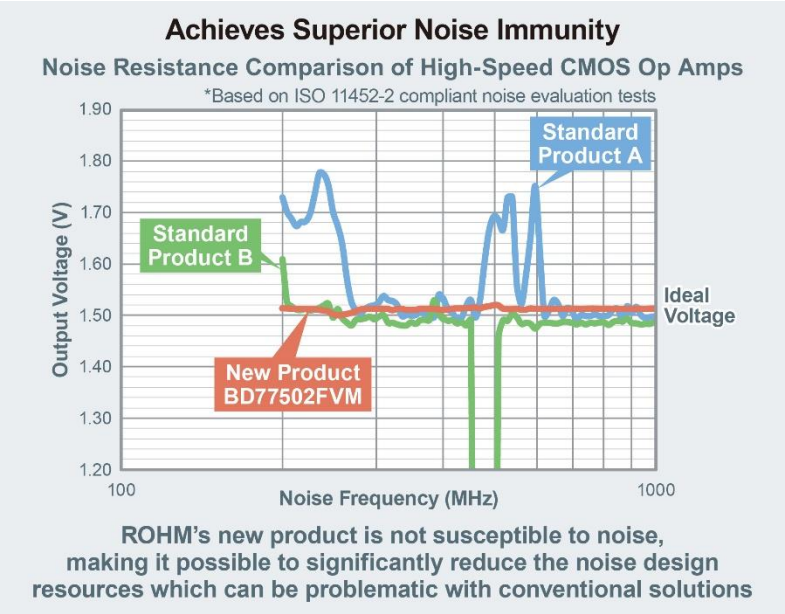

Figure 6. Noise Evaluation Comparison: BD77502FVM vs General Products

High-Speed Op Amps Eliminate Oscillation by Adopting Extremely Stable Nano Cap™ Control Technology

Nano Cap™ refers to extremely stable control technology achieved by combining advanced analog expertise covering circuit design, processes, and layout utilizing ROHM's vertically integrated production system. Stable control eliminates the problem of unstable operation related to capacitors in analog circuits, contributing to a reduction in design resources for virtually all applications regardless of field (i.e. automotive, industrial equipment, consumer).

For anomaly detection applications requiring high-speed, high accuracy amplification of minute signals (i.e. from sensors), CMOS op amps capable of high-speed transmission with low input bias current are often used. However, the higher the speed, the greater the susceptibility to parasitic capacitance as seen from the output pin, making stable operation difficult (Fig. 7). As a result, multiple amplification stages are typically included in op amps to improve the amplification factor, but as the number of amplifications increases, circuit operation can become unstable due to the effects of wiring resistance and parasitic capacitance.

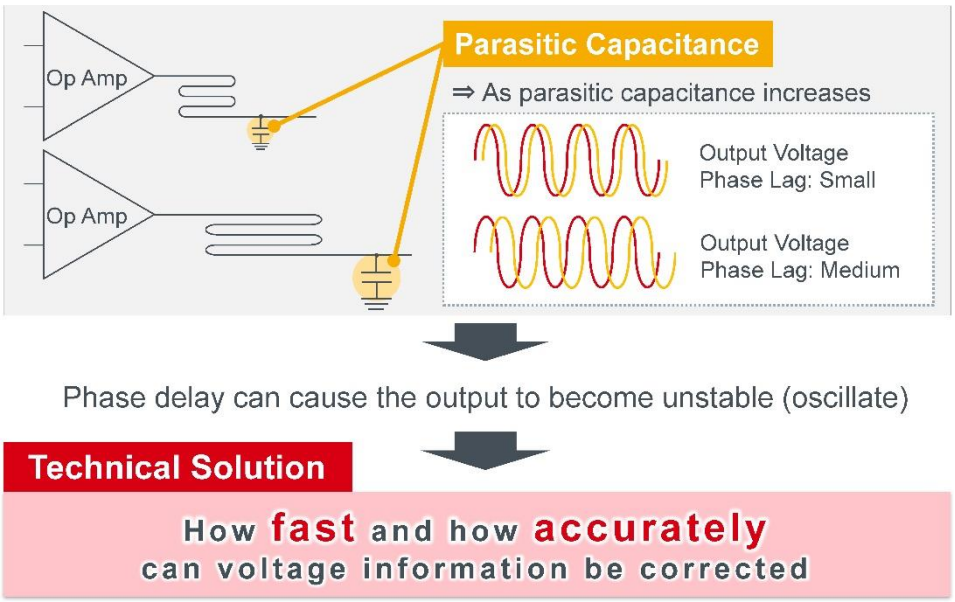

Figure 7. The Effects of Parasitic Capacitance on Op Amp Operation

In response, the new BD7750x series utilizes Nano Cap™ extremely stable control technology to reduce the number of amplifications by increasing the amplification factor while adopting a layout that minimizes the path between the input and output to reduce the effects of wiring resistance and parasitic capacitance (Fig. 8). Leveraging Nano Cap™ technology that integrates analog circuit design, layout, and processes allowed ROHM to succeed in achieving stable, high-speed operation.

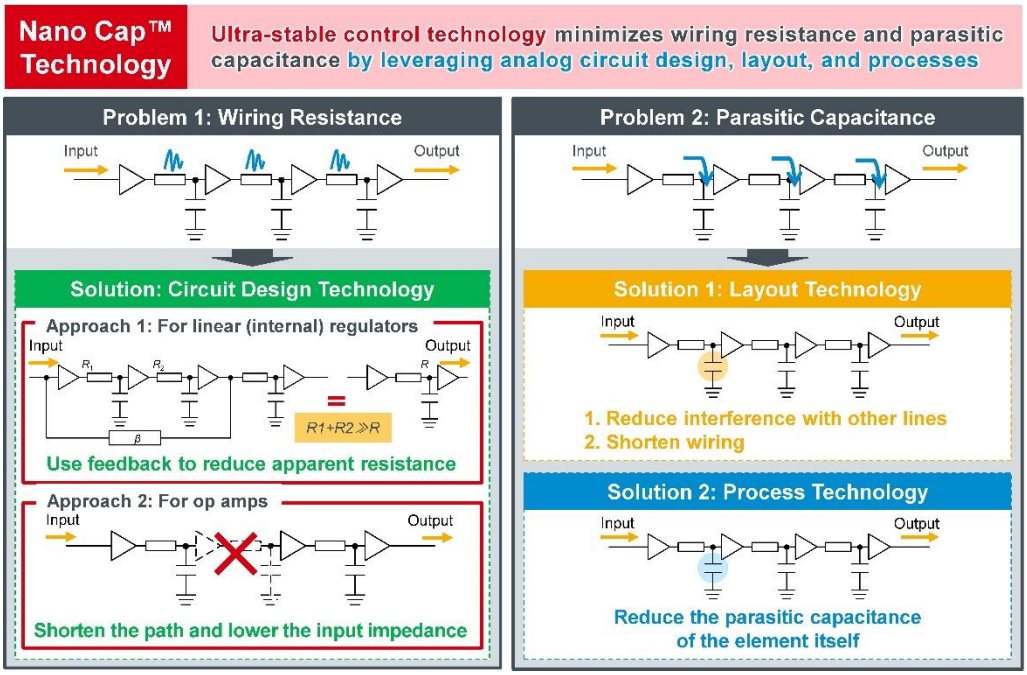

Figure 8. Extremely Stable Nano Cap™ Control Combines 3 Core Technologies

Output stability is indicated by a characteristic called phase margin, which becomes unstable when the phase drops below 0° and gain=0. For example, with a load capacitance of 300nF, the phase in general-purpose products drops below 0° while the phase in the Nano Cap™-equipped BD7750x stays above 0° (Fig. 9). In other words, whereas standard high-speed op amps are easily affected by load capacitance (i.e. due to wiring), making them difficult to handle, the BD7750x series ensures stable operation without oscillation, facilitating application design.

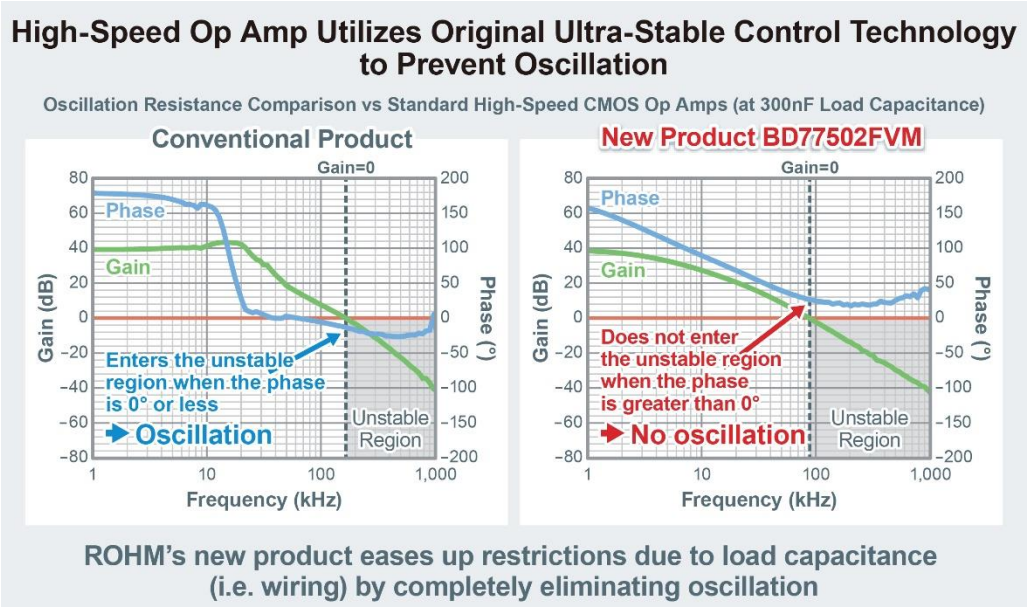

Figure 9. Oscillation Resistance Comparison: BD77502FVM vs General Product

What's more, the BD7750x utilizes a CMOS configuration that minimizes input bias current to enable high accuracy sensing, while universal compatibility makes it easy to replace conventional products. A wide supply voltage range of 7.0 to 15V is also provided. Additional features include an input offset voltage of ±4mV (typ.), input range between VSS and VDD-2.0V, and operating temperature range from -40°C to +85°C. Current consumption is 1.3mA for 1ch products and 2.6mA for 2ch models. And besides providing CMOS high-speed operation with high noise immunity, the BD7750x meets market needs by delivering stable control.

Future Developments

ROHM's newly developed BD7750x series of high-speed CMOS EMARMOUR™ op amps is expected to be adopted in a variety of applications where noise-induced malfunctions cannot be allowed, such as automotive systems, FA (Factory Automation), industrial robots, and medical equipment.

At the same time, Nano Cap™ technology is used to provide stable, high-speed operation regardless of capacitive load, meeting the growing needs of anomaly detection systems used in measurement and control devices for high-speed sensing technology (i.e. sensors that handle very small signals).

And going forward, the lineup will be expanded to support the automotive market by improving reliability while reducing design load in a wide range of applications.

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