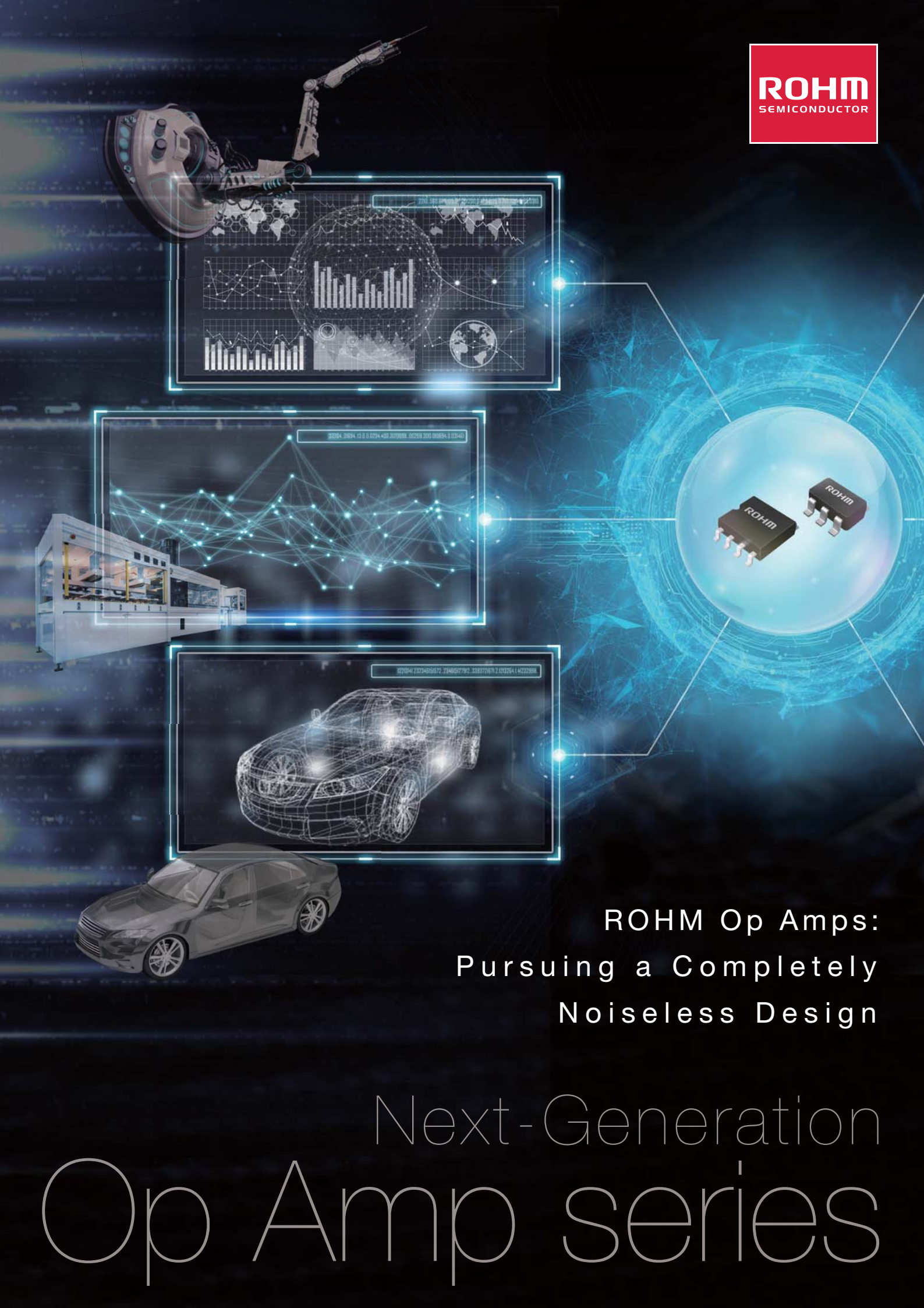


ROHM Op Amps:
Pursuing a Completely
Noiseless Design

Next-Generation Op Amp series

Revolutionary noise design achieves refined operation featuring greater accuracy

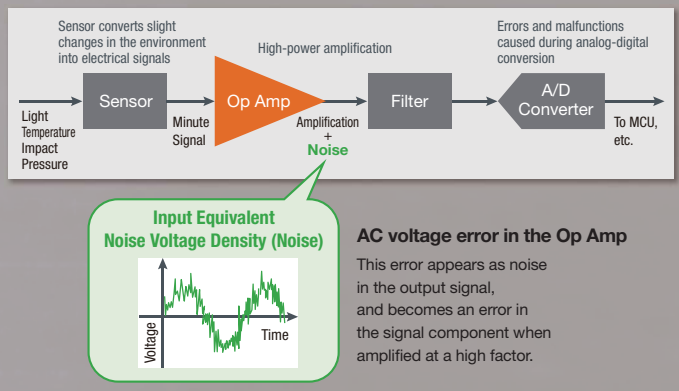
2 Op Amps that pave the way to the sensing technology of tomorrow

The importance of sensors continues to grow in the automotive and industrial equipment fields. Op Amps are essential for amplifying weak sensor signals, and achieving more accurate operation requires that the Op Amp itself have high immunity against EMI (electromagnetic interference) from external sources, and the Op Amp itself must not emit noise.
At ROHM, we have developed bipolar Op Amps for automotive use that minimizes the effects of EMI along with a CMOS Op Amp for industrial applications featuring the industry-low noise and breakthrough noise tolerance.

Development Background — Increasing voltage amplification accuracy by suppressing noise

In recent years, the importance of and demand for sensors has risen due to advances in the field of automotive electronics, such as the introduction of ADAS (Advanced Driver Assist Systems). In addition, the use of IoT is rapidly expanding in the industrial equipment field. Advanced control utilizing sensors has become indispensable. In these areas, improving control accuracy and reducing power consumption are key issues, and peripheral circuits are being designed to operate at increasingly lower voltages.
Signals output from sensors are very small, making them susceptible to the effects of noise from surrounding electronic and communications equipment. This often causes noise to be amplified with the input signal, increasing the possibility of erroneous recognition that can lead to malfunctions. At the same time, to achieve high accuracy voltage amplification it is extremely important that the Op Amp itself does not generate noise. In response, leveraging considerable expertise allowed ROHM to develop automotive-grade Op Amps featuring high EMI tolerance that eliminates the needs for noise designs as well as models that provide unprecedented* noise performance ideal for industrial equipment.

The Role of an Op Amp



AC voltage error in the Op Amp
This error appears as noise in the output signal, and becomes an error in the signal component when amplified at a high factor.

Applications depend on Op Amps to provide increased precision, demanding amplification of small signals with greater accuracy.

Technical Background — Development system integrating design and manufacturing

ROHM utilizes a comprehensive production system that integrates all processes, from product planning and circuit design to layout, prototype evaluation and test development. In the development of these 2 types of Op Amps, the development process covering circuit design and element layout is carried out in seamless cooperation with the product process (i.e. packaging), taking into consideration element form and materials. Conducting a thorough review of each process and optimally combining remedial measures allowed ROHM to develop Op Amps with exceptionally high EMI immunity as well as a CMOS op amp that provides the lowest*noise in the industry.

Factors considered during the development process

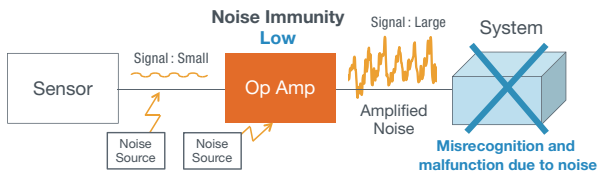
Circuit design :	Element characteristics, power supply fluctuations, signal level, etc.
Layout :	Element arrangement, pair characteristics, signal interference, etc.

Factors considered during the manufacturing process

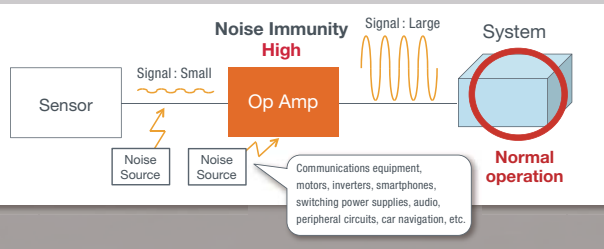
Wafer :	Element shape, element materials, wiring materials, etc.
Package :	Heat dissipation characteristics, frame materials, wire materials, etc.

Rising demand for better noise performance
following the increasing density and electrification of automotive systems

When using an Op Amp with low noise immunity



When using an Op Amp with high noise immunity



EMI Immunity Op Amp

Ultra Low Noise Op Amp

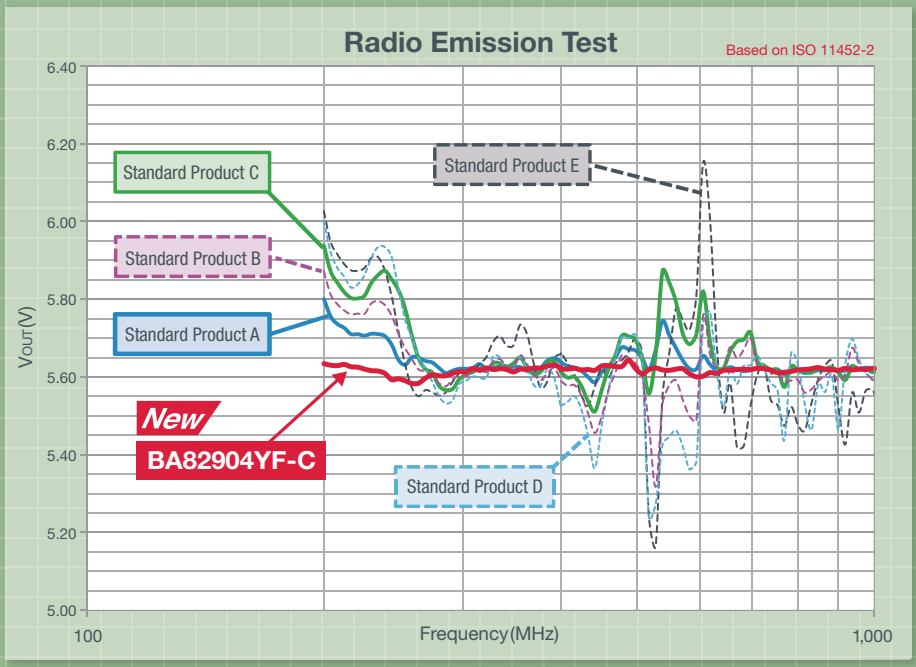
Ultra-High EMI Immunity

High EMI Immunity Op Amp

EMI Immunity Op Amp
BA82904YF-C

Industry-leading* noise immunity significantly reduces the design load for countermeasures against noise

As shown in the graph of the output voltage fluctuation at different noise frequencies at right, in contrast to the measured peaks of standard products A to E that are easily affected by frequency-based noise, ROHM's new product minimizes fluctuations based on frequency, making it possible to limit output voltage variations to less than ±1% (vs ±3.5 to ±10% with standard products). Achieving high EMI immunity greatly reduces the burden placed on designers of automotive electrical systems to develop noise countermeasures that typically require much time and effort. This reduces the cost and space previously required for external components such as the CR filter and shielding.



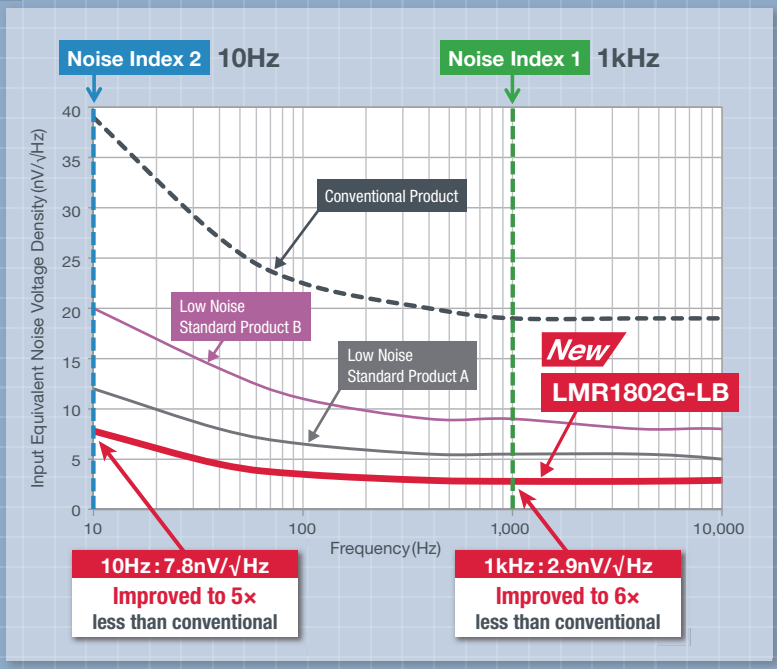
Ultra-Low Noise

Low-Noise CMOS Op Amp

Ultra Low Noise Op Amp
LMR1802G-LB

Achieving greater accuracy through the industry's lowest* noise

To meet the increasing need for high accuracy sensor control, ROHM developed a CMOS Op Amp that significantly reduces the noise generated within the Op Amp itself. Typically, noise generated by the internal transistors and resistors can cause errors during signal amplification, which can degrade amplification accuracy. In response, ROHM improved both the circuit design and manufacturing processes to achieve the lowest* noise in the industry, as shown in the graph at right. As a reference, 2.9nV/√Hz is approx. 6× less than the conventional value, while 7.8nV/√Hz is 5× less. In addition, the new design suppresses the input bias current and input offset voltage (that are sources of error during amplification) while improving the phase margin of the oscillation margin (which is in a trade-off relationship with conventional noise) to an industry-best 68°. The result is not only lower noise, but significantly greater accuracy and operational stability as well. These improvements make it possible to design a peripheral circuit that can maximize sensor performance.



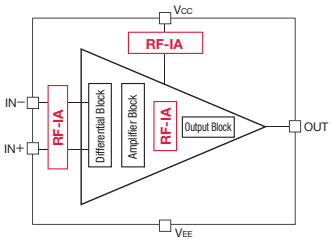
*ROHM October 2018 study

Significantly improving noise immunity by conducting a thorough review of circuits, layout, element size, and other factors

ROHM thoroughly analyzed previous products, added noise countermeasures circuits, reviewed the layout, and selected processes that generate optimal capacitances to dramatically improve EMI immunity. The key to success was to utilize a flexible approach in selecting the optimum solution, rather than simply following the industry trend of reducing chip size. This breakthrough noise immunity could never be achieved with just one countermeasure, but was instead the culmination of 3 factors.

Circuit review

Noise tolerance is improved by incorporating a newly developed noise countermeasure circuit RF-IA in required locations.

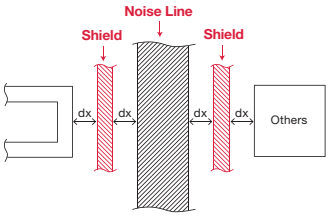


Added newly developed noise countermeasure circuits(RF-IA)

*RF-IA stands for Radio Frequency Impedance Adjuster

Layout review

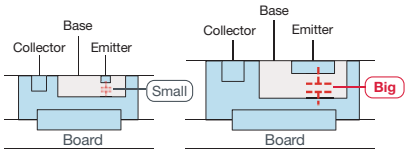
In addition to reviewing wiring interference, shields were placed in the noise line and the impedance of the internal analog core adjusted.



① Noise Line Shield
② Review of Wiring Interference
③ Impedance Adjustment of Internal Analog Core

Utilizing optimized processes

Focusing on fact that the noise immunity is high when the parasitic capacitance is large made it possible to select the process and element size that will result in the ideal parasitic capacitance.



Parasitic capacitance differs based on process and element size

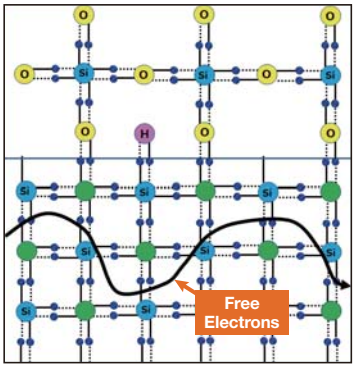
Process that yielded the ideal parasitic capacitance selected

EMI noise immunity is improved when the above 3 measures are fully aligned

Achieving the lowest* noise in the industry by combining aspects of both circuit design and the production process

An analysis of ROHM's previous low-noise Op Amps was conducted from the standpoint of the manufacturing process. As a result, it was discovered that minimizing electron scattering due to impurities makes it possible to suppress flicker noise. This significantly improves noise characteristics in the low frequency band. In addition, by adjusting the size of the transistor and circuit structure and decreasing the resistance value, ROHM was able to reduce thermal noise (white noise) generated from the internal transistors, resistors, and wiring. The key to achieving lower noise was approaching this challenge from both manufacturing and design aspects, allowing ROHM to deliver the lowest* noise characteristics on the market which would not be possible otherwise. The advantages of ROHM's vertically integrated production system are on full display here as well.

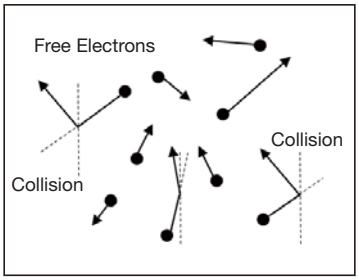
Improvements through the manufacturing process



Flicker noise

Flicker noise is believed to be caused by the scattering (fluctuation) of electrons due to impurities contained within the semiconductor. Therefore, suppressing electron scattering within the semiconductor will cause the electrons to flow more smoothly.

Improvements through circuit design



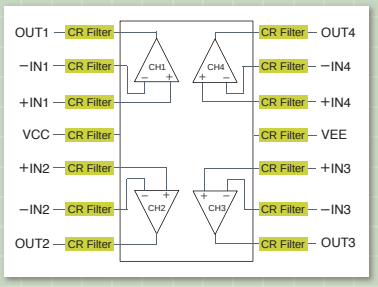
Thermal noise

Thermal noise occurs in the internal resistance components, pure resistors, transistors, wiring, and other elements. Improvements are achieved by reducing the resistance value and optimizing the circuit configuration and transistor size.

Significantly reducing the time, effort, and costs for noise countermeasures

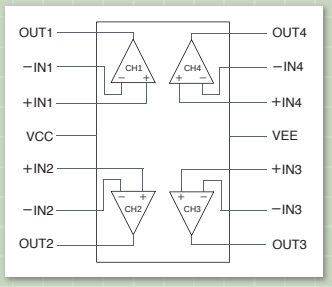
Breakthrough EMI noise immunity eliminates the need for an external CR filter and shield previously required, contributing to greater space savings while reducing peripheral component costs.
Also, previously when integrating noise countermeasures, if noise evaluation fails after implementing functional and noise designs, it was necessary to start from the beginning, placing a considerable burden in terms of time, effort, and cost.
In response, ROHM's new Op Amp allows users to significantly reduce design man-hours and costs, contributing to shorter delivery times for set design.

Conventional Op Amp



CR filter consisting of a capacitor and resistor used to supplement noise immunity

ROHM's New Product



No need to worry about noise
Facilitates noise design

Provides superior versatility and complies with international standards for reliability

ROHM's new high EMI immunity Op Amp maintains the same performance as conventional products, ensuring worry-free operation even when used as a replacement.
In addition, qualification under the international automotive standard AEC-Q100 ensures superior reliability.

When designing a new model(board)

For a Conventional Op Amp

Possibility of failure

Functional Design	Noise Countermeasure Design	Set FAB	Set Evaluation	Noise Evaluation	Noise Countermeasure Redesign	Set FAB	Set Evaluation	Noise Evaluation

Designing noise countermeasures is extremely difficult

Noise Evaluation Site(Location)
Usage fee : Approx. 500,000 yen/day

Noise Evaluation Site(Location)
Usage fee : Approx. 500,000 yen/day

For ROHM's New Op Amp

Functional Design	Set FAB	Set Evaluation	Noise Evaluation

Less time spent on designing noise countermeasures

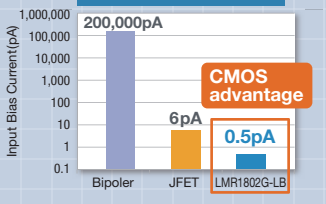
Passes the first time

High EMI immunity reduces both the set design load and design costs
Enables quick response for sets requiring short delivery times

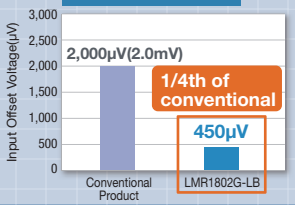
Significantly reduces input bias current and input offset voltage

The main cause of input bias current is said to be element leakage current that prevents damage caused by static electricity, but by optimizing the element size ROHM was able to limit the current to 0.5pA (around half that of conventional models). For input offset voltage, ROHM conducted a review of the circuit design in order to increase voltage gain and minimized the effects of device variations by increasing the transistor element size.
Furthermore, selecting a production process that can optimize the input offset voltage is another factor allowing ROHM to achieve a low value of 450μV (1/4th of conventional).

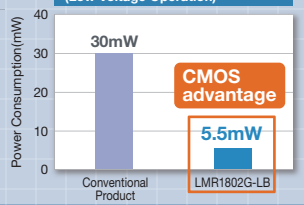
Low Input Bias Current



Input Offset Voltage



Lower Power Consumption (Low Voltage Operation)

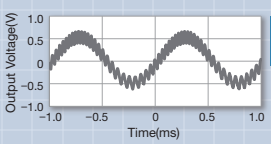


	Conventional Product*	LMR1802G-LB
Input Equivalent Noise Voltage Density	5nV/√Hz	2.9nV/√Hz
Circuit Current	6mA	1.1mA
Supply Voltage	4V to 32V	2.5V to 5.5V

*Comparison with a conventional bipolar low-noise type at 5V

Improved phase margin ensures superior stability

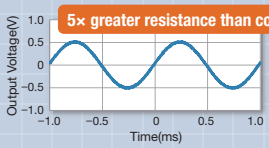
The 3rd feature is excellent stability. One problem with conventional Op Amps is that the phase margin becomes smaller as noise is reduced, increasing the likelihood of oscillation. ROHM's new product achieves a high phase margin of 68° through optimized phase compensation integrated into several areas in the circuit in order to suppress oscillation. In addition, the capacitive load characteristics which is an indicator of how easily oscillation can occur has been raised to 500pF.



Oscillation Example

*Load capacitance 200pF connected

5× greater resistance than conventional products



LMR1802G-LB

*Load capacitance 1,000pF connected

	Standard Product A	Standard Product B	Conventional Product	LMR1802G-LB
Input Equivalent Noise Voltage Density	5.5nV/√Hz	7.5nV/√Hz	19nV/√Hz	2.9nV/√Hz
Phase Margin*	24°	60°	40°	68°
Capacitive Load Characteristics	100pF	250pF	100pF	500pF

*Under no-load conditions

*ROHM October 2018 study

Product Lineup

Automotive-Grade Ground Sense Op Amps Featuring High EMI Immunity

■ Ideal for impedance conversion and amplifying weak signals ■ Optimized for high-voltage circuits, including engine ECUs and EVs

Part No.	No. of ch	Supply Voltage (V)	Circuit Current (mA)	Input Offset Voltage (mV)	Input Bias Current (nA)	Output Current (mA)	Input Voltage (V)	Output Voltage (V)	Voltage Gain (dB)	CMRR (dB)	PSRR (dB)	Slew Rate (V/μs)	Gain Bandwidth Product (MHz)	Operating Temperature (°C)	Package
New BA82904YF-C	2	3 to 36	0.5	2.0	20	30	V_{EE} to $V_{CC}-1.5$	V_{EE} to $V_{CC}-1.5$	100	80	100	0.2	0.5	−40 to +125	SOP8
New BA82904YFVM-C															MSOP8
New BA82902YF-C	4	3 to 36	0.7	2.0	20	30	V_{EE} to $V_{CC}-1.5$	V_{EE} to $V_{CC}-1.5$	100	80	100	0.2	0.5	−40 to +125	SOP14
New BA82902YFV-C															SSOP-B14

Automotive-Grade Ground Sense Op Amps

Part No.	No. of ch	Supply Voltage (V)	Circuit Current (mA)	Input Offset Voltage (mV)	Input Bias Current (nA)	Output Current (mA)	Input Voltage (V)	Output Voltage (V)	Voltage Gain (dB)	CMRR (dB)	PSRR (dB)	Slew Rate (V/μs)	Gain Bandwidth Product (MHz)	Operating Temperature (°C)	Package
BA2904YF-C	2	3 to 36	0.5	2.0	20	30	V_{EE} to $V_{CC}-1.5$	V_{EE} to $V_{CC}-1.5$	100	80	100	0.2	0.5	−40 to +125	SOP8
BA2904YFV-C															SSOP-B8
BA2904YFVM-C															MSOP8
BA2902YF-C	4	3 to 36	0.7	2.0	20	30	V_{EE} to $V_{CC}-1.5$	V_{EE} to $V_{CC}-1.5$	100	80	100	0.2	0.5	−40 to +125	SOP14
BA2902YFV-C															SSOP-B14
BA2904YF-M	2	3 to 36	0.5	2.0	20	30	V_{EE} to $V_{CC}-1.5$	V_{EE} to $V_{CC}-1.5$	100	80	100	0.2	0.5	−40 to +125	SOP8
BA2904YFV-M															SSOP-B8
BA2904YFVM-M															MSOP8
BA2902YF-M	4	3 to 36	0.7	2.0	20	30	V_{EE} to $V_{CC}-1.5$	V_{EE} to $V_{CC}-1.5$	100	80	100	0.2	0.5	−40 to +125	SOP14
BA2902YFV-M															SSOP-B14

Low-Noise CMOS Op Amp

Part No.	No. of Circuits	Supply Voltage (V)	Input Equivalent Noise Voltage Density (nV/√Hz)	Phase Margin (°)	Capacitive Load Characteristics (pF)	Input Bias Current (pA)	Input Offset Voltage (mV)	Operating Temperature (°C)	Package (mm)
New LMR1802G-LB	1	2.5 to 5.5	2.9(1kHz) 7.8(10Hz)	68*	500	0.5	0.45	−40 to +125	SSOP5 (2.9×2.8×1.25)

*Under no-load conditions

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Catalog No.61X7167E-B 11.2018 ROHM © 3000IS

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