ROHM SEMICONDUCTOR

Pursuing a Completely
Noiseless Design
ROHM Op Amps

EMARMOUR

High EMI Immunity Op Amps

&

Ultra-Low noise CMOS Op Amps

Next Generation Op Amp

Outstanding noiseless performance changes the common wisdom in circuit design

Not affected by external noise

High EMI Immunity Op Amps

EMARMOUR

2 Novel Op Amps

As the demand for sensors increases in automotive systems and industrial equipment, so does the need for sensing circuits that operate safely and with high accuracy.
In sensing circuits, how to process the weak electrical signals output by sensor elements can significantly affect safety and performance.
This requires an Op Amp for amplifying the signal to a level that the system can accurately process.
When an Op Amp amplifies weak signals, external noise from other devices as well as semiconductor noise emitted from the Op Amp itself can cause interference, but the pursuit for noise immunity invariably puts a limit on performance.
ROHM has succeeded in commercializing high performance Op Amps that exceed the limits of existing noise performance by leveraging integrated manufacturing and reviewing not only circuit design but also layout, processes, and element variations.

Development Background

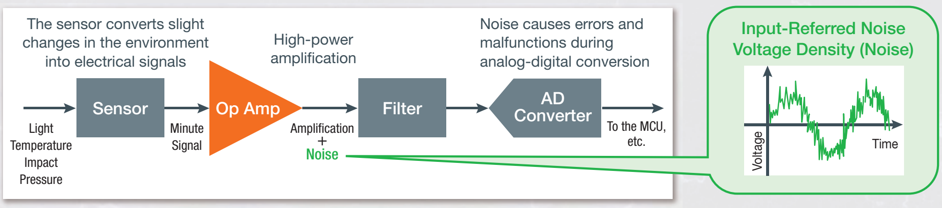
Noiseless Op Amps promote higher performance and reliability in sensing circuits

With the IEC61508 safety standard as the core, circuit standards related to functional safety have been established in various fields such as machine manufacturing, transportation, and medical equipment where additional safety is required. Particularly in the automotive sector, a variety of safety equipment based on functional safety are rapidly being developed to prevent traffic accidents. A key component of the electrical circuit design of these applications is the sensing circuit. As signals output from sensors are often weak and easily affected by noise from surrounding electrical systems and communications equipment, if the input signal is amplified with the noise there is a high possibility of erroneous recognition that can lead to malfunction.
At the same time, to achieve high accuracy voltage amplification it is extremely important that the Op Amp itself does not generate noise. To enhance the reliability of sensing circuits in automotive and industrial equipment, ROHM developed high EMI immunity Op Amps that eliminate the need for noise countermeasures along with models that provide class-leading* low noise performance.

No noise generated during signal processing

Low-Noise CMOS Op Amps

The challenges of Op Amps used in sensing circuits



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.

Ultra-High EMI Immunity

High EMI Immunity Op Amps

EMARMOUR

【The Need for High EMI Immunity Op Amps】

There are 2 main reasons for using high EMI immunity Op Amps
The first is to shut out external noise in electronic devices that protect human lives and ADAS (Advanced Driver Assistance Systems) to prevent traffic accidents.
The second is to cope with increased noise generated by high voltage batteries and drive equipment along with high power motors in AC and power steering systems installed in electric vehicles.
ROHM's high EMI immunity EMARMOUR™ Op Amp series provides stronger noise protection for electronic circuits.

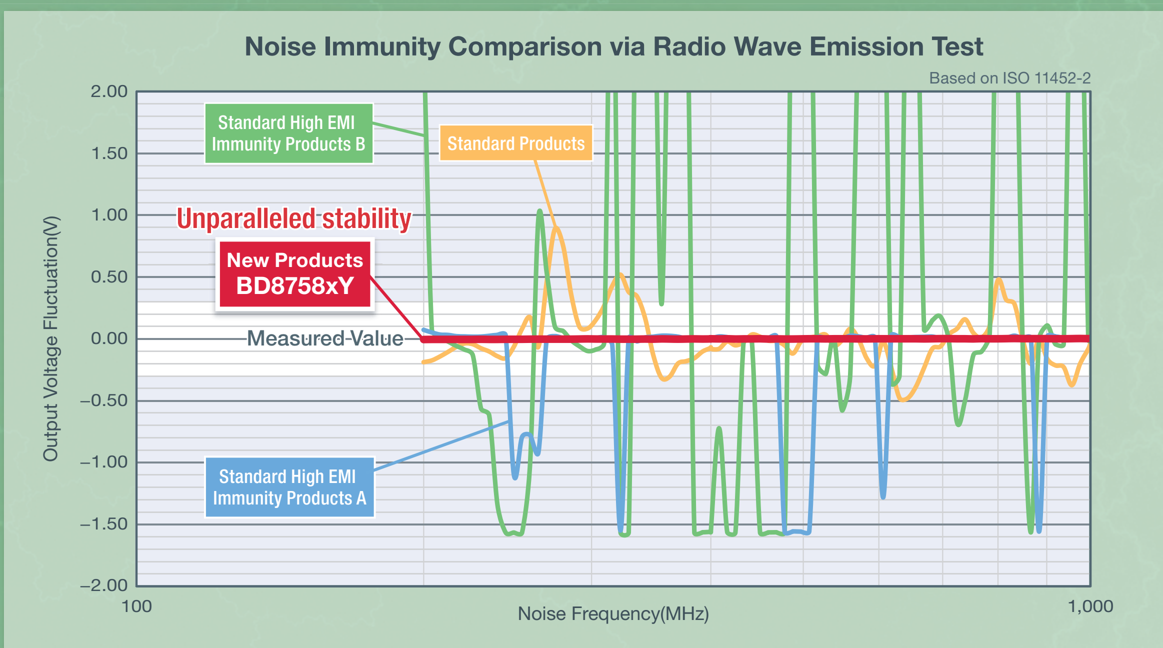
What is EMARMOUR™?

EMARMOUR™ is the brand name reserved by ROHM only for those products leveraging proprietary technologies covering layout, processes, and circuit design to achieve ultra-high noise immunity that minimizes output voltage fluctuation across the entire noise frequency band during noise evaluation testing under the international ISO 11452-2 standard. This unprecedented noise immunity both reduces design load while improving reliability by solving issues related to noise in the development of a variety of systems.

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

As shown in the graph of the output voltage fluctuation vs noise frequency below, in contrast to the measured peaks of standard and general-purpose high EMI immunity products that are easily affected by frequency-based noise, ROHM's new products minimize fluctuations due to 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.



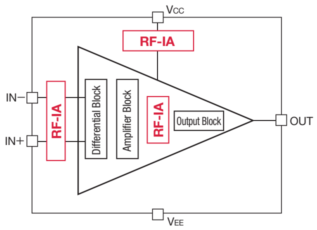
*EMARMOUR™ is a trademark or registered trademark of ROHM Co., Ltd.

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

In addition to conducting a thorough analysis of previous products, adding noise countermeasures circuits, and reviewing the layout, ROHM 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. Breakthrough noise immunity could never be achieved with just one countermeasure, but was the culmination of 3 factors.

Circuit review

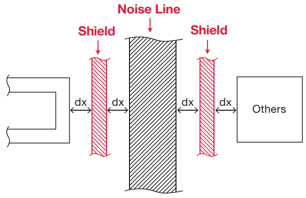
Noise tolerance is improved by incorporating a newly developed noise countermeasure circuit RF-IA in required locations.



Added newly developed noise countermeasure circuits(RF-IA)

Layout review

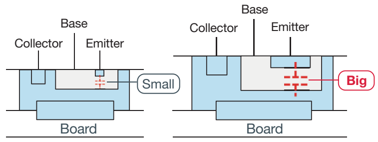
In addition to reviewing wiring interference, shields were placed in the noise line and the impedance of the internal analog core adjusted.



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

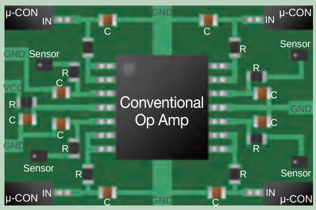
Process that yielded the ideal parasitic capacitance selected

Susceptibility to external noise is prevented by fully aligning the above 3 measures

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

High EMI noise immunity created from an unprecedented design 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 high EMI immunity Op Amps allow users to significantly reduce design man-hours and costs, thereby reducing delivery times for short-term set designs.

Conventional Op Amp

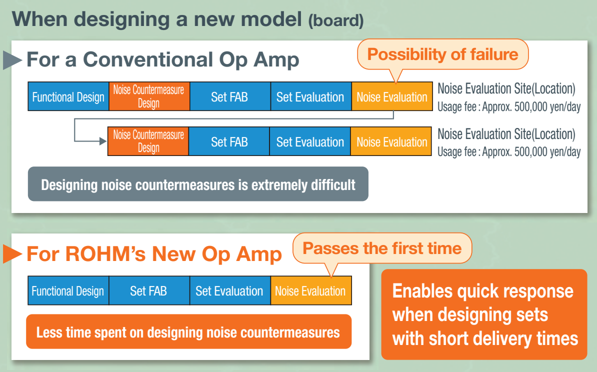


Utilizes CR filters consisting of a capacitor and resistor to boost noise immunity

ROHM High EMI Immunity Op Amp

No CR Filter Required
(Eliminates up to 18 parts in the case of 4ch)

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 Amps maintain the same performance as conventional products, ensuring worry-free operation even when used as replacements. In addition, compliance with the international automotive standard AEC-Q100 ensures superior reliability.

Ultra-Low Noise

Low-Noise CMOS Op Amps

【The Need for Low-Noise CMOS Op Amps】

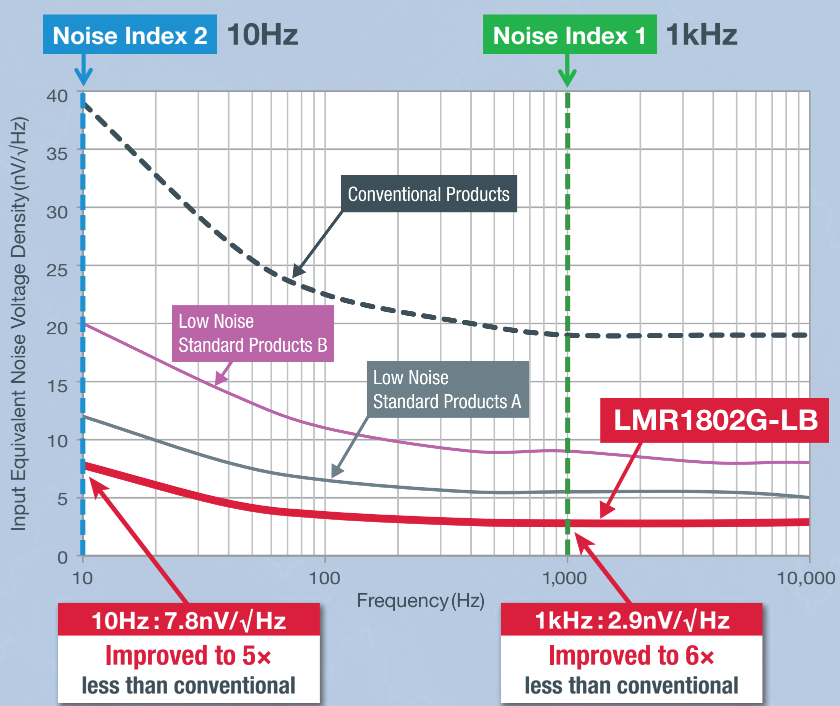
In sensor circuits, the Op Amp is responsible for amplifying the weak signals of the sensor element and transmitting them to the MCU as accurately as possible. In most cases, the errors to be most concerned about are the input offset (an error of the Op Amp) and the individual error of the sensor element itself, but in general the entire system is calibrated (corrected) to compensate for these errors. If the MCU read value increases or decreases with respect to the expected value, the accuracy of the set can be improved by correcting the output value accordingly. However, there are some electrical characteristics of Op Amps that cannot be calibrated, including small fluctuations in the output voltage referred to as the input equivalent noise voltage.

Since this fluctuation always occurs randomly, it cannot be compensated for, and the amplitude of the error is amplified in proportion to that of the Op Amp. In this case a lower noise CMOS Op Amp is needed, since a system that carries out high accuracy amplification cannot be established unless the input equivalent noise voltage of the Op Amp is as small as possible.

Achieving greater accuracy through the industry's lowest* noise

To meet the increasing need for high accuracy sensor control, ROHM developed low noise CMOS Op Amps that significantly reduce the noise generated by 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 production process and circuit design to achieve the lowest* noise in the industry [5x less (7.8nV/√Hz) and 6x less (2.9nV/√Hz) vs conventional as shown in the graph below)].

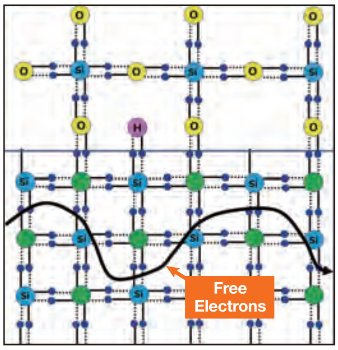
In addition, the new design suppresses input bias current and input offset voltage (that are sources of error during amplification) while improving the phase margin of the oscillation margin (which is in a trade-off relationship with conventional noise) to an Industry's highest level 68°. The result 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.



Achieves the industry's lowest* noise by combining aspects of both circuit design and the production process

An analysis of conventional 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, significantly improving 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, delivering best-in-class* low noise characteristics which would not be possible otherwise. The advantages of ROHM's integrated production system are on full display here as well.

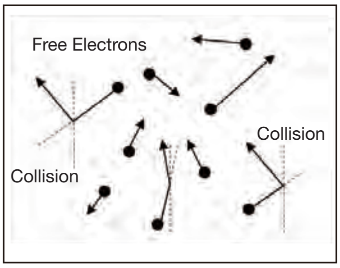
Improvements through the manufacturing process



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 ensures that the electrons flow more smoothly.

Improvements through circuit design

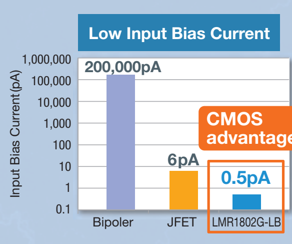


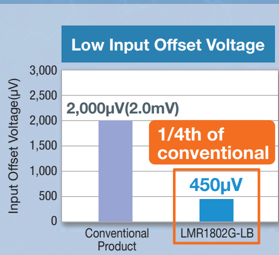
Thermal noise

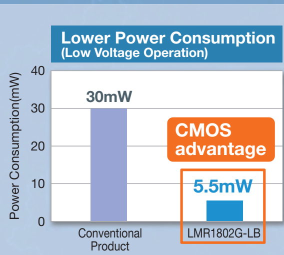
Thermal noise occurs in the internal resistance components, pure resistors, transistors, wiring, and other elements.
Improvements are achieved by reducing the resistance value and optimizing both the circuit configuration and transistor size.

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 1/12th that of conventional JFET models). For input offset voltage, ROHM conducted a review of the circuit design to increase voltage gain and increased the transistor element size to minimize the effects of device variations. Furthermore, selecting a production process that can optimize the input offset voltage allowed ROHM to achieve a low value of 450μV (around 1/4th of conventional).





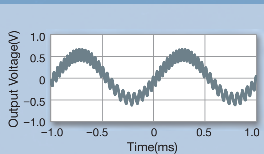


	Conventional Product*	LMR1802G-LB
Input Equivalent Noise Voltage Density	5nV/√Hz	2.9nV/√Hz
Circuit Current	6mA	1.1mA
Supply Voltage	4V to 32V	2.5V to 5.5V

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

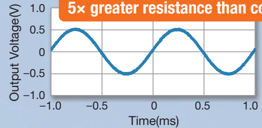
Improved phase margin ensures superior stability

Low-noise CMOS Op Amps maintain high stability. One problem with conventional Op Amps is that the phase margin becomes smaller as noise is reduced, increasing the likelihood of oscillation. In contrast, ROHM's new products achieve a high phase margin of 68° by integrating optimized phase compensation that suppresses oscillation into several areas in the circuit. At the same time, the capacitive load characteristics (which is an indicator of how easily oscillation can occur) has been raised to 500pF.



Oscillation Example

Connected to a 200pF capacitive load



5× greater resistance than conventional products

LMR1802G-LB

Connected to a 1,000pF capacitive load

	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

*At no load

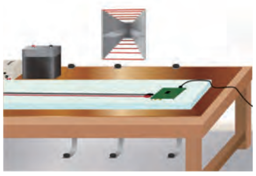
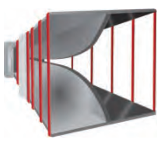
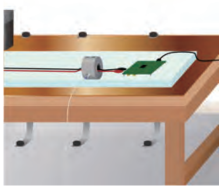
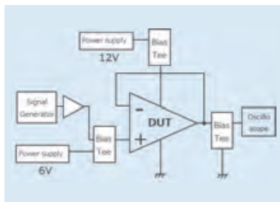
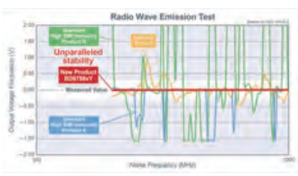
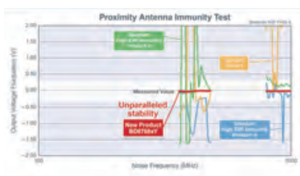
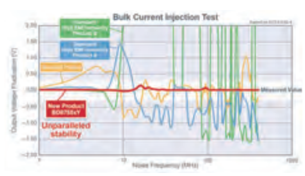
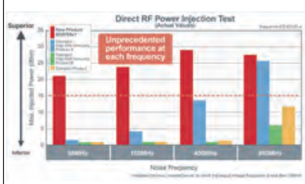
*ROHM October 2021 study

Clears 4 international noise evaluation tests with breakthrough performance

Noise Evaluation Testing of Ultra-High EMI Immunity Op Amps

To prevent Op Amps from malfunctioning due to noise without taking special measures in applications, ROHM developed true high EMI Op Amps capable of handling a variety of noise by conducting tests normally performed by electronic product manufacturers using an in-house anechoic chamber, including not only DPI, but also radio wave emission (irradiating electromagnetic waves from an antenna), proximity immunity (irradiating electromagnetic waves from an antenna), and BCI tests (applying noise to wiring harnesses with injection probes).


ROHM EMC Site

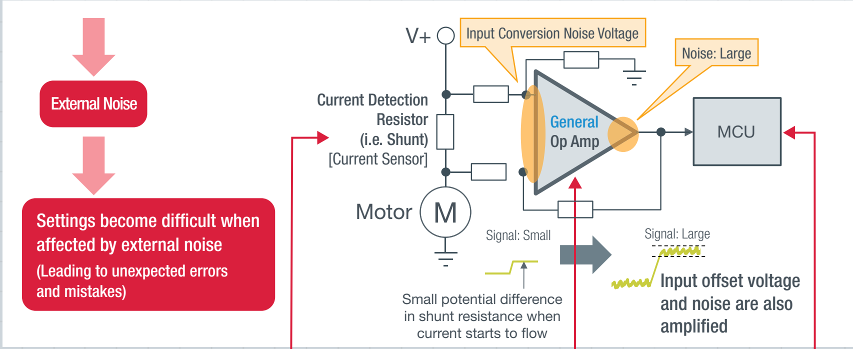
Evaluation Tests	Radio Wave Emission Test	Proximity Antenna Immunity Test	BCI Test	DPI Test
Target Op Amps	Good: EMARMOUR™ High EMI Immunity Op Amp Average: Standard High EMI Immunity Op Amp	Good: EMARMOUR™ High EMI Immunity Op Amp Average: Standard High EMI Immunity Op Amp	Good: EMARMOUR™ High EMI Immunity Op Amp Average: Standard High EMI Immunity Op Amp	Good: EMARMOUR™ High EMI Immunity Op Amp Better: Standard High EMI Immunity Op Amp (Resistant to noise only in specific frequency bands due to filter measures)
Test Overview	Test commonly carried out by electronics manufacturers. Noise test that cannot be prevented by input filters due to electromagnetic radiation from the antenna.	This test is increasingly common due to the proliferation of cell phones. Noise test that cannot be prevented by input filters due to electromagnetic radiation from the antenna.	A test in which noise is applied to the wiring harness connected to an electronic device using a current injection probe. The immunity of electronic devices is evaluated when excited by strong magnetic field noise.	A test in which noise signals are directly applied to a semiconductor terminal. Countermeasures are relatively easy, such as installing a filter at the input terminal in advance.
Test conditions	ISO 11452-2 Compliant	ISO 11452-9 Compliant	ISO 11452-4 Compliant	IEC 62132-4 Compliant
Test Method Measurement Circuit Measurement Environment	Substitution Method (Traveling Wave Power) Frequency vs Output Voltage :Voltage follower  	Frequency vs Output Voltage :Voltage follower  	Frequency vs Output Voltage :Voltage follower  	Frequency vs Max. Injection Power :Voltage follower 
Measurement Results	 	 	 	

*EMARMOUR™ are trademarks or registered trademarks of ROHM Co., Ltd.

Noise-free design

Significant consideration for noise is required even for a simple current sensing circuit design using a shunt resistor (as shown below)

Current detection involves monitoring the current value by passing current through a minute resistor such as shunt resistor then amplifying and reading the small voltage across the resistor. In the circuit, the acceptable current detection error is first set and Input Offset Voltage × Amplification Factor Error confirmed to be within the range that can be calibrated, then determine whether the uncorrectable Input Conversion Noise Voltage × Amplification Factor is an acceptable measurement error.
System design is also required, including the acceptable range, shunt resistor characteristics, and MCU/program design. The most troublesome among these is noise, which is an uncertain factor. Reducing both internal and external noise will result in a worry-free design.



Detection Resistor	Op Amp Design	MCU
• Resistance Error (Resistance Tolerance) • Temperature Coefficient of Resistance • At Overload • Thermal Resistance • Land Pattern • Solder	• Absolute Max. Ratings for Withstand Voltage and Temperature • Input Offset Absolute Max. Variation • Input Offset Temperature Drift • Input Conversion Noise (Required) • Common Mode Input Voltage Range • Slew Rate	• Initial Value Settings • Threshold Design • AD Resolution • Hysteresis Width • Abnormalities • Protection Circuits

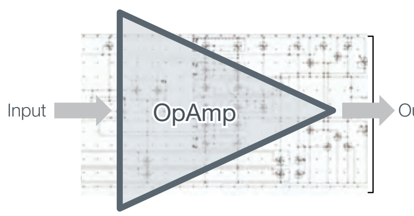
ROHM Real Model

Class-leading* simulation accuracy.

ROHM Real Model is ROHM's proprietary modeling technology that achieves high characteristics reproducibility by designing and recombining the characteristics of the entire transistor circuit for each function.

Conventional Modeling Technology

Element-Based Modeling

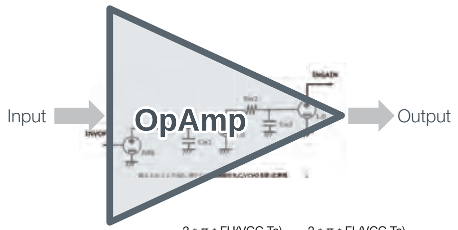


Since the characteristics of each element are modeled and connected together, it is difficult to match all characteristics, including parasitic elements, with the actual device

Simulation results do not match the actual device

ROHM Real Model

Formula-Based Modeling



$$G(s) = AdB(VCC,Ta)\,\frac{2\cdot\pi\cdot FH(VCC,Ta)}{s+2\cdot\pi\cdot FH(VCC,Ta)}\,\frac{2\cdot\pi\cdot FL(VCC,Ta)}{s+2\cdot\pi\cdot FL(VCC,Ta)}$$

Relationship between input and output is mathematically formulated (modeled) based on actual evaluation results

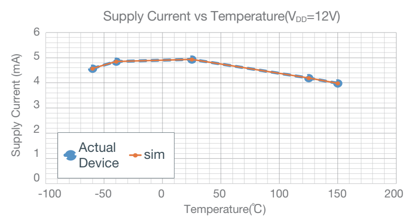
Simulation matches the actual device

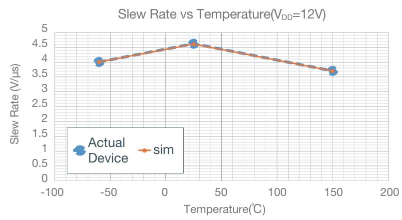
Reproduce phase margins with high accuracy

Complete lineup of high accuracy SPICE models developed using ROHM's proprietary model-based technology. Faithfully reproducing the electrical and temperature characteristics of the actual IC contributes to more efficient application development.

Op Amp SPICE Models			
Category	Characteristics	ROHM	Standard Product
DC	Zero Input Current	Good	Good
	Circuit Current	Good	Good
	Short-Circuit Output Current	Good	Good
	Max and Min Output Voltage Amplitudes	Good	Good
	Input Bias Current	Good	Better
	Common Mode Supply Voltage Removal Ratio	Good	Average
	DC Output Resistance	Good	Better
	Rail-to-Rail	Good	Good
	Source/Sink Output Current Limit	Good	Good
	Input Offset Voltage	Good	Good
	Input Capacitance	Good	Better
	Supply Voltage Dependence	Good	Average
	Temperature Characteristics	Good	Average
AC	Slew Rate	Good	Better
	Unity Gain Frequency	Good	Good
	1-Pole or 2-Pole Amp Gain/Phase	Good	Good
	Common Mode Supply Voltage Removal Ratio	Good	Average
	AC Output Resistance	Good	Better
	Phase Margin (Oscillation Margin)	Good	Better

Completely reproduces temperature characteristics





*ROHM October 2021 study

High EMI Immunity EMARMOUR™ Series Product Lineup

Op Amps

High EMI Immunity Ground Sense Op Amps

Element Structure	Part No.	ch	Supply Voltage (V)	Input Offset Voltage (Max)	Input Bias Current (Typ)(nA)	Slew Rate (Typ)(V/μs)	Circuit Current (Typ)(mA)	EMARMOUR™ (High EMI Immunity)	Nano Cap™ (Stable Output)	Package	ComfySIL™ Functional Safety Category	Automotive Grade (AEC-Q100 Qualified)
Bipolar	BA82904YF-C	2	3.0 to 36	6mV@25℃ 9mV@−40 to 125℃	20	0.2	0.5	✓	–	SOP8	FSs	YES
	BA82904YFVM-C									MSOP8	FSs	YES
	BA82902YF-C	4					0.7			SOP14	FSs	YES
	New BA82902YFV-C									SSOP-B14	FSs	YES

High EMI Immunity 150°C Operation Ground Sense Op Amps

Element Structure	Part No.	ch	Supply Voltage (V)	Input Offset Voltage (Max)	Input Bias Current (Typ)(nA)	Slew Rate (Typ)(V/μs)	Circuit Current (Typ)(mA)	EMARMOUR™ (High EMI Immunity)	Nano Cap™ (Stable Output)	Package	ComfySIL™ Functional Safety Category	Automotive Grade (AEC-Q100 Qualified)
Bipolar	New LM2904EYF-C	2	3.0 to 32	6mV@25℃ 9mV@−40 to 150℃	20	0.2	0.6	✓	–	SOP8	FSs	YES
	☆ LM2904EYFJ-C									SOP-J8	FSs	YES
	New LM2904EYFVM-C									MSOP8	FSs	YES
	☆ LM2902EYF-C	4					1			SOP14	FSs	YES
	☆ LM2902EYFV-C									SSOP-B14	FSs	YES

High EMI Immunity Ground Sense Op Amps

Element Structure	Part No.	ch	Supply Voltage (V)	Input Offset Voltage (Max)	Input Bias Current (Typ)(nA)	Slew Rate (Typ)(V/μs)	Circuit Current (Typ)(mA)	EMARMOUR™ (High EMI Immunity)	Nano Cap™ (Stable Output)	Package	ComfySIL™ Functional Safety Category	Automotive Grade (AEC-Q100 Qualified)
Bipolar	BA83472YF-C	2	3.0 to 36	10mV@25℃ 10mV@−40 to 125℃	100	8.5	4.3	✓	–	SOP8	FSs	YES
	BA83472YFVM-C									MSOP8	FSs	YES
	New BA83474YF-C	4					8.6			SOP14	FSs	YES
	New BA83474YFV-C									SSOP-B14	FSs	YES

High EMI Immunity Input/Output Rail-to-Rail Op Amps

Element Structure	Part No.	ch	Supply Voltage (V)	Input Offset Voltage (Max)	Input Bias Current (Typ)(nA)	Slew Rate (Typ)(V/μs)	Circuit Current (Typ)(mA)	EMARMOUR™ (High EMI Immunity)	Nano Cap™ (Stable Output)	Package	ComfySIL™ Functional Safety Category	Automotive Grade (AEC-Q100 Qualified)
CMOS	New BD87581YG-C	1	4.0 to 14	9mV@25℃ 10mV@−40 to 125℃	0.001	3.5	2.3	✓	–	SSOP5	FSs	YES
	New BD87582YFVM-C	2					5			MSOP8	FSs	YES
	New BD87584YFV-C	4					10			SSOP-B14	FSs	YES

High EMI Immunity High Speed Ground Sense Op Amps

Element Structure	Part No.	ch	Supply Voltage (V)	Input Offset Voltage (Max)	Input Bias Current (Typ)(nA)	Slew Rate (Typ)(V/μs)	Circuit Current (Typ)(mA)	EMARMOUR™ (High EMI Immunity)	Nano Cap™ (Stable Output)	Package	ComfySIL™ Functional Safety Category	Automotive Grade (AEC-Q100 Qualified)
CMOS	BD77501G	1	7.0 to 15	27mV@25℃	0.001	10	1.3	✓	✓	SSOP5	–	–
	BD77502FVM	2					2.6			MSOP8	–	–
	New BD77504FV	4					5.2			SSOP-B14	–	–

Nano Cap™ is ROHM'S Extremely stable control technology.

Comparators

High EMI Immunity Open Collector Comparators

Element Structure	Part No.	ch	Supply Voltage (V)	Input Offset Voltage (Max)	Input Bias Current (Typ)(nA)	Slew Rate (Typ)(V/μs)	Circuit Current (Typ)(mA)	EMARMOUR™ (High EMI Immunity)	Nano Cap™ (Stable Output)	Package	ComfySIL™ Functional Safety Category	Automotive Grade (AEC-Q100 Qualified)
Bipolar	BA82903YF-C	2	2.0 to 36	5mV@25℃ 9mV@−40 to 125℃	50	1.3	0.6	✓	–	SOP8	FSs	YES
	BA82903YFVM-C									MSOP8	FSs	YES
	BA82901YF-C	4					0.8			SOP14	FSs	YES
	BA82901YFV-C									SSOP-B14	FSs	YES

High EMI Immunity 150°C Operation Open Collector Comparators

Element Structure	Part No.	ch	Supply Voltage (V)	Input Offset Voltage (Max)	Input Bias Current (Typ)(nA)	Slew Rate (Typ)(V/μs)	Circuit Current (Typ)(mA)	EMARMOUR™ (High EMI Immunity)	Nano Cap™ (Stable Output)	Package	ComfySIL™ Functional Safety Category	Automotive Grade (AEC-Q100 Qualified)
Bipolar	New LM2903EYF-C	2	3.0 to 32	5mV@25℃ 9mV@−40 to 150℃	50	1.3	0.6	✓	–	SOP8	FSs	YES
	New LM2903EYFVM-C									MSOP8	FSs	YES
	☆ LM2901EYF-C	4		5mV@25℃ 8mV@−40 to 150℃			1.2			SOP14	FSs	YES
	New LM2901EYFV-C									SSOP-B14	FSs	YES

☆: Development planned

*EMARMOUR™, Nano Cap™ and ComfySIL™ are trademarks or registered trademarks of ROHM Co., Ltd.

Low-Noise CMOS Op Amps Product Lineup

Ultra-Low Noise Ground Sense Op Amps

Element Structure	Part No.	ch	Supply Voltage (V)	Input Offset Voltage (Max)	Input Offset Voltage Temperature Drift (Max) (μV/°C)	Input-Referred Noise Voltage Density (Typ)(nV/√Hz)	Gain Bandwidth Product (MHz)	Slew Rate (Typ)(V/μs)	Input Bias Current (Typ)(nA)	Circuit Current (Typ)(mA)	Package	ComfySIL™ Functional Safety Category	Automotive Grade (AEC-Q100 Qualified)
CMOS	New LMR1802YG-C	1	2.5 to 5.5	450μV@25℃ 500μV@−40 to 125℃	–	2.9	4.4	1.1	0.0005	1.1	SSOP5	FSs	YES
	☆ LMR2802YFVM-C	2	2.5 to 5.5	450μV@25℃ 500μV@−40 to 125℃	–	2.9	4.4	1.1	0.0005	2.2	MSOP8	FSs	YES

High Precision & Input/Output Rail-to-Rail Op Amps

Element Structure	Part No.	ch	Supply Voltage (V)	Input Offset Voltage (Max)	Input Offset Voltage Temperature Drift (Max) (μV/°C)	Input-Referred Noise Voltage Density (Typ)(nV/√Hz)	Gain Bandwidth Product (MHz)	Slew Rate (Typ)(V/μs)	Input Bias Current (Typ)(nA)	Circuit Current (Typ)(mA)	Package	ComfySIL™ Functional Safety Category	Automotive Grade (AEC-Q100 Qualified)
CMOS	New TLR377YG-C	1	2.5 to 5.5	1200μV@25℃ 1300μV@−40 to 125℃	4.0	8	4	2	0.0005	0.645	SSOP5	FSs	YES
	☆ TLR2377YF-C	2	2.5 to 5.5	1200μV@25℃ 1300μV@−40 to 125℃	4.0	8	4	2	0.0005	1.245	SOP8	FSs	YES
	☆ TLR2377YFJ-C	2	2.5 to 5.5	1200μV@25℃ 1300μV@−40 to 125℃	4.0	8	4	2	0.0005	1.245	SOP-J8	FSs	YES
	New TLR2377YFVM-C	2	2.5 to 5.5	1200μV@25℃ 1300μV@−40 to 125℃	4.0	8	4	2	0.0005	1.245	MSOP8	FSs	YES
	☆ TLR4377YF-C	4	2.5 to 5.5	1200μV@25℃ 1300μV@−40 to 125℃	4.0	8	4	2	0.0005	2.49	SOP-J14	FSs	YES
	☆ TLR4377YFV-C	4	2.5 to 5.5	1200μV@25℃ 1300μV@−40 to 125℃	4.0	8	4	2	0.0005	2.49	SSOP-B14	FSs	YES
	New TLR376YG-C	2	2.5 to 5.5	150μV@25℃ 550μV@−40 to 125℃	4.0	8	4	2	0.0005	0.645	SSOP5	FSs	YES
	New TLR2376YFJ-C	2	2.5 to 5.5	150μV@25℃ 550μV@−40 to 125℃	4.0	8	4	2	0.0005	1.245	SOP-J8	FSs	YES
	New TLR2376YFVM-C	2	2.5 to 5.5	150μV@25℃ 550μV@−40 to 125℃	4.0	8	4	2	0.0005	1.245	MSOP8	FSs	YES
	New TLR4376YFV-C	4	2.5 to 5.5	150μV@25℃ 550μV@−40 to 125℃	4.0	8	4	2	0.0005	2.49	SSOP-B14	FSs	YES

High Precision & Input/Output Rail-to-Rail High Speed Op Amps

Element Structure	Part No.	ch	Supply Voltage (V)	Input Offset Voltage (Max)	Input Offset Voltage Temperature Drift (Max) (μV/°C)	Input-Referred Noise Voltage Density (Typ)(nV/√Hz)	Gain Bandwidth Product (MHz)	Slew Rate (Typ)(V/μs)	Input Bias Current (Typ)(nA)	Circuit Current (Typ)(mA)	Package	ComfySIL™ Functional Safety Category	Automotive Grade (AEC-Q100 Qualified)
CMOS	☆ BD7281YG-C	1	2.5 to 5.5	1.7mV@25℃ 2mV@−40 to 125℃	4.0	12	7	10	0.0005	1.7	SSOP5	FSs	YES
	☆ BD7282YFJ-C	2	2.5 to 5.5	1.7mV@25℃ 2mV@−40 to 125℃	4.0	12	7	10	0.0005	3.4	SOP-J8	FSs	YES
	☆ BD7282YFVM-C	2	2.5 to 5.5	1.7mV@25℃ 2mV@−40 to 125℃	4.0	12	7	10	0.0005	3.4	MSOP8	FSs	YES
	☆ BD7284YFV-C	4	2.5 to 5.5	1.7mV@25℃ 2mV@−40 to 125℃	4.0	12	7	10	0.0005	6.8	SSOP-B14	FSs	YES

☆: Development planned

ComfySIL™ is given to products that conform to the ComfySIL™ concept for functional safety.

ComfySIL Functional Safety

ComfySIL™ Compatible Products

The abbreviations of FSp, FSm, and FSs are shown in the Functional Safety column for ComfySIL™ Compatible Models.

ComfySIL™ Functional Safety Category Abbreviations	
	FSp: FS process compliant FSm: FS mechanism implemented FSs: FS supportive

For more information on ComfySIL™, please visit ROHM's website. **ROHM's Website: https://www.rohm.com/functional-safety**

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