MIC4414/4415



1.5A, 4.5V to 18V, Low-Side MOSFET Driver

General Description

The MIC4414 and MIC4415 are low-side MOSFET drivers designed to switch an N-channel enhancement type MOSFET in low-side switch applications. The MIC4414 is a non-inverting driver and the MIC4415 is an inverting driver. These drivers feature short delays and high peak current to produce precise edges and rapid rise and fall times.

The MIC4414/15 are powered from a 4.5V to 18V supply and can sink and source peak currents up to 1.5A, switching a 1000pF capacitor in 12ns. The on-state gate drive output voltage is approximately equal to the supply voltage (no internal regulators or clamps). High supply voltages, such as 10V, are appropriate for use with standard N-channel MOSFETs. Low supply voltages, such as 5V, are appropriate for use with many logic-level N-channel MOSFETs.

In a low-side configuration, the driver can control a MOSFET that switches any voltage up to the rating of the MOSFET.

The MIC4414 and MIC4415 are available in an ultra-small 4-pin 1.2mm x 1.2mm thin QFN package and is rated for -40°C to +125°C junction temperature range.

Data sheets and support documentation can be found on Micrel's web site at: www.micrel.com.

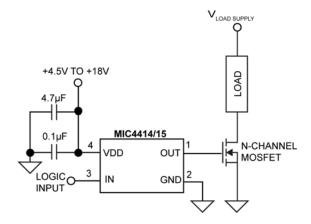
Features

- Ultra-small 4-pin 1.2mm x 1.2mm thin QFN package
- +4.5V to +18V operating supply voltage range
- 1.5A peak current
 - 3.5Ω output resistance at 18V
 - 9Ω output resistance at 5V
- · Low steady-state supply current
 - 77μA control input low
 - 445µA control input high
- 12ns rise and fall times into 1000pF load
- MIC4414 (non-inverting)
- MIC4415 (inverting)
- -40°C to +125°C junction temperature range

Applications

- Switch mode power supplies
- Solenoid drivers
- Motor driver

Typical Application



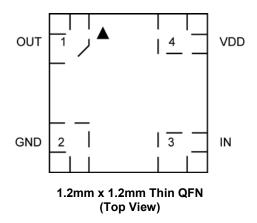
August 2012 M9999-080112-A

Ordering Information

Part Number	Marking	Configuration	Package	Junction Temperature Range	Lead Finish
MIC4414YFT	D9	Non-Inverting	4-pin 1.2mm x 1.2mm Thin QFN	-40°C to +125°C	Pb-Free
MIC4415YFT	D8	Inverting	4-pin 1.2mm x 1.2mm Thin QFN	-40°C to +125°C	Pb-Free

Note:

Pin Configuration



Pin Description

Pin Number	Pin Name	Pin Function
1	OUT	Gate Output: Connection to gate of external MOSFET.
2	GND	Ground.
3	IN	Control Input: MIC4414: Logic high drives the gate output above the supply voltage. Logic low forces the gate output near ground. Do not leave floating. MIC4415: Logic low drives the gate output above the supply voltage. Logic high forces the gate output
		near ground. Do not leave floating.
4	VDD	Supply Voltage: +4.5V to +18V supply.

^{1.}Thin QFN pin 1 identifier = "▲"

Absolute Maximum Ratings⁽¹⁾

Operating Ratings⁽³⁾

VDD to GND	+4.5V to +18V
IN to GND	0V to VDD
Junction Temperature (T _J)	40°C to +125°C
Thermal Resistance	
1.2mm x 1.2mm Thin QFN (θ_{JC})	60°C/W
1.2mm x 1.2mm Thin QFN (θ_{JA})	140°C/W

Electrical Characteristics(4)

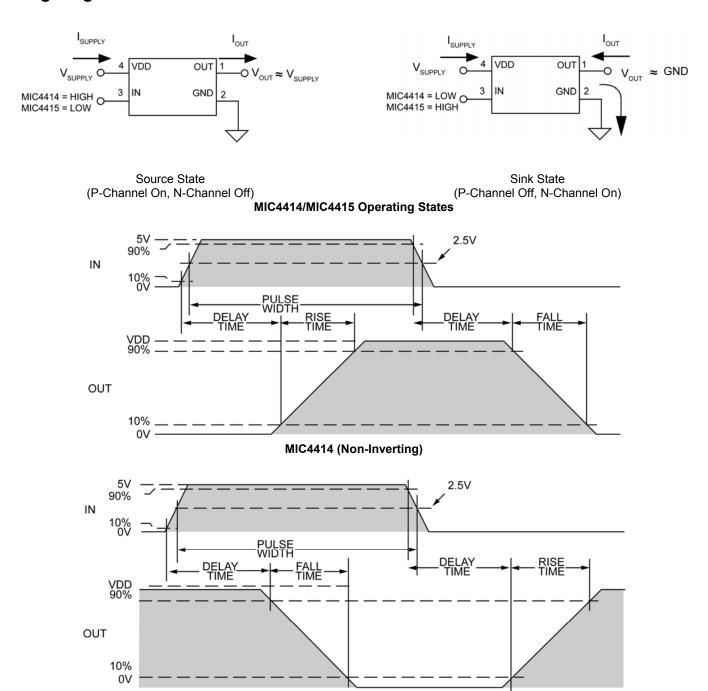
 $4.5V \le VDD \le 18V$, C_L = 1000pF; T_A = 25°C, **Bold** values indicate -40°C $\le T_J \le +125$ °C.

Parameter	Condition		Min	Тур	Max	Units	
Supply Current	MIC4414: IN = 0V, VDD = 18V			77	200		
	MIC4415: IN = 5V, VDD = 18V			''	200		
Supply Current	MIC4414: IN = 5V, VDD = 18V			445	1500	μΑ	
	MIC4415: IN = 0V, VDD = 18V			443	1500		
IN Voltage	IN = Logic Low				0.8	V	
iiv voitage	IN = Logic High		3			V	
IN Current	$0V \le VIN \le VDD$	-10		+10	μA		
Output Dice Time	VDD = 5V, C _L = 1000pF			30		- ns	
Output Rise Time	VDD = 18V, C _L = 1000pF			12			
Outrot Fall Time	VDD = 5V, C _L = 1000pF			33			
Output Fall Time	VDD = 18V, C _L = 1000pF			12		ns	
Dalay Time IN Dising	VDD = 5V, C _L = 1000pF			52			
Delay Time, IN Rising	VDD = 18V, C _L = 1000pF		29		ns		
Dala Tara IN Fallin	VDD = 5V, C _L = 1000pF VDD = 18V, C _L = 1000pF			58		ns	
Delay Time, IN Falling				30			
O. t t Off t \ / - t	OUT = High OUT = Low			-25		- mV	
Output Offset Voltage				25			
Output Resistance	\/DD 5\/ \ \ 40 \\ A	Source		9		Ω	
	VDD = 5V, I _{OUT} = 10mA	Sink		9			
	VDD = 18V, I _{OUT} = 10mA	Source		3.5	10		
		Sink		3.5	10		
Output Reverse Current		L	250			mA	

Notes:

- 1. Exceeding the absolute maximum rating may damage the device.
- 2. Devices are ESD sensitive. Handling precautions are recommended. Human body model, $1.5k\Omega$ in series with 100pF.
- 3. The device is not guaranteed to function outside operating range.
- 4. Specification for packaged product only.

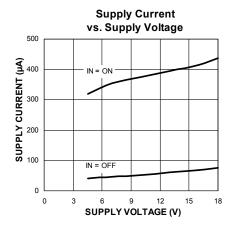
Timing Diagram

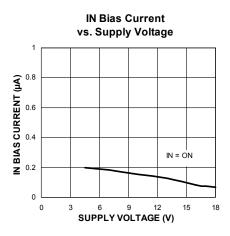


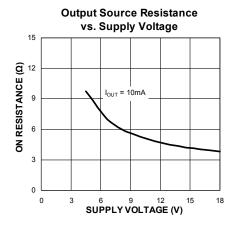
MIC4415 (Inverting)

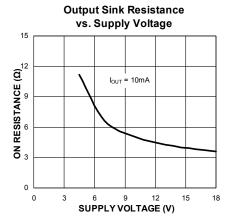
Typical Characteristics

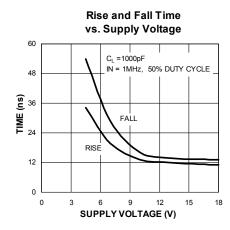
MIC4414 ON IN=5V, OFF IN=0V. MIC4415 ON IN=0V, OFF IN=5V.

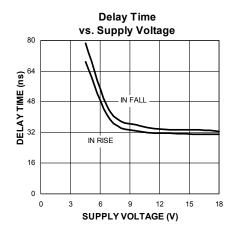


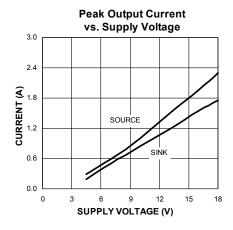


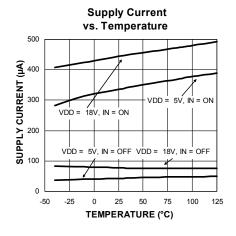


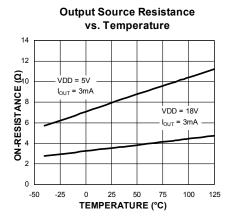






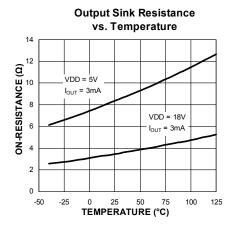


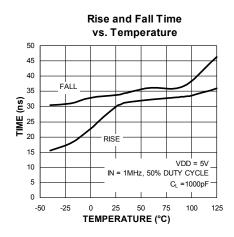


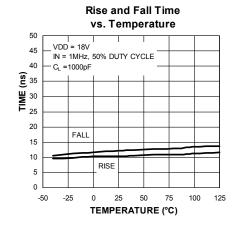


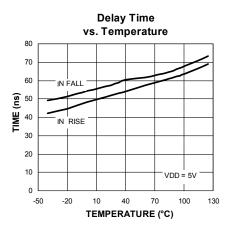
Typical Characteristics (Continued)

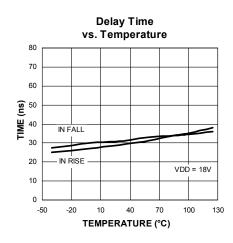
MIC4414 ON IN=5V, OFF IN=0V. MIC4415 ON IN=0V, OFF IN=5V.

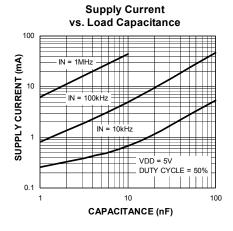


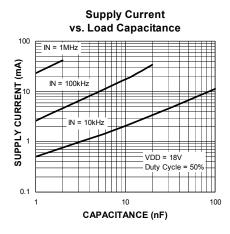


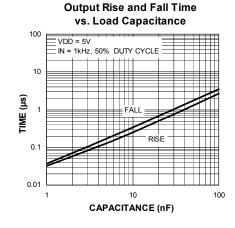


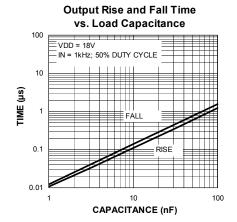






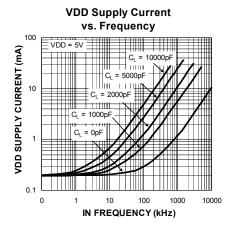


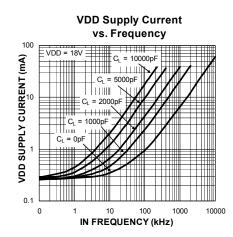




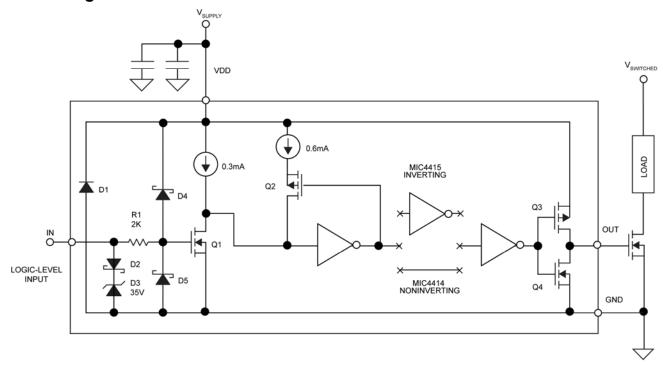
Typical Characteristics (Continued)

MIC4414 ON IN=5V, OFF IN=0V. MIC4415 ON IN=0V, OFF IN=5V.





Functional Diagram



Functional Description

The MIC4414 is a non-inverting driver. A logic high on the IN (control) pin produces gate drive output. The MIC4415 is an inverting driver. A logic low on the IN (control) pin produces gate drive output. The OUT is used to turn on an external N-channel MOSFET. The OUT pin will be driven to 0V or VDD depending on the status of IN pin.

VDD

VDD (supply) is rated for +4.5V to +18V. External capacitors are recommended to decouple noise.

IN

IN must be forced high or low by an external signal. A floating input will cause unpredictable operation.

A high input turns on Q1, which sinks the output of the 0.3mA and the 0.6mA current source, forcing the input of the first inverter low.

Hysteresis

The control threshold voltage, when IN is rising, is slightly higher than the control threshold voltage when IN is falling. When IN is low, Q2 is on, which applies the additional 0.6mA current source to Q1. Forcing IN high turns on Q1 which must sink 0.9mA from the two current sources. The higher current through Q1 causes a larger drain-to-source voltage drop across Q1. A slightly higher control voltage is required to pull the input of the first inverter down to its

threshold.

Q2 turns off after the first inverter output goes high. This reduces the current through Q1 to 0.3mA. The lower current reduces the drain-to-source voltage drop across Q1. A slightly lower control voltage will pull the input of the first inverter up to its threshold.

Drivers

The second (optional) inverter permits the driver to be manufactured in inverting and non-inverting versions.

The last inverter functions as a driver for the output MOSFETs Q3 and Q4.

OUT

OUT is designed to drive a capacitive load. The OUT voltage is either approximately the supply voltage or approximately ground, depending on the logic state applied to IN. If IN is high, and VDD (supply) drops to zero, the gate output will be floating (unpredictable).

ESD Protection

D1 protects VDD from negative ESD voltages. D2 and D3 clamp positive and negative ESD voltages applied to IN. R1 isolates the gate of Q1 from sudden changes on the IN pin. D4 and D5 prevent Q1's gate voltage from exceeding the supply voltage or going below ground.

Application Information

The MIC4414 and MIC4415 are designed to provide high peak current for charging and discharging capacitive loads. The 1.5A peak value is a nominal value determined under specific conditions. This nominal value is used to compare its relative size to other low-side MOSFET drivers. The MIC4414 and MIC4415 are not designed to directly switch 1.5A continuous loads.

Supply Bypass

A capacitor from VDD to GND is recommended to control switching and supply transients. Load current and supply lead length are some of the factors that affect capacitor size requirements.

4.7µF or 10µF ceramic or tantalum capacitor is suitable for many applications. Low-ESR (equivalent series resistance) metalized film capacitors may also be suitable. An additional 0.1µF ceramic capacitor is suggested in parallel with the larger capacitor to control high-frequency transients. The low ESR (equivalent series resistance) of ceramic and tantalum capacitors makes them especially effective, but also makes them susceptible to uncontrolled inrush current from low impedance voltage sources (such as NiCd batteries or automatic test equipment). Avoid instantaneously applying voltage, capable of very high peak current, directly to or near low ESR capacitors without additional current limiting. Normal power supply turn-on (slow rise time) or printed circuit trace resistance is usually adequate.

Circuit Layout

Avoid long power supply and ground traces. They exhibit inductance that can cause voltage transients (inductive kick). Even with resistive loads, inductive transients can sometimes exceed the ratings of the MOSFET and the driver. When a load is switched off, supply lead inductance forces current to continue flowing and results in a positive voltage spike. Inductance in the ground (return) lead to the supply has similar effects, except the voltage spike is negative. Switching transitions momentarily draw current from VDD to GND. This combines with supply lead inductance to create voltage transients at turn on and turnoff. Transients can also result in slower apparent rise or fall times when driver's ground shifts with respect to the control input.

Minimize the length of supply and ground traces or use ground and power planes when possible. Bypass capacitors should be placed as close as practical to the driver.

MOSFET Selection

Standard MOSFET

A standard N-channel power MOSFET is fully enhanced with a gate-to-source voltage of approximately 10V and has an absolute maximum gate-to-source voltage of ±20V. The MIC4414/15's on-state output is approximately equal to the supply voltage. The lowest usable voltage depends upon the behavior of the MOSFET.

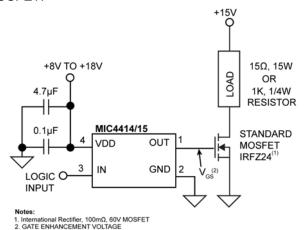


Figure 1. Using a Standard MOSFET

Logic-Level MOSFET

Logic-level N-channel power MOSFETs are fully enhanced with a gate-to-source voltage of approximately 5V and some of them have an absolute maximum gate-to-source voltage of ±10V. They are less common and generally more expensive. The MIC4414/15 can drive a logic-level MOSFET if the supply voltage, including transients, does not exceed the maximum MOSFET gate-to-source rating (10V).

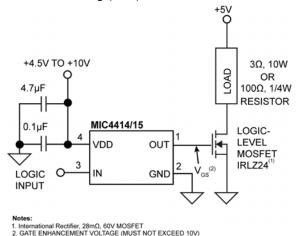


Figure 2. Using a Logic-Level MOSFET

At low voltages, the MIC4414/15's internal P- and N-channel MOSFET's on-resistance will increase and slow the output rise time. Refer to "Typical Characteristics" graphs.

Inductive Loads

Switching off an inductive load in a low-side application forces the MOSFET drain higher than the supply voltage (as the inductor resists changes to current). To prevent exceeding the MOSFET's drain-to-gate and drain-to-source ratings, a Schottky diode should be connected across the inductive load.

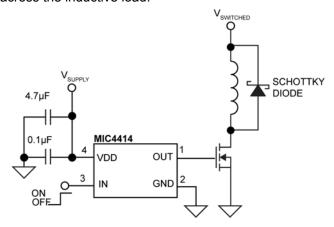


Figure 3. Switching an Inductive Load

Power Dissipation

The maximum power dissipation must not be exceeded to prevent die meltdown or deterioration. Power dissipation in on/off switch applications is negligible.

Fast repetitive switching applications, such as SMPS (switch mode power supplies), cause a significant increase in power dissipation with frequency. Power is dissipated each time current passes through the internal output MOSFETs when charging or discharging the external MOSFET. Power is also dissipated during each transition when some current momentarily passes from VDD to GND through both internal MOSFETs. Power dissipation is the product of supply voltage and supply current:

$$P_D = V_{DD} \times I_{DD}$$
 Equation 1

where:

 P_D = Power dissipation (W)

 V_{DD} = Supply voltage (V)

 I_{DD} = Supply current (A)

Supply current is a function of supply voltage, switching

frequency, and load capacitance. Determine this value from the "Typical Characteristics: Supply Current vs. Frequency" graph or measure it in the actual application.

Do not allow P_D to exceed P_D (MAX), as shown in the Eq 2.

 $T_{\scriptscriptstyle J}$ (junction temperature) is the sum of $T_{\scriptscriptstyle A}$ (ambient temperature) and the temperature rise across the thermal resistance of the package. In another form:

$$P_{D}(MAX) \le \frac{125 - T}{\frac{A}{140}}$$
 Equation 2

where:

 $P_D(MAX)$ = maximum power dissipation (W)

125 = Operating maximum junction temperature (°C)

 T_A = ambient temperature (°C)

140 = package thermal resistance (°C/W)

High-Frequency Operation

Although the MIC4414/15 driver will frequencies greater than 1MHz, the MOSFET's capacitance and the load will affect the output waveform MOSFET's drain). example, (at the For MIC4414/IRL3103 test circuit using a 47Ω, 5W load resistor will produce an output waveform that closely matches the input signal shape up to about 500kHz. The same test circuit with a $1k\Omega$ load resistor operates only up to about 25kHz before the MOSFET source waveform shows significant change.

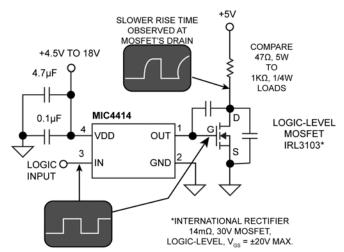
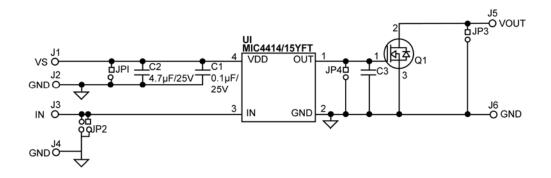


Figure 4. MOSFET Capacitance Effects at High Switching Frequency

When the MOSFET is driven off, the slower rise occurs because the MOSFET's output capacitance recharges through the load resistance (RC circuit). A lower load resistance allows the output to rise faster. For the fastest driver operation, choose the smallest power MOSFET that will safely handle the desired voltage, current, and safety margin. The smallest MOSFETs generally have the lowest capacitance.

Evaluation Board Schematic



Bill of Materials

Item	Part Number	Manufacturer	Description	Qty.
C1	GRM188R71E104KA01D	Murata ⁽¹⁾	0.1µF/25V Ceramic Capacitor, X7R, Size 0603	1
	C2012X5R1E475K	TDK ⁽²⁾		
C2	GRM21BR61E475KA12L	Murata	4.7μF/25V Ceramic Capacitor, X5R, Size 0805	
	08053D475KAT2A	AVX ⁽³⁾		
C3 (OPEN)			Used as gate Capacitor, different values	
Q1 (OPEN)				
U1	MIC4414YFT	Microl Inc (4)	4 FA/4 FV to 40V Love Cido MOCFET Driver	
	MIC4415YFT	Micrel, Inc. ⁽⁴⁾	1.5A/4.5V to 18V Low Side MOSFET Driver	

Notes:

1. Murata: <u>www.murata.com</u>.

2. TDK: www.tdk.com.

3. AVX: <u>www.avx.com</u>.

4. Micrel, Inc.: www.micrel.com.

PCB Layout

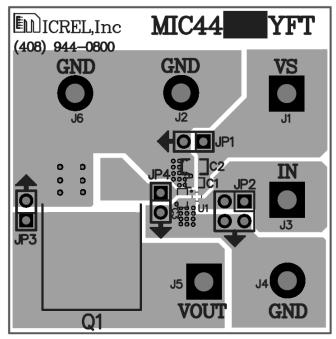
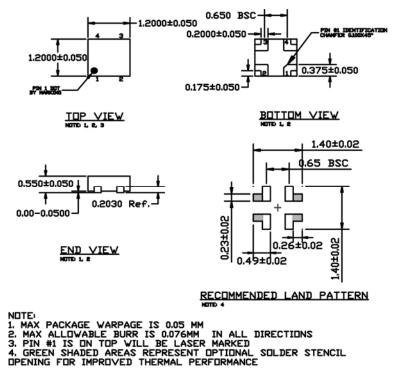


Figure 5. MIC4414/15 Evaluation Board Top Layer



Figure 6. MIC4414/15 Evaluation Board Bottom Layer

Package Information



4-Pin 1.2mm x 1.2mm Thin QFN (FT)

MICREL, INC. 2180 FORTUNE DRIVE SAN JOSE, CA 95131 USA

TEL +1 (408) 944-0800 FAX +1 (408) 474-1000 WEB http://www.micrel.com

Micrel makes no representations or warranties with respect to the accuracy or completeness of the information furnished in this data sheet. This information is not intended as a warranty and Micrel does not assume responsibility for its use. Micrel reserves the right to change circuitry, specifications and descriptions at any time without notice. No license, whether express, implied, arising by estoppel or otherwise, to any intellectual property rights is granted by this document. Except as provided in Micrel's terms and conditions of sale for such products, Micrel assumes no liability whatsoever, and Micrel disclaims any express or implied warranty relating to the sale and/or use of Micrel products including liability or warranties relating to fitness for a particular purpose, merchantability, or infringement of any patent, copyright or other intellectual property right.

Micrel Products are not designed or authorized for use as components in life support appliances, devices or systems where malfunction of a product can reasonably be expected to result in personal injury. Life support devices or systems are devices or systems that (a) are intended for surgical implant into the body or (b) support or sustain life, and whose failure to perform can be reasonably expected to result in a significant injury to the user. A Purchaser's use or sale of Micrel Products for use in life support appliances, devices or systems is a Purchaser's own risk and Purchaser agrees to fully indemnify Micrel for any damages resulting from such use or sale.

© 2012 Micrel, Incorporated.



OOO «ЛайфЭлектроникс" "LifeElectronics" LLC

ИНН 7805602321 КПП 780501001 P/C 40702810122510004610 ФАКБ "АБСОЛЮТ БАНК" (ЗАО) в г.Санкт-Петербурге К/С 3010181090000000703 БИК 044030703

Компания «Life Electronics» занимается поставками электронных компонентов импортного и отечественного производства от производителей и со складов крупных дистрибьюторов Европы, Америки и Азии.

С конца 2013 года компания активно расширяет линейку поставок компонентов по направлению коаксиальный кабель, кварцевые генераторы и конденсаторы (керамические, пленочные, электролитические), за счёт заключения дистрибьюторских договоров

Мы предлагаем:

- Конкурентоспособные цены и скидки постоянным клиентам.
- Специальные условия для постоянных клиентов.
- Подбор аналогов.
- Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.
- Приемлемые сроки поставки, возможна ускоренная поставка.
- Доставку товара в любую точку России и стран СНГ.
- Комплексную поставку.
- Работу по проектам и поставку образцов.
- Формирование склада под заказчика.
- Сертификаты соответствия на поставляемую продукцию (по желанию клиента).
- Тестирование поставляемой продукции.
- Поставку компонентов, требующих военную и космическую приемку.
- Входной контроль качества.
- Наличие сертификата ISO.

В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.

Конструкторский отдел помогает осуществить:

- Регистрацию проекта у производителя компонентов.
- Техническую поддержку проекта.
- Защиту от снятия компонента с производства.
- Оценку стоимости проекта по компонентам.
- Изготовление тестовой платы монтаж и пусконаладочные работы.



Тел: +7 (812) 336 43 04 (многоканальный) Email: org@lifeelectronics.ru