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## FAIRCHILD

SEMICONDUCTOR®

# FSFR2100 — Fairchild Power Switch (FPS™) for Half-Bridge Resonant Converters

### Features

- Variable Frequency Control with 50% Duty Cycle for Half-bridge Resonant Converter Topology
- High Efficiency through Zero Voltage Switching (ZVS)
- Internal SuperFET™s with Fast-Recovery Type Body Diode (t<sub>rr</sub>=120 ns)
- Fixed Dead Time (350 ns) Optimized for MOSFETs
- Up to 300kHz Operating Frequency
- Pulse Skipping for Frequency Limit (Programmable) at Light-Load Condition
- Remote On/Off Control Using Control Pin
- Protection Functions: Over-Voltage Protection (OVP), Over-Load Protection (OLP), Over-Current Protection (OCP), Abnormal Over-Current Protection (AOCP), Internal Thermal Shutdown (TSD)

### Applications

- PDP and LCD TVs
- Desktop PCs and Servers
- Adapters
- Telecom Power Supplies
- Audio Power Supplies

### Description

The FSFR2100 is a highly integrated power switch designed for high-efficiency half-bridge resonant converters. Offering everything necessary to build a reliable and robust resonant converter, the FSFR2100 simplifies designs and improves productivity, while improving performance. The FSFR2100 combines power MOSFETs with fast-recovery type body diodes, a highside gate-drive circuit, an accurate current controlled oscillator, frequency limit circuit, soft-start, and built-in protection functions. The high-side gate-drive circuit has a common-mode noise cancellation capability, which guarantees stable operation with excellent noise immunity. The fast-recovery body diode of the MOSFETs reliability against abnormal improves operation conditions, while minimizing the effect of the reverse recovery. Using the zero-voltage-switching (ZVS) technique dramatically reduces the switching losses and efficiency is significantly improved. The ZVS also reduces the switching noise noticeably, which allows a small-sized Electromagnetic Interference (EMI) filter.

The FSFR2100 can be applied to various resonant converter topologies, such as: series resonant, parallel resonant, and LLC resonant converters.

### **Related Resources**

- <u>AN-4151</u> Half-Bridge LLC Resonant Converter <u>Design Using FSFR2100 Fairchild Power Switch</u> (<u>FPS<sup>™</sup>)</u>
- Evaluation Board: FEBFSFR2100\_D015v1

Ordering Information						
Part Number	Package	Operating Junction Temperature	RDS <sub>(ON_MAX)</sub>	Maximum Output Power without Heatsink (V <sub>IN</sub> =350~400 V) <sup>(1,2)</sup>	Maximum Output Power with Heatsink $(V_{IN}$ =350~400 V) <sup>(1,2)</sup>	
FSFR2100	9-SIP	-40 to +130°C	0.38 Ω	200 W	450 W	

### Notes:

1. The junction temperature can limit the maximum output power.

2. Maximum practical continuous power in an open-frame design at 50°C ambient.





### **Pin Definitions**

Pin #	Name	Description		
1	V <sub>DL</sub>	his is the drain of the high-side MOSFET, typically connected to the input DC link voltage.		
2	CON	This pin is for enable/disable and protection. When the voltage of this pin is above 0.6 V, the IC operation is enabled. When the voltage of this pin drops below 0.4 V, gate drive signals for both MOSFETs are disabled. When the voltage of this pin increases above 5 V, protection is triggered.		
3	RT	This pin programs the switching frequency. Typically, an opto-coupler is connected to control the switching frequency for the output voltage regulation.		
4	CS	This pin senses the current flowing through the low-side MOSFET. Typically, negative voltage is applied on this pin.		
5	SG	This pin is the control ground.		
6	PG	This pin is the power ground. This pin is connected to the source of the low-side MOSFET.		
7	LV <sub>CC</sub>	This pin is the supply voltage of the control IC.		
8	NC	No connection.		
9	HVcc	This is the supply voltage of the high-side gate-drive circuit IC.		
10	V <sub>CTR</sub>	This is the drain of the low-side MOSFET. Typically, a transformer is connected to this pin.		

### Absolute Maximum Ratings

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.  $T_A=25^{\circ}C$  unless otherwise specified.

Symbol	Parameter	Min.	Max.	Unit	
V <sub>DS</sub>	Maximum Drain-to-Source Voltage (V <sub>DL</sub> -V <sub>CTR</sub> and	600		V	
LV <sub>CC</sub>	Low-Side Supply Voltage		-0.3	25.0	V
$HV_{CC}$ to $V_{CTR}$	High-Side $V_{CC}$ Pin to Low-side Drain Voltage		-0.3	25.0	V
HV <sub>CC</sub>	High-Side Floating Supply Voltage		-0.3	625.0	V
V <sub>CON</sub>	Control Pin Input Voltage		-0.3	LV <sub>CC</sub>	V
V <sub>CS</sub>	Current Sense (CS) Pin Input Voltage		-5.0	1.0	V
V <sub>RT</sub>	R <sub>T</sub> Pin Input Voltage		-0.3	5.0	V
dV <sub>CTR</sub> /dt	Allowable Low-Side MOSFET Drain Voltage Slew	Rate		50	V/ns
PD	Total Power Dissipation <sup>(3)</sup>			12	W
т	Maximum Junction Temperature <sup>(4)</sup>		+150	°C	
IJ	Recommended Operating Junction Temperature <sup>(4</sup>	-40	+130		
T <sub>STG</sub>	Storage Temperature Range	-55	+150	°C	
MOSFET Sec	tion				
V <sub>DGR</sub>	Drain Gate Voltage ( $R_{GS}$ =1 M $\Omega$ )		600		V
V <sub>GS</sub>	Gate Source (GND) Voltage			±30	V
I <sub>DM</sub>	Drain Current Pulsed <sup>(5)</sup>			33	А
		T <sub>C</sub> =25°C		11	٥
ID		T <sub>C</sub> =100°C		7	A
Package Sect	ion				
Torque	Recommended Screw Torque		5-	-7	kgf∙cm

Notes:

3. Per MOSFET when both MOSFETs are conducting.

4. The maximum value of the recommended operating junction temperature is limited by thermal shutdown.

5. Pulse width is limited by maximum junction temperature.

### **Thermal Impedance**

T<sub>A</sub>=25°C unless otherwise specified.

Symbol	Parameter	Value	Unit
$\theta_{\text{JC}}$	Junction-to-Case Center Thermal Impedance (Both MOSFETs Conducting)	10.44	°C/W
θ <sub>JA</sub>	Junction-to-Ambient Thermal Impedance	80	°C/W

Electrical	Characteristics ess otherwise specified.					
Symbol	Parameter	Test Conditions	Min.	Тур.	Max.	Unit
MOSFET Se	ection					
		I <sub>D</sub> =200 μA, T <sub>A</sub> =25°C	600			
BVDSS	Drain-to-Source Breakdown Voltage	I <sub>D</sub> =200 μΑ, T <sub>A</sub> =125°C		650		V
R <sub>DS(ON)</sub>	On-State Resistance	V <sub>GS</sub> =10 V, I <sub>D</sub> =5.5 A		0.32	0.38	Ω
t <sub>rr</sub>	Body Diode Reverse Recovery Time <sup>(6)</sup>	V <sub>GS</sub> =0 V, I <sub>Diode</sub> =11.0 A		120		ns
C <sub>ISS</sub>	Input Capacitance <sup>(6)</sup>	V <sub>DS</sub> =25V. V <sub>GS</sub> =0 V.		1148		pF
C <sub>OSS</sub>	Output Capacitance <sup>(6)</sup>	f=1.0 MHz		671		pF
Supply Sec	tion					
I <sub>LK</sub>	Offset Supply Leakage Current	H-V <sub>CC</sub> =V <sub>CTR</sub> =600 V/500 V			50	μA
I <sub>Q</sub> HV <sub>CC</sub>	Quiescent HVcc Supply Current	(HV <sub>CC</sub> UV+) - 0.1 V		50	120	μA
I <sub>Q</sub> LV <sub>CC</sub>	Quiescent LVcc Supply Current	(LV <sub>CC</sub> UV+) - 0.1 V		100	200	μA
1.1.1.7	Operating HVcc Supply Current	$f_{OSC}$ =100 KHz, $V_{CON}$ > 0.6 V		6	9	mA
IOI I V CC	(RMS Value)	No Switching, $V_{CON}$ < 0.4 V		100	200	μA
lol Voo	Operating LV <sub>cc</sub> Supply Current	$f_{OSC}$ =100KHz, $V_{CON}$ > 0.6 V		7	11	mA
102 000	(RMS Value)	No Switching, $V_{CON} < 0.4 V$		2	4	mA
UVLO Secti	on					
$LV_{CC}UV+$	CcUV+ LVcc Supply Under-Voltage Positive-Going Threshold (LVcc Star		13.0	14.5	16.0	V
LV <sub>CC</sub> UV-	LV <sub>CC</sub> Supply Under-Voltage Negative-G	Going Threshold (LV <sub>CC</sub> Stop)	10.2	11.3	12.4	V
LV <sub>CC</sub> UVH	LV <sub>CC</sub> Supply Under-Voltage Hysteresis			3.2		V
HV <sub>cc</sub> UV+	HV <sub>CC</sub> Supply Under-Voltage Positive-G	oing Threshold (HV <sub>CC</sub> Start)	8.2	9.2	10.2	V
HV <sub>CC</sub> UV-	HVcc Supply Under-Voltage Negative-C	Going Threshold (HV <sub>cc</sub> Stop)	7.8	8.7	9.6	V
HV <sub>cc</sub> UVH	HV <sub>CC</sub> Supply Under-Voltage Hysteresis	i		0.5		V
Oscillator &	Feedback Section				1	
V <sub>CONDIS</sub>	Control Pin Disable Threshold Voltage		0.36	0.40	0.44	V
V <sub>CONEN</sub>	Control Pin Enable Threshold Voltage		0.54	0.60	0.66	V
V <sub>RT</sub>	V-I Converter Threshold Voltage		1.5	2.0	2.5	V
f <sub>osc</sub>	Output Oscillation Frequency	R <sub>τ</sub> =5.2 KΩ	94	100	106	KHz
DC	Output Duty Cycle		48	50	52	%
f <sub>SS</sub>	Internal Soft-Start Initial Frequency	$f_{SS}=f_{OSC}+40$ kHz, RT=5.2 K $\Omega$		140		KHz
tss	Internal Soft-Start Time		2	3	4	ms

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Continued on the following page...

### Electrical Characteristics (Continued)

T<sub>A</sub>=25°C unless otherwise specified.

Symbol	Parameter	Test Conditions	Min.	Тур.	Max.	Unit
Protection	Section					
I <sub>OLP</sub>	OLP Delay Current	V <sub>CON</sub> =4 V	3.6	4.8	6.0	μA
V <sub>OLP</sub>	OLP Protection Voltage	V <sub>CON</sub> > 3.5 V	4.5	5.0	5.5	V
V <sub>OVP</sub>	LV <sub>CC</sub> Over-Voltage Protection	L-V <sub>CC</sub> > 21 V	21	23	25	V
VAOCP	AOCP Threshold Voltage	∆V/∆t=-0.1 V/µs	-1.0	-0.9	-0.8	V
t <sub>BAO</sub>	AOCP Blanking Time <sup>(6)</sup>	$V_{CS} < V_{AOCP}; \Delta V / \Delta t$ =-0.1 V/µs		50		ns
V <sub>OCP</sub>	OCP Threshold Voltage	V/∆t=-1 V/µs	-0.64	-0.58	-0.52	V
t <sub>BO</sub>	OCP Blanking Time <sup>(6)</sup>	V <sub>CS</sub> < V <sub>OCP</sub> ; ΔV/Δt=-1 V/μs	1.0	1.5	2.0	μs
t <sub>DA</sub>	Delay Time (Low Side) Detecting from $V_{AOCP}$ to Switch Off <sup>(6)</sup>	ΔV/Δt=-1 V/μs		250	400	ns
T <sub>SD</sub>	Thermal Shutdown Temperature <sup>(6)</sup>		110	130	150	°C
I <sub>SU</sub>	Protection Latch Sustain LV <sub>CC</sub> Supply Current	LV <sub>CC</sub> =7.5 V		100	150	μA
V <sub>PRSET</sub>	Protection Latch Reset LV <sub>CC</sub> Supply Voltage		5			V
Dead-Time	Control Section					
DT	Dead Time <sup>(7)</sup>			350		ns

Notes:

6.

This parameter, although guaranteed, is not tested in production. These parameters, although guaranteed, are tested only in EDS (wafer test) process. 7.





FSFR2100 — Fairchild Power Switch (FPS<sup>™</sup>) for Half-Bridge Resonant Converters

### **Functional Description**

### 1. Basic Operation

FSFR2100 is designed to drive high-side and low-side MOSFETs complementarily with 50% duty cycle. A fixed dead time of 350 ns is introduced between consecutive transitions, as shown in Figure 16.



Figure 16. MOSFETs Gate Drive Signal

### 2. Internal Oscillator

FSFR2100 employs a current-controlled oscillator, as shown in Figure 17. Internally, the voltage of R<sub>T</sub> pin is regulated at 2 V and the charging/discharging current for the oscillator capacitor, C<sub>T</sub>, is obtained by copying the current flowing out of R<sub>T</sub> pin (I<sub>CTC</sub>) using a current mirror. Therefore, the switching frequency increases as I<sub>CTC</sub> increases.



Figure 17. Current Controlled Oscillator

### 3. Frequency Setting

Figure 18 shows a typical voltage gain curve of a resonant converter, where the gain is inversely proportional to the switching frequency in the ZVS region. The output voltage can be regulated by modulating the switching frequency. Figure 19 shows the typical circuit configuration for  $R_T$  pin, where the opto-coupler transistor is connected to the  $R_T$  pin to modulate the switching frequency.



Figure 18. Resonant Converter Typical Gain Curve



The minimum switching frequency is determined as:

$$f^{\min} = \frac{5.2k\Omega}{R_{\min}} \times 100(kHz) \tag{1}$$

Assuming the saturation voltage of opto-coupler transistor is 0.2 V, the maximum switching frequency is determined as:

$$f^{\max} = \left(\frac{5.2k\Omega}{R_{\min}} + \frac{4.68k\Omega}{R_{\max}}\right) \times 100(kHz)$$
<sup>(2)</sup>

To prevent excessive inrush current and overshoot of output voltage during startup, increase the voltage gain of the resonant converter progressively. Since the voltage gain of the resonant converter is inversely proportional to the switching frequency, the soft-start is implemented by sweeping down the switching frequency from an initial high frequency ( $f^{/SS}$ ) until the output voltage is established. The soft-start circuit is made by connecting R-C series network on the R<sub>T</sub> pin, as shown in Figure 19. FSFR2100 also has an internal soft-start for

3 ms to reduce the current overshoot during the initial cycles, which adds 40 kHz to the initial frequency of the external soft-start circuit, as shown in Figure 20. The initial frequency of the soft-start is given as:

$$f^{ISS} = \left(\frac{5.2k\Omega}{R_{\min}} + \frac{5.2k\Omega}{R_{SS}}\right) \times 100 + 40 \ (kHz) \tag{3}$$

It is typical to set the initial frequency of soft-start two ~ three times the resonant frequency ( $f_0$ ) of the resonant network.

The soft-start time is three to four times of the RC time constant. The RC time constant is as follows:

$$T_{SS} = R_{SS} \cdot C_{SS} \tag{4}$$



Figure 20. Frequency Sweeping of Soft-start

### 4. Control Pin

The FSFR2100 has a control pin for protection, cycle skipping, and remote on/off. Figure 21 shows the internal block diagram for control pin.



Figure 21. Internal Block of Control Pin

**Protection**: When the control pin voltage exceeds 5V, protection is triggered. Detailed applications are described in the protection section.

**Pulse Skipping**: FSFR2100 stops switching when the control pin voltage drops below 0.4 V and resumes switching when the control pin voltage rises above 0.6 V. To use pulse-skipping, the control pin should be connected to the opto-coupler collector pin. The frequency that causes pulse skipping is given as:

$$f^{\text{SKIP}} = \left(\frac{5.2 \,\text{k}\,\Omega}{\text{R}_{\text{min}}} + \frac{4.16 \,\text{k}\,\Omega}{\text{R}_{\text{max}}}\right) \text{x100(kHz)}$$
(5)



Figure 22. Control Pin Configuration for Pulse Skipping

**Remote On / Off:** When an auxiliary power supply is used for standby, the main power stage using FSFR2100 can be shut down by pulling down the control pin voltage, as shown in Figure 23. R1 and C1 are used to ensure soft-start when switching resumes.



Figure 23. Remote On / Off Circuit

### 5. Current Sensing

**Current Sensing Using Resistor:** FSFR2100 senses drain current as a negative voltage, as shown in Figure 24 and Figure 25. Half-wave sensing allows low power dissipation in the sensing resistor, while full-wave sensing has less switching noise in the sensing signal.



Figure 24. Half-Wave Sensing



Figure 25. Full-Wave Sensing

**Current Sensing Using Resonant Capacitor Voltage:** For high-power applications, current sensing using a resistor may not be available due to the severe power dissipation in the resistor. In that case, indirect current sensing using the resonant capacitor voltage can be a good alternative because the amplitude of the resonant capacitor voltage ( $V_{cr}^{p-p}$ ) is proportional to the resonant current in the primary side ( $I_p^{p-p}$ ) as:

$$V_{Cr}^{\ \ p-p} = \frac{I_p^{\ \ p-p}}{2\pi f_s C_r}$$

To minimize power dissipation, a capacitive voltage divider is generally used for capacitor voltage sensing, as shown in Figure 26.



### 6. Protection Circuits

The FSFR2100 has several self-protective functions, such as Overload Protection (OLP), Over-Current Protection (OCP), Abnormal Over-Current Protection (AOCP), Over-Voltage Protection (OVP), and Thermal Shutdown (TSD). OLP, OCP, and OVP are auto-restart mode protections; while AOCP and TSD are latch-mode protections, as shown in Figure 27.

**6.1 Auto-restart Mode Protection:** Once a fault condition is detected, switching is terminated and the MOSFETs remain off. When  $LV_{CC}$  falls to the  $LV_{CC}$  stop voltage of 11.3 V, the protection is reset. The FPS resumes normal operation when  $LV_{CC}$  reaches the start voltage of 14.5 V.

(6)

**6.2** Latch-Mode Protection: Once this protection is triggered, switching is terminated and the MOSFETs remain off. The latch is reset only when  $LV_{CC}$  is discharged below 5 V.



Figure 27. Protection Blocks

**6.3 Over-Current Protection (OCP)**: When the sensing pin voltage drops below -0.58 V, OCP is triggered and the MOSFETs remain off. This protection has a shutdown time delay of  $1.5 \,\mu$ s to prevent premature shutdown during startup.

**6.4 Abnormal Over-Current Protection (AOCP)**: If the secondary rectifier diodes are shorted, large current with extremely high di/dt can flow through the MOSFET before OCP or OLP is triggered. AOCP is triggered without shutdown delay when the sensing pin voltage drops below -0.9V. This protection is latch mode and reset when LV<sub>CC</sub> is pulled down below 5 V.

6.5 Overload Protection (OLP): Overload is defined as the load current exceeding its normal level due to an unexpected abnormal event. In this situation, the protection circuit should trigger to protect the power supply. However, even when the power supply is in the normal condition, the overload situation can occur during the load transition. To avoid premature triggering of protection, the overload protection circuit should be designed to trigger only after a specified time to determine whether it is a transient situation or a true overload situation. Figure 26 shows a typical overload protection circuit. By sensing the resonant capacitor voltage on the control pin, the overload protection can be implemented. Using RC time constant, shutdown delay can be also introduced. The voltage obtained on the control pin is given as:

$$V_{CON} = \frac{C_B}{2(C_B + C_{sense})} V_{Cr}^{p-p}$$
(7)

where  $V_{\text{Cr}}{}^{\text{p-p}}$  is the amplitude of the resonant capacitor voltage.

**6.6 Over-Voltage Protection (OVP)**: When the  $LV_{CC}$  reaches 23 V, OVP is triggered. This protection is used when auxiliary winding of the transformer to supply  $V_{CC}$  to FPS<sup>TM</sup> is utilized.

**6.7** Thermal Shutdown (TSD): The MOSFETs and the control IC in one package makes it easy for the control IC to detect the abnormal over-temperature of the MOSFETs. If the temperature exceeds approximately 130°C, the thermal shutdown triggers.

### 7. PCB Layout Guidelines

Duty unbalance problems may occur due to the radiated noise from main transformer, the inequality of the secondary side leakage inductances of main transformer, and so on. Among them, it is one of the dominant reasons that the control components in the vicinity of RT pin are enclosed by the primary current flow pattern on PCB layout. The direction of the magnetic field on the components caused by the primary current flow is changed when the high and low side MOSFET turns on by turns. The magnetic fields with opposite direction from each other induce a current through, into, or out of the RT pin, which makes the turn-on duration of each MOSFET different. It is highly recommended to separate the control components in the vicinity of  $R_T$  pin from the primary current flow pattern on PCB layout. Figure 28 shows an example for the duty balanced case.



Figure 28. Example for Duty Balancing

Application	FPS™ Device	Input Voltage Range	Rated Output Power	Output Voltage (Rated Current)
LCD TV	FSFR2100	390 V <sub>DC</sub> (340~400 V <sub>DC</sub> )	200 W	24 V-8.3 A
eatures High efficiency Reduced EMI Enhanced sys	y ( >94% at 400 V <sub>D0</sub> noise through zero stem reliability with v	c input) -voltage-switching (ZVS) various protection functions		
Vcc=16-2 C111 3300/ 275% C110 3300/ 275% C110 3300/ C110 3300/ C110 3300/ C110 3300/ C110 3300/ C110 275% C111 C110 C111 C110 C10 C	Brownout circu	iit R113 400k R112 0 R113 400k R112 0 R112 0 R11	C102 22aF830V	D211     C202       VP2010DN     C201       22000F     C201       22000F     C201       22000F     C201       22000F     C201       2000F     C201       2000F     C201       2000F     C201       2000F     C201       2000F     C201       2000F     C201       10k     C204       10k     C204       203     C203       470F     33k       7k     7k

# FSFR2100 — Fairchild Power Switch (FPS<sup>™</sup>) for Half-Bridge Resonant Converters

# FSFR2100 — Fairchild Power Switch (FPS<sup>™</sup>) for Half-Bridge Resonant Converters

### Typical Application Circuit (Continued)

Usually, LLC resonant converters require large leakage inductance value. To obtain a large leakage inductance, sectional winding method is used.

- Core: EC35 (Ae=106 mm2)
- Bobbin: EC35 (Horizontal)
- Transformer Model Number: SNX-2468-1

EC35  $2 N_p$   $13 N_{s2}$   $12 N_{s1}$  128mm  $N_p$  128mm  $N_p$  128mm  $N_p$  128mm  $N_p$  128mm  $N_p$  128mm 

Figure 30. Transformer Construction

	$\textbf{Pin}~(\textbf{S} \rightarrow \textbf{F})$	Wire	Turns	Note
Np	$6 \rightarrow 2$	0.08φ×88 (Litz Wire)	36	
N <sub>s1</sub>	12  ightarrow 9	0.08φ×234 (Litz Wire)	4	Bifilar Winding
N <sub>s2</sub>	10 → 13	0.08φ×234 (Litz Wire)	4	Bifilar Winding

	Pins	Specifications	Remark
Primary-Side Inductance (L <sub>p</sub> )	26	550 μH ± 10%	100 kHz, 1 V
Primary-Side Effective Leakage (Lr)	26	110 μH ± 10%	Short one of the Secondary Windings

For more detailed information regarding the transformer, visit <u>http://www.santronics-usa.com/documents.html</u> or contact <u>sales@santronics-usa.com</u> or +1-408-734-1878 (Sunnyvale, California USA).



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Мы молодая и активно развивающаяся компания в области поставок электронных компонентов. Мы поставляем электронные компоненты отечественного и импортного производства напрямую от производителей и с крупнейших складов мира.

Благодаря сотрудничеству с мировыми поставщиками мы осуществляем комплексные и плановые поставки широчайшего спектра электронных компонентов.

Собственная эффективная логистика и склад в обеспечивает надежную поставку продукции в точно указанные сроки по всей России.

Мы осуществляем техническую поддержку нашим клиентам и предпродажную проверку качества продукции. На все поставляемые продукты мы предоставляем гарантию.

Осуществляем поставки продукции под контролем ВП МО РФ на предприятия военно-промышленного комплекса России, а также работаем в рамках 275 ФЗ с открытием отдельных счетов в уполномоченном банке. Система менеджмента качества компании соответствует требованиям ГОСТ ISO 9001.

Минимальные сроки поставки, гибкие цены, неограниченный ассортимент и индивидуальный подход к клиентам являются основой для выстраивания долгосрочного и эффективного сотрудничества с предприятиями радиоэлектронной промышленности, предприятиями ВПК и научноисследовательскими институтами России.

С нами вы становитесь еще успешнее!

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