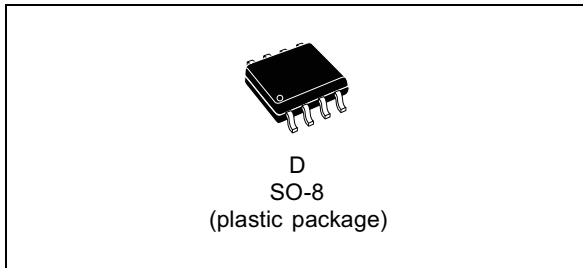


Constant voltage and constant current controller for battery chargers and adapters

Datasheet - production data



Features

- Constant voltage and constant current control
- Low voltage operation
- Low external component count
- Current sink output stage
- Easy compensation
- 2 kV ESD protection
- Voltage reference:
 - Fixed output voltage reference 2.545 V
 - 0.5% and 1% voltage precision

Applications

- Adapters
- Battery chargers

Description

The TSM1011 is a highly integrated solution for SMPS applications requiring CV (constant voltage) and CC (constant current) modes.

The TSM1011 device integrates one voltage reference and two operational amplifiers (with ORed outputs - common collectors).

The voltage reference combined with one operational amplifier makes it an ideal voltage controller. The other operational amplifier, combined with few external resistors and the voltage reference, can be used as a current limiter.

Figure 1. Pin connections (top view)

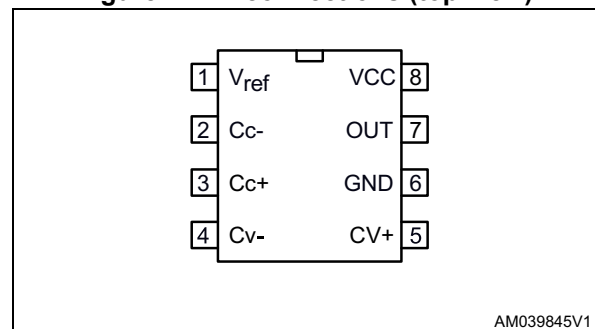


Table 1. Order codes

| Part number | Temperature range | Package D ⁽¹⁾ | Marking |
|-------------|-------------------|--------------------------|---------|
| TSM1011ID | -0 to 105 °C | • | M1011 |
| TSM1011AID | | • | M1011A |

1. D = "Small Outline" package (SO) - also available in tape and reel (DT).

Contents

| | | |
|-----------|--|-----------|
| 1 | Pin description | 3 |
| 2 | Absolute maximum ratings | 3 |
| 3 | Operating conditions | 3 |
| 4 | Electrical characteristics | 4 |
| 5 | Internal schematic | 6 |
| 6 | Voltage and current control | 7 |
| | 6.1 Voltage control | 7 |
| | 6.2 Current control | 7 |
| 7 | Compensation | 9 |
| 8 | Start-up and short-circuit conditions | 10 |
| 9 | Voltage clamp | 10 |
| 10 | Package information | 11 |
| | 10.1 SO-8 package information | 11 |
| 11 | Revision history | 13 |

1 Pin description

Table 2 gives the pin descriptions for the SO-8 package.

Table 2. SO-8 pinout

| Name | Pin no. | Type | Function |
|------------------|---------|---------------|--|
| V _{Ref} | 1 | Analog output | Voltage reference |
| CC- | 2 | Analog input | Input pin of the operational amplifier |
| CC+ | 3 | Analog input | Input pin of the operational amplifier |
| CV- | 4 | Analog input | Input pin of the operational amplifier |
| CV+ | 5 | Analog input | Input pin of the operational amplifier |
| GND | 6 | Power supply | Ground line. 0 V reference for all voltages. |
| OUT | 7 | Analog output | Output of the two operational amplifiers |
| VCC | 8 | Power supply | Power supply line |

2 Absolute maximum ratings

Table 3. Absolute maximum ratings

| Symbol | DC supply voltage | Value | Unit |
|-------------------|---|--------------|------|
| VCC | DC supply voltage (50 mA =< I _{CC}) | -0.3 V to Vz | V |
| V _i | Input voltage | -0.3 to VCC | V |
| PT | Power dissipation | | W |
| T _{stg} | Storage temperature | -55 to 150 | °C |
| T _j | Junction temperature | 150 | °C |
| I _{ref} | Voltage reference output current | 10 | mA |
| ESD | Electrostatic discharge | 2 | KV |
| R _{thja} | Thermal resistance junction to ambient SO-8 package | 175 | °C/W |

3 Operating conditions

Table 4. Operating conditions

| Symbol | Parameter | Value | Unit |
|-------------------|-------------------------|-----------|------|
| VCC | DC supply conditions | 4.5 to Vz | V |
| T _{oper} | Operational temperature | 0 to 105 | °C |

4 Electrical characteristics

$T_{amb} = 25\text{ °C}$ and $V_{CC} = +18\text{ V}$ (unless otherwise specified).

Table 5. Electrical characteristics

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|----------------------------------|---|--|----------|------------|------------------|-------------------------|
| Total current consumption | | | | | | |
| I_{CC} | Total supply current, excluding current in voltage reference | $V_{CC} = 18\text{ V}$, no load $T_{min.} < T_{amb} < T_{max.}$ | | | 1 | mA |
| V_z | VCC clamp voltage | $I_{CC} = 50\text{ mA}$ | | 28 | | V |
| Operators | | | | | | |
| V_{io} | Input offset voltage TSM1011 TSM1011A | $T_{amb} = 25\text{ °C}$ $T_{min.} \leq T_{amb} \leq T_{max.}$ $T_{amb} = 25\text{ °C}$ $T_{min.} \leq T_{amb} \leq T_{max.}$ | | 1 0.5 | 4 5 2 3 | mV |
| DV_{io} | Input offset voltage drift | | | 7 | | $\mu\text{V}/\text{°C}$ |
| I_{io} | Input offset current | $T_{amb} = 25\text{ °C}$ $T_{min.} \leq T_{amb} \leq T_{max.}$ | | 2 | 30 50 | nA |
| I_{ib} | Input bias current | $T_{amb} = 25\text{ °C}$ $T_{min.} \leq T_{amb} \leq T_{max.}$ | | 20 50 | 150 200 | nA |
| SVR | Supply voltage rejection ration | $V_{CC} = 4.5\text{ V to }28\text{ V}$ | 65 | 100 | | dB |
| V_{icm} | Input common mode voltage range for CV op-amp | | 1.5 | | $V_{CC} - 1.5$ | V |
| V_{icm} | Input common mode voltage range for CC op-amp | | 0 | | $V_{CC} - 1.5$ | V |
| CMR | Common mode rejection ratio | $T_{amb} = 25\text{ °C}$ $T_{min.} \leq T_{amb} \leq T_{max.}$ | 70 60 | 85 | | dB |
| Output stage | | | | | | |
| G_m | Transconduction gain. Sink current only ⁽¹⁾ | $T_{amb} = 25\text{ °C}$ $T_{min.} \leq T_{amb} \leq T_{max.}$ | 1 | 3.5 2.5 | | mA/mV |
| V_{ol} | Low output voltage at 10 mA sinking current | | | 200 | 600 | mV |
| I_{os} | Output short-circuit current. Output to V_{CC} . Sink current only. | $T_{amb} = 25\text{ °C}$ $T_{min.} \leq T_{amb} \leq T_{max.}$ | | 27 | 50 | mA |

Table 5. Electrical characteristics (continued)

| Symbol | Parameter | Test condition | Min. | Typ. | Max. | Unit |
|--------------------------|--|--|----------------|----------------|---------------|------|
| Voltage reference | | | | | | |
| V_{Ref} | Reference input voltage, Iload = 1 mA TSM1011 1% precision TSM1011A 0.5% precision | $T_{amb} = 25\text{ }^{\circ}\text{C}$ | 2.519 2.532 | 2.545 2.545 | 2.57 2.557 | V |
| ΔV_{Ref} | Reference input voltage deviation over the temperature range | $T_{min.} \leq T_{amb} \leq T_{max.}$ | | 20 | 30 | mV |
| RegLine | Reference input voltage deviation over the VCC range | Iload = 5 mA | | | 20 | mV |
| RegLoad | Reference input voltage deviation over the output current | VCC = 18 V, $0 < I_{load} < 10\text{ mA}$ | | | 10 | mV |

- The current depends on the voltage difference between the negative and the positive inputs of the amplifier. If the voltage on the minus input is 1 mV higher than the positive amplifier, the sinking current at the output OUT will be increased by 3.5 mA.

6 Voltage and current control

6.1 Voltage control

The voltage loop is controlled via a first transconductance operational amplifier, the resistor bridge R_1 , R_2 , and the optocoupler which is directly connected to the output.

The relative values of R_1 and R_2 should be chosen in accordance with [Equation 1](#):

Equation 1

$$R_1 = R_2 \times V_{Ref} / (V_{out} - V_{Ref})$$

where V_{out} is the desired output voltage.

To avoid the discharge of the load, the resistor bridge R_1 , R_2 should have high impedance. For this type of application, a total value of 100 K Ω (or more) would be appropriate for the resistors R_1 and R_2 .

For example, with $R_2 = 100$ K Ω , $V_{out} = 4.10$ V, $V_{Ref} = 2.5$ V, then $R_1 = 41.9$ K Ω .

Note: If the low drop diode is to be inserted between the load and the voltage regulation resistor bridge to avoid current flowing from the load through the resistor bridge, this drop should be taken into account in [Equation 1](#) by replacing V_{out} by $(V_{out} + V_{drop})$.

6.2 Current control

The current loop is controlled via the second transconductance operational amplifier, the sense resistor R_{sense} , and the optocoupler.

V_{sense} threshold is achieved externally by a resistor bridge tied to the V_{Ref} voltage reference. Its midpoint is tied to the positive input of the current control operational amplifier, and its foot is to be connected to the lower potential point of the sense resistor, as shown in [Figure 4](#). The resistors of this bridge are matched to provide the best precision possible.

The control equation verifies that:

Equation 2

$$R_{sense} \cdot I_{lim} = V_{sense}$$

$$V_{sense} = \frac{R_5 \cdot V_{ref}}{(R_4 + R_5)}$$

Equation 3

$$I_{lim} = \frac{R_5 \cdot V_{ref}}{(R_4 + R_5) \cdot R_{sense}}$$

where I_{lim} is the desired limited current, and V_{sense} is the threshold voltage for the current control loop.

Note that the R_{sense} resistor should be chosen taking into account the maximum dissipation (P_{lim}) through it during the full load operation.

Equation 4

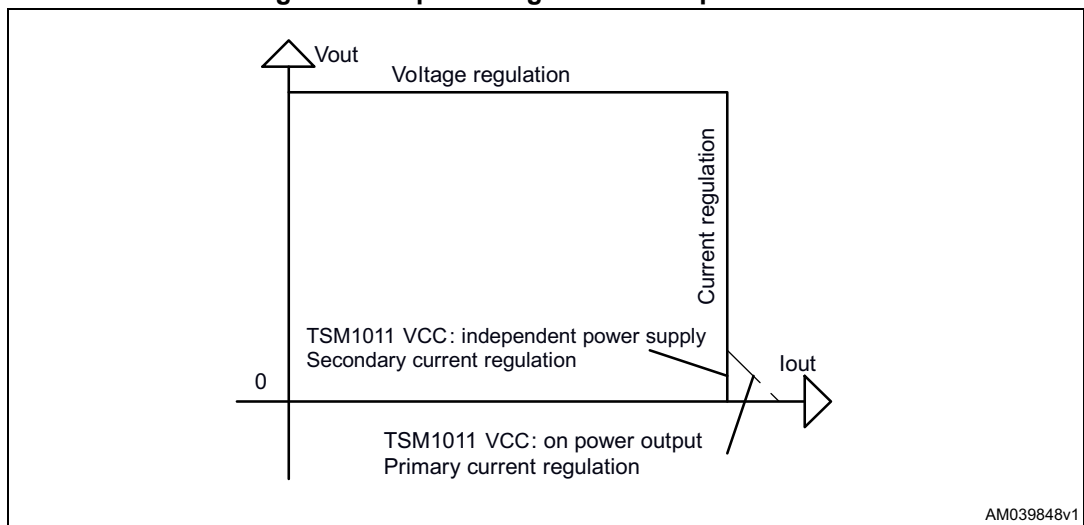
$$P_{lim} = V_{sense} \cdot I_{lim}$$

Therefore, for most adapter and battery charger applications, a quarter-watt, or half-watt resistor to make the current sensing function is sufficient.

The current sinking outputs of the two transconductance operational amplifiers are common (to the output of the IC). This makes an ORing function which ensures that whenever the current or the voltage reaches too high values, the optocoupler is activated.

The relation between the controlled current and the controlled output voltage can be described with a square characteristic as shown in the following V/I output power graph.

Figure 4. Output voltage versus output current



7 Compensation

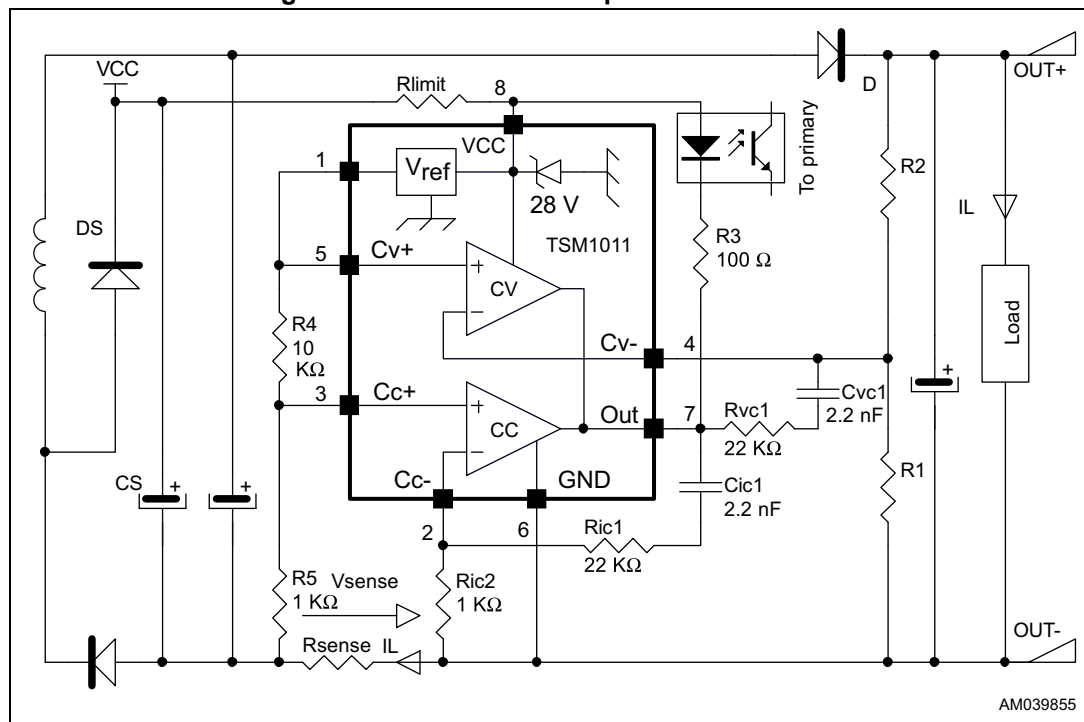
The voltage control transconductance operational amplifier can be fully compensated. Both its output and negative input are directly accessible for external compensation components.

An example of a suitable voltage control compensation network is shown in *Figure 6*. It consists of a capacitor $C_{vc1} = 2.2 \text{ nF}$ and a resistor $R_{cv1} = 22 \text{ K}\Omega$ in series.

The current control transconductance operational amplifier can be fully compensated. Both of its output and negative input are directly accessible for external compensation components.

An example of a suitable current control compensation network is also shown in *Figure 6*. It consists of a capacitor $C_{ic1} = 2.2 \text{ nF}$ and a resistor $R_{ic1} = 22 \text{ K}\Omega$ in series.

Figure 5. Schematic of compensation network



8 Start-up and short-circuit conditions

Under start-up or short-circuit conditions the TSM1011 is not provided with a high enough supply voltage. This is due to the fact that the chip has its power supply line in common with the power supply line of the system.

Therefore, the current limitation can only be ensured by the primary PWM module, which should be chosen accordingly.

If the primary current limitation is not considered to be precise enough for the application, then a sufficient supply for the TSM1011 has to be ensured under all conditions. This means that it is necessary to add some circuitry to supply the chip with a separate power line. This can be achieved in numerous ways, including an additional winding on the transformer.

9 Voltage clamp

The schematic in [Figure 10](#) shows how to realize a low-cost power supply for the TSM1011 (with no additional windings).

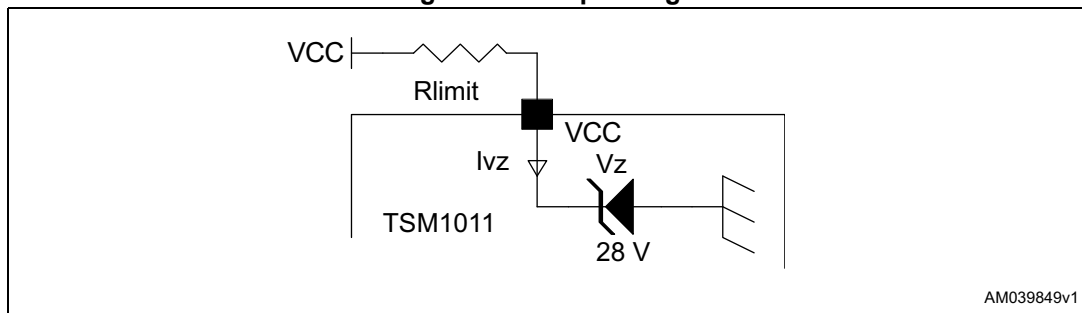
Please pay attention to the fact that in the particular case presented here, this low-cost power supply can reach voltages as high as twice the voltage of the regulated line.

Since the absolute maximum rating of the TSM1011 supply voltage is 28 V. In the aim to protect the TSM1011 against such high voltage values an internal Zener clamp is integrated (see [Figure 6](#)).

Equation 5

$$R_{limit} = I_{vz} \cdot (VCC - V_z)$$

Figure 6. Clamp voltage



10 Package information

In order to meet environmental requirements, ST offers these devices in different grades of ECOPACK® packages, depending on their level of environmental compliance. ECOPACK specifications, grade definitions and product status are available at: www.st.com. ECOPACK is an ST trademark.

10.1 SO-8 package information

Figure 7. SO-8 package outline

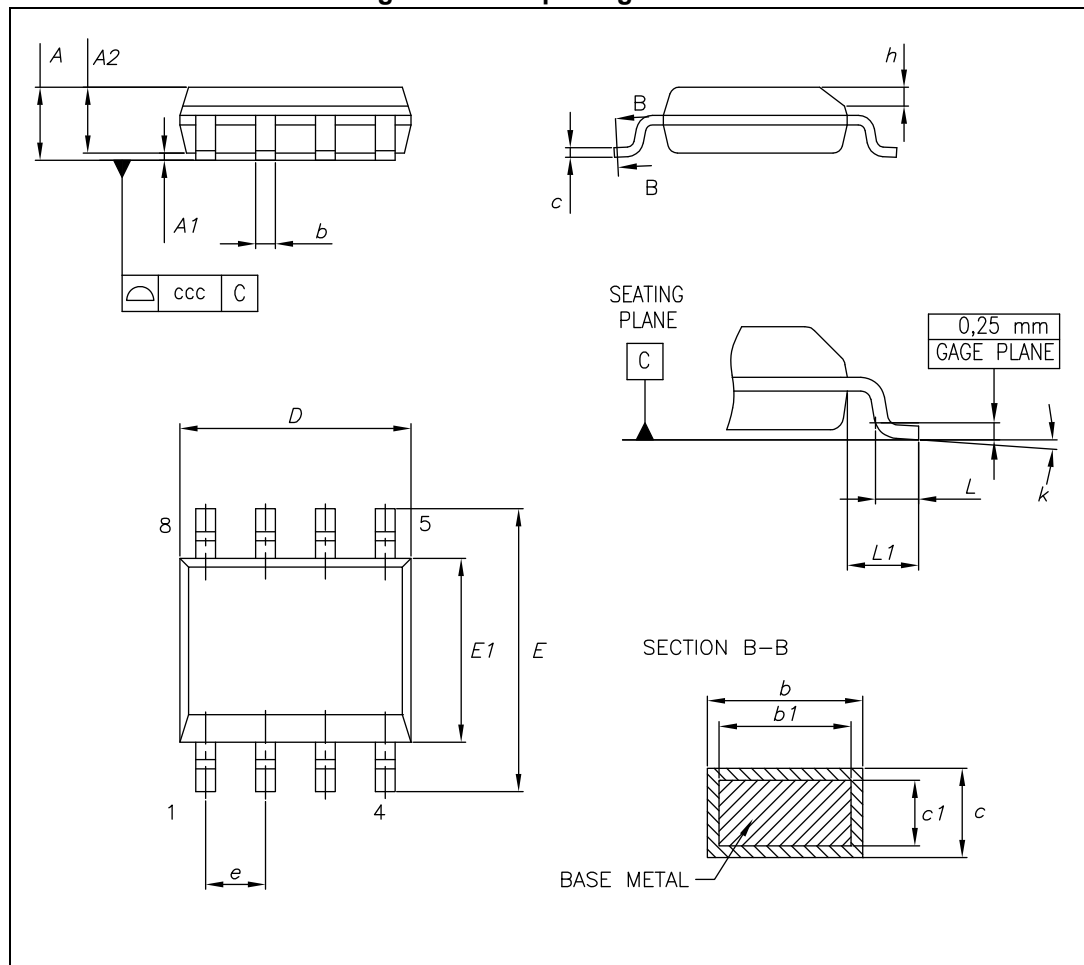


Table 6. SO-8 package mechanical data

| Symbol | Dimensions (mm) | | |
|-------------------|-----------------|------|------|
| | Min. | Typ. | Max. |
| A | | | 1.75 |
| A1 | 0.10 | | 0.25 |
| A2 | 1.25 | | |
| b | 0.28 | | 0.48 |
| c | 0.17 | | 0.23 |
| D ⁽¹⁾ | 4.80 | 4.90 | 5.00 |
| E | 5.80 | 6.00 | 6.20 |
| E1 ⁽²⁾ | 3.80 | 3.90 | 4.00 |
| e | | 1.27 | |
| h | 0.25 | | 0.50 |
| L | 0.40 | | 1.27 |
| L1 | | 1.04 | |
| k | 0° | | 8° |
| ccc | | | 0.10 |

1. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 mm in total (both sides).
2. Dimension "E1" does not include interlead flash or protrusions. Interlead flash or protrusions shall not exceed 0.25 mm per side.

11 Revision history

Table 7. Document revision history

| Date | Revision | Changes |
|--------------|----------|---|
| 01 -Nov-2003 | 1 | Initial release. |
| 15-Apr-2016 | 2 | Removed Mini SO-8 package from the whole document. Updated Section 10: Package information on page 11 (replaced Figure 7 on page 11 by new figure, updated Table 6 on page 12). Minor modifications throughout document. |

IMPORTANT NOTICE – PLEASE READ CAREFULLY

STMicroelectronics NV and its subsidiaries ("ST") reserve the right to make changes, corrections, enhancements, modifications, and improvements to ST products and/or to this document at any time without notice. Purchasers should obtain the latest relevant information on ST products before placing orders. ST products are sold pursuant to ST's terms and conditions of sale in place at the time of order acknowledgement.

Purchasers are solely responsible for the choice, selection, and use of ST products and ST assumes no liability for application assistance or the design of Purchasers' products.

No license, express or implied, to any intellectual property right is granted by ST herein.

Resale of ST products with provisions different from the information set forth herein shall void any warranty granted by ST for such product.

ST and the ST logo are trademarks of ST. All other product or service names are the property of their respective owners.

Information in this document supersedes and replaces information previously supplied in any prior versions of this document.

© 2016 STMicroelectronics – All rights reserved

Компания «Океан Электроники» предлагает заключение долгосрочных отношений при поставках импортных электронных компонентов на взаимовыгодных условиях!

Наши преимущества:

- Поставка оригинальных импортных электронных компонентов напрямую с производств Америки, Европы и Азии, а так же с крупнейших складов мира;
- Широкая линейка поставок активных и пассивных импортных электронных компонентов (более 30 млн. наименований);
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения «JONHON», а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов «FORSTAR».



JONHON

«JONHON» (основан в 1970 г.)

Разъемы специального, военного и аэрокосмического назначения:

(Применяются в военной, авиационной, аэрокосмической, морской, железнодорожной, горно- и нефтедобывающей отраслях промышленности)

«FORSTAR» (основан в 1998 г.)

ВЧ соединители, коаксиальные кабели, кабельные сборки и микроволновые компоненты:

(Применяются в телекоммуникациях гражданского и специального назначения, в средствах связи, РЛС, а так же военной, авиационной и аэрокосмической отраслях промышленности).



Телефон: 8 (812) 309-75-97 (многоканальный)

Факс: 8 (812) 320-03-32

Электронная почта: ocean@oceanchips.ru

Web: <http://oceanchips.ru/>

Адрес: 198099, г. Санкт-Петербург, ул. Калинина, д. 2, корп. 4, лит. А