

RoHS Recast Compliant

ADM5S

ADM5S 44P/180D Specifications

February 15, 2016

Version 1.4



Apacer Technology Inc.

1F, No.32, Zhongcheng Rd., Tucheng Dist., New Taipei City, Taiwan, R.O.C

Tel: +886-2-2267-8000 Fax: +886-2-2267-2261

www.apacer.com

Features:

- **Standard ATA/IDE Bus Interface**
 - ATA command set compatible
 - Compliant with ATA/ATAPI-8
 - ATA operating mode supports up to:
 - PIO Mode up to 4
 - Multiword DMA Mode up to 2
 - Ultra DMA Mode up to 6
- **Connector Type**
 - 44-pin female connector (2.00mm pitch)
- **Power Consumption***
 - Supply voltage: 3.3V & 5V
 - Active mode: 245 mA
 - Idle mode: 5 mA
- **Performance***
 - Sustained read: Up to 75 MB/sec
 - Sustained write: Up to 65 MB/sec
- **Capacity**
 - 128, 256, 512 MB
 - 1, 2, 4, 8, 16, 32 GB
- **NAND Flash Type:** SLC
- **MTBF:** > 2,000,000 hours
- **Temperature Range**
 - Operation:
 - Standard: 0°C to 70°C
 - Extended: -40°C to 85°C
 - Storage: -40°C to 100°C
- **Form Factor**
 - ATA Disk Module
 - Dimension: 49.39x27.10x6.00, unit: mm
- **Flash Management**
 - Advanced wear-leveling algorithms
 - Built-in hardware ECC
 - Flash block management
 - S.M.A.R.T.
 - Power failure management
 - ATA secure erase
- **Shock & Vibration****
 - Shock: 1,500 G
 - Vibration: 15 G
- **RoHS Recast Compliant (2011/65/EU)**
- **Master/Slave Switch** (optional)

*Performance and power consumption addressed here are typical and may vary from flash configurations or platforms.

**Non-operating

Table of Contents

| | |
|--|-----------|
| 1. General Description | 3 |
| 2. Functional Block | 3 |
| 3. Pin Assignments..... | 4 |
| 4. Product Specifications..... | 5 |
| 4.1 Capacity..... | 5 |
| 4.2 Performance | 5 |
| 4.3 Environmental Specifications | 6 |
| 5. Flash Management | 7 |
| 5.1 Advanced Wear-Leveling Algorithms | 7 |
| 5.2 Built-in Hardware ECC | 7 |
| 5.3 Flash Block Management | 7 |
| 5.4 Power Failure Management | 7 |
| 5.5 Mean Time Between Failures (MTBF) | 7 |
| 6. Software Interface | 8 |
| 6.1 Command Set..... | 8 |
| 6.2 S.M.A.R.T. | 9 |
| 6.3 ATA Secure Erase..... | 9 |
| 7. Electrical Specifications..... | 10 |
| 8. Mechanical Specifications | 11 |
| 8.1 Without Housing | 11 |
| 8.2 With Housing | 11 |
| 9. Product Ordering Information..... | 12 |
| 9.1 Product Code Designations..... | 12 |
| 9.2 Valid Combinations..... | 13 |
| 9.2.1 Middle Profile (standard temperature series) | 13 |
| 9.2.2 Middle Profile with Housing (standard temperature series)..... | 13 |
| 9.2.3 Middle Profile (extended temperature series)..... | 13 |
| 9.2.4 Middle Profile with Housing (extended temperature series)..... | 14 |

1. General Description

Apacer's ATA Disk Module 5S (ADM5S) SSD delivers smooth performance and low power consumption. This device supports DMA mode up to UDMA 6 that offers advanced data transfer technology and internal memory efficiency, which effectively decreases the loading for the microprocessor. Compliant with ATA/ATAPI-8 standards, our ADM5S supports data transfer modes up to PIO 4, Multiword DMA 2, and Ultra DMA 6. Equipped with power Error Correction Coding (ECC) up to 72bit/1KB, the ADM5S can provide high data integrity. Aside from data efficiency, the ADM5S also comes with power management. The device can work at 3.3V or 5V power supply, with the output voltage automatically adjusted by the voltage regulator in the core. In addition, the built-in ECC engine can support multi-mode correction capability up to 72 bits and perform effective decoding throughput with high reliability.

ADM is a cost-effective solution with standard ATA compliance deployable at all major operating systems such as Microsoft's Windows series, Apple's Mac OS family, and Unix variants. Featuring technologies as wear leveling, S.M.A.R.T, power failure management, and ATA Secure Erase, Apacer's ADM is definitely the ideal and reliable system storage.

2. Functional Block

The ATA-Disk Module (ADM) includes the ATA controller and flash media, as well as the ATA standard interface. Figure 2-1 shows the functional block diagram.



Figure 2-1 Functional Block Diagram

3. Pin Assignments

Table 3-1 lists the pin assignments with respective signal names for the 44-pin configuration. A “#” suffix indicates the active low signal. The pin type can be input, output or input/output.

Table 3-1 Pin Assignments for the 44-Pin Configuration

| Pin No. | Signal Name | Pin Type | I/O Type* | Pin No. | Signal Name | Pin Type | I/O Type |
|---------|-------------------------------|----------|-----------|---------|---------------------|----------|----------|
| 1 | RESET# | I | I2U | 2 | GND | - | Ground |
| 3 | D7 | I/O | I1Z, O2 | 4 | D8 | I/O | I1Z, O2 |
| 5 | D6 | I/O | I1Z, O2 | 6 | D9 | I/O | I1Z, O2 |
| 7 | D5 | I/O | I1Z, O2 | 8 | D10 | I/O | I1Z, O2 |
| 9 | D4 | I/O | I1Z, O2 | 10 | D11 | I/O | I1Z, O2 |
| 11 | D3 | I/O | I1Z, O2 | 12 | D12 | I/O | I1Z, O2 |
| 13 | D2 | I/O | I1Z, O2 | 14 | D13 | I/O | I1Z, O2 |
| 15 | D1 | I/O | I1Z, O2 | 16 | D14 | I/O | I1Z, O2 |
| 17 | D0 | I/O | I1Z, O2 | 18 | D15 | I/O | I1Z, O2 |
| 19 | GND | - | Ground | 20 | NC | - | - |
| 21 | DMARQ# | O | O1 | 22 | GND | - | Ground |
| 23 | IOWR# STOP | I | I2Z | 24 | GND | - | Ground |
| 25 | IORD# HDMARDY# HSTROBE# | I | I2Z | 26 | GND | - | Ground |
| 27 | IORDY DDMARDY# DSTROBE | O | O1 | 28 | NC/CSEL | I | I1U |
| 29 | DMACK# | I | I2U | 30 | NC/WP# ¹ | -/I | -/I1U |
| 31 | INTRQ | O | O1 | 32 | IOCS16# | O | O2 |
| 33 | A1 | I | I1Z | 34 | PDIAG# | I/O | I1U, O1 |
| 35 | A0 | I | I1Z | 36 | A2 | I | I1Z |
| 37 | CS1FX# | I | I2Z | 38 | CS3FX# | I | I2Z |
| 39 | DASP# | I/O | I1U, O6 | 40 | GND | - | Ground |
| 41 | VDD | - | Power | 42 | VDD | - | Power |
| 43 | GND | - | Ground | 44 | NC | - | - |

*Pin 30 is selectable as NC or WP# through a zero ohm resistor jumper. Default is NC. Note that pin 30 is a GND pin on standard ATA interface. This pin could be redesigned for host to control the write protect function on ADM

4. Product Specifications

4.1 Capacity

Capacity specifications of the ATA-Disk Module (ADM) product family are available as shown in Table 4-1.

Table 4-1 Capacity Specifications (unformatted)

| Capacity | Total bytes | Cylinders | Heads | Sectors | Max LBA |
|----------|----------------|-----------|-------|---------|------------|
| 128 MB | 128,057,344 | 977 | 8 | 32 | 250,112 |
| 256 MB | 256,901,120 | 980 | 16 | 32 | 501,760 |
| 512 MB | 512,483,328 | 993 | 16 | 63 | 1,000,944 |
| 1 GB | 1,011,032,064 | 1959 | 16 | 63 | 1,974,672 |
| 2 GB | 2,011,226,112 | 3897 | 16 | 63 | 3,928,176 |
| 4 GB | 4,011,614,208 | 7773 | 16 | 63 | 7,835,184 |
| 8 GB | 8,012,390,400 | 15525 | 16 | 63 | 15,649,200 |
| 16 GB | 16,013,942,784 | 16383 | 16 | 63 | 31,277,232 |
| 32 GB | 32,017,047,552 | 16383 | 16 | 63 | 62,533,296 |

*Cylinders, heads or sectors are not applicable for these capacities. Only LBA addressing applies

**Notes: 1 GB = 1,000,000,000 bytes; 1 sector = 512 bytes.

LBA count addressed in the table above indicates total user storage capacity and will remain the same throughout the lifespan of the device. However, the total usable capacity of the SSD is most likely to be less than the total physical capacity because a small portion of the capacity is reserved for device maintenance usages.

4.2 Performance

Performance of the ATA-Disk Module is listed in Table 4-2.

Table 4-2 Performance Specifications

| Capacity Performance | 128 MB | 256 MB | 512 MB | 1 GB | 2 GB | 4 GB | 8 GB | 16 GB | 32 GB |
|-------------------------|--------|--------|--------|------|------|------|------|-------|-------|
| Sustained read (MB/s) | 24 | 24 | 31 | 31 | 35 | 38 | 70 | 75 | 75 |
| Sustained write (MB/s) | 11 | 11 | 20 | 20 | 28 | 34 | 60 | 65 | 65 |

*Results may differ from various flash configurations and platforms.

4.3 Environmental Specifications

Environmental specifications of the ATA-Disk Module (ADM) follow the MIL-STD-810F standard.

Table 4-3 Environmental Specifications

| Environment | | Specifications | |
|---------------------------|-----------|---|---------------|
| Temperature | Operation | Standard | 0°C to 70°C |
| | | Extended | -40°C to 85°C |
| | Storage | -40°C to 100°C | |
| Vibration (Non-Operating) | | Sine wave: 10~2000Hz, 15G (X, Y, Z axes) | |
| Shock (Non-Operating) | | Half sine wave, 1,500 G, 11 ms (X, Y, Z ; All 6 axes) | |

5. Flash Management

5.1 Advanced Wear-Leveling Algorithms

Flash memory devices differ from Hard Disk Drives (HDDs) in terms of how blocks are utilized. For HDDs, when a change is made to stored data, like erase or update, the controller mechanism on HDDs will perform overwrites on blocks. Unlike HDDs, flash blocks cannot be overwritten and each P/E cycle wears down the lifespan of blocks gradually. Repeatedly program/erase cycles performed on the same memory cells will eventually cause some blocks to age faster than others. This would bring flash storages to their end of service term sooner. Wear leveling is an important mechanism that level out the wearing of blocks so that the wearing-down of blocks can be almost evenly distributed. This will increase the lifespan of SSDs. Commonly used wear leveling types are Static and Dynamic.

5.2 Built-in Hardware ECC

The properties of NAND flash memory make it ideal for applications that require high integrity while operating in challenging environments. The integrity of data to NAND flash memory is generally maintained through ECC algorithms. This ATA-Flash Drive is programmed with a hardware ECC engine which correct up to 72 bits per 1KB.

5.3 Flash Block Management

Current production technology is unable to guarantee total reliability of NAND flash memory array. When a flash memory device leaves factory, it comes with a minimal number of initial bad blocks during production or out-of-factory as there is no currently known technology that produce flash chips free of bad blocks. In addition, bad blocks may develop during program/erase cycles. When host performs program/erase command on a block, bad block may appear in Status Register. Since bad blocks are inevitable, the solution is to keep them in control. Apacer flash devices are programmed with ECC, block mapping technique and S.M.A.R.T to reduce invalidity or error. Once bad blocks are detected, data in those blocks will be transferred to free blocks and error will be corrected by designated algorithms.

5.4 Power Failure Management

Power Failure Management plays a crucial role when experiencing unstable power supply. Power disruption may occur when users are storing data into the SSD. In this urgent situation, the controller would run multiple write-to-flash cycles to store the metadata for later block rebuilding. This urgent operation requires about several milliseconds to get it done. At the next power up, the firmware will perform a status tracking to retrieve the mapping table and resume previously programmed NAND blocks to check if there is any incompleteness of transmission.

5.5 Mean Time Between Failures (MTBF)

Mean Time Between Failures (MTBF) is predicted based on reliability data for the individual components in the drive. The prediction result for the drive is more than 2,000,000 hours.

Notes about the MTBF: The MTBF is predicated and calculated based on "Telcordia Technologies Special Report, SR-332, Issue 2" method.

6. Software Interface

6.1 Command Set

This section defines the software requirements and the format of the commands the host sends to the ATA-Disk Module (ADM). Commands are issued to the ADM by loading the required registers in the command block with the supplied parameters, and then writing the command code to the Command register. The manner in which a command is accepted varies.

Table 6-1 Command Set

| Command | Code | Command | Code |
|-----------------------------|------------|------------------------------|------------|
| Check-Power-Mode | E5H or 98H | SMART | B0H |
| Execute-Drive-Diagnostic | 90H | Set-Multiple-Mode | C6H |
| Erase Sector(s) | C0H | Set-Sleep-Mode | E6H or 99H |
| Flush-Cache | E7H | Standby | E2H or 96H |
| Format Track | 50H | Standby-Immediate | E0H or 94H |
| Identify-Drive | ECH | Translate-Sector | 87H |
| Idle | E3H or 97H | Write-Buffer | E8H |
| Idle-Immediate | E1H or 95H | Write-DMA | CAH or CBH |
| Initialize-Drive-Parameters | 91H | Write-Multiple | C5H |
| NOP | 00H | Write-Multiple-Without-Erase | CDH |
| Read-Buffer | E4H | Write-Sector(s) | 30H or 31H |
| Read-DMA | C8H or C9H | Write-Sector-Without-Erase | 38H |
| Read-Multiple | C4H | Write-Verify | 3CH |
| Read-Sector(s) | 20H or 21H | | |
| Read-Verify-Sector(s) | 40H or 41H | | |
| Recalibrate | 1XH | | |
| Request-Sense | 03H | | |
| Security-Disable-Password | F6H | | |
| Security-Erase-Prepare | F3H | | |
| Security-Erase-Unit | F4H | | |
| Security-Freeze-Lock | F5H | | |
| Security-Set-Password | F1H | | |
| Security-Unlock | F2H | | |
| Seek | 7XH | | |
| Set-Features | EFH | | |

6.2 S.M.A.R.T.

S.M.A.R.T. is an acronym for Self-Monitoring, Analysis and Reporting Technology, an open standard allowing disk drives to automatically monitor their own health and report potential problems. It protects the user from unscheduled downtime by monitoring and storing critical drive performance and attributes parameters. Ideally, this should allow taking proactive actions to prevent impending drive failure.

6.3 ATA Secure Erase

ATA Secure Erase is an ATA disk purging command currently embedded in most of the storage drives. Defined in ATA specifications, (ATA) Secure Erase is part of Security Feature Set that allows storage drives to erase all user data areas. The erase process usually runs on the firmware level as most of the ATA-based storage media currently in the market are built-in with this command. ATA Secure Erase can securely wipe out the user data in the drive and protects it from malicious attack.

7. Electrical Specifications

Table 7-1 Operating Range

| | |
|-----------------------------|----------------------------|
| Ambient Temperature | 0°C to 70°C |
| Extended Temperature | -40°C to 85°C |
| Operating voltage | 3.135-3.465V 4.75-5.25V |

Table 7-2 Power Consumption

| Capacity Modes | 128 MB | 256 MB | 512 MB | 1 GB | 2 GB | 4 GB | 8 GB | 16 GB | 32 GB |
|---------------------------------|---------------|---------------|---------------|-------------|-------------|-------------|-------------|--------------|--------------|
| Active (mA) | 110 | 110 | 125 | 125 | 130 | 150 | 220 | 240 | 245 |
| Idle (mA) | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |

*Results were tested at 5.0V power supply and may differ from various flash configurations and platforms.

8. Mechanical Specifications

8.1 Without Housing



8.2 With Housing



9. Product Ordering Information

9.1 Product Code Designations



9.2 Valid Combinations

9.2.1 Middle Profile (standard temperature series)

| Capacity | P/N (3.3V) | P/N (5V) |
|----------|---------------------|---------------------|
| 128MB | AP-FM0128D2503S-T1M | AP-FM0128D2505S-T1M |
| 256MB | AP-FM0256D2503S-T1M | AP-FM0256D2505S-T1M |
| 512MB | AP-FM0512D2503S-T1M | AP-FM0512D2505S-T1M |
| 1GB | AP-FM001GD2503S-T1M | AP-FM001GD2505S-T1M |
| 2GB | AP-FM002GD2503S-T1M | AP-FM002GD2505S-T1M |
| 4GB | AP-FM004GD2503S-T1M | AP-FM004GD2505S-T1M |
| 8GB | AP-FM008GD2503S-T1M | AP-FM008GD2505S-T1M |
| 16GB | AP-FM016GD2503S-T1M | AP-FM016GD2505S-T1M |
| 32GB | AP-FM032GD2503S-T1M | AP-FM032GD2505S-T1M |

9.2.2 Middle Profile with Housing (standard temperature series)

| Capacity | P/N (3.3V) | P/N (5V) |
|----------|---------------------|---------------------|
| 128MB | AP-FM0128D2503S-T1H | AP-FM0128D2505S-T1H |
| 256MB | AP-FM0256D2503S-T1H | AP-FM0256D2505S-T1H |
| 512MB | AP-FM0512D2503S-T1H | AP-FM0512D2505S-T1H |
| 1GB | AP-FM001GD2503S-T1H | AP-FM001GD2505S-T1H |
| 2GB | AP-FM002GD2503S-T1H | AP-FM002GD2505S-T1H |
| 4GB | AP-FM004GD2503S-T1H | AP-FM004GD2505S-T1H |
| 8GB | AP-FM008GD2503S-T1H | AP-FM008GD2505S-T1H |
| 16GB | AP-FM016GD2503S-T1H | AP-FM016GD2505S-T1H |
| 32GB | AP-FM032GD2503S-T1H | AP-FM032GD2505S-T1H |

9.2.3 Middle Profile (extended temperature series)

| Capacity | P/N (3.3V) | P/N (5V) |
|----------|----------------------|----------------------|
| 128MB | AP-FM0128D2503S-TW1M | AP-FM0128D2505S-TW1M |
| 256MB | AP-FM0256D2503S-TW1M | AP-FM0256D2505S-TW1M |
| 512MB | AP-FM0512D2503S-TW1M | AP-FM0512D2505S-TW1M |
| 1GB | AP-FM001GD2503S-TW1M | AP-FM001GD2505S-TW1M |
| 2GB | AP-FM002GD2503S-TW1M | AP-FM002GD2505S-TW1M |
| 4GB | AP-FM004GD2503S-TW1M | AP-FM004GD2505S-TW1M |
| 8GB | AP-FM008GD2503S-TW1M | AP-FM008GD2505S-TW1M |
| 16GB | AP-FM016GD2503S-TW1M | AP-FM016GD2505S-TW1M |
| 32GB | AP-FM032GD2503S-TW1M | AP-FM032GD2505S-TW1M |

ATA Disk Module
AP-FMxxxxD250XS-XTX1X



9.2.4 Middle Profile with Housing (extended temperature series)

| Capacity | P/N (3.3V) | P/N (5V) |
|-----------------|----------------------|----------------------|
| 128MB | AP-FM0128D2503S-TW1H | AP-FM0128D2505S-TW1H |
| 256MB | AP-FM0256D2503S-TW1H | AP-FM0256D2505S-TW1H |
| 512MB | AP-FM0512D2503S-TW1H | AP-FM0512D2505S-TW1H |
| 1GB | AP-FM001GD2503S-TW1H | AP-FM001GD2505S-TW1H |
| 2GB | AP-FM002GD2503S-TW1H | AP-FM002GD2505S-TW1H |
| 4GB | AP-FM004GD2503S-TW1H | AP-FM004GD2505S-TW1H |
| 8GB | AP-FM008GD2503S-TW1H | AP-FM008GD2505S-TW1H |
| 16GB | AP-FM016GD2503S-TW1H | AP-FM016GD2505S-TW1H |
| 32GB | AP-FM032GD2503S-TW1H | AP-FM032GD2505S-TW1H |

Note: Valid combinations are those products in mass production or will be in mass production. Consult your Apacer sales representative to confirm availability of valid combinations and to determine availability of new combinations.

Revision History

| Revision | Date | Description | Remark |
|----------|------------|--|--------|
| 0.1 | 05/23/2014 | Preliminary | |
| 1.0 | 07/18/2014 | Official release | |
| 1.1 | 09/11/2014 | Added extended temperature specification | |
| 1.2 | 1/19/2015 | Capacity reorganized. | |
| 1.3 | 1/21/2015 | Updated mechanical specifications. | |
| 1.4 | 2/15/2016 | Added 128MB and 256MB support | |

Global Presence

| | |
|------------------------------|---|
| Taiwan (Headquarters) | Apacer Technology Inc. Apacer Technology Inc. 1F., No.32, Zhongcheng Rd., Tucheng Dist., New Taipei City 236, Taiwan R.O.C. Tel: 886-2-2267-8000 Fax: 886-2-2267-2261 amtsales@apacer.com |
| U.S.A. | Apacer Memory America, Inc. 46732 Lakeview Blvd., Fremont, CA 94538 Tel: 1-408-518-8699 Fax: 1-510-249-9568 sa@apacerus.com |
| Japan | Apacer Technology Corp. 5F, Matsura Bldg., Shiba, Minato-Ku Tokyo, 105-0014, Japan Tel: 81-3-5419-2668 Fax: 81-3-5419-0018 jpservices@apacer.com |
| Europe | Apacer Technology B.V. Science Park Eindhoven 5051 5692 EB Son, The Netherlands Tel: 31-40-267-0000 Fax: 31-40-267-0000#6199 sales@apacer.nl |
| China | Apacer Electronic (Shanghai) Co., Ltd Room D,22/FL,No2,Lane600,JieyunPlaza, Tianshan RD,Shanghai,200051,China Tel: 86-21-6228-9939 Fax: 86-21-6228-9936 sales@apacer.com.cn |
| India | Apacer Technologies Pvt Ltd Unit No.201, "Brigade Corner", 7th Block Jayanagar, Yediyur Circle, Bangalore – 560082, INDIA. Tel: +91-80-4152-9061/62/63 Fax:+91-80-4170-0215 sales_india@apacer.com |

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