

## Halogen-free & RoHS Recast Compliant **CS710-CF** Industrial CF Product Specifications



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Version 1.4



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## Specifications Overview:

- **CompactFlash Association Specification Revision 6.1 Standard Interface**
  - ATA command set compatible
  - ATA transfer mode supports: PIO Mode 6, Multiword DMA Mode 4, Ultra DMA Mode 6 in True-IDE mode
- **Capacity**
  - 128, 256, 512 MB
  - 1, 2, 4, 8, 16, 32, 64 GB
- **Performance\***
  - Sequential read: Up to 55 MB/sec
  - Sequential write: Up to 55 MB/sec
  - Random read (4K): Up to 2,000 IOPS
  - Random write (4K): Up to 1,000 IOPS
- **Flash Management**
  - Global Wear Leveling
  - Built-in BCH ECC capable of correcting up to 96 bits in 1KB data
  - Supports S.M.A.R.T commands
  - Flash Block Management
  - Power Failure Management
- **Reliability**
  - Supply voltage power-down detection for full power-down robustness
- **NAND Flash Type: SLC**
- **MTBF: >2,000,000 hours**
- **Temperature Range**
  - Operating:
    - Standard: 0°C to 70°C
    - Wide: -40°C to 85°C
  - Storage: -40°C to 100°C
- **Supply Voltage**
  - 3.3V ± 5%
  - 5.0V ± 10%
- **Power Consumption\***
  - Operating Voltage: 3.3V
    - Active mode: 145 mA
    - Standby mode: 10 mA
  - Operating Voltage: 5.0V
    - Active mode: 145 mA
    - Standby mode: 10 mA
- **Connector Type**
  - 50 pins female
- **Form Factor**
  - 36.4mm x 42.8mm x 3.3mm
  - Net Weight: 9.79 g
- **Halogen Free**
- **RoHS Recast Compliant**
  - Complies with 2011/65/EU Standard

\*Varies from capacities. The values for performances and power consumptions presented are typical and may vary depending on flash configurations or platform settings.

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## 1. General Descriptions

Apacer's value-added Industrial CompactFlash Card offers high performance, high reliability and power-efficient storage. Regarding standard compliance, this CompactFlash Card complies with CompactFlash specification revision 6.1, supporting transfer modes up to Programmed Input Output (PIO) Mode 6, Multi-word Direct Memory Access (DMA) Mode 4, Ultra DMA Mode 6 in True-IDE Mode.

Apacer's value-added CFC provides complete PCMCIA – ATA functionality and compatibility. Apacer's CompactFlash technology is designed for applications in Point of Sale (POS) terminals, telecom, IP-STB, medical instruments, surveillance systems, industrial PCs and handheld applications such as the new generation of Digital Single Lens Reflex (DSLR) cameras.

### 1.1 Intelligent Endurance Design

#### 1.1.1 Error Correction Code (ECC)

The CompactFlash card is programmed with BCH Error Detection Code (EDC) and Error Correction Code (ECC) algorithms capable of correcting up to 96 random bits in 1KB bytes data.

High performance is achieved through hardware-based error detection and correction.

#### 1.1.2 Global Wear Leveling

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. Global Wear leveling is an important mechanism that levels out the wearing of blocks so that the wearing-down of all blocks can be almost evenly distributed. This will increase the lifespan of SSDs.

#### 1.1.3 S.M.A.R.T. Technology

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 calibration parameters. Ideally, this should allow taking proactive actions to prevent impending drive failure. Apacer SMART feature adopts the standard SMART command B0h to read data from the drive. When the Apacer SMART Utility running on the host, it analyzes and reports the disk status to the host before the device is in critical condition.

| Code | SMART Subcommand                  |
|------|-----------------------------------|
| D0h  | READ DATA                         |
| D1h  | READ ATTRIBUTE THRESHOLDS         |
| D2h  | Enable/Disable Attribute Autosave |
| D4h  | Execute Off-line Immediate        |
| D5h  | Read Log (optional)               |
| D6h  | Write Log (optional)              |
| D8h  | Enable Operations                 |

| Code | SMART Subcommand   |
|------|--------------------|
| D9h  | Disable operations |
| DAh  | Return Status      |

**General SMART attribute structure**

| Byte  | Description |
|-------|-------------|
| 0     | ID (Hex)    |
| 1 – 2 | Status flag |
| 3     | Value       |
| 4     | Worst       |
| 5*-11 | Raw Data    |

\*Byte 5: LSB

**SMART attribute ID list**

| ID (Hex)   | Attribute Name          |
|------------|-------------------------|
| 12 (0x0C)  | Power cycle count       |
| 160 (0xA0) | Initial bad block count |
| 161 (0xA1) | Bad block count         |
| 162 (0xA2) | Spare block count       |
| 163 (0xA3) | Max. erase count        |
| 164 (0xA4) | Avg. erase count        |
| 241 (0xF1) | Total LBAs written      |
| 242 (0xF2) | Total LBAs read         |

### 1.1.4 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.

### 1.1.5 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.

## 2. Functional Block

The CompactFlash Card (CFC) includes a controller and flash media, as well as the CompactFlash standard interface. Figure 2-1 shows the functional block diagram.

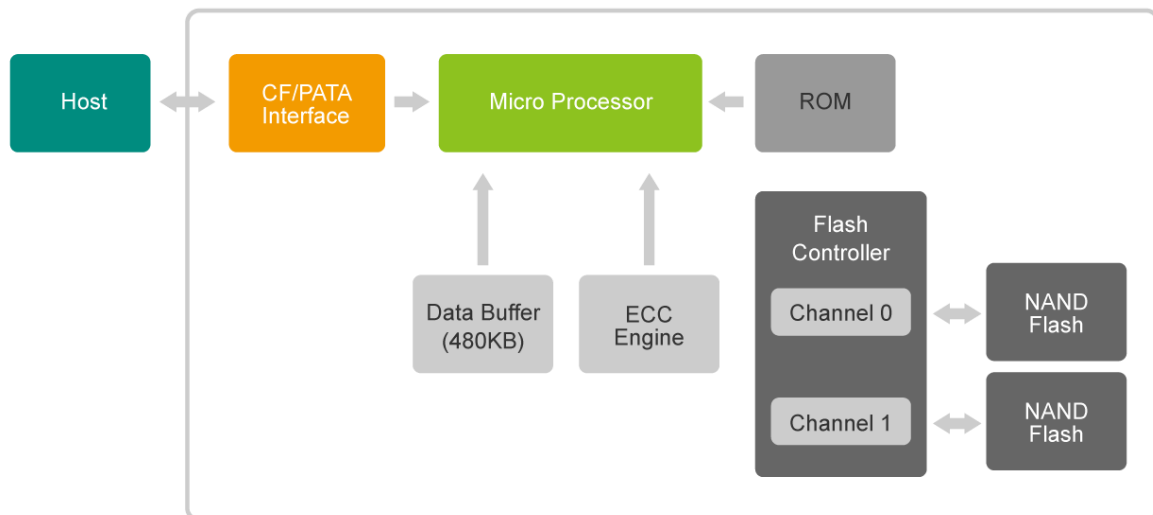


Figure 2-1 Functional Block Diagram

### 3. Pin Assignments

Table 3-1 lists the pin assignments with respective signal names for the 50-pin configuration. A “#” suffix indicates the active low signal. The pin type can be input, output or input/output.

Table 3-1 Pin Assignments

| Pin No. | Memory card mode |              | I/O card mode |              | True IDE mode      |              |
|---------|------------------|--------------|---------------|--------------|--------------------|--------------|
|         | Signal name      | Pin I/O type | Signal name   | Pin I/O type | Signal name        | Pin I/O type |
| 1       | GND              | -            | GND           | -            | GND                | -            |
| 2       | D3               | I/O          | D3            | I/O          | D3                 | I/O          |
| 3       | D4               | I/O          | D4            | I/O          | D4                 | I/O          |
| 4       | D5               | I/O          | D5            | I/O          | D5                 | I/O          |
| 5       | D6               | I/O          | D6            | I/O          | D6                 | I/O          |
| 6       | D7               | I/O          | D7            | I/O          | D7                 | I/O          |
| 7       | #CE1             | I            | #CE1          | I            | #CS0               | I            |
| 8       | A10              | I            | A10           | I            | A10 <sup>1</sup>   | I            |
| 9       | #OE              | I            | #OE           | I            | #ATA SEL           | I            |
| 10      | A9               | I            | A9            | I            | A9 <sup>1</sup>    | I            |
| 11      | A8               | I            | A8            | I            | A8 <sup>1</sup>    | I            |
| 12      | A7               | I            | A7            | I            | A7 <sup>1</sup>    | I            |
| 13      | VCC              | -            | VCC           | -            | VCC                | -            |
| 14      | A6               | I            | A6            | I            | A6 <sup>1</sup>    | I            |
| 15      | A5               | I            | A5            | I            | A5 <sup>1</sup>    | I            |
| 16      | A4               | I            | A4            | I            | A4 <sup>1</sup>    | I            |
| 17      | A3               | I            | A3            | I            | A3 <sup>1</sup>    | I            |
| 18      | A2               | I            | A2            | I            | A2                 | I            |
| 19      | A1               | I            | A1            | I            | A1                 | I            |
| 20      | A0               | I            | A0            | I            | A0                 | I            |
| 21      | D0               | I/O          | D0            | I/O          | D0                 | I/O          |
| 22      | D1               | I/O          | D1            | I/O          | D1                 | I/O          |
| 23      | D2               | I/O          | D2            | I/O          | D2                 | I/O          |
| 24      | WP               | O            | #IOIS16       | O            | #IOCS16            | O            |
| 25      | #CD2             | O            | #CD2          | O            | #CD2               | O            |
| 26      | #CD1             | O            | #CD1          | O            | #CD1               | O            |
| 27      | D11              | I/O          | D11           | I/O          | D11                | I/O          |
| 28      | D12              | I/O          | D12           | I/O          | D12                | I/O          |
| 29      | D13              | I/O          | D13           | I/O          | D13                | I/O          |
| 30      | D14              | I/O          | D14           | I/O          | D14                | I/O          |
| 31      | D15              | I/O          | D15           | I/O          | D15                | I/O          |
| 32      | #CE2             | I            | #CE2          | I            | #CS1               | I            |
| 33      | #VS1             | O            | #VS1          | O            | #VS1               | O            |
| 34      | #IORD            | I            | #IORD         | I            | #IORD              | I            |
| 35      | #IOWR            | I            | #IOWR         | I            | #IOWR              | I            |
| 36      | #WE              | I            | #WE           | I            | #WE                | I            |
| 37      | RDY/-BSY         | O            | #IREQ         | O            | INTRQ              | O            |
| 38      | VCC              | -            | VCC           | -            | VCC                | -            |
| 39      | #CSEL            | I            | #CSEL         | I            | #CSEL              | I            |
| 40      | #VS2             | O            | #VS2          | O            | #VS2               | O            |
| 41      | RESET            | I            | RESET         | I            | #RESET             | I            |
| 42      | #WAIT            | O            | #WAIT         | O            | IORDY              | O            |
| 43      | #INPACK          | O            | #INPACK       | O            | DMARQ <sup>2</sup> | O            |
| 44      | #REG             | I            | #REG          | I            | DMACK <sup>2</sup> | I            |
| 45      | BVD2             | O            | #SPKR         | O            | #DASP              | I/O          |
| 46      | BVD1             | O            | #STSCHG       | O            | #PDIAG             | I/O          |

| Pin No. | Memory card mode |              | I/O card mode |              | True IDE mode |              |
|---------|------------------|--------------|---------------|--------------|---------------|--------------|
|         | Signal name      | Pin I/O type | Signal name   | Pin I/O type | Signal name   | Pin I/O type |
| 47      | D8               | I/O          | D8            | I/O          | D8            | I/O          |
| 48      | D9               | I/O          | D9            | I/O          | D9            | I/O          |
| 49      | D10              | I/O          | D10           | I/O          | D10           | I/O          |
| 50      | GND              | -            | GND           | -            | GND           | -            |

1. The signal should be grounded by the host.
2. Connection required when UDMA is in use.



## 4. Product Specifications

### 4.1 Capacity

Capacity specifications of the Compact Flash Card series (CFC) are available as shown in Table 4-1. It lists the specific capacity and the default numbers of heads, sectors and cylinders for each product line.

**Table 4-1** Capacity Specifications

| Capacity | Total bytes*   | Cylinders | Heads | Sectors | Max LBA     |
|----------|----------------|-----------|-------|---------|-------------|
| 128 MB   | 127,696,896    | 433       | 16    | 36      | 249,408     |
| 256 MB   | 250,961,920    | 557       | 16    | 55      | 490,160     |
| 512 MB   | 510,787,584    | 1,732     | 16    | 36      | 997,632     |
| 1 GB     | 1,011,032,064  | 1,959     | 16    | 63      | 1,974,672   |
| 2 GB     | 2,011,226,112  | 3,897     | 16    | 63      | 3,928,176   |
| 4 GB     | 4,011,614,208  | 7,773     | 16    | 63      | 7,835,184   |
| 8 GB     | 8,012,390,400  | 15,525    | 16    | 63      | 15,649,200  |
| 16 GB    | 16,013,942,784 | 16,383    | 16    | 63      | 31,277,232  |
| 32 GB    | 32,017,047,552 | 16,383    | 16    | 61      | 62,533,296  |
| 64 GB    | 64,023,257,088 | 65,535    | 16    | 63      | 125,045,424 |

Note:

Display of total bytes varies from operating systems.

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 CF cards is listed in Table 4-2.

**Table 4-2** Performance Specifications

| Performance                     | Capacity |        |        |       |       |       |       |       |       |       |  |
|---------------------------------|----------|--------|--------|-------|-------|-------|-------|-------|-------|-------|--|
|                                 | 128 MB   | 256 MB | 512 MB | 1 GB  | 2 GB  | 4 GB  | 8 GB  | 16 GB | 32 GB | 64 GB |  |
| <b>Sequential Read* (MB/s)</b>  | 24       | 28     | 38     | 55    | 55    | 55    | 55    | 55    | 55    | 55    |  |
| <b>Sequential Write* (MB/s)</b> | 4        | 8      | 16     | 24    | 42    | 45    | 44    | 55    | 55    | 55    |  |
| <b>Random Read IOPS** (4K)</b>  | 2,000    | 2,000  | 2,000  | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 | 2,000 |  |
| <b>Random Write IOPS** (4K)</b> | 90       | 200    | 400    | 800   | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 | 1,000 |  |

Note:

Results may differ from various flash configurations or host system setting.

\*Sequential performance is based on CrystalDiskMark 5.2.1 with file size 1,000MB.

\*\*Random performance measured using IOMeter with Queue Depth 32.

### 4.3 Environmental Specifications

Environmental specifications of the Compact Flash Card series (CFC) are shown in Table 4-3.

**Table 4-3** Environmental Specifications

| Item                    | Specifications   |
|-------------------------|--|
| Operating temp.         | 0°C to 70°C (Standard); -40°C to 85°C (Wide)               |
| Non-operating temp.     | -40°C to 100°C   |
| Operating vibration     | 7.69 GRMS, 20~2000 Hz/random (compliant with MIL-STD-810G) |
| Non-operating vibration | 4.02 GRMS, 15 ~ 2000 Hz/sine (compliant with MIL-STD-810G) |
| Operating shock         | 50G, 11ms, half-sine wave                                  |
| Non-operating shock     | 1,500G, 0.5ms, half-sine wave                              |

### 4.4 Mean Time Between Failures (MTBF)

MTBF, an acronym for Mean Time Between Failures, is a measure of a device's reliability. Its value represents the average time between a repair and the next failure. The measure is typically in units of hours. The higher the MTBF value, the higher the reliability of the device. The predicted result of this CompactFlash Card is higher than 2,000,000 hours.

### 4.5 Certification and Compliance

The CompactFlash card complies with the following global standards:

- CE
- FCC
- Halogen-free
- EMC
- RoHS Recast (2011/65/EU)

## 5. Software Interface

### 5.1 CF-ATA Command Set

Table 5-1 summarizes the CF-ATA command set with the paragraphs that follow describing the individual commands and the task file for each.

**Table 5-1** CFC-ATA Command Set

| Command Set                  | Command                      | Code       | Protocol          |
|------------------------------|------------------------------|------------|-------------------|
| CFA Feature Set              | Request Sense                | 03h        | Non-data          |
|                              | Write Sectors Without Erase  | 38h        | PIO data-out      |
|                              | Erase Sectors                | C0h        | Non-data          |
|                              | Write Multiple Without Erase | CDh        | PIO data-out      |
|                              | Translate Sector             | 87h        | PIO data-in       |
|                              | Write Multiple w/o erase     | CDh        | PIO               |
|                              | Write sector(s) w/o erase    | 38h        | PIO               |
| General Feature Set          | Execute Drive Diagnostic     | 90h        | Device diagnostic |
|                              | Flush Cache                  | E7h        | Non-data          |
|                              | Identify Device              | ECh        | PIO data-in       |
|                              | Read DMA                     | C8h        | DMA               |
|                              | Read Multiple                | C4h        | PIO data-in       |
|                              | Read Sector(s)               | 20h or 21h | PIO data-in       |
|                              | Read Verify Sector(s)        | 40h or 41h | Non-data          |
|                              | Set Feature                  | EFh        | Non-data          |
|                              | Set Multiple Mode            | C6h        | Non-data          |
|                              | Write DMA                    | CAh        | DMA               |
|                              | Write Multiple               | C5h        | PIO data-out      |
|                              | Write Sector(s)              | 30h or 31h | PIO data-out      |
|                              | NOP                          | 00h        | Non-data          |
|                              | Read Buffer                  | E4h        | PIO data-in       |
|                              | Write Buffer                 | E8h        | PIO data-out      |
|                              | Set Feature                  | EFh        | Non-data          |
| Power Management Feature Set | Check Power Mode             | E5h or 98h | Non-data          |
|                              | Idle                         | E3h or 97h | Non-data          |
|                              | Idle Immediate               | E1h or 95h | Non-data          |
|                              | Set sleep mode               | E6h or 99h | Non-data          |
|                              | Sleep                        | E6h or 99h | Non-data          |
|                              | Standby                      | E2h or 96h | Non-data          |

| Command Set                     | Command                          | Code       | Protocol     |
|---------------------------------|----------------------------------|------------|--------------|
|                                 | Standby Immediate                | E0h or 94h | Non-data     |
| Security Mode Feature Set       | Security Set Password            | F1h        | PIO data-out |
|                                 | Security Unlock                  | F2h        | PIO data-out |
|                                 | Security Erase Prepare           | F3h        | Non-data     |
|                                 | Security Erase Unit              | F4h        | PIO data-out |
|                                 | Security Freeze Lock             | F5h        | Non-data     |
|                                 | Security Disable Password        | F6h        | PIO data-out |
|                                 | Media Lock                       | DEh        | Non-data     |
|                                 | Media Unlock                     | DFh        | Non-data     |
| SMART Feature Set               | SMART Disable Operations         | B0h        | Non-data     |
|                                 | SMART Enable/Disable Autosave    | B0h        | Non-data     |
|                                 | SMART Enable Operations          | B0h        | Non-data     |
|                                 | SMART Return Status              | B0h        | Non-data     |
|                                 | SMART Execute Off-line Immediate | B0h        | Non-data     |
|                                 | SMART Read Data                  | B0h        | PIO data-in  |
| Host Protected Area Feature Set | Data Set Management              | 06h        | DMA          |
|                                 | Read Native Max Address          | F8h        | Non-data     |
|                                 | Read native max addr Ext         | 27h        | Non-data     |
|                                 | Set Max Address                  | F9h        | Non-data     |
| Others                          | Format Track                     | 50h        | PIO data-out |
|                                 | Initialize Drive Parameters      | 91h        | Non-data     |
|                                 | Recalibrate                      | 1Xh        | Non-data     |
|                                 | Seek                             | 7Xh        | Non-data     |
|                                 | Write Verify                     | 3Ch        | PIO data-out |
|                                 | Download Microcode               | 92h        | PIO data-in  |
|                                 | Download Microcode DMA           | 93h        | DMA          |
| 48-bit Address Feature Set      | Read Sector Ext                  | 24h        | PIO data-in  |
|                                 | Read DMA Ext                     | 25h        | DMA          |
|                                 | Read Multiple Ext                | 29h        | PIO data-in  |
|                                 | Write Sector Ext                 | 34h        | PIO data-out |
|                                 | Write DMA Ext                    | 35h        | DMA          |
|                                 | Read Verify Sector Ext           | 42h        | Non-data     |
|                                 | Write Multiple FUA Ext           | CEh        | PIO data-out |
|                                 | Flush Cache Ext                  | EAh        | Non-data     |
|                                 | Read Log Ext                     | 2Fh        | PIO          |
| Read Log DMA Ext                | 57h                              | DMA        |              |

| Command Set | Command             | Code | Protocol |
|-------------|---------------------|------|----------|
|             | Write DMA FUA Ext   | 3Dh  | DMA      |
|             | Write Log Ext       | 3Fh  | PIO      |
|             | Write Log DMA Ext   | 57h  | DMA      |
|             | Write Multiple Ext  | 39h  | PIO      |
|             | Set max address Ext | 37h  | Non-data |

## 6. Electrical Specifications

### 6.1 Operating Voltage

Table 6-1 lists the supply voltage for the CompactFlash card.

**Table 6-1** Operating Range

| Item                   | Range            |
|------------------------|------------------|
| Supply voltage at 3.3V | 3.135 to 3.465 V |
| Supply voltage at 5V   | 4.75 to 5.25 V   |

### 6.2 Power Consumption

Table 6-2 and 6-3 list the power consumption for the CompactFlash card.

**Table 6-2** Power Consumption @3.3V

| Capacity<br>Mode | 128 MB | 256 MB | 512 MB | 1 GB | 2 GB | 4 GB | 8 GB | 16 GB | 32 GB | 64 GB |
|------------------|--------|--------|--------|------|------|------|------|-------|-------|-------|
| Active (mA)      | 70     | 70     | 100    | 120  | 125  | 130  | 135  | 120   | 125   | 145   |
| Standby (mA)     | 10     | 10     | 10     | 10   | 10   | 10   | 10   | 10    | 10    | 10    |

**Table 6-3** Power Consumption @5V

| Capacity<br>Mode | 128 MB | 256 MB | 512 MB | 1 GB | 2 GB | 4 GB | 8 GB | 16 GB | 32 GB | 64 GB |
|------------------|--------|--------|--------|------|------|------|------|-------|-------|-------|
| Active (mA)      | 70     | 75     | 105    | 115  | 120  | 130  | 135  | 125   | 125   | 145   |
| Standby (mA)     | 10     | 10     | 10     | 10   | 10   | 10   | 10   | 10    | 10    | 10    |

Note:

\*All values are typical and may vary depending on flash configurations or host system settings.

\*\*Active power is an average power measurement performed using CrystalDiskMark with 128KB sequential read/write transfers.

## 6.3 AC/DC Characteristics

The following section provides general AC/DC characteristics of this CompactFlash card.

### 6.3.1 DC Characteristics

- Absolute Maximum Ratings**

| Parameter  | Remark               |
|--|----------------------|
| Supply voltage on 3.3V supply pins               | -0.5V to 3.63V       |
| Supply voltage on 1.2V supply pins               | -0.5V to 1.32V       |
| Voltage on CF/PATA pins with respect to ground   | -0.5V to 6.7V        |
| Voltage on flash pins with respect to ground     | -0.5V to VDDF + 0.5V |
| Voltage on GPIO8..15 pins with respect to ground | -0.5V to VDDG + 0.5V |
| Voltage on other pins with respect to ground     | -0.5V to VCC + 0.5V  |
| Storage temperature                              | -40°C to 125°C       |

- DC Parameters**

| Parameter                  | Remark                     |
|----------------------------|----------------------------|
| Supply Voltage VCC, AVCC   | 3.30V ± 5%                 |
| Supply Voltage VDDF, VDDG  | 3.30V ± 5%, 1.80V ± 5%     |
| Supply Voltage VDDC, AVDDC | 1.2V ± 5%                  |
| Temperature (ambient)      | -40°C to 85°C (industrial) |

- General DC characteristics**

| Symbol              | Parameter                | Min                  | Max                   | Unit | Remark   |
|---------------------|--------------------------|----------------------|-----------------------|------|--|
| V <sub>IL,H</sub>   | Input LOW Voltage        | -0.3                 | 0.8                   | V    | CF/PATA host interface   |
| V <sub>IH,H</sub>   | Input HIGH Voltage       | 2.0                  | 5.5                   | V    |  |
| V <sub>IL</sub>     | Input LOW Voltage        | -0.3                 | 0.3*V <sub>DD</sub>   | V    | V <sub>DD</sub> is VDDF (flash IF), VDDG (GPIO8..15) or VCC (other pins) |
| V <sub>IH</sub>     | Input HIGH Voltage       | 0.7*V <sub>DD</sub>  | *V <sub>DD</sub> +0.3 | V    |  |
| V <sub>OL</sub>     | Output LOW Voltage       |                      | 0.4                   | V    | at 4mA (12mA for DASP)   |
| V <sub>OH,H</sub>   | Output HIGH Voltage      | VCC-0.51             |                       | V    | at 6mA, CF/PATA pins   |
| V <sub>OH</sub>     | Output HIGH Voltage      | V <sub>DD</sub> -0.4 |                       | V    | at 4mA, other pins   |
| I <sub>LI</sub>     | Input Leakage Current    | -5                   | 5                     | µA   | if not pull-up/pull-down   |
| I <sub>LO</sub>     | Output Leakage Current   | -5                   | 5                     | µA   | if not pull-up/pull-down   |
| I <sub>PURB33</sub> | Pull-Up Current          | 1.5                  | 2.5                   | mA   | F <sub>n</sub> RB0..3 pins, at 3.3V                                      |
| I <sub>PURB18</sub> | Pull-Up Current          | 0.6                  | 1.4                   | mA   | F <sub>n</sub> RB0..3 pins, at 1.8V                                      |
| I <sub>PU</sub>     | Pull-Up Current          | 15                   | 110                   | µA   | other pins   |
| I <sub>PD</sub>     | Pull-Down Current        | 20                   | 160                   | µA   |  |
| C <sub>IO</sub>     | Input/Output Capacitance |                      | 10                    | pF   |  |
| ESD                 | ESD Protection           | 2                    |                       | kV   | HBM  |

• **Operating Currents**

| Symbol             | Parameter          | Typ | Max  | Unit | Remark  |
|--------------------|--------------------|-----|------|------|---|
| I <sub>VCC</sub>   | VCC current        |     |      |      |   |
|                    | Sleep mode         | 3.0 | 4.5  | mA   |   |
|                    | Operating          | 15  | 85   | mA   | in UDMA6 mode                                 |
| I <sub>VDDC</sub>  | VDDC current       |     |      |      | at 25°C                                       |
|                    | Sleep mode         | 1   | 6    | mA   |   |
|                    | Operating          | 50  | 80   | mA   | at 160 MHz CPU clock                          |
| I <sub>VDDF</sub>  | VDDF, VDDG current |     |      |      | at 80 MHz flash clock,<br>typical CF card PCB |
|                    | at 1.8V            | 8   | 25   | mA   |   |
|                    | at 3.3V            | 15  | 60   | mA   |   |
| I <sub>AVCC</sub>  | AVCC current       | 0.4 | 0.6  | mA   |   |
| I <sub>AVDDC</sub> | AVDDC current      |     |      |      |   |
|                    | Sleep mode         | 20  | 200  | μA   |   |
|                    | Operating          | 4.5 | 14.0 | mA   | typ for 400 MHz PLL                           |

• **Voltage Regulator Parameters**

1.2V switching regulator (supply for VDDC)

| Symbol           | Parameter                  | Min  | Typ  | Max  | Unit | Remark       |
|------------------|----------------------------|------|------|------|------|--------------|
| V <sub>I</sub>   | Input voltage (CIN)        | 3.00 | 3.30 | 3.60 | V    |              |
| V <sub>O</sub>   | Output voltage             | 1.15 | 1.20 | 1.25 | V    |              |
| I <sub>O</sub>   | Average load current       |      |      | 600  | mA   |              |
| V <sub>R20</sub> | Output ripple 20 MHz BW    |      |      | 15   | mV   |              |
| T <sub>on</sub>  | Startup time               |      | 50   |      | μS   |              |
| L <sub>O</sub>   | Output filtering inductor  |      | 2.2  |      | μH   |              |
| C <sub>O</sub>   | Output filtering capacitor |      | 2x10 |      | μF   | 2 capacitors |
| ESR              | Output capacitor ESR       | 2    |      | 200  | mΩ   |              |
| ESL              | Output capacitor ESL       |      |      | 4    | nH   |              |

1.8V linear regulator (supply for VDDF/VDDG)

| Symbol          | Parameter                  | Min  | Typ  | Max  | Unit | Remark |
|-----------------|----------------------------|------|------|------|------|--------|
| V <sub>I</sub>  | Input voltage (FIN)        | 3.00 | 3.30 | 3.60 | V    |        |
| V <sub>O</sub>  | Output voltage (FOUT)      | 1.72 | 1.80 | 1.88 | V    |        |
| I <sub>O</sub>  | Average load current       |      |      | 150  | mA   |        |
| T <sub>on</sub> | Startup time               |      | 10   |      | μS   |        |
| C <sub>O</sub>  | Output filtering capacitor |      | 2.2  |      | μF   |        |
| ESR             | Output capacitor ESR       | 4    |      | 200  | mΩ   |        |
| ESL             | Output capacitor ESL       |      |      | 4    | nH   |        |

• **SLEVCC Switchable ISO7816 Power Supply Output Parameters**

| Symbol           | Parameter               | Min         | Typ | Max | Unit | Remark       |
|------------------|-------------------------|-------------|-----|-----|------|--------------|
| V <sub>SLE</sub> | SLEVCC Output Voltage   | VCC<br>-0.2 |     | VCC | V    | When enabled |
| I <sub>SLE</sub> | SLEVCC Output Current   |             |     | 30  | mA   |              |
| T <sub>SLE</sub> | SLEVCC Ramp Up Time     |             | 10  |     | μS   |              |
| C <sub>SLE</sub> | SLEVCC Output Capacitor |             | 0.1 |     | μF   |              |



● **Supply Voltage Monitor Parameters**

| Symbol              | Parameter                    | Min  | Typ  | Max  | Unit | Remark                   |
|---------------------|------------------------------|------|------|------|------|--------------------------|
| ReS <sub>1.2R</sub> | 1.2V Reset rising threshold  |      | 95   |      | %    | of 1.2V regulator output |
| ReS <sub>3.3R</sub> | 3.3V Reset rising threshold  | 2.23 | 2.35 | 2.47 | V    | at VCC pin               |
| ReS <sub>3.3F</sub> | 3.3V Reset falling threshold | 2.15 | 2.20 | 2.25 | V    | at VCC pin               |
| S <sub>5VH</sub>    | 5V sense high threshold      | 4.31 | 4.40 | 4.49 | V    | at SENSE5V pin           |
| S <sub>5VL</sub>    | 5V sense low threshold       | 3.01 | 3.07 | 3.13 | V    | at SENSE5V pin           |
| S <sub>3V</sub>     | 3.3V sense threshold         | 2.84 | 2.90 | 2.96 | V    | at SENSE3V pin           |

The ReS<sub>1.2R</sub> and ReS<sub>3.3R</sub> thresholds are used by the reset logic to release the internal reset signal on a system power-on. The ReS<sub>3.3L</sub> threshold is used to assert the internal reset signal on a system power down.

The S<sub>3V</sub> and S<sub>5V</sub> threshold comparators generate interrupts to the firmware. The S<sub>3V</sub> comparator normally monitors the 3.3V VCC supply, the S<sub>5V</sub> comparator normally monitors the 5V or 3.3V module supply. The S<sub>3V</sub> interrupt can be used to stop accesses to the flash memory early on a system power down event. The S<sub>5V</sub> interrupt can be used to implement a supply hold-up functionality when a backup energy source is available.

In packages that do not have the SENSE3V pin, SENSE3V is internally connected to VCC.

**6.3.2 AC Characteristics**

The AC Characteristics reference the timing diagrams of the CompactFlash Specification Revision 4.1 and the symbols in these timing diagrams. The AC characteristics are valid for a supply voltage of 3.3V ± 5%.

● **Attribute Memory Read and Write Characteristics**

See figures 25 and 26 in the CF Specification Revision 4.1.

| Symbol     | Parameter                           | Min | Max | Unit |
|------------|-------------------------------------|-----|-----|------|
| tc(R)      | Read cycle time                     | 250 |     | ns   |
| ta(A)      | Address access time                 |     | 250 | ns   |
| ta(CE)     | Card Enable access time             |     | 250 | ns   |
| ta(OE)     | Output Enable access time           |     | 125 | ns   |
| tdis(CE)   | Output disable time from CE         |     | 100 | ns   |
| tdis(OE)   | Output disable time from OE         |     | 100 | ns   |
| ten(CE)    | Output enable time from CE          | 5   |     | ns   |
| ten(OE)    | Output enable time from OE          | 5   |     | ns   |
| tv(A)      | Data valid time from address change | 0   |     | ns   |
| tsu(A)     | Address setup time                  | 30  |     | ns   |
| tc(W)      | Write cycle time                    | 250 |     | ns   |
| tw(WE)     | Write pulse time                    | 150 |     | ns   |
| trec(WE)   | Address hold time from WE           | 30  |     | ns   |
| tsu(D-WEH) | Data setup time for WE              | 80  |     | ns   |
| th(D)      | Data hold time                      | 30  |     | ns   |

● **Common Memory Read and Write Characteristics**

See figures 27 and 28 in the CF Specification Revision 4.1. The wait functionality is not used.

| Symbol     | Parameter                     | Min | Max | Unit |
|------------|-------------------------------|-----|-----|------|
| tc         | Cycle time                    | 80  |     | ns   |
| ta(OE)     | Output Enable access time     |     | 45  | ns   |
| tdis(OE)   | Output disable time from OE   |     | 45  | ns   |
| tsu(A)     | Address setup time            | 10  |     | ns   |
| th(A)      | Address hold time             | 10  |     | ns   |
| tsu(CE)    | Card Enable setup time        | 0   |     | ns   |
| th(CE)     | Card Enable hold time         | 10  |     | ns   |
| tw(WE)     | Write pulse time              | 55  |     | ns   |
| tsu(A)     | Address setup time for WE     | 10  |     | ns   |
| tsu(CE)    | Card Enable setup time for WE | 0   |     | ns   |
| tsu(D-WEH) | Data setup time for WE        | 30  |     | ns   |
| th(D)      | Data hold time                | 10  |     | ns   |
| trec(WE)   | Write recovery time           | 15  |     | ns   |

● **I/O Access Read and Write Characteristics**

See figures 29 and 30 in the CF Specification Revision 4.1. The wait functionality is not used.

| Symbol          | Parameter                         | Min | Max | Unit |
|-----------------|-----------------------------------|-----|-----|------|
| td(IORD)        | Data delay after IORD             |     | 45  | ns   |
| th(IORD)        | Data hold following IORD          | 5   |     | ns   |
| tw(IORD)        | IORD pulse width                  | 55  |     | ns   |
| tsuA(IORD)      | Address setup time for IORD       | 15  |     | ns   |
| thA(IORD)       | Address hold time from IORD       | 10  |     | ns   |
| tsuCE(IORD)     | Card Enable setup time for IORD   | 5   |     | ns   |
| thCE(IORD)      | Card Enable hold time from IORD   | 10  |     | ns   |
| tsuREG(IORD)    | REG setup time for IORD           | 5   |     | ns   |
| thREG(IORD)     | REG hold time from IORD           | 0   |     | ns   |
| tdfINPACK(IORD) | INPACK delay falling from IORD    | 0   | 45  | ns   |
| tdrINPACK(IORD) | INPACK delay rising from IORD     |     | 45  | ns   |
| tdfIOIS16(ADR)  | IOIS16 delay falling from address |     | 35  | ns   |
| tdrIOIS16(ADR)  | IOIS16 delay rising from address  |     | 35  | ns   |
| tsu(IOWR)       | Data setup time for IOWR          | 15  |     | ns   |
| th(IOWR)        | Data hold time from IOWR          | 5   |     | ns   |
| tw(IOWR)        | IOWR pulse width                  | 55  |     | ns   |
| tsuA(IOWR)      | Address setup time for IOWR       | 15  |     | ns   |
| thA(IOWR)       | Address hold time from IOWR       | 10  |     | ns   |
| tsuCE(IOWR)     | Card Enable setup time for IOWR   | 5   |     | ns   |
| thCE(IOWR)      | Card Enable hold time from IOWR   | 10  |     | ns   |
| tsuREG(IOWR)    | REG setup time for IOWR           | 5   |     | ns   |
| thREG(IOWR)     | REG hold time from IOWR           | 0   |     | ns   |

- **True-IDE PIO Mode Read and Write Characteristics**

See figure 31 in the CF Specification Revision 4.1. The IORDY functionality is not used.

| Symbol | Parameter                        | Min | Max | Unit |
|--------|----------------------------------|-----|-----|------|
| t0     | Cycle time                       | 80  |     | ns   |
| t1     | Address setup time for IORD/IOWR | 10  |     | ns   |
| t9     | Address hold time from IORD/IOWR | 10  |     | ns   |
| t2     | IORD/IOWR pulse width            | 55  |     | ns   |
| t2i    | IORD/IOWR recovery time          | 20  |     | ns   |
| t5     | Data setup time for IORD         | 10  |     | ns   |
| t6     | Data hold following IORD         | 5   |     | ns   |
| t6z    | Output disable time from IORD    |     | 20  | ns   |
| t3     | Data setup time for IOWR         | 15  |     | ns   |
| t4     | Data hold following IOWR         | 5   |     | ns   |

- **True-IDE MDMA Mode Read and Write Characteristics**

See figure 32 in the CF Specification Revision 4.1.

| Symbol   | Parameter                         | Min | Max | Unit |
|----------|-----------------------------------|-----|-----|------|
| tO       | Cycle time                        | 80  |     | ns   |
| tD       | IORD/IOWR pulse width             | 55  |     | ns   |
| tE       | IORD data access                  |     | 45  | ns   |
| tF       | Data hold following IORD          | 5   |     | ns   |
| tG       | Data setup time for IORD/IOWR     | 10  |     | ns   |
| tH       | Data hold following IOWR          | 5   |     | ns   |
| tI       | DMACK setup time for IORD/IOWR    | 0   |     | ns   |
| tJ       | DMACK hold following IORD/IOWR    | 5   |     | ns   |
| tKR, tKW | IORD/IOWR recovery time           | 20  |     | ns   |
| tLR, tLW | IORD/IOWR to DMARQ delay          |     | 35  | ns   |
| tM       | CS0, CS1 setup for IORD/IOWR      | 5   |     | ns   |
| tN       | CS0, CS1 hold following IORD/IOWR | 10  |     | ns   |
| tZ       | Output disable time from DMACK    |     | 25  | ns   |

- **True-IDE UDMA Mode Read and Write Characteristics**

The interface timing in the True-IDE UDMA modes is not only depending on the interface hardware, but also on the correct setup of the UDMA registers in the firmware, according to the UDMA transfer mode selected by the host. With a correct register setup, the interface timing complies to the UDMA Mode 0 to Mode 7 timing specifications of the CF Specification Revision 6.1, and to the UDMA Mode 0 to Mode 6 timing specifications of the ATA/ATAPI-7 Standard.

- **Toggle Mode Flash Memory Interface Characteristics**

The AC Characteristics for the flash memory interface are based on the F9 flash interface clock cycle time.  $\tau$  is  $\frac{1}{2}$  of the flash interface clock cycle time configured in the preformat. In Toggle mode, the valid range for  $\tau$  is 5ns to 10ns. The table lists the flash memory interface timing based on  $\tau$ , valid for a load of not more than 45pF on the flash interfacepins.

| Symbol            | Parameter                         | Min         | Typ | Max         | Unit |
|-------------------|-----------------------------------|-------------|-----|-------------|------|
| t <sub>CALS</sub> | CLE, ALE setup time               | 6 τ - 2     |     |             | ns   |
| t <sub>CALH</sub> | CLE, ALE hold time                | 1.5 τ - 2   |     |             | ns   |
| t <sub>CS</sub>   | CE# setup time                    | 6 τ - 2     |     |             | ns   |
| t <sub>CH</sub>   | CE# hold time                     | 1.5 τ - 2   |     |             | ns   |
| t <sub>CAS</sub>  | Data (command/address) setup time | 2.5 τ - 2   |     |             | ns   |
| t <sub>CAH</sub>  | Data (command/address) hold time  | 1.5 τ - 2   |     |             | ns   |
| t <sub>WC</sub>   | Write cycle time                  | 7.5 τ       |     |             | ns   |
| t <sub>WP</sub>   | WE# low pulse width               | 4 τ - 2     |     |             | ns   |
| t <sub>WH</sub>   | WE# high pulse width              | 4 τ - 2     |     |             | ns   |
| t <sub>DSC</sub>  | DQS cycle time                    |             | 2 τ |             | ns   |
| t <sub>DQSH</sub> | DQS high time                     | 0.94 τ      |     |             | ns   |
| t <sub>DQSL</sub> | DQS low time                      | 0.94 τ      |     |             | ns   |
| t <sub>DS</sub>   | Data output setup time to DQS     | 0.5 τ - 1.5 |     |             | ns   |
| t <sub>DH</sub>   | Data output hold time from DQS    | 0.5 τ - 1.5 |     |             | ns   |
| t <sub>RC</sub>   | Read cycle time                   |             | 2 τ |             | ns   |
| t <sub>RP</sub>   | RE# low pulse width               | 0.94 τ      |     |             | ns   |
| t <sub>REH</sub>  | RE# high pulse width              | 0.94 τ      |     |             | ns   |
| t <sub>DQSQ</sub> | DQS to input data skew            |             |     | 0.5 τ - 1.6 | ns   |
| t <sub>QH</sub>   | Input data hold from DQS          | 0.5 τ + 0.8 |     |             | ns   |

● **ONFI-2 Mode Flash Memory Interface Characteristics**

The AC Characteristics for the flash memory interface are based on the F9 flash interface clock cycle time. τ is ½ of the flash interface clock cycle time configured in the preformat. In ONFI-2 mode, the valid range for τ is 5ns to 10ns. The table lists the flash memory binterface timing based on τ, valid for a load of not more than 45pF on the flash interface pins.

| Symbol            | Parameter                         | Min         | Typ | Max         | Unit |
|-------------------|-----------------------------------|-------------|-----|-------------|------|
| t <sub>CK</sub>   | Average clock cycle time          |             | 2 τ |             | ns   |
| t <sub>CKH</sub>  | Clock high time                   | 0.94 τ      |     | 1.06 τ      | ns   |
| t <sub>CKL</sub>  | Clock low time                    | 0.94 τ      |     | 1.06 τ      | ns   |
| t <sub>CALS</sub> | ALE, CLE, W/R# setup time to CLK  | τ - 3       |     |             | ns   |
| t <sub>CALH</sub> | ALE, CLE, W/R# hold time from CLK | τ - 3       |     |             | ns   |
| t <sub>CS</sub>   | CE# setup time to CLK             | 5 τ - 3     |     |             | ns   |
| t <sub>CH</sub>   | CE# hold time from CLK            | τ - 3       |     |             | ns   |
| t <sub>CAS</sub>  | Data output setup time to CLK     | τ - 3       |     |             | ns   |
| t <sub>CAH</sub>  | Data output hold time from CLK    | τ - 3       |     |             | ns   |
| t <sub>DQSS</sub> | DQS phase                         | 2 τ - 2     |     | 2 τ + 2     | ns   |
| t <sub>DQSH</sub> | DQS high time                     | 0.94 τ      |     | 1.06 τ      | ns   |
| t <sub>DQSL</sub> | DQS low time                      | 0.94 τ      |     | 1.06 τ      | ns   |
| t <sub>DS</sub>   | Data output setup time to DQS     | 0.5 τ - 1.5 |     |             | ns   |
| t <sub>DH</sub>   | Data output hold time from DQS    | 0.5 τ - 1.5 |     |             | ns   |
| t <sub>DQSQ</sub> | DQS to input data skew            |             |     | 0.5 τ - 1.6 | ns   |
| t <sub>QH</sub>   | Input data hold from DQS          | 0.5 τ + 0.8 |     |             | ns   |

## 7. Physical Characteristics

### 7.1 Dimensions

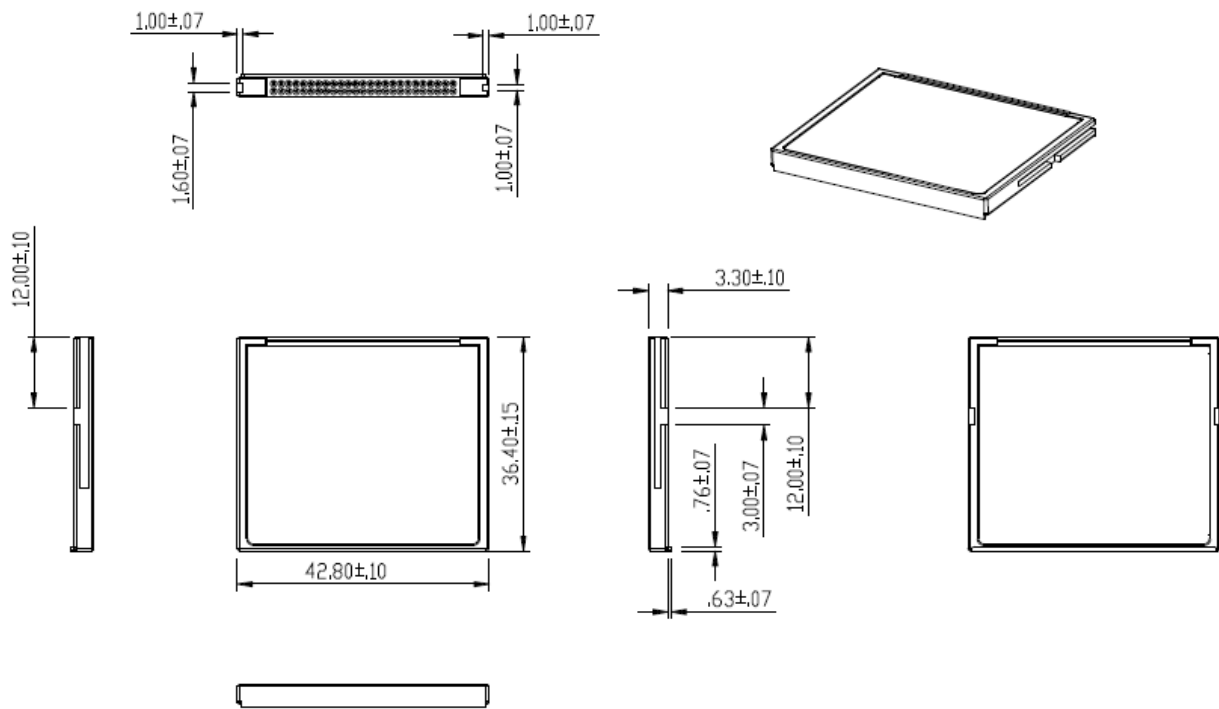


Figure 7-1 Physical Dimensions

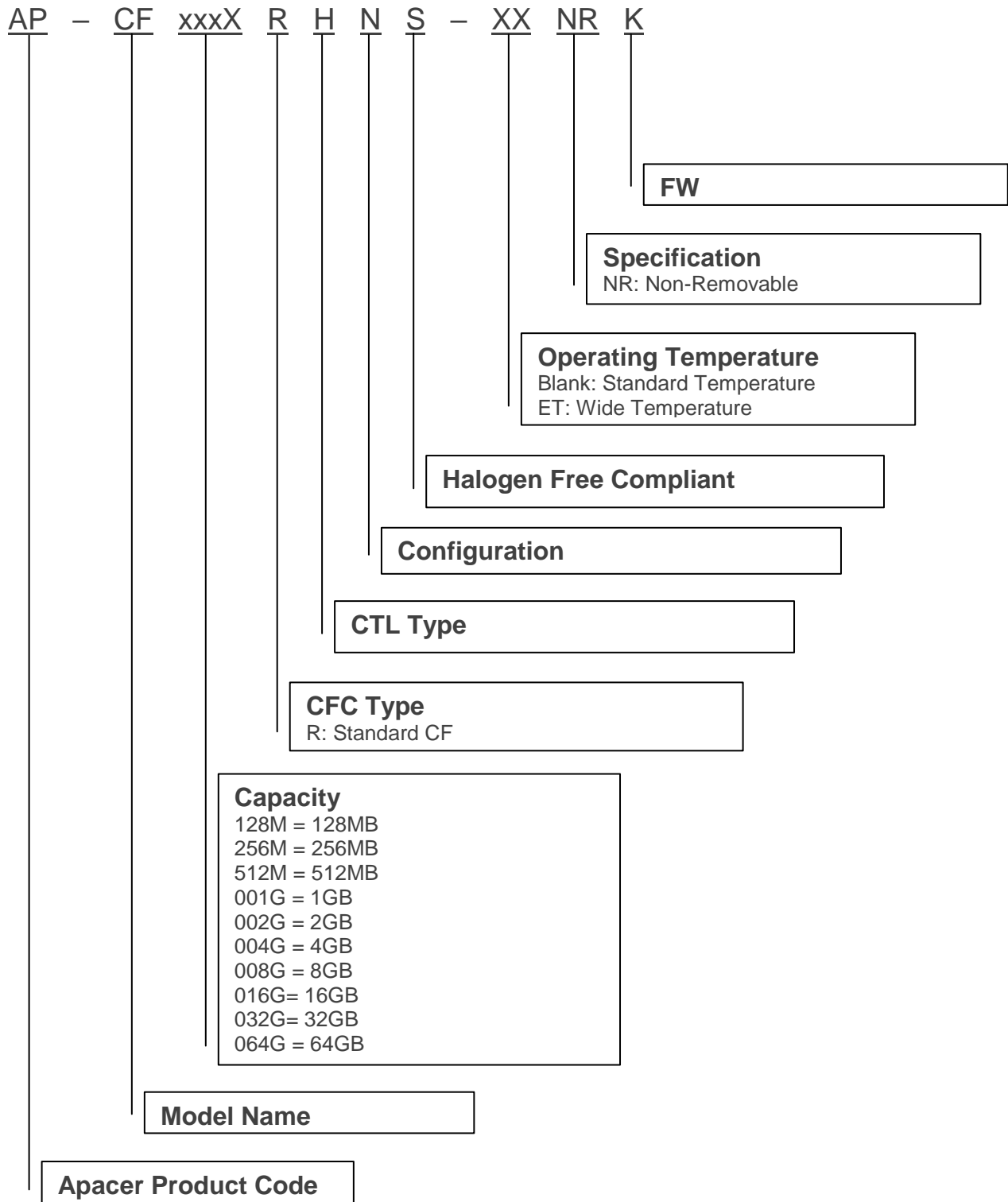
Unit: mm

### 7.2 Net Weight

| Capacity | Net Weight (g) |
|----------|----------------|
| 128 MB   | 8.32           |
| 256 MB   | 8.32           |
| 512 MB   | 8.32           |
| 1 GB     | 8.32           |
| 2 GB     | 9.61           |
| 4 GB     | 8.32           |
| 8 GB     | 8.32           |
| 16 GB    | 8.32           |
| 32 GB    | 9.79           |
| 64 GB    | 8.32           |

## 8. Product Ordering Information

### 8.1 Product Code Designations



## 8.2 Valid Combinations

| Capacity | Standard Temperature | Wide Temperature    |
|----------|----------------------|---------------------|
| 128MB    | AP-CF128MRHNS-NRK    | AP-CF128MRHNS-ETNRK |
| 256MB    | AP-CF256MRHNS-NRK    | AP-CF256MRHNS-ETNRK |
| 512MB    | AP-CF512MRHNS-NRK    | AP-CF512MRHNS-ETNRK |
| 1GB      | AP-CF001GRHNS-NRK    | AP-CF001GRHNS-ETNRK |
| 2GB      | AP-CF002GRHNS-NRK    | AP-CF002GRHNS-ETNRK |
| 4GB      | AP-CF004GRHNS-NRK    | AP-CF004GRHNS-ETNRK |
| 8GB      | AP-CF008GRHNS-NRK    | AP-CF008GRHNS-ETNRK |
| 16GB     | AP-CF016GRHNS-NRK    | AP-CF016GRHNS-ETNRK |
| 32GB     | AP-CF032GRHNS-NRK    | AP-CF032GRHNS-ETNRK |
| 64GB     | AP-CF064GRHNS-NRK    | AP-CF064GRHNS-ETNRK |

**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 | Description   | Date      |
|----------|---|-----------|
| 0.1      | Preliminary release   | 8/10/2018 |
| 0.2      | <ul style="list-style-type: none"> <li>- Added Net Weight to Form Factor on Specifications Overview page</li> <li>- Updated the functional block diagram at 2. Functional Block</li> <li>- Added 7.2 Net Weight</li> <li>- Updated Supply Voltage on Specifications Overview page</li> </ul>  | 8/15/2018 |
| 1.0      | Official release  | 9/3/2018  |
| 1.1      | <ul style="list-style-type: none"> <li>- Updated product photo on the cover page</li> <li>- Added extended temperature support</li> </ul>   | 10/9/2018 |
| 1.2      | <ul style="list-style-type: none"> <li>- Renamed extended temperature to wide temperature</li> <li>- Revised SMART attribute ID list at 1.1.3 S.M.A.R.T. Technology</li> <li>- Renamed Power Failure Management to DataDefender at Flash Management on Specifications Overview page and 1.1.5 section and updated the technology description</li> </ul> | 2/20/2019 |
| 1.3      | Added ID 241 and 242 to SMART attribute ID list at 1.1.3 S.M.A.R.T. Technology  | 3/19/2019 |
| 1.4      | <ul style="list-style-type: none"> <li>- Replaced DataDefender with Power Failure Management at Flash Management on Specifications Overview</li> <li>- Updated technology description for 1.1.5 Power Failure Management</li> </ul>   | 4/19/2019 |



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

Наши преимущества:

- Оперативные поставки широкого спектра электронных компонентов отечественного и импортного производства напрямую от производителей и с крупнейших мировых складов;
- Поставка более 17-ти миллионов наименований электронных компонентов;
- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- Лицензия ФСБ на осуществление работ с использованием сведений, составляющих государственную тайну;
- Поставка специализированных компонентов (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Aeroflex, Peregrine, Syfer, Eurofarad, Texas Instrument, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Помимо этого, одним из направлений компании «ЭлектроПласт» является направление «Источники питания». Мы предлагаем Вам помощь Конструкторского отдела:

- Подбор оптимального решения, техническое обоснование при выборе компонента;
- Подбор аналогов;
- Консультации по применению компонента;
- Поставка образцов и прототипов;
- Техническая поддержка проекта;
- Защита от снятия компонента с производства.



#### Как с нами связаться

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