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## Appendix B - ATmega88 Automotive Specification at 1.8V

This document contains information specific to devices operating at voltage between 1.8V and 3.6V. Only deviations with standard operating characteristics are covered in this appendix, all other information can be found in the complete Automotive datasheet. The complete ATmega88 automotive datasheet can be found on [www.atmel.com](http://www.atmel.com)



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**8-bit AVR<sup>®</sup>  
Microcontroller  
with 8K Bytes  
In-System  
Programmable  
Flash**

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**ATmega88**

**Appendix B**

**Preliminary**

7738A-AVR-07/07



## Electrical Characteristics

### Absolute Maximum Ratings\*

|  |                        |
|--|------------------------|
| Operating Temperature.....   | -55°C to +150°C        |
| Storage Temperature .....  | -65°C to +175°C        |
| Voltage on any Pin except $\overline{\text{RESET}}$ with respect to Ground ..... | -0.5V to $V_{CC}+0.5V$ |
| Voltage on $\overline{\text{RESET}}$ with respect to Ground.....                 | -0.5V to +13.0V        |
| Maximum Operating Voltage .....  | 6.0V                   |
| DC Current per I/O Pin .....   | 30.0 mA                |
| DC Current $V_{CC}$ and GND Pins.....  | 200.0 mA               |

\*NOTICE: Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

### DC Characteristics

$T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ ,  $V_{CC} = 1.8\text{V}$  to  $3.6\text{V}$  (unless otherwise noted)

| Symbol    | Parameter   | Condition  | Min.               | Typ. | Max.              | Units            |
|-----------|---|--|--------------------|------|-------------------|------------------|
| $V_{IL}$  | Input Low Voltage, except XTAL1 and $\overline{\text{RESET}}$ pin             | $V_{CC} = 1.8\text{V} - 3.6\text{V}$               | -0.5               |      | $0.1V_{CC}^{(1)}$ | V                |
| $V_{IH}$  | Input High Voltage, except XTAL1 and $\overline{\text{RESET}}$ pins           | $V_{CC} = 1.8\text{V} - 3.6\text{V}$               | $0.75V_{CC}^{(2)}$ |      | $V_{CC} + 0.5$    | V                |
| $V_{IL1}$ | Input Low Voltage, XTAL1 pin  | $V_{CC} = 1.8\text{V} - 3.6\text{V}$               | -0.5               |      | $0.1V_{CC}^{(1)}$ | V                |
| $V_{IH1}$ | Input High Voltage, XTAL1 pin   | $V_{CC} = 1.8\text{V} - 3.6\text{V}$               | $0.9V_{CC}^{(2)}$  |      | $V_{CC} + 0.5$    | V                |
| $V_{IL2}$ | Input Low Voltage, $\overline{\text{RESET}}$ pin                              | $V_{CC} = 1.8\text{V} - 3.6\text{V}$               | -0.5               |      | $0.1V_{CC}^{(1)}$ | V                |
| $V_{IH2}$ | Input High Voltage, $\overline{\text{RESET}}$ pin                             | $V_{CC} = 1.8\text{V} - 3.6\text{V}$               | $0.9V_{CC}^{(2)}$  |      | $V_{CC} + 0.5$    | V                |
| $V_{IL3}$ | Input Low Voltage, $\overline{\text{RESET}}$ pin as I/O                       | $V_{CC} = 1.8\text{V} - 3.6\text{V}$               | -0.5               |      | $0.1V_{CC}^{(1)}$ | V                |
| $V_{IH3}$ | Input High Voltage, $\overline{\text{RESET}}$ pin as I/O                      | $V_{CC} = 1.8\text{V} - 3.6\text{V}$               | $0.6V_{CC}^{(2)}$  |      | $+0.7V_{CC}$      | V                |
| $V_{OL}$  | Output Low Voltage <sup>(3)</sup> , I/O pin except $\overline{\text{RESET}}$  | $I_{OL} = 0.5\text{mA}$ , $V_{CC} = 1.8\text{V}$   |                    |      | 0.25              | V                |
| $V_{OH}$  | Output High Voltage <sup>(4)</sup> , I/O pin except $\overline{\text{RESET}}$ | $I_{OH} = -0.5\text{mA}$ , $V_{CC} = 1.8\text{V}$  | 1.25               |      |                   | V                |
| $I_{IL}$  | Input Leakage Current I/O Pin   | $V_{CC} = 3.6\text{V}$ , pin low (absolute value)  |                    |      | 1                 | $\mu\text{A}$    |
| $I_{IH}$  | Input Leakage Current I/O Pin   | $V_{CC} = 3.6\text{V}$ , pin high (absolute value) |                    |      | 1                 | $\mu\text{A}$    |
| $R_{RST}$ | Reset Pull-up Resistor  |  | 30                 |      | 60                | $\text{k}\Omega$ |
| $R_{PU}$  | I/O Pin Pull-up Resistor  |  | 20                 |      | 50                | $\text{k}\Omega$ |

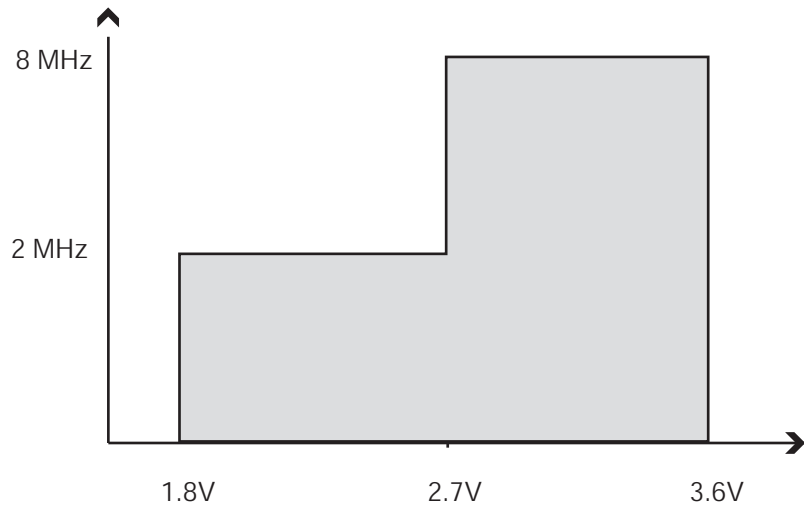
$T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ ,  $V_{CC} = 1.8\text{V}$  to  $3.6\text{V}$  (unless otherwise noted) (Continued)

| Symbol     | Parameter                               | Condition   | Min. | Typ.     | Max.     | Units         |
|------------|---|---|------|----------|----------|---------------|
| $I_{CC}$   | Power Supply Current <sup>(5)</sup>     | Active 2MHz, $V_{CC} = 1.8\text{V}$   |      | 0.8      | 1.2      | mA            |
|            |   | Idle 2MHz, $V_{CC} = 1.8\text{V}$   |      | 0.2      | 0.4      | mA            |
|            | Power-down mode                         | WDT disabled, $V_{CC} = 1.8\text{V}$<br>WDT enabled, $V_{CC} = 1.8\text{V}$ |      | 0.2<br>4 | 18<br>24 | $\mu\text{A}$ |
| $V_{ACIO}$ | Analog Comparator Input Offset Voltage  | $V_{CC} = 2.7\text{V}$<br>$V_{in} = V_{CC}/2$                               |      | <10      | 40       | mV            |
| $I_{ACLK}$ | Analog Comparator Input Leakage Current | $V_{CC} = 2.7\text{V}$<br>$V_{in} = V_{CC}/2$                               | -50  |          | 50       | nA            |
| $t_{ACPD}$ | Analog Comparator Propagation Delay     | $V_{CC} = 2.7\text{V}$  |      | 500      |          | ns            |

## Maximum Speed vs. $V_{CC}$

Maximum frequency is dependent on  $V_{CC}$ . As shown in Figure 1, the Maximum Frequency vs.  $V_{CC}$  curve is linear between  $1.8\text{V} < V_{CC} < 3.6\text{V}$ .

**Figure 1.** Maximum Frequency vs.  $V_{CC}$



## ADC Characteristics<sup>(6)</sup> Preliminary

$T_A = -40^{\circ}\text{C}$  to  $85^{\circ}\text{C}$ ,  $V_{CC} = 1.8\text{V}$  to  $3.6\text{V}$  (unless otherwise noted)

| Symbol    | Parameter  | Condition   | Min            | Typ  | Max                     | Units            |
|-----------|--|---|----------------|------|-------------------------|------------------|
|           | Resolution   |   |                | 8    |                         | Bits             |
|           | Absolute accuracy<br>(Including INL, DNL,<br>quantization error, gain<br>and offset error) | $V_{REF} = 2.7\text{V}$ , $V_{CC} = 2.7\text{V}$ ,<br>ADC clock = 200 kHz                         |                | 2    | 3.5                     | LSB              |
|           |  | $V_{REF} = 2.7\text{V}$ , $V_{CC} = 2.7\text{V}$ ,<br>ADC clock = 200 kHz<br>Noise Reduction Mode |                | 2    | 3.5                     | LSB              |
|           | Integral Non-Linearity<br>(INL)  | $V_{REF} = 2.7\text{V}$ , $V_{CC} = 2.7\text{V}$ ,<br>ADC clock = 200 kHz                         |                | 0.6  | 2.5                     | LSB              |
|           | Differential Non-Linearity<br>(DNL)  | $V_{REF} = 2.7\text{V}$ , $V_{CC} = 2.7\text{V}$ ,<br>ADC clock = 200 kHz                         |                | 0.30 | 1.0                     | LSB              |
|           | Gain Error   | $V_{REF} = 2.7\text{V}$ , $V_{CC} = 2.7\text{V}$ ,<br>ADC clock = 200 kHz                         | -3.5           | -1.3 | 3.5                     | LSB              |
|           | Offset Error   | $V_{REF} = 2.7\text{V}$ , $V_{CC} = 2.7\text{V}$ ,<br>ADC clock = 200 kHz                         |                | 1.8  | 3.5                     | LSB              |
|           | Conversion Time  | Free Running<br>Conversion  | 13 cycles      |      |                         | $\mu\text{s}$    |
|           | Clock Frequency  |   | 50             |      | 200                     | kHz              |
| $AV_{CC}$ | Analog Supply Voltage  |   | $V_{CC} - 0.3$ |      | $V_{CC} + 0.3$          | V                |
| $V_{REF}$ | Reference Voltage  |   | 1.0            |      | $AV_{CC}$               | V                |
| $V_{IN}$  | Input Voltage  |   | GND            |      | $V_{REF} - 50\text{mV}$ | V                |
|           | Input Bandwidth  |   |                | 38.5 |                         | kHz              |
| $V_{INT}$ | Internal Voltage<br>Reference  |   | 1.0            | 1.1  | 1.2                     | V                |
| $R_{REF}$ | Reference Input<br>Resistance  |   | 22.4           | 32   | 41.6                    | $\text{k}\Omega$ |
| $R_{AIN}$ | Analog Input Resistance  |   |                | 100  |                         | $\text{M}\Omega$ |

- Notes:
1. "Max" means the highest value where the pin is guaranteed to be read as low
  2. "Min" means the lowest value where the pin is guaranteed to be read as high
  3. Although each I/O port can sink more than the test conditions ( $0.5\text{mA}$  at  $V_{CC} = 1.8\text{V}$ ) under steady state conditions (non-transient), the following must be observed:
    - 1] The sum of all IOL, for ports B0 - B5, should not exceed 50 mA.  
If IOL exceeds the test condition, VOL may exceed the related specification. Pins are not guaranteed to sink current greater than the listed test condition.
  4. Although each I/O port can source more than the test conditions ( $0.5\text{mA}$  at  $V_{CC} = 1.8\text{V}$ ) under steady state conditions (non-transient), the following must be observed:
    - 1] The sum of all IOH, for ports B0 - B5 should not exceed 50 mA.  
If IOH exceeds the test condition, VOH may exceed the related specification. Pins are not guaranteed to source current greater than the listed test condition.
  5. Minimum  $V_{CC}$  for Power-down is 2.5V.
  6. Based on standard voltage range (2.7V - 5.5V) characterization results. To be confirmed after actual silicon characterization.

## Ordering Information

| Power Supply | Speed (MHz) | ISP Flash | Ordering Code  | Package | Operation Range             |
|--------------|-------------|-----------|----------------|---------|-----------------------------|
| 1.8 - 3.6V   | 2-8         | 8KB       | ATmega88V-15AT | MA      | Automotive (-40°C to +85°C) |
| 1.8 - 3.6V   | 2-8         | 8KB       | ATmega88V-15MT | PN      | Automotive (-40°C to +85°C) |

:

| Package Type |   |
|--------------|---|
| <b>MA</b>    | 32-lead, Thin (1.0 mm) Plastic Quad Flat Package (TQFP)                                   |
| <b>PN</b>    | 32-pad, 5 x 5 x 1.0 body, Lead Pitch 0.50 mm Quad Flat No Lead (QFN): E2/D2 3.1 +/- 0.1mm |



## Atmel Corporation

2325 Orchard Parkway  
San Jose, CA 95131, USA  
Tel: 1(408) 441-0311  
Fax: 1(408) 487-2600

## Regional Headquarters

### Europe

Atmel Sarl  
Route des Arsenalux 41  
Case Postale 80  
CH-1705 Fribourg  
Switzerland  
Tel: (41) 26-426-5555  
Fax: (41) 26-426-5500

### Asia

Room 1219  
Chinachem Golden Plaza  
77 Mody Road Tsimshatsui  
East Kowloon  
Hong Kong  
Tel: (852) 2721-9778  
Fax: (852) 2722-1369

### Japan

9F, Tonetsu Shinkawa Bldg.  
1-24-8 Shinkawa  
Chuo-ku, Tokyo 104-0033  
Japan  
Tel: (81) 3-3523-3551  
Fax: (81) 3-3523-7581

## Atmel Operations

### Memory

2325 Orchard Parkway  
San Jose, CA 95131, USA  
Tel: 1(408) 441-0311  
Fax: 1(408) 436-4314

### Microcontrollers

2325 Orchard Parkway  
San Jose, CA 95131, USA  
Tel: 1(408) 441-0311  
Fax: 1(408) 436-4314

La Chantrerie  
BP 70602  
44306 Nantes Cedex 3, France  
Tel: (33) 2-40-18-18-18  
Fax: (33) 2-40-18-19-60

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Fax: (33) 4-42-53-60-01

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Colorado Springs, CO 80906, USA  
Tel: 1(719) 576-3300  
Fax: 1(719) 540-1759

Scottish Enterprise Technology Park  
Maxwell Building  
East Kilbride G75 0QR, Scotland  
Tel: (44) 1355-803-000  
Fax: (44) 1355-242-743

### RF/Automotive

Theresienstrasse 2  
Postfach 3535  
74025 Heilbronn, Germany  
Tel: (49) 71-31-67-0  
Fax: (49) 71-31-67-2340

1150 East Cheyenne Mtn. Blvd.  
Colorado Springs, CO 80906, USA  
Tel: 1(719) 576-3300  
Fax: 1(719) 540-1759

### Biometrics/Imaging/Hi-Rel MPU/ High Speed Converters/RF Datacom

Avenue de Rochepleine  
BP 123  
38521 Saint-Egreve Cedex, France  
Tel: (33) 4-76-58-30-00  
Fax: (33) 4-76-58-34-80

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