

AVR[®]

EMC Characteristics

**An overview on Radiated
Emissions and Conducted
Immunity for the AVR
Microcontroller**



- **” The extent to which a piece of hardware will tolerate electrical interference from other equipment, and will interfere with other equipment” (<http://www.hyperdictionary.com>)**
- **All end-products must comply with the EMC directives, which covers:**
 - An upper limit for conducted and radiated emissions
 - A lower limit for conducted and radiated immunity
 - Limits are specified in international standards from IEC, CISPR and others.

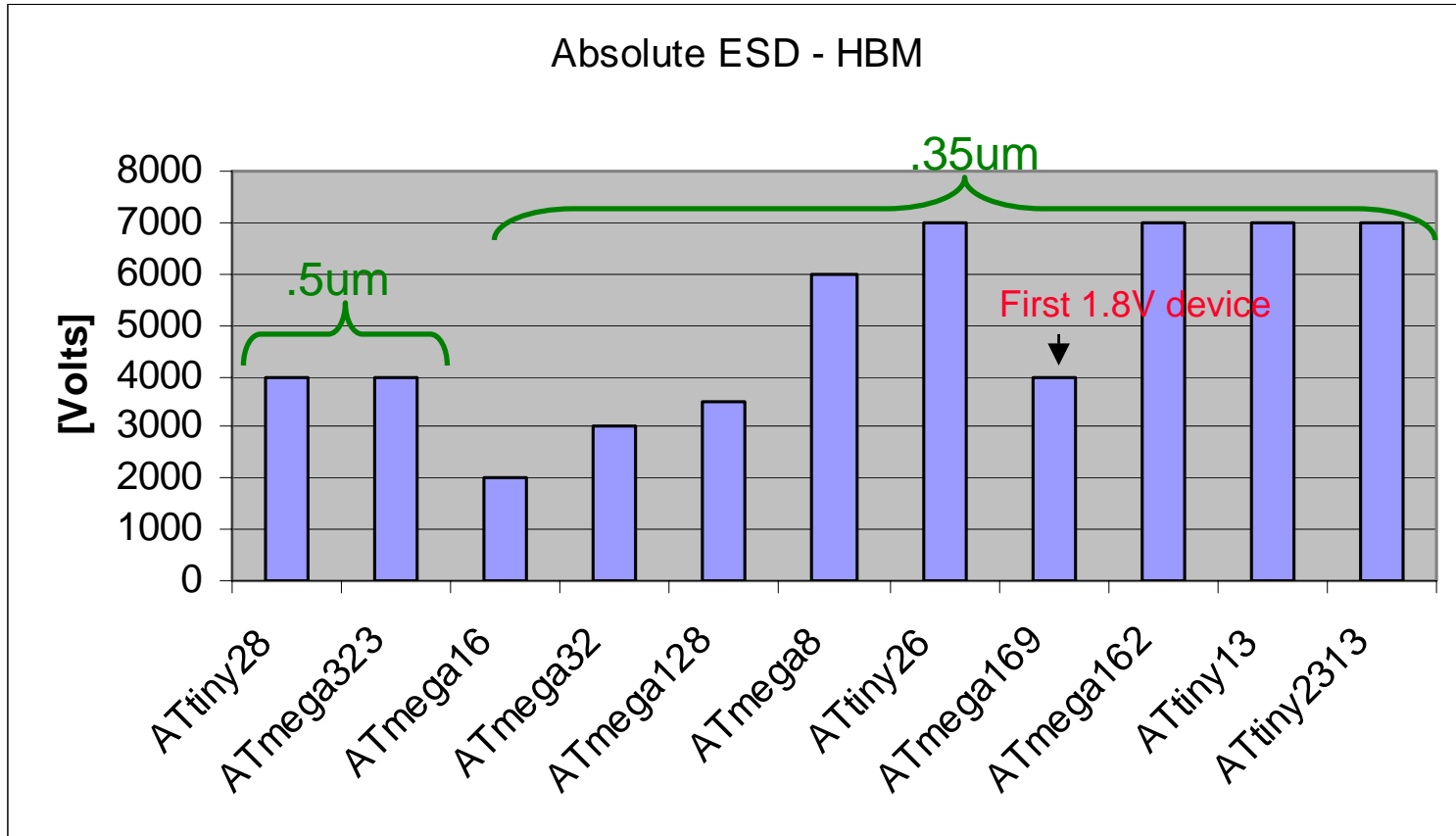
- **Radiated emissions – RF/ HF noise**
 - EMC Directives specify upper limit to E and H-fields surrounding a product.
 - The Directive covers the frequency band to 1GHz
 - In Automotive and Wireless Communication the frequency band are often extended up to 3GHz (or higher)
- **Conducted emissions – noise on supply lines**
 - EMC Directives specify limits to noise introduced on the power lines to which electrical equipment is connected
 - The Directive covers the frequency band up to 30MHz

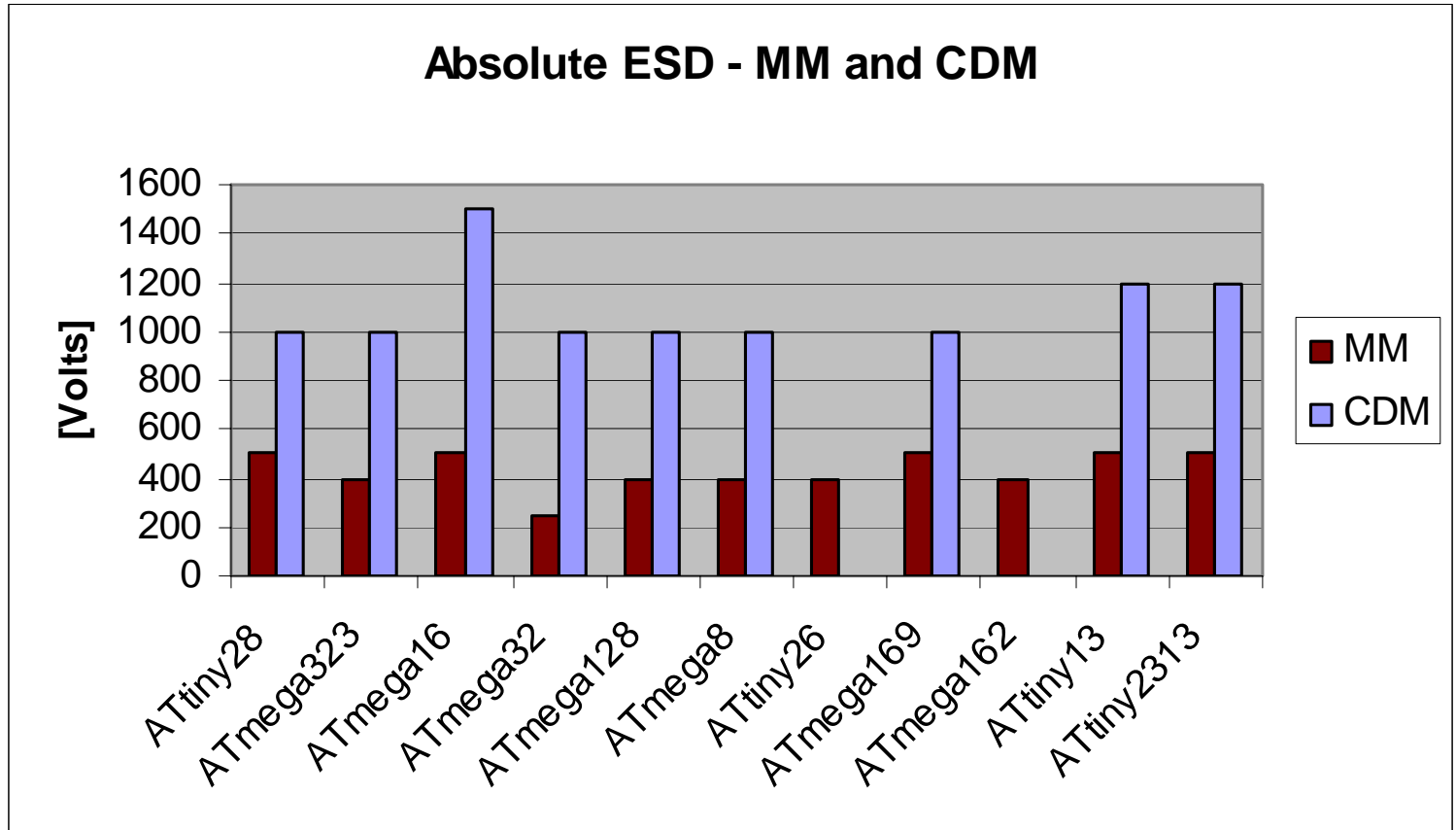
- **Conducted immunity – ESD and EFT**
 - Immunity to conducted electrical disturbances, such as Electrostatic Discharge (ESD) and Electrical Fast Transients (EFT)
 - Operates with failure severities
 - temporary, unrecoverable and destructive failures

- **Radiated immunity – incoming RF and HF noise**
 - Immunity to radiated noise in surrounding environment. Originating from e.g. electrical motors and wireless communication.
 - Limited the noise frequencies up to 1GHz.

- **Immunity to conducted disturbance**
 - Destructive ESD level
 - Human Body Model (HBM), MIL-STD-883E
 - Charged Device Model (CDM) JEDEC JESD22-C101
 - Machine Model (MM), JEDEC JESD22-A115-A
 - Latch-up level
 - JEDEC std 17
 - Susceptibility to ESD on IO
 - IEC 61000-4-2
 - Susceptibility to EFT on supply and IO
 - IEC 61000-4-4

- **Radiated and conducted emissions**
 - Radiation emissions from the device (die and package)
 - IEC61967-2
 - Conducted emissions from device supply and IO (Not done...)
 - IEC61967-4





- **ST Micro**

- ST6 and ST7
 - HBM – 2000V
 - MM – 200V
- ST7Lite2
 - HBM – 4000V
 - MM – TBD

- **Motorola**

- MC9S08xx32
 - HBM – 2000V
 - MM – 200V

- **Atmel AVR**

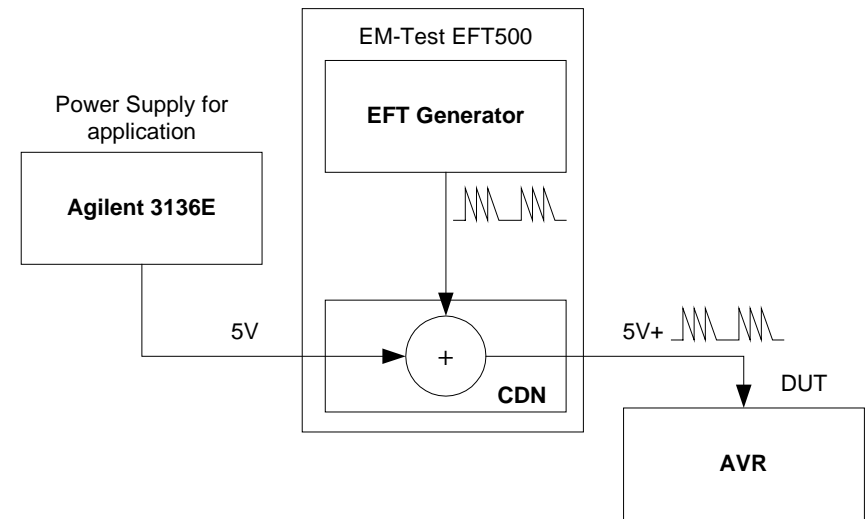
- ATmega128
 - HBM – 3500V
 - MM – 400V
 - CDM – 1000V
- ATmega8
 - HBM – 6000V
 - MM – 400V
 - CDM – 1000V
- ATmega169
 - HBM – 4000V
 - MM – 500V
 - CDM – 1000V
- ATtiny13/ ATtiny2313
 - HBM – 7000V
 - MM – 500V
 - CDM – 1200V

- **AVR has superior absolute ESD ratings**
 - Good margins to competitor's absolute ESD performance!
 - Few competitors dare present these data
- **EMC Directives specify 4kV ESD (HBM) for domestic applications...**
 - AVR meets this without any external ESD protection



- **Device is exposed to Electrical Fast Transients (EFT) on supply or IO lines until it fails functionally.**

- **Test detects failures that is caused by:**
 - Corruption of SRAM
 - Corruption of Registers
 - Corruption of EEPROM
 - Corruption of program execution



- **EMS - Burst on Supply**

- ATmega16
 - Pass up to 2.4kV
- ATmega32 (rev. D)
 - Pass up to 2.4kV
- ATmega8535
 - Pass up to 1.9kV
- ATmega8
 - Pass up to 1.9kV

- **Standards define EFT levels according to environment:**

- 500V is protected environment
- 1kV is typical domestic applications
- 2kV is industrial environment
- 4kV is severe industrial environment

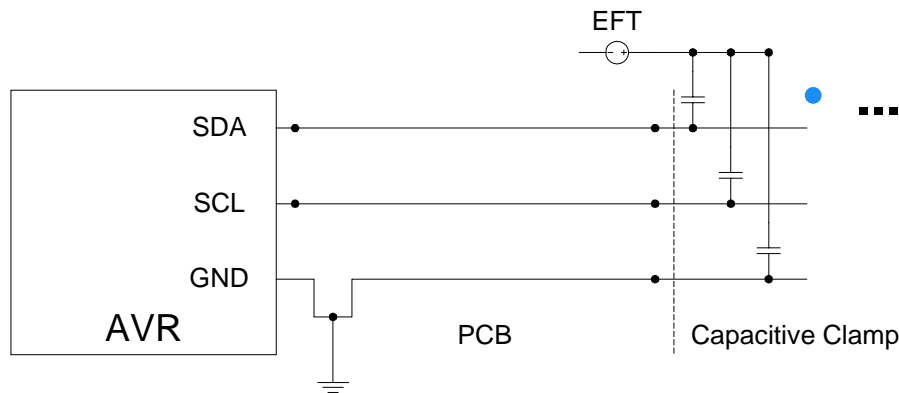
- **...for end-products that is!**

- **Burst on IO**

- ATmega32
 - Pass up to 1.2kV
- ATmega8
 - Pass up to 1.6kV

- **Standards define EFT levels according to environment:**

- 250V is protected environment
- 500V is typical domestic applications
- 1kV is industrial environment
- 2kV is severe industrial environment



- **...for end-products that is!**

- ST Micro

- ST620xC
 - -2.5kV/ + 3.0kV
- ST7LITE2
 - -/+1.5kV
- ST7226xG
 - -/+1kV
- ST92Fxxx
 - -/+1.5kV

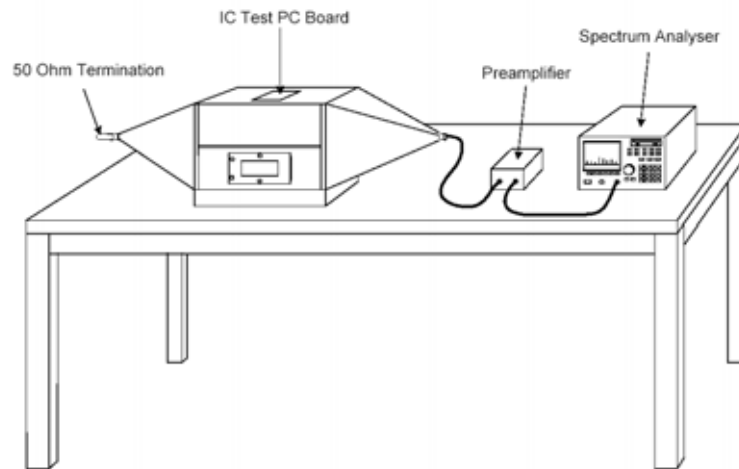
- **The only competitor that dare present EMC in their datasheets....**

- Atmel AVR

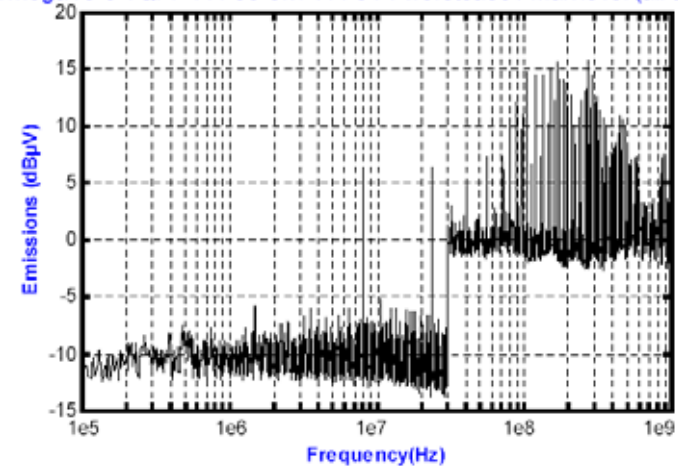
- ATmega8 and ATmega8535
 - Pass up to 1.9kV
- ATmega16 and ATmega32
 - Pass up to 2.4kV



- Measured in test cell (TEM) according to IEC61967-2



ATmega16-8 TQFP44 / 35-5k / v1 / 5V / worstcase / Max level (all directions)



- **ST Micro is among the few that provide emission data for microcontrollers**
 - Most manufacturers are not able to provide these data...
- **Atmel AVR (mega16@8MHz)**
 - 0.1MHz to 30MHz : <7dBuV
 - 30MHz to 130MHz: <15dBuV
 - 130MHz to 1GHz: <16dBuV
- **Emissions data for ST7265x**

Monitored Frequency Band	Max vs. [f_{osc}/f_{CPU}]		Unit
	3MHz	6MHz	
0.1MHz to 30MHz	21	28	dB μ V
30MHz to 130MHz	16	30	
130MHz to 1GHz	8	31	
SAE EMI Level	2	4	-



- Few can present EMC data
- Few have good EMC characteristics
- Compared to ST Micro, which are known to be good devices in EMC sense – AVR performs very well!!!



- **Good EMC performance does not guarantee that no EMC related problems are encountered!**
 - Immunity
 - Place it decoupling as close to the device as possible
 - Use decoupling with good EMI characteristics (low ESR)
 - Use line-filters on IO lines
 - Use “clean-IO-gnd” for IO filters
 - External Clock sources must be protected well
 - Emissions
 - Limit current and loop sizes
 - Use “clean-IO-gnd” for line decoupling
 - Run from as low operating voltage as possible