ΕΠΛ 605: Προχωρημένη Αρχιτεκτονική Υπολογιστών

Voltage - Frequency Tuning

Voltage – frequency - power relation

Operating voltage	Cortex-A57 frequency
0.8V Underdrive	600MHz
0.9V Nominal	900MHz
1.0V Overdrive	1.15GHz

Source [arm.com]
Cortex-A57 is an ARM CPU found in smartphones

- Higher CPU operating voltage allows higher operating frequency
- But of-course pushing voltage as high as possible for higher frequencies is not realistic because of thermal/power constrains

CPUpower = Voltage^2 * Frequency * Capacitance

Hardware heterogeneity

- Same chips are not actually the same

- Two chips of the same model (i7-5820K) one achieves 4.4GHz at 1.3V and the other 4.8GHz

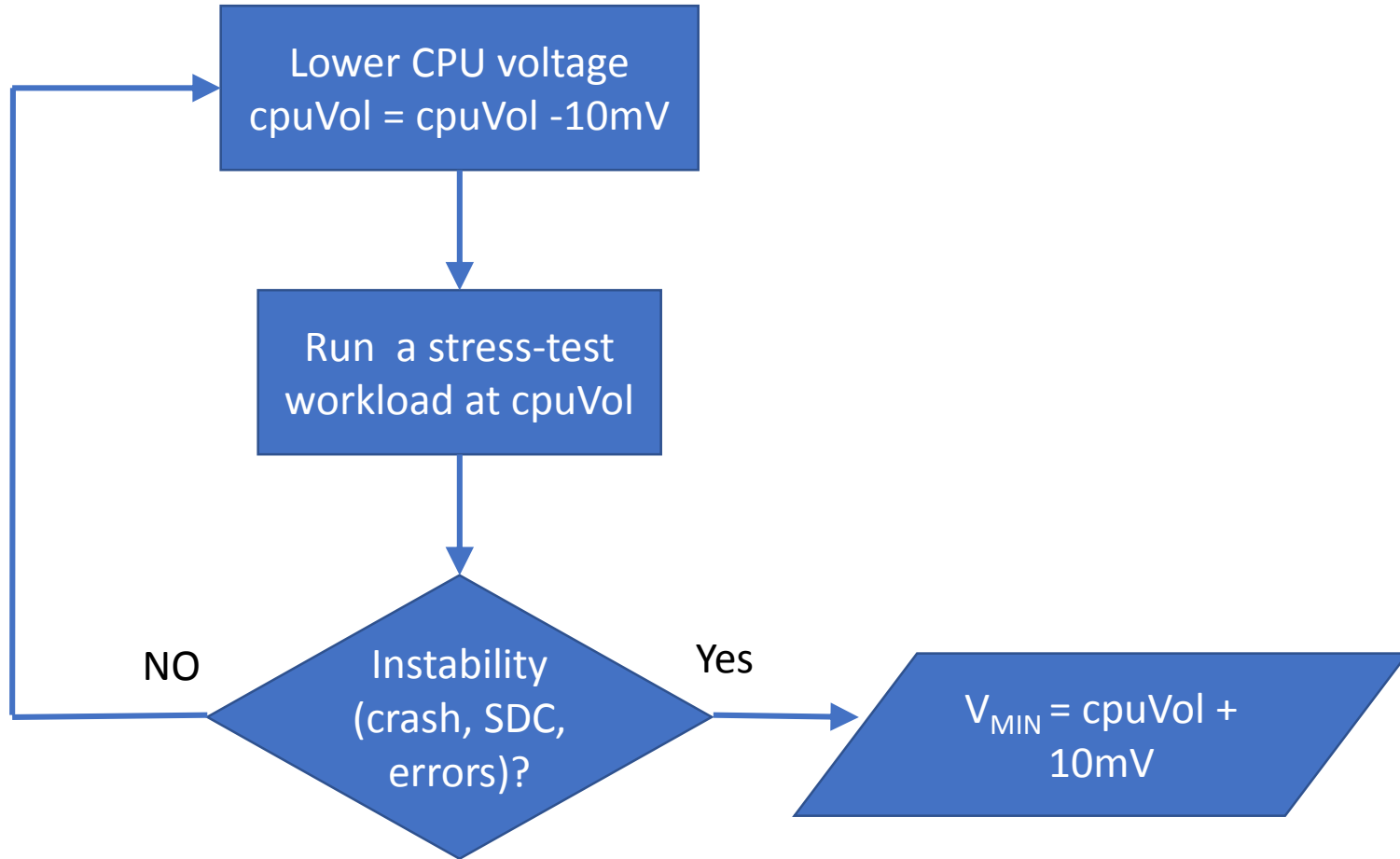# Heterogeneity among same products is a result of product binning

- Variations among chips of the same model exist due to the product binning
  - Intel/AMD cannot manufacture 1000 different products for each possible variation. Maybe they can sell 5-10 different CPU products, hence, some chips within the same product bin are faster than others
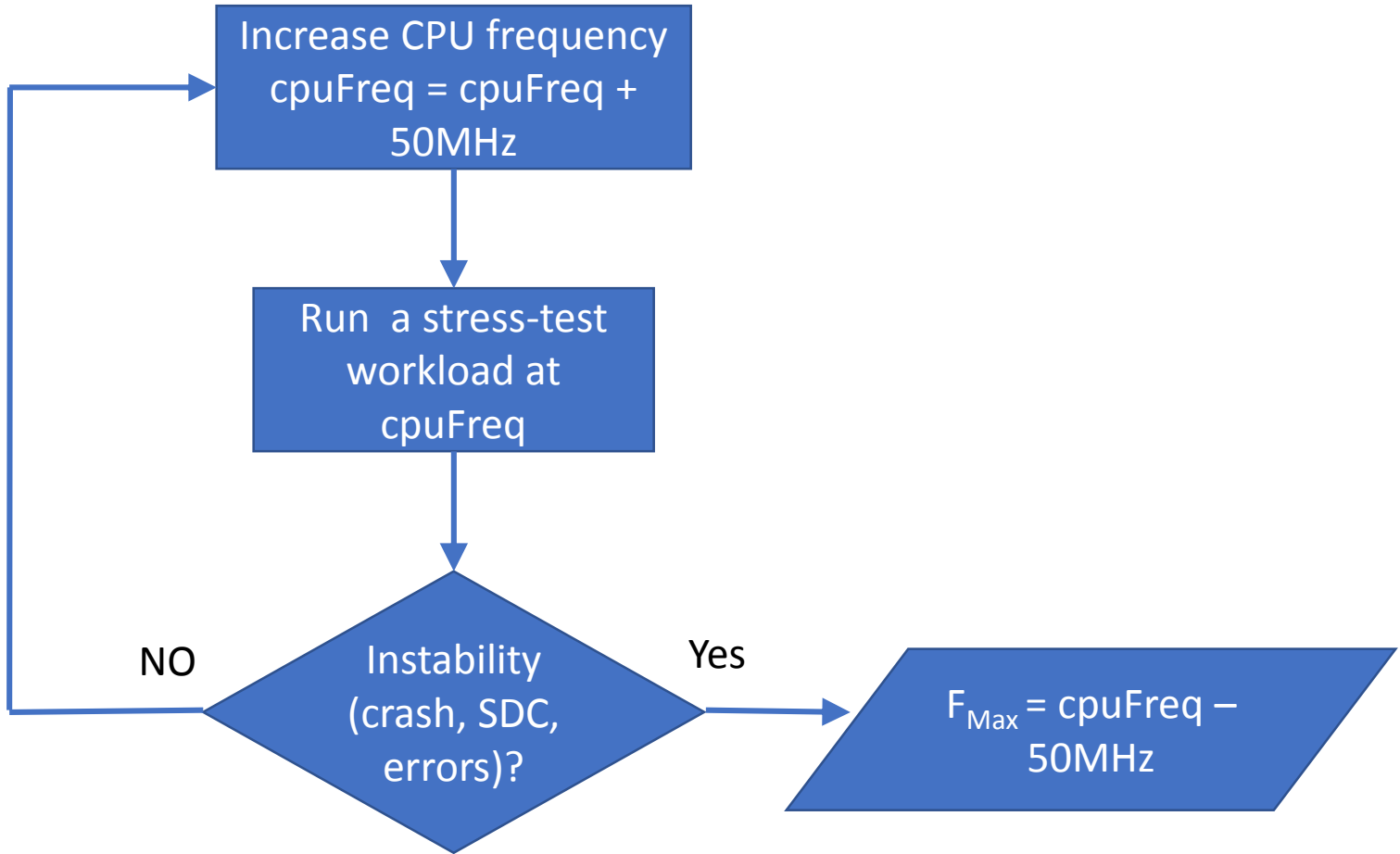
CPU Products Names: X100   X200   X300

F_{req1} (2.7GHz) < F_{req2} (3GHz) < F_{req3} (3.3GHz)
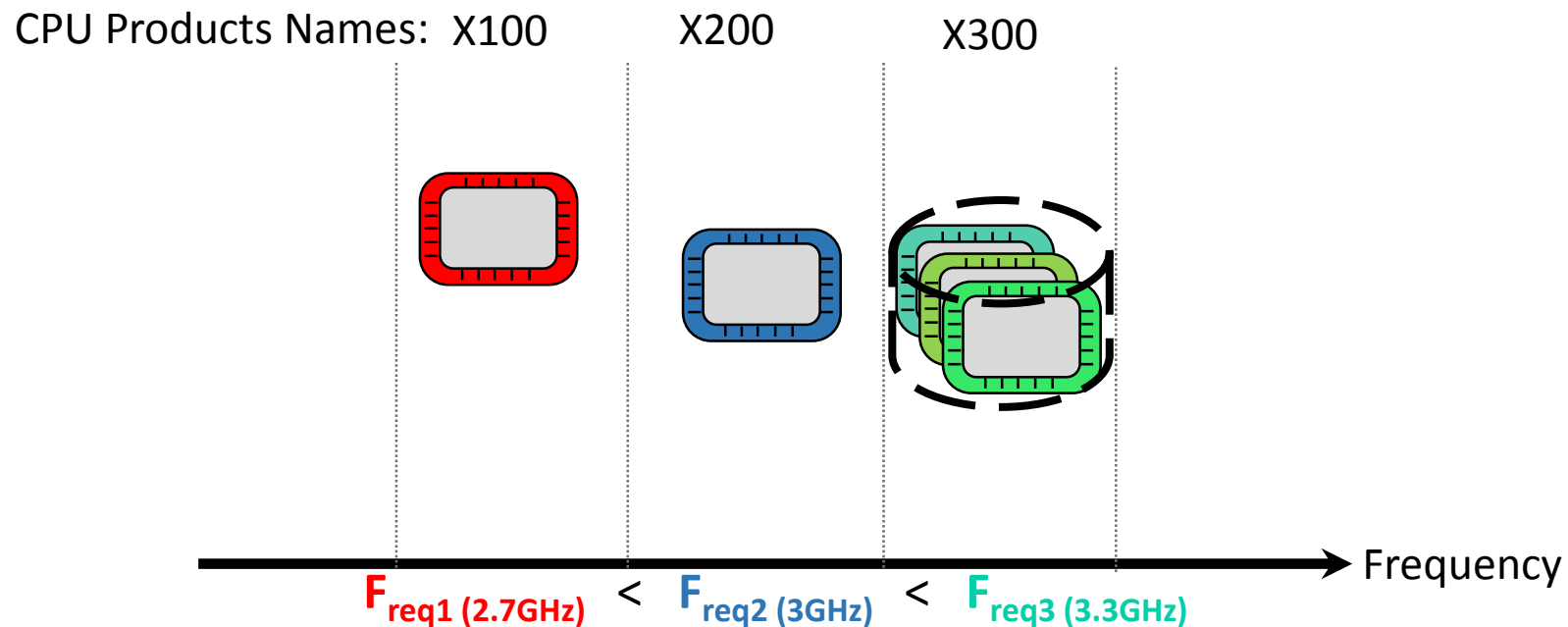
Frequency

Exploiting Hardware heterogeneity

- Motivation: Make the most out of each chip

- Three approaches:
  - $F_{MAX \text{ (max frequency)}}$ testing: for a given voltage find the maximum working frequency
  - Overclocking: testing higher voltages and higher frequencies. The limit is the thermal and power consumption
  - Undervolting ($V_{MIN \text{ (minimum voltage)}}$ testing): for a given frequency find the minimum working voltage
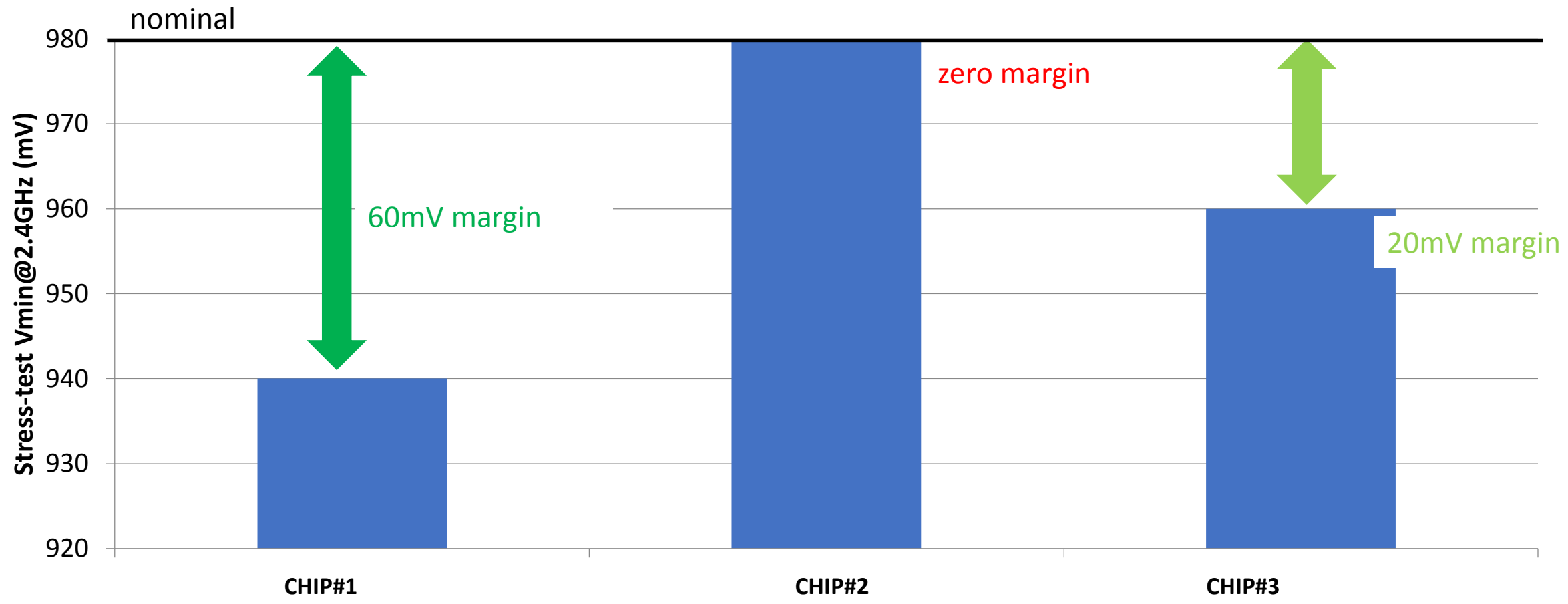
V$_{MIN}$ Test

F$_{MAX}$ Test

Increase CPU frequency
cpuFreq = cpuFreq +
50MHz

Run a stress-test
workload at
cpuFreq

Instability
(crash, SDC,
errors)?

NO

Yes

F$_{Max}$ = cpuFreq −
50MHz

V$_{MIN}$ testing results on X-Gene2 chips (Uniserver project work)
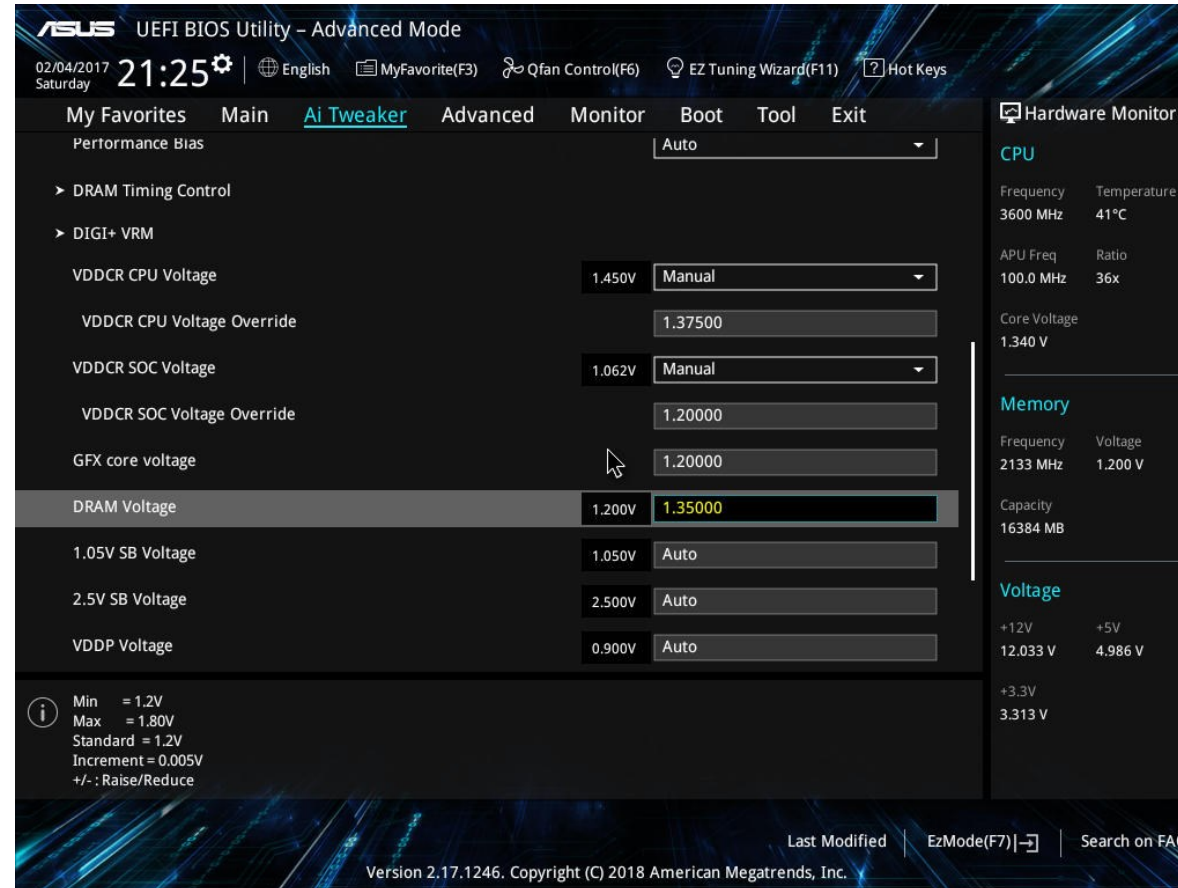

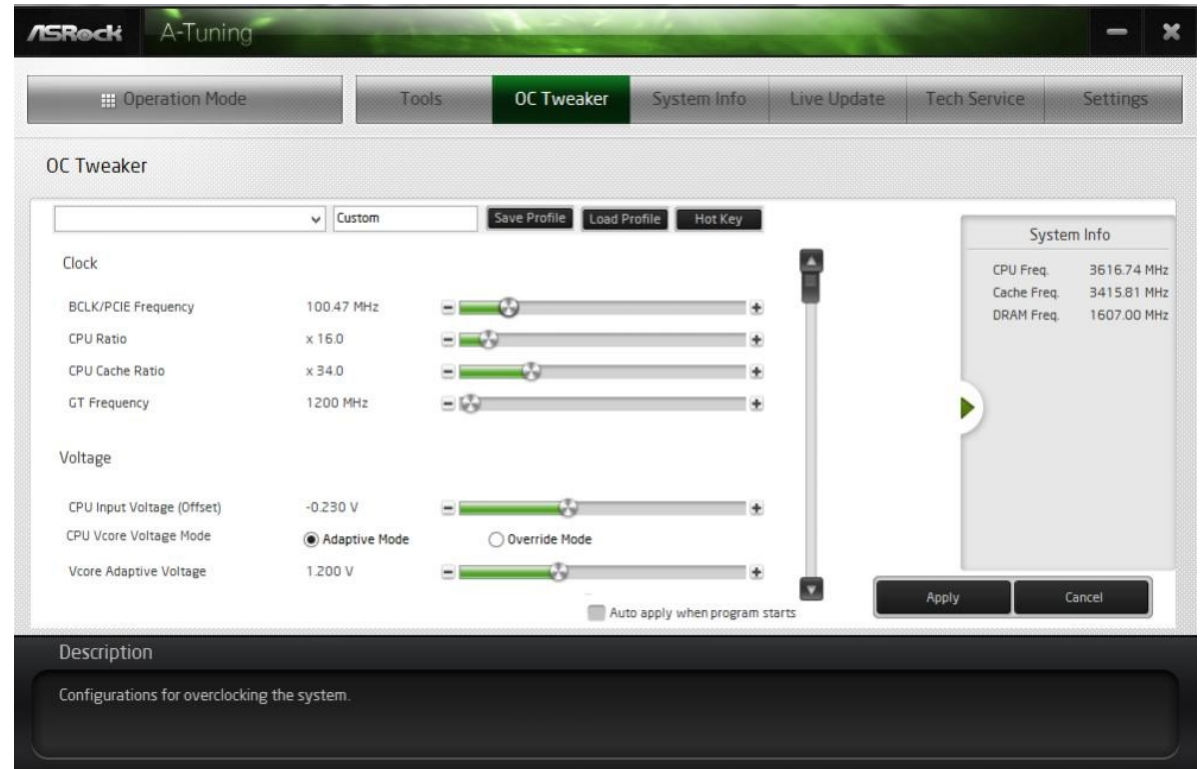
We can lower the voltage on chips #1 and #2 to save power

Tools that allow modifying voltage and frequency
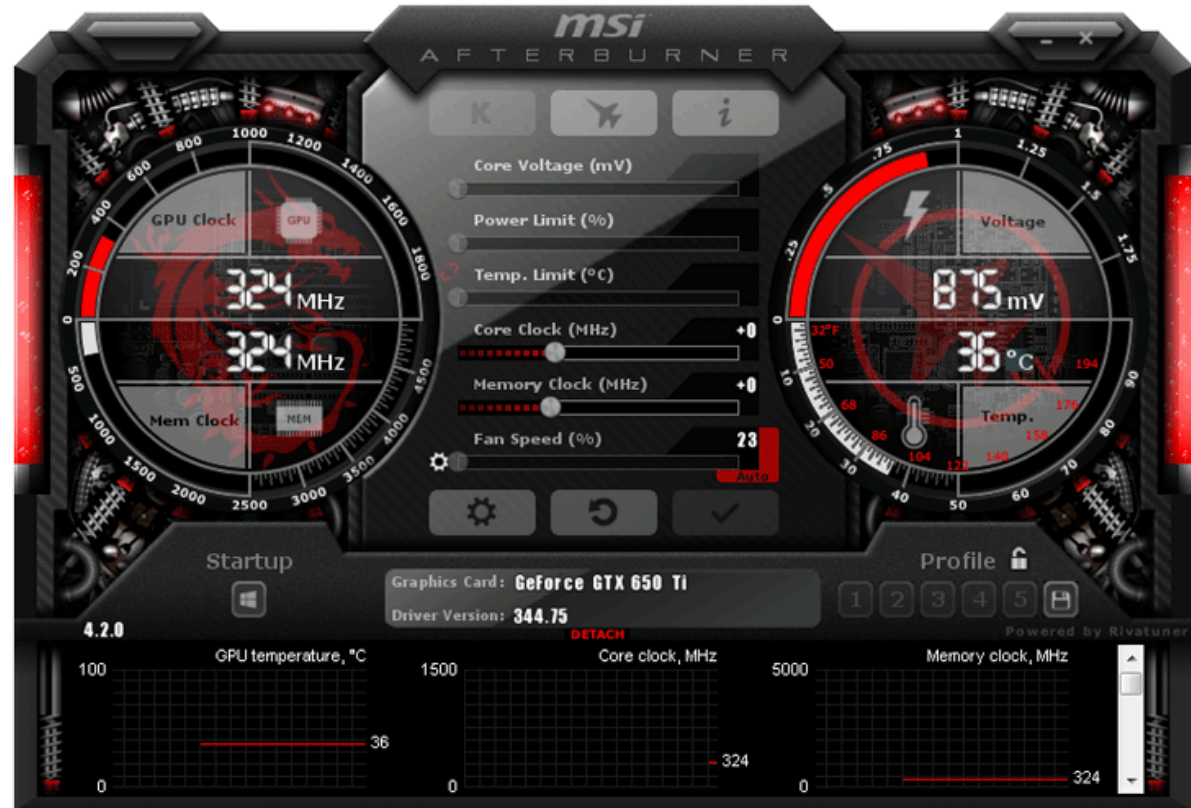
- UEFI/BIOS

Tools that allow modifying voltage and frequency

• Motherboard software tools

e.g. ASUS A-Tuning

Even comes with auto

overclocking feature

Tools that allow modifying voltage and frequency

- MSI Afterburner for GPUs

Intel Extreme Tuning Utility (IETU)

Allows modifying CPU, Cache and on-board GPU voltage and frequency for Intel CPUs

Live demonstration of IETU