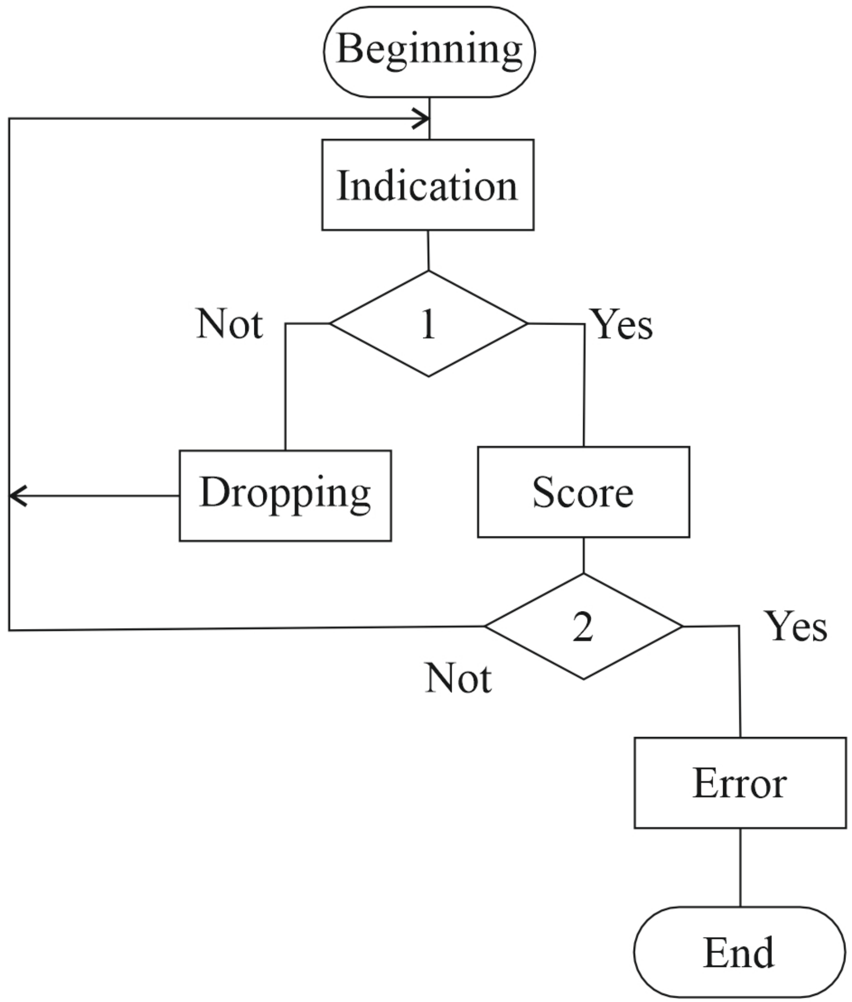
Active fault tolerance methods assume certain time costs for error detection and subsequent self-repair.
In general, failure resistance can be described as follows:
there is a set of identical elements and a switching device (for example, a multiplexer), in case of detection of a failure, the multiplexer instead of the failed element connects to the input one of the reserve elements.
Obviously, in this case, the reliability will be calculated based on the reliability of the switch and the number of spare elements.

Self-synchronous circuits do not issue an error signal. Indicators of such schemes allow detection of failures, termination of switching, but an error signal is not issued. An example of an error detection algorithm:

- determine what state the circuit is in (if the circuit is in a steady state, we forcefully set the counter to the beginning, with the appearance of the anti-spacer, an error signal is immediately generated). If the scheme is in a transitional state, then we proceed to the account.

- we compare the counter value with the threshold value, if they are equal, issue an error signal and stop the count. If the value of the counter is less than the threshold value, then we return to the beginning.



Algorithm of the device for monitoring
the failure of self-synchronous digital devices.

Energy efficiency of computer systems.

Determines the effective use of energy resources for the implementation of data storage, transmission and processing functions. In effect, this means spending less energy (i.e., power consumption) to ensure the same level of performance, or increasing performance while maintaining the same level of power consumption.

A traditional indicator of the energy efficiency of computer systems is the ratio of the number of performed operations (flops) per Watt of consumed energy. Flops refers to the number of floating-point operations performed by the computer per second.

Currently, for computer systems, energy saving while providing high computing power is gaining relevance (the Green500 rating is based on this indicator).

The leader of this list in 2013 with an indicator of 3.21 gigaflops per Watt was recognized as the supercomputer Eurora, which is located in the computing complex of Italy.

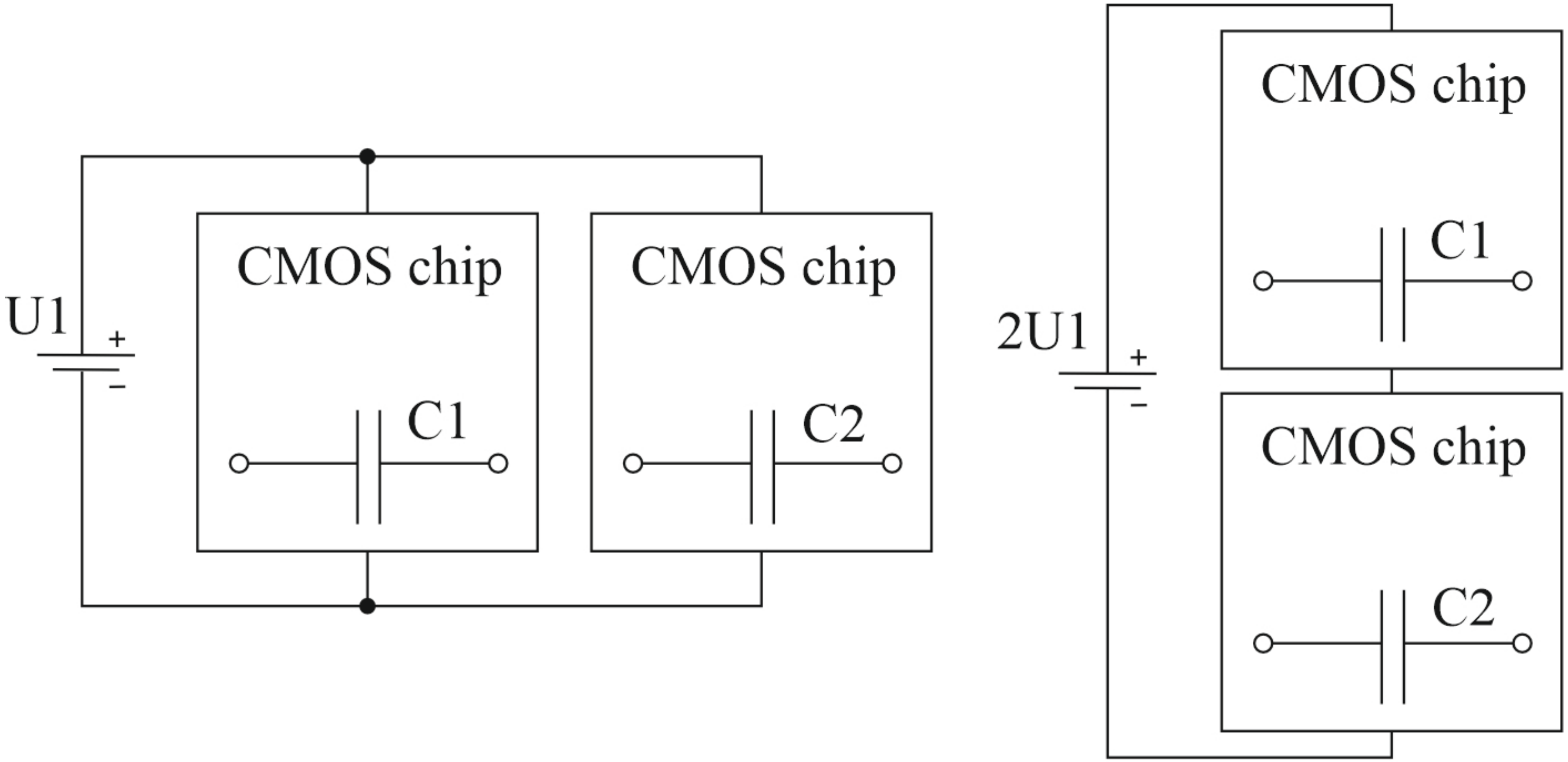
Several hundred supercomputer systems, most of which are single products, participate in the Green500 rating. At the same time, there is a multimillion-dollar market for embedded systems, mobile devices and applications, for which energy efficiency means the duration of autonomous operation without recharging the battery. Assessment and improvement of the energy efficiency of such systems and applications working on them is extremely relevant. In this regard, means, technologies and results of measuring the consumed power of both hardware and software of mobile computing devices and software are of particular importance.

Measuring and instrumental support is a necessary condition for solving engineering and research tasks of building energy-efficient computer (primarily embedded) systems and mobile applications, among which the following should be noted:

1. Research on ways to reduce the power consumption of embedded systems on FPGAs by introducing functional redundancy. This direction of research is related to the fact that the power consumption of CMOS microcircuits significantly depends on the clock frequency.

Functional redundancy inside the FPGA crystal will theoretically reduce power consumption by reducing the clock frequency in proportion to the redundancy factor.

2. Research of the energy efficiency of electrical power supply schemes of logical elements. Currently, it is generally accepted to supply parallel supply voltage to all microcircuits located on the printed circuit board. An alternative is their serial connection to a power source with an increased level in the form of a voltage divider circuit. It is a generally accepted fact that one of the main sources of dissipated leakage power in CMOS microcircuits is the charge/discharge currents of the parasitic capacitances of the logic elements at the time of their switching. Therefore, it can be assumed that with the serial connection (b) of CMOS microcircuits to the power source, the dissipated power will be lower due to a decrease in the total parasitic capacitance, in contrast to the parallel connection (a), in which the total capacitance increases. The verification of this hypothesis is relevant for solving the circuit engineering tasks of increasing the energy efficiency of digital systems and requires practical experiments with the use of measuring tools.



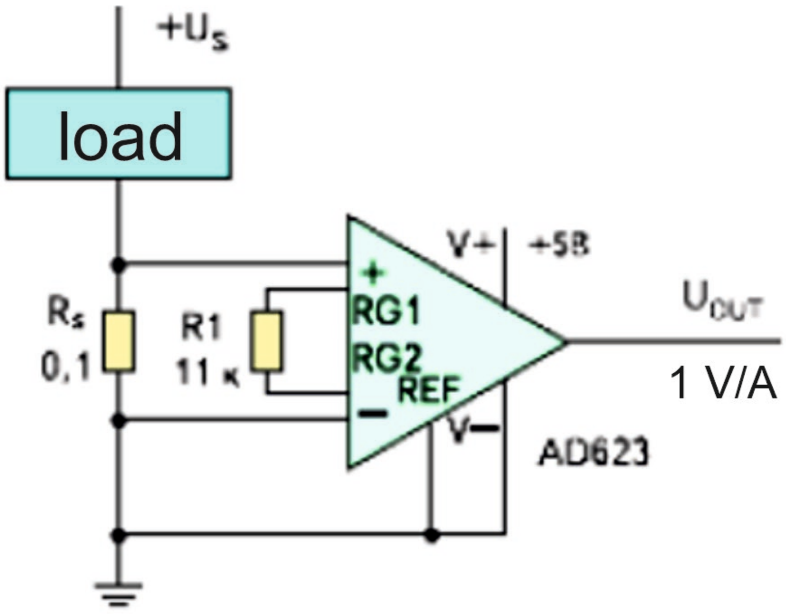
The method of connecting CMOS (Complementary Metal-Oxide-Semiconductor) microcircuits.

3. Identification of the most energy-intensive components of microcontrollers and microprocessor systems (timers, peripheral device controllers, DAC/ADC, etc.) and selection of more energy-efficient architectures and operating modes.

4. Measurement of the amount of energy spent on the execution of this or that software tool on a given hardware platform. This direction is particularly relevant for the selection of functionally alternative applications by users of open mobile platforms, taking into account their energy consumption.

5. Evaluation of the energy consumption of both individual instructions of the processor and commands of high-level programming languages, as well as numerous API functions. The results of such an assessment can be used in the future to solve the tasks of forecasting the energy consumption of software based on static analysis of the executable or output software code.

Methods and schematic solutions for measurement power consumption of digital systems.

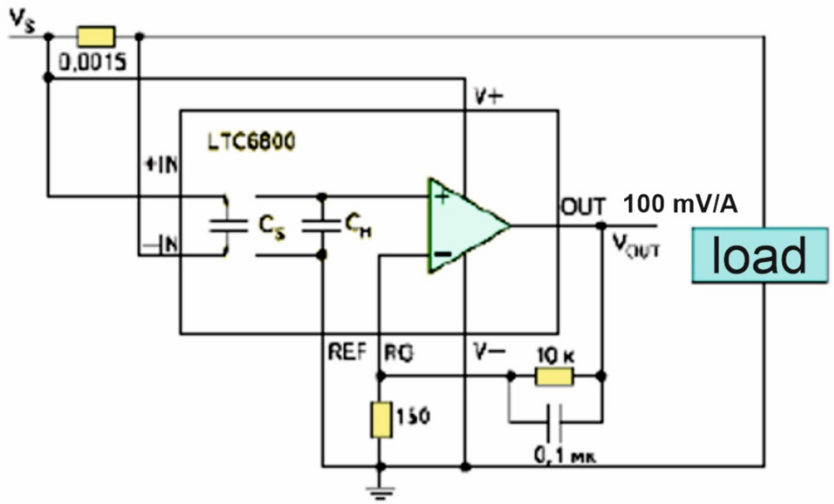


Current measurement scheme in the negative pole with a measuring amplifier

It should be noted that there is a conversion error caused by the non-zero value of the minimum output voltage of the amplifier, which is insignificant for most practical applications. To eliminate this drawback, either a bipolar power supply of the amplifier is required, or the elimination of the output signal level by connecting the REF pin to a reference voltage source.

The advantage of current measurement schemes in the positive pole of the load is that the load is grounded and a short circuit in the load can be detected. Disadvantages include a high common-mode input voltage, as well as the need to eliminate the output signal to a level acceptable for further processing in the system (bonding to "ground").

LTC2053 amplifiers are suitable for measuring the current in the positive pole of the load; LTC6800 (Linear Technology); INA337 (Texas Instruments). The figure shows a circuit using the LTC6800. The supply voltage of the circuit cannot exceed the maximum permissible supply voltage of the amplifier (5.5 V).



The scheme of measuring the current in the positive pole with the instrument amplifier LTC6800.

Most of the batteries of modern mobile devices use built-in measuring chips (voltage, temperature and current monitors), and also support an intelligent interface to ensure efficient and safe charging, estimate the level of the remaining battery charge and predict the "lifetime" of the mobile device.

To measure the remaining capacity, battery charge in mobile devices, the following approaches are used:

- the charge level is determined based on the use of a built-in mathematical model of the storage battery, which takes into account the level of the released voltage and the temperature of the battery implemented, for example, in the MAX 17040 microcircuit.

- the second approach is based on the measurement of the battery discharge current using a low-resistance resistor, implemented by battery parameter monitors such as DS2760 and TI BQ20z70 with I-Wire interface. The DS2760 provides battery health data collection with built-in 12-bit current ADC, 10-bit voltage ADC, and 10-bit temperature sensor.

Utilities for modeling energy consumption of digital systems.

One of the important tasks in the development of electrical circuits, embedded and mobile computer systems is the forecasting of consumed energy.

Modern environments for the development and simulation of analog and digital devices, such as HSPICE or Proteus, can be used for these purposes. Programmable integrated circuit manufacturers also have tools for estimating the power consumption of FPGA designs. For example, Altera offers the PowerPlay Early Power Estimator and PowerPlay Power Analyzer utilities, which allow you to predict the energy consumption of systems under development, starting from the early design stages, with an accuracy of +-20%. Although Altera does not recommend using the obtained simulation results as data for the specification of requirements, they are a reference point that helps developers estimate the energy budget of the project and compare the energy efficiency of different implementation options on different crystals. One of the most popular utilities for monitoring the energy consumption of mobile devices and applications, running on the Android platform, is PowerTutor. With this tool, mobile software developers can evaluate how changes to the app's code affect the device's energy efficiency. Based on the data displayed by the utility, users of mobile devices can develop the optimal operating mode, which allows to extend the life of the battery, as well as identify the most energy-intensive applications.