

Embedded Controllers

Architecture	manufacturer	Comment
8051	Intel, Philips, Siemens, Dallas Semi.	Legacy market
9S08, 9S12	Freescale	Automotive market
PIC	Microchip	8-bit market
Arm	Many licenses	Mobile electronics

Advanced RISC Machine (Arm) includes the following RISC features:

- Load/store architecture
- Orthogonal instruction set
 - Any instruction can use any data type and any addressing mode
- Large 16 × 32-bit register file
- Mostly single-cycle execution
- Conditional execution of most instructions
- Powerful indexed addressing modes
- Simple, fast, 2-priority-level interrupt subsystem, switched register banks

Cheap Arm development kit

<http://focus.ti.com/docs/toolsw/folders/print/iar-kickstart.html>

<http://www.ti.com/ez430>

Cheap 8051 development kit

<http://www.silabs.com/toolstick>

- *Embedded system demand: volume, volume, ...*
 - 400 Million units/year: automobiles, PCs, cell phones
 - 30 Million units/year: ADSL modems and printers
- *Consumer electronics products*

Product	Average Unit Price	Annual Revenue
Wireless phone	\$136	\$11.5 Billion
Digital cameras	\$271	\$ 4.2 Billion
Portable CD players	\$ 48	\$ 0.9 Billion
MP3 players	\$137	\$ 0.7 Billion
Compact audio systems	\$111	\$ 0.5 Billion

Source: CEA Market Research (US). Data for 2004 calendar year.

Human factors

Safety: The risk to humans or the environment.

Fun: The degree to which our customers enjoy/like/appreciate the product

Specifications

Accuracy: The difference between desired and actual parameter

Precision: The number of distinguishable measurements

Resolution: The smallest change that can be reliably detected

Response time: The time difference between triggering event and resulting action

Bandwidth: The amount of information processed per time

Compatibility: The conformance of the device to existing standards

Size and weight: The physical space required by the system

Power: The amount of energy it takes to operate the system

Testing

Testability: The ease with which proper operation of the device can be verified

Mean time between failure:

The reliability of the device defining the life of a product

Maintainability: The flexibility with which the device can be modified

Maintenance schedule

Cost of maintenance

Economic issues

Manufacturability: The ease at which the design can be produced

Nonrecurring engineering cost (NRE cost): The one-time cost to design and test the product

Labor costs: training, development, and testing

Unit cost: The cost required to manufacture one additional product

- material costs includes parts and supplies

Time-to-prototype: The time required to design build and test an example system

Time-to-market: The time required to deliver the product to the customer

Considerations

- ROM size must be big enough to hold instructions and fixed data
- RAM size big enough to hold locals, parameters, and globals
- EEPROM holds nonvolatile constants that are field configurable
- speed must be fast enough to execute the software in real time
- I/O bandwidth affects how fast can the computer input/output data
- 8 16 or 32 bit data size should match most of the data
- numerical operations like multiply, divide, signed, floating point
- special functions like multiply/accumulate, fuzzy logic, complex
- enough parallel ports for all the input/output digital signals
- enough serial ports to interface with other computers or I/O devices
- timer functions to generate signals, measure frequency/period
- pulse width modulation for the outputs in many control applications
- ADC that is used to convert analog inputs to digital numbers
- package size and environmental issues
- second source availability
- availability of high level language compilers, simulators, emulators
- power requirements because many systems will be battery operated

considering speed and memory size

execute a benchmark program similar to your specific application

rather than just comparing bus frequency

family of devices with a range of execution speeds and memory configurations.

Case Studies

1) EKG machine

2) Stepper controller

Inputs: 2 switches

Outputs: 4 to stepper motor

Memory:

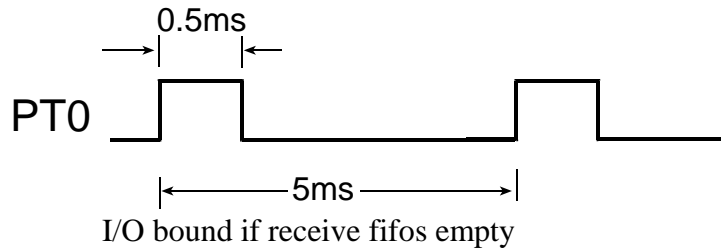
Program ROM (op codes) 472 bytes

Data ROM (FSM) 92 bytes

Data RAM 7 bytes plus stack

(2 nested functions +1 interrupt)

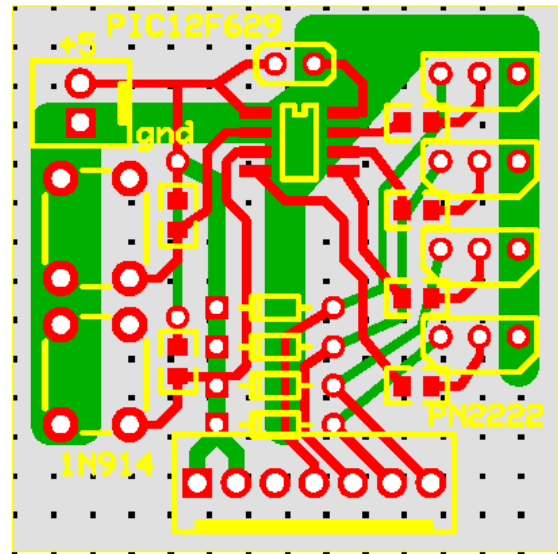
Speed: (every 5ms) profiling

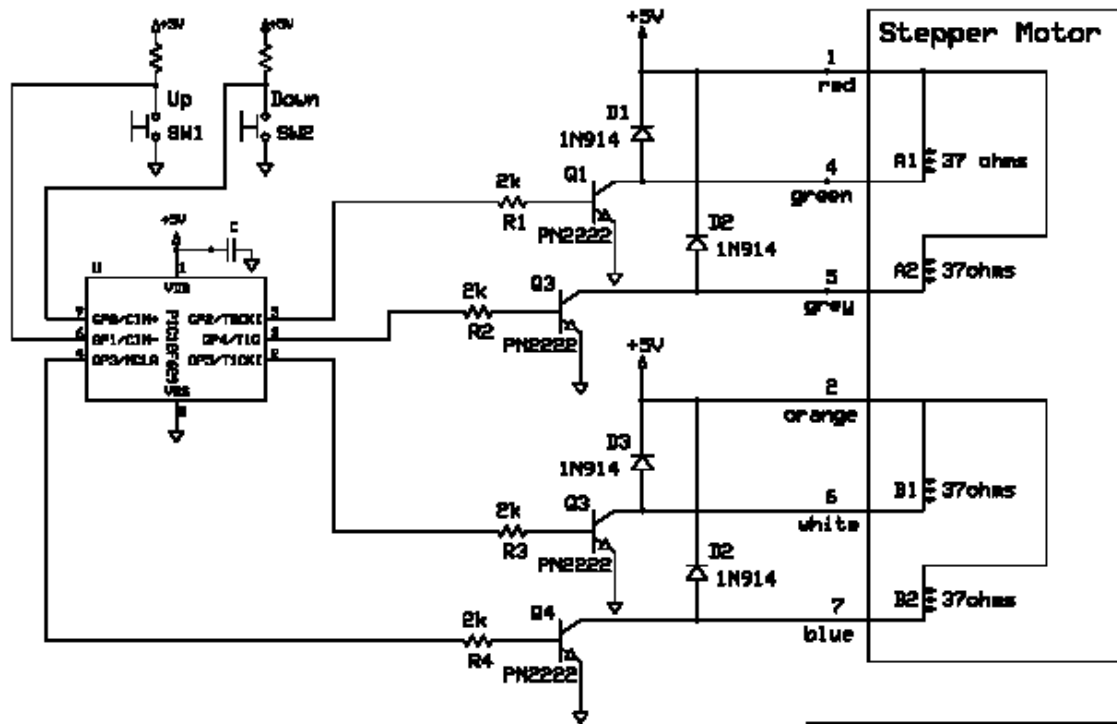


Possible Solution

PIC12F629-I/P 4MHz Microcontroller

- Configuration: Flash
- 1K x 14 EPROM bits
- 64 bytes RAM
- 6 I/O lines
- \$1 in large quantity





EE345L Lab 5 w/pic		
Stepper Motor Interface		
Jonathan Valvano	Rev 2.0 4/26/2004	Page 1 of 1