Selecting the right embedded MCU

Selecting the right MCU for a project is not easy. Functionality, price per unit, power consumption, footprint, development environment and costs, 3rd-party support and long-term availability are just a few considerations to be made.

A $300 industrial grade quad-core Intel i7-7xxx PC or a $0.30 PIC10F200? It all depends on the use-case. In any project where performance is more important than price, the selection is easy. But, when more than 1.000 units are needed, price do matter. And in most non-consumer products, longevity really matters. Some products might be in production in 10 or even more years, and spare MCU boards are needed even longer.

Let's go through some options - excluding the embedded PC market.

High-end Linux platforms

Need lots of Flash, a large graphic LCD with highly flexible GUI, camera, USB, CAN, ethernet, SD/MMC and all the other standard communication and I/O features? The NXP i.MX 6SoloX would be the go-to solution. Sporting an 800 MHz ARM Cortex-A9 capable of running Linux or Android on a 3D-accelerated WXGA screen, – AND – a 227 MHz ARM Cortex-M4 perfectly suited for those real-time features desperately needed for most embedded problems, it's basically comparable to a PC.

NXP guarantees availability of the i.MX 6SoloX ARM Cortex-A9 MCU to up to year 2030!

Supporting external LP-DDR2, DDR3 RAM, NAND, NOR Flash, (e)MMC, (e)SD, and SDXC, it gives the performance and scalability needed for most products. Thanks to NXP's longevity program, they *guarantee* availability to 2030. At less than $28 at 100pcs on the spot market, it is worth it, if you need it. Even higher performance can be obtained with the i.MX 6Quad 1 GHz quad ARM Cortex-A9.

GCC, Eclipse, QT, Python or even Node.js – everything's at your fingertips!

Low to medium-end ARM solutions

The ARM core is the undisputed industry standard for anything more advanced than GPIO and LED driving. Not only does it exist in versions costing as low as $1.74 for 500 pcs on the spot, with a budgetary price of $0.75 in volumes: The NXP 50 MHz Cortex-M0-based LPC1112JHI33 draws less than 9mA. And, as with the Linux-platform, GCC and Eclipse makes a familiar and modern development environment – unless you need Keil's or IAR's multi-thousand-dollars compilers.

But NXP also provides the midrange, 204 MHz XGA-LCD, USB and ethernet-capable LPC43S57JBD208 containing both a Cortex-M4F and a Cortex-M0 at $9.22 for 1.000 pcs on the spot, with guaranteed availability to 2025.

For anything more advanced than the 8-pin PIC12LF1552, an ARM Cortex-M0 can actually be cheaper

Why ARM?

Above is only fraction of the variants provided by NXP mentioned. ST and Infineon are but two other manufacturers providing guaranteed long-time availability. And if longevity is of minor concern, there are an additional 15 manufacturers supported by

both Keil and IAR compilers. Plus the manufacturer's that are only supported by one – rather than both – of those compilers…

There is evidently an ARM-based MCU that fits almost any project at hand. The large amount of variants available from any given manufacturer allows not only future-proof designs with possible pin-compatible upgraded chips. The large number of manufacturers also guarantees a reasonable replacement could be found with maybe as little as a re-CAD of the PCB.

The time invested by firmware designers in getting to know the cores, as well as money invested in development tools, is likely to be amortized over a multitude of current and future embedded projects.

It's a compelling reason to attempt to standardize on the architecture.

Ultra-small microcontrollers – 8051 and PIC

But, why not look into PIC or AVR? The electronic designer's favorite 8-bit MCUs, such as the 180µA PIC10F200 in its 3x3mm SOT-23(OT) package is only half the price of NXP's LPC1112 in volumes.

But for anything more advanced than the 8-pin PIC12LF1552, the ARM can actually be cheaper – and much easier to develop on, thanks to the modern development tools available. That is much appreciated by all seasoned firmware designers. However, if the footprint is an issue, or power consumption below 10mA is required, 8051 may be the remaining choice.

But with ARM as the general choice – even for designs that your gut reflexes would select a PIC – why even mentioning 8051? The 40-year old architecture has been outlived decades ago, hasn't it? Not so! The original 4KB ROM, 128 byte RAM and 1 MIPS 80c51 is no longer that limited. More than 50 manufacturers currently develop MCUs based on the 8051 architecture.

If you need ethernet, Wiznet's 8051-based W7100A can do that.

At $0.75/pc, the 24MHz Novution N79E715AS16 is a contender for NXP's LPC1112. Doubling the sum gives you TI's low-power CC2540 with both USB and Bluetooth LE. And if you need ethernet, Wiznet's 8051-based W7100A can do that for you, although at almost $5.

But if super-ultra low-power is the issue, an 8051 such as the Silicon Labs C8051F98x draws as little as 150µA – less than the PIC10F200, and that's for $1/pc on the spot. In my personal opinion, only if sub-100 µA is needed, the PIC should be considered. For example, PIC10LF32x draws the neglectable 25µA at $0.45 for 3000 pcs on the spot.

Another time-tested option for really low power requirements is the TI MSP-430 family. With several series and variants ranging from very small and basic features to 100+ pins with USB, CAN and an abundance of other peripherals; the MSP-430 could also meet most typical lower-end systems requirements. However, there is an increasing competition, price- and feature overlap from the low range, low-power optimized ARMs – in particular low-power Cortex M0/M0+ variants.

MCU Core priorities

1) ARM
2) 8051
3) PIC
4) other

Primary manufacturers*:

- NXP**
- STMicroelectronics**
- Infineon**
- Silicon Labs**
- Atmel
- Cypress
- Texas Instruments

*) Provides both ARM and 8051. Supported by both Keil and IAR.

**) Provides longevity programs

Conclusions

When selecting MCU, in my personal opinion, one shall always investigate if an ARM-based MCU will be sufficient.

Great development tools, large flash and RAM and a wide range of options, makes development a breeze. A suitable combination of price, performance and functionality can be obtained thanks to the large amount of versions available.

But, if an ARM turns out too expensive, physically large or power-hungry, go for an 8051-based core. NXP, ST, Infineon and Silicon Labs all provide both ARM-based and 8051-based cores, longevity programs, and are supported by both Keil and IAR compilers.

If neither an ARM- or 8051-based MCU that fulfills all requirements can be found, proprietary cores such as PIC, should be considered.

The above mentioned MCUs are just mentioned due to their specific characteristics. For more general use, there are even cheaper solution.
All prices are as of 2017-03-31.

Since 1985, Prevas have succeeded in developing more than 5,000 products, gathering a wealth of knowledge in the field. We are happy to aid in selecting the correct MCU, development tools and 3rd-party software modules. Prevas can also develop subsystems – or even the entire product – according to customer specifications.

About the author

Fredrik Lundström has 20 years of experience developing firmware and software for embedded MCUs ranging from PIC and 80C51 to ARM Cortex-M and embedded Linux.