

Embedded and mobile systems

An introduction



Course contents

- Part 1: Digital Signal Processors (DSPs): architecture, real time signal processing; examples using the TI 'C5510 and '6748 DSPs
- Part 2: Embedded systems and microcontrollers
- Part 3: The Android programming language and development system

Microcontroller units (MCUs)

- From very small (3mm!) to rather sophisticated...

Dual 10-Channel 24-Bit MicroConverter[®]

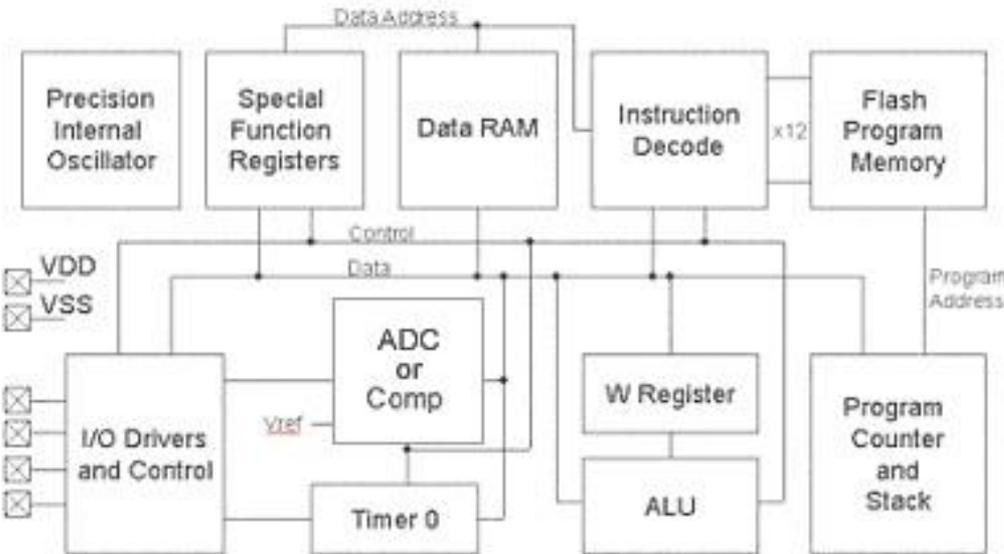
...with 1-cycle flash 8052

ANALOG DEVICES ADuC845

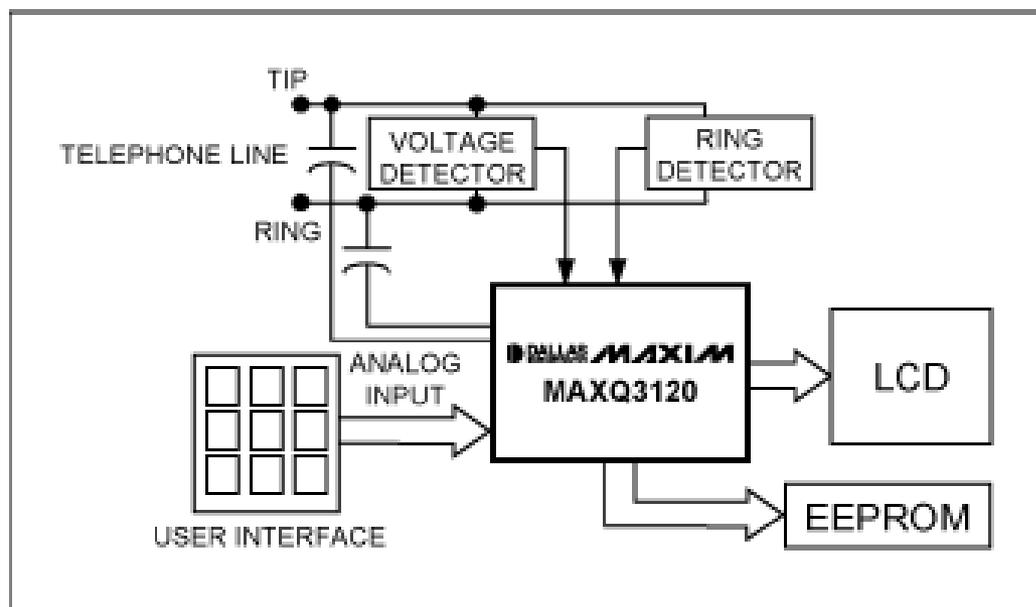
8mm

- 21-bit effective resolution @ 50 Hz
- 15 ppm max INL
- 24-bit monotonic
- low offset ± 0.6 ppm
- offset drift: ± 0.002 ppm/ $^{\circ}$ C
- 62 kbyte flash memory

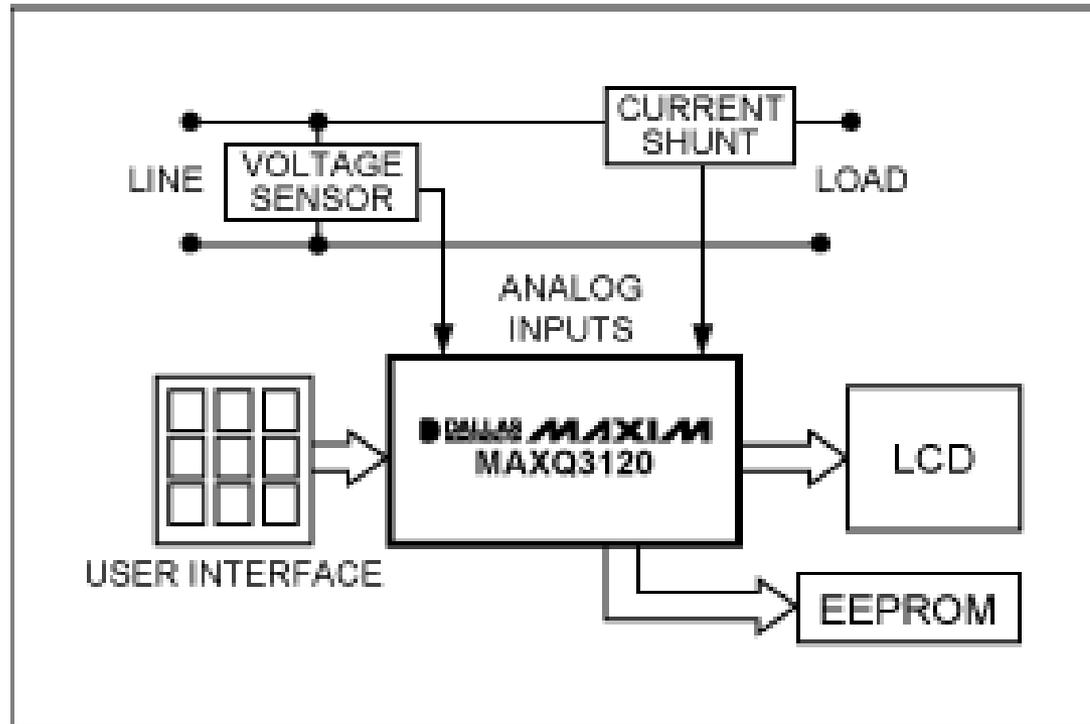
The diagram shows the internal architecture of the ADuC845. It features a central MUX (Multiplexer) that routes signals to a Primary 24-Bit Σ - Δ ADC and an Auxiliary 24-Bit Σ - Δ ADC. The Primary ADC is connected to a 12-Bit DAC, and the Auxiliary ADC is connected to a Dual 16-Bit Σ - Δ DAC. Other components include an Ext. VREF Detect block, an Internal VREF block, Flash/EE Memory, a 1-Cycle 8052, a PLL, a Temperature Sensor, General Timers, and GPIO and Serial I/O.



MCU example: telephone



MCU example: electricity monitoring



MCU example: electric motor control

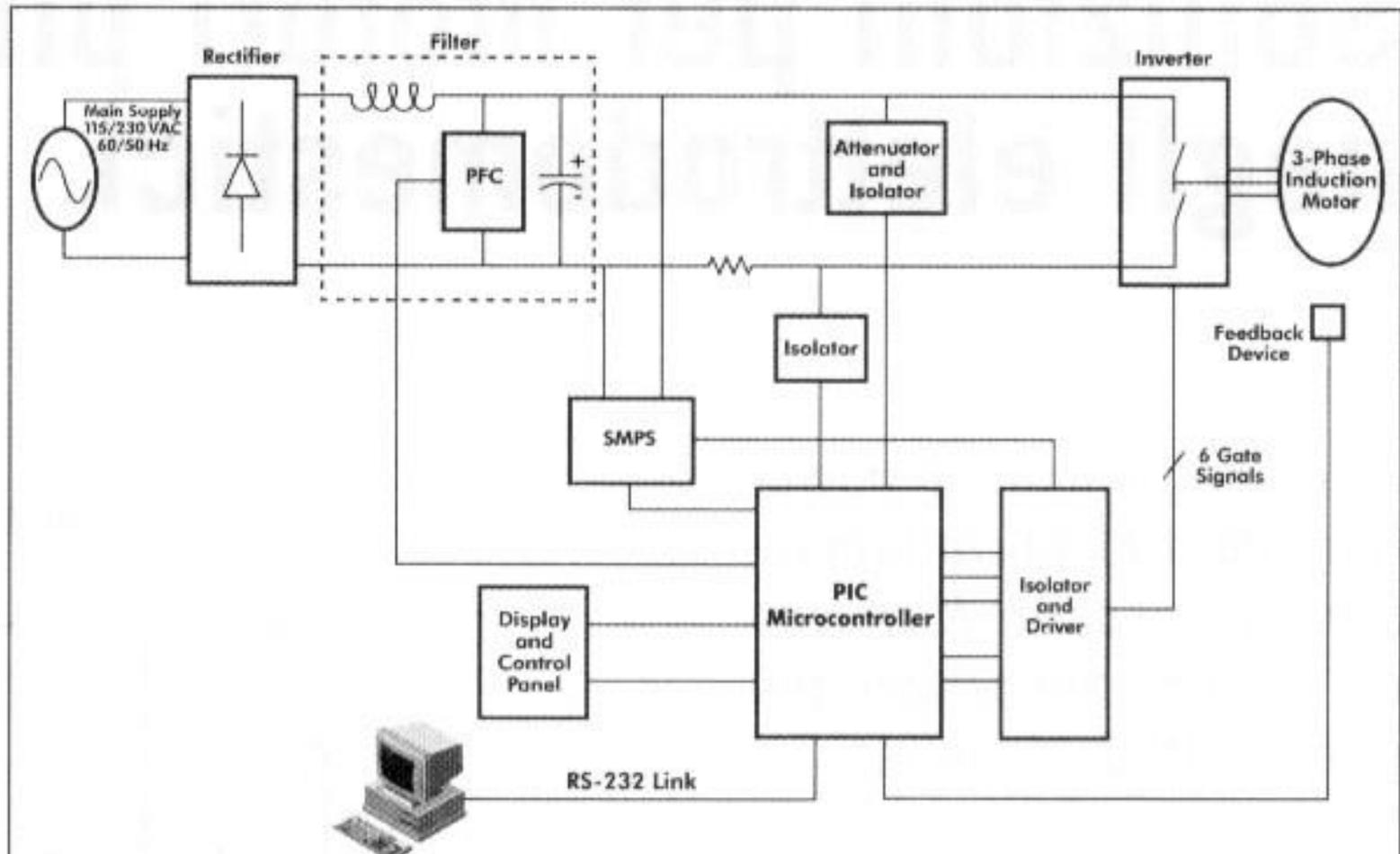
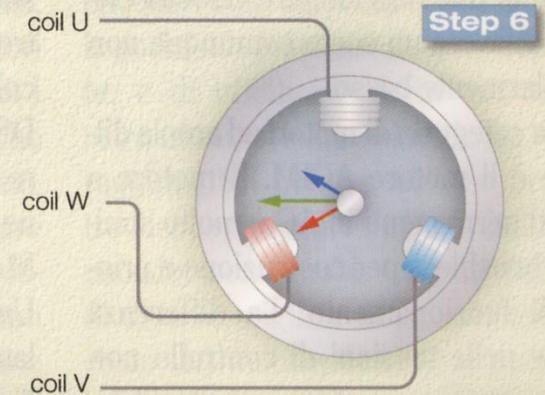
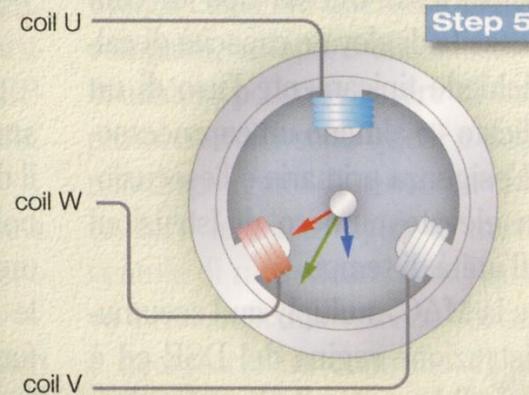
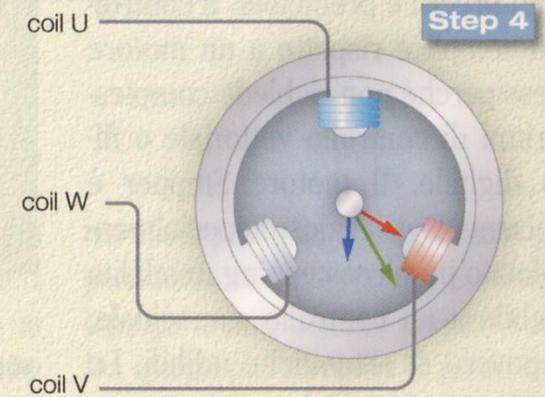
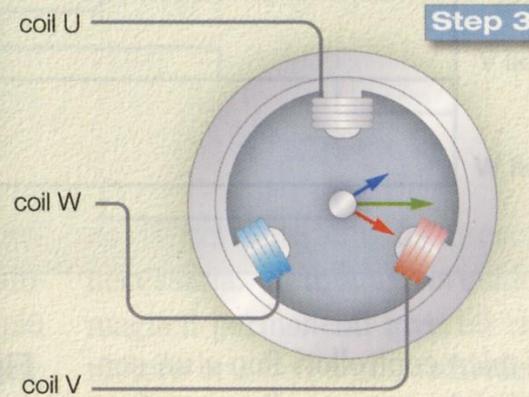
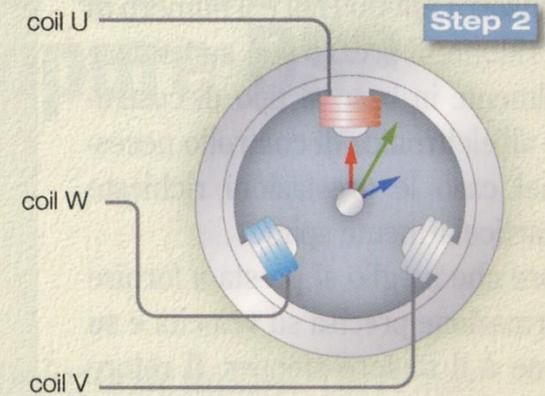
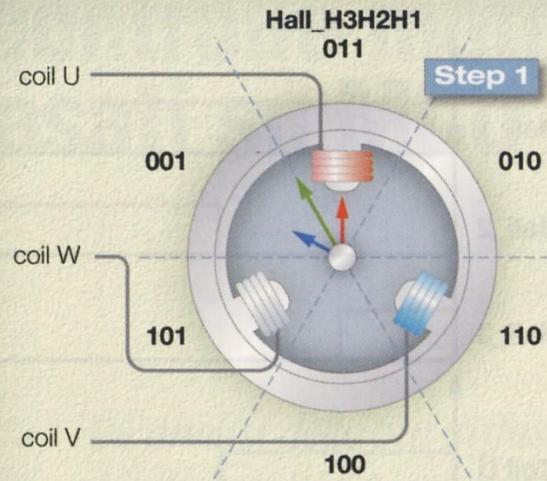


Figura 2

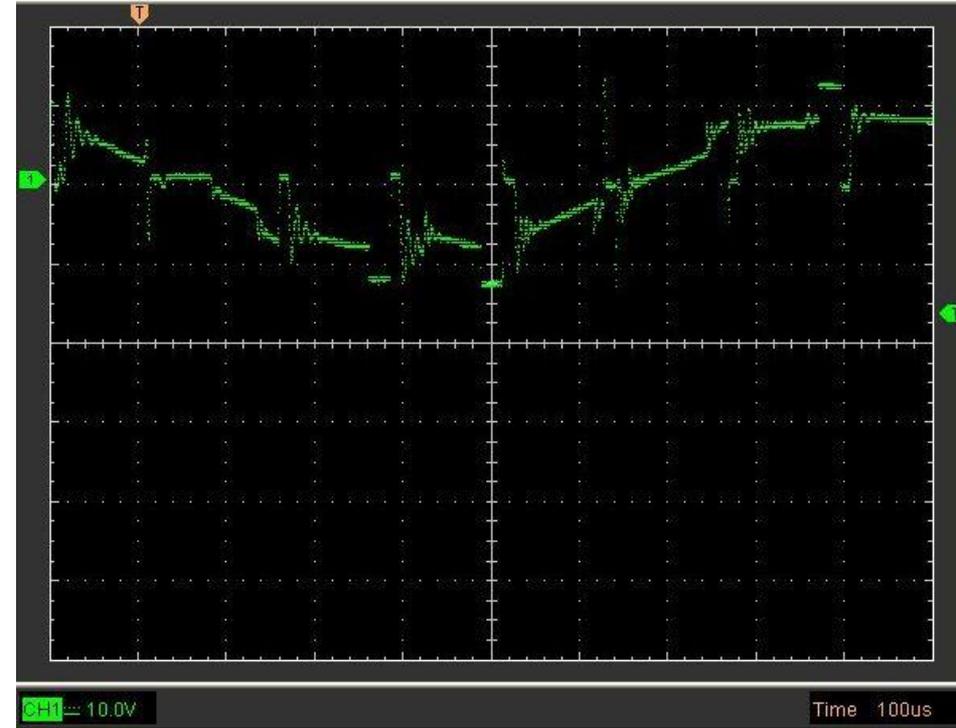
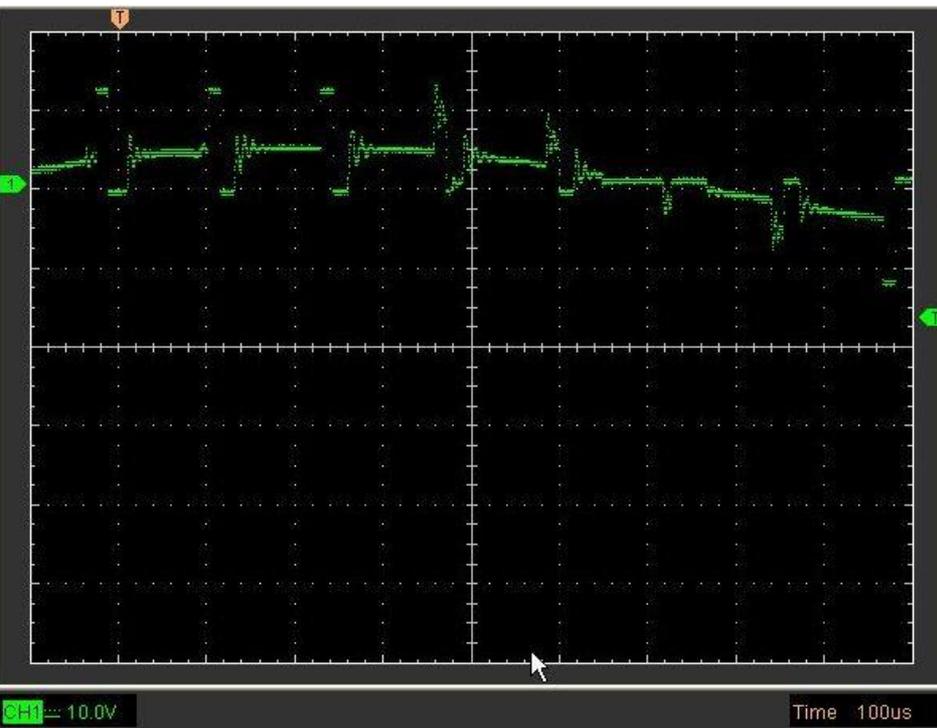
Pilotaggio a frequenza variabile di un ACIM trifase usando MCU PIC18Fxx31

MCU example: electric motor control

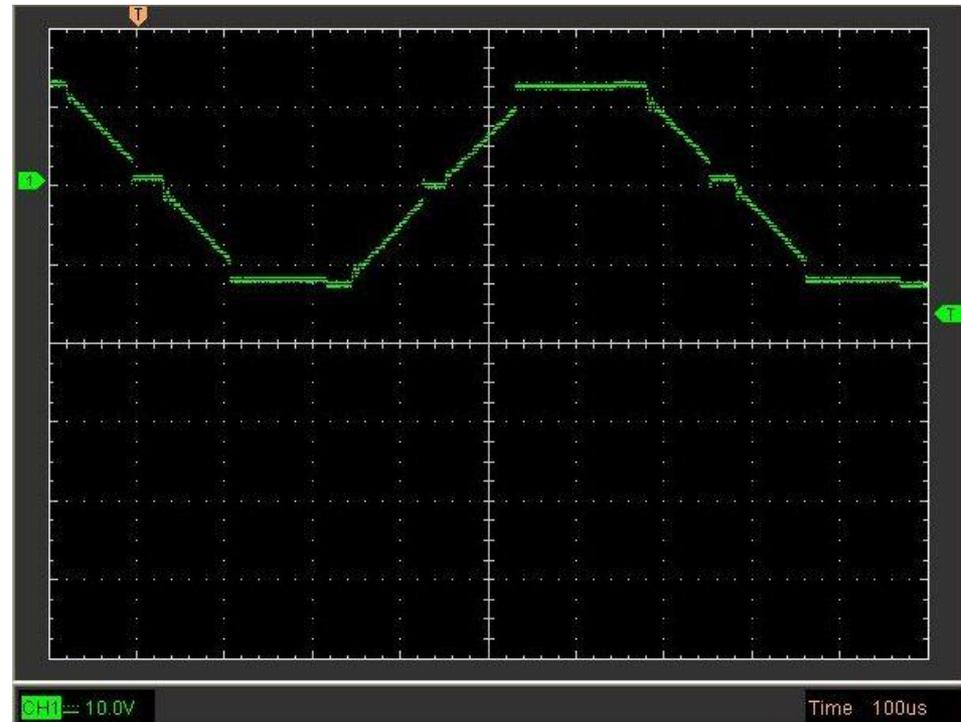
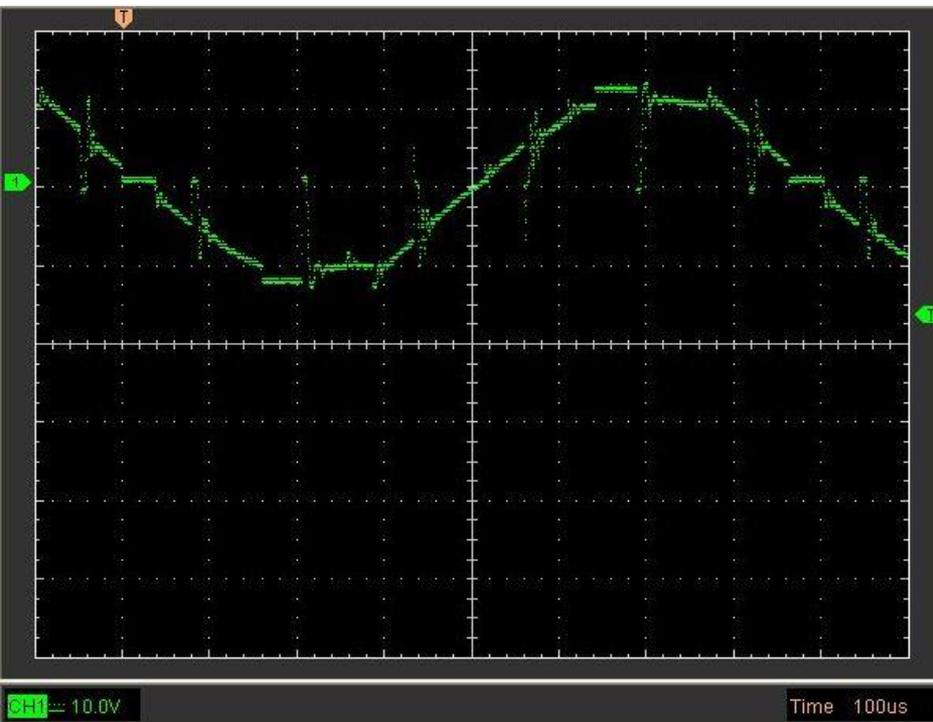
- DC brushless motor actuation (possibly with sensorless control)



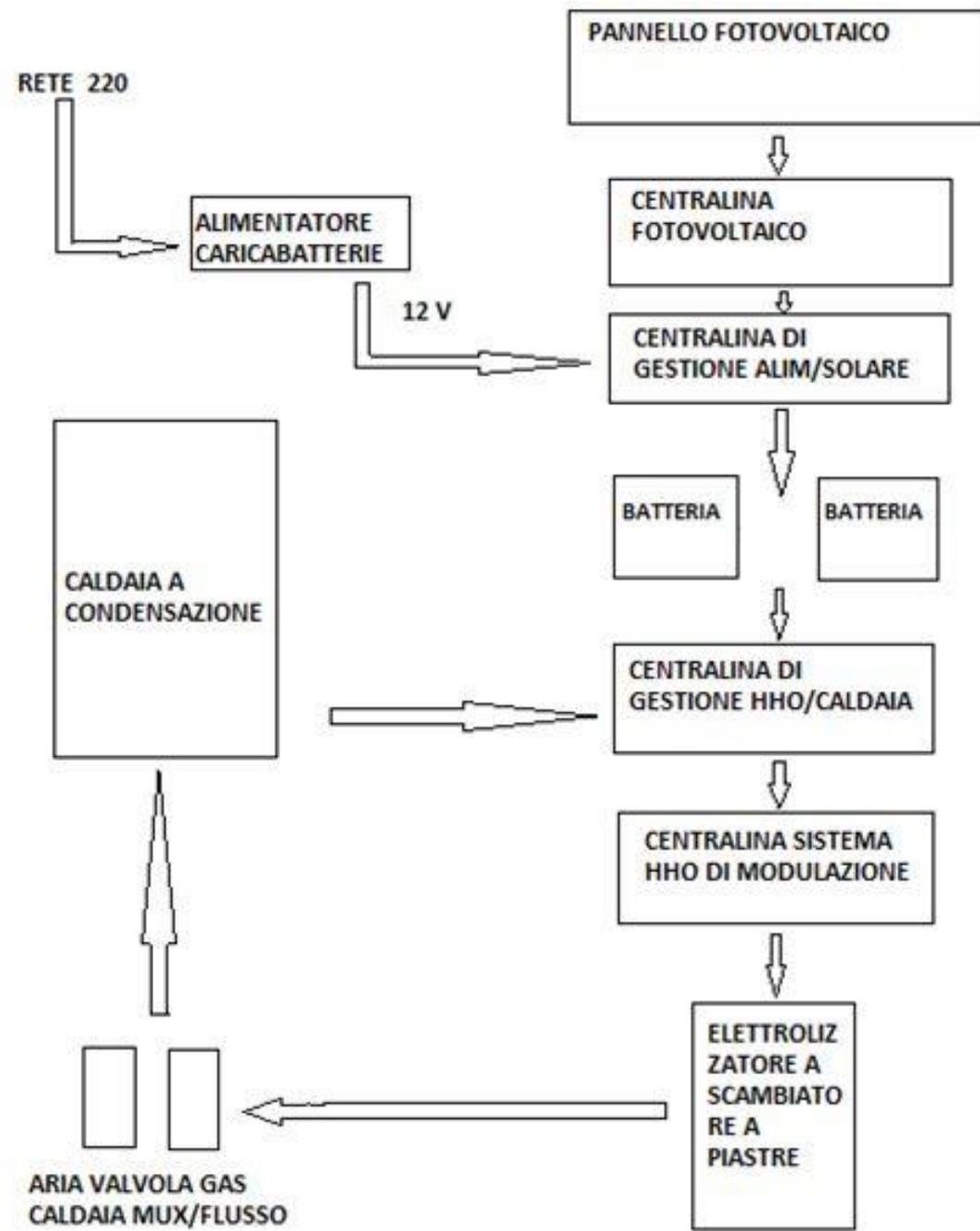
DC brushless motor actuation with sensorless control



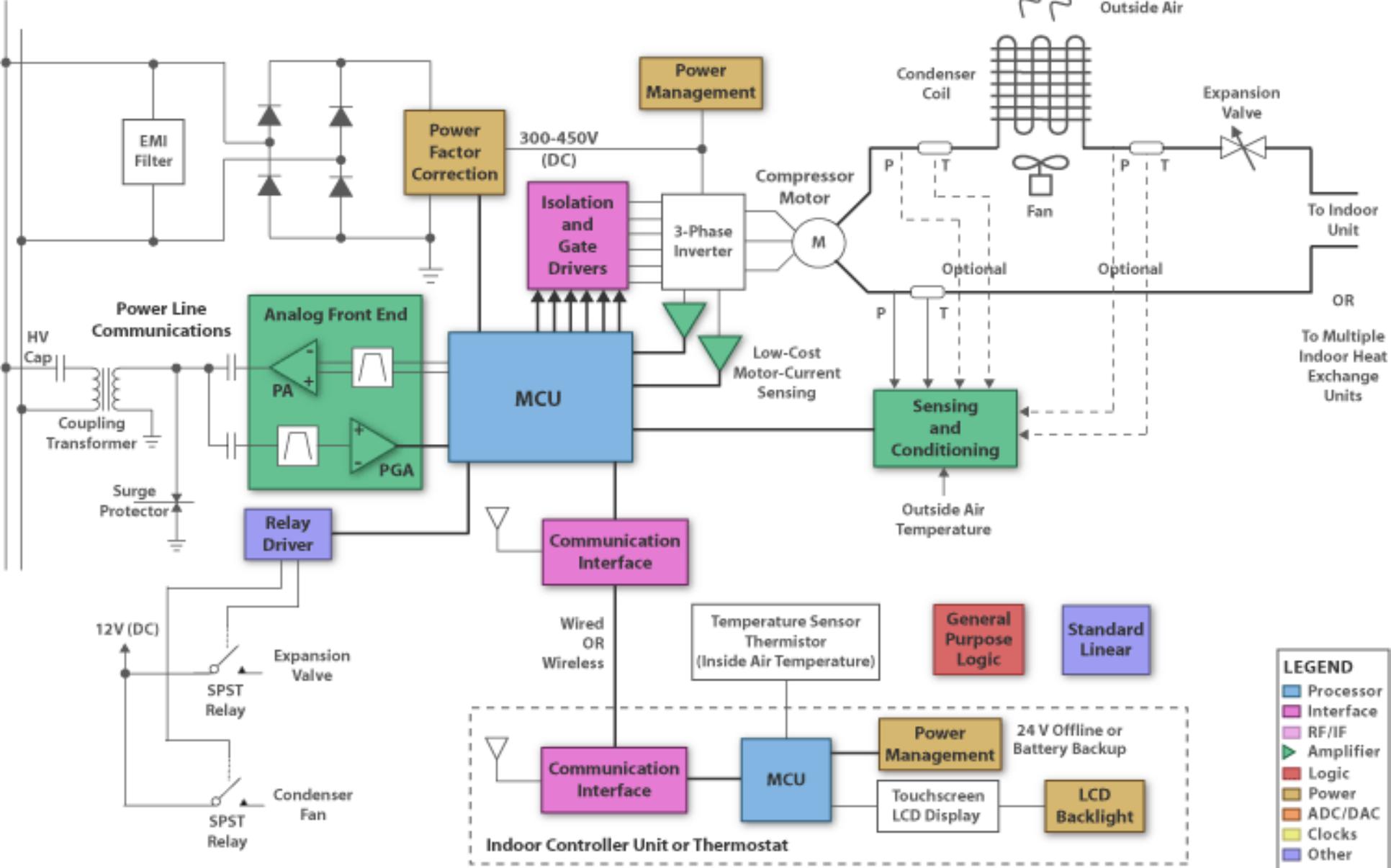
DC brushless motor actuation with sensorless control



MCU: heating appliances



MCU: air conditioning



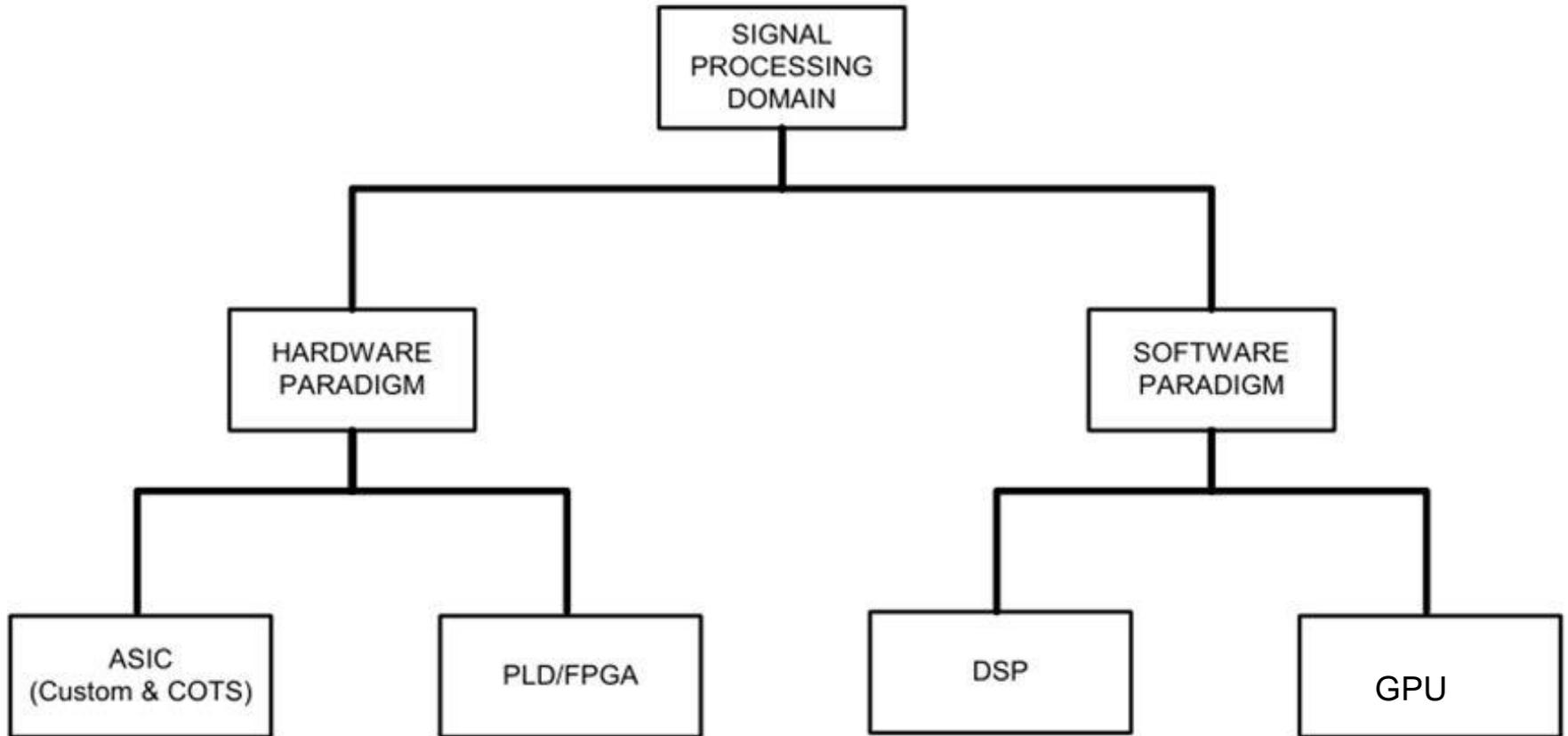
Arduino

Arduino is an open source computer hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical world



Be careful about the so-called Arduino effect...

Digital DSP solutions

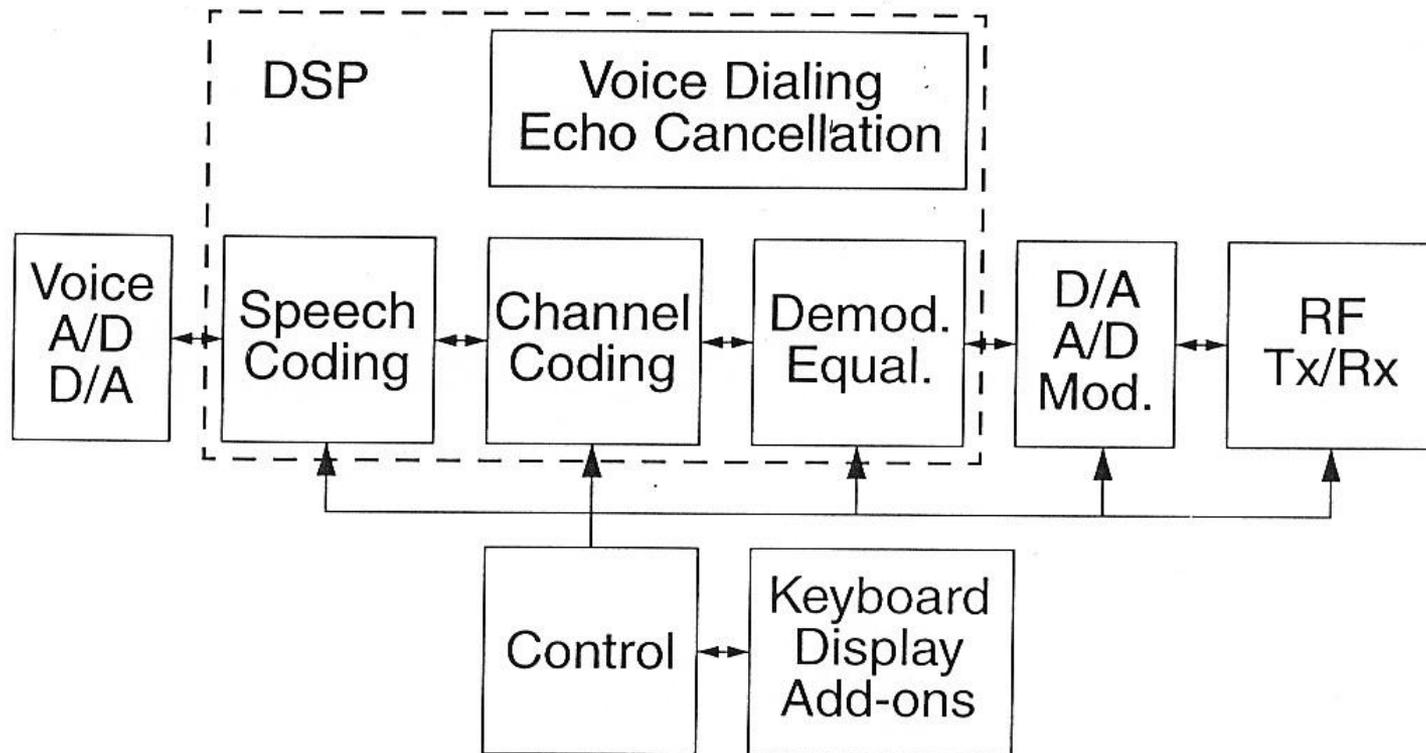




DSP: applications

- Machine vision
- Avionics and defense
- Audio
- Video encoding/decoding
- Biometrics
- Grid automation

DSP example: simple mobile phone



Video processing for cars

Example [Spectrum, Nov. 2013]:

Real-life Bambis cause 1 million collisions, 200 deaths, 29 000 injuries, and US \$1 billion in property damage each year in the U.S. alone.

BMW's system can identify all major deer species, along with moose, cows, horses, camels, and yes, wild boars.

The system fuses views from a windshield-mounted near-infrared camera and a bumper-mounted long-wavelength infrared camera, and extracts and classifies about 150 discrete features, among them temperature, shape, velocity, and directional vectors.

Small electric motors in each unit swivel the spotlight to track its target.



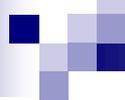
Video processing for cars

Example [Spectrum, Apr. 2014]:

In the Mercedes S-class. semiautonomous driving is provided by “sensor fusion.”

An array of two dozen sensors integrates stereoscopic 3-D cameras with near- and far-infrared cameras, ultrasonic sensors, and short-, mid-, and long-range radar. The whole shebang is tied to an antilock brake, stability control, power train, and electric steering system.



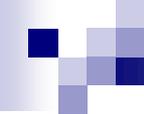


Video processing for cars

Example [Spectrum, Feb. 2016]: self driving cars

Computer drivers

- are in principle fundamentally safer drivers: they never text, do their makeup, or fall asleep at the wheel (human error, in contrast, causes roughly 93% of crashes)
- can have 360-degree vision, and thanks to lidar, radar, and ultrasonic sensors, they can see through fog and in the dark
- can have “telepathy” and react faster
- can take far more rigorous driver tests than the 20-minute road tests
- have the potential to accumulate far more wisdom than any human.



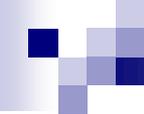
Android

Well, you know it... anyway

- The first-generation Android phones were released in October 2008. As of June 2015, Android had 82.8% of the global smartphone market share
- Android devices now include smartphones, tablets, e-readers, robots, jet engines, NASA satellites, game consoles, refrigerators, televisions, cameras, health-care devices, smartwatches, automobile in-vehicle “infotainment” systems (for controlling the radio, GPS, phone calls, thermostat, etc.) and more
- Mobile app revenue (across all mobile platforms) is expected to reach reach \$99 billion by 2019

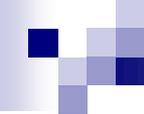
Apps: several business models

- Sell the app
- Sell paid upgrades (“lite” version is free), or use it to drive sales of a more feature-rich version of the app
- Sell an app to a company that brands it as their own
 - Many companies use free apps to build brand awareness and drive sales of other products and services
- *In-app advertising* (e.g., banner ads)
- *In-app billing*: sell virtual goods (e. g., digital content)
- ...



Android great apps characteristics

- Up-to-date with the latest Android features, but compatible with multiple Android versions to support the widest possible audience
- Work properly
- Bugs are fixed promptly
- Launch quickly and are responsive
- Don't require excessive memory, bandwidth or battery power
- Are novel and creative
- Enduring—something that your users will use regularly



Android great apps characteristics

- Use quality graphics, images, animations, audio and video
- Are intuitive and easy to use (don't require extensive help documentation)
- Give users reasons and a means to tell others about your app
- Localized for each country in which the app is offered
- Offer better performance, capabilities and ease-of-use than competitive apps
- Are designed to run optimally across a broad variety of Android devices
- Future-proofed for new hardware devices