

## Embedded Systems Essentials with Arm: Getting Started

### Module 5

#### TP (5): Thinking point

Imagine you're sitting comfortably on a plane, heading off on a well-deserved holiday. The pilot's voice comes smoothly over the intercom, "we have now reached our cruising altitude of thirty-five thousand feet". Your curious mind thinks this over. Apart from a few bumps, the plane has been rising steadily over the past hour. Its altitude, which can vary continuously, is an "analog" quantity. With the aid of some on-board instrumentation, the pilot has changed that analog quantity into digital form – a number which describes its size, thirty-five thousand feet.

Almost all physical variables around us, which a microcontroller may need to measure, are in analog form, for example temperature, altitude, blood pressure, or sound waves. Transducers can measure each of these as voltages, which become the "analog" of the original quantity. That's where the term "analog" comes from. But the microcontroller is a relentlessly digital device, so it needs to convert the analog quantity into digital form - giving a number which the microcontroller can process.

As your plane approaches its destination and comes in to land, the pilot is in contact with the control tower. They tell her to drop to 5,000 feet. As the pilot does this, she is effectively converting from digital to analog. She receives some "input data" in digital form, '5,000 feet', and by adjusting the height of the plane, converts this to the analog output, the actual altitude of the plane.

A microcontroller needs to convert in both directions between digital and analog. Most microcontrollers have dedicated Analog to Digital Converter (ADC) and Digital to Analog Converter (DAC) circuits on-chip. Both of these circuits have operating characteristics and limitations which, as users, we need to understand. Conversion from analog to digital is electronically the more challenging task. It is also more widely applied, as once a signal is digitized, it is usually preferable to keep it in that form.

Write a list of all the analog quantities that you can think of that a microcontroller may need to convert into digital. You could just let your mind wander freely on this. Alternatively think of quantities in familiar topics, for example: personal health, industrial, domestic, agriculture, medical, office, or aerospace.