

Microprocessors
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U N I V E R S I D A D
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Lookup Table vs Regression

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1 Introduction

In this assignment, we compared the performance of two methods to calculate relative humidity (RH) from voltage values measured by the ESP32 ADC.

- **Method 1:** Direct calculation using the exponential function $RH = 3.0504 \cdot e^{0.0012 \cdot mV}$.
- **Method 2:** Using a pre-generated *Lookup Table* (LUT) in C, created with Python and `sympy`.

The main objective was to measure the execution time difference between both approaches.

2 Lookup Table Generation

The LUT was generated from the regression equation using Python and the `sympy` library. The script exported a C header file (`lookuptable.h`) containing 4096 values (12-bit ADC resolution).

Listing 1: Python script snippet for LUT generation

```
import sympy as sp

x = sp.symbols('x')
poly = 3.0504*sp.exp(0.0012*x)

lut_size = 4096
lookup = [int(poly.subs(x, i)) for i in range(lut_size)]

with open("lookuptable.h", "w") as f:
    f.write("#ifndef LOOKUPTABLE_H\n")
    f.write("#define LOOKUPTABLE_H\n\n")
    f.write(f"#define LUT_SIZE {lut_size}\n")
    f.write("static const int lookup_table[LUT_SIZE] = {\n")
    for i, val in enumerate(lookup):
        f.write(f"{val}, ")
        if (i+1) % 8 == 0:
            f.write("\n")
    f.write("};\n\n#endif\n")
```

3 Timing Measurement

The measurement was performed using `esp_timer_get_time()` in the ESP32. Two metrics were recorded:

- Computation time of RH (in microseconds).
- Interval between log prints (in milliseconds).

4 Results

The obtained results are summarized in Table 1.

Method	RH (%)	Calc Time (μs)	Interval (ms)
With LUT	3.0	1	1000
With LUT	100.0	0–1	1000
Without LUT	3.6	10	1000
Without LUT	100.0	30	1000
Without LUT	15.2	10	999

Table 1: Execution time comparison with and without Lookup Table

5 Discussion

The use of the LUT drastically reduced computation time (0–1 μs) compared to the exponential function evaluation (10–30 μs). This demonstrates that for real-time embedded applications, the LUT approach provides significantly better performance, at the cost of memory usage for storing precomputed values.

6 Conclusion

The Lookup Table method proved to be much more efficient in terms of execution time, showing a clear advantage over direct exponential calculation. This approach is especially useful when fast and deterministic processing is required in embedded systems such as the ESP32.