A platform for energy consumption measurements of the communicating objects

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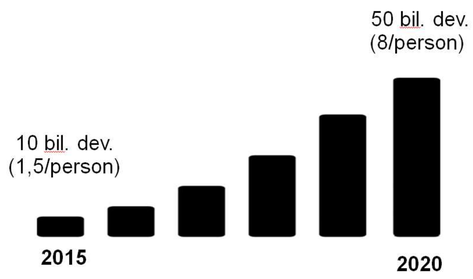
Abstract

This poster presents a platform able to measure the energy consumption of the communicating objects. The platform is based on the V-I-T (voltage-intensity-time) method which consists in measuring the voltage drop on a low value resistor, traversed by the current supplying the communicating object. Simultaneous measurements using the platform and using a calibrated instruments allowed to extract relative measurement errors less than 2%. The platform was used to measure the energy consumption of an analog radio front-end function of the data-rate and modulation type. The energy consumption of a micro-controller executing flash memory erase/write cycles was also performed.

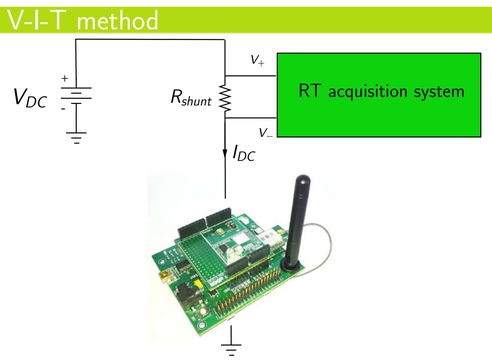
Context and motivations



- The number of connected devices is dramatically increasing (up to 50 billion connected devices expected in 2020)[1] ⇒ Energy efficiency in networks is becoming a big challenge;
- Before reducing the energy consumption, a precise evaluation should be performed ⇒ development of an accurate and versatile energy consumption platform.

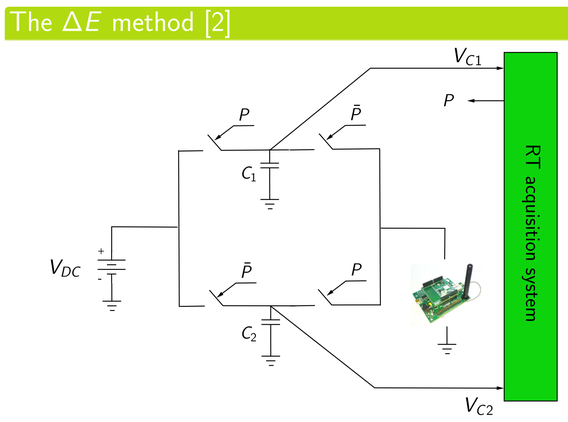
Energy consumption measurement strategies

The V-I-T method



- The measured energy: $E = V_{DC} \cdot \frac{V_+ - V_-}{R_{shunt}} \cdot t$;
- Advantage: easy to implement;
- Drawback: measurement uncertainty because of the R_{shunt} and $V = V_+ - V_-$ uncertainties;

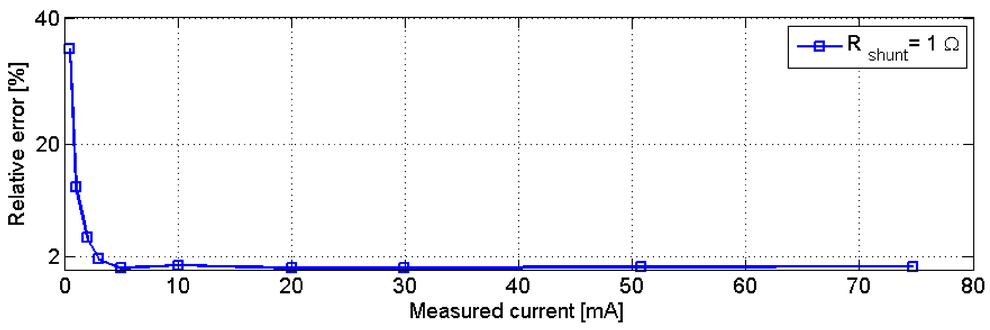
The ΔE method [2]

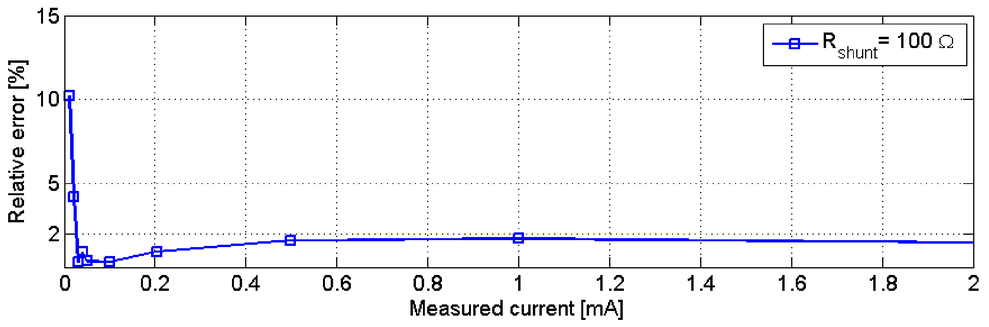


- The measured energy ⇒ $E = \frac{C \cdot {V_C}^2}{2}$;
- Advantage: suitable for instruction level measurements;
- Drawback: not versatile;

Platform accuracy

The $6\frac{1}{2}$ digit Fluke 8846 multimeter was used to quantify each channel accuracy.

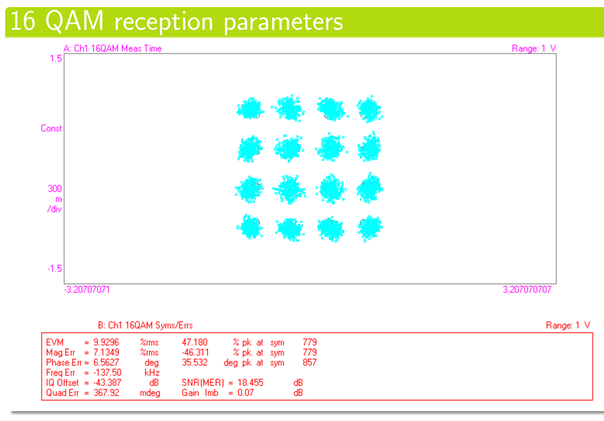




The relative error stays below 2% if the proper R_{shunt} is chosen.

Max 2830 radio front-end energy consumption [3]

16 QAM reception parameters

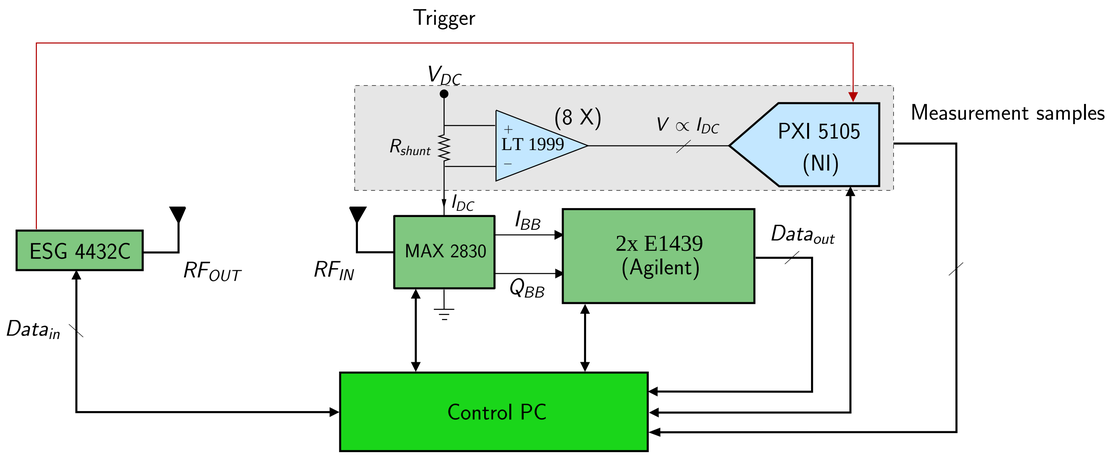


- ESG4432C in Tx mode, MAX 2380 in Rx mode;
- $f_C = 2.45 GHz$; $EVM \leq 10\%$;
- Each measurement, average value from 1000 samples;

	1 Msaps	5 Msaps	7.5 Msaps
QPSK	71.24 mW	71.25 mW	71.26 mW
16 QAM	71.26 mW	71.26 mW	71.26 mW

The power consumption of the MAX2830 in Rx mode is independent from the datarate and modulation type.

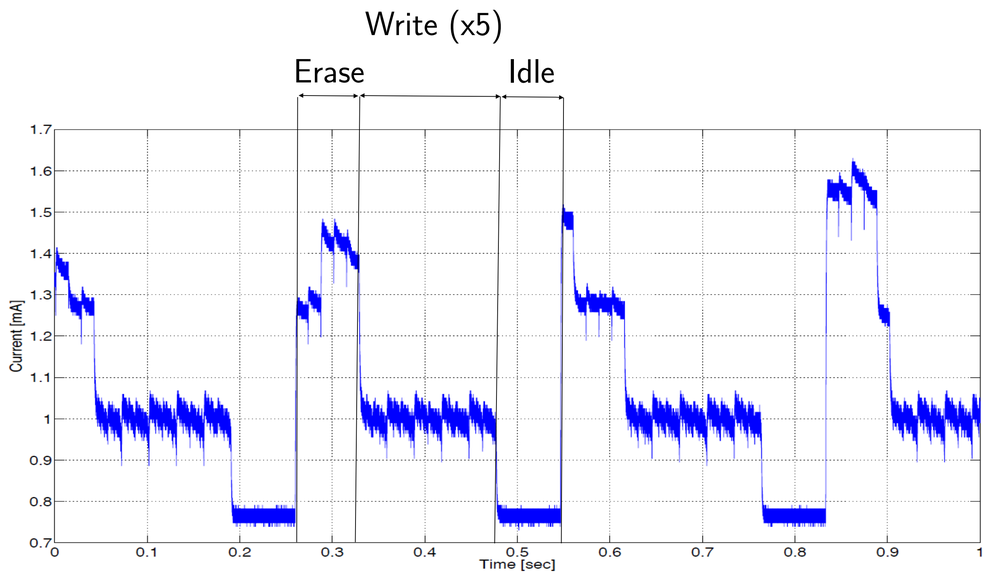
Measurement platform synoptic



- NI PXI 5105 : 12 bits resolution and 60 MHz bandwidth;
- LT 1999 instrumentation amplifiers;
- Simultaneously measurements on eight channels;
- Trigger capability;

- Current measurements from μA up to mA (in different ranges);
- R_{shunt} : high precision resistors (1% tolerance) : 1Ω upto $1K\Omega$
- $E = \frac{V_{DC} \cdot V_{out}}{G \cdot R_{shunt}} \cdot t_{acquisition}$

MSP 430FG4618 energy consumption profile



- The micro controller executes erase-write flash memory cycles;
- Write mode : consecutive values are written in flash memory;
- Current variation function of the written data.

6 - Conclusion

In this poster, the development of a energy consumption measurement platform was presented. The platform is designed in order to extract energy consumption profiles of the communicating objects for Internet of Things (IoT). The measurement accuracy was quantified by computing the relative error between the measurement performed with a calibrated multimeter. The ability to simultaneously measure the energy consumption on eight channels and its low price are the main advantages of the presented platform. The main drawback is the low dynamic range which makes inaccurate measurements when low and high value currents are measured at the same time. The use of non-linear gain instrumentation amplifiers may work around the problem.

References

[1] More data, less energy, making network stanby more efficient in billions of connected devices. *International Energy Agency*, 2014.

[2] Naehyuck Chang, Kwanho Kim, and Hyung Gyu Lee. Cycle-accurate energy measurement and characterization with a case study of the arm7tdmi [microprocessors]. *IEEE Transactions on Very Large Scale Integration (VLSI) Systems*, 10(2):146–154, April 2002.

[3] MAXIM. *MAX2830 Industry's 2.4GHz to 2.5GHz 802.11g/b RF Transceiver, PA, and Rx/Tx/Antenna Diversity Switch*, april 2008.