# An energy measurement system for battery powered applications

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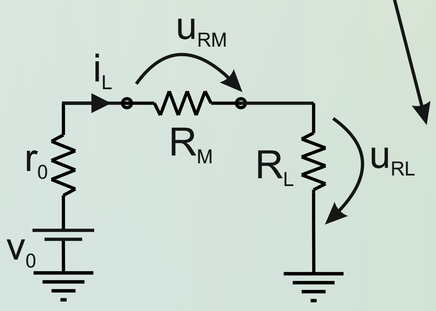
**Abstract.** For energy independent prototype systems, the measurement and counting of the internal energy flow is of great importance. An energy measurement system, developed for battery powered prototypes is presented herein. The measurement system is meant to precisely assess the values of the energy in low voltage prototypes. For this purpose it's aimed for current and voltage measurements, hence returning data that can be further processed, in order to determine the value of energy flown into the prototype. An application for energy measurement of a commercially available battery is presented herein.

## Theory and experimental details

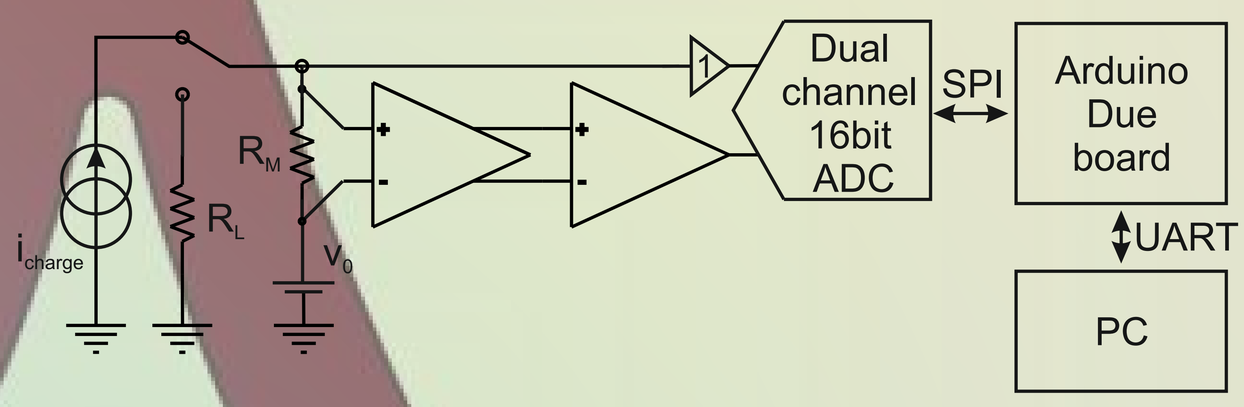
Energy measurement through a branch of a circuit requires

- measurement of the electric potential (voltage) of the branch ($u_{RL}$)
- measurement of the current flowing through the branch ($i_L$)
  $i_L=u_{RL}/R_M$
- measurement of time (t)




$i_L=v_0/(r_0+R_M+R_L)$; if $R_M<<r_0+R_L$ ⟶ $i_L\approx v_0/(r_0+R_L)$

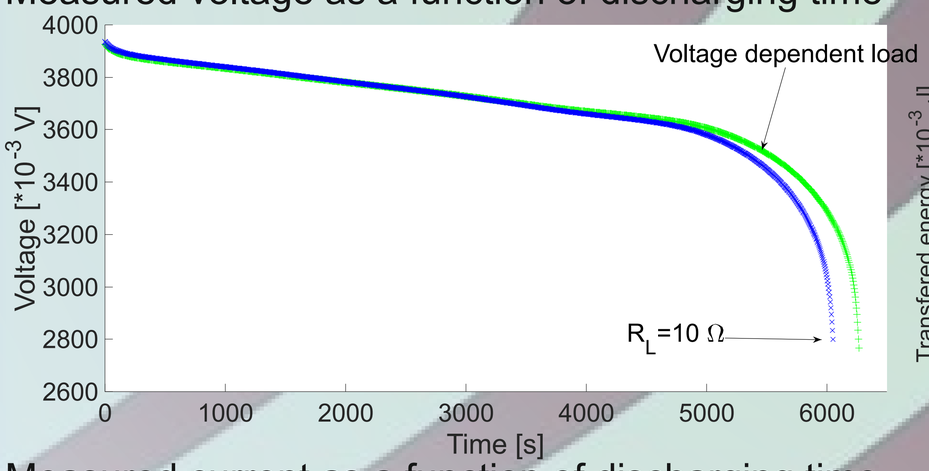
$E=i_L \cdot u_{RL}$ - energy flowing through the branch
$P=E/\Delta t$ - power transferred to $R_L$ in the time $\Delta t$
$C=i_L \cdot \Delta t$ - charge transferred to $R_L$ in the time $\Delta t$



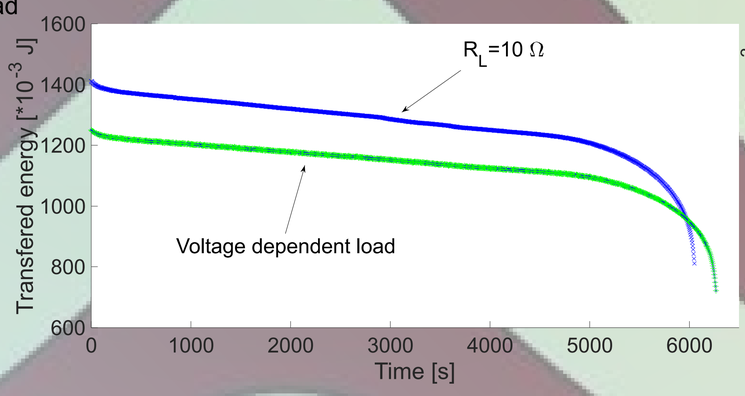

> A system for automatic measurement of the electric potential and current through a branch has been developed. Local embedded calculation of energy, power and transferred charge is performed in the Arduino Due board.
> The system has been tested on a simple one Li-Ion cell charging/ discharging circuit.
> The charging current is limited with a constant current source while the discharging current is dependent on the load resistor

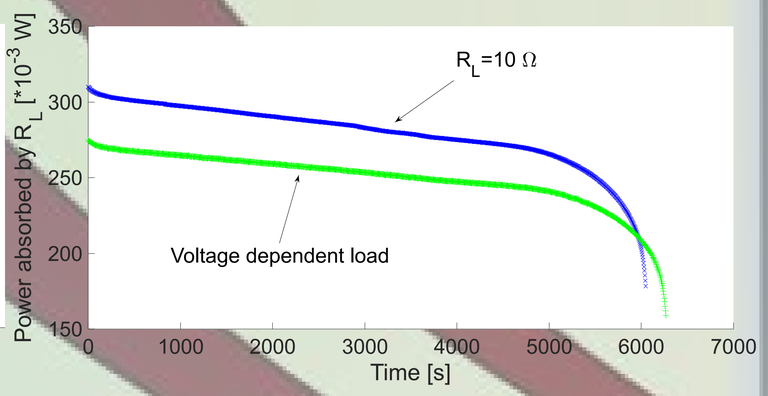
## Results and dicussions

### Measured voltage as a function of discharging time

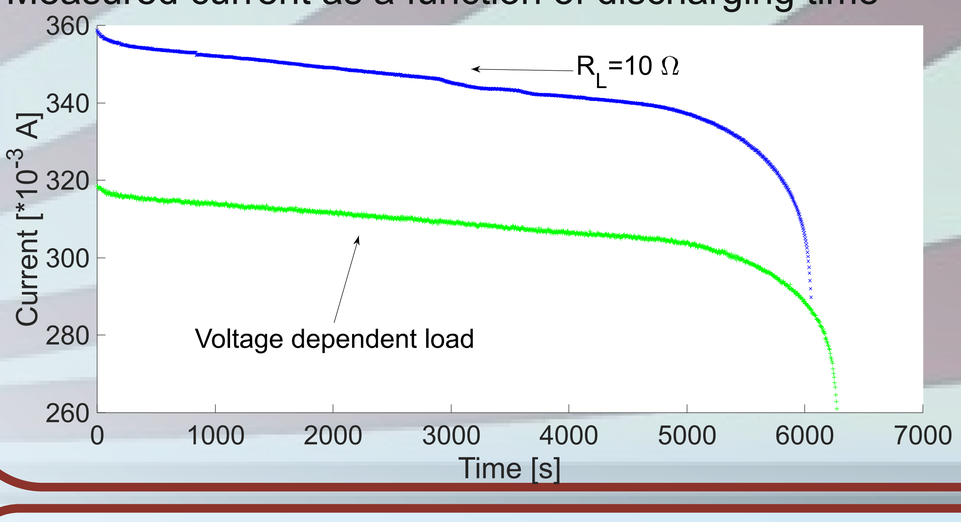



### Calculated energy and power dissipated by the load resistor

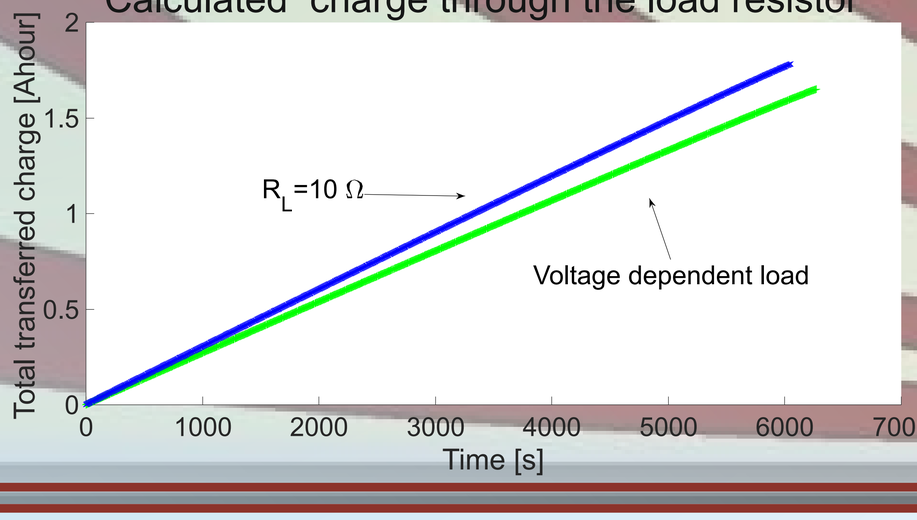



### Measured current as a function of discharging time




### Calculated charge through the load resistor




## Conclusions

- ►An energy measurement system for low voltage applications has been developed
- ►The system performs automatic measurements and of voltage, current and time
- ►Based on the direct measured quantities, the developed system can compute values of transferred energy, power and charge
- ►The system can be used to measure charge and power for applications where counting of transferred energy is important

## References

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