# *Development of an Advanced Power Management for Autonomous Micro-Robots*

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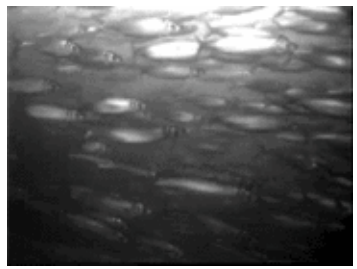
# Introduction

- Swarm robots are a population made up of agents. (school of fishes)
  - Independent to each other
  - Performing a common task



- It is supposed to put lots of these bots into work in one experience
- One of the concerns is the problem of ENERGY!

# Problem: Energy

- Each robot has two motors each consuming about 70-90 mA
- On each robot there are two microcontrollers connected to each other using a TWI BUS
- The applied Voltage is about 3.7V from a Li-Pol Battery which provides 250 mAh

# Problem: Energy

- Some calculations:
  - The practically measured current consumption:
    - Standby: 6mA
    - Working: 200mA
  - The robot works about 1 hour and 15 minutes when it is in a full working mode.
  - Practically they work round 2 hours while they are not always in full working mode

# Problem: Energy

- For longer experiences we need to provide the necessary power for the robots.
- Some of known and common resources:
  - Solar cells
  - Inductive power supply
  - Simple Recharge

# Solar cells

- Each cell provides about 1/2 volt, 1.9mA in sunlight
- Based on current amount of Energy consumption of each robot (3.7 Volts, 200mA), we need a Matrix of 8x100 of such Solar cells.
- Problems:
  - The Robots are too small and are not cable of mounting such huge area on them
  - The working environment is not necessarily under sun-light
  - What about nights?

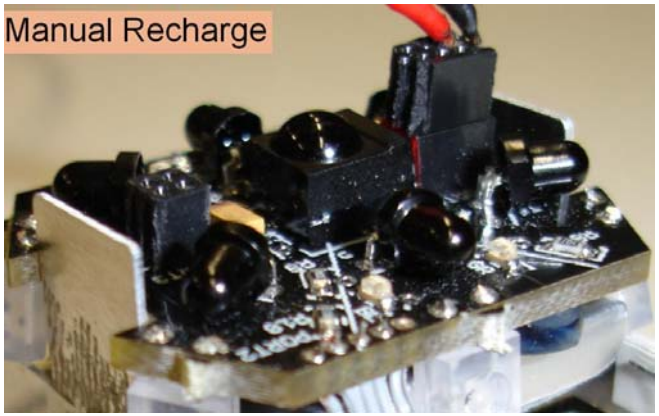
# Inductive power supply

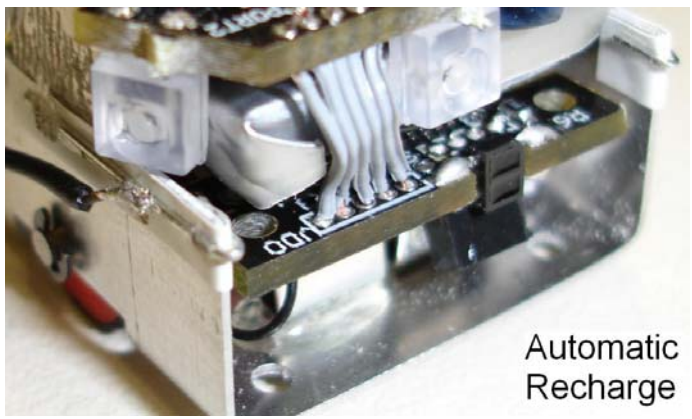
- In this approach robots are inside a very strong magnetic field.
- On each of them there is an Inductive element which inside this powerful magnetic field provides the necessary power for the robots
- Problems:
  - To provide such amount of energy we need to provide a very strong and powerful magnetic field. Such magnetic field might be harmful for other electronic components inside
  - The amount of Energy waste in this method is high

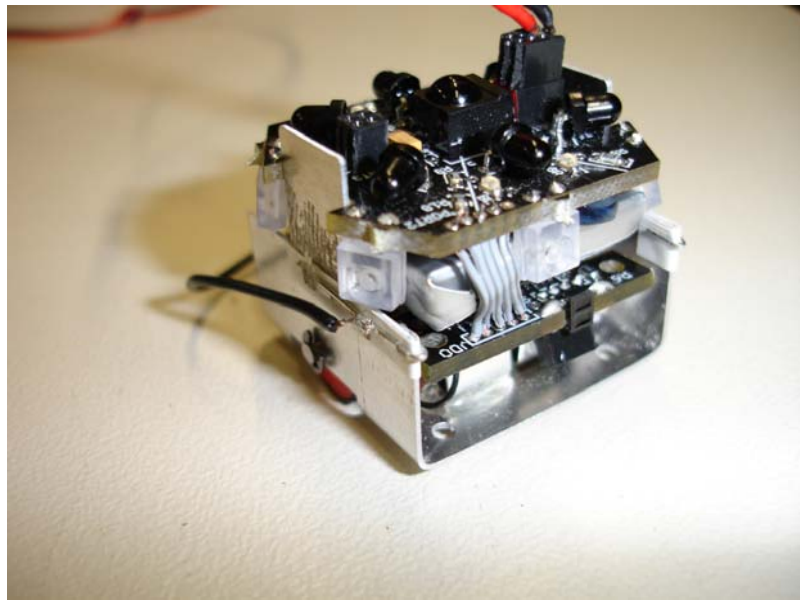
# Simple Recharge

- In this method each robot gets recharged when the level of energy of the battery gets low.
- It can be done manually or automatically
- Problems:
  - In manual mode, It causes interruption in the current task of the robot.

# Manual and Automatic Recharge



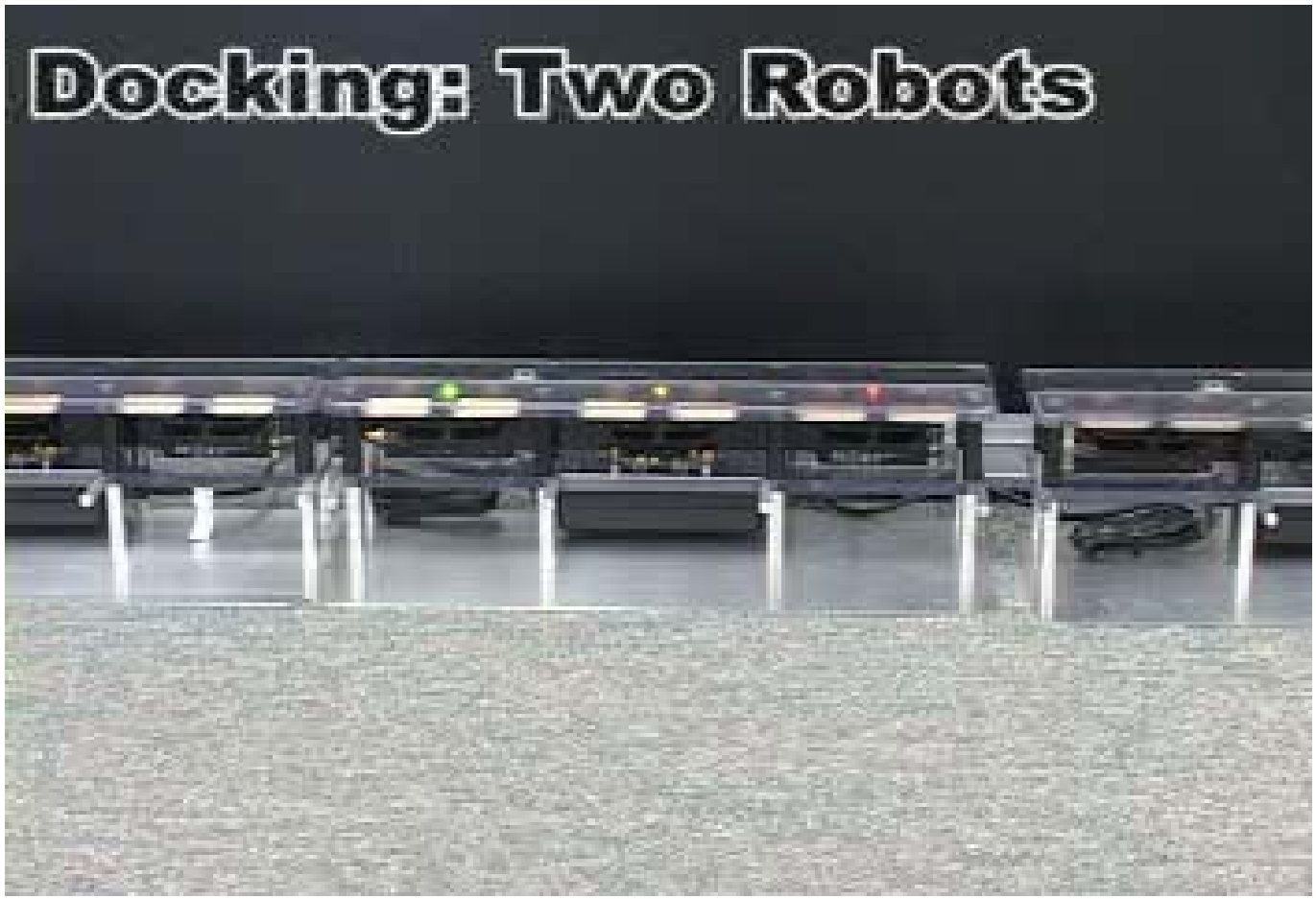
# Goal: automatic recharging

- The Goal is to add the ability of recharge to the robots while they are doing their task on the field

# What others recently have done

- MIT has developed such automatic recharging for swarm robots
- But there are differences between their work and ours:
  - The size of their robot are much bigger than ours
  - They benefit the usage of a camera to find the recharging station.

# A video from MIT



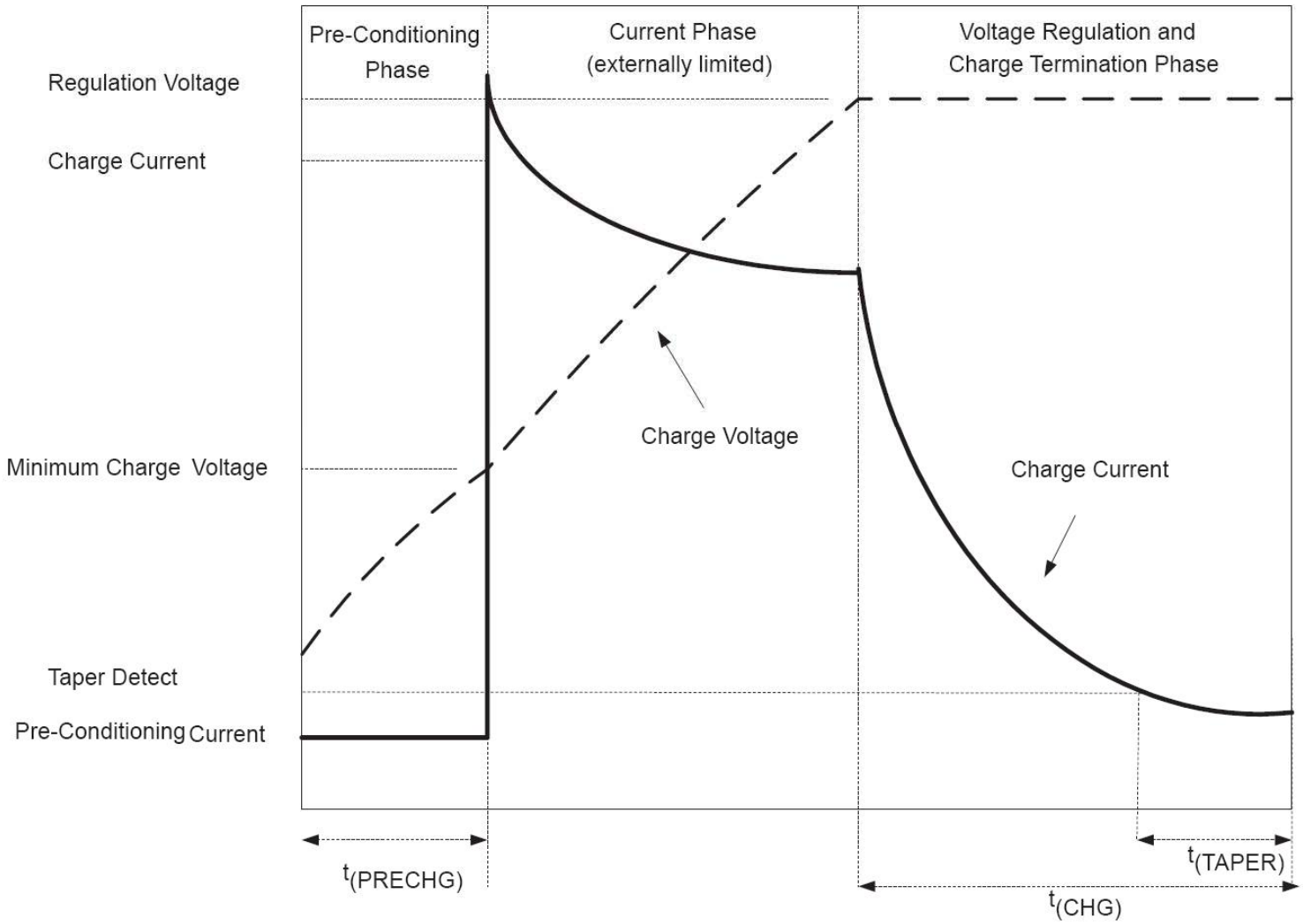
# Requirements

- A proper recharge circuitry to control the recharge process
- A docking station so that robots attach themselves to this station to recharge
- A software to control the level of energy
  - This software should also have the ability to find a free station to recharge

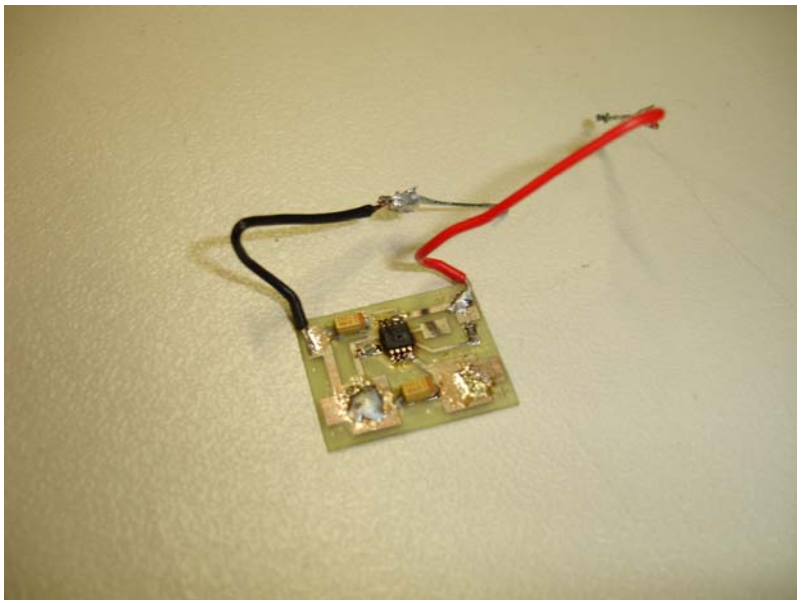
# Hardware: Power control chips...

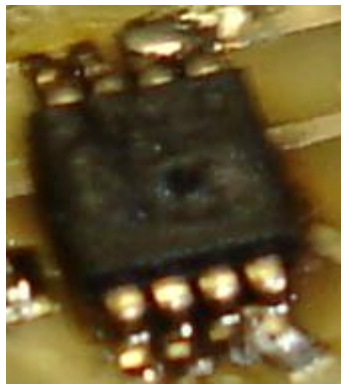
- Texas Instruments bq24200
  - Works specifically with current limited wall supplies
  - Max. Current supply: 500mA
  - Charge-in-progress, charge completion and fault conditions
  - ....

## APPLICATION INFORMATION



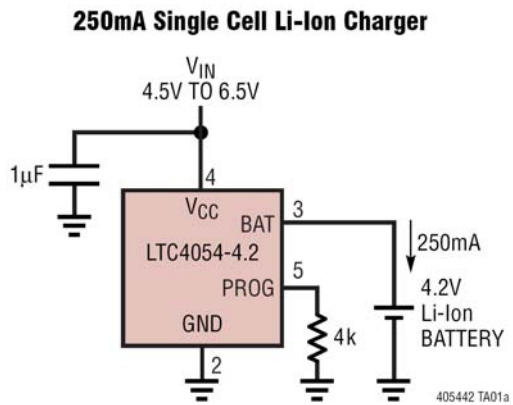
# Developed circuit



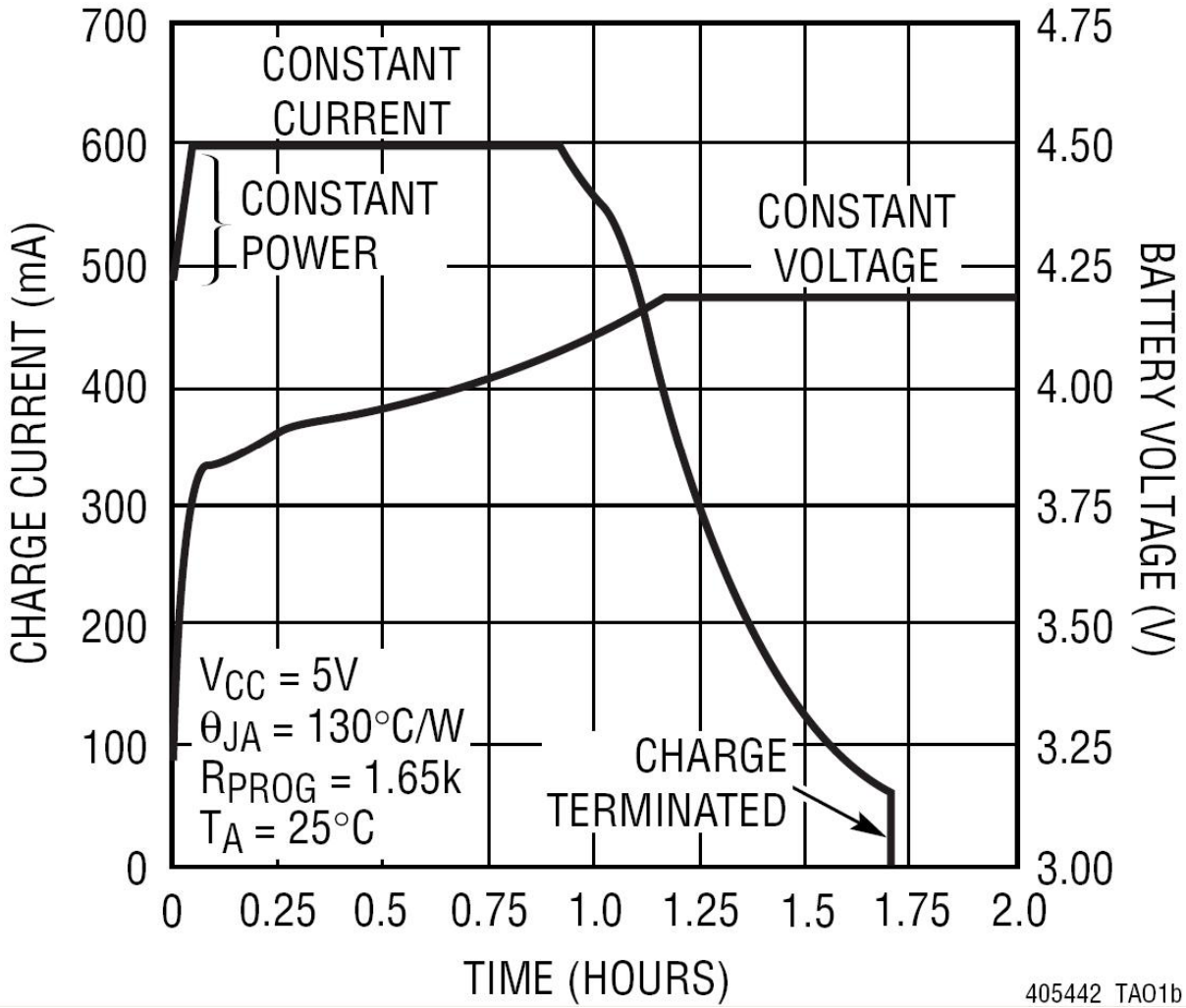


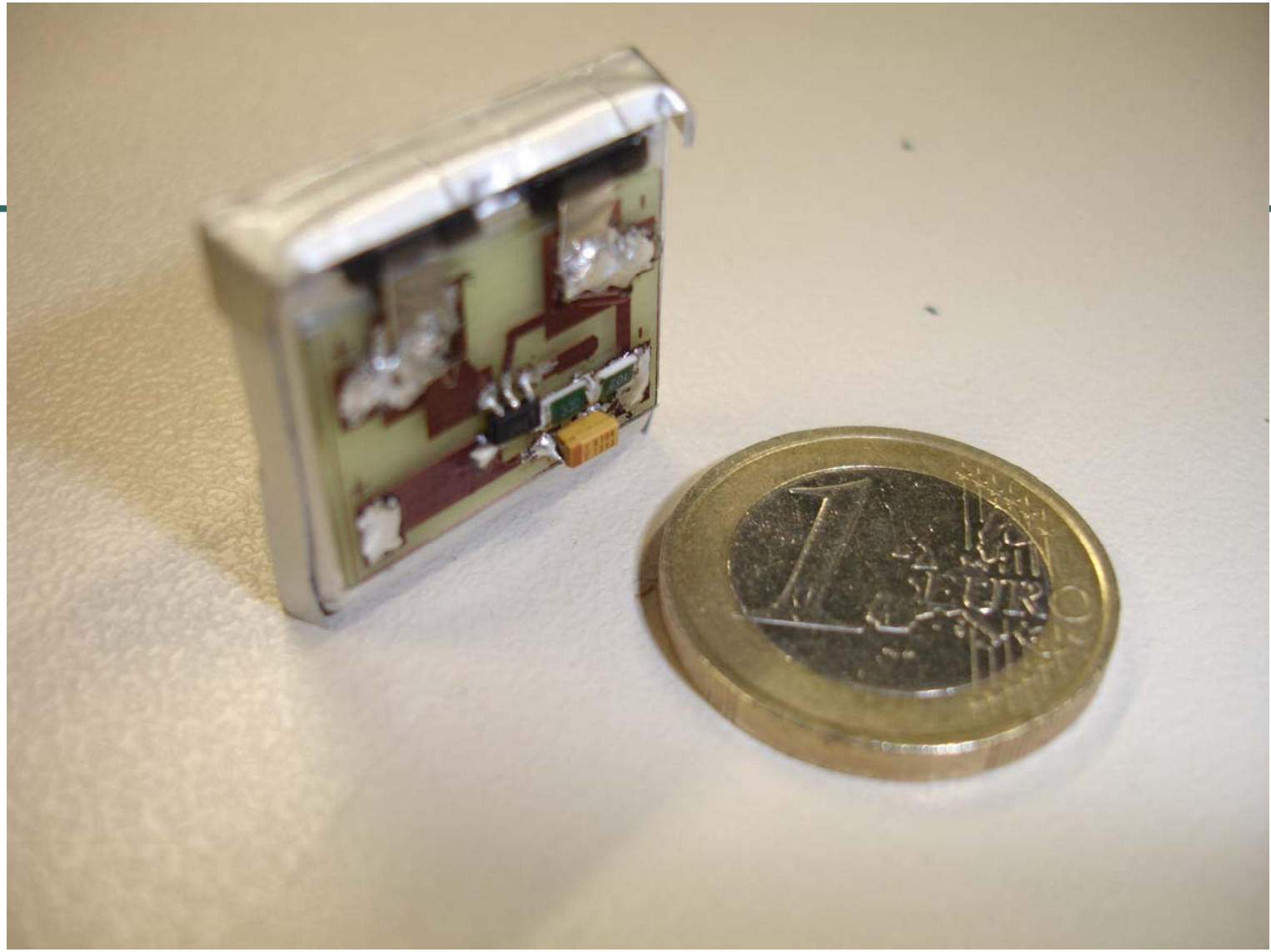
# ...Hardware: Power control chips

- Linear Technology LTC 4054-4.2
  - Programmable Current Up to 800mA
  - No MOSFET, sense resistor or Blocking Diode is required
  - Constant Current/Constant Voltage Operation with thermal regulation



# Complete Charge Cycle (750mAh Battery)

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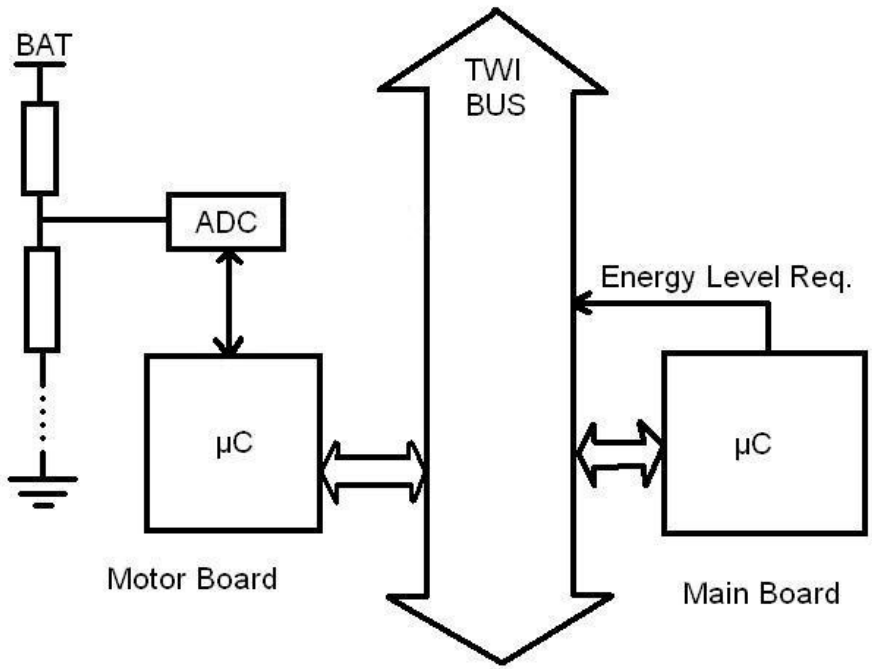
# Software

- How can robot understand that the energy level is now so low that it needs a recharge?



# What to be done yet

- Optimizing the energy consumption on each element:
  - IR-LEDs
  - Micro Controllers
- Solving problems regarding lack of orientation
- Improvement of the design of the chassis to minimize the friction between gears

# Future

- Development and Implementing software based on genetic programming to give the ability of partially learning and dynamic programming to the robots

# Thanks for your Attention

Any Questions?