R&D PROJECTS
@
EMBEDDED SYSTEMS RESEARCH GROUP
CAMPUS DE NAYER

Patrick Pelgrims

AmiEs-2015, 24-26 September
@
Vives UC, Ostend, Belgium

EMBEDDED SYSTEMS RESEARCH TEAM

- **Coordinator:**
  - Patrick Pelgrims
- **Members**
  - Wim Dams
  - Jan Derua
  - Marc Roggemans
  - Marc Scheirs
  - Lars Struyf
  - Bart Tanghe
  - Johan Van Bauwel
  - Dirk Van Merode
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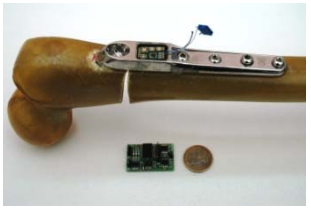
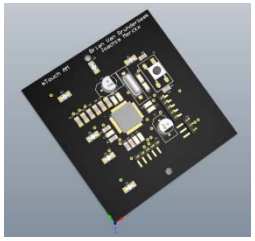
EMSYS VISION

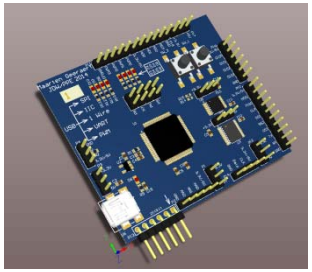
- As a research group specialized in embedded systems, our goal is to build and use our expertise in the development of state-of-the-art digital, analog and software systems, both for the industry and in support of the Electronics-ICT curriculum.
- Development happens from design to realization as proof-of-concepts, demonstrators, industrial cases or prototypes.

SOME EMSYS - PARTNERS

TARGET MARKETS AND APPLICATION EXAMPLES

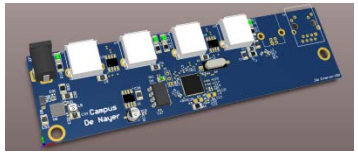
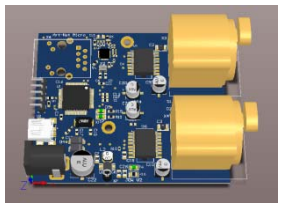
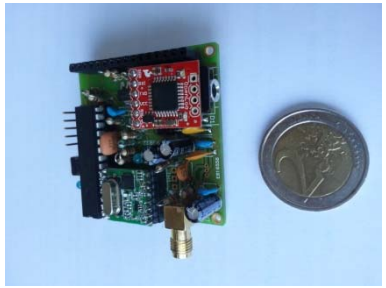
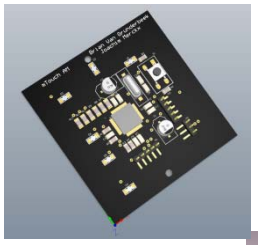
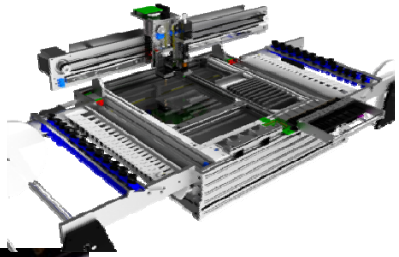


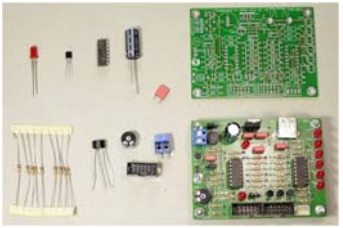


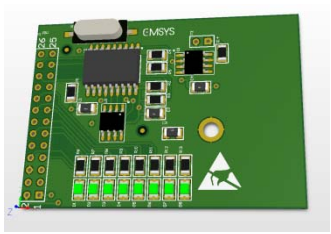


CURRENT PROJECTS

- Industrial oriented projects
  - USB-Ethernet, Ethernet-DMX
  - KNX
  - Pick & Place
  - Pico Satellite
  - Etc…
- Development for education and advisory services
  - KIT1, XC888
  - Raspberry
  - FPGA, ZYNQ
  - Elektor etc…

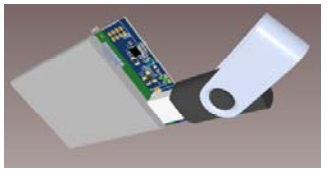
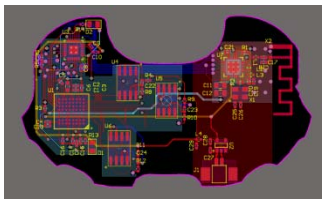
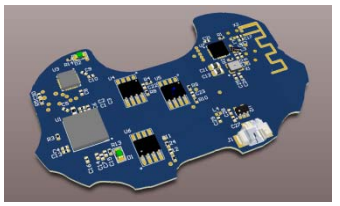






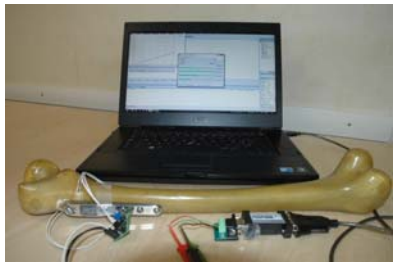
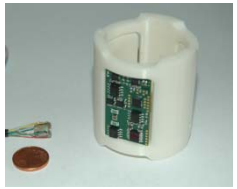
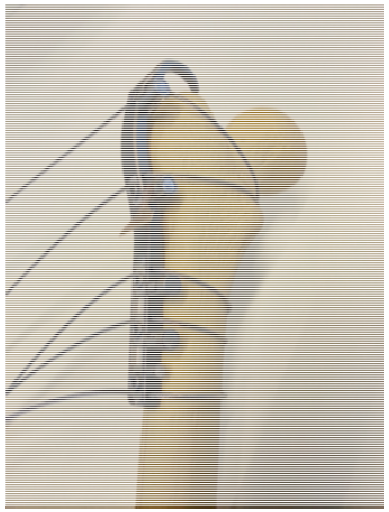


CURRENT BIOMEDICAL PROJECTS

- Instrumentation for orthopedic applications (PWO INS-OT)
  - Embedded orthese pressure sensing and logging system
  - Implantable Knee angle measurement system

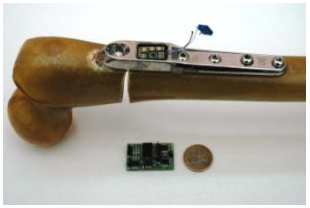





- Instrumentation for biomedical applications
  - Orthopedic instrumentation and measurement system
  - Sensor design (MICAS ESAT)
  - Synergy between University MICAS ESAT KU Leuven and Thomas More UC

PWO INS-OT

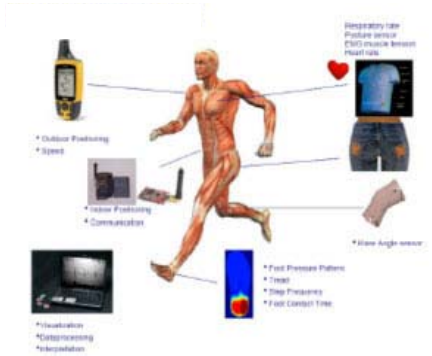
EMSYS | EMBEDDED SYSTEMS TECHNOLOGY @THOMAS MORE



EmSys develops and realize analog, digital and software systems for different application domains based upon:

- FPGA
- PCB
- Microcontrollers
- Sensors
- Microprocessors
- Embedded OS
- Embedded Software
- Communication

MOBILAB | EXPERTISECENTRUM WELZIJN & TECHNOLOGIE @THOMAS MORE



MOBILAB uses *off-the-shelf* sensors and measurement systems but they are expensive, not always mobile and have limitations like:

- Size
- Power
- Resolution
- Accuracy
- Open interface
- Synchronization
- Multi purpose

PWO INS-OT CASES

MOBILAB | EXPERTISECENTRUM WELZIJN & TECHNOLOGIE @THOMAS MORE

Orthopaedic

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E-MSYS | EMBEDDED SYSTEMS TECHNOLOGY @THOMAS MORE

Electronics-ICT

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Embedded Orthopaedic Applications

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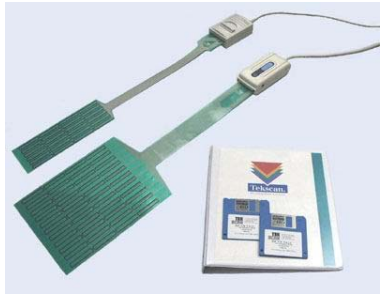

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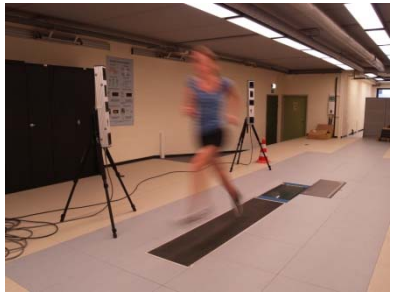
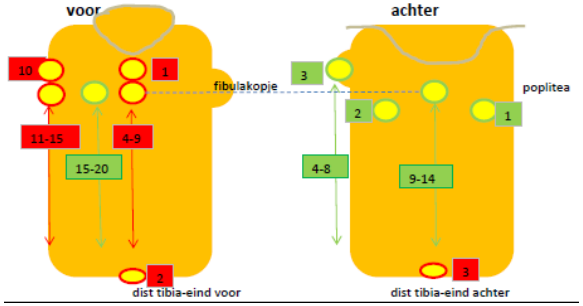


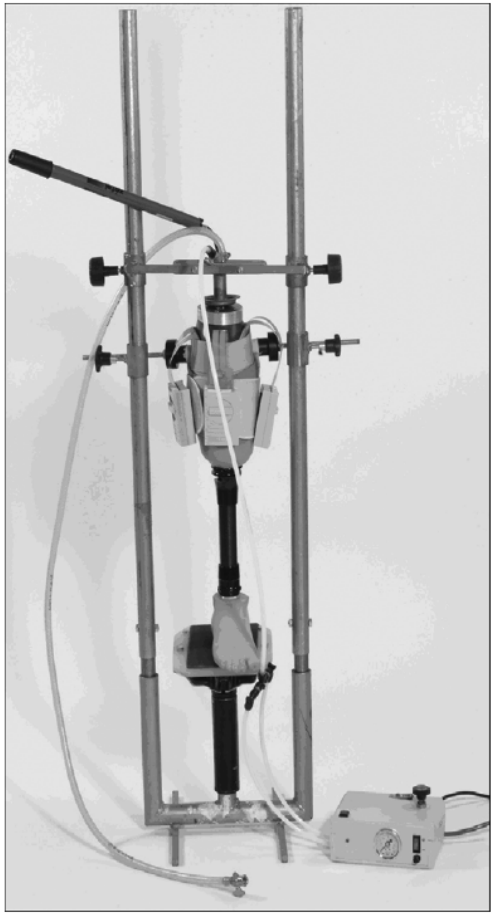
PROSTHESIS SYSTEM SPECIFICATIONS

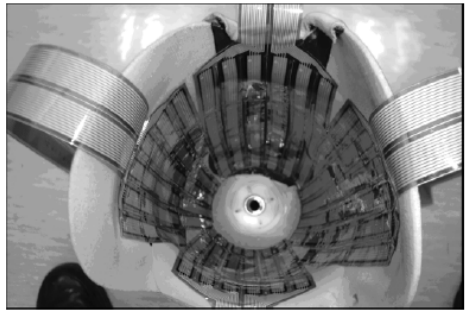
- Lower leg prosthesis

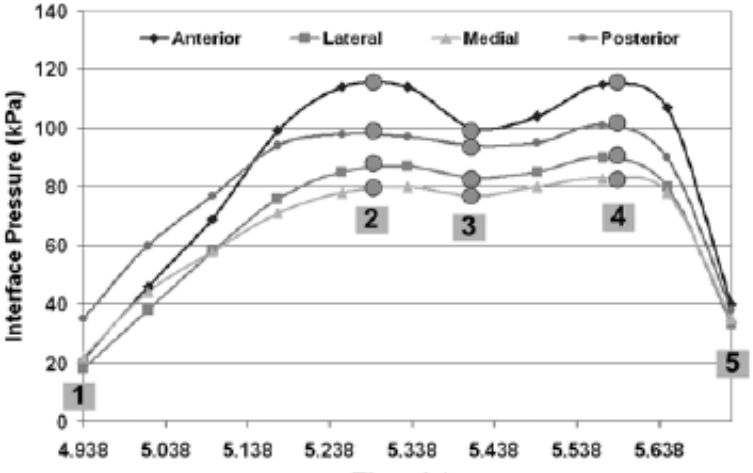
Orthese Socket	Max. Sens. area.	Measurement range	Precision	Sample Frequency	Number of sensors	Sync.
High end pressure	10x10mm	0psi tot 50psi	<2%	5 tot 200Hz	N x 16	Coda MOTION.
High end temperature.	10x10mm	10°C tot 50°C	0,1°C	**5 tot 200Hz**	N x 16	Coda MOTION.
Low end pressure	10x10mm	0psi tot 30psi	<10%	50Hz	16	RF
Low end temperature	10x10mm	10°C tot 50°C	<10%	**50Hz**	10	RF

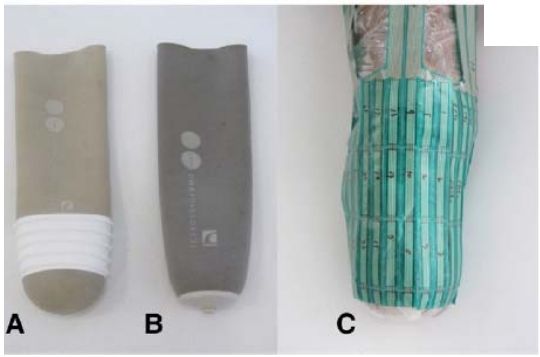


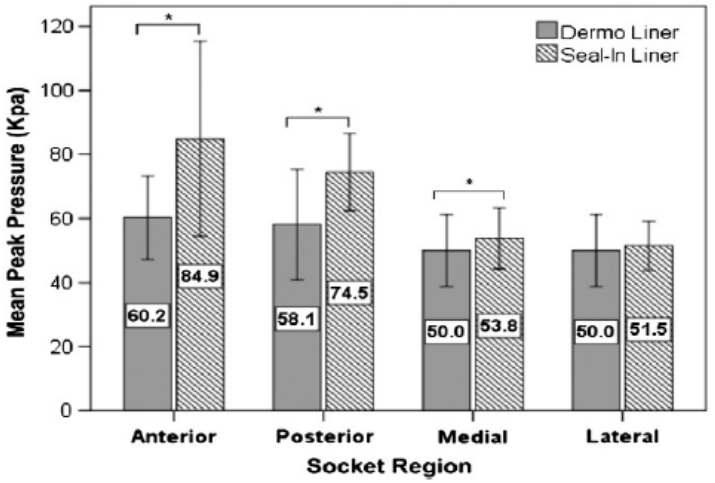
EXISTING AND EXPENSIVE SOLUTION





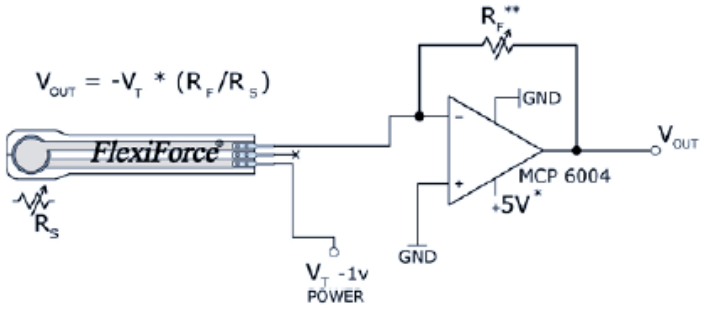




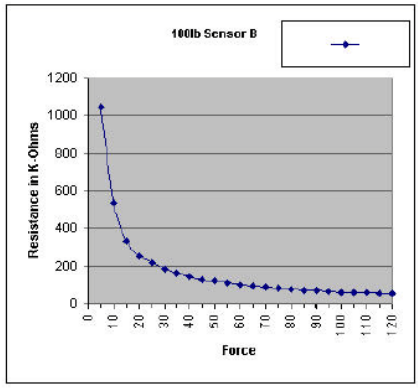


INS-OT: PROPOSED SENSOR USAGE

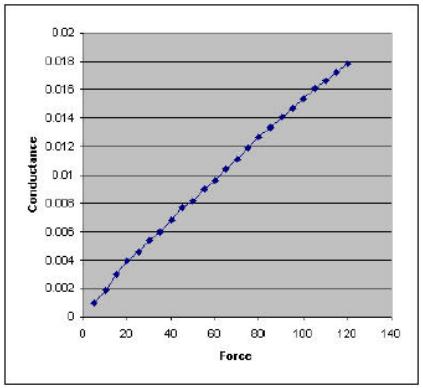
- ‘FlexiForce ™’ sensor based



Resistance Curve:



Conductance Curve:



STANDARD FLEXIFORCE SENSOR (MODEL A201)

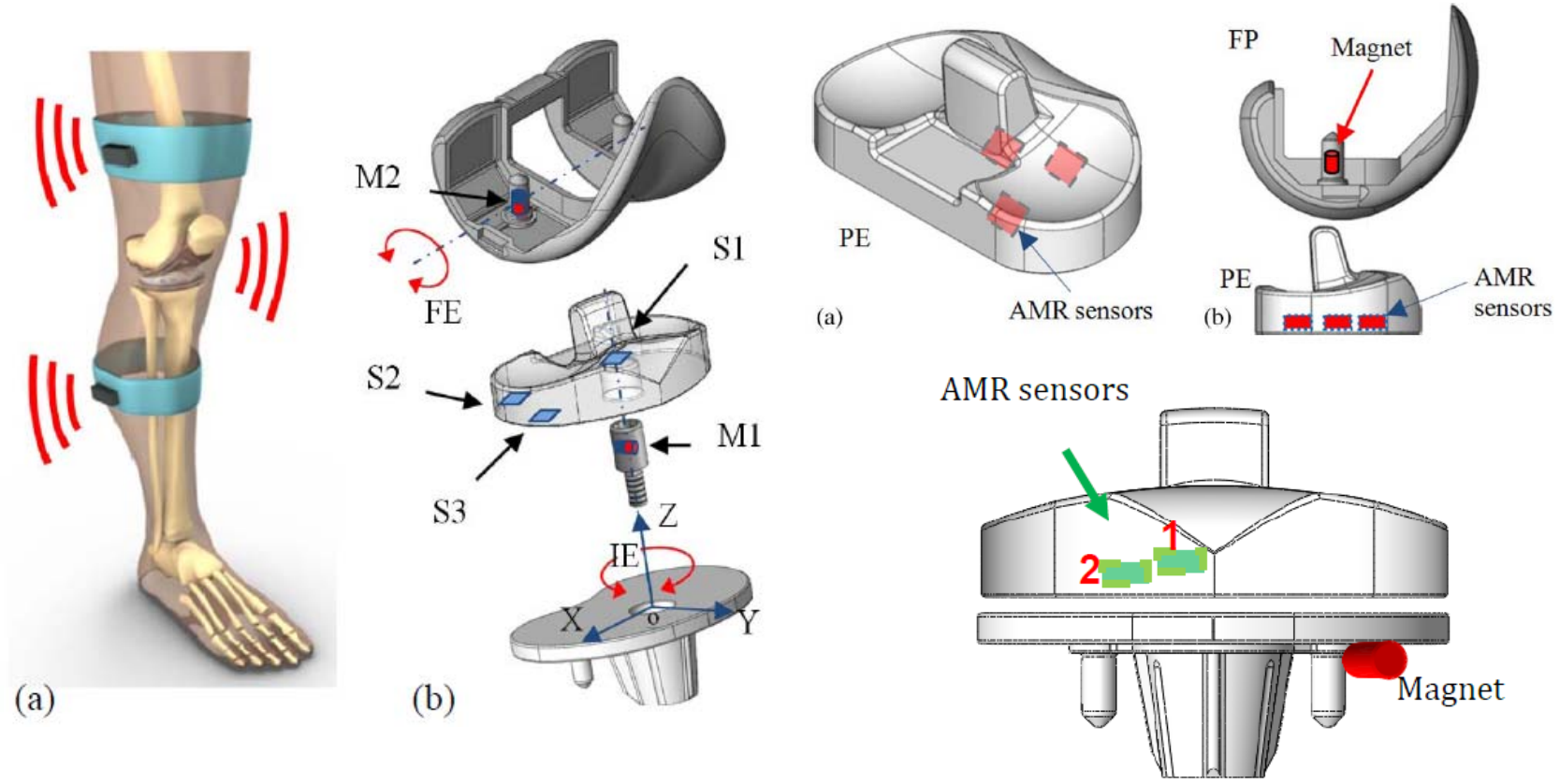
Thickness	0.008 (0.208 mm)
Length	8” (203 mm) 6” (152 mm) 4” (102 mm) 2” (51 mm)
Width	0.55” (14 mm)
Sensing Area	0.375” (9.53 mm) diameter
Connector	3-pin male square pin (center pin is inactive)
Force Ranges	0-1 lb (4.4 N) 0-25 lbs (110 N) 0-100 lbs (440 N)*
Operating Temperature Range	15°F to 140°F (-9°C to 60°C)
Linearity (Error)	+/- 3%
Repeatability	+/- 2.5% of full scale (conditioned sensor, 80% force applied)
Hysteresis	<4.5% of full scale (conditioned sensor, 80% force applied)
Drift	<5% per logarithmic time scale (constant load of 90% sensor rating)
Response Time	<5 microseconds
Output Change/Degree F	Up to 0.2% (~0.36% / °C). Loads <10 lbs, operating temperature can be increased to 165°F (74°C).

REQUIRED SYSTEM SPECIFICATIONS

- Knee angel measurement

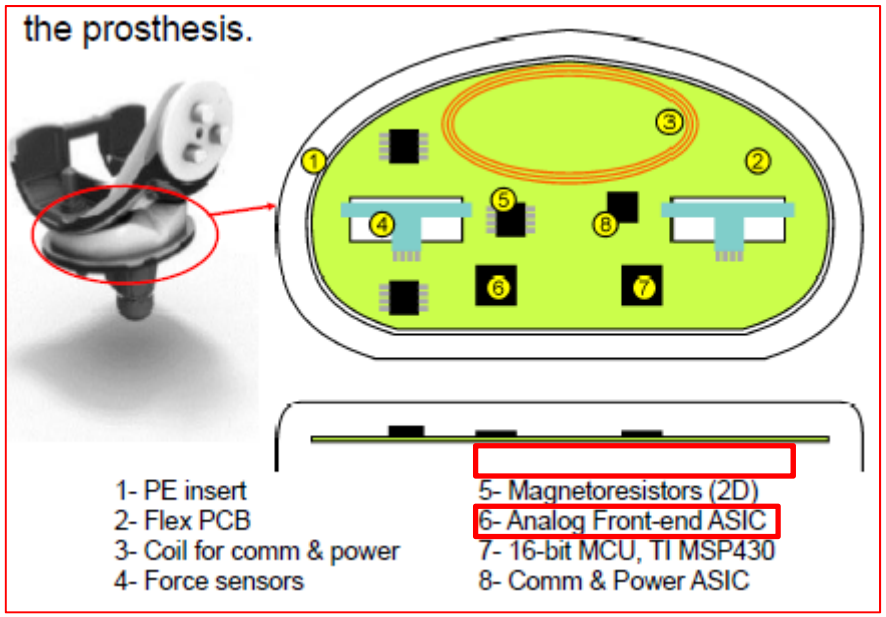
Knee Implant	Max. Sens. Area.	Measurement	Resolution	Sample Frequency	Cabling	Sync.
High end	Integrated in the knee	f/e, v/v	Angle better than 2°	5 tot 200Hz	in knee spacer	Coda MOTION
Low end	Integrated in the knee	f/e, v/v	f/e: 5°, v/v: 2°	50Hz	in knee spacer	RF

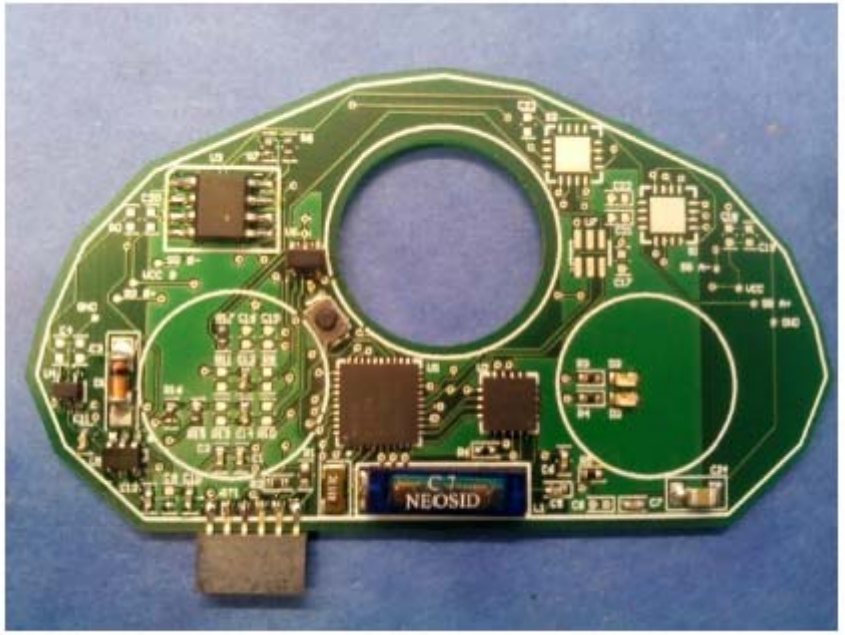
KNEE ANGLE MEASUREMENT CONCEPT



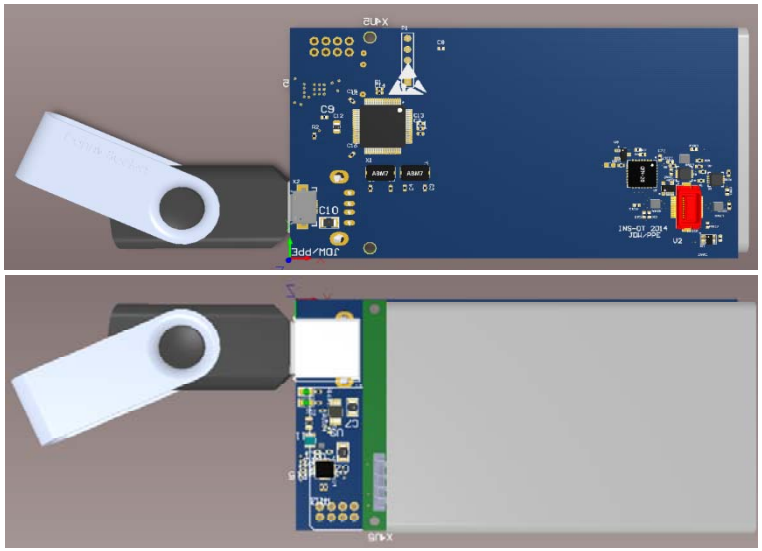
INS-OT PROPOSED SOLUTION (ARAMI)

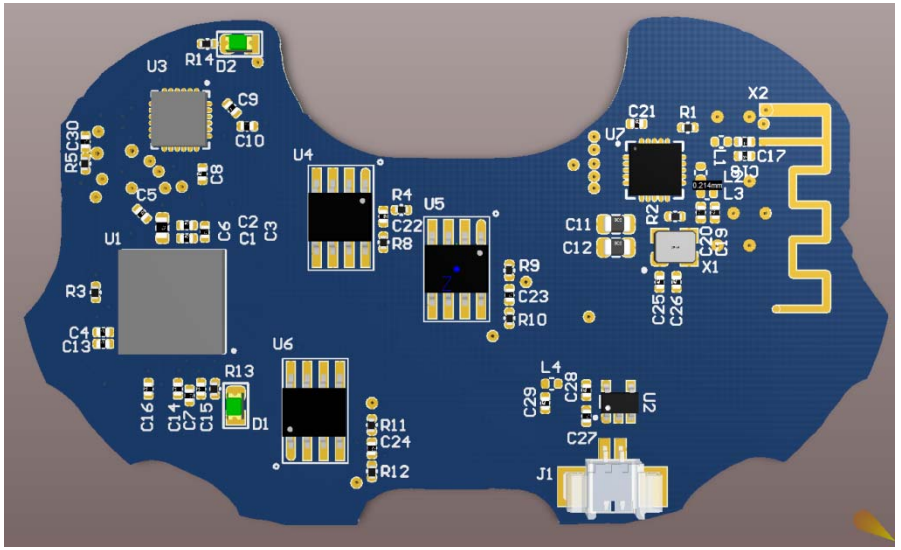
- Prototype principle based on ‘Magnetism’
- C.O.T.S. solution in stead of multiple ASIC !





TARGET DEVICES: ORTHESE & E-KNEE





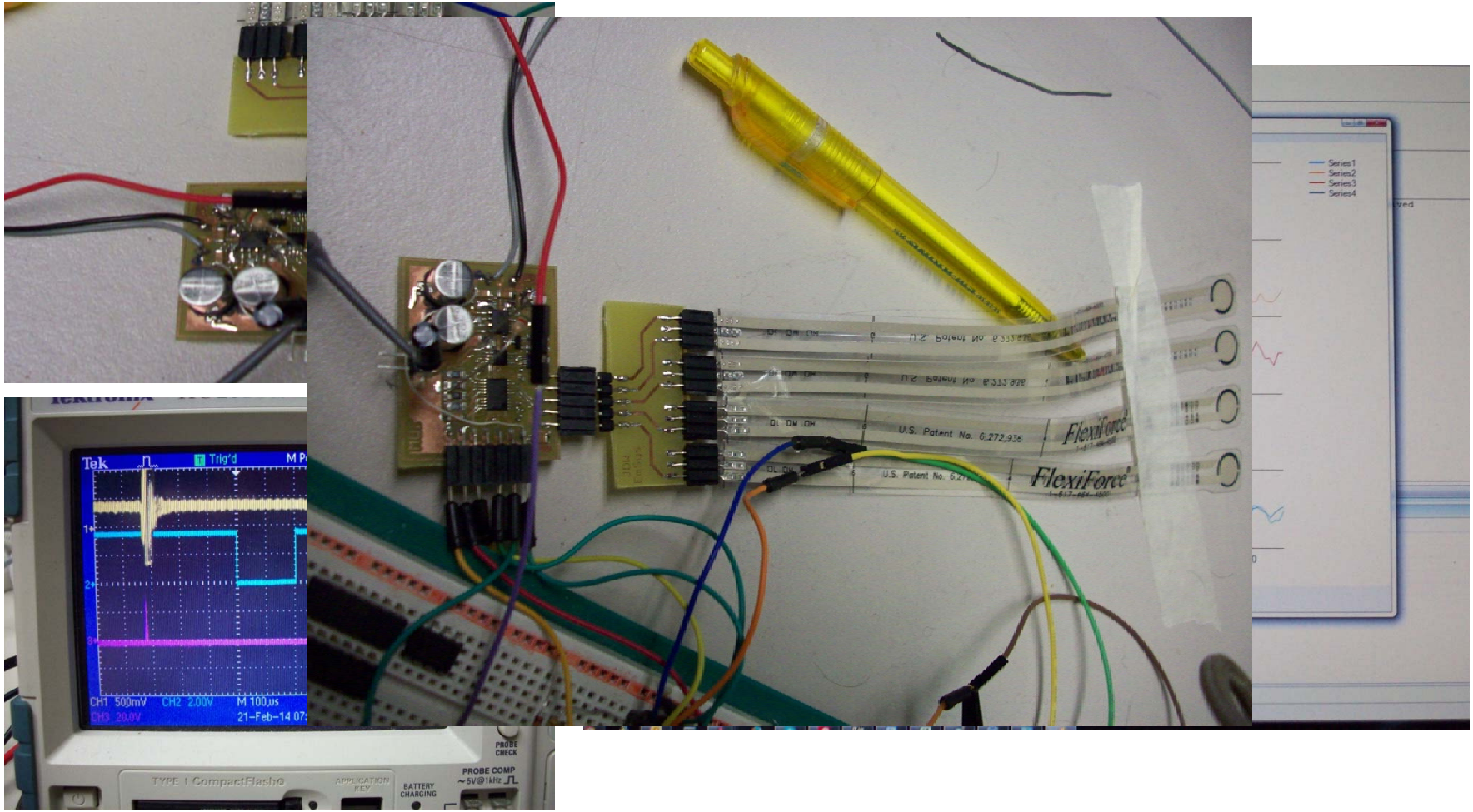
Requirement and Specifications for Logger

- Resistive pressure sensors
- 16 channels individual configurable
- Sampling rate up to 200Hz
- Resolution better than 8 bit (e.g. Tekscan ™)
- Lifetime exclusive RF 24h
- Local data storage (USB Stick up to 32GB)
- USB and wireless interface

Requirement and Specifications for E-Knee

- Knee with build in strong magnet(s)
- 6 magnetic sensors
- Sampling rate up to 200Hz
- Resolution better than 16bit
- Targeting inductive powering (communication)
- No local data storage
- Integrated wireless interface

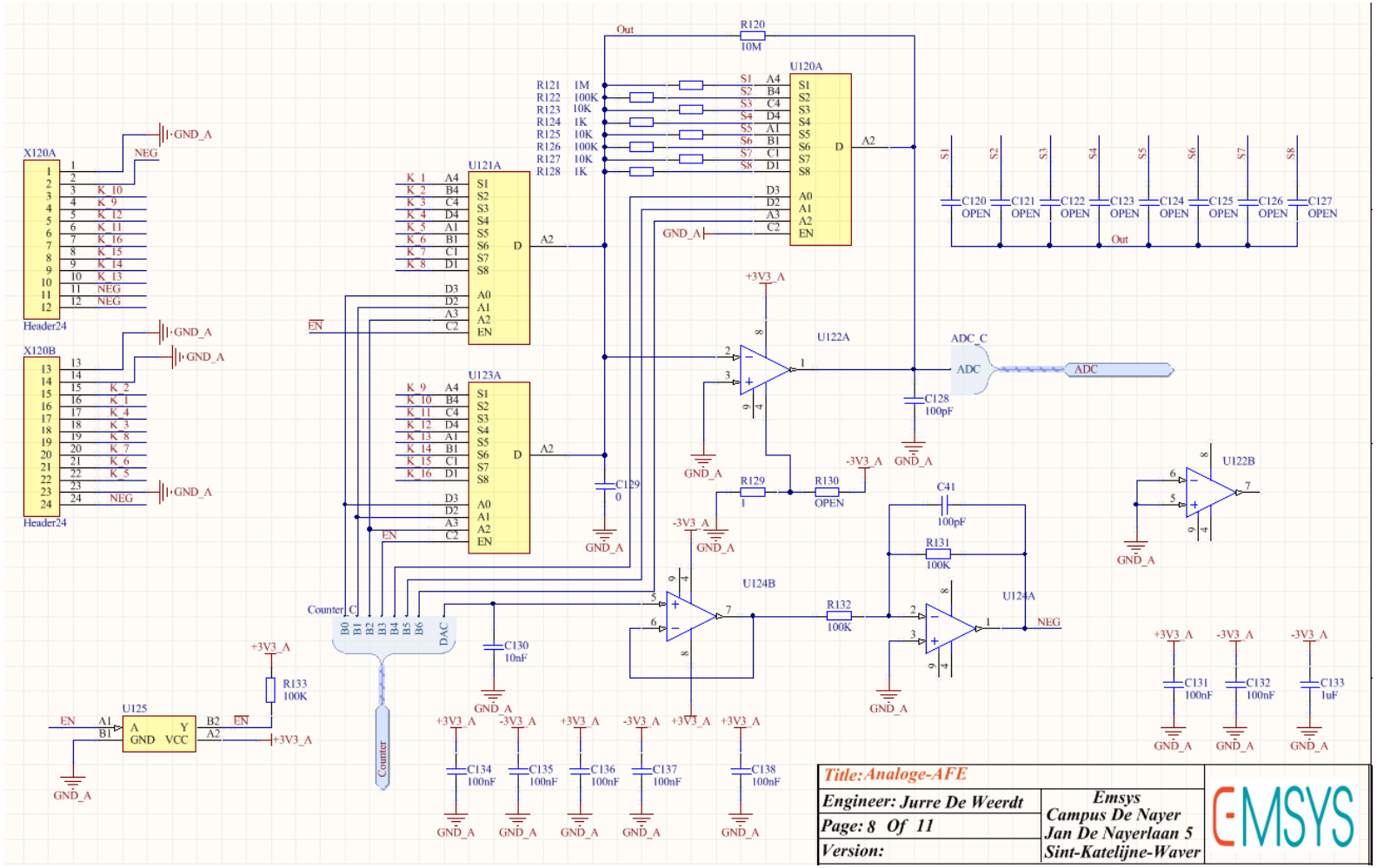
ORTHESE: AFE PROTOTYPE VALIDATION



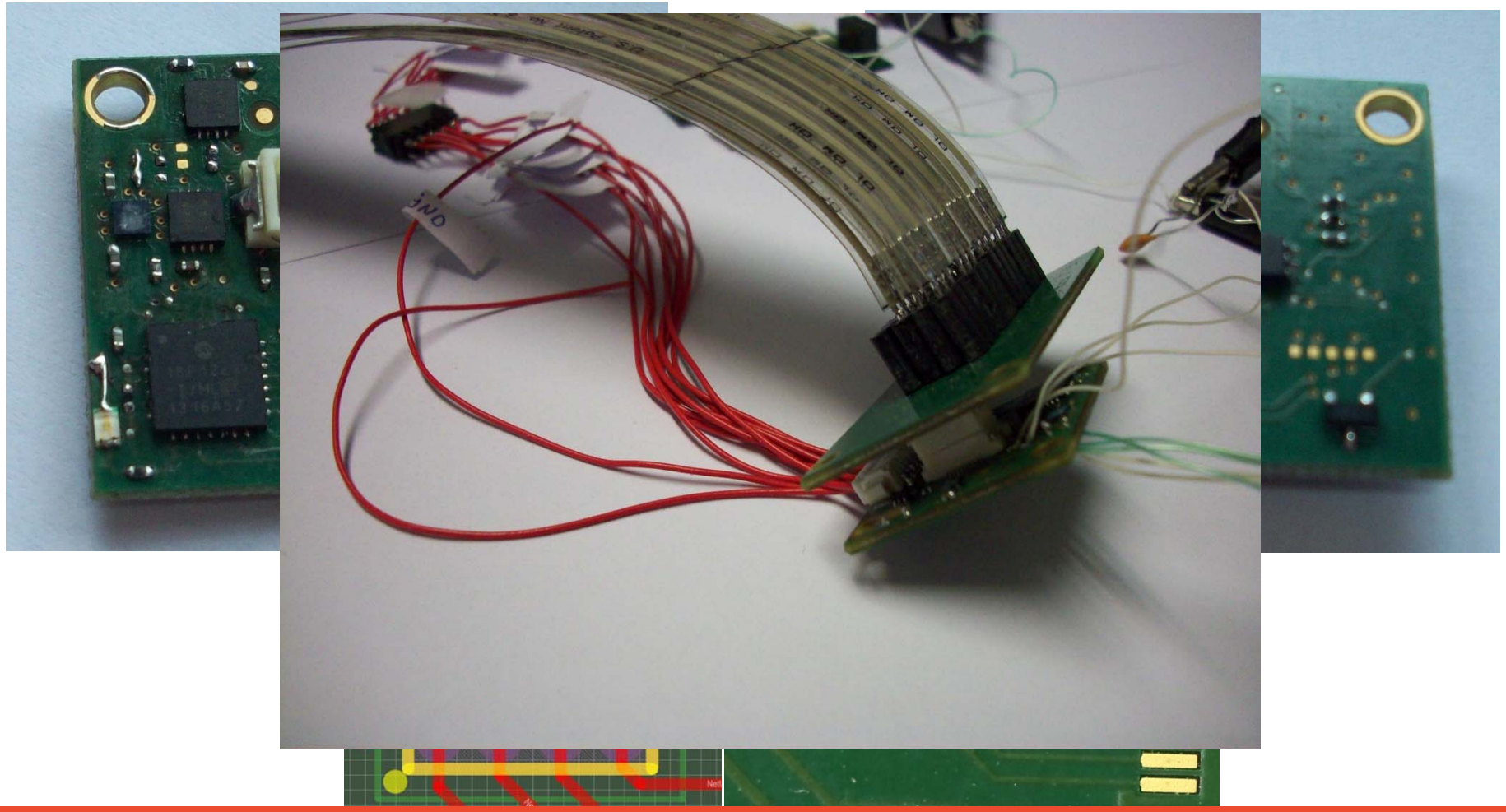
ORTHESE: 16 CHANNEL AFE

- 16 Channel time multiplexing prototype
- 1/16 current consumption !
- Total current consumption less then1.5mA @3.3V
- AFE on-board data handling and processing
- Miniaturized design for patient comfort
  - Ultra fine pitch BGA
  - 100µm technology (limit PCB size and manufacturing cost)
  - Ultra small drill hole technology (200µm diameter)
  - Li-ion battery based
  - Ultra Low Power (ULP) analog and digital circuitry
- Realized AFE size: 20mmx24mm (Incl. µC)

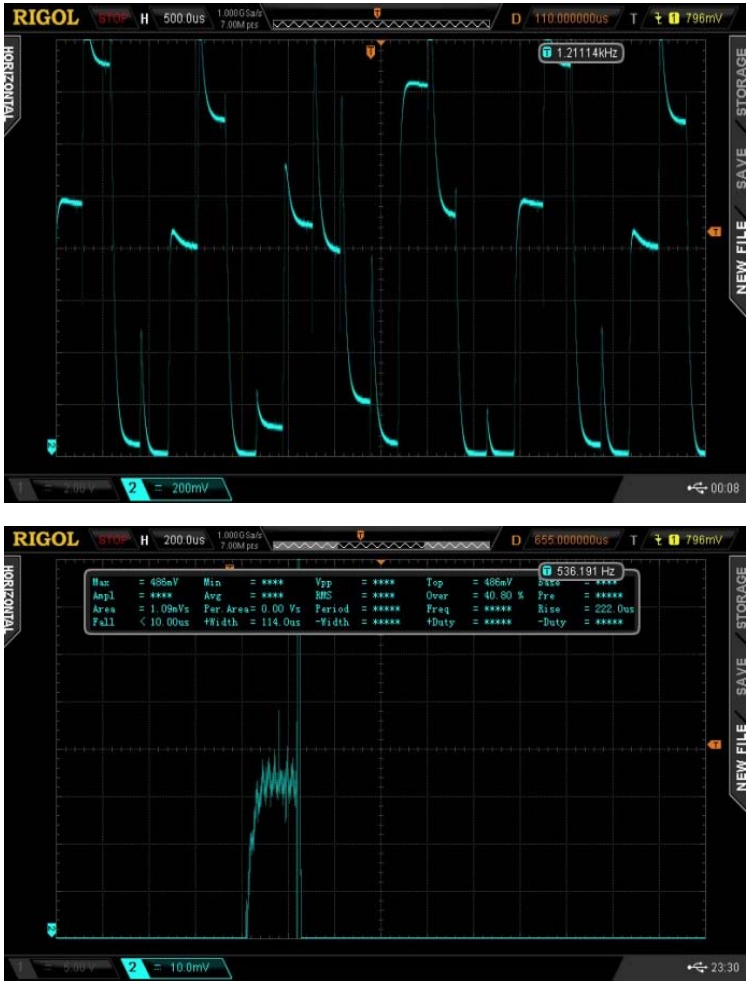
ORTHESE: 16 CHANNEL AFE SCHEMA

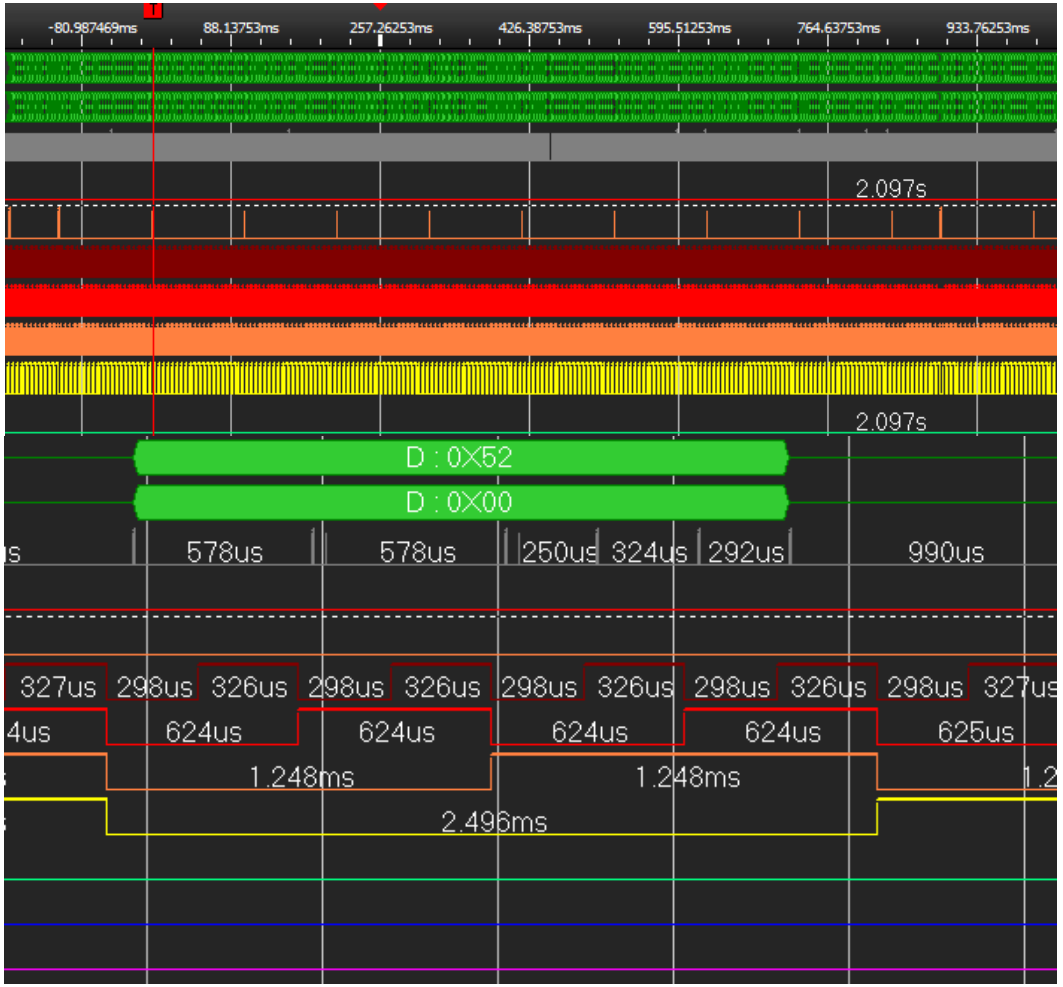


ORTHESE: AFE 16CHANNELS PROTOTYPE

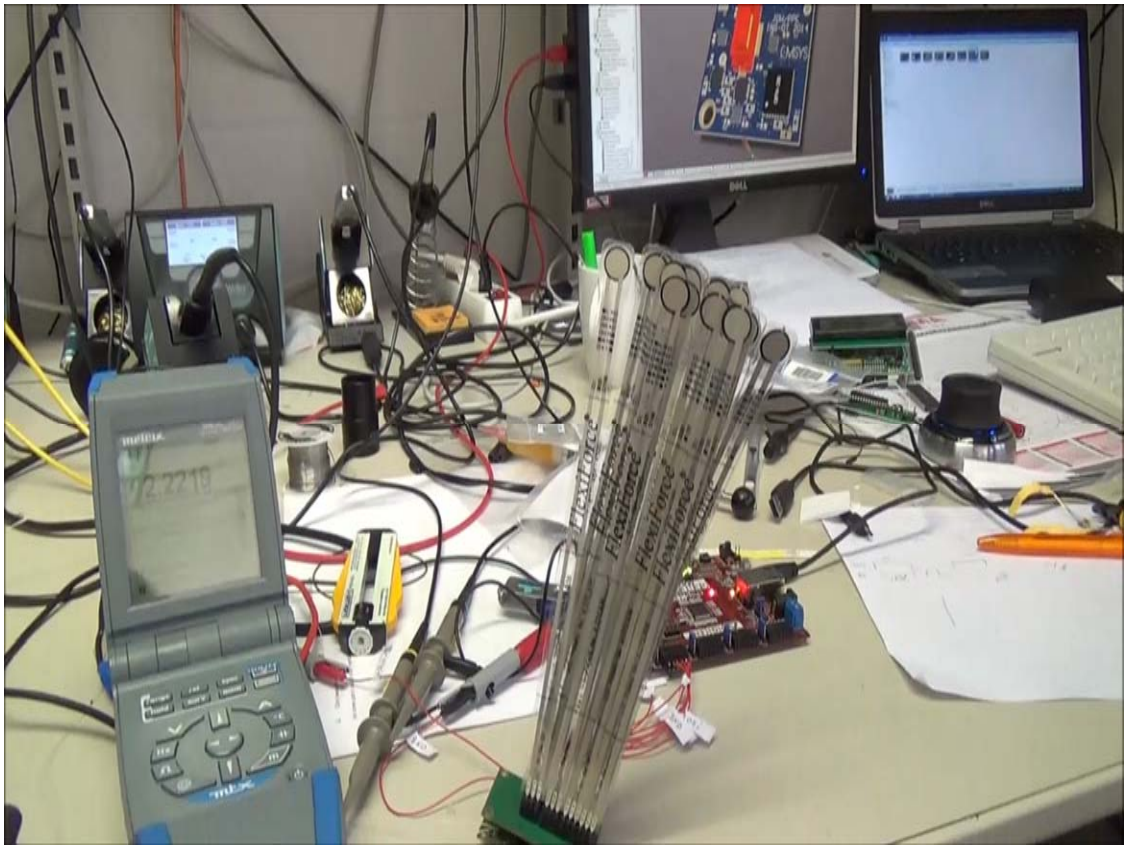


ORTHESE: AFE PROTOTYPE SIGNALS





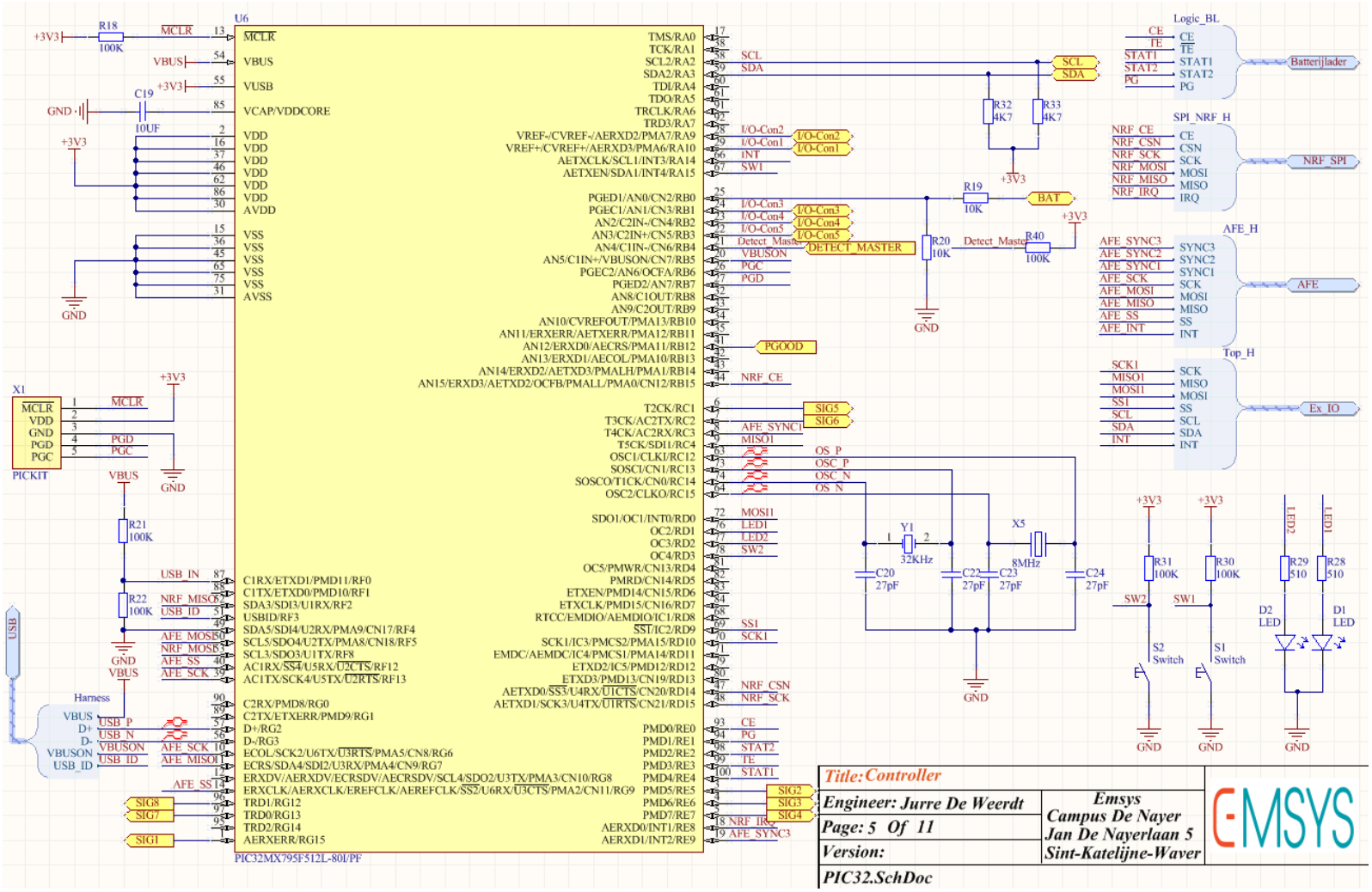
ORTHESE: AFE IN ACTION



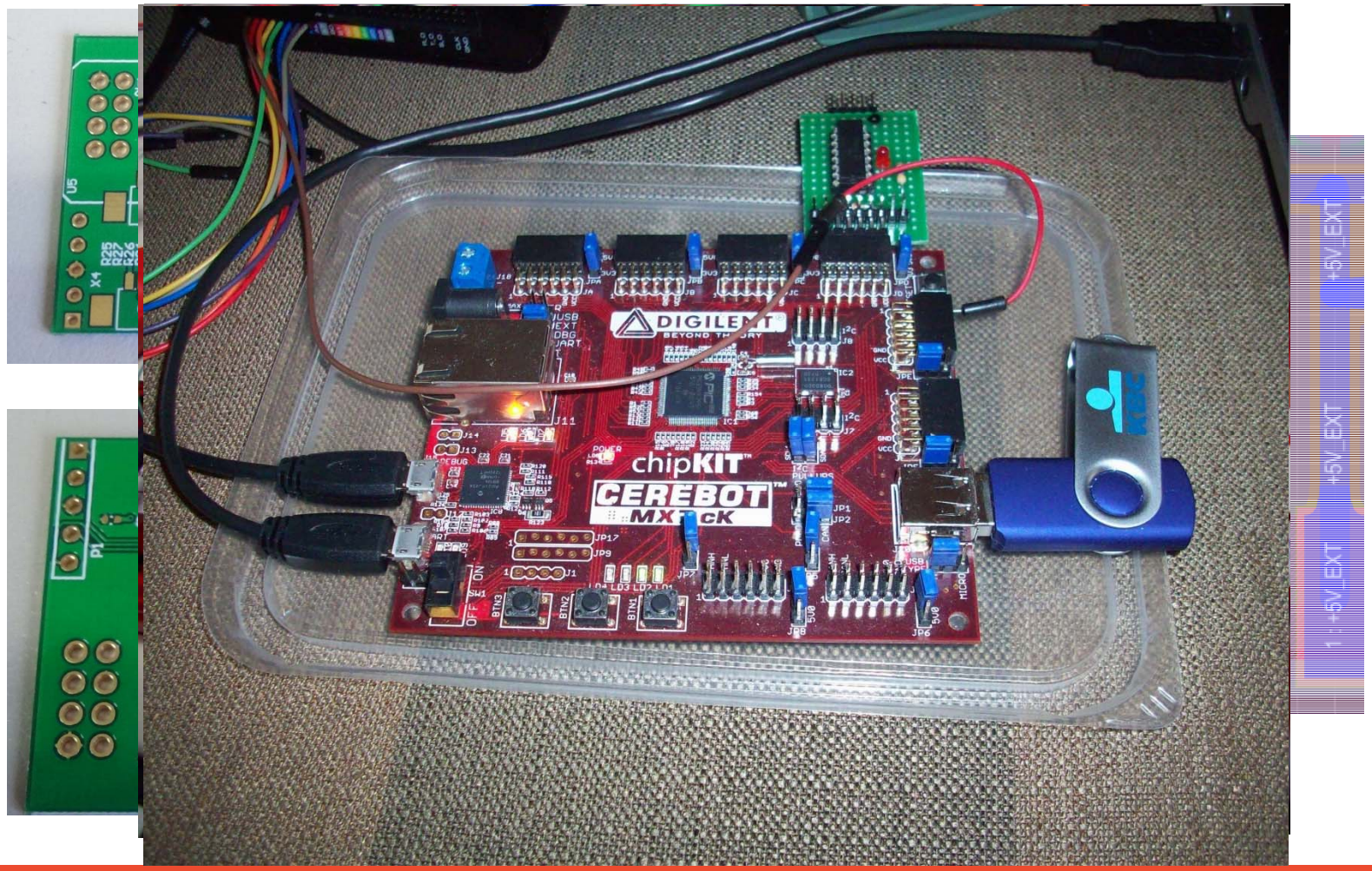
ORTHESE: MAIN LOGGER FEATURES

- Power circuitries for: USB, µC, AFE, RF
- Microchip PIC32 based system
- SPI+ for AFE data handling and configuration
- Real Time Clock and Calendar function
- Up to 5 external input for e.g. synchronization
- USB HOST (MSD or other USB to … devices)
- USB Slave (configuration and software update)
- Onboard Microchip Li-Ion Battery manager
- RF communication SPI NRF24L01+ module
- User interface (buttons, e-paper LCD,…)

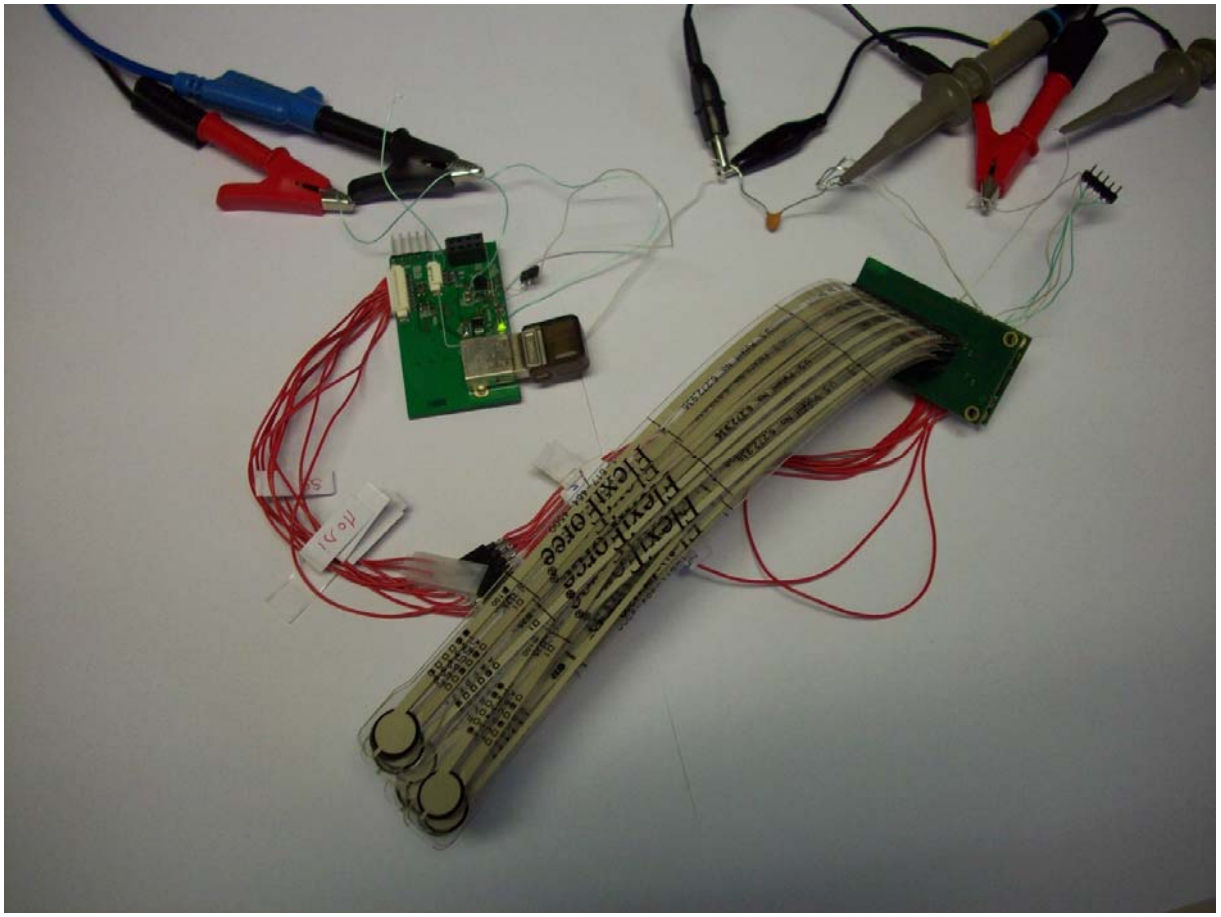
ORTHESE: LOGGER SCHEMATIC



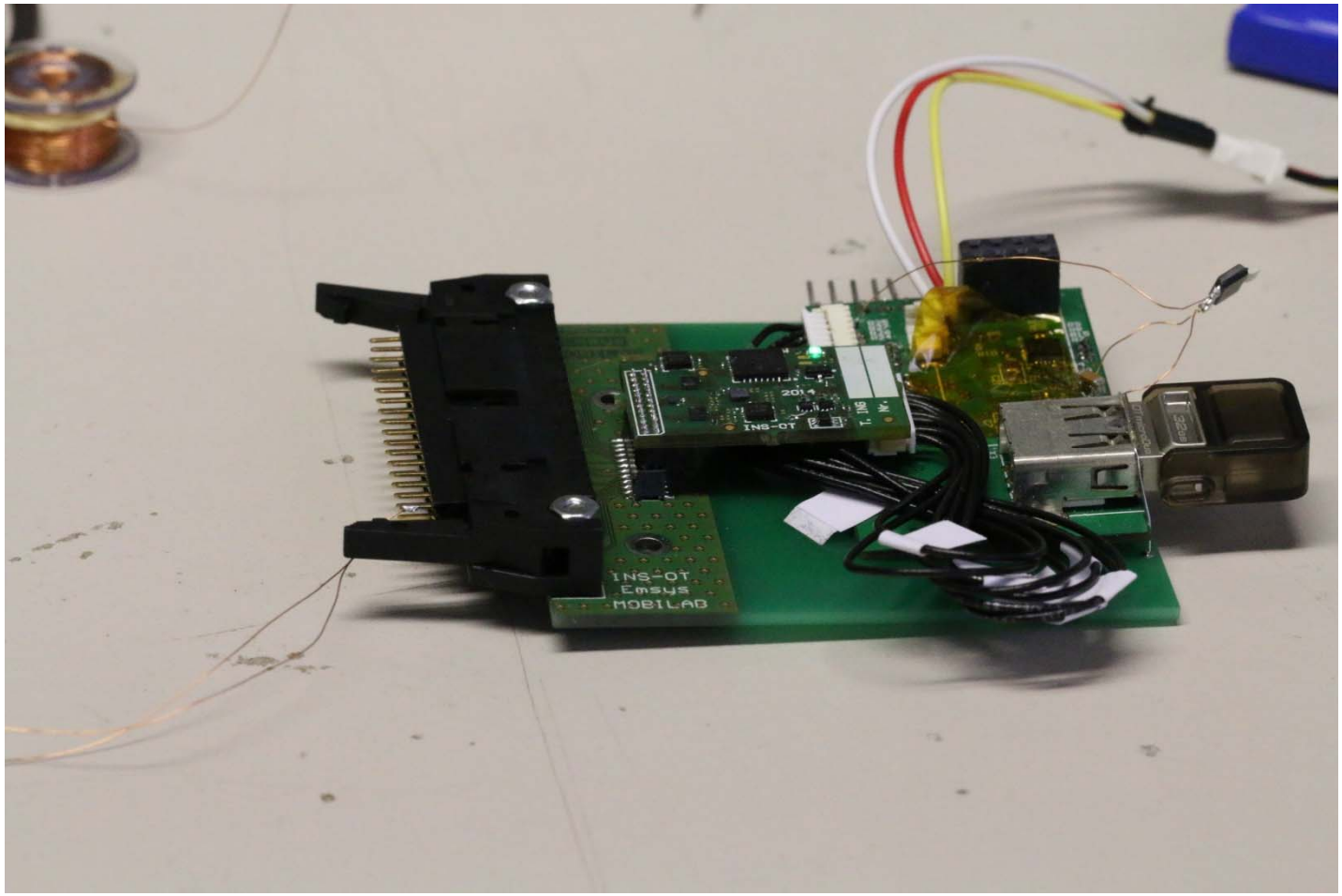
ORTHESE: LOGGER & DUMMY AFE



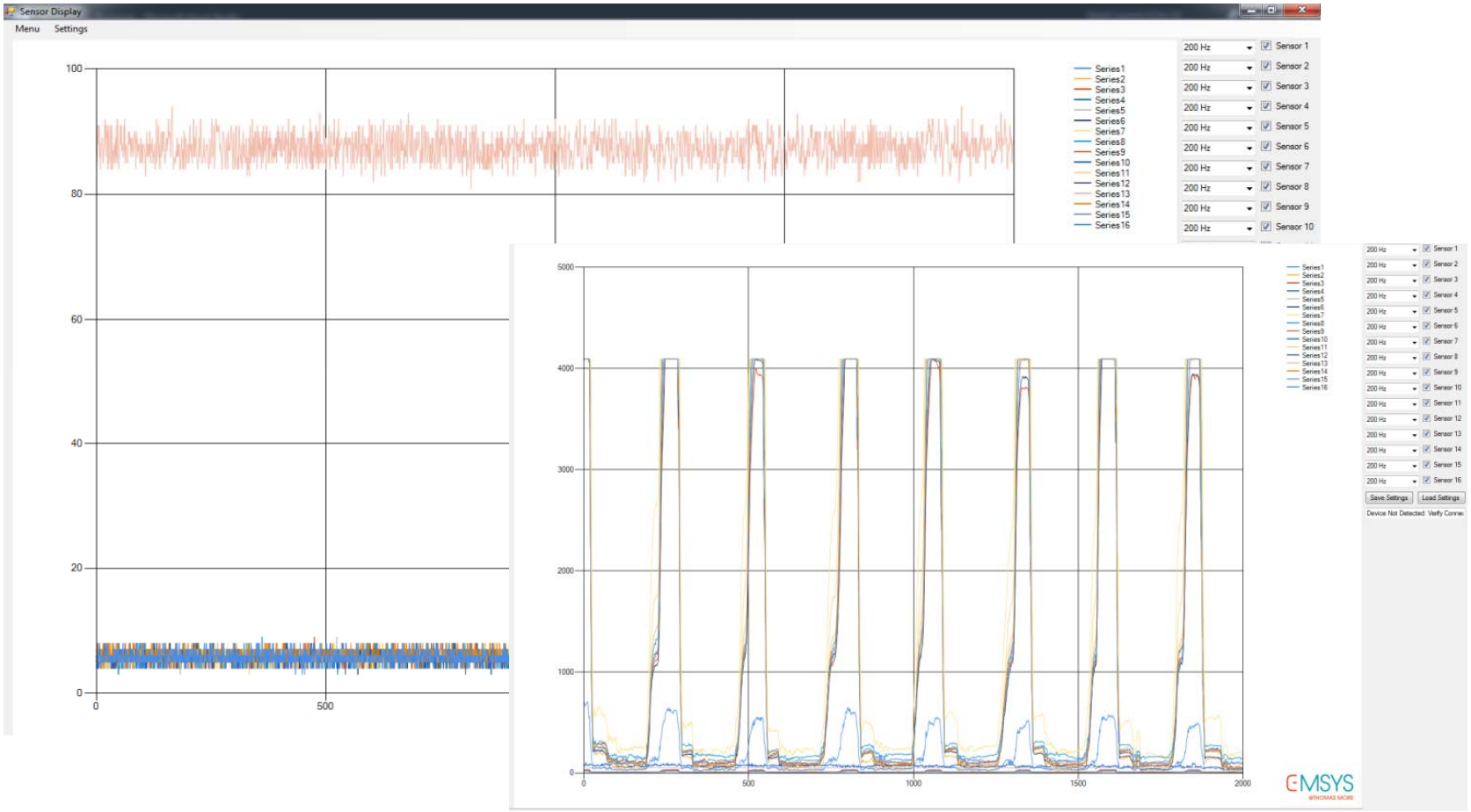
ORTHESE: FUNCTIONAL CONCEPT



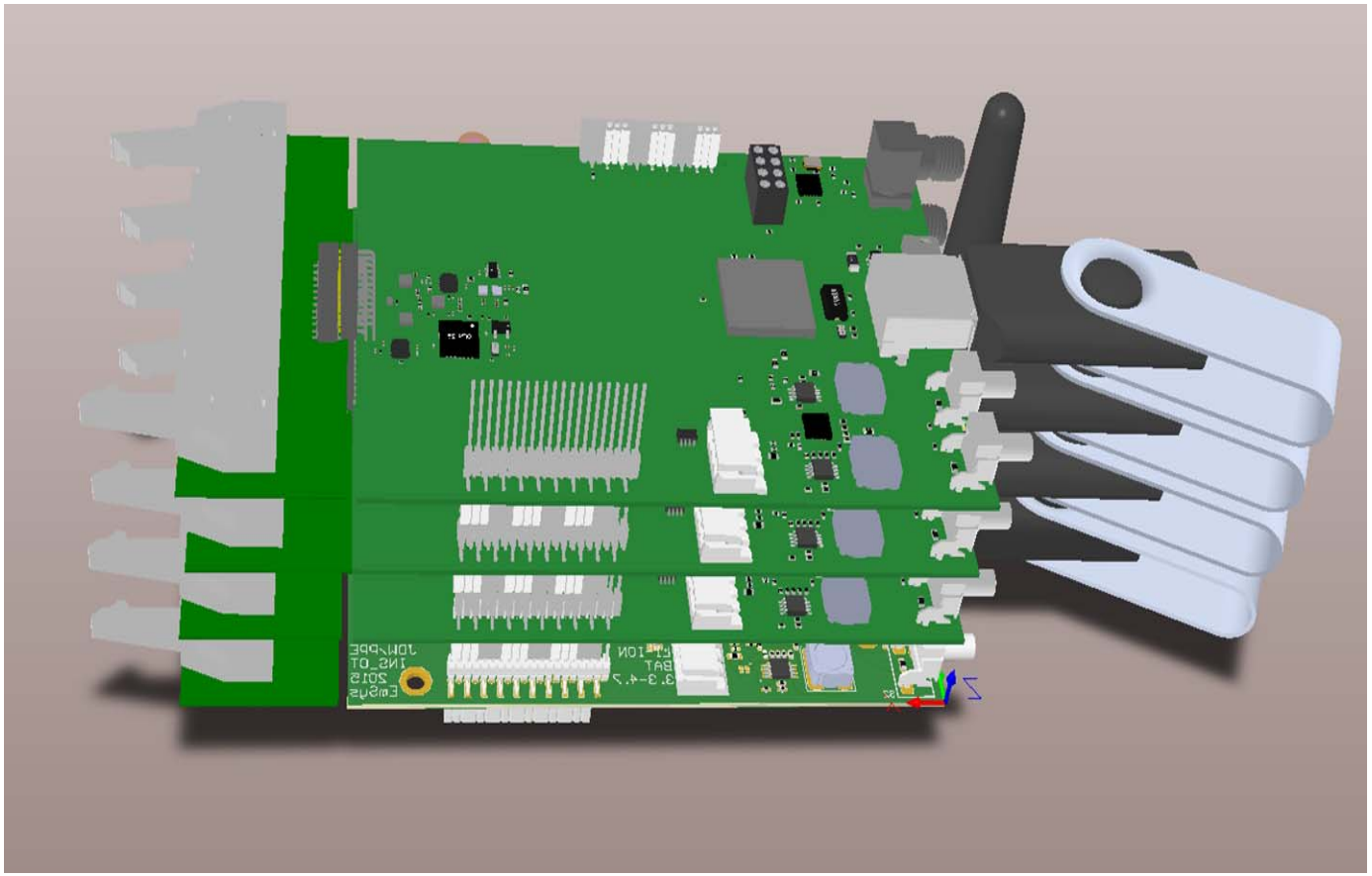
ORTHESE: FUNCTIONAL PROTOTYPE



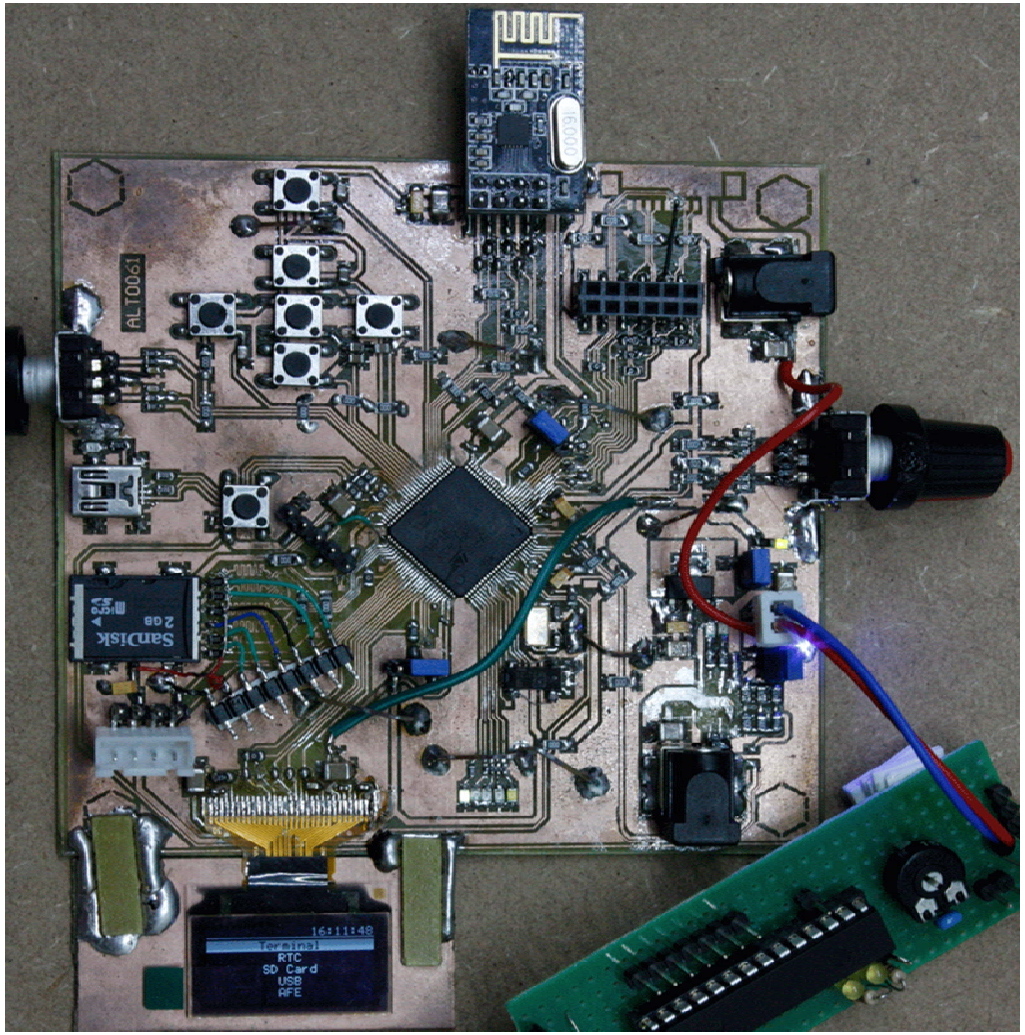
S/N AND REAL TIME MEASUREMENTS



ORTHESE: N.16 CHANNEL DESIGN



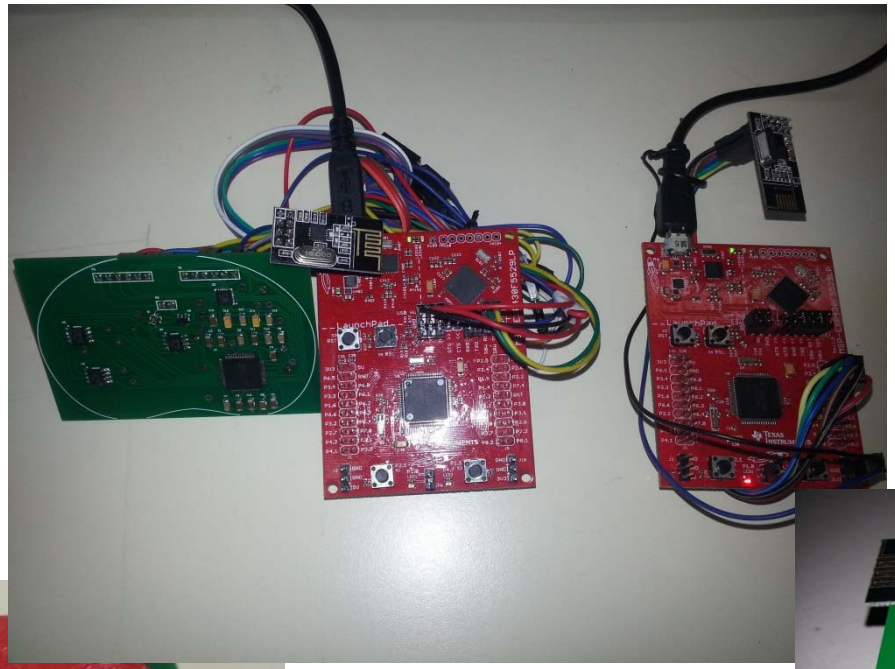
ORTHESE: NEW STM32 BASED DESIGN

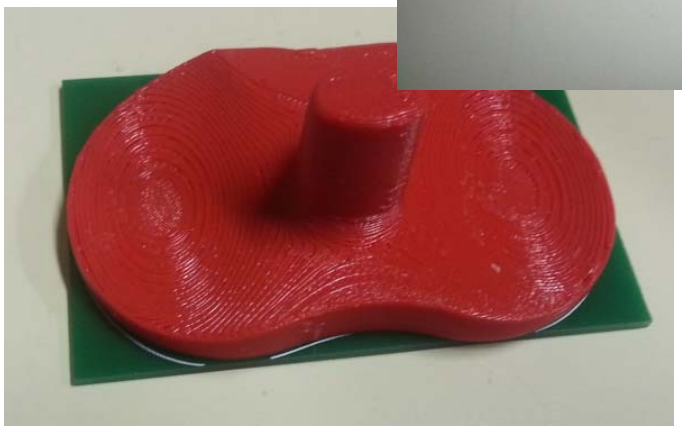


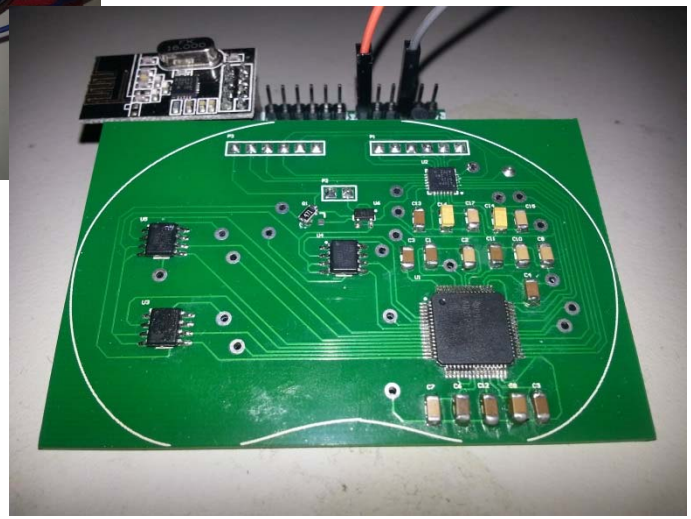
KNEE: CONCEPT & FEATURES

- 3 dual analog/digital channel magneto sensors
- 6 Channel synchronous sampling
- Programmable gain
- Software/hardware SPI
- Modular design to migrate design
- Onboard ULP µC
- Onboard processing (Magnetics to angle calculation)
- External RF communication module
- Total current consumption
  - 7..12mA with analog sensors
  - Less than 5 mA with digital sensors
- Prototype same size as HDPE block
- Inductive powering and communication with C.O.T.S.

KNEE: CONCEPT PROTOTYPE V1.0

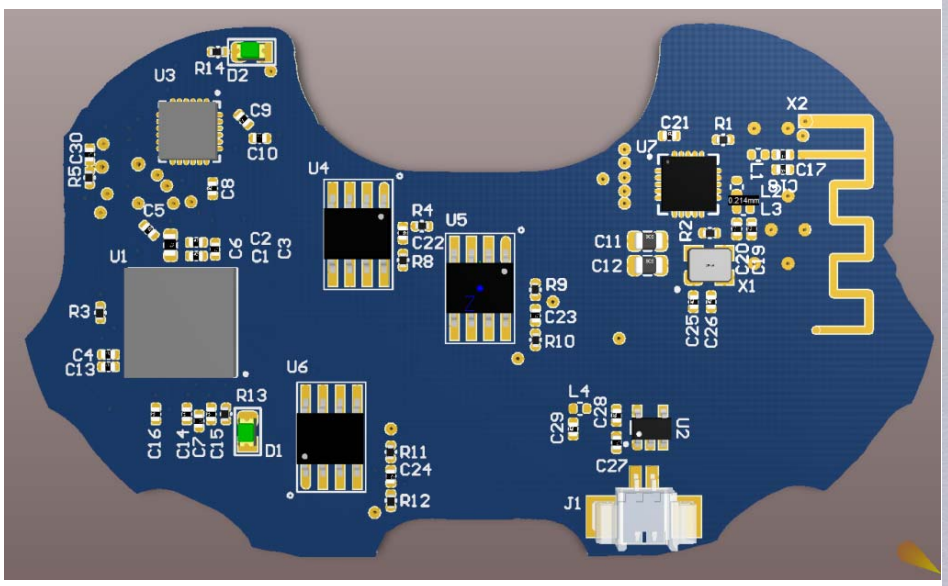


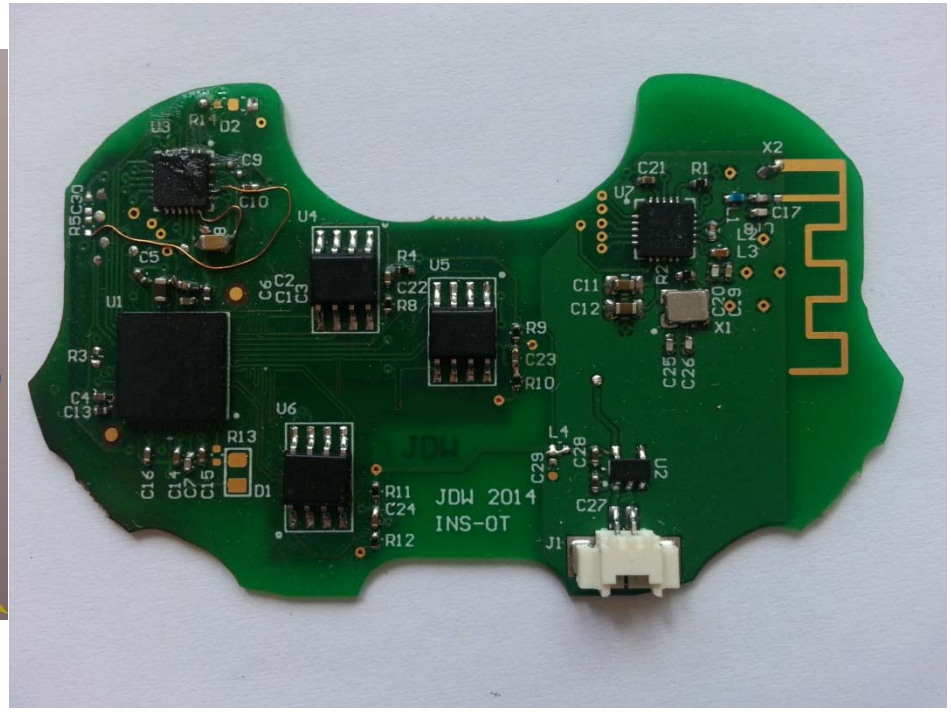




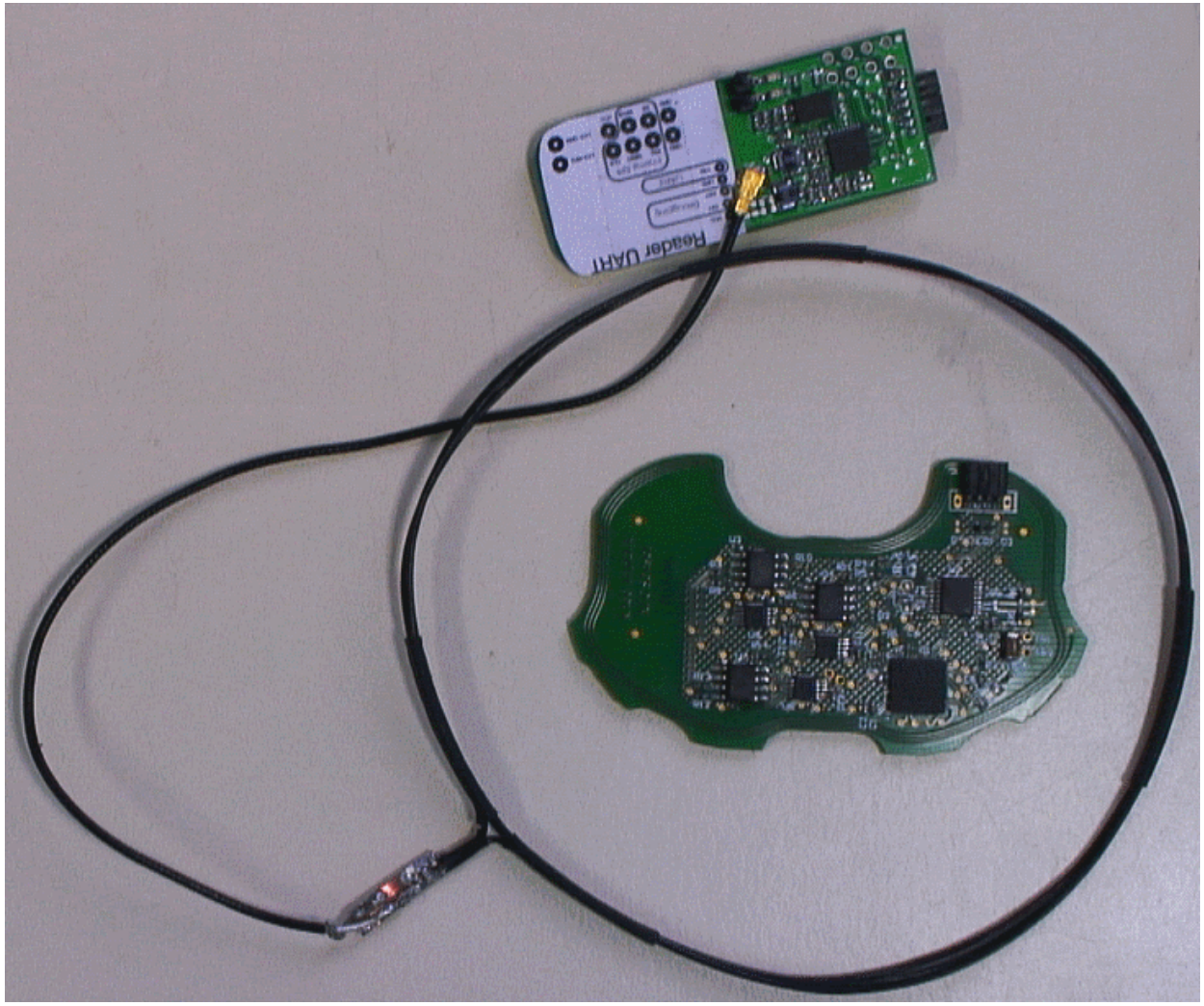
KNEE CONCEPT/PROTOTYPE IN ACTION

KNEE: CAD AND PCB PROTOTYPE V2.0



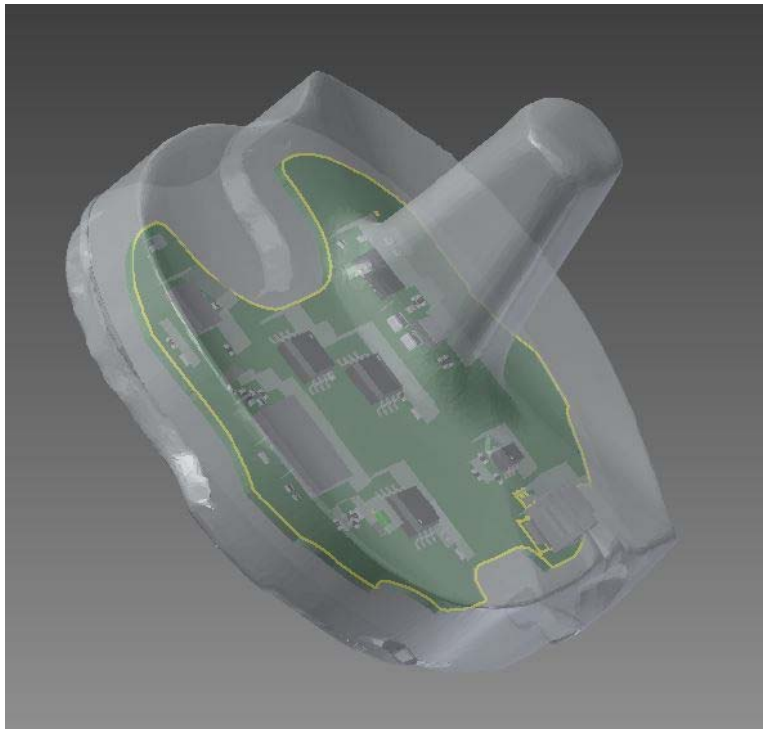


INDUCTIVE POWERED PROTOTYPE V3.0

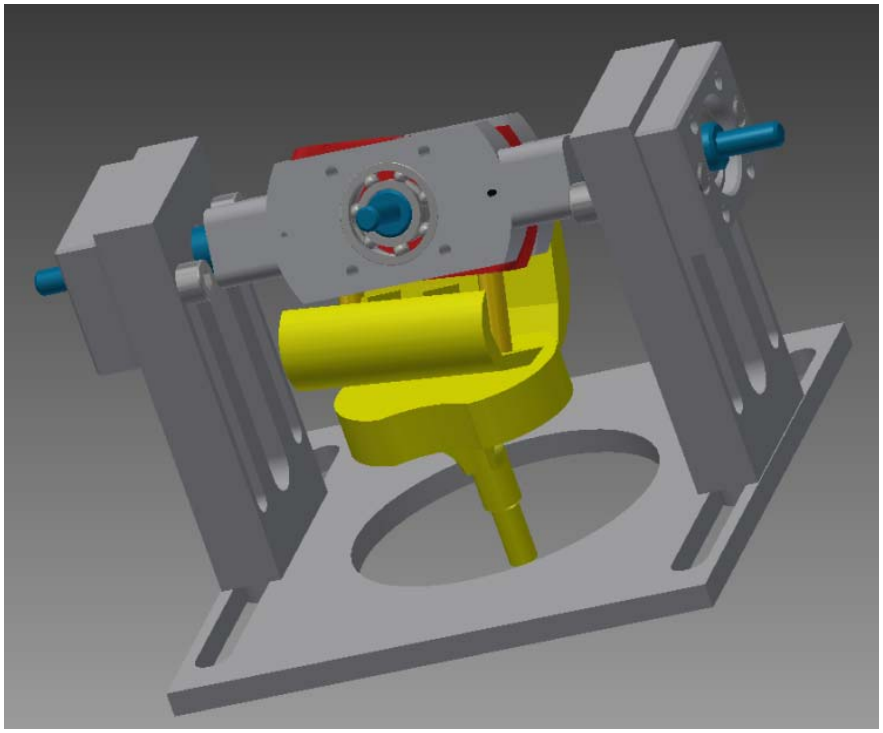


KNEE: INTEGRATION AND TESTING

Integrated PCB



Flexible E-Knee test system



LINK WITH EDUCATION 2015-2016

- International Bachelor & Master thesis subjects
  - Embedded STM32 based wireless orthese logger
  - 64 channel ERZ32 based wireless saddle pressure sensing system
  - Full digital knee angle sensing system
  - Knee model parameter extraction
  - Portable inductive powering and communication system for implantable instrumentation
  - Embedded high resolution and low power strain gauge measurement system
  - Fully automated pressure bench for sensor calibration

THANKS & QUESTIONS

Feel free to contact us if one is interested in some research topics or possible projects or international cooperation

Thank you

for your

attention!

Are there some questions?