

## Tomografia di Impedenza

### Sheffield

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Figure 4. (a) Electrodes placed around the thorax in order to produce impedance images of the changes in lung resistivity during expiration. (b) An x-ray image obtained using 16 electrodes placed around the thorax. The lungs are well resolved in this image which shows the increase in resistivity on inspiration. Anterior is at the bottom and the left side of the trunk on the right of the image.



Dispositivo commerciale  
Sheffield Mark 3.5  
Maltron

Sheffield Mk1 (Barber e Brown Uni. Sheffield 1984)

# Drager

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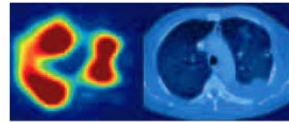


Fig. 6. Functional EIT image (left) and CT scan from a patient with a pleural effusion after rupture of the diaphragm, resulting in a significantly reduced ventilation of the lower left lung. The red color represents regions with the highest volume changes, the nonventilated regions are displayed in deep blue.

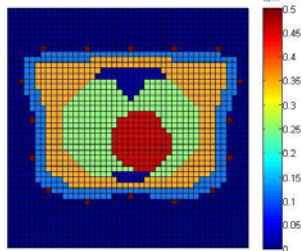
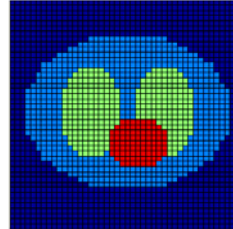
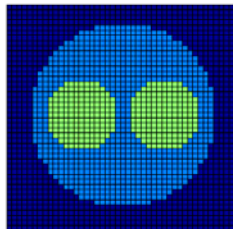
Drager Medical - 2008

# PULMOVISTA 500

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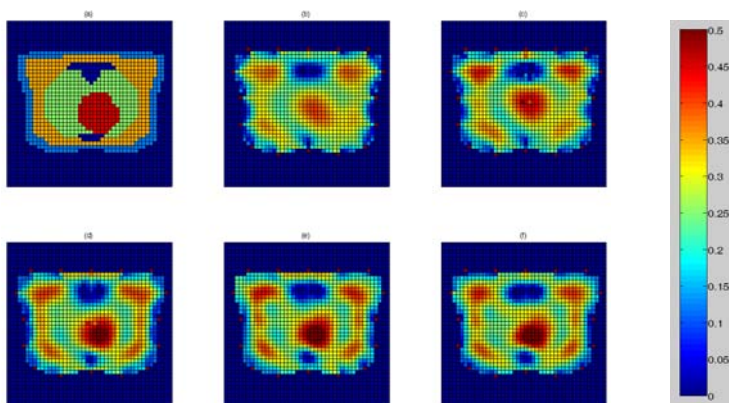
## MODELLI DEL TORACE



### Modello VH

- Polmone 0.25 S/m
- Cuore 0.45 S/m
- Muscoli 0.35 S/m
- Ossa 0.02 S/m
- Pelle/grasso 0.03 S/m

## Ricostruzioni con varie tecniche



- (a) Distribuzione originale; (b) ricostruzione con matrice di regolarizzazione nulla e  $J=S$  ;  
 (c) ricostruzione con matrice di regolarizzazione nulla e  $J$  calcolata da  $Y$  ,  
 (d)  $L$ = matrice identità, (e)  $L$  = versione discreta dell'operatore gradiente,  
 (f)  $L$  = versione discreta dell'operatore Laplaciano.

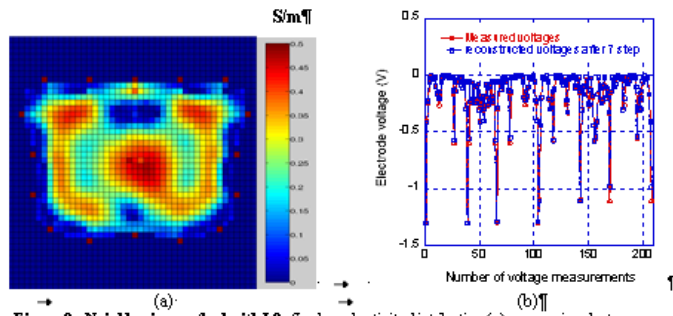
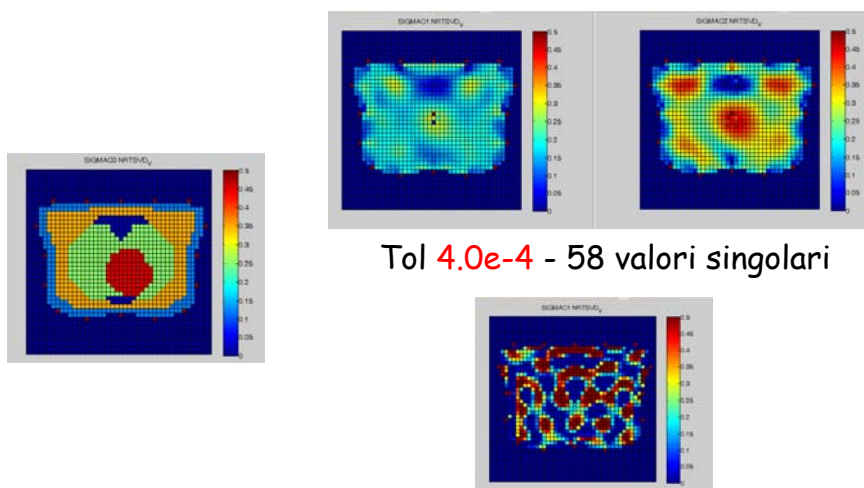


Figure 6. - Neighboring method with  $L0$ : final conductivity distribution (a), comparison between measured and simulated electrode voltage after iterations (b).

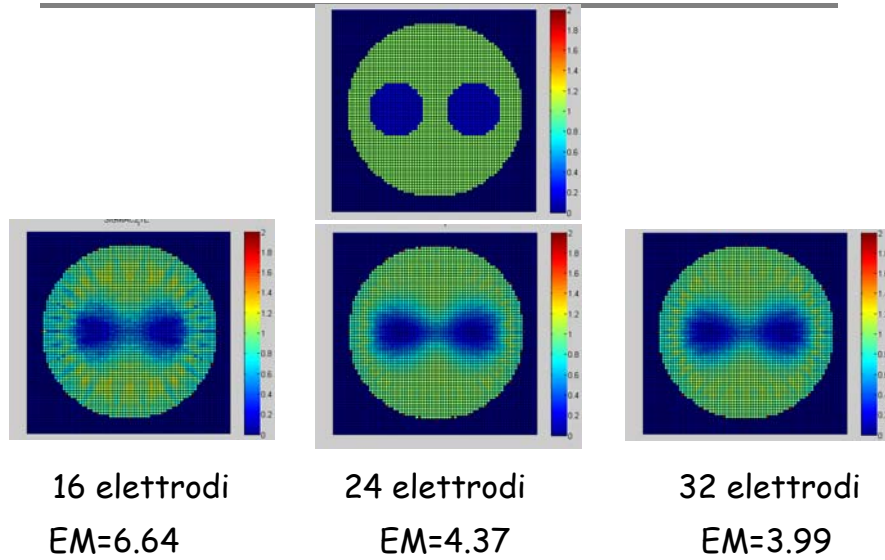
## Effetto della tolleranza della TSVD



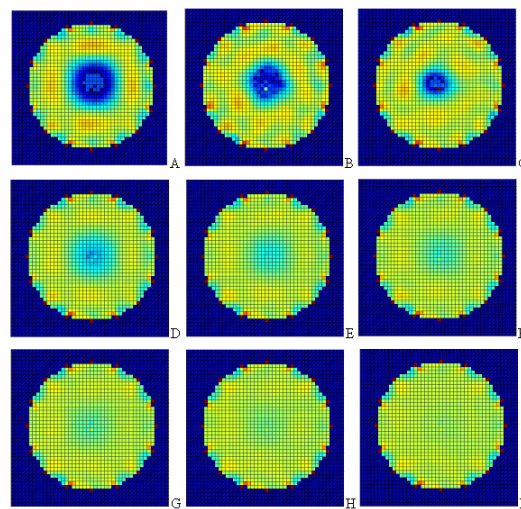
Tol  $4.0e-4$  - 58 valori singolari

Tol  $4.0e-8$  - 95 valori singolari

## Effetto numero elettrodi



## Risoluzione spaziale



## Confronto FEM - FD (Ammettenze)

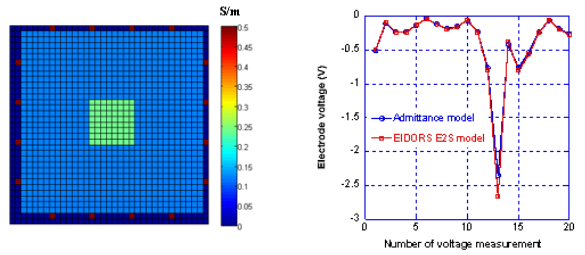


Figure 4. Electrode voltages for the square geometry with square anomaly by using the FD method and the FEM method implemented in EIDORS

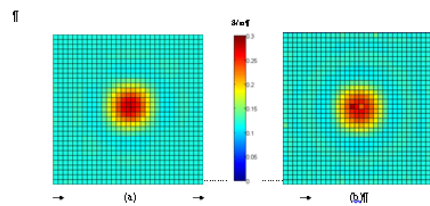
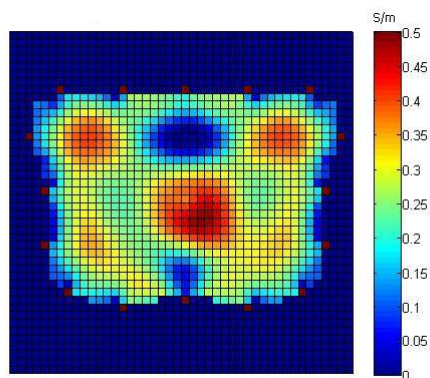
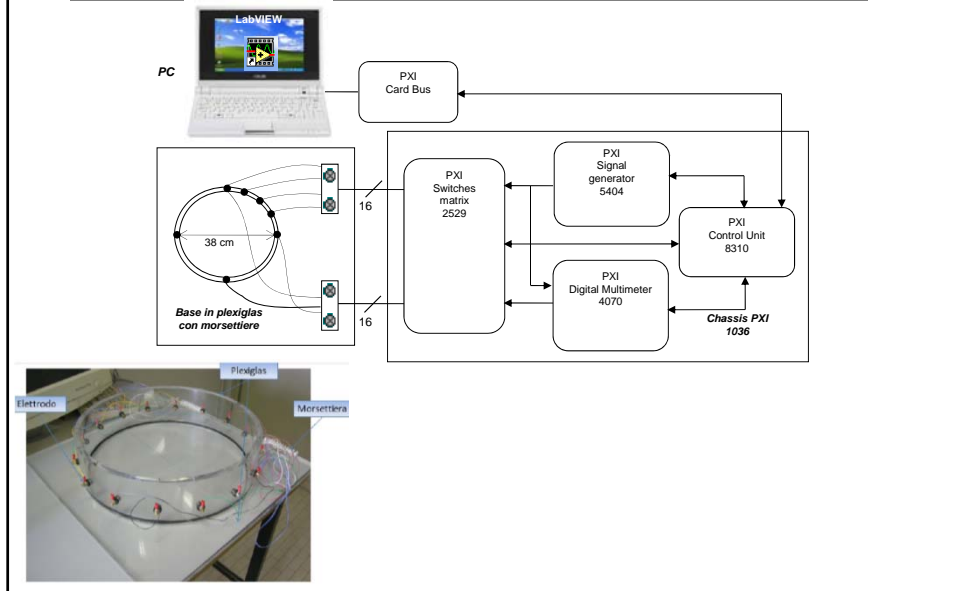


Figure 5. Reconstructed conductivity maps of the square geometry by using EIDORS (a) and the technique proposed in this paper (b)

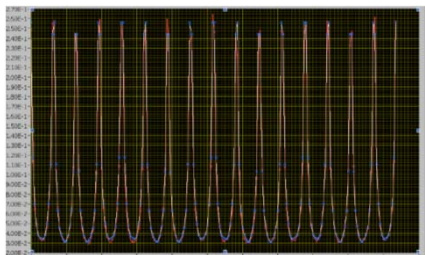
...e in un ciclo respiratorio completo



## Sistema Sperimentale



## Uniform Phantom ( $\sigma = 0.0564 \text{ S/m}$ )

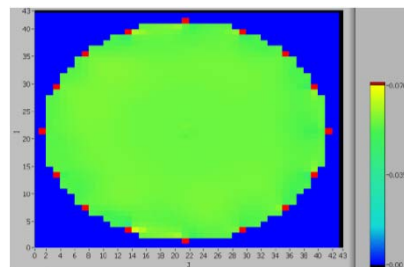


208 acquired  
experimental voltages  
(blue points)  
and simulated voltages  
(red points)

error function

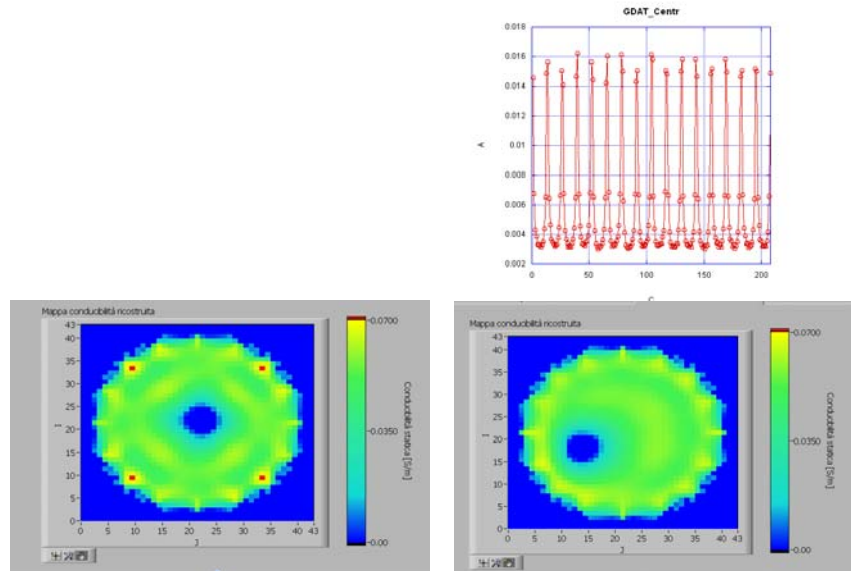
$$E = \frac{[\mathbf{g}^{rec}(c) - \mathbf{g}^{meas}]^T \cdot [\mathbf{g}^{rec}(c) - \mathbf{g}^{meas}]}{(\mathbf{g}^{meas})^T \cdot \mathbf{g}^{meas}} \times 100$$

$$\sigma = 0.0564 \text{ S/m} \quad E = 0.28 \%$$

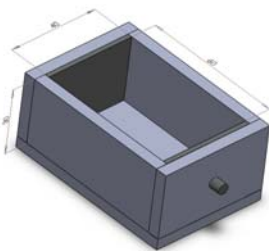


reconstructed conductivity image

## Sistema sperimentale (cilindri dielettrici)



## Phantom Materials



saline solutions are prepared by adding various concentrations of sodium chloride (FU-Ph.Eur) to deionised water at room temperature

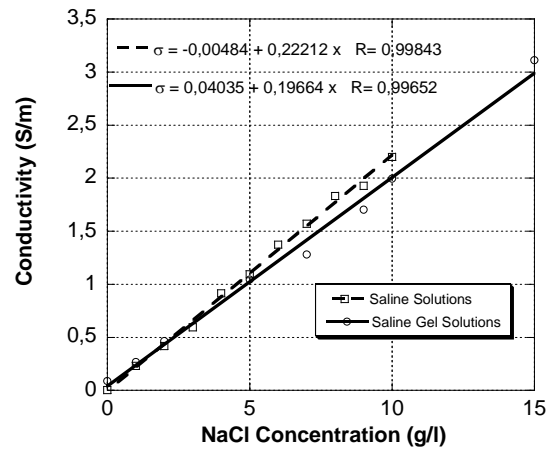
saline gels are prepared by adding agar gel (Agar-Agar E406, powder) to saline solutions while the water is heated to 85 °C and stirred vigorously

The solution is then put inside the test cell to cool to room temperature and finally the resistance measurements are performed.

$$\sigma = \frac{1}{R_M} \cdot \frac{l}{S} = \frac{50}{R_M} \quad [S/m]$$

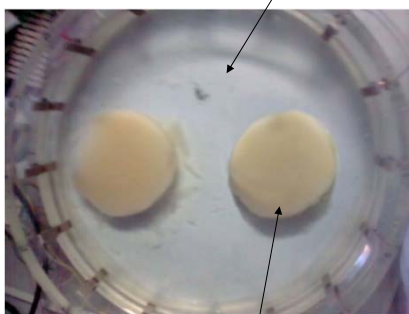


## Conductivity of the saline and saline gel solutions as a function of the salt concentration

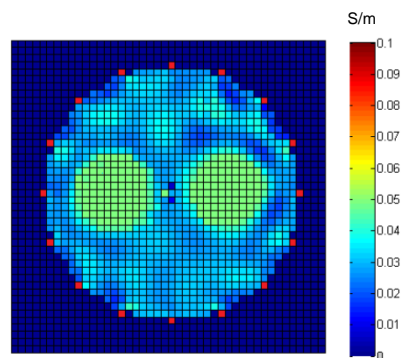


## Two Cylinder Phantom

Deionised Water  $\rightarrow \sigma \cong 0 \text{ S/m}$



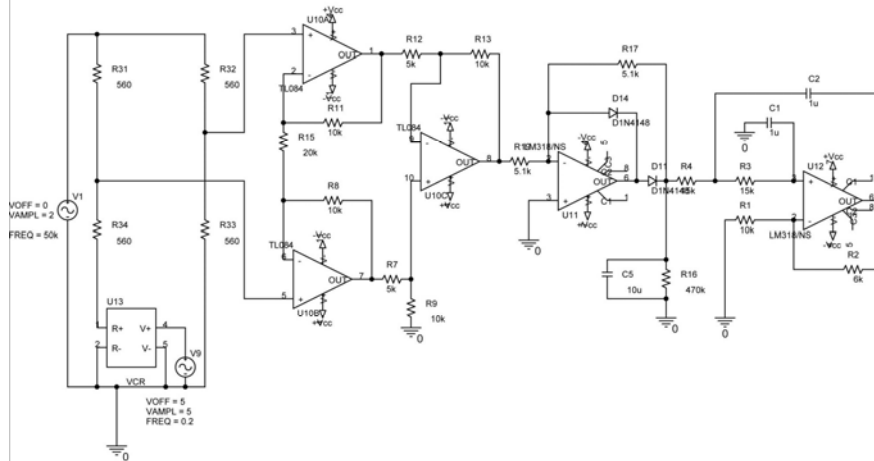
cylinder  $\rightarrow \sigma = 0.05 \text{ S/m}$



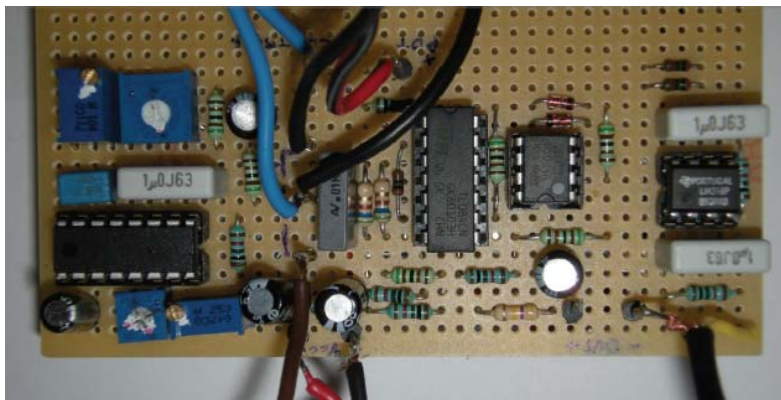
Reconstructed image



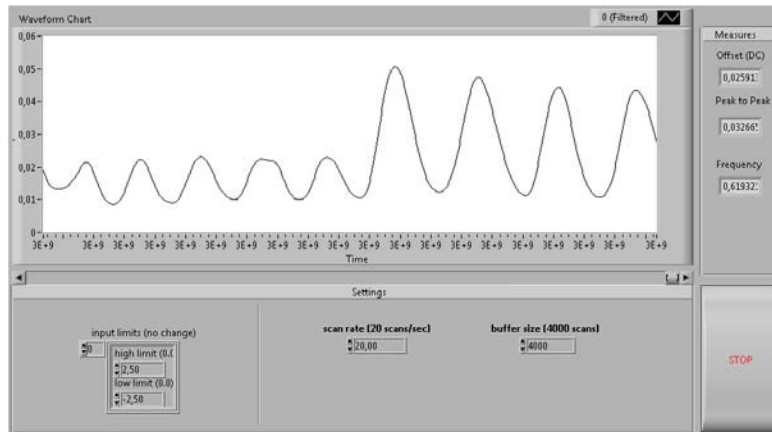
## Schematico completo



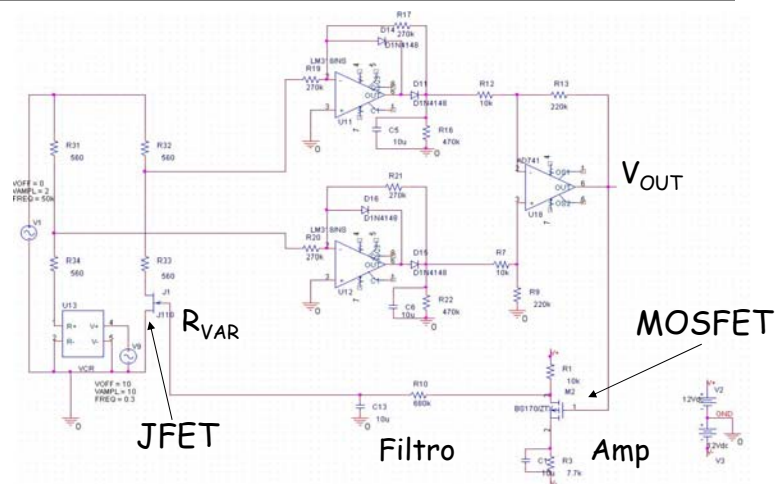
## Realizzazione 3: Il sistema completo



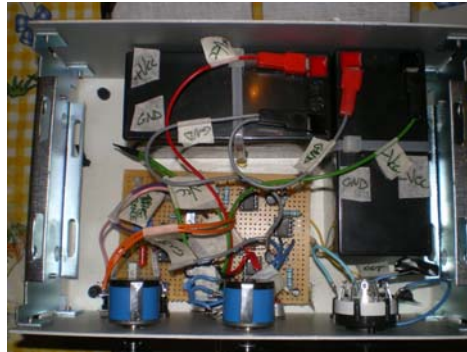
## Test dello strumento: Tracciati di respirazione



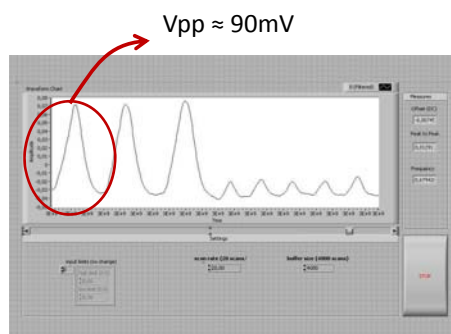
## Progetto: Retroazione



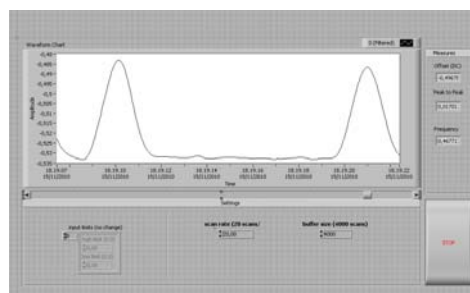
## Realizzazione 2: Il sistema completo



## Test dello strumento: Tracciati di respirazione



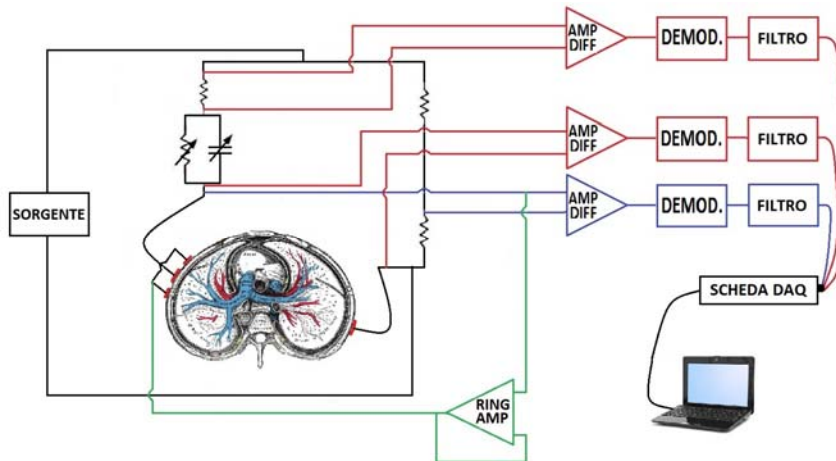
Respirazione forzata + normale



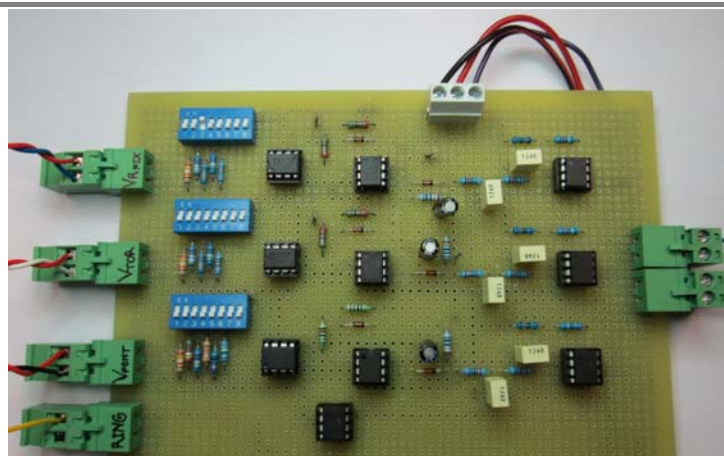
Respirazione + apnea

# Progetto

- Schema del nuovo impedenziometro progettato

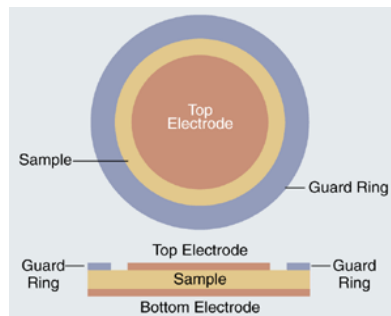


## Realizzazione: Il blocco di misura



## Gli elettrodi con anello di guardia: Generalità

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si mantengono equipotenziali sfruttando la massa virtuale di un amplificatore operazionale

## Realizzazione (7): L'anello di guardia

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Il Test alternativo della sua efficienza



## Test dello strumento: Test dell'anello di guardia

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Acqua normale



Caso 'singolo elettrodo' -  $R = 3530 \Omega$

Caso 'coppia cortocircuitata' -  $R = 3000 \Omega$

Caso 'anello di guardia' -  $R = 9320 \Omega$

Acqua salata



$R = 810 \Omega$

$R = 683 \Omega$

$R = 2600 \Omega$

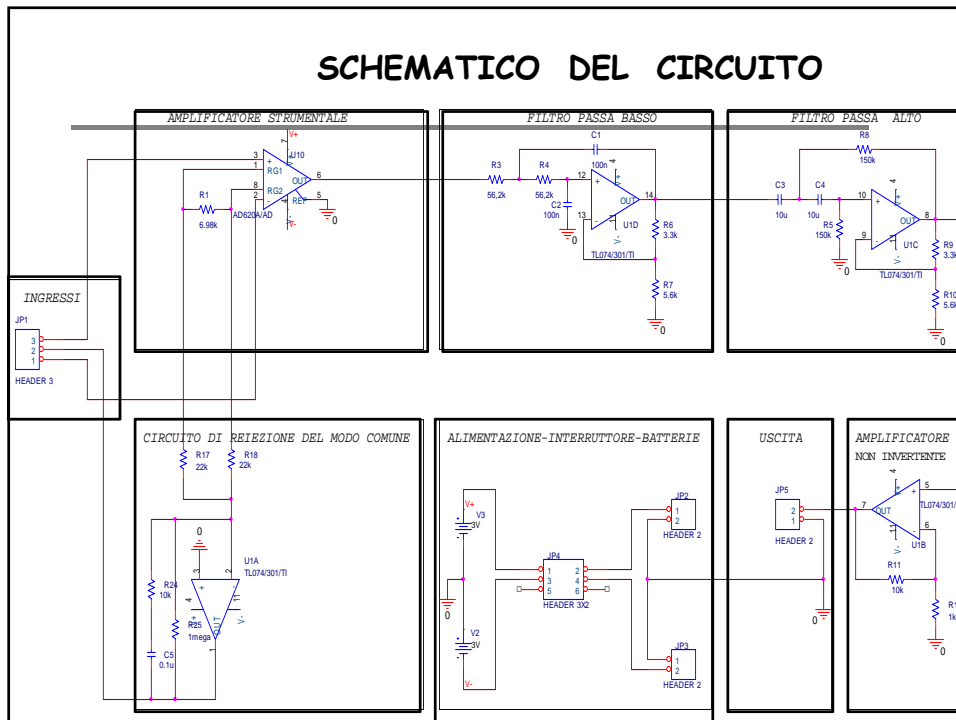
*Corso di Strumentazione e  
tecniche per la diagnostica*

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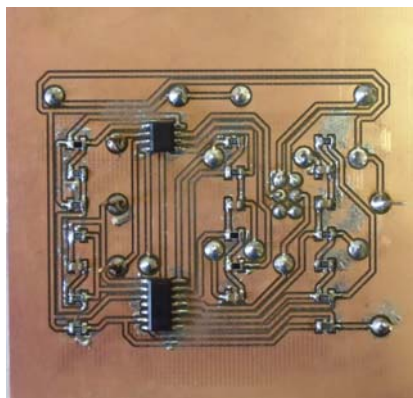
## Elettrocardiografo



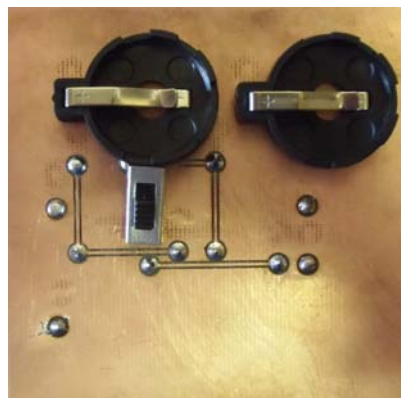
## SCHEMATICO DEL CIRCUITO



## REALIZZAZIONE CIRCUITO STAMPATO



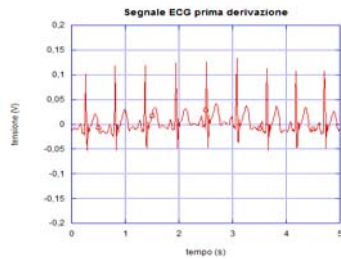
*Circuito stampato  
Layer Top*



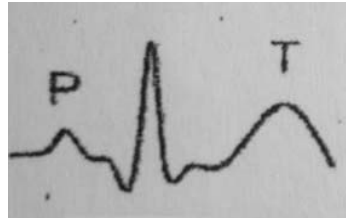
*Circuito stampato  
Layer Bottom*

## MISURE EFFETTUATE SUL CIRCUITO CON ACQUISIZIONE SU LabVIEW

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Acquisizione della I derivazione con passa banda(0,1-30 Hz)



Forma d'onda ideale della I derivazione

*Corso di Strumentazione e  
tecniche per la diagnostica*

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**Sistemi wireless**

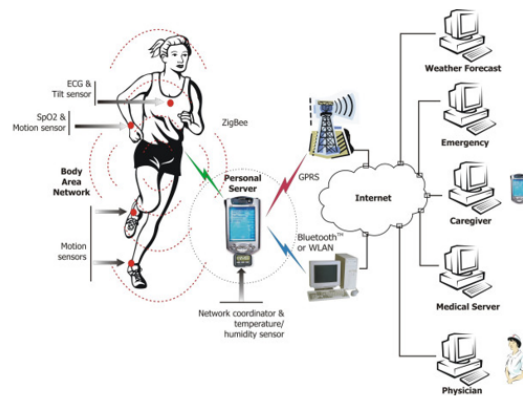


Figura 1 – Rete di sensori per il monitoraggio degli atleti durante l'attività sportiva [2].



(a)

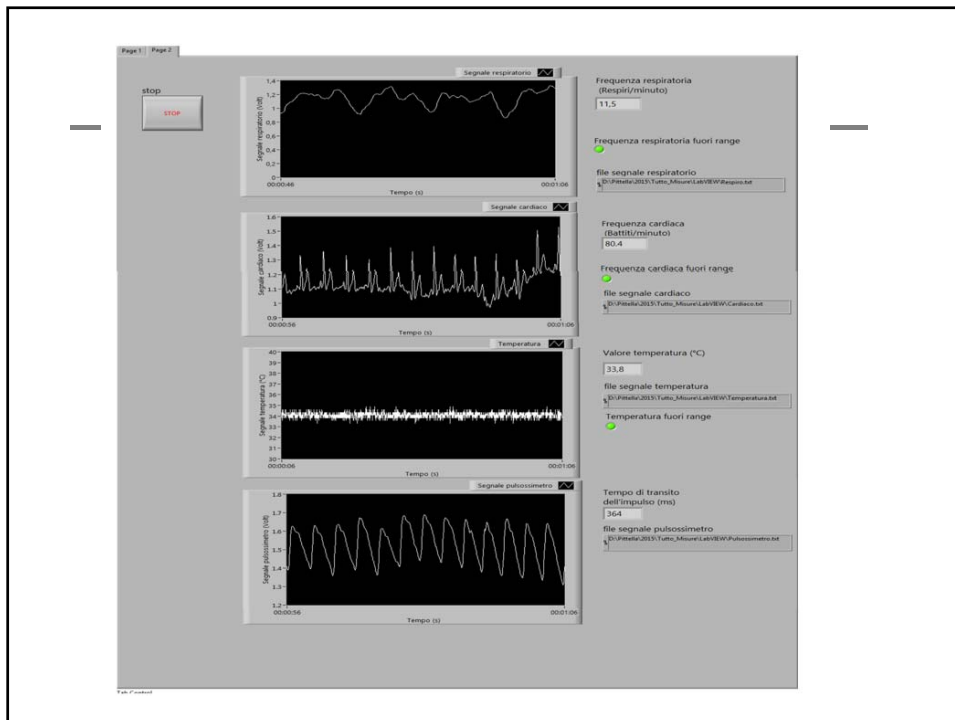


eZ430-RF2500T  
Wireless Development Tool



(b)

Figura 3 – Foto dell'EZ430-RF2500: access point (a) e end device (b).



*Corso di Strumentazione e  
tecniche per la diagnostica*

**Correzione artefatti**

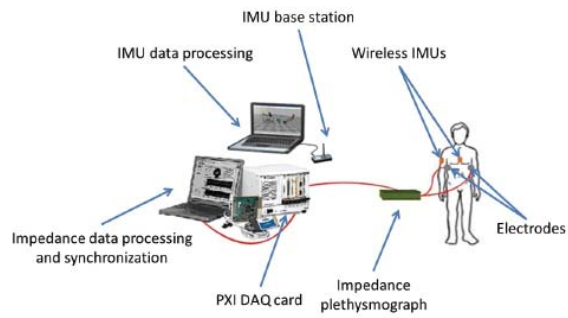
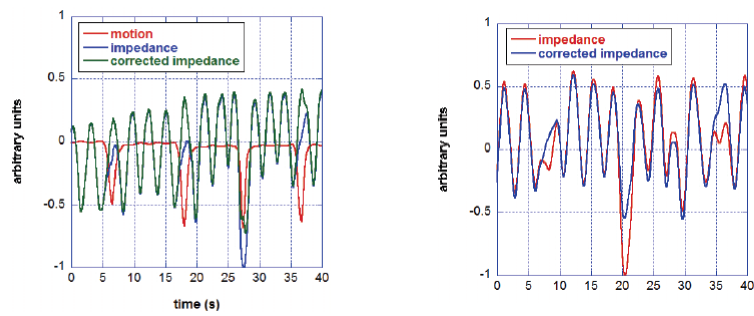


Fig. 1. Experimental set-up.

wireless inertial measurement units - IMUs - (Xsens MTw development kit) attached to the body by click-in straps.



## TESI

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- EIT 3D CONFRONTO FD CON EIDORS - TEORICO SPERIMENTALE
- EIT CON ANELLO DI GUARDIA - TEORICO SPERIMENTALE
- IMPEDENZIOMETRIA INDOSSABILE - TEORICO SPERIMENTALE
- PULSOSSIMETRO TEORICO SPERIMENTALE

COLLABORAZIONE CON DOTT. LUCA CECCHINI