



STUDY, REALIZATION AND APPLICATION OF CONSTANT PHASE ELEMENTS

PHD BRAINSTORMING DAY – 29/10/2019

STUDENT: EMANUELE MURGANO
XXXIV CYCLE

SUPERVISOR: PROF. RICCARDO CAPONETTO
PHD COORDINATOR: PROF. PAOLO ARENA



OUTLINE

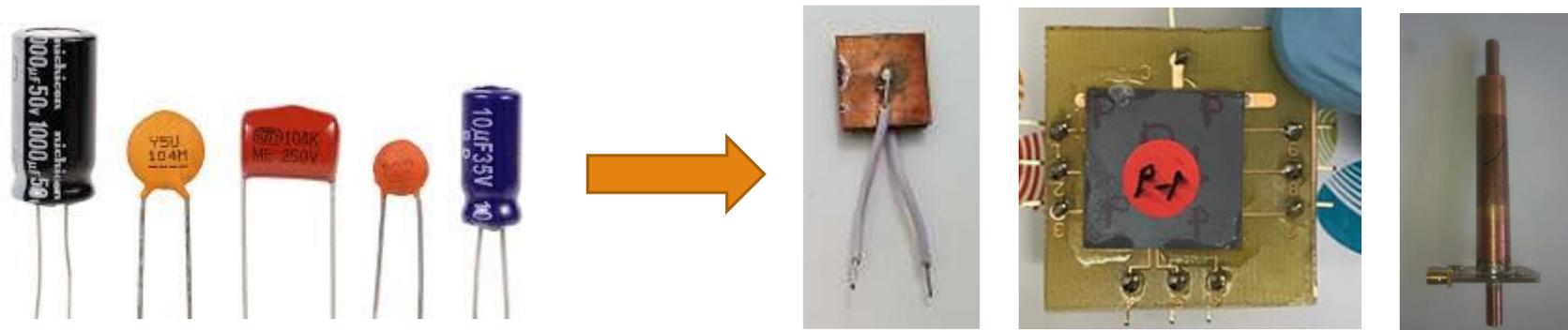
- Constant Phase Elements
- Realization of CPEs
- Activities

Constant Phase Elements

Constant Phase Elements (CPEs) are devices that have a constant phase in a large frequency windows that can be different to the common -90° of the standard capacitor. Their physical realization allows to obtain fractional-order devices useful in implementing control strategies based on fractional-order calculus.

$$Z(s) = \frac{1}{sC}$$

$$Z_{CPE}(s) = \frac{1}{s^\alpha C}, \quad \alpha \in \mathbb{R}$$





Realization of CPEs /1

Carbon-black-based CPE

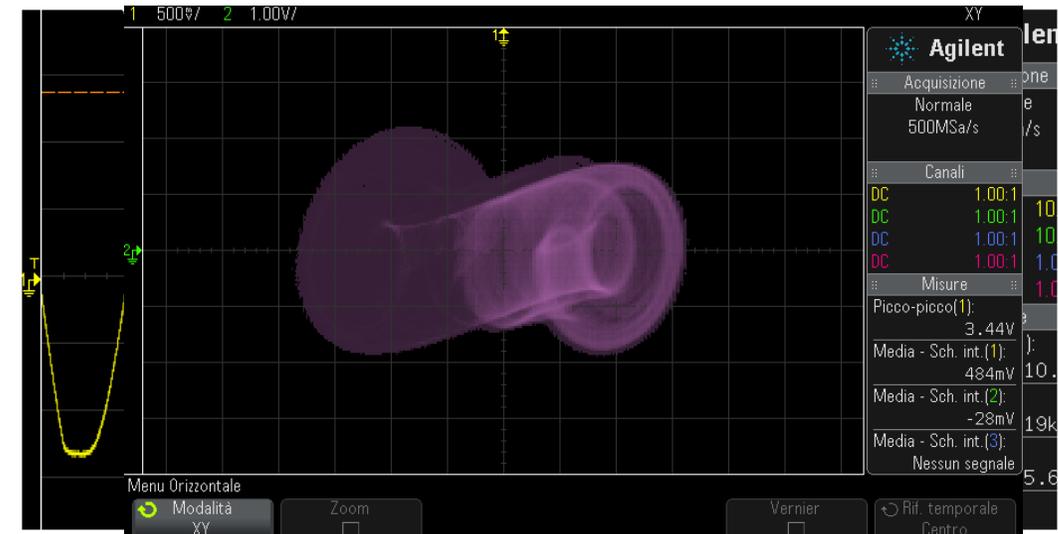


Parameters

$$\alpha \cong 0,81$$

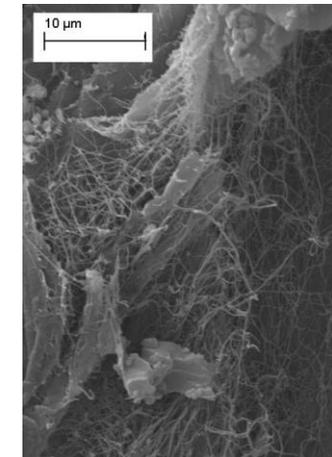
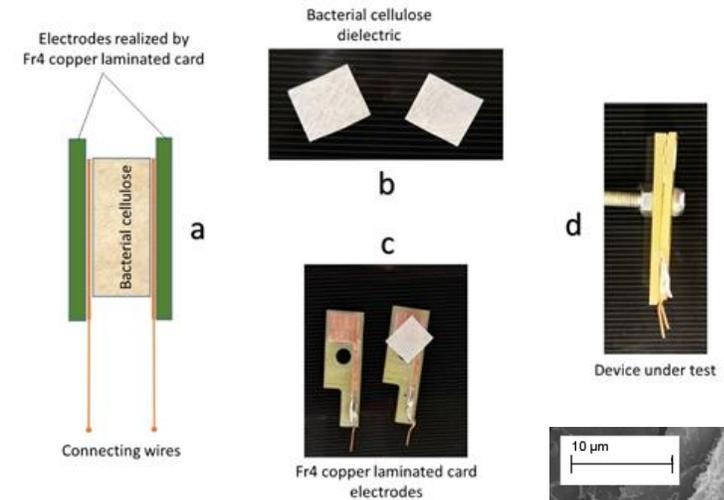
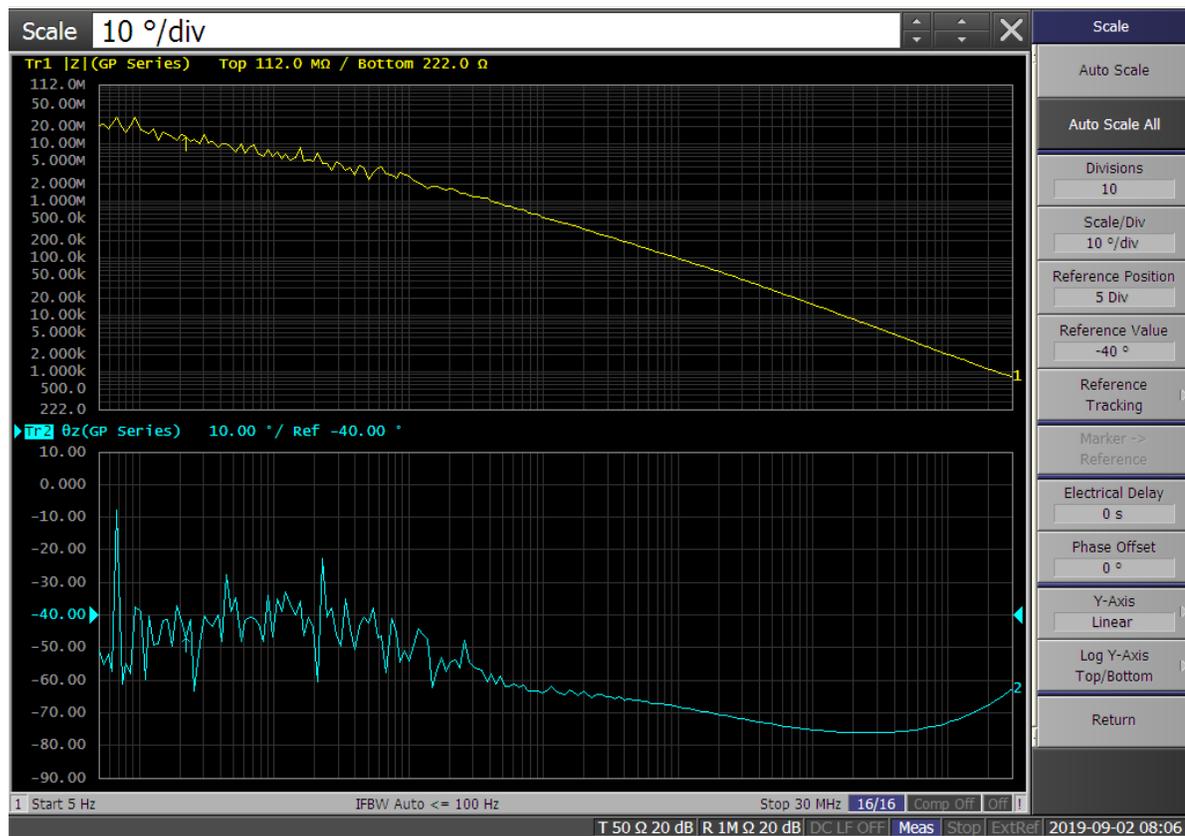
$$C \cong 2,7 n^F / s^{1-\alpha}$$

Fractional-order Differing System



Realization of CPEs /2

Bacterial cellulose-based FOE

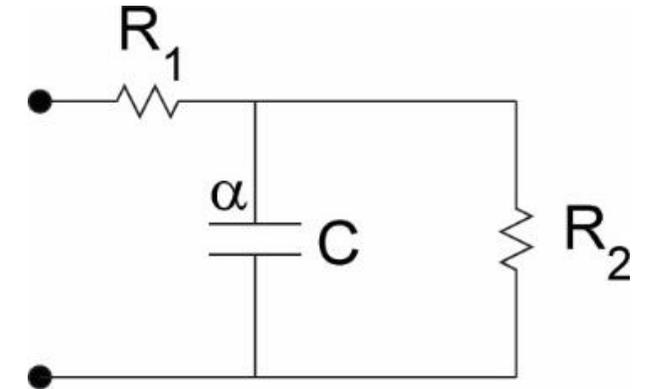
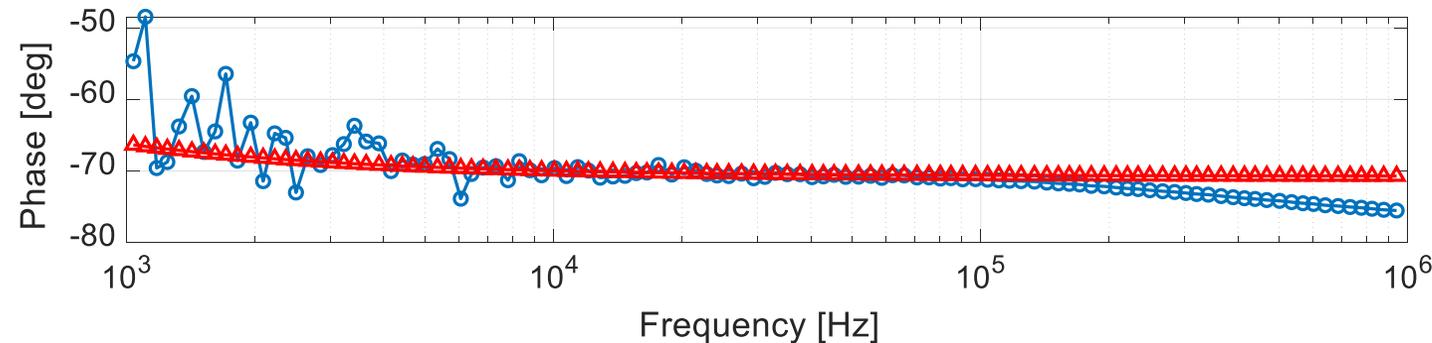
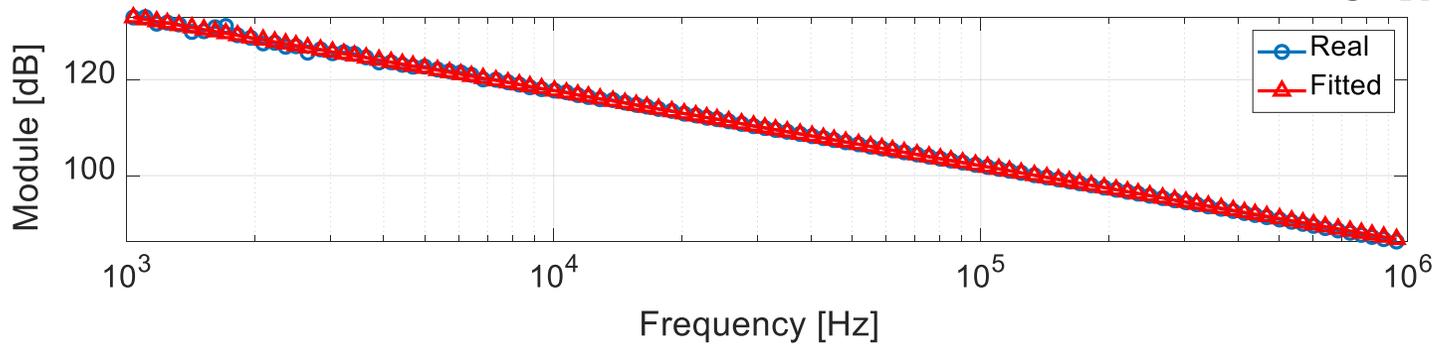




Realization of CPEs /2

Equivalent model

In the frequency range [10; 1000] kHz: $Z(s) = R_1 + \frac{R_2}{s^\alpha R_2 C + 1}$

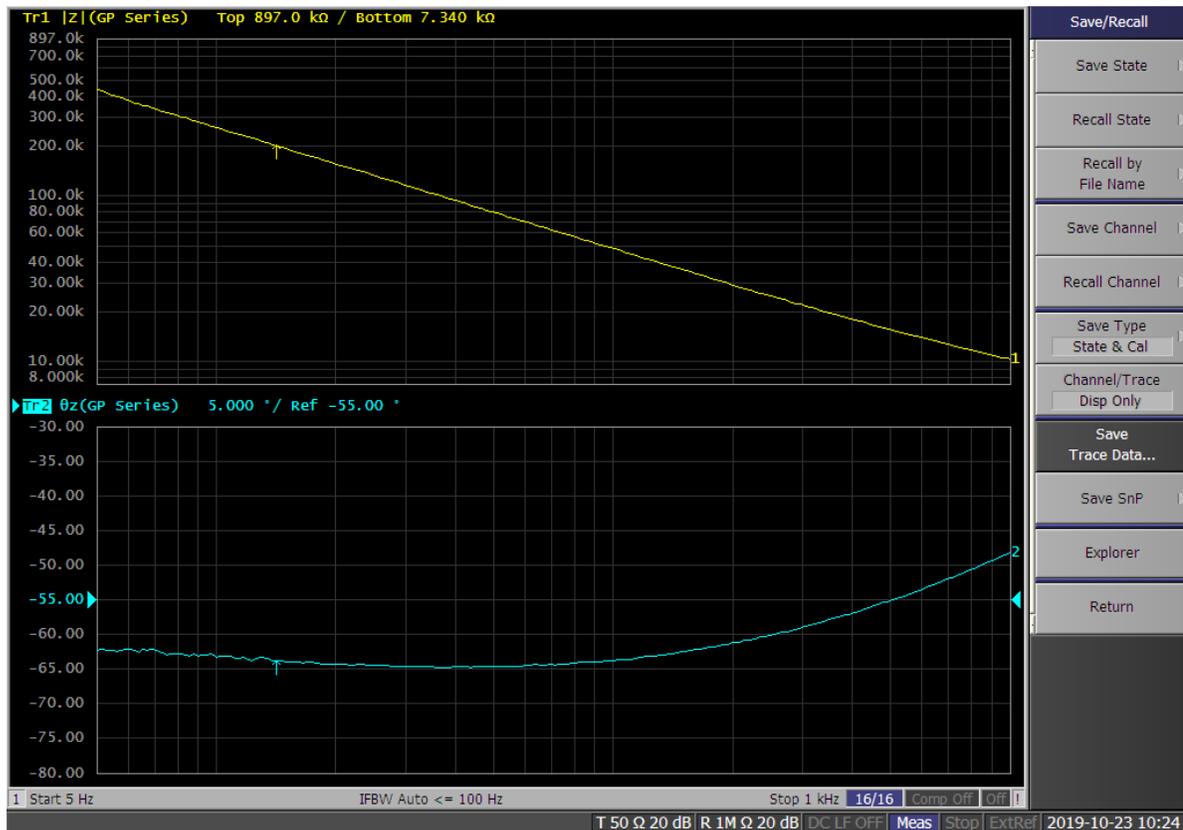


Param.	Value
C	$1.632 \times 10^{-10} \left[F / s^{1-\alpha} \right]$
α	0,799
R_1	0,5 [Ω]
R_2	$3,205 \times 10^7$ [Ω]



Realization of CPEs /2

Bacterial cellulose + ILs-based CPE



Ionic Liquids (ILs) used:

- 1-ethyl-3-methylimidazolium
trifluoromethanesulphonate (**TFMS**)

and

- 1-ethyl-3-methylimidazolium
tetrafluoroborate (**BF₄**)



Activities

Attended events:

- 6th - 9th October, IEEE International Conference on Systems, Man and Cybernetics (SMC 2019), Bari.

Publications:

- Biswas K., Caponetto R., Di Pasquale G., Graziani S., Pollicino A., **Murgano E.**, “Realization and characterization of carbon black based fractional order element”, *Microelectronics Journal*.
- Caponetto R., Machado J. T., **Murgano E.**, Xibilia M.G., “Model Order Reduction: A Comparison between Integer and Non-Integer Order Systems Approaches”, *MDPI Entropy Journal*.
- Caponetto R., Di Pasquale G., Graziani S., **Murgano E.**, Pollicino A., “Realization of Green Fractional Order Devices by using Bacterial Cellulose”, *AEU - International Journal of Electronics and Communications*.
- Buscarino A., Caponetto R., **Murgano E.**, Xibilia M.G., “Carbon Black Based Fractional Order Element: Wien oscillator implementation”, 6th Conference on Control, Decision and Information Technologies (CoDIT), Paris.
- Buscarino A., Caponetto R., **Murgano E.**, Graziani S., “Carbon Black Based Fractional Order Element: an RC implementation”, 18th European Control Conference (ECC), Naples.
- Buscarino A., Caponetto R., Fortuna L., **Murgano E.**, “Chaos in a Fractional Order Duffing System: a circuit implementation”, IEEE International Conference on Systems, Man and Cybernetics (SMC 2019), Bari.
- Caponetto R., **Murgano E.**, “ Model Order Reduction: a comparison between Fractional and Integer Order Approximation”, IEEE International Conference on Systems, Man and Cybernetics (SMC 2019), Bari.