Development of lock-in resistivimeter for measuring resistivity and induced polarization

J. Oliveira and F. Hiodo

January 8, 2016

Abstract

Scaled models of Cole-Cole RC circuit and reduced Clay model were tested with three levels of white noise in order to develop a low cost lock-in resistivimeter. Such device had maximum power of 60 Watts and displayed reliable stability under 67% and 11% of white noise in the respective models. Made with low cost components the resistivemeter had a frequency sweep from 13 to 120 Hertz. We used this frequency bandwidth to find the less time consuming operational settings able to recovered the Cole-Cole exponent and relaxation time. In order to test i we wrote a OCTAVE inversion algoritm and found it 8 sample frequency evenly spaced in the bandwidth were enough for recovery of relaxation time with deviation of less than a order of magnitude. Our results points towards application in lab samples and the field, the latter could be used not only for SIP but for resistivity and IP as well even under high electrical noise.

Introduction

In our work we design the transmitter and receiver, both which has two channels. The reference channel is fed directly in the receiver while the signal channel is injected from the transmitter into the subsurface and then to the receiver. The ideal lock-in transmitter would have a infinite frequency sweep without any distortion and would delivery constant power of 100 Watts for all frequencies. Ours transmitter deliver a stable power close to 60 Watts for the frequency band of 13 to 120 Hz with minimal distortion. Bellow 13 Hz the electrical sin wave distortion increase drastically with frequency.

Inside the receiver the two input signals are multiplied together and then filtered by a low-pass filter of frequency no greater than the input wave, the resulting DC voltage will be proportional only to the resistivity if the two inputs are in phase, and only to the imaginary resistivity if they are in quadrature. Where the last is related to polarization effects.

Sincronous Detection

The synchronous detection also known as Lock-in uses two signals, this method is sensitive to the difference of frequency and phase between the reference input for that reason it can track signals with the same characteristics of the reference channel attenuating any others.

Examples (Optional)

This is the first sentence of the example section.

Results

Table 1 *Measured voltage on scaled models with three levels of white noise.*

Noise level (%)	Output		Noise Level (%)	Output	
	In Phase	Quadrature		In Phase	Quadrature
0	1.52	8.45	0	5.24	1.80
	1.60	8.50		4.75	1.90
	1.44	8.46		4.80	1.92
	1.48	8.40		5.30	1.81
40	1.06	8.42	11	4.70	1.32
	1.28	8.41		4.60	1.20
	1.29	8.37		4.68	1.26
	1.30	8.45		4.50	1.28
67	1.29	8.48	27	2.30	1.30
	1.28	8.48		2.05	1.20
	1.29	8.48		2.12	1.24
	1.30	8.50		2.50	1.32

Conclusions

In relation to others instruments in use, our low power resistivimeter is able to reject great amount of noise in scaled models, returning stable measures with levels of white noise of 67% in RC circuit and 11% in clay scaled model. This results strongly support the viabilty of such low cost device in geoelectrical measures, even in noise environments.

The inversion of Cole-Cole parameters: relaxation time and Cole-Cole expoent points towards application as a multifrequency resistivimeter for Spectral Induced Polarization with a bandwith of 13 to 120 Hertz. In this specter 8 points evenly distributed were enough to recover the Cole-Cole parameters.

Table 2 *Sampling effect on the inversion of Cole-Cole parameters*

Sinthetic Model			**Sampling**	**Calculated Model**			**Missfit**
Model	τ	e_{cc}		τ	e_{cc}	τ **deviation**	
A	567.243	0.0452261	2	517.092	0.045(1)	113 <τ<1702	0.02
			4	474.313	0.045(1)	454 <τ<1702	0.01
			8	567.243	0.0452261	568 <τ<850	0.02
			16	517.092	0.045(1)	453 <τ<568	0.03
B	2.89942	0.0452261	2	2.89942	0.045(1)	0.5 <τ<2.9	0.007
			4	2.89942	0.045(1)	0.5 <τ<2.9	0.013
			8	2.89942	0.045(1)	1.5 <τ<11.6	0.015
			16	2.89942	0.0452261	2.3 <τ<2.9	<10^{-5}
C	622.257	0.834171	2	622.257	0.834171	622.257	<10^{-5}
			4	622.257	0.834171	622.257	
			8	622.257	0.834171	622.257	
			16	622.257	0.834171	622.257	

Table 3 *Noise effect on the inversion of Cole-Cole parameters*

Sinthetic Model			**Noise**	**Calculated Model**		
Model	τ	e_{cc}	**(%)**	τ	e_{cc}	τ **deviation**
A	567.243	0.0452261	5	567.243	0.0452261	567 <τ<860
			10	517.092	0.0452(5)	113 <τ<3405
			25	517.092	0.045(1)	56 <τ<5670
			250	517.092	0.045(2)	170 <τ<11344
B	2.89942	0.0452261	5	2.89942	0.0452(5)	1.15 <τ<11.6
			10	2.89942	0.045(1)	2.3 <τ<4.4
			25	2.89942	0.045(5)	1.8 <τ<5.8
			250	2.89942	0.04(1)	1.8 <τ<14500
C	622.257	0.834171	5	622.257	0.834171	622.257
			10	622.257	0.834171	622.257
			25			
			250	622.257	0.8(1)	435 <τ<1245

Acknowledgements (Optional)

This is the first sentence of the acknowledgements.