Acta Geophysica (2020) 68:123–132
https://doi.org/10.1007/s11600-019-00389-w

Novel wide-angle AVO attributes using rational function

Received: 3 July 2019 / Accepted: 28 November 2019 / Published online: 9 December 2019

Abstract
C AVO ( ) (40°). H , (-), - - , . H , - AVO. - - , - - AVO. AVO . O - AVO .

Keywords S L - AVO R

Introduction

I , AVO (A V O -) . T AVO - AVO - . B , - , NMO - (K B 1983; 1985). H , , -

* @ . . .
* J 12@163.
* I J @ .
[1] C I S E , C U P (B), B 102249, C
[2] S K L P R P , C U P (B), B 102249, C

. AVO - - . (D T 1995; D U , 2006). H , AVO , AVO (B - 1961; A R 1980; S 1985). B , , , (O B 1963; M . 1987). T , - AVO . T - , , - . T , , . T , - (M 2015). I , , , (H 1961; H 2004; A . 2009; U . 1949). A , -

S

, I

,

D

I , AVO

. T

., . I ,

, ;

, AVO,

,

. T

,

.

Theory

AVO ,

PVO ;

$\theta($):

$$H(\theta) = |H(\theta)|e^{i\phi(\theta)} \tag{1}$$

$|H(\theta)|$ AVO $\phi(\theta)$ PVO;

. F (1)

:

$$(s) = \sum_{k=1}^{n} \frac{C_k}{s - A_k} + D \tag{2}$$

$s = j2\pi r$, A_k , C_k

, r ,

D

.

B ,

(L . 2016):

$$R_{pp}^{sph} = \frac{\int_1^0 B(x)J_0(\omega r\sqrt{1-x^2}/v_1)e^{i\omega x(h+z)/v_1}\mathrm{d}x + i\int_0^\infty B(x)J_0(\omega r\sqrt{1+x^2}/v_1)e^{-\omega x(h+z)/v_1}\mathrm{d}x}{\int_1^0 J_0(\omega r\sqrt{1-x^2}/v_1)e^{i\omega x(h+z)/v_1}\mathrm{d}x + i\int_0^\infty J_0(\omega r\sqrt{1+x^2}/v_1)e^{-\omega x(h+z)/v_1}\mathrm{d}x} \tag{3}$$

B PP- :

$$B(x) = \frac{\rho_2 v_2 x - \rho_1 v_1\sqrt{1 - v_2^2/v_1^2(1-x^2)}}{\rho_2 v_2 x + \rho_1 v_1\sqrt{1 - v_2^2/v_1^2(1-x^2)}} \tag{4}$$

v_1, v_2, ρ_1, ρ_2 P-

, , J_0

B , r

$(r = (h+z) * tan\theta)$, h z

, , i

$x = cos\theta, \omega$.

T (3)

,

(2)

; ,

.

I (2), A_k

, , V F

(G S 1999) ,

,

.

S A_k (2), $H(s)$

$\sigma(s)$, $\sigma(s)$

; :

$$\begin{pmatrix} \sigma(s)H(s) \\ \sigma(s) \end{pmatrix} = \begin{pmatrix} \sum_{k=1}^{n} \frac{C_k}{s-\widetilde{A}_k} + D \\ \sum_{k=1}^{n} \frac{\widetilde{C}_k}{s-\widetilde{A}_k} + 1 \end{pmatrix} \tag{5}$$

N (5) $\sigma(s)$

$\sigma(s)\,H(s)$.

M (5) $H(s)$

:

$$\sum_{k=1}^{n} \frac{C_k}{s - \widetilde{A}_k} + D = \left[\sum_{k=1}^{n} \frac{\widetilde{C}_k}{s - \widetilde{A}_k} + 1\right] H(s) \tag{6}$$

O

$$(\sigma H)_{\mathrm{fit}}(s) = \sigma_{\mathrm{fit}}(s)H(s) \tag{7}$$

E (6) $C_k, \widetilde{C}_k$. S

,

:

$$A\widetilde{x} = b \tag{8}$$

$\widetilde{x}$. E
(8) - :
θ_k s_k :

$$A_k\widetilde{x} = b_k \tag{9}$$

$$A_k = \left[\frac{1}{s_k-\widetilde{A}_1} \cdots \frac{1}{s_k-\widetilde{A}_N}\ 1\ \frac{-H(s_k)}{s_k-\widetilde{A}_1} \cdots \frac{-H(s_k)}{s_k-\widetilde{A}_N} \right] \tag{10}$$

$$\widetilde{x} = \left[c_1 \cdots c_N\ D\ \widetilde{c}_1 \cdots \widetilde{c}_N \right] \tag{11}$$

$$b_k = H(s_k) \tag{12}$$

T , $H(s)$
(6) .
I (6) -
,
:

$$(\sigma H)_{\rm fit}(s) = h\frac{\prod_{k=1}^{n+1}(s-z_k)}{\prod_{k=1}^{n}(s-\widetilde{A}_k)}, \sigma_{\rm fit}(s) = \frac{\prod_{k=1}^{n}(s-\widetilde{z}_k)}{\prod_{k=1}^{n}(s-\widetilde{A}_k)} \tag{13}$$

$z_k, (k = 1, 2, 3 \ldots n)$ $(\sigma H)_{\rm fit}(s)$, $\widetilde{A}_k$
$\sigma_{\rm fit}(s)$ $(\sigma H)_{\rm fit}(s)$, $\widetilde{z}_k$ $\sigma_{\rm fit}(s)$.
F :

$$H(s) = \frac{(\sigma H)_{\rm fit}(s)}{\sigma_{\rm fit}(s)} = h\frac{\prod_{k=1}^{n+1}(s-z_k)}{\prod_{k=1}^{n}(s-\widetilde{z}_k)} \tag{14}$$

E (14) $H(s)$
$\sigma_{\rm fit}(s)$. T , $\sigma_{\rm fit}(s)$
$H(s)$. A $H(s)$
E . (14).
V F
. B ,
.

Results

Fitting

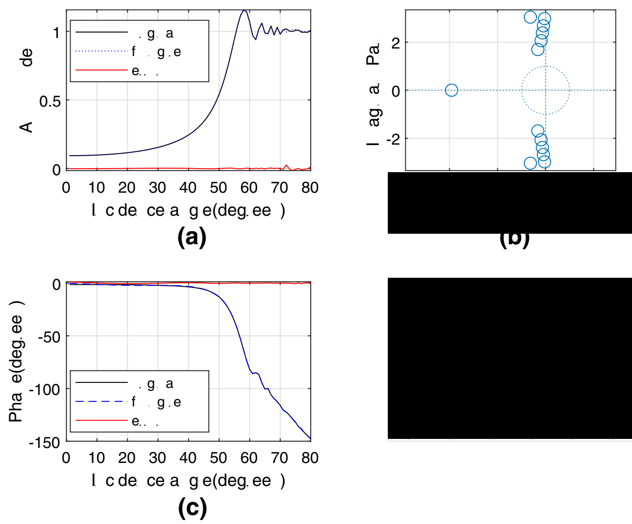
I , -
C . (1998) L . (2016) ,
T 1, v_1, v_2, ρ_1, ρ_2 .

Table 1 P AVO (-)

M	$v_1/(\mathrm{m\,s^{-1}})$	$\rho_1/(\mathrm{g\,cm^{-3}})$	$v_2/(\mathrm{m\,s^{-1}})$	$\rho_2/(\mathrm{g\,cm^{-3}})$
A (1 /)	3093	2.40	4050	2.21
B (1 /)	3093	2.40	4114	2.32
C (2 /)	2642	2.29	2781	2.08
D (2 /)	2642	2.29	3048	2.23
E	2000	2.40	2933	2.20

F , AVO .
B - -
, ,
-
.
T ; , -
, ,
.
−40 B, -
. T R
10 H ,
10 H .
T - AVO -
A D
F . 1 - ( ) ( ) ,
. I -
AVO . T
- ( )
( ). F ,
, ,
. A ,
, -
.

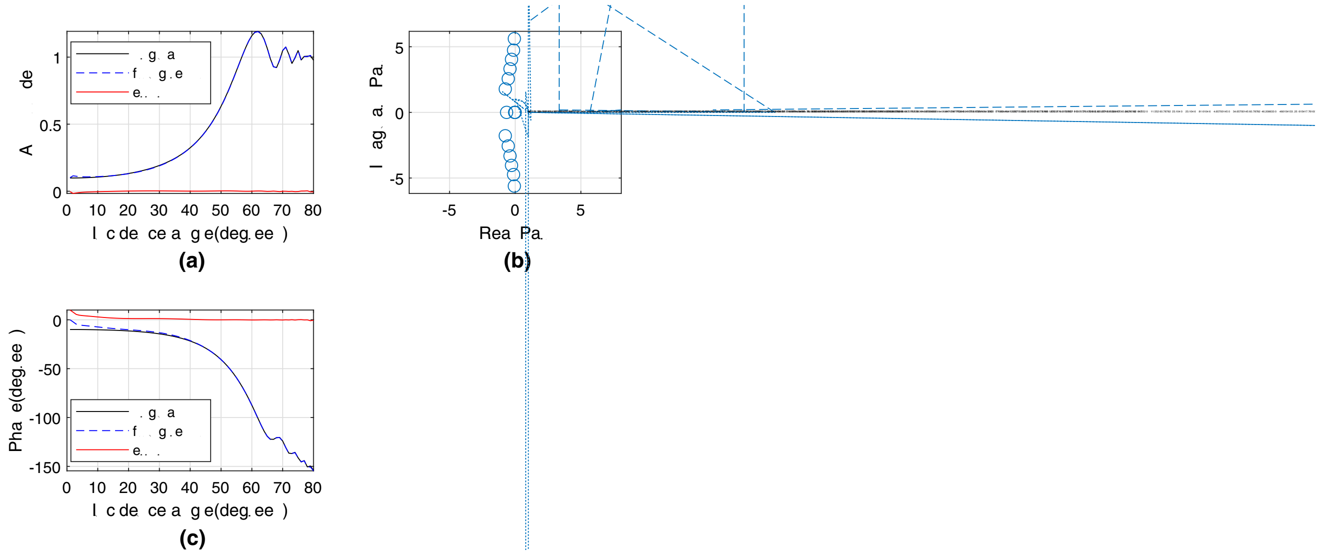
A
AVO, ,
AVO. I F . 2 M E ( ), 12
−40 B. N 6
,
F . 2 M E ( ); 6 -
,
. S



[redacted]

[redacted]

, AVO. I - A F. 4, (S. 1985) , . T. , ; F. 3 4 E. - AVO , F. 3 - AVO - , , - . M A B , [illegible]



Applying

. F -
AVO, A C,
B , , / , A
AVO AVO 1, C 2; B
. F A D, D, / ,

Fig. 4 M E: **a** I - ρ_1. **b** A - ρ_1. **c** I -

B AVO 1, D
2. F
, A B,
AVO 1, A /
, B / ; C
D AVO 2, C /
, D / .

F , A D,
. T
F . 5 .
T , -
- . A ,
,
-
40°.
A ,
,
-
. T A C
F . 6. F , F . 6
- F . 6
. I ,
A, C.
I ,
, AVO - -
-
, AVO -
. A
B D F . 7,
F . 6 .
I AVO, -
.
F . 8 A B,

Fig. 6 C AVO (A: , C:). **a** I - ( ). **b** L ( )

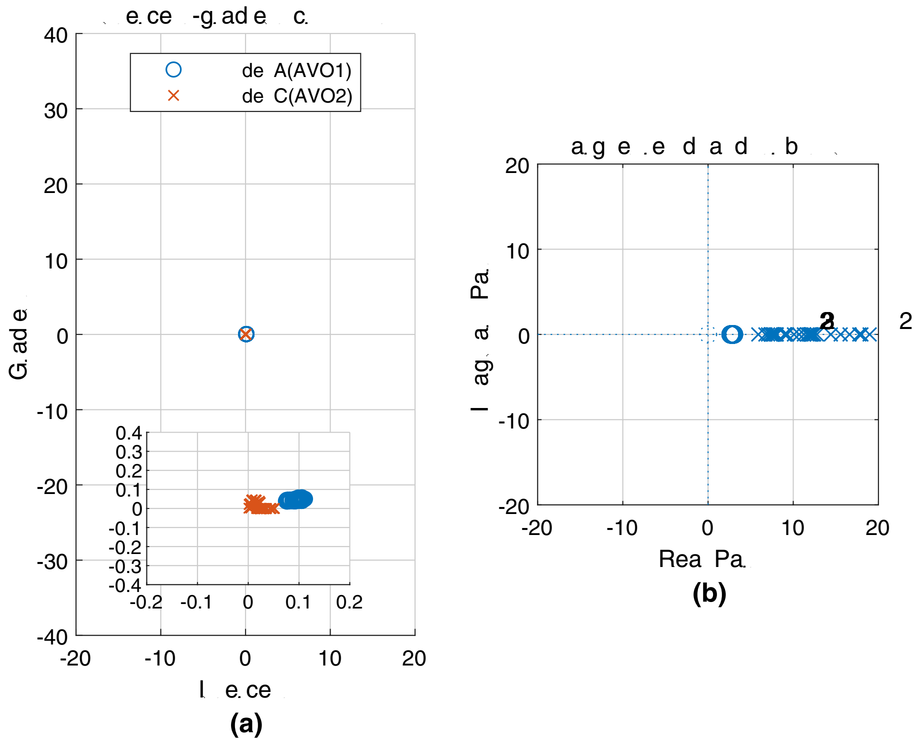
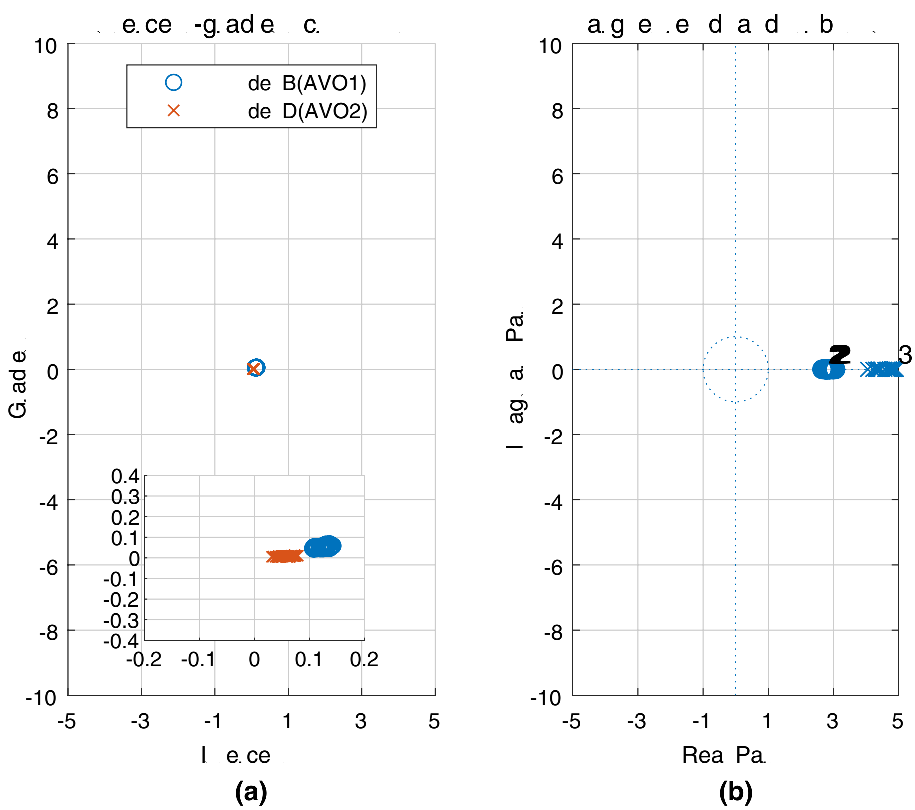
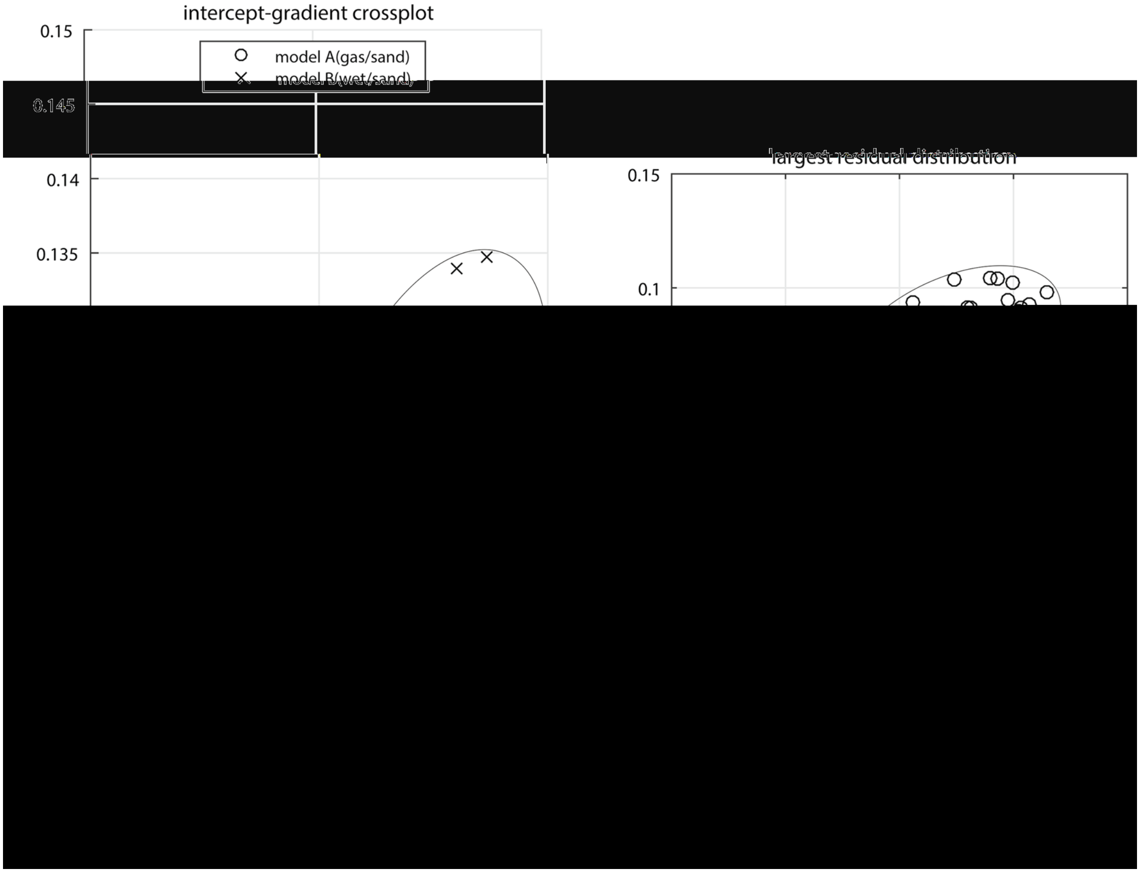


Fig. 7 C AVO (B: , D:). **a** I - ( ). **b** L ( )





[redacted]

Fig. 8 C AVO (A: , B:). **a** I - - - ( ). **b** L ( )

F . 9 C D. A AVO , A B 0.0483 C D 0.0557; - - , - , A B 0.1006 > 0.0483, C D 36.0907 > 0.0557. T - , , - .

Conclusion

T : AVO . I ,

- AVO, , V. F . B AVO , - AVO - AVO . B , - , . T - - , AVO . T - - . A , - AVO , - . S , AVO - . I , - , .

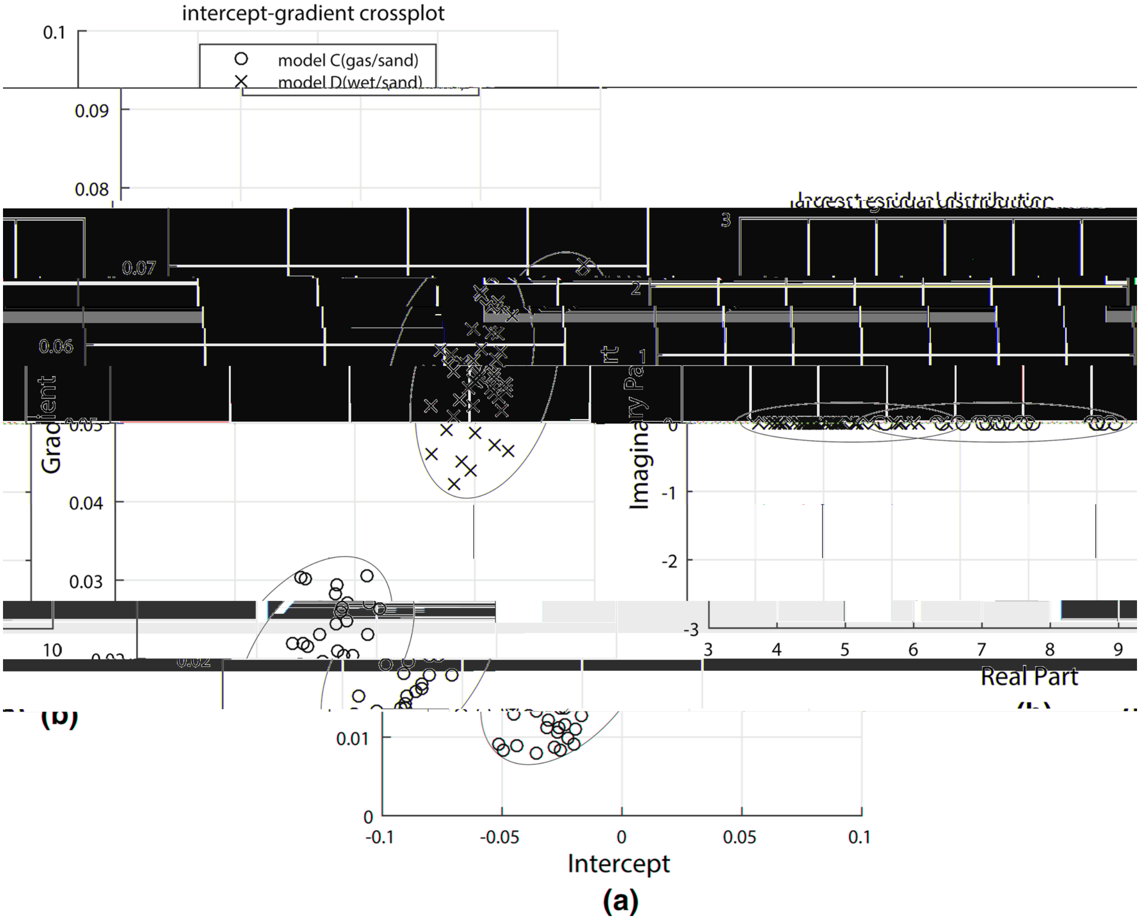


Fig. 9 C AVO (C: , D:). **a** I - - ( ). **b** L ( )

Acknowledgements T C U P (B). AVO/AVA V F , J L - G H .

References

A K, R PG (1980) Q , - . I. . H. F , N &
A M, T I, A A, U B (2009) E - . G 74(5): B33 B53
B R (1961) A . G P 9(4):485 502
C JP, F DJ, S H (1998) F . G 63(3):948 956
V, H F (1961) R . S G E G 5(2):122 132
D , T A (1995) I . G 60(5):1426 1436
D JE, U C (2006) L ( ) . G 71(5):E49 E55
G B, S A (1999) R . IEEE T P D 14(3):1052 1061
H AB (2004) S . S T P E A 23(1):2586
K PM, B H (1983) R . G 48(6):655 664
L J, S, H DC, & S, B J (2016) S - - PP - . C J G 59:3810 3819
M C, D PM, J DD (1987) I . G 52(5):606 617
O B P (1963) A - . G P 11(1):59 72
S RT (1985) A . G - 50(50):609 614

U C, H AB, D JE (1949) A . S T P E A 24(1):202 205
DF (1985) S - - . G 50(2):185
M GA (2015) E - - . G 77(4):149