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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

A TI-59 Calculator Program for
Computation of Schlumberger Resistivity Sounding
Curve for Models with as many as 25 Horizontal Layers

by

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Although this program has been extensively tested, the USGS cannot guarantee that it will give correct results in any or all particular applications.

TITLE Schlumberger Resistivity Sounding

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DATE 10/20/80

Partitioning (Op 17) 2,3,9,8,9

This program was developed to do rapid computation of theoretical Schlumberger resistivity sounding curves. It is based on the application of Ghosh's linear filter (Ghosh, 1971) to resistivity transforms calculated for a given earth model.

Haines and Campbell (1980) wrote a program for the computation of Schlumberger and Wenner sounding curves over structures with as many as 10 horizontal layers. Although it is generally not possible to visually recognize more than 8 layers on a field curve, the present program can be used to compute sounding curves from digitized electric logs provided the number of layers does not exceed 25.

The input data consists of the thicknesses, the resistivities, and the number of layers (up to 25). The program will compute the apparent resistivities at the rate of 6 points per logarithmic cycle starting at abscissa value of $AB/2$ of 1 and ending at 10,000. The computed apparent resistivities will be stored successively in registers 37 to 61. This represents the output of the program, and the contents of these registers can be recalled by the user.

Note: The dimensions of the computed electrode spacings ($AB/2$) and apparent resistivities will correspond to those of the entered thicknesses and resistivities, respectively.

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The following is the output of computed apparent resistivities for the above-mentioned illustrating example.

Computed apparent resistivities	Stored in registers	
241.1431472	37	- for AB/2=1
217.0136337	38	
179.1268944	39	
139.846785	40	
113.1147091	41	
100.9726029	42	
96.86244975	43	- for AB/2=10
95.1592856	44	
93.71288423	45	
91.59566606	46	
86.95311787	47	
76.90352711	48	
61.51721231	49	- for AB/2=100
46.82094031	50	
40.00588464	51	
43.1819453	52	
53.71142519	53	
68.20108221	54	
84.45314038	55	- for AB/2=1000
100.9135485	56	
116.0076031	57	
128.363842	58	
137.3269032	59	
143.100719	60	
146.4431868	61	- for AB/2=10000

USER INSTRUCTIONS

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
1	Clear memory		2nd CMs	
2	Repartition memory storage area	9	2nd Op 17	239.89
3	Load Side 1 of Card Load Side 2 of Card		INV 2nd Write	1. 2.
4	Input layer parameters: starting with the first layer, enter and store thicknesses and resistivities as shown in the following example of a 4-layer model:			
	Thickness Resistivity			
	First Layer 1 259	1.00259	STO 12	1.00259
	Second Layer 46 94	46.00094	STO 13	46.00094
	Third Layer 150 27	150.00027	STO 14	150.00027
	Fourth Layer --- 150	0.00150	STO 15	0.00150
	There are 25 available registers, from no. 12 to no. 36, for layer parameters entry.			
	The last input resistivity value represents the resistivity of the infinitely thick last layer.			

- 5 Enter number of layers (N=4 for above example) 4 4.
- 6 Press A to start program A
- 7 End of program is indicated by the display of 61

Press RCL followed by a register number from 37 to 61 to display successively the computed apparent resistivities for AB/2 of 1, 1.46, 2.15, 3.16, 4.64, 6.81, 10, 14.6,, 10000.

Operating Restriction

The values of layer resistivities should not be larger than 99999. A six digit number will be considered as a decimal fraction. Layer thicknesses can be entered up to a 4-digit number.

USER DEFINED KEYS	DATA REGISTERS (INV)	LABELS (Op 08)
A Starting of program	8 ⁰ 1.467799268	INV Inv CE CLR x ¹¹ x ²
B	8 ¹	√ 1/x STO RCL SUM y ²
C 12-36 for input	8 ²	EE () = GT0 X
D layer parameter	8 ³ filter	SBR - RST + R/S .
E	8 ⁴ coefficients	+/- = CLR INV 1/x 10 ^x
A'	8 ⁵	STO RCL STO RCL STO RCL
B'	8 ⁶ (for recalling	STO RCL STO RCL STO RCL
C' 37-61 computed appar-	8 ⁷	STO RCL STO RCL STO RCL
D' 7 ⁶ 100	8 ⁸	STO RCL STO RCL STO RCL
E' 7 ⁹ 100000	8 ⁹	STO RCL STO RCL STO RCL
FLAGS - 0	- 1	- 2
	- 3	- 4
	- 5	- 6
	- 7	- 8
	- 9	- 0

References

- Ghosh, D. P., 1971, Inverse filter coefficients for computation of apparent resistivity standard curves for a horizontally stratified earth, *Geophys. Prospect.*, 19, p. 769-775.
- Haines, D. N. and Campbell, D. L., 1980, Texas Instruments Model 59 Hand Calculator Program to calculate theoretical Wenner and Schlumberger vertical electrode soundings of a structure of up to 10 horizontal layers, U.S. Geological Survey Open-File Report 80-190, 15 p.

PROGRAMMER _____ DATE _____

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
000	76	LBL		055	10	10	Summation	110	95	=	
001	11	R	start,	056	08	8	↓	111	42	STO	
002	42	STO	store no.	057	09	9		112	08	08	
003	01	01	of layers	058	32	XIT		113	73	RC*	
004	43	RCL	max	059	43	RCL		114	08	08	
005	79	79	AB/2	060	04	04		115	22	INV	
006	32	XIT		061	42	STO		116	59	INT	
007	43	RCL	min.	062	03	03		117	65	X	
008	80	80		063	73	RC*		118	43	RCL	
009	33	X*	AB/2	064	05	05		119	79	79	
010	55	+	and	065	65	X		120	95	=	
011	43	RCL	store	066	73	RC*		121	42	STO	
012	78	78		067	03	03		122	10	10	
013	95	=		068	95	=		123	69	DP	
014	42	STO		069	44	SUM		124	38	38	
015	02	02		070	10	10		125	43	RCL	
016	03	3		071	69	DP		126	01	01	
017	07	7		072	23	23		127	42	STO	
018	42	STO		073	69	DP		128	00	00	
019	09	09	clear	074	23	23		129	97	DSZ	
020	25	CLR	register	075	43	RCL		130	00	00	
021	42	STO		076	05	05		131	01	01	
022	10	10		077	67	EQ		132	35	35	
023	71	SBR	to recall	078	00	00		133	69	DP	
024	01	01	and stor	079	85	85		134	38	38	
025	05	05	p and h	080	69	DP		135	73	RC*	
026	43	RCL		081	25	25		136	08	08	
027	02	02	next	082	61	GTO		137	59	INT	
028	65	X	AB/2	083	00	00		138	42	STO	
029	43	RCL		084	63	63		139	11	11	
030	80	80		085	43	RCL	↑	140	73	RC*	
031	95	=		086	10	10	store	141	08	08	
032	42	STO		087	72	ST*	apparent	142	22	INV	
033	02	02		088	04	04	resistivity	143	59	INT	
034	77	GE	test for	089	06	6	limit of	144	65	X	
035	00	00	max. AB/2	090	01	1	computation	145	43	RCL	
036	42	42		091	32	XIT		146	79	79	
037	69	DP	if no, go	092	43	RCL	test for	147	95	=	
038	29	29	to next	093	04	04	limit, if	148	42	STO	
039	61	GTO	AB/2	094	67	EQ	yes stop.	149	07	07	
040	00	00		095	01	01	if no, go	150	71	SBR	↑
041	20	20		096	03	03	back and	151	01	01	to compute
042	03	3		097	69	DP	Continue.	152	62	62	transforms
043	07	7		098	24	24		153	97	DSZ	decrement
044	42	STO		099	61	GTO		154	00	00	no. of layers
045	03	03		100	00	00		155	01	01	if zero
046	42	STO		101	48	48		156	33	33	store
047	04	04		102	68	HDP		157	43	RCL	transform.
048	25	CLR		103	91	R/S		158	10	10	if no,
049	08	8	store	104	00	0	↓	159	72	ST*	Continue
050	01	1	first filter	105	01	1					
051	42	STO	coefficient	106	01	1					
052	05	05		107	85	+					
053	25	CLR	clear for	108	43	RCL					
054	32	STO		109	01	01					

convolve resistivity transform with filter coefficients

test for conv. if no continue, if yes go 085

store apparent resistivity limit of computation test for limit, if yes stop. if no, go back and Continue.

store Pn, recall and store resistivity and thickness of (n-1) layer separately.

Counter for no. layers

↑ to compute transforms
decrement no. of layers
if zero store transform, if no, Continue

MERGED CODES

62 [STO]	72 [STO]	84 [GTO]
63 [RCL]	73 [RCL]	85 [RCL]
64 [XIT]	74 [SUM]	92 [INV]

PROGRAMMER _____ DATE _____

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
160	09	09		215	07	07					
161	92	RTN		216	33	NR					
162	02	2		217	54)					
163	65	X		218	22	INV					
164	43	RCL		219	49	PRD					
165	11	11		220	05	05					
166	65	X		221	48	EXC					
167	43	RCL		222	05	05					
168	02	02		223	42	STD					
169	35	1/X		224	10	10					
170	95	=		225	92	RTN					
171	94	+/-									
172	22	INV									
173	23	LHX									
174	42	STD									
175	06	06									
176	53	(
177	53	(
178	01	1									
179	75	-									
180	43	RCL									
181	06	06									
182	54)									
183	55	+									
184	53	(
185	01	1									
186	85	+									
187	43	RCL									
188	06	06									
189	54)									
190	54)									
191	42	STD									
192	06	06									
193	65	X									
194	43	RCL									
195	07	07									
196	95	=									
197	42	STD									
198	06	06									
199	85	+									
200	43	RCL									
201	10	10									
202	95	=									
203	42	STD									
204	05	05									
205	53	(
206	01	1									
207	85	+									
208	43	RCL									
209	06	06									
210	65	X									
211	43	RCL									
212	10	10									
213	55	+									
214	43	RCL									

Compute resistivity transforms from $T_i = \frac{P_1 + P_2 V_i}{1 + P_2 V_i P_1 / P_2^2}$, $V_i = \frac{1 - e^{-2diu}}{1 + e^{-2diu}}$

Store in Registers

100. 78
 100000. 79
 1.467799268 80
 0.0148 81
 -0.0814 82
 0.4018 83
 -1.5716 84
 1.972 85
 0.1884 86
 0.1064 87
 -0.0499 88
 0.0225 89

Filter coefficients

MERGED CODES
 62 [] [] 72 [sto] [] 83 [gro] []
 63 [] [] 73 [rcl] [] 84 [] []
 64 [] [] 74 [sum] [] 92 [inv] []