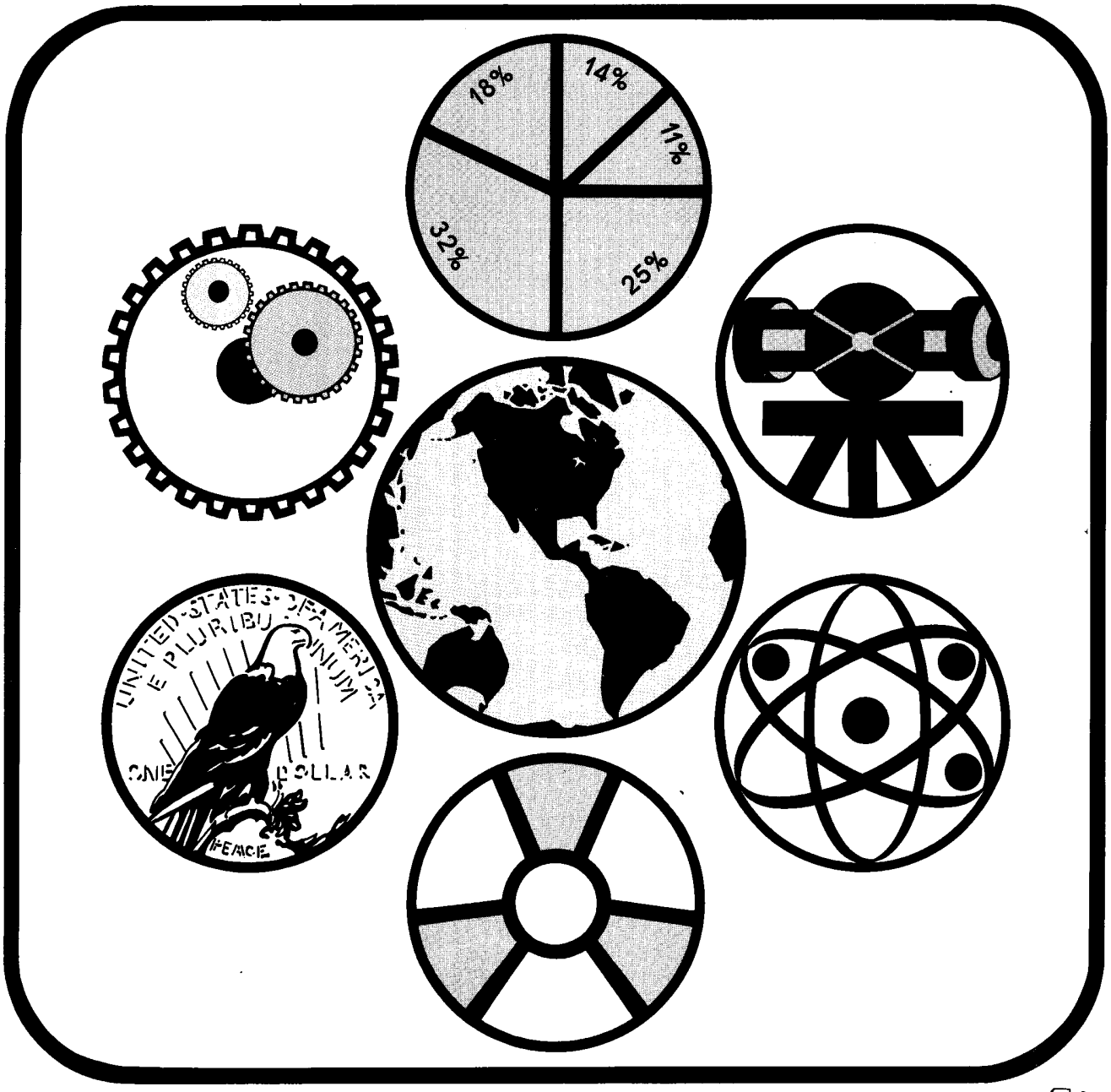
Programmable TI58/59 Specialty Pakettes Electronic Engineering



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THE TI-59 PAKETTE STORY

Since the early days of handheld programmable calculators, Texas Instruments (TI) has been deeply involved in supplying not only calculators with exceptional power but also programs (software) to match. Many experts were put to work within their special fields of endeavor to design quality Software Libraries for TI calculator users. Among the Libraries produced by TI for the TI-59 are:

- Statistics
- Real Estate and Investment
- Surveying
- Navigation
- Farming
- Math/Utilities
- Aviation
- Leisure
- Business Decisions
- Securities Analysis
- Electrical Engineering
- RPN Simulator

Fully recognizing TI-59 users may require programs other than those included in TI-59 Libraries, a second program source was developed. This source, the Professional Program Exchange, gathers, compiles and redistributes programs **written by TI-59 users** who defined their own specific program needs and filled these needs by writing programs. These programs, now in Pakettes, add a new dimension to the software made available to TI-59 user. Combining some of the best TI originated programs with the most popular programs found in the Professional Program Exchange, Program Pakettes offer a true software value. Current TI Pakette offerings include:

- Securities
- Statistical Testing
- Civil Engineering
- Electronic Engineering
- Blackbody
- Oil/Gas/Energy
- Printer Utility
- Astrology
- Programming Aids
- 59 Fun
- 3-D Graphics
- Fluid Dynamics
- Mathematics
- Lab Chemistry
- Production Planning
- Marketing/Sales

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6 5 8 0 0 1
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PPX-59
professional program exchange

TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title	Rev.
CLASS "A" AMPLIFIER DESIGNED TO SPECIFIED TOLERANCES	

Abstract of Program

Biasing, load and emitter resistors are calculated for a class "A" bipolar transistor amplier. Design is constrained to a maximum allowable percent collector current variation specified by the user. Program outputs include signal power, stage minimum power gain, minimum and maximum collector currents, transistor thermal resistance, quiescent collector current, minimum and maximum junction temperatures, base-emitter voltages at Tmax and Tmin, and thevenin-Equivalent circuit values. Self-heating effects are considered and the program insures that Tmax ∠ Tjmax. An alarm is provided when the chosen transistor is unsuitable due to a small hfe min/max spread.

Original SR-52 Program by B. R. Kelso, FPO New York, N.Y.

User Benefits:

Time is saved and errors reduced by allowing the user to "plug in" transistor data sheet parameters and proceed directly to optimized design without lengthy breadboard sessions.

Category Name	Required Progs.	Prog. Steps	Card Sides	PC-100A Needed / Library Module ID
Electronic Eng.		503	3	☐ / ☐

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Signature _____ Date _____

Name Texas Instruements _____ Tel. No. _____

Address _____

City _____ State _____ Zip _____

Submission Checklist

- ☑ Recorded Magnetic Cards
- ☑ Submission Abstract
- ☑ Program Description
- ☑ User Instructions
- ☑ Sample Problem
- ☑ Listing
- ☐ _____
- ☐ _____

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TEXAS INSTRUMENTS
Calculator Products Division

Program Description

Program Title:
Class "A" Amplifier designed to specified tolerances

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:

METHOD: 1) Find the transistor's thermal resistance:

$\theta_{ja} = (T_{jmax} - 25°C)/PD$

2) Find the trial minimum load resistance:

$R_{li} = \theta_{ja} V_{cc}^2/[4.4(T_{jmax} - T_{amax})] = R_{ln}$

3) Find the trial emitter resistance:

$R_{EI} = R_{LI} \times 10\% = R_{EN}$

4) Find the trial operating point:

$I_{CQ} = V_{cc}/[2(r_{LN} + R_{EN})]$

5) Find the operating point current limits:

$I_{cmax} = I_{cq}(1 + \Delta I_{cq})$ Where ΔI_{cq} = max % change

$I_{min} = I_{cq}(1 - \Delta I_{cq})$ In quiescent current

6) Find approximate maximum junction temperature:

$T_{max} = \theta_{JA} I_{cq}[V_{cc} - (R_{ln} + R_{en}) I_{cq}) + T_{amax}$

7) Find the actual Vbe Voltage at Tmax:

$V_{bex} = V_{eelmin} + \Delta V_{belog}(I_{cmax}/I_1) - 0.0022(T_{max} - 25°C)$

8) Find the minimum junction temperature:

$T_{min} = \theta_{ja} I_{cmin}[V_{cc} - (R_{ln} + R_{en}) I_{cmin}] + T_{amin}$

9) Find the base-emitter voltage at Tmin:

$V_{ben} = V_{belmax} + \Delta V_{be} \log(I_{cmin}/I_1) - 0.0022(T_{min} - 25°C)$

10) Make a better estimate for RE:

$R_e(n+1) = [-2(V_{bex} - V_{ben})]/[I_{cmax} - I_{cmin}]$

11) Iterate beginning at Step 2 until $RE_{(n+1)} = RE_n \pm 5\%$

12) Find Thevenin - Equivalent circuit values:

$R_B = [hfe_{max} hfe_{min}[Re(n+1)(I_{cmax} - I_{cmin}) + V_{bex} - V_{ben}]/$
$[hfe_{max} I_{cmin} - hfe_{min} I_{cmax}]$

$V_{BB} = V_{ben} + I_{cmin}[R_B/hfe_{min}) + RE(n+1)]$

13) Find the biasing resistors:

$R_1 = R_B V_{CC}/V_{BB}$

☐ See Continuation Sheet

Continued From: ☑ Program Description ☐ User Instructions ☐ Stmt. of Example

Program Title: Class "A" Amplifier designed to specified tolerances - continued	Rev.

$R_2 = R_B V_{CC} / (V_{cc} - V_{bb})$

14) Find the stage minimum power gain:

$A_p = [R_B R_L hfe_{min}] / [RE(R_B + hfe_{min} R_E)]$

15) Find the stage minimum signal gain:

$P_s = (1 - \Delta I_{CQ})^2 [V_{cc}^2 R_L / 8 (R_L + R_E)^2]$

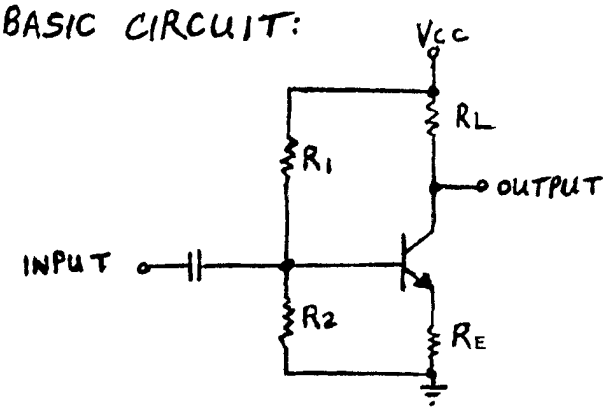
Limitations: This procedure regards the change in transistor base-emitter voltage as constant over a (log) decade variation in collector current. This assumption yields a very small error with careful selection of the expected operating point on the V_{BE}/I_c curve; however, under very high current condition the logarithmic assumption breaks down. Also, low frequencies only.

REFERENCES: Helms, Ward J., Electronics magazine, August 8, 1974.

Terms Defined:

Icmin - Minimum collector current
Icmax - Maximum collector current
θ-ja - Transistor thermal resistance
Icq - Quiescent collector current
Tmax - Maximum junction temperature (Program insures that Tmax < Tjmax.)
Vbex - Base-emitter voltage at Tmax
Tmin - Minimum junction temperature (With self-heating effects considered)
Vben - Base-emitter voltage at Tmin
R_B and V_{BB} - Thevenin-Equivalent circuit values.

BASIC CIRCUIT:



6,5	8,0,0,1

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User Instructions

Program Title
Class "A" Amplifier designed to Spec. Tolerances

Execute				

Partition (OP 17)	Parenthesis Levels		
719 . 29	2	t Register	☑
Angular Mode (if applicable)	SBR Levels	Absolute Addresses	☐
	0		
Library Module ID		Disturbs Pending Operations	☑

LABELS (Op 08)

INV	ln x	CE	CLR	x:t	x²
√x	1/x	STO	RCL	SUM	y^x
EE	(	)	÷	GTO	×
SBR	−	RST	+	R/S	•
+/−	=	CLR	INV	log	CP
tan	Pgm	P→R	sin ✓	cos ✓	CMs
Exc	Prd	|x|	Eng	Fix	Int
Deg	Pause	x=t	Nop	Op	Rad
Lbl	x≥t ✓	Σ+ ✓	x̄	Grad	St flg
If flg	D.MS ✓	π ✓	List	Write	Dsz
Adv	Prt				

USER DEFINED KEYS

A EXECUTE
0 P_S
1 Vcc
2 Δ Icq (%)
3 ΔV_{BE}
4 V_{BEIMIN}
5 $V_{VBEIMAX}$
6 T_{JMAX}
7 P_D at 25° C
8 I_1
9 θ_{JA}

FLAGS	0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS			OUTPUT/MODE (see legend below)
1	Enter Program Banks 1,2,3 -- Be sure to set partition to 719.29 (3 op 17)					
2-13	Choose Vcc. Regulation ≥ ± 5%.					
	Enter Vcc in Volts	Vcc	STO	0	1	Vcc
2	Choose the maximum allowable collector current variation, ΔI_{CQ}. When ΔI_{CQ} < ± 10%, power output will be poor.					
	Enter ΔI_{CQ} in percent	ΔI_{CQ}(%)	STO	0	2	ΔI_{CQ}(%)
4	Using the transistors' V_{BE} vs. I_c curve, choose I, and 10I, such that the desired operating point is bracketed, determine ΔV_{BE} by subtracting V_{BE} @I, from V_{BE} @$10I_1$.					
	Enter ΔV_{BE} in volts	ΔV_{BE}	STO	0	3	ΔV_{BE}
5	From the device data sheet, determine the minimum V_{BE} @ I_1.					
	Enter $V_{BE\ I\ MIN}$ in Volts	$V_{BE\ I\ MIN}$	STO	0	4	V_{BEIMIN}
6	Determine the maximum V_{BE} @ I_1.					
	Enter V_{BEIMAX} in Volts	$V_{BEI\ MAX}$	STO	0	5	V_{BEIMAX}
7	Enter T_{JMAX} in °C.	T_{JMAX}	STO	0	6	T_{JMAX}

Modes: (n)• —Printed only (n)—Displayed Briefly (Pause)
n• —Printed and displayed

DATA REGISTERS (INV List)

10 $R_{L1} = R_n$
11 $R_{E1} = R_{EN}$
12 I_{CQ}
13 I_{CMAX}
14 I_{CMIN}
15 T_{MAX}
16 V_{BEX}
17 T_{MIN}
18 V_{BEN}
19 RE(n+1)
20 T_{AMIN}
21 T_{AMAX}
22 $h_{FE\ MIN}$
23 $h_{FE\ MAX}$
24 R_B
25 V_{BB}
26 R_1
27 R_2
28 Ap (db)
29

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☐ See Continuation Sheet

Continued From: ☐ Program Description ☑ User Instructions ☐ Stmt. of Example

Program Title:
Class "A" Amplifier designed to Spec. Tolerances

Rev.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
	Input (Continued):			
8	Enter P_D (at 25° C) in watts	P_D	STO 07	P_D
9	Enter I_1	I_1	STO 08	I_1
10	Enter the design minimum ambient temperature, T_{AMIN} in °C	T_{AMIN}	STO 20	T_{AMIN}
11	Enter the design maximum ambient temperature, $T_{A\ MAX}$ in °C	$T_{A\ MAX}$	STO 21	$T_{A\ MAX}$
12	Enter $h_{FE\ MIN}$	$h_{FE\ MIN}$	STO 22	$h_{FE\ MIN}$
13	Enter $h_{FE\ MAX}$	$h_{FE\ MAX}$	STO 23	$h_{FE\ MAX}$

14 EXECUTE - Press A

The display will go blank, then a number (1-5) will flash (pause) followed by a value in the display. Follow instructions according to the number flashed in the display. If number is missed when it is flashed, press X≥ t to reveal number which is also put in the t register press x≥ t again and follow instructions.

Flashed No.		PROCEDURE	DISPLAY	ENTER	PRESS
14a	1	Minimum load resistance, $R_{L\ MIN}$ is displayed. A larger number may be entered if desired.	(1) $R_{L\ MIN}$	R_L (optional)	R/S
14b	2	Operating point for maximum output voltage swing is displayed. A different value (in amps) may be entered if desired.	(2) I_{CQ}	I_{CQ}(optional)	R/S
14c	3	Indicates that either the $h_{FE\ MIN/MAX}$ spread is too small or ΔI_{QC} is too small. Consider using an emitter follower for this stage or select another transistor type.	(3) flashing 9's		CLEAR
14d	4	Enter the standard resistor value (in ohms) nearest the displayed value	(4) R	R_{STD}	R/S
14e	5	End of execution proceed to output values	(5) 5	Continue next step	

Continued From: ☐ Program Description ☒ User Instructions ☐ Stmt. of Example

Program Title: CLASS "A" Amplifier Designed to Spec. Tolerances

Rev.

STEP	PROCEDURE	ENTER	PRESS	DISPLAY
15-30	Output Values:			
15	Examine signal power (watts)		RCL 00	P_s
16	Examine the stage minimum Power gain (decibels)		RCL 28	A_p
	NOTE: If A_p and/or P_s are insufficient, add a heatsink and repeat the procedure or select a transistor with a higher h_{FE} MIN.			
17	Examine R_L in Ohms		RCL 10	R_L
18	Examine R_E in Ohms		RCL 19	R_E
19	Examine R_1 in Ohms		RCL 26	R_1
20	Examine R_2 in Ohms		RCL 27	R_2
21	Examine $I_{C\,MIN}$ (Min. Collector Current)		RCL 14	$I_{C\,MIN}$
22	Examine $I_{C\,MAX}$ (Max. Collector Current)		RCL 13	$I_{C\,MAX}$
23	Examine θ_{JA} (Transistor Thermal Resistance)		RCL 09	θ_{JA}
24	Examine I_{CQ} (Quiescent Collector Current)		RCL 12	I_{CQ}
25	Examine T_{MAX} (Max. Junction Temperature)		RCL 15	T_{MAX}
26	Examine V_{BEX} (Base-Emitter Voltage at T_{MAX})		RCL 16	V_{BEX}
27	Examine T_{MIN} (min. Junction Temperature)		RCL 17	T_{MIN}
28	Examine V_{BEN} (Base-emitter Voltage at T_{MIN})		RCL 18	V_{BEN}
29	Examine R_B (Thevenin equivalent)		RCL 24	R_B
30	Examine V_{BB} (Thevenin equivalent)		RCL 25	V_{BB}

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Calculator Products Division

Sample Problem

Statement of Example

A single-stage class"A" amplifier is needed to operate from a 30-volt power supply. The maximum power output and maximum power gain must be obtained from a Texas Instruments Type TIS98 transistor over an ambient temperature range of 0°C to 70°C with a maximum quiescent-current variation of + 20%. From the transistor's data sheet, determine: T_{max} = 150°C, P_D = 0.36W, Δ Vbe = 0.10V from 3 to 30 MA, V_{be1min} = 0.54 vat 3_{ma} at 25°C, V_{ee1max} = 0.74 V A T 3MA at25°C, I_1 = 0.001A, h_{FEEMAX} = 600 at 150°C at 18MA, H_{FEMIN} = 100 at 80°C at 12MA.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
3	OP 1 7	719. 29	Partition
Read card banks, 1, 2 and 3			
30	STO 0 1	30.	Vcc
20	STO 0 2	20.	ΔIcq (%)
.1	STO 0 3	0.1	ΔVbe
.54	STO 0 4	0.54	Vbe_1MIN
.74	STO 0 5	0.74	Vbe_1MAx
150	STO 0 6	150.	Tjmax
.36	STO 0 7	0.36	Pd
.001	STO 0 8	0.001	I_1
70	STO 2 1	70.	TAmax
0	STO 2 0	0.	Tamin
600	STO 2 3	600	Hfe Max
100	STO 2 2	100	Hfe Min
	A		EXECUTE
		(1) 887.7840909	RL Min (not Changed)
	R/S	(2) 0.01536	Icq (not changed)
	R/S	(2) 0.0143453655	Icq (not changed)
	R/S	(2) 0.0142624571	
	R/S	(4) 120.2204612	R -- stand, R entered
120	R/S	(5) 5	Finished execution

Modes: (n)* --Printed only (n)--Displayed Briefly (Pause)
n* --Printed and displayed

☐ Over

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Sample Problem (cont'd)

6 5 8 0 0 1
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ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	RCL 00	0.0606253981	Ps
	RCL 28	22.91777965	Ap
	RCL 10	932.1732955	RL
	RCL 19	120.	RE
	RCL 26	46773.39562	R_1
	RCL 27	4382.853221	R_2
	RCL 14	0.0114099657	Icmin
	RCL 13	0.0171149485	Icmax
	RCL 09	347.2222222	~~0~~ JA
	RCL 12	0.0142624571	Icq
	RCL 15	144.2836306	Tmax
	RCL 16	0.4009135723	Vbex
	RCL 17	71.31228539	Tmin
	RCL 18	0.7438414059	Vben
	RCL 24	4007.348707	RB
	RCL 25	2.570274397	VBB

Modes: (n)* —Printed only (n)—Displayed Briefly (Pause)
n* —Printed and displayed

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PPX-59 Professional Program Exchange

6 5 8 0 0 1
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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	11	A	
002	43	RCL	
003	06	06	
004	75	-	
005	02	2	
006	05	5	
007	95	=	
008	55	÷	
009	43	RCL	
010	07	07	
011	95	=	
012	42	STO	
013	09	09	
014	65	×	
015	43	RCL	
016	01	01	
017	33	X²	
018	55	÷	
019	53	(	
020	04	4	
021	93	.	
022	04	4	
023	65	×	
024	53	(	
025	43	RCL	
026	06	06	
027	75	-	
028	43	RCL	
029	21	21	
030	95	=	
031	32	X:T	
032	01	1	
033	66	PAU	
034	32	X:T	
035	91	R/S	
036	42	STO	
037	10	10	
038	65	×	
039	93	.	
040	01	1	
041	95	=	
042	42	STO	
043	11	11	
044	76	LBL	
045	88	DMS	
046	43	RCL	
047	11	11	
048	85	+	
049	43	RCL	
050	10	10	
051	95	=	
052	65	×	
053	02	2	
054	95	=	
055	35	1/X	
056	65	×	
057	43	RCL	
058	01	01	
059	95	=	
060	32	X:T	
061	02	2	
062	66	PAU	
063	32	X:T	
064	91	R/S	
065	42	STO	
066	12	12	
067	43	RCL	
068	02	02	
069	65	×	
070	93	.	
071	00	0	
072	01	1	
073	85	+	
074	01	1	
075	95	=	
076	65	×	
077	43	RCL	
078	12	12	
079	95	=	
080	42	STO	
081	13	13	
082	43	RCL	
083	02	02	
084	65	×	
085	93	.	
086	00	0	
087	01	1	
088	94	+/-	
089	85	+	
090	01	1	
091	95	=	
092	65	×	
093	43	RCL	
094	12	12	
095	95	=	
096	42	STO	
097	14	14	
098	43	RCL	
099	06	06	
100	32	X:T	
101	43	RCL	
102	09	09	
103	65	×	
104	43	RCL	
105	12	12	
106	65	×	
107	53	(	
108	43	RCL	
109	01	01	
110	75	-	
111	53	(	
112	43	RCL	
113	10	10	
114	85	+	
115	43	RCL	
116	11	11	
117	54	)	
118	65	×	
119	43	RCL	
120	12	12	
121	54	)	
122	85	+	
123	43	RCL	
124	21	21	
125	95	=	
126	42	STO	
127	15	15	
128	22	INV	
129	77	GE	
130	39	COS	
131	43	RCL	
132	10	10	
133	65	×	
134	01	1	
135	93	.	
136	00	0	
137	05	5	
138	95	=	
139	42	STO	
140	10	10	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

6 5 8 0 0 1
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LOC	CODE	KEY	COMMENTS
141	76	LBL	
142	39	COS	
143	43	RCL	
144	04	04	
145	85	+	
146	43	RCL	
147	03	03	
148	65	×	
149	53	(	
150	43	RCL	
151	13	13	
152	55	÷	
153	43	RCL	
154	08	08	
155	54	)	
156	28	LOG	
157	95	=	
158	75	-	
159	93	.	
160	00	0	
161	00	0	
162	02	2	
163	02	2	
164	65	×	
165	53	(	
166	43	RCL	
167	15	15	
168	75	-	
169	02	2	
170	05	5	
171	54	)	
172	95	=	
173	42	STO	
174	16	16	
175	32	X:T	
176	43	RCL	
177	09	09	
178	65	×	
179	43	RCL	
180	14	14	
181	65	×	
182	53	(	
183	43	RCL	
184	01	01	
185	75	-	
186	53	(	
187	43	RCL	
188	10	10	
189	85	+	
190	43	RCL	
191	11	11	
192	54	)	

LOC	CODE	KEY	COMMENTS
193	65	×	
194	43	RCL	
195	14	14	
196	54	)	
197	85	+	
198	43	RCL	
199	20	20	
200	95	=	
201	42	STO	
202	17	17	
203	43	RCL	
204	05	05	
205	85	+	
206	43	RCL	
207	03	03	
208	65	×	
209	53	(	
210	43	RCL	
211	14	14	
212	55	÷	
213	43	RCL	
214	08	08	
215	54	)	
216	28	LOG	
217	75	-	
218	93	.	
219	00	0	
220	00	0	
221	02	2	
222	02	2	
223	65	×	
224	53	(	
225	43	RCL	
226	17	17	
227	75	-	
228	02	2	
229	05	5	
230	54	)	
231	95	=	
232	42	STO	
233	18	18	
234	77	GE	
235	89	π	
236	00	0	
237	42	STO	
238	19	19	
239	43	RCL	
240	10	10	
241	65	×	
242	93	.	
243	01	1	
244	95	=	
245	44	SUM	
246	10	10	

LOC	CODE	KEY	COMMENTS
247	00	0	
248	42	STO	
249	11	11	
250	61	GTO	
251	88	DMS	
252	76	LBL	
253	89	π	
254	02	2	
255	94	+/-	
256	65	×	
257	53	(	
258	43	RCL	
259	16	16	
260	75	-	
261	43	RCL	
262	18	18	
263	54	)	
264	55	÷	
265	53	(	
266	43	RCL	
267	13	13	
268	75	-	
269	43	RCL	
270	14	14	
271	54	)	
272	95	=	
273	42	STO	
274	19	19	
275	32	X:T	
276	43	RCL	
277	11	11	
278	65	×	
279	01	1	
280	93	.	
281	00	0	
282	05	5	
283	95	=	
284	22	INV	
285	77	GE	
286	77	GE	
287	43	RCL	
288	11	11	
289	65	×	
290	93	.	
291	09	9	
292	05	5	
293	95	=	
294	77	GE	
295	77	GE	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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LOC	CODE	KEY	COMMENTS
296	43	RCL	
297	10	10	
298	65	×	
299	93	.	
300	09	9	
301	08	8	
302	95	=	
303	22	INV	
304	77	GE	
305	78	Σ+	
306	43	RCL	
307	23	23	
308	65	×	
309	43	RCL	
310	22	22	
311	65	×	
312	53	(	
313	43	RCL	
314	19	19	
315	65	×	
316	53	(	
317	43	RCL	
318	13	13	
319	75	-	
320	43	RCL	
321	14	14	
322	54	)	
323	85	+	
324	43	RCL	
325	16	16	
326	75	-	
327	43	RCL	
328	18	18	
329	54	)	
330	55	÷	
331	53	(	
332	43	RCL	
333	23	23	
334	65	×	
335	43	RCL	
336	14	14	
337	75	-	
338	43	RCL	
339	22	22	
340	65	×	
341	43	RCL	
342	13	13	
343	54	)	
344	95	=	
345	42	STO	
346	24	24	
347	04	4	
348	66	PAU	
349	32	X:T	
350	91	R/S	
351	42	STO	
352	19	19	
353	43	RCL	
354	18	18	
355	85	+	
356	43	RCL	
357	14	14	
358	65	×	
359	53	(	
360	53	(	
361	43	RCL	
362	24	24	
363	55	÷	
364	43	RCL	
365	22	22	
366	54	)	
367	85	+	
368	43	RCL	
369	19	19	
370	95	=	
371	42	STO	
372	25	25	
373	43	RCL	
374	23	23	
375	55	÷	
376	43	RCL	
377	22	22	
378	75	-	
379	43	RCL	
380	13	13	
381	55	÷	
382	43	RCL	
383	14	14	
384	95	=	
385	29	CP	
386	77	GE	
387	38	SIN	
388	76	LBL	
389	78	Σ+	
390	03	3	
391	66	PAU	
392	32	X:T	
393	00	0	
394	23	LNX	
395	91	R/S	
396	76	LBL	
397	77	GE	
398	43	RCL	
399	19	19	
400	42	STO	
401	11	11	
402	61	GTO	
403	88	DMS	
404	76	LBL	
405	38	SIN	
406	43	RCL	
407	24	24	
408	65	×	
409	43	RCL	
410	01	01	
411	55	÷	
412	43	RCL	
413	25	25	
414	95	=	
415	42	STO	
416	26	26	
417	43	RCL	
418	24	24	
419	65	×	
420	43	RCL	
421	01	01	
422	55	÷	
423	53	(	
424	43	RCL	
425	01	01	
426	75	-	
427	43	RCL	
428	25	25	
429	95	=	
430	42	STO	
431	27	27	
432	43	RCL	
433	24	24	
434	65	×	
435	43	RCL	
436	10	10	
437	65	×	
438	43	RCL	
439	22	22	
440	55	÷	
441	53	(	
442	43	RCL	
443	11	11	
444	65	×	
445	53	(	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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LOC	CODE	KEY	COMMENTS
446	43	RCL	
447	24	24	
448	85	+	
449	43	RCL	
450	22	22	
451	65	×	
452	43	RCL	
453	11	11	
454	95	=	
455	28	LOG	
456	65	×	
457	01	1	
458	00	0	
459	95	=	
460	42	STO	
461	28	28	
462	53	(	
463	01	1	
464	75	-	
465	53	(	
466	43	RCL	
467	02	02	
468	65	×	
469	93	.	
470	00	0	
471	01	1	
472	54	)	
473	54	)	
474	33	X^2	
475	65	×	
476	53	(	
477	43	RCL	
478	01	01	
479	33	X^2	
480	65	×	
481	43	RCL	
482	10	10	
483	54	)	
484	55	÷	
485	53	(	
486	08	8	
487	65	×	
488	53	(	
489	43	RCL	
490	10	10	
491	85	+	
492	43	RCL	
493	19	19	
494	54	)	
495	33	X^2	
496	95	=	
497	42	STO	
498	00	00	
499	05	5	
500	32	X:T	
501	05	5	
502	91	R/S	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title	Rev.
RF AMPLIFIER ANALYSIS	

Abstract of Program

Given the Y - parameters of a two port network, such as a transistor used as an RF Amplifier, this program calculates the input admittance, transducer gain and Linvill's C - factor for a specified load admittance assumed to be pure conductance.

Original SR-52 Program by R. B. Formeister, Phoenix, Arizona, September 1976

User Benefits:

Provides short-cut to the design of input matching networks based on loading in collector circuit, while predicting performance and alerting the designer to possible stability problems.

Category Name	Required Progs.	Prog. Steps	Card Sides	PC-100A Needed / Library Module ID
Electronic Eng.	None	307	2	☐ / ☐

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Address _____

City _____ State _____ Zip _____

Submission Checklist

- ☑ Recorded Magnetic Cards
- ☑ Submission Abstract
- ☑ Program Description
- ☑ User Instructions
- ☑ Sample Problem
- ☑ Listing
- ☐ _____
- ☐ _____

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Program Description

Program Title: RF Amplifier Analysis

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:

The Linvill stability factor is computed from the equation

$$C = \frac{|y_{12}\, y_{21}|}{2g_{11}\, g_{22} - R_e(y_{12}\, y_{21})}$$

If C is less than unity, the device is unconditionally stable. If C is > 1, the device is potentially unstable depending on source and load admittances.

The transducer gain, G_{oo}, is computed from the relation that:

$$G_{oo} = \frac{c}{2} \left| \frac{y_{21}}{y_{12}} \right|$$

Since an accurate input inpedance match is usually desired, a model using the y-parameters with specified load admittance and assuming resonance is forced on the output port (real load only) has been solved for Y_{in}, the complex input admittance. The value found for Y_{in} can than be used to design the input matching network.

The effect of source impedance on output admittance is usually small when computing Y_{in}. These solutions have been found to be very accurate in actual application, where

$$Bin = b_{11} + Im \left[\frac{-y_{12}y_{21}}{g_{22} + G_L} \right]$$

$$Gin = g_{11} + Re \left[\frac{-y_{12}y_{21}}{g_{22} + G_L} \right]$$

NOTATION

Any type of notation (floating, engineering, EE, or FIX) may be used but it must be specified in program steps 8, 9, and 10. Engineering notation is recommended and is used in sample and listing.

☐ See Continuation Sheet

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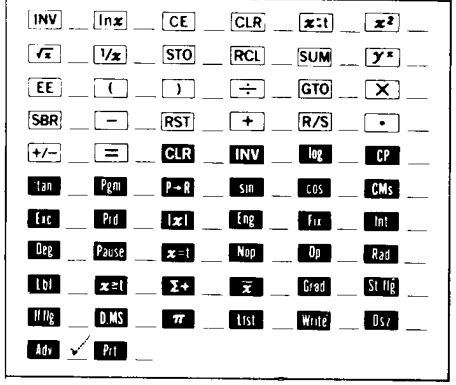
User Instructions

Program Title
RF Amplifier Analysis

List Input	Calc/C	Bin	Gin	Goo

Partition (OP 17): 479 . 59 *
Parenthesis Levels: 1
t Register: ☑
Angular Mode (if applicable): N/A
SBR Levels: 2
Absolute Addresses: ☐
Library Module ID: N/A
* for TI-58 319.19
Disturbs Pending Operations: ☑

LABELS (Op 08)



USER DEFINED KEYS

- A Print Input
- B Calculate/Print/
- C display Bin
- D display Gin
- E Display Goo
- A'
- B'
- C'
- D'
- E'

FLAGS	0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS			OUTPUT/MODE (see legend below)
1	Enter Program					
2	Enter Y- Parameters of device to be analyzed	G11	STO	0	1	G11
		G12	STO	0	2	G12
		G21	STO	0	3	G21
		G22	STO	0	4	G22
		B11	STO	0	5	B11
		B12	STO	0	6	B12
		B21	STO	0	7	B21
		B22	STO	0	8	B22
3	Enter Load Conductance	G_L	STO	0	9	G_L
4	Print input parameters to check (with PC100A Only)			A		Input parameters with labels are printed
5	Calculate, print output, display stability factor			B		Stability factor (C), Bin, Gin, Goo are printed. Only C is displayed.
6	DISPLAY B_{in}			C		B_{in}
7	DISPLAY G_{in}			D		G_{in}
8	DISPLAY G_{oo}			E		G_{oo}

With printer, follow steps 1, 2, 3, 4, 5
Without printer, follow steps 1, 2, 3, 5, 6, 7, 8.

Modes: (n)• —Printed only (n)—Displayed Briefly (Pause)
n• —Printed and displayed

DATA REGISTERS (INV LIST)

- 0 I/o Looping
- 1 G11
- 2 G12
- 3 G21
- 4 G22
- 5 B11
- 6 B12
- 7 B21
- 8 B22
- 9 GL
- 0 G12 x G21
- 1 B12 x B21
- 2 R10 - R11
- 3 B12 x G21
- 4 G12 x B21
- 5 R12 - R14
- 6 C
- 7 Bin
- 8 Gin
- 9 Goo (DB)

☐ See Continuation Sheet

6	5	8	0	0	2

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Sample Problem

Statement of Example

Calculate the performance of a transistor whose y-parameters are:

Y_{11} = 3.0 + j3.8 mmho
Y_{12} = .017 - j.37 mmho
Y_{21} = 57 - j32 mmho
Y_{22} = .54 + j1.1 mmho

Assume a collector circuit load of 470 ohms (=G_L)

NOTE: Watch units of measure!

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
3×10^{-3}	STO 01	3. -03	G_{11}
$.017 \times 10^{-3}$	STO 02	17. - 06	G_{12}
57×10^{-3}	STO 03	57. - 03	G_{21}
$.54 \times 10^{-3}$	STO 04	540. - 06	G_{22}
3.8×10^{-3}	STO 05	3.8 -03	B_{11}
$-.37 \times 10^{-3}$	STO 06	-370. -06	B_{12}
-32×10^{-3}	STO 07	-32. -03	B_{21}
1.1×10^{-3}	STO 08	1.1 -03	B_{22}
470	1/x	2.1276596. -03	
	STO 09	2.1276596. -03	G_L
	A	3. -03 G11 17. -06 G12 57. -03 G21 540. -06 G22 3.8 -03 B11 -370. -06 B12 -32. -03 B21 1.1 -03 B22	Print input parameters with labels
	B	2.1276596-03 GL 1.2828109 00 C 11.90973 -03 BIN 7.0751077 -03 GIN 20.538394 00 GOO	Calculate, Print all output, display C only

Mo ly (n)—Displayed Briefly (Pause) displayed

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Sample Problem (cont'd)

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ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	C	11.90973 - 03	B_{in}
	E	7.0751077 -03	G_{in}
	D	20.538394 00	G_{oo}

Modes: (n)* —Printed only (n)—Displayed Briefly (Pause)
n*—Printed and displayed

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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	98	ADV	
002	22	INV	
003	58	FIX	
004	22	INV	
005	57	ENG	
006	69	OP	
007	04	04	
008	57	ENG	
009	68	NOP	
010	68	NOP	
011	73	RC*	
012	00	00	
013	69	OP	
014	20	20	
015	69	OP	
016	06	06	
017	92	RTN	
018	76	LBL	
019	12	B	
020	43	RCL	
021	02	02	
022	65	×	
023	43	RCL	
024	03	03	
025	95	=	
026	42	STO	
027	10	10	
028	43	RCL	
029	06	06	
030	65	×	
031	43	RCL	
032	07	07	
033	95	=	
034	42	STO	
035	11	11	
036	94	+/-	
037	85	+	
038	43	RCL	
039	10	10	
040	95	=	
041	42	STO	
042	12	12	
043	43	RCL	
044	06	06	
045	65	×	
046	43	RCL	
047	03	03	
048	95	=	
049	42	STO	
050	13	13	
051	43	RCL	
052	07	07	

LOC	CODE	KEY	COMMENTS
053	65	×	
054	43	RCL	
055	02	02	
056	95	=	
057	42	STO	
058	14	14	
059	85	+	
060	43	RCL	
061	13	13	
062	95	=	
063	42	STO	
064	15	15	
065	43	RCL	
066	12	12	
067	33	X^2	
068	85	+	
069	43	RCL	
070	15	15	
071	33	X^2	
072	95	=	
073	34	√X	
074	42	STO	
075	16	16	
076	43	RCL	
077	04	04	
078	85	+	
079	43	RCL	
080	09	09	
081	95	=	
082	65	×	
083	43	RCL	
084	01	01	
085	75	-	
086	43	RCL	
087	10	10	
088	85	+	
089	43	RCL	
090	11	11	
091	95	=	
092	35	1/X	
093	65	×	
094	43	RCL	
095	16	16	
096	95	=	
097	42	STO	
098	16	16	
099	43	RCL	
100	02	02	
101	33	X^2	
102	85	+	
103	43	RCL	
104	06	06	
105	33	X^2	
106	95	=	

LOC	CODE	KEY	COMMENTS
107	42	STO	
108	19	19	
109	43	RCL	
110	03	03	
111	33	X^2	
112	85	+	
113	43	RCL	
114	07	07	
115	33	X^2	
116	95	=	
117	55	÷	
118	43	RCL	
119	19	19	
120	95	=	
121	34	√X	
122	55	÷	
123	02	2	
124	65	×	
125	43	RCL	
126	16	16	
127	95	=	
128	28	LOG	
129	65	×	
130	01	1	
131	00	0	
132	95	=	
133	42	STO	
134	19	19	
135	43	RCL	
136	04	04	
137	85	+	
138	43	RCL	
139	09	09	
140	95	=	
141	35	1/X	
142	65	×	
143	53	(	
144	43	RCL	
145	11	11	
146	75	-	
147	43	RCL	
148	10	10	
149	54	)	
150	85	+	
151	43	RCL	
152	01	01	
153	95	=	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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LOC	CODE	KEY	COMMENTS
154	42	STO	
155	18	18	
156	43	RCL	
157	04	04	
158	85	+	
159	43	RCL	
160	09	09	
161	95	=	
162	35	1/X	
163	65	×	
164	43	RCL	
165	15	15	
166	95	=	
167	94	+/-	
168	85	+	
169	43	RCL	
170	05	05	
171	95	=	
172	42	STO	
173	17	17	
174	01	1	
175	06	6	
176	42	STO	
177	00	00	
178	01	1	
179	05	5	
180	00	0	
181	00	0	
182	00	0	
183	00	0	
184	98	ADV	
185	71	SBR	
186	98	ADV	
187	01	1	
188	04	4	
189	02	2	
190	04	4	
191	03	3	
192	01	1	
193	71	SBR	
194	98	ADV	
195	02	2	
196	02	2	
197	02	2	
198	04	4	
199	03	3	
200	01	1	
201	71	SBR	
202	98	ADV	
203	02	2	
204	02	2	
205	00	0	
206	01	1	
207	00	0	
208	01	1	
209	71	SBR	
210	98	ADV	
211	43	RCL	
212	16	16	
213	92	RTN	
214	76	LBL	
215	13	C	
216	43	RCL	
217	17	17	
218	92	RTN	
219	76	LBL	
220	14	D	
221	43	RCL	
222	18	18	
223	92	RTN	
224	76	LBL	
225	15	E	
226	43	RCL	
227	19	19	
228	92	RTN	
229	76	LBL	
230	11	A	
231	01	1	
232	42	STO	
233	00	00	
234	02	2	
235	02	2	
236	00	0	
237	02	2	
238	00	0	
239	02	2	
240	71	SBR	
241	98	ADV	
242	02	2	
243	02	2	
244	00	0	
245	02	2	
246	00	0	
247	03	3	
248	71	SBR	
249	98	ADV	
250	02	2	
251	02	2	
252	00	0	
253	03	3	
254	00	0	
255	02	2	
256	71	SBR	
257	98	ADV	
258	02	2	
259	02	2	
260	00	0	
261	03	3	
262	00	0	
263	03	3	
264	71	SBR	
265	98	ADV	
266	01	1	
267	04	4	
268	00	0	
269	02	2	
270	00	0	
271	02	2	
272	71	SBR	
273	98	ADV	
274	01	1	
275	04	4	
276	00	0	
277	02	2	
278	00	0	
279	03	3	
280	71	SBR	
281	98	ADV	
282	01	1.	
283	04	4	
284	00	0	
285	03	3	
286	00	0	
287	02	2	
288	71	SBR	
289	98	ADV	
290	01	1	
291	04	4	
292	00	0	
293	03	3	
294	00	0	
295	03	3	
296	71	SBR	
297	98	ADV	
298	02	2	
299	02	2	
300	02	2	
301	07	7	
302	00	0	
303	00	0	
304	71	SBR	
305	98	ADV	
306	92	RTN	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title	Rev.
BIPOLAR JUNCTION TRANSISTOR ANALYSIS	

Abstract of Program

This program calculates the emitter bypass and coupling capacitors for a B.J.T. circuit. The program is designed for a low frequency analysis. The capacitors are found using pole zero cancellation.

Original SR-52 Program by Alan Charbonneau, San Luis Obispo, California, Sept. 1976.

User Benefits:

This program allows the user to vary circuit parameters and quickly determine the effect on the biasing capacitors.

Category Name	Required Progs.	Prog. Steps	Card Sides	PC-100A Needed / Library Module ID
Electronic Eng.	None	282	2	☐ / ☐

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Submission Checklist

- ☑ Recorded Magnetic Cards
- ☑ Submission Abstract
- ☑ Program Description
- ☑ User Instructions
- ☑ Sample Problem
- ☑ Listing
- ☐ _____
- ☐ _____

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TEXAS INSTRUMENTS
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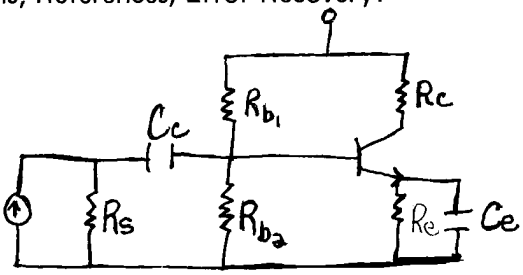
Program Description

Program Title:
Bipolar Junction Transistor Analysis

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:



In order to solve for the values of the coupling capacitors (Cc, Ce), R_{b1} R_{b2}, Rc, Re, Rs, h_{ie}, h_{fe} and the lower cutoff frequency (fL) (in Hz) desired must all be known. These equations only apply for a low frequency analysis.

$$R_B = \frac{(R_{B_1})(R_{B_2})}{(R_{B_2}+R_{B_1})} \qquad Rs' = \frac{(Rs)(RB)}{(Rs+R_B)} \qquad R_\square = Rs + \frac{(R_B)(h_{ie})}{(R_B+h_{ie})}$$

$$B = \frac{R_B + h_{ie} + R_e(h_{fe}+1)}{R_B + h_{ie}} \qquad K = \frac{R_s' + h_{ie} + R_e(h_{fe}+1)}{R_s' + h_{ie}}$$

$$f_e = \frac{(B-1)f_L}{B(K-1)} \qquad f_\square = \frac{f_L}{B} = \frac{1}{R_\square C_c}$$

$$C_c = \frac{1}{2\pi f_\square R_\square} \qquad C_e \frac{1}{2\pi f_e R_E}$$

References: L. F. Amplifier Notes. Calif. Polytechnic St. Univ. (San Luis Obispo)

Any type of notation (Floating, Engineering, EE, or FIX) may be used but it must be specified in program steps 8, 9 and 10. Engineering notation is recommended and is used in sample and listing.

☐ See Continuation Sheet

6 5 8 0 0 3

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User Instructions

Program Title
Bipolar Junction Transistor Analysis

R_{B2}	R_e	f_L	h_{fe}	C_E
R_{al}	R_c	R_s	h_{ie}	C_c

Partition (OP 17): 479 . 59*	Parenthesis Levels: 3	t Register ☑
Angular Mode (if applicable): n/a	SBR Levels: 1	Absolute Addresses ☐
Library Module ID: n/a	*for TI-58 319.19	Disturbs Pending Operations ☑

LABELS (Op 08)

INV	lnx	CE	CLR	x:t	x²
√x	1/x	STO	RCL	SUM	y^x
EE	(	)	÷	GTO	×
SBR	−	RST	+	R/S	•
+/−	=	CLR	INV	log	CP
tan	Pgm	P→R	sin	cos	CMs
Exc	Prd	|x|	Eng	Fix	Int
Deg	Pause	x=t	Nop	Op	Rad
Lbl	x≠t	Σ+	x̄	Grad	St flg
If flg	D.MS	π	List	Write	Dsz
Adv	Prt				

USER DEFINED KEYS

A	Enter R_{Bl}
B	Enter R_c
C	Enter R_s
D	Enter h_{ie}
E	Displays C_c
A'	Enter R_{B2}
B'	Enter R_e
C'	Enter f_L
D'	Enter h_{fe}
E'	Displays C_e

FLAGS	0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)
1	Enter Program			
2	Enter R_{Bl}	R_{Bl}	A	R_{Bl}
3	Enter R_{B2}	R_{B2}	*A	R_{B2}
4	Enter R_c	R_c	B	R_c
5	Enter R_e	R_e	*B	R_e
6	Enter R_s	R_s	C	R_s
7	Enter f_L (Cutoff freq.)	f_L	*C	f_L
8	Enter h_{ie}	h_{ie}	D	h_{ie}
9	Enter h_{fe}	h_{fe}	*D	h_{fe}
10	Press E to solve for C_c		E	C_c
11	Press *E to solve for C_e		*E	C_e

All output displayed and printed.

Steps 2-9 may be executed in any order desired and can be changed after the program has been run individually.
Step 11 must always follow step 10 and this must be repeated for each variable change.
If program will be used exclusively with a printer, Step 201 can be changed from GTO to SBR. It is then only necessary to press E for output. *E' will then be executed automatically after E.

Modes: (n)*—Printed only (n)—Displayed Briefly (Pause)
n*—Printed and displayed

DATA REGISTERS (INV List)

0	
1	R_{Bl}
2	R_{B2}
3	R_c
4	R_E
5	R_s
6	f_L
7	h_{ie}
8	h_{fe}
9	R_B
10	B
11	R_s
2	
3	
4	
5	
6	
7	
8	
9	

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☐ See Continuation Sheet

6,5 8,0 0,3
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Sample Problem

Statement of Example

Given Circuit Parameters:

R_{B1} = 150k Ω
R_{B2} = 39k Ω
R_c = 5.6k Ω
R_e = 2.2k Ω
h_{fe} = 80
h_{ie} = 1.3k Ω
f_L = 250H
R_s = 4.7k Ω

Each parameter may be varied by choosing the appropriate user defined key.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
150×10^3	A	150.03 RB1	Enter R_{B1}
39×10^3	2nd A'	39.03 RB2	Enter R_{B2}
5.6×10^3	B	5.6 03 RC	Enter R_c
2.2×10^3	2nd B'	2.2 03 RE	Enter R_e
4.7×10^3	C	4.7 03 RS	Enter R_s
250	2nd C'	250. 00 FL	Enter F_L
1.3×10^3	D	1.3 03 HIE	Enter H_{ie}
80	2nd D'	80. 00 HFE	Enter H_{fe}
	E	698.44205-09 CC	C_c calculated
	2nd E'	11.318692-06 CE	C_e calculated
			All values printed and displayed.

Modes: (n)* —Printed only (n)—Displayed Briefly (Pause)
n* —Printed and displayed

☐ Over

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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	99	PRT	
002	22	INV	
003	57	ENG	
004	22	INV	
005	58	FIX	
006	69	OP	
007	04	04	
008	57	ENG	
009	68	NOP	
010	68	NOP	
011	32	X:T	
012	69	OP	
013	06	06	
014	92	RTN	
015	76	LBL	
016	11	A	
017	42	STO	
018	01	01	
019	32	X:T	
020	03	3	
021	05	5	
022	01	1	
023	04	4	
024	00	0	
025	02	2	
026	61	GTO	
027	99	PRT	
028	76	LBL	
029	16	A'	
030	42	STO	
031	02	02	
032	32	X:T	
033	03	3	
034	05	5	
035	01	1	
036	04	4	
037	00	0	
038	03	3	
039	61	GTO	
040	99	PRT	
041	76	LBL	
042	12	B	
043	42	STO	
044	03	03	
045	32	X:T	
046	03	3	
047	05	5	
048	01	1	
049	05	5	
050	00	0	
051	00	0	
052	61	GTO	
053	99	PRT	

LOC	CODE	KEY	COMMENTS
054	76	LBL	
055	17	B'	
056	42	STO	
057	04	04	
058	32	X:T	
059	03	3	
060	05	5	
061	01	1	
062	07	7	
063	00	0	
064	00	0	
065	61	GTO	
066	99	PRT	
067	76	LBL	
068	13	C	
069	42	STO	
070	05	05	
071	32	X:T	
072	03	3	
073	05	5	
074	03	3	
075	06	6	
076	00	0	
077	00	0	
078	61	GTO	
079	99	PRT	
080	76	LBL	
081	18	C'	
082	42	STO	
083	06	06	
084	32	X:T	
085	02	2	
086	01	1	
087	02	2	
088	07	7	
089	00	0	
090	00	0	
091	61	GTO	
092	99	PRT	
093	76	LBL	
094	14	D	
095	42	STO	
096	07	07	
097	32	X:T	
098	02	2	
099	03	3	
100	02	2	
101	04	4	
102	01	1	
103	07	7	
104	61	GTO	
105	99	PRT	

LOC	CODE	KEY	COMMENTS
106	76	LBL	
107	19	D'	
108	42	STO	
109	08	08	
110	32	X:T	
111	02	2	
112	03	3	
113	02	2	
114	01	1	
115	01	1	
116	07	7	
117	61	GTO	
118	99	PRT	
119	76	LBL	
120	15	E	
121	43	RCL	
122	01	01	
123	65	×	
124	43	RCL	
125	02	02	
126	55	÷	
127	53	(	
128	43	RCL	
129	01	01	
130	85	+	
131	43	RCL	Scan by Dan
132	02	02	
133	54	)	
134	95	=	
135	42	STO	
136	09	09	
137	85	+	
138	43	RCL	
139	07	07	
140	85	+	
141	43	RCL	
142	04	04	
143	65	×	
144	53	(	
145	43	RCL	
146	08	08	
147	85	+	
148	01	1	
149	54	)	
150	95	=	
151	55	÷	
152	53	(	
153	43	RCL	
154	09	09	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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LOC	CODE	KEY	COMMENTS
155	85	+	
156	43	RCL	
157	07	07	
158	54	)	
159	95	=	
160	42	STO	
161	10	10	
162	55	÷	
163	53	(	
164	53	(	
165	53	(	
166	43	RCL	
167	09	09	
168	65	×	
169	43	RCL	
170	07	07	
171	54	)	
172	55	÷	
173	53	(	
174	43	RCL	
175	09	09	
176	85	+	
177	43	RCL	
178	07	07	
179	54	)	
180	85	+	
181	43	RCL	
182	05	05	
183	54	)	
184	65	×	
185	02	2	
186	65	×	
187	89	π	
188	65	×	
189	43	RCL	
190	06	06	
191	54	)	
192	95	=	
193	32	X:T	
194	01	1	
195	05	5	
196	01	1	
197	05	5	
198	00	0	
199	00	0	
200	98	ADV	
201	61	GTO	
202	99	PRT	

LOC	CODE	KEY	COMMENTS
203	76	LBL	
204	10	E'	
205	43	RCL	
206	05	05	
207	65	×	
208	43	RCL	
209	09	09	
210	55	÷	
211	53	(	
212	43	RCL	
213	05	05	
214	85	+	
215	43	RCL	
216	09	09	
217	54	)	
218	95	=	
219	42	STO	
220	11	11	
221	85	+	
222	43	RCL	
223	07	07	
224	85	+	
225	43	RCL	
226	04	04	
227	65	×	
228	53	(	
229	43	RCL	
230	08	08	
231	85	+	
232	01	1	
233	54	)	
234	95	=	
235	55	÷	
236	53	(	
237	43	RCL	
238	11	11	
239	85	+	
240	43	RCL	
241	07	07	
242	54	)	
243	95	=	

LOC	CODE	KEY	COMMENTS
244	75	-	
245	01	1	
246	95	=	
247	65	×	
248	43	RCL	
249	10	10	
250	95	=	
251	55	÷	
252	53	(	
253	43	RCL	
254	04	04	
255	65	×	
256	53	(	
257	43	RCL	
258	10	10	
259	75	-	
260	01	1	
261	54	)	
262	65	×	
263	43	RCL	
264	06	06	
265	65	×	
266	02	2	
267	65	×	
268	89	π	
269	54	)	
270	95	=	
271	32	X:T	
272	01	1	
273	05	5	
274	01	1	
275	07	7	
276	00	0	
277	00	0	
278	71	SBR	
279	99	PRT	
280	98	ADV	
281	92	RTN	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title	Rev.
POWER SUPPLY FILTER DESIGN	

Abstract of Program

Calculates the value of filter capacitor, load resistance, average output voltage, minimum and maximum output voltage for both full- and half-wave rectifier circuits. User specifies line frequency, secondary voltage, rectifier voltage drop, maximum desired ripple and maximum load current.

Original SR-52 Program by B. R. Kelso, FPO New York, N.Y.

User Benefits:

Rapid component selection and guaranteed maximum ripple.

Category Name	Required Progs.	Prog. Steps	Card Sides	PC-100A Needed / Library Module ID
Electronic Eng.		322	2	☐ / ☐

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Signature _____ Date _____

Name Texas Instruments _____ Tel. No. _____

Address _____

City _____ State _____ Zip _____

Submission Checklist

- ☑ Recorded Magnetic Cards
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- ☑ Program Description
- ☑ User Instructions
- ☑ Sample Problem
- ☑ Listing
- ☐ _____
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TEXAS INSTRUMENTS
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Program Description

Program Title: Power Supply Filter Design

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:

This procedure makes the assumption that the transformer (fig. 1) will be operated within its design limits. First, peak secondary voltage is found based on the secondary's nominal RMS rating:

$$E_o(pk) = \sqrt{2}\, V_s$$

where V_s is the secondary voltage (RMS). Next, the load resistance is calculated:

$$R_L = E_o(pk)/I_L$$

Where I_L is the maximum load current. Next, $t_{(a-c)}$ is found (fig. 2)

$$t_{(a-c)} = (1/f_L)/2 \text{ for full-wave circuits, or}$$

$$t_{(a-c)} = 1/f_L \text{ for half-wave circuits, where } f_L$$

is the primary line frequency. Next, the ripple frequency f is found:

$$f = 1/t_{(a-c)}$$

Next, the ripple factor is calculated:

$$f_r = e_r/100$$

where e_r is the maximum ripple in percent. Next, $t_{(d-b)}$ is found:

$$t_{(d-b)} = \arcsin(E_o(pk) - f_r E_o(pk))/E_o(pk)/2\pi f_L$$

Next, $t_{(a-b)}$ is found:

$$t_{(a-b)} = (1/f_L)/4 + t_{(d-b)} \text{ for full-wave circuits, or}$$

$$t_{(a-b)} = 3((1/f_L)/4) + t_{(d-b)} \text{ for half-wave circuits.}$$

Next, the capacitor value is found:

$$C = t_{(a-b)}/R_L \ln(1/(1-f_r))$$

Next, the average output voltage is found:

$$E_o(avg) = (E_o(pk) - f_r E_o(pk) + E_o(pk))/2$$

Next, the minimum output voltage is found:

$$E_o(min) = f_r E_o(pk)$$

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☐ See Continuation Sheet

Continued From: ☒ Program Description ☐ User Instructions ☐ Stmt. of Example

Program Title: POWER SUPPLY FILTER DESIGN	Rev.

Reference: Cogburn, Onis J., "Power Supply Design Made Fast and Simple", Electronics magazine, August 30, 1973

Figure 1: Basic Circuit

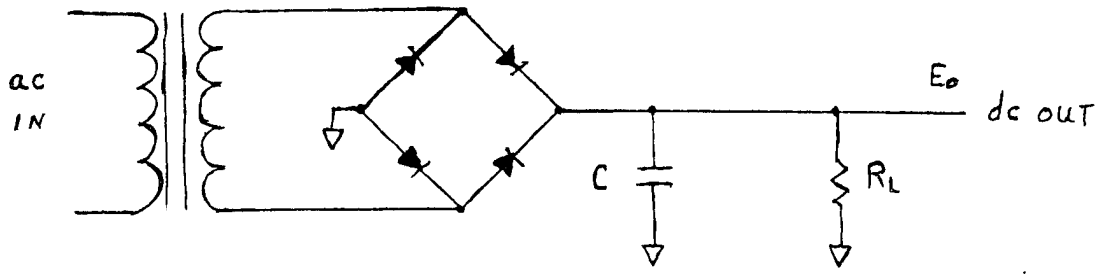
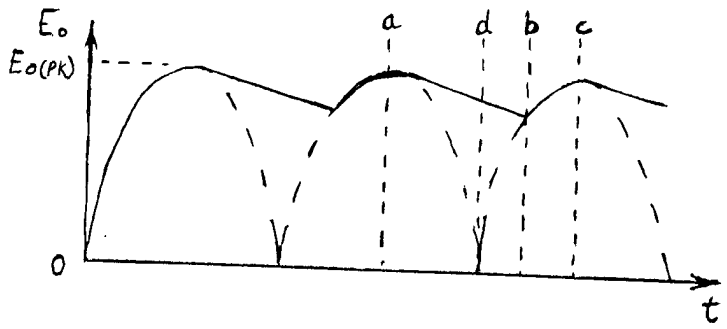


Figure 2: Output Waveform



Limitations:
1. Procedure valid only when the transformer is operated within its design limits.
2. Rectifier forward voltage drop must be doubled before entering if a full-wave bridge circuit is used.

NOTATION:

Any type of notation (floating, ENGineering, EE or FIX) may be used but it must be specified in program steps 8, 9 and 10. ENGineering notation is recommended and is used in sample and listing.

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User Instructions

Program Title Power Supply Filter Design

Full Wave	Half Wave	Display		
f_L	V_s	V_d	max. rip	I_L

Partition (OP 17): 479 . 59

Parenthesis Levels: 1

t Register: ☑

Angular Mode (if applicable): RAD

SBR Levels: 1

Absolute Addresses: ☐

Library Module ID: N/A

Disturbs Pending Operations: ☑

LABELS (Op 08)

INV	lnx	CE	CLR	x:t	x²
√x	1/x	STO	RCL	SUM	yˣ
EE	(	)	÷	GTO	×
SBR	−	RST	+	R/S	•
+/−	=	CLR	INV	log	CP
tan	Pgm	P→R	sin	cos	CMs
Exc	Prd	|x|	Eng	Fix	Int
Deg	Pause	x=t	Nop	Op	Rad
Lbl	x≥t	Σ+	x̄	Grad	St flg
If flg	D.MS	π	List	Write	Dsz
Adv	Prt				

USER DEFINED KEYS

A	Line Frequency
B	Secondary Voltage
C	Rectifier Drop
D	Max. Ripple (%)
E	Maximum Load
A'	Full Wave/Execute
B'	Half Wave/Execute
C'	Display Results
D'	
E'	

FLAGS	Full Wave 0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)
1	Enter Program			
2	Enter line frequency (Hz)	f_L	A	f_L
3	Enter secondary voltage (rms)	v_s	B	v_s
4	Enter rectifier voltage drop (volts). Double this value if a bridge is used.	V_d	C	V_d
5	Enter maximum desired ripple in percent. ≈ 20% gives the greatest filtering action with the smallest capacitor value.	c_r(%)	D	e_r(%)
6	Enter maximum load current	I_L	E	I_L
7a	Execute for full wave		2nd A	All output is printed with labels
or 7b	Execute for half wave		2nd B	All output is printed with labels
	If printer unavailable - DISPLAY ROUTINE:			PAUSE — DISPLAYED
8	Examine capacitor value (farads)		2nd C	(1) — C
9	Examine resistor value (ohms)		R/S	(2) — R_L
10	Examine average output (volts)		R/S	(3) — $E_{o(avg)}$
11	Examine peak output (volts)		R/S	(4) — $E_{o(pk)}$
12	Examine minimum output (volts)		R/S	(5) — $E_{o(min)}$
	Steps 2-6 may be executed in any order.			

Modes: (n)•—Printed only (n)—Displayed Briefly (Pause)
n•—Printed and displayed

DATA REGISTERS (INV List)

0		
1	f_L	
2		v_s
3	V_d	
4		E_r
5	I_L	
6		$E_{o(pk)}$
7	R_L	
8		f
9	f_r	
0	C	
1	$E_{o(avg)}$	
2		$t_{(d-b)}$
3	$t_{(a-b)}$	
4		$E_{o(min)}$
5		
6		
7		
8		
9		

☐ See Continuation Sheet

6,5 8,0,0,4
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TEXAS INSTRUMENTS
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Sample Problem

Statement of Example

Design an unregulated full-wave bridge power supply which will provide 3 amps current from a transformer with a 24 vac secondary. Ripple must not be greater than 15% at full load. The primary line frequency is 60 Hz and each rectifier drops 0.65v when conducting.

Change to Radian Mode

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
60	A	60.00 FL	Line Frequency
24	B	24.00 VS	Secondary volts
1.3	C	1.300 VD	Rectifier drop X 2
15	D	15.00 %ER	Ripple (%)
3	E	3.00 IL	Load Current
		Printed and Displayed	
	2nd A	FULL WAVE	Full Wave Output
		3.8804387 -03 C	Printed Only.
		10.880375 - 00 RL	
		30.193041 00 AVG	
		32.641125 00 PK	
		27.744957 00 MIN	
	2nd C	(1) 3.8804387 - 03	C = 3880 μF
	R/S	(2) 10.880375 00	R_L = 10.88 ohms
	R/S	(3) 30.193041 00	E_o(Avg) = 30.2 vde
	R/S	(4) 32.641125 00	E_o (pk) = 32.6 v
	R/S	(5) 27.744957 00	E_o (min) = 27.7
		(Pause) / Display	

Modes: (n)* —Printed only (n)—Displayed Briefly (Pause)
n* —Printed and displayed

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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	99	PRT	
002	22	INV	
003	57	ENG	
004	22	INV	
005	58	FIX	
006	69	OP	
007	04	04	
008	57	ENG	
009	68	NOP	
010	68	NOP	
011	32	X:T	
012	69	OP	
013	06	06	
014	92	RTN	
015	76	LBL	
016	11	A	
017	42	STO	
018	01	01	
019	32	X:T	
020	02	2	
021	01	1	
022	02	2	
023	07	7	
024	61	GTO	
025	99	PRT	
026	76	LBL	
027	12	B	
028	42	STO	
029	02	02	
030	32	X:T	
031	04	4	
032	02	2	
033	03	3	
034	06	6	
035	61	GTO	
036	99	PRT	
037	76	LBL	
038	13	C	
039	42	STO	
040	03	03	
041	32	X:T	
042	04	4	
043	02	2	
044	01	1	
045	06	6	
046	61	GTO	
047	99	PRT	

LOC	CODE	KEY	COMMENTS
048	76	LBL	
049	14	D	
050	42	STO	
051	04	04	
052	32	X:T	
053	06	6	
054	01	1	
055	01	1	
056	07	7	
057	03	3	
058	05	5	
059	61	GTO	
060	99	PRT	
061	76	LBL	
062	15	E	
063	42	STO	
064	05	05	
065	32	X:T	
066	02	2	
067	04	4	
068	02	2	
069	07	7	
070	61	GTO	
071	99	PRT	
072	76	LBL	
073	17	B'	
074	22	INV	
075	76	LBL	
076	16	A'	
077	86	STF	
078	00	00	
079	70	RAD	
080	02	2	
081	34	√X	
082	65	×	
083	43	RCL	
084	02	02	
085	75	-	
086	43	RCL	
087	03	03	
088	95	=	
089	42	STO	
090	06	06	
091	42	STO	
092	14	14	
093	55	÷	
094	43	RCL	
095	05	05	
096	95	=	
097	42	STO	
098	07	07	

LOC	CODE	KEY	COMMENTS
099	43	RCL	
100	01	01	
101	22	INV	
102	87	IFF	
103	00	00	
104	38	SIN	
105	65	×	
106	02	2	
107	95	=	
108	76	LBL	
109	38	SIN	
110	42	STO	
111	08	08	
112	43	RCL	
113	04	04	
114	55	÷	
115	01	1	
116	00	0	
117	00	0	
118	95	=	
119	42	STO	
120	09	09	
121	49	PRD	
122	14	14	
123	94	+/-	
124	85	+	
125	01	1	
126	95	=	
127	22	INV	
128	38	SIN	
129	55	÷	
130	02	2	
131	55	÷	
132	89	π	
133	55	÷	
134	43	RCL	
135	01	01	
136	95	=	
137	42	STO	
138	12	12	
139	43	RCL	
140	01	01	
141	35	1/X	
142	55	÷	
143	04	4	
144	87	IFF	
145	00	00	
146	28	LOG	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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LOC	CODE	KEY	COMMENTS
147	65	×	
148	03	3	
149	76	LBL	
150	28	LOG	
151	85	+	
152	43	RCL	
153	12	12	
154	95	=	
155	42	STO	
156	13	13	
157	55	÷	
158	43	RCL	
159	07	07	
160	55	÷	
161	53	(	
162	01	1	
163	75	-	
164	43	RCL	
165	09	09	
166	54	)	
167	35	1/X	
168	23	LNX	
169	95	=	
170	42	STO	
171	10	10	
172	01	1	
173	94	+/-	
174	49	PRD	
175	14	14	
176	43	RCL	
177	06	06	
178	44	SUM	
179	14	14	
180	75	-	
181	53	(	
182	24	CE	
183	65	×	
184	43	RCL	
185	09	09	
186	95	=	
187	85	+	
188	43	RCL	
189	06	06	
190	95	=	
191	55	÷	
192	02	2	
193	95	=	
194	42	STO	
195	11	11	

LOC	CODE	KEY	COMMENTS
196	69	OP	
197	00	00	
198	22	INV	
199	57	ENG	
200	22	INV	
201	58	FIX	
202	04	4	
203	03	3	
204	01	1	
205	03	3	
206	04	4	
207	02	2	
208	01	1	
209	07	7	
210	69	OP	
211	03	03	
212	87	IFF	
213	00	00	
214	85	+	
215	02	2	
216	03	3	
217	01	1	
218	03	3	
219	02	2	
220	07	7	
221	02	2	
222	01	1	
223	61	GTO	
224	75	-	
225	76	LBL	
226	85	+	
227	02	2	
228	01	1	
229	04	4	
230	01	1	
231	02	2	
232	07	7	
233	02	2	
234	07	7	
235	76	LBL	
236	75	-	
237	69	OP	
238	02	02	
239	98	ADV	
240	69	OP	
241	05	05	
242	43	RCL	
243	10	10	
244	32	X:T	
245	01	1	
246	05	5	
247	00	0	
248	00	0	
249	71	SBR	
250	99	PRT	

LOC	CODE	KEY	COMMENTS
251	43	RCL	
252	07	07	
253	32	X:T	
254	03	3	
255	05	5	
256	02	2	
257	07	7	
258	71	SBR	
259	99	PRT	
260	43	RCL	
261	11	11	
262	32	X:T	
263	01	1	
264	03	3	
265	04	4	
266	02	2	
267	02	2	
268	02	2	
269	71	SBR	
270	99	PRT	
271	43	RCL	
272	06	06	
273	32	X:T	
274	03	3	
275	03	3	
276	02	2	
277	06	6	
278	00	0	
279	00	0	
280	71	SBR	
281	99	PRT	
282	43	RCL	
283	14	14	
284	32	X:T	
285	03	3	
286	00	0	
287	02	2	
288	04	4	
289	03	3	
290	01	1	
291	71	SBR	
292	99	PRT	
293	98	ADV	
294	92	RTN	
295	76	LBL	
296	18	C'	
297	01	1	
298	66	PAU	
299	43	RCL	
300	10	10	
301	91	R/S	

MERGED CODES

62	Pgm	Ind	72	STO	Ind	83	GTO	Ind
63	Exc	Ind	73	RCL	Ind	84	Op	Ind
64	Prd	Ind	74	SUM	Ind	92	INV	SBR

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LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
302	02	2									
303	66	PAU									
304	43	RCL									
305	07	07									
306	91	R/S									
307	03	3									
308	66	PAU									
309	43	RCL									
310	11	11									
311	91	R/S									
312	04	4									
313	66	PAU									
314	43	RCL									
315	06	06									
316	91	R/S									
317	05	5									
318	66	PAU									
319	43	RCL									
320	14	14									
321	92	RTN									

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title	Rev.
ZENER POWER SUPPLY DESIGN	

Abstract of Program

This program calculates component values and power rating pertaining to a Zener Diode regulated power supply. It can be used without a PC-100A using user defined keys or interactively with the printer prompting for input and results printed with headings.

Original SR-52 Program by B. R. Kelso, FPO New York.

User Benefits:

This program results in significant time savings to the user.

Category Name	Required Progs.	Prog. Steps	Card Sides	PC-100A Needed / Library Module ID
Electronic Eng.		208	1	☐ / ☐

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Signature _____ Date _____

Name Texas Instruments Tel. No. _____

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Submission Checklist

- ☑ Recorded Magnetic Cards
- ☑ Submission Abstract
- ☑ Program Description
- ☑ User Instructions
- ☑ Sample Problem
- ☑ Listing
- ☐ _____
- ☐ _____

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Program Description

Program Title: ZENER POWER SUPPLY DESIGN

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:

First, the limiting resistor current is found:

$I_{RI} = I_{ZMIN} + I_{OUTMAX}$

Where I_{ZMIN} = minimum Zener Operating Current

I_{OUTMAX} = maximum anticipated power supply load current

Then, the limiting resistor voltage drop is found:

$E_{RI} = Vcc - Vz$

Where Vcc is the unregulated input voltage

Vz is the rated Zener voltage

Next, the limiting resistor value is found:

$R_I = E_{RI}/I_{RI}$

Then, the limiting resistor power rating is found:

$P_{RIMAX} = I_{RI}E_{RI}K$

Where K = 2 (which operates the resistor at 50% rating)

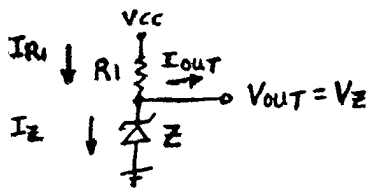
Next, the maximum power dissipated by the Zener Diode is calculated:

$P_{Zmax} = I_{RI}V_Z$

Then, the safe Zener Diode Power Rating is found:

$P_Z = 2\,P_{ZMAX}$

NOTE: The resistor power rating and the Zener Diode Power Rating are twice the actual power dissipation. Basic Circuit:



SPECIAL NOTES ON PARTITIONING: The memory between steps 160 and 239 (data registers 90-99) is split between data memory and program memory to save space and to enable program to be recorded on 2 card banks. For this reason, partitioning is done under program control in the interactive version. At the end of the interactive version the memory space is repartitioned to 479.59 (6 op 17). It is suggested that the magnetic card be recorded at 479.59 (6OP 17), the initial calculator partition, so that repartitioning is not necessary prior to reading the card.

The user defined key version may be used without reading in card bank 2. If the interactive version is never to be used, it is only necessary to key in steps 120-207 and the alphanumeric data registers are unnecessary. The user-defined key version (without printer) does not partition under program control and may be used with any partition except 159.99 or 959.00.

For printer version, engineering or fix notation should not be used. Any type of notation may be used without printer.

☐ See Continuation Sheet

Continued From: ☒ Program Description ☐ User Instructions ☐ Stmt. of Example

Program Title: ZENER POWER SUPPLY DESIGN	Rev.

SPECIAL INSTRUCTIONS FOR KEYING IN AND RECORDING PROGRAM

1. Set partition to 159.99 (10 op 17)
2. Store alphanumeric data registers 60-93 only.
3. Repartition to 239.89 (9 op 17)
4. Key in steps 000-207 or program (be careful, step 208 is really part of an alphanumeric data register).
5. Repartition to 479.59 (6 op 17)
6. Record Magnetic Card Banks 1 and 2.

Scan by Dan

6 5 8 0 0 6

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User Instructions

Program Title	ZENER POWER SUPPLY DESIGN			
R_1	P_{R1}	P_Z	I_{Supply}	Interactive
V_{cc}	$V_Z = V_{out}$	I_{ZMIN}	I_{OUTMX}	Execute

Partition (OP 17) 479 . 59	Parenthesis Levels 1	t Register	☑
Angular Mode (if applicable)	SBR Levels 1	Absolute Addresses	☐
Library Module ID		Disturbs Pending Operations	☐

LABELS (Op 08)

INV	ln x	CE	CLR	x:t	x²
√x	1/x	STO	RCL	SUM	y^x
EE	(	)	÷	GTO	×
SBR	−	RST	+	R/S	•
+/−	=	CLR	INV	log	CP
tan	Pgm	P→R	sin	cos	GMs
Exc	Prd	|x|	Eng ✓	Fix	Int
Deg	Pause	x=t	Nop	Op	Rad
Lbl	x≠t	Σ+	x̄	Grad	St flg
If flg	D.MS	π ✓	List ✓	Write	Dsz
Adv ✓	Prt ✓				

USER DEFINED KEYS

A	Enter Input Voltage
B	Enter Output Voltage
C	Enter Min. Zener Cur
D	Enter Output Curr
E	Execute
A'	Examine R_1
B'	Examine P_{R1}
C'	Examine P_Z
D'	Examine I_{Supply}
E'	Start interactive

FLAGS	Not Used 0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)
	USING USER-DEFINED KEYS (WITHOUT A PRINTER:)			
1	Enter program (Only Bank 1 necessary if used without printer)			
2	Enter unregulated input (volts)	Vcc	A	Vcc
3	Enter desired Output (volts)	Vz=Vout	B	Vz=Vout
4	Enter desired Minimum Zener bias current (amps)	IZMIN	C	IZMIN
5	Enter Maximum Output Load Current (amps)	I_{OUTMAX}	D	I_{OUTMAX}
6	Execute		E	Pz
7	Examine Value of R_1 (ohms)		2nd A'	R_1
8	Examine Power Rating of R_1 (watts)		2nd B'	P_{R1}
9	Examine Power Rating of Zener Diode (watts)		2nd C'	P_Z
10	Examine Power Source Load Current (amps)		2nd D'	I_{Supply}

Modes: (n)•—Printed only (n)—Displayed Briefly (Pause)
n•—Printed and displayed

DATA REGISTERS (INV Dsz)

60 - 93 Alphanumeric Registers

05 Used for DSZ
06 Used for Reg. Index
07 Used for Print Reg. Index

11 Vcc
12 $V_Z = V_{out}$
13 IZMIN
14 I_{OUTMAX}
15 R_1
16 PRIMAX
17 PZMAX
18 I_{R1}
19 E_{R1}

☐ See Continuation Sheet

Continued From: ☐ Program Description ☒ User Instructions ☐ Stmt. of Example

Program Title: ZENER POWER SUPPLY DESIGN	Rev.

INTERACTIVE (WITH A PC-100A): (USER INSTRUCTIONS)

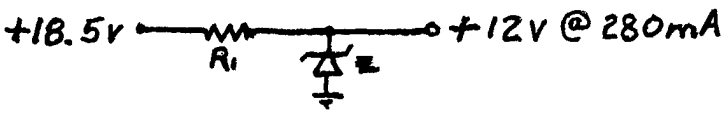
Step	Procedure	Enter	Press	Printed Output
1	ENTER PROGRAM (Banks 1 and 2)			
2	RESET AND START PROGRAM: PRINT HEADING (Or Press 2nd E')		RST R/S	ZENER POWER SUPPLY DESIGN SOURCE VOLTAGE ?
3	ENTER UNREGULATED INPUT VOLTAGE AFTER "?" Prompt.	Vcc	R/S	(SOURCE VOLTAGE) VOLT ZENER VOLTAGE ?
4	ENTER DESIRED OUTPUT Voltage after "?" prompt	$V_Z = V_{out}$	R/S	(ZENER VOLTAGE) VOLT MIN ZENER CURR ?
5	ENTER DESIRED MINIMUM Zener Bias Current in Amps after "?" prompt.	$I_{Z\ MIN}$	R/S	(MIN ZENER CURR) AMPS MAX OUTPUT CURR ?
6	ENTER MAXIMUM OUTPUT Load Current in Amps after "?" prompt	$I_{OUT\ MAX}$	R/S	(MAX OUTPUT CURR) AMPS
7	SIT BACK AND WATCH. Values will be printed with appropriate headings.			R1 VALUE (Value of R1) Ohms R1 POWER (R1 Power Rating) Watt ZENER PWR (Zener Power Rating) Watt SRC CURR (Source Load Current) Amps

TEXAS INSTRUMENTS
Calculator Products Division

Sample Problem

Statement of Example

A regulated 12 volt D.C. source is needed to supply a maximum of 0.28 amps from an 18.5 volt source. The basic circuit is shown below:



Find the value of R_1, the power rating of R_1, the power rating of the Zener Diode and the maximum current drain on the 18.5 volt source, minimum Zener Current = .02A.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
WITHOUT A PRINTER — USING USER DEFINED KEYS:			
18.5	A	18.5	Source Voltage
12	B	12.	Zener Voltage
.02	C	0.02	min. Zener Current
.28	D	0.28	max. Output Current
	E	7.2	Execute
	2nd A'	21.66666667	Value of R_1 (Ω)
	2nd B'	3.9	R_1 Power Rating (w)
	2nd C'	7.2	Zener Power Rating (w)
	2nd D'	0.3	Source Current (A)
INTERACTIVE (WITH A PC-100A)			
	E'	ZENER POWER SUPPLY DESIGN	
		Source Voltage ?	
18.5	R/S	18.5 VOLT	Enter source voltage
		Zener Voltage ?	after question mark
12	R/S	12. VOLT	Enter Zener Voltage
		Min. Zener Curr ?	after question mark
.02	R/S	0.02 Amps	Enter Minimum Zener
		Max. Output Curr ?	Current after question mark
.28	R/S	0.28 Amps	Enter Maximum Output current after ? results appear shortly.

Modes: (n)* —Printed only (n)—Displayed Briefly (Pause)
n* —Printed and displayed

Over

Sample Problem (cont'd)

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
		R1 VALUE 21.66666667 OHMS R1 POWER 3.9 WATT ZENER PWR 7.2 WATT SRC CURR 0.3 AMPS	
		Modes: (n)* —Printed only (n)—Displayed Briefly (Pause) n*—Printed and displayed	

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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	10	E'	
002	22	INV	
003	58	FIX	
004	22	INV	
005	57	ENG	
006	25	CLR	
007	01	1	
008	00	0	
009	69	OP	
010	17	17	
011	08	8	
012	08	8	
013	42	STO	
014	07	07	
015	69	OP	
016	00	00	
017	71	SBR	
018	99	PRT	
019	71	SBR	
020	99	PRT	
021	09	9	
022	69	OP	
023	17	17	
024	06	6	
025	00	0	
026	42	STO	
027	07	07	
028	01	1	
029	01	1	
030	42	STO	
031	06	06	
032	04	4	
033	42	STO	
034	05	05	
035	76	LBL	
036	89	π	
037	98	ADV	
038	07	7	
039	01	1	
040	69	OP	
041	04	04	
042	71	SBR	
043	99	PRT	
044	00	0	
045	91	R/S	
046	72	ST*	
047	06	06	
048	71	SBR	
049	90	LST	
050	69	OP	
051	26	26	
052	97	DSZ	
053	05	05	
054	89	π	

LOC	CODE	KEY	COMMENTS
055	15	E	
056	98	ADV	
057	04	4	
058	42	STO	
059	05	05	
060	76	LBL	
061	57	ENG	
062	98	ADV	
063	69	OP	
064	00	00	
065	71	SBR	
066	98	ADV	
067	73	RC*	
068	06	06	
069	71	SBR	
070	90	LST	
071	69	OP	
072	26	26	
073	97	DSZ	
074	05	05	
075	57	ENG	
076	06	6	
077	69	OP	
078	17	17	
079	00	0	
080	92	RTN	
081	76	LBL	
082	99	PRT	
083	73	RC*	
084	07	07	
085	69	OP	
086	01	01	
087	69	OP	
088	27	27	
089	76	LBL	
090	98	ADV	
091	73	RC*	
092	07	07	
093	69	OP	
094	02	02	
095	69	OP	
096	27	27	
097	73	RC*	
098	07	07	
099	69	OP	
100	03	03	
101	69	OP	
102	27	27	
103	69	OP	
104	05	05	
105	92	RTN	
106	76	LBL	
107	90	LST	
108	32	X:T	
109	25	CLR	

LOC	CODE	KEY	COMMENTS
110	73	RC*	
111	07	07	
112	69	OP	
113	04	04	
114	32	X:T	
115	69	OP	
116	27	27	
117	69	OP	
118	06	06	
119	92	RTN	
120	76	LBL	
121	15	E	
122	53	(	
123	43	RCL	
124	13	13	
125	85	+	
126	43	RCL	
127	14	14	
128	54	)	
129	42	STO	
130	18	18	
131	32	X:T	
132	53	(	
133	43	RCL	
134	11	11	
135	75	-	
136	43	RCL	
137	12	12	
138	54	)	
139	53	(	
140	42	STO	
141	19	19	
142	55	÷	
143	32	X:T	
144	54	)	
145	42	STO	
146	15	15	
147	53	(	
148	43	RCL	
149	18	18	
150	65	×	
151	32	X:T	
152	65	×	
153	02	2	
154	54	)	
155	42	STO	
156	16	16	
157	53	(	
158	32	X:T	
159	65	×	
160	43	RCL	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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LOC	CODE	KEY	COMMENTS
161	12	12	
162	65	×	
163	02	2	
164	54	)	
165	42	STO	
166	17	17	
167	92	RTN	
168	76	LBL	
169	11	A	
170	42	STO	
171	11	11	
172	92	RTN	
173	76	LBL	
174	12	B	
175	42	STO	
176	12	12	
177	92	RTN	
178	76	LBL	
179	13	C	
180	42	STO	
181	13	13	
182	92	RTN	
183	76	LBL	
184	14	D	
185	42	STO	
186	14	14	
187	92	RTN	
188	76	LBL	
189	16	A'	
190	43	RCL	
191	15	15	
192	92	RTN	
193	76	LBL	
194	17	B'	
195	43	RCL	
196	16	16	
197	92	RTN	
198	76	LBL	
199	18	C'	
200	43	RCL	
201	17	17	
202	92	RTN	
203	76	LBL	
204	19	D'	
205	43	RCL	
206	18	18	
207	92	RTN	

See Note on entering Program in "Program Description"

Alphanumeric Data Registers

Contents	Reg.
3632413515.	60
1700423227.	61
3713221700.	62
42322737.	63
4617311735.	64
42322737.	65
1322170000.	66
42322737.	67
3024310046.	68
1731173500.	69
1541353500.	70
13303336.	71
3013440032.	72
4137334137.	73
15413535.	74
13303336.	75
3502004213.	76
2741170000.	77
32233036.	78
3502003332.	79
4317350000.	80
43133737.	81
4617311735.	82
33433500.	83
43133737.	84
3635150015.	85
4135350000.	86
13303336.	87
461731.	88
1735003332.	89
4317350000.	90
36413333.	91
2745001617.	92
3624223100.	93

Labels and Locations

LOC	CODE	KEY
001	10	E'
036	89	π
061	57	ENG
082	99	PRT
090	98	ADV
107	90	LST
121	15	E
169	11	A
174	12	B
179	13	C
184	14	D
189	16	A'
194	17	B'
199	18	C'
204	19	D'

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

6 5 8 0 0 7
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professional program exchange

TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title	Rev.
RESISTIVE VOLTAGE DIVIDER	

Abstract of Program

This program was assembled to provide the user with a method to quickly design (empirically) resistive voltage divider networks often encountered in basic designs; and to evaluate the various parameters of intermediate and completed network designs.

Original SR-52 Program by Clarence R. Carpenter, Pittsburgh, PA., September, 1976.

User Benefits:

Saves engineering time and provides complete engineering data (i.e. voltage levels, resistance values and power dissipated by the divider resistors, and all currents.

Category Name	Required Progs.	Prog. Steps	Card Sides	PC-100A Needed / Library Module ID
Electronic Eng.		155	1	☐ / ☐

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Address _____

City _____ State _____ Zip _____

Submission Checklist

- ☑ Recorded Magnetic Cards
- ☑ Submission Abstract
- ☑ Program Description
- ☑ User Instructions
- ☑ Sample Problem
- ☑ Listing
- ☐ _____
- ☐ _____

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TEXAS INSTRUMENTS
Calculator Products Division

Program Description

Program Title: Resistive Voltage Divider

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:

Given three (of eleven) parameters describing a resistive voltage divider network, as inputs, the program will compute the values of the remaining eight. The program is divided into two separate sections and will accept two different sets of input parameters.

(1) E_i, E_o & R_t (2) E_i, R_1, R_2

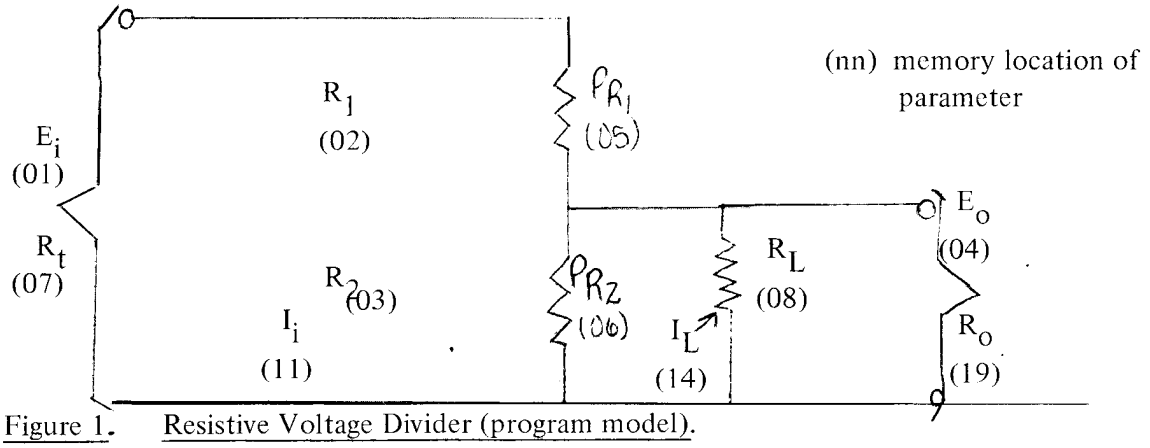


Figure 1. Resistive Voltage Divider (program model).

Table 1. Parameter Description and Derivation.

symbol	description	derivation
E_i	input voltage	keyboard input (ki)
E_o	output voltage	I_i X R_o or (ki)
R_1	divider resistor	E_i - E_o ÷ I_i or (ki)
R_2	divider resistor	R_o x R_L ÷ R_L - R_o or (ki)
R_o	output (net) resistance	R_2 x R_L ÷ R_L + R_2
R_t	total (input) resistance	R_o + R_1 or (ki)

☒ See Continuation Sheet

Continued From: ☒ Program Description ☐ User Instructions ☐ Stmt. of Example

Program Title: RESISTIVE VOLTAGE DIVIDER	Rev.

TABLE 1 - (Continued) Parameter Description and Derivation

I_i	input (source) current	$E_i \div R_t$
I_{RL}	load current	$E_o \div R_L$
P_{R1}	power disipated by R_1	$I_i^2 \times R_1$
P_{R2}	power disipated by R_2	$E_o^2 \div R_2$
R_L	load resistor	programed or (ki)

Procedure.

The intended procedure for the development of a resistive voltage divider network utilizes the first program section to determine initialvalues for R_1 and R_2 and to check other variables for reasonable values (or levels)

Standard values for R_1 and R_2 are then chosen (See Table 2) and the second section of the program is run to recompute all parameter values.

Note 1.

In both sections of the program the input variables may be entered in any order and only changed input variables need to be entered for subsequent calculations; that is, previous input values, which are still valid, need not be reentered.

Note 2.

For convenience $R_L = 1$ megohm has been incorporated in the program, however, any value (> zero) for R_L may be substituted in the program by keying in the following sequence:

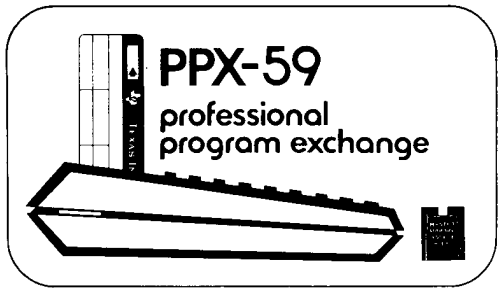
enter	press	display
desired value of R_L (> 0)	STO 0 8	R_L

TABLE 2. One decade of STANDARD VALUE (5%) RESISTORS.

1.1	1.6	2.4	3.6	5.1	7.5
1.2	1.8	2.7	3.9	5.6	8.2
1.3	2.0	3.0	4.3	6.2	9.1
1.5	2.2	3.3	4.7	6.8	10.0

Scan by Dan

6 5 8 0 0 7



User Instructions

Program Title RESISTIVE VOLTAGE DIVIDER

run-1	Eo-out	R_1-out	R_2-out	run-2
E_i-in	Eo-in	R_1-in	R_2-in	R_t-in

Partition (OP 17) 479 . 59 *	Parenthesis Levels	t Register ☐
Angular Mode (if applicable) N/A	SBR Levels 1	Absolute Addresses ☐
Library Module ID N/A	* for TI-58 239.29	Disturbs Pending Operations ☐

LABELS (Op 08)

INV	lnx	CE	CLR	x:t	x²
√x	1/x	STO	RCL	SUM	y^x
EE	(	)	÷	GTO	×
SBR	−	RST	+	R/S	•
+/−	=	CLR	INV	log	CP
tan	Pgm	P→R	sin	cos	GMs
Exc	Prd	|x|	Eng	Fix	Int
Deg	Pause	x=t	Nop	Op	Rad
Lbl	x≠t	Σ+	x̄	Grad	St flg
If flg	D.MS	π	List	Write	Dsz
Adv	Prt				

USER DEFINED KEYS

A	Enter E_i
B	Enter E_o
C	Enter R_1
D	Enter R_2
E	Enter R_t
A'	run program-1
B'	Display E_o
C'	Display R_1
D'	Display R_2
E'	run program-2

FLAGS	0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS			OUTPUT/MODE (see legend below)
	Enter Program					
1	Given: E_i, E_o, & R_t - Find: R_1, R_2, I_i, I_{RL}, P_{R1} & P_{R2}					
a.	Enter known parameters (any order)	E_i		A		E_i
		E_o		B		E_o
		R_t		E		R_t
	(if $R_L \neq 10^6$ ohms)	R_L	STO	0	8	R_L
	(else press R/S after E)					
b.	Run program		2nd	A'		I_{RL}
	—to display all parameters, go to step 3.					
2.	Given: E_i, R_1, & R_2 - Find: E_o, R_t, I_i, I_{RL}, P_{R1} & P_{R2}					
a.	Enter known parameters (any order)	E_i		A		E_i
		R_1		C		R_1
		R_2		D		R_2
	(if $R_L \neq 10^6$ ohms)	R_L	STO	0	8	R_L
	(else press R/S after E)		2nd	E'		I_{RL}
b.	Run program - 2 -- to display all parameters, go to step 3.					
3	To display desired parameters after running either program --					
		E_i	RCL	0	1	E_i
		E_o	2nd	B'		E_o

Modes: (n)• —Printed only (n)—Displayed Briefly (Pause)
n• —Printed and displayed

DATA REGISTERS (INV List)

0	
1	E_i
2	R_1
3	R_2
4	E_o
5	P_{R1}
6	P_{R2}
7	R_t
8	R_L
9	
10	
11	I_i
12	
13	
14	I_{RL}
15	
16	
17	
18	
19	R_o

☐ See Continuation Sheet

Continued From: ☐ Program Description ☒ User Instructions ☐ Stmt. of Example

Program Title: RESISTIVE VOLTAGE DIVIDER

Rev.

R_1	2nd	C'	R_1
R_2	2nd	D'	R_2
R_t	RCL	0 7	R_t
I_i	RCL	1 1	I_i
I_{RL}	RCL	1 4	I_{RL}
P_{R1}	RCL	0 5	P_{R1}
P_{R2}	RCL	0 6	P_{R2}

6 5 8 0 0 7
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Sample Problem

Statement of Example

Design a resistive voltage divider network which will provide an output voltage of 5.5 volts 0.25 volts with an input voltage of 7.15 volts. The network will be presented with a load resistance of 10,000 ohms. The input current (source loading) shall be between 0.9 and 1.1 ma. Determine the standard (5%) resistance values for R_1 and R_2, also the minimum (standard) power rating of both resistors which will allow at least 200% safety margin.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
Enter program			
The total resistance (R_t) is determined by E_i I_i and in this case is 7150 ohms The following sequence will enter the initial values and compute the precise values for R_1 and R_2.			
(R_t) 7150	E	7150	
(E_i) 7.15	A	7.15	
(E_o) 5.5	B	5.5	
(R_L) 10000	STO 0 8	10000	
run program 1	2nd A'	0.00055	load current (I_{R_L})
display R1	2nd C'	1650	ohms (R1)
Display R2	2nd D'	1222.22222	ohms (R2)
Select standard values for R1 and R2 (from table 2) as inputs to program 2. (Ei) need not be reentered - see note 1).			
(R1) 1600	C	1600	
(R2) 12000	D	12000	
run program 2	2nd E'	.0005528351	load current (IRL)
display Eo	2nd B'	5.528350515	volts (Eo)
display Ii	RCL 1 1	.0010135309	amps (Ii)

Modes: (n)* —Printed only (n)—Displayed Briefly (Pause)
n* —Printed and displayed

☐ Over

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
These values for R1 and R2 meet the tolerances set in the original problem, however other values could (and should) be tried.			
Enter 1800 ohms for R1 and recompute.			
(R1) 1800	C	1800	
run program	2 2nd E'	0.000537594	amps (I_{R_L})
display Eo	2nd B'	5.37593985	volts
Although still within tolerance, the error in output voltage is greater than the first run. Try a new standard value for R2 (15 Kohms).			
(R2) 15 000	D	15000	
run program	2 2nd E'	0.00055	amps (I_{R_L})
display Eo	2nd B'	5.5	volts
display Ii	RCL 1 1	.0009166667	amps
display PR1	RCL 0 5	0.0015125	watts
display PR2	RCL 0 6	0.0020166667	watts
These computed values are within the tolerances required - Eo being exact.			
Standard 1/10 watt resistors would be suitable for both R1 and R2.			
(Total design time including loading the program - less than 5 minutes.)			

Modes: (n)* --Printed only (n)—Displayed Briefly (Pause)
n*--Printed and displayed

PPX-59 Professional Program Exchange

6 5 8 0 0 7
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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	16	A'	
002	43	RCL	
003	01	01	
004	55	÷	
005	43	RCL	
006	07	07	
007	95	=	
008	42	STO	
009	11	11	
010	43	RCL	
011	01	01	
012	75	-	
013	43	RCL	
014	04	04	
015	95	=	
016	55	÷	
017	43	RCL	
018	11	11	
019	95	=	
020	42	STO	
021	02	02	
022	94	+/-	
023	85	+	
024	43	RCL	
025	07	07	
026	95	=	
027	42	STO	
028	19	19	
029	65	×	
030	43	RCL	
031	08	08	
032	55	÷	
033	53	(	
034	43	RCL	
035	08	08	
036	75	-	
037	43	RCL	
038	19	19	
039	95	=	
040	42	STO	
041	03	03	
042	61	GTO	
043	48	EXC	
044	76	LBL	
045	10	E'	
046	43	RCL	
047	03	03	
048	65	×	
049	43	RCL	
050	08	08	
051	55	÷	
052	53	(	
053	43	RCL	
054	08	08	

LOC	CODE	KEY	COMMENTS
055	85	+	
056	43	RCL	
057	03	03	
058	95	=	
059	42	STO	
060	19	19	
061	85	+	
062	43	RCL	
063	02	02	
064	95	=	
065	42	STO	
066	07	07	
067	35	1/X	
068	65	×	
069	43	RCL	
070	01	01	
071	95	=	
072	42	STO	
073	11	11	
074	65	×	
075	43	RCL	
076	19	19	
077	95	=	
078	42	STO	
079	04	04	
080	76	LBL	
081	48	EXC	
082	43	RCL	
083	11	11	
084	33	X^2	
085	65	×	
086	43	RCL	
087	02	02	
088	95	=	
089	42	STO	
090	05	05	
091	43	RCL	
092	04	04	
093	33	X^2	
094	55	÷	
095	43	RCL	
096	03	03	
097	95	=	
098	42	STO	
099	06	06	
100	43	RCL	
101	04	04	
102	55	÷	
103	43	RCL	
104	08	08	
105	95	=	
106	42	STO	
107	14	14	
108	92	RTN	

LOC	CODE	KEY	COMMENTS
109	76	LBL	
110	17	B'	
111	43	RCL	
112	04	04	
113	92	RTN	
114	76	LBL	
115	18	C'	
116	43	RCL	
117	02	02	
118	92	RTN	
119	76	LBL	
120	19	D'	
121	43	RCL	
122	03	03	
123	92	RTN	
124	76	LBL	
125	11	A	
126	42	STO	
127	01	01	
128	92	RTN	
129	76	LBL	
130	12	B	
131	42	STO	
132	04	04	
133	92	RTN	
134	76	LBL	
135	13	C	
136	42	STO	
137	02	02	
138	92	RTN	
139	76	LBL	
140	14	D	
141	42	STO	
142	03	03	
143	92	RTN	
144	76	LBL	
145	15	E	
146	42	STO	
147	07	07	
148	91	R/S	
149	01	1	
150	52	EE	
151	06	6	
152	42	STO	
153	08	08	
154	92	RTN	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

6,5 8, 0,0 ,8
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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title	Rev.
FIELD EFFECT TRANSISTOR ANALYSIS	

Abstract of Program

This program calculates the source bypass and coupling capacitors for a F.E.T. circuit. The method used is pole zero cancellation. The program is designed for a low frequency analysis. Engineering notation is used.

Original SR-52 Program by Alan Charbonneau, San Luis Obispo, Calif., Sept. 1976

User Benefits:

This program allows the user to vary circuit parameters and quickly determine the effect on the circuit capacitances.

Category Name	Required Progs.	Prog. Steps	Card Sides	PC-100A Needed / Library Module ID
Electron. Eng.		328	2	☐ / ☐

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- ☑ Recorded Magnetic Cards
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- ☑ User Instructions
- ☑ Sample Problem
- ☑ Listing
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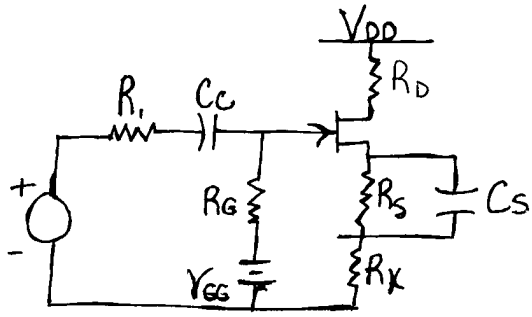
Program Description

Program Title:
Field Effect Transistor Analysis

Rev.

Method, Equations, Sketches, Limitations, References, Error Recovery:



The solution for the values of the coupling capacitors (C_c, C_s) requires that values are known for R_1, R_s, R_G, R_x, g_m (mutual conductance) and the lower cut off frequency. (f_L in Hz)

$$Ks = \frac{1 + g_m(Rx + Rs)}{1 + gmRx}$$

$$R = R_1 + R_G$$
$$W = W_s$$
$$f_s = f_o \qquad f_s = \frac{fL}{Ks}$$

$$C_s = \frac{1}{2\pi f_s R_s} \qquad C_c = \frac{1}{2\pi f_o R_o}$$

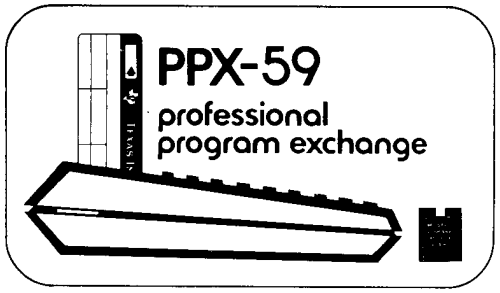
These equations only apply for a low frequency analysis.

References: L. F. Amplifier Notes
Calif. Polytechnic St. University (San Luis Obispo)

NOTE: Engineering Notation is used throughout the program. Fixed notation may be used with engineering notation only when used without a printer; the alphanumeric routines do not work in fixed notation.

☐ See Continuation Sheet

6 5 8 0 0 8



User Instructions

Program Title Field Effect Transistor Analysis

R_G	R_x	f_L	Show C_s	Pt C_c, C_s
R_1	R_s	g_m	find C_c	Print All

Partition (OP 17) 479 . 59 *	Parenthesis Levels 3	t Register ☑
Angular Mode (if applicable) N/A	SBR Levels 2	Absolute Addresses ☐
Library Module ID No	* for TI-58 399.09	Disturbs Pending Operations ☐

LABELS (Op 08)

INV	lnx	CE	CLR	x:t	x²
√x	1/x	STO	RCL	✓SUM	y^x
EE	(	)	÷	GTO	×
SBR	−	RST	+	R/S	•
+/−	=	CLR	INV	log	CP
✓tan	Pgm	P→R	sin	cos	CMs
✓Exc	✓Prd	|x|	Eng	Fix	Int
Deg	Pause	x=t	Nop	Op	Rad
Lbl	x≥t	Σ+	x̄	Grad	St flg
If flg	D.MS	π	List	Write	✓Dsz
Adv	✓Prt				

USER DEFINED KEYS

A	Enter R_1
B	Enter R_s
C	Enter g_m
D	Calculate C_c
E	Print input and output
A'	Enter R_c
B'	Enter R_x
C'	Enter f_L
D'	Recall C_s
E'	Print only C_c, C_s

FLAGS	Not Used 0	1	2	3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS		OUTPUT/MODE (see legend below)
1	Enter Program Banks 1 and 2 (w/o printer bank 1 only)				
2	Enter R_1	R_1		A	R_1*
3	Enter R_G	R_G	2nd	*A'	R_G*
4	Enter R_s	R_s		B	R_s*
5	Enter R_x	R_x	2nd	*B'	R_x*
6	Enter g_m	g_m		C	g_m*
7	Enter f_L	f_L	2nd	*C'	f_L*
	WITHOUT PRINTER				
8	Calculate C_c and C_s and display C_c			D	C_c
9	Recall value of C_s calculated in step 8		2nd	*D'	C_s

Modes: (n)*—Printed only (n)—Displayed Briefly (Pause)
n*—Printed and displayed

DATA REGISTERS (INV List)

0	Looping
1	R_1
2	R_G
3	R_s
4	R_x
5	g_m
6	f_L
7	f_s
8	C_c
9	C_s
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

See Continuation Sheet

Continued From: ☐ Program Description ☒ User Instructions ☐ Stmt. of Example

Program Title: FIELD EFFECT TRANSISTOR ANALYSIS

Rev.

STEP	PROCEDURE	PRESS	PRINTED OUTPUT	
	WITH PRINTER:			
10	Calculate C_c and C_s and print input and output	E	FET ANALYSIS	
			INPUT	
			(R_1)	R1
			(R_9)	RG
			(R_s)	RS
			(R_x)	RX
			(g_m)	GM
			(f_L)	FL
			OUTPUT	
			(C_c)	CC
			(C_s)	CS
11	Calculate C_c and C_s and print output only	2nd E	FET ANALYSIS	
			OUTPUT	
			(C_c)	CC
			(C_s)	CS

NOTES:

Steps 2-7 may be executed in any order desired and can be changed individually before or after output is printed or displayed. Keys D, E and *E' will calculate both values. Key *D' will only recall the previously calculated value of C_s.
*CMs can be used to clear all inputted values.

TEXAS INSTRUMENTS
Calculator Products Division

Sample Problem

Statement of Example

Given circuit parameters:

R_1 = 100 kΩ
R_G = 2.2 MΩ
R_c = 6.8 KΩ
R_x = .33 KΩ
g_m = 2.0 mV
f_L = 8 Hz

Each parameter may be varied by choosing the appropriate user defined key.

☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
100 EE 3	A	100. 03*	Enter R_1
2.2 EE 6	2nd A'	2.2 06*	Enter R_G
6.8 EE 3	B	6.8 03*	Enter R_s
330	2nd B'	330 00*	Enter R_x
2 EE 3±	C	2. -03*	Enter g_m
8	2nd C'	8. 00*	Enter f_L
WITHOUT PRINTER:			
	D	79.514943 -09	C_c and C_s calculated C_c Displayed
	2nd D	26.89476 -06	C_s Displayed

Modes: (n)*—Printed only (n)—Displayed Briefly (Pause)
n*—Printed and displayed

☒ Over

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	WITH PRINTER:		
	E	FET ANALYSIS	
		INPUT	
		100. 03 RI	
		2.2 06 RG	
		6.8 03 RS	
		330. 00 RX	
		2. -03 GM	
		8. 00 FL	
		OUTPUT	
		79.514943-09 CC	
		26.89476-06 CS	
	2nd E	FET ANALYSIS	
		OUTPUT	
		79.514943-09 CC	
		26.89476-06 CS	
		Modes: (n)* —Printed only (n)—Displayed Briefly (Pause) n*—Printed and displayed	

PPX-59 Professional Program Exchange

6 5 8 0 0 8
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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	43	RCL	
002	22	INV	
003	57	ENG	
004	69	OP	
005	04	04	
006	57	ENG	
007	73	RC*	
008	00	00	
009	69	OP	
010	06	06	
011	69	OP	
012	20	20	
013	92	RTN	
014	76	LBL	
015	97	DSZ	
016	22	INV	
017	57	ENG	
018	69	OP	
019	04	04	
020	57	ENG	
021	32	X:T	
022	69	OP	
023	06	06	
024	92	RTN	
025	76	LBL	
026	11	A	
027	42	STO	
028	01	01	
029	32	X:T	
030	03	3	
031	05	5	
032	00	0	
033	02	2	
034	61	GTO	
035	97	DSZ	
036	76	LBL	
037	16	A'	
038	42	STO	
039	02	02	
040	32	X:T	
041	03	3	
042	05	5	
043	02	2	
044	02	2	
045	61	GTO	
046	97	DSZ	
047	76	LBL	
048	12	B	
049	42	STO	
050	03	03	
051	32	X:T	
052	03	3	
053	05	5	

LOC	CODE	KEY	COMMENTS
054	03	3	
055	06	6	
056	61	GTO	
057	97	DSZ	
058	76	LBL	
059	17	B'	
060	42	STO	
061	04	04	
062	32	X:T	
063	03	3	
064	05	5	
065	04	4	
066	04	4	
067	61	GTO	
068	97	DSZ	
069	76	LBL	
070	13	C	
071	42	STO	
072	05	05	
073	32	X:T	
074	02	2	
075	02	2	
076	03	3	
077	00	0	
078	61	GTO	
079	97	DSZ	
080	76	LBL	
081	18	C'	
082	42	STO	
083	06	06	
084	32	X:T	
085	02	2	
086	01	1	
087	02	2	
088	07	7	
089	61	GTO	
090	97	DSZ	
091	76	LBL	
092	14	D	
093	71	SBR	
094	30	TAN	
095	43	RCL	
096	08	08	
097	92	RTN	
098	76	LBL	
099	19	D'	
100	43	RCL	
101	09	09	
102	92	RTN	
103	76	LBL	
104	30	TAN	
105	53	(	
106	43	RCL	
107	06	06	

LOC	CODE	KEY	COMMENTS
108	65	×	
109	53	(	
110	43	RCL	
111	05	05	
112	65	×	
113	43	RCL	
114	04	04	
115	85	+	
116	01	1	
117	54	)	
118	55	÷	
119	53	(	
120	53	(	
121	43	RCL	
122	04	04	
123	85	+	
124	43	RCL	
125	03	03	
126	54	)	
127	65	×	
128	43	RCL	
129	05	05	
130	85	+	
131	01	1	
132	54	)	
133	54	)	
134	53	(	
135	42	STO	
136	07	07	
137	65	×	
138	02	2	
139	65	×	
140	89	π	
141	65	×	
142	53	(	
143	43	RCL	
144	01	01	
145	85	+	
146	43	RCL	
147	02	02	
148	54	)	
149	54	)	
150	35	1/X	
151	42	STO	
152	08	08	

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MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

PPX-59 Professional Program Exchange

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LOC	CODE	KEY	COMMENTS
153	53	(	
154	02	2	
155	65	×	
156	89	π	
157	65	×	
158	43	RCL	
159	07	07	
160	65	×	
161	43	RCL	
162	03	03	
163	54	)	
164	35	1/X	
165	42	STO	
166	09	09	
167	92	RTN	
168	76	LBL	
169	15	E	
170	22	INV	
171	57	ENG	
172	71	SBR	
173	30	TAN	
174	71	SBR	
175	99	PRT	
176	01	1	
177	42	STO	
178	00	00	
179	69	OP	
180	00	00	
181	02	2	
182	04	4	
183	03	3	
184	01	1	
185	03	3	
186	03	3	
187	04	4	
188	01	1	
189	03	3	
190	07	7	
191	69	OP	
192	03	03	
193	69	OP	
194	05	05	
195	03	3	
196	05	5	
197	00	0	
198	02	2	
199	71	SBR	
200	43	RCL	
201	03	3	
202	05	5	
203	02	2	
204	02	2	
205	71	SBR	
206	43	RCL	

LOC	CODE	KEY	COMMENTS
207	03	3	
208	05	5	
209	03	3	
210	06	6	
211	71	SBR	
212	43	RCL	
213	03	3	
214	05	5	
215	04	4	
216	04	4	
217	71	SBR	
218	43	RCL	
219	02	2	
220	02	2	
221	03	3	
222	00	0	
223	71	SBR	
224	43	RCL	
225	02	2	
226	01	1	
227	02	2	
228	07	7	
229	71	SBR	
230	43	RCL	
231	98	ADV	
232	76	LBL	
233	48	EXC	
234.	08	8	
235	42	STO	
236	00	00	
237	69	OP	
238	00	00	
239	22	INV	
240	57	ENG	
241	03	3	
242	02	2	
243	69	OP	
244	02	02	
245	04	4	
246	01	1	
247	03	3	
248	07	7	
249	03	3	
250	03	3	
251	04	4	
252	01	1	
253	03	3	
254	07	7	
255	69	OP	
256	03	03	
257	69	OP	
258	05	05	

LOC	CODE	KEY	COMMENTS
259	01	1	
260	05	5	
261	01	1	
262	05	5	
263	71	SBR	
264	43	RCL	
265	01	1	
266	05	5	
267	03	3	
268	06	6	
269	71	SBR	
270	43	RCL	
271	98	ADV	
272	98	ADV	
273	98	ADV	
274	92	RTN	
275	76	LBL	
276	99	PRT	
277	22	INV	
278	57	ENG	
279	69	OP	
280	00	00	
281	02	2	
282	01	1	
283	00	0	
284	00	0	
285	01	1	
286	07	7	
287	00	0	
288	00	0	
289	03	3	
290	07	7	
291	69	OP	
292	02	02	
293	01	1	
294	03	3	
295	03	3	
296	01	1	
297	01	1	
298	03	3	
299	69	OP	
300	03	03	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

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6 5 8 0 0 8
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LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
322	30	TAN									
323	71	SBR									
324	99	PRT									
325	71	SBR									
326	48	EXC									
327	92	RTN									
328	00	0									
329	00	0									
330	00	0									

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

6 5 8 0 0 9
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TEXAS INSTRUMENTS
Calculator Products Division

Submission Abstract

Program Title	Rev.
SOLUTION OF RESISTIVE NETWORKS	

Abstract of Program

This program solves for the total resistance of both simple and complicated D.C. networks.

Original SR-52 Program by Craig Byrd of Chula Vista, California

User Benefits:

Assists in solving resistive networks. Also can be used to solve capacitive and inductive circuits.

Category Name	Required Progs.	Prog. Steps	Card Sides	PC-100A Needed / Library Module ID
Electronic Eng.		170	1	☐ / ☐

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Signature _____ Date _____

Name Texas Instruments Tel. No. _____

Address _____

City _____ State _____ Zip _____

Submission Checklist

- ☑ Recorded Magnetic Cards
- ☑ Submission Abstract
- ☑ Program Description
- ☑ User Instructions
- ☑ Sample Problem
- ☑ Listing
- ☐ _____
- ☐ _____

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TEXAS INSTRUMENTS
Calculator Products Division

Program Description

Program Title: SOLUTION OF RESISTIVE NETWORKS

Rev.

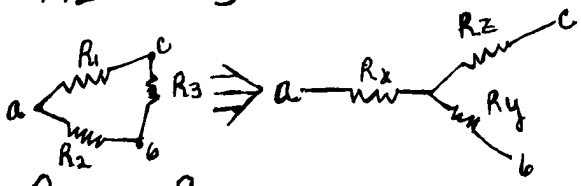
Method, Equations, Sketches, Limitations, References, Error Recovery:

This program uses network simplification to solve for the Δ to y and y to Δ networks. It also sums series resistors and sums the reciprocals of parallel resistors to solve for the total resistance.

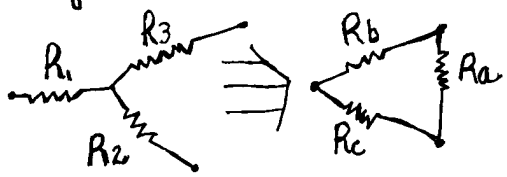
Eqs.

R_T (series) = $R_1 + R_2 + R_3 \ldots + R_n$ R_T (parallel) = $\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots + \frac{1}{R_n}$

R_Δ to R_y



R_y to R_Δ



$$Rx = \frac{R_1 \cdot R_2}{(R_1+R_2+R_3)} \qquad Rz = \frac{R_1 \cdot R_3}{(R_1+R_2+R_3)}$$

$$Ry = \frac{R_2 \cdot R_3}{(R_1+R_2+R_3)}$$

$$Ra = \frac{R_1R_2+R_2R_3+R_3R_1}{R_1}$$

$$Rb = \frac{R_1R_2+R_2R_3+R_3R_1}{R_2}$$

$$Rc = \frac{R_1R_2+R_2R_3+R_3R_1}{R_3}$$

*Solve Δ to y ckts first and then sum the series and parallel legs to find the total resistance.

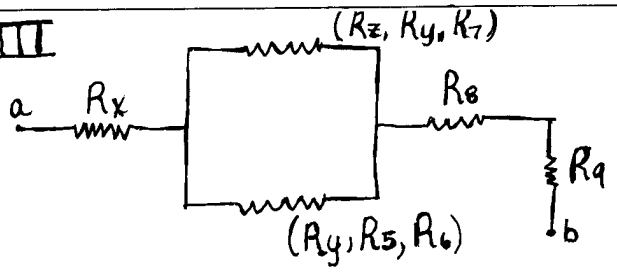
See Continuation Sheet

Continued From: ☒ Program Description ☐ User Instructions ☐ Stmt. of Example

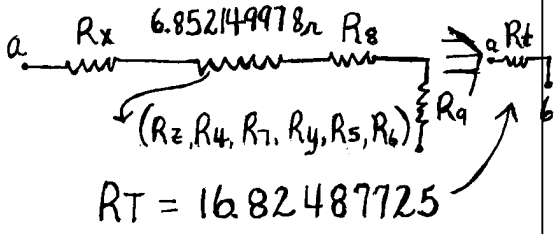
Program Title: SOLUTION OF RESISTIVE NETWORKS

Rev.

III

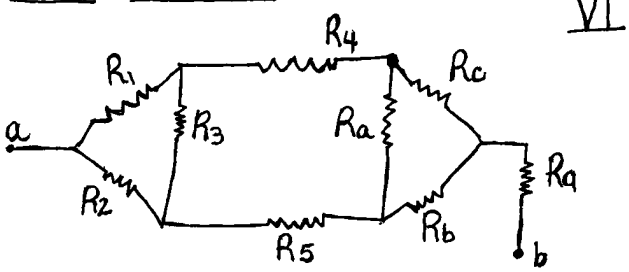


IV

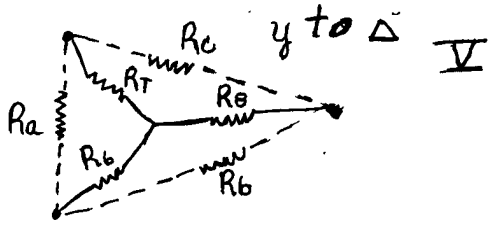


Final Circuit

VI

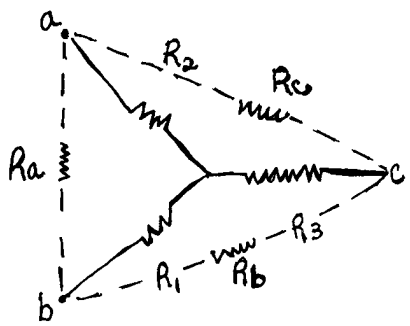


V



*Procedure for Solving Circuitry:
Solve Δ to y transformations first
In transforming from Δ to y networks, if the R values are entered clockwise, the Rx, Ry and Rz values are shown in their respective clockwise positions. If the Δ resistors are entered counter clockwise, the y resistors value are shown in their counter clockwise position.

In transforming a Y circuit to a Δ circuit the Δ value resistor are shown opposite the y value entry.



Example: If Y entered 3-2-1 the Δ values are 3.67Ω (Ra)
Opposite R_3, 5.5Ω (Rb) Opposite R_2 and the 1Ω (Rc) Opposite R_1.

In using the Δ to Y or Y to Δ methods you must press E to initialize the program

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6 5 | 8 0 0 9

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User Instructions

Program Title SOLUTION OF RESISTIVE NETWORKS

	Recall	Recall		
Δ - Y	Series	Parallel	Y - Δ	Init.

Partition (OP 17): 479 . 59 *

Parenthesis Levels: 1

Angular Mode (if applicable):

SBR Levels: 1

Library Module ID:

* for TI-58 239.29

t Register ☐

Absolute Addresses ☑

Disturbs Pending Operations ☐

LABELS (Op 08)

INV	lnx	CE	CLR	x:t	x²
√x	1/x	STO ✓	RCL ✓	SUM ✓	y^x ✓
EE ✓	(	)	÷ ✓	GTO	×
SBR	− ✓	RST	+ ✓	R/S	•
+/−	=	CLR	INV	log	CP
tan ✓	Pgm	P→R	sin ✓	cos ✓	CMs
Exc	Prd	|x|	Eng	Fix	Int
Deg	Pause	x=t	Nop	Op	Rad
Lbl	x≥t	Σ+	x̄	Grad	St flg
If flg	DMS	π	List	Write	Dsz
Adv	Prt				

USER DEFINED KEYS

A	Δ to Y
B	Series
C	Parallel
D	Y to Δ
E	Initialize
A'	
B'	Series Total
C'	Parallel Total
D'	
E'	

FLAGS 0	Branch Cont. 1	Branch Cont. 2	Branch Cont. 3	4	5	6	7	8	9

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)
1	Enter Program			
2	Initialize		E	0
3	ΔR Values (If any)	R_1, R_2 & R_3	A (3 tms)	0
	ΔR Solutions		R/S (3 tms)	Rx, Ry, Rz
5	Initialize		E	0
6	YR Values (If Any)	R_1, R_2 & R_3	D (3 tms)	R_1, R_2, 0
7	Press Run 5 times		R/S	0, 0, Ra, Rb, Rc
8	Series Networks (R_1-R_N)	(Series Values)	B	0
9	Series Sum (R_1 - R_N)		B'	Series Sum
10	Parallel Networks ($\frac{1}{R_1} - \frac{1}{R_N}$)	(Parl. Values)	C	0
11	Parallel Sum ($\frac{1}{R_1} - \frac{1}{R_N}$)		C'	Parallel Sum

Modes: (n)* —Printed only (n)—Displayed Briefly (Pause)
n* —Printed and displayed

DATA REGISTERS (INV STO)

0	Pointer
1	Δ or Y Values
2	Δ or Y Values
3	Δ or Y Values
4	Sum of Δ Values
5	Series Sums
6	Parallel Sums
7	Sum of Y Values
8	
9	
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	

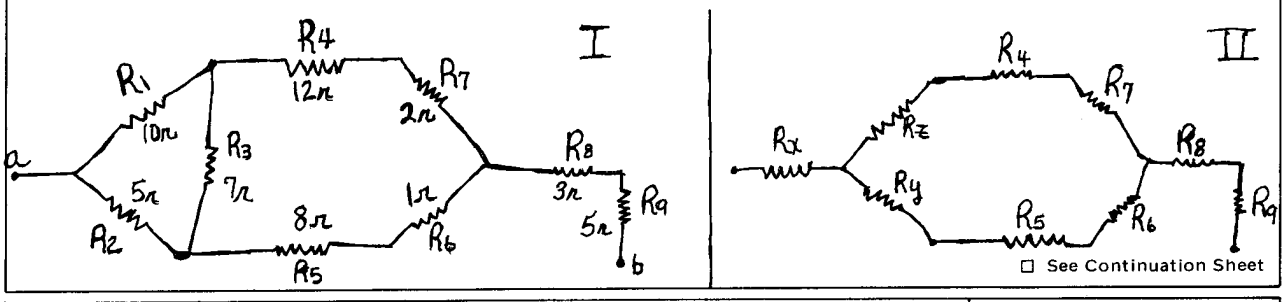
☐ See Continuation Sheet

TEXAS INSTRUMENTS
Calculator Products Division

Sample Problem

Statement of Example

Solve the following resistive network for the total resistance and then transform the Y network (R_8, R_7 & R_6) into a Δ network (Ra, Rb, & Rc)



☐ See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	E	0	Initialize
10	A	10	$\left\{\begin{matrix} R_1 \\ R_2 \\ R_3 \end{matrix}\right\}$ $\left\{\begin{matrix} \Delta \\ \text{to} \\ Y \end{matrix}\right\}$
5	A	5	
7	A	0	
	R/S	2.272727273	Rx
	R/S	1.590909091	Ry
	R/S	3.181818182	Rz
	B	0	Series Leg (Rz)
12	B	0	(R_4)
2	B	0	(R_7)
	B'	17.18181818	Series Leg Total
	C	0	1st Parallel Leg
1.590909091	B	0	Series Leg (Ry)
8	B	0	(R_5)
1	B	0	(R_6)
	B'	10.59090909	Series Leg Total
	C	0	2nd Parallel Leg
	C'	6.552149978	Parallel Total
	B	0	Parallel Total
2.272727273	B	0	Rx
3	B	0	R8
5	B	0	R9
	B'	16.82487725	CKT R Total

Modes: (n)* —Printed only (n)—Displayed Briefly (Pause)
n* —Printed and displayed

☐ Over

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Sample Problem (cont'd)

6 5 8 0 0 9
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ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	E	0	Initialize
3	D	3	$\{R_8, R_7, R_6\}$ $\{Y$ to $\Delta\}$
2	D	2	
1	D	0	
	R/S	0	
	R/S	0	
	R/S	3.666666667	
	R/S	5.5	
	R/S	11	

Modes: (n)* —Printed only (n)—Displayed Briefly (Pause)
n*—Printed and displayed

PPX-59 Professional Program Exchange

6,5 8,0,0,9
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LOC	CODE	KEY	COMMENTS
000	76	LBL	
001	16	A'	
002	03	3	
003	42	STO	
004	00	00	
005	87	IFF	
006	02	02	
007	44	SUM	
008	25	CLR	
009	91	R/S	
010	92	RTN	
011	76	LBL	
012	11	A	
013	72	ST*	
014	00	00	
015	44	SUM	
016	04	04	
017	97	DSZ	
018	00	00	
019	91	R/S	
020	16	A'	
021	76	LBL	
022	39	COS	
023	73	RC*	
024	00	00	
025	97	DSZ	
026	00	00	
027	43	RCL	
028	86	STF	
029	01	01	
030	86	STF	
031	02	02	
032	03	3	
033	42	STO	
034	00	00	
035	61	GTO	
036	39	COS	
037	76	LBL	
038	43	RCL	
039	87	IFF	
040	01	01	
041	38	SIN	
042	76	LBL	
043	30	TAN	
044	65	×	
045	73	RC*	
046	00	00	
047	55	÷	
048	43	RCL	
049	04	04	
050	95	=	
051	91	R/S	
052	87	IFF	
053	02	02	
054	16	A'	
055	61	GTO	
056	39	COS	
057	76	LBL	
058	38	SIN	
059	97	DSZ	
060	00	00	
061	30	TAN	
062	76	LBL	
063	91	R/S	
064	91	R/S	
065	76	LBL	
066	44	SUM	
067	22	INV	
068	86	STF	
069	02	02	
070	22	INV	
071	86	STF	
072	01	01	
073	61	GTO	
074	39	COS	
075	76	LBL	
076	12	B	
077	44	SUM	
078	05	05	
079	25	CLR	
080	91	R/S	
081	76	LBL	
082	17	B'	
083	48	EXC	
084	05	05	
085	91	R/S	
086	76	LBL	
087	13	C	
088	35	1/X	
089	44	SUM	
090	06	06	
091	25	CLR	
092	91	R/S	
093	76	LBL	
094	18	C'	
095	48	EXC	
096	06	06	
097	35	1/X	
098	91	R/S	
099	76	LBL	
100	52	EE	
101	73	RC*	
102	00	00	
103	97	DSZ	
104	00	00	
105	42	STO	
106	16	A'	
107	86	STF	
108	03	03	
109	61	GTO	
110	52	EE	
111	76	LBL	
112	55	÷	
113	43	RCL	
114	07	07	
115	55	÷	
116	73	RC*	
117	00	00	
118	95	=	
119	91	R/S	
120	97	DSZ	
121	00	00	
122	55	÷	
123	61	GTO	
124	85	+	
125	76	LBL	
126	42	STO	
127	87	IFF	
128	03	03	
129	45	Y×	
130	76	LBL	
131	75	-	
132	65	×	
133	73	RC*	
134	00	00	
135	54	)	
136	44	SUM	
137	07	07	
138	87	IFF	
139	03	03	
140	85	+	
141	61	GTO	
142	52	EE	
143	76	LBL	
144	85	+	
145	22	INV	
146	86	STF	
147	03	03	
148	16	A'	
149	61	GTO	
150	55	÷	
151	76	LBL	
152	14	D	
153	72	ST*	
154	00	00	
155	97	DSZ	
156	00	00	
157	91	R/S	
158	16	A'	
159	61	GTO	

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

PPX-59 Professional Program Exchange

6,5 8,0,0,9
For TI use only

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
160	52	EE									
161	76	LBL									
162	15	E									
163	47	CMS									
164	81	RST									
165	76	LBL									
166	45	Y^x									
167	97	DSZ									
168	00	00									
169	75	-									

Scan by Dan

MERGED CODES

62 Pgm Ind	72 STO Ind	83 GTO Ind
63 Exc Ind	73 RCL Ind	84 Op Ind
64 Prd Ind	74 SUM Ind	92 INV SBR

ELECTRONIC ENGINEERING

- **CLASS "A" AMPLIFIER DESIGNED TO SPECIFIED TOLERANCES**
  Biasing, load and emitter resistors are calculated for a class "A" bipolar transistor amplifier. Design is constrained to a maximum allowable percent collector current variation specified by the user.
  TI-59 only.

- **RF AMPLIFIER ANALYSIS**
  Calculates the input admittance, transducer gain, and Linvill's C-factor for a specified load admittance assumed to be pure conductance when given the Y-parameters of a two part network, such as a transistor used as an RF Amplifier.
  TI-58 or TI-59.

- **BIPOLAR JUNCTION TRANSISTOR ANALYSIS**
  Calculates the emitter bypass and coupling capacitors for a B.J.T. circuit. The program is designed for a low frequency analysis.
  TI-58 or TI-59.

- **POWER SUPPLY FILTER DESIGN**
  Load resistance, filter capacitor value, and the minimum, maximum, and average output voltages for both the full- and half-wave rectifier circuits are calculated.
  TI-59 only.

- **ZENER POWER SUPPLY DESIGN**
  Calculates component values and power rating pertaining to a Zener diode regulated power supply.
  TI-59 only.

- **RESISTIVE VOLTAGE DIVIDER**
  Provides a method to empirically design and evaluate resistive voltage divider networks often encountered in basic designs.
  TI-58 or TI-59.

- **FIELD EFFECT TRANSISTOR ANALYSIS**
  Calculates the source bypass and coupling capacitors for a F.E.T. circuit using the pole zero cancellation method.
  TI-58 or TI-59.

- **SOLUTION OF RESISTIVE NETWORKS**
  Solves for the total resistance of both simple and complicated D.C. networks.
  TI-58 or TI-59.

PREPROGRAMMED MAGNETIC CARDS ARE NOT INCLUDED.
(The program Code Lists must be keyed into blank magnetic cards.)

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