

# Programmable TI58/59 Specialty Pakettes Blackbody Radiation



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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:

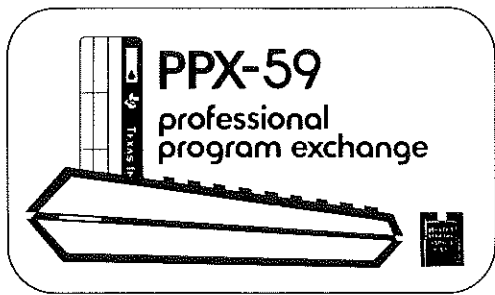
- Statistics
- Real Estate and Investment
- Surveying
- Navigation
- Aviation
- Leisure
- Business Decisions
- Securities Analysis

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

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# TEXAS INSTRUMENTS Calculator Products Division

## Submission Abstract

Program Title <b>BLACKBODY PHOTON RADIANCE</b>	Rev.
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**Abstract of Program**

Computes wavelength of maximum photon radiance, total photon radiance, in-band photon radiance, and spectral photon radiance of blackbody radiator at input temperature and wavelength band limits.

**User Benefits:**

Useful in calculations of infrared target photon radiation in performance analyses of infrared sensors with photon detectors.

Category Name <u>Optics</u>	Required Progs. _____	Prog. Steps <u>335</u>	Card Sides <u>2</u>	PC-100A Needed <input type="checkbox"/>
				Library Module ID <input type="checkbox"/>

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Signature \_\_\_\_\_ Date \_\_\_\_\_  
 Name Texas Instruments Tel. No. \_\_\_\_\_  
 Address \_\_\_\_\_  
 City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

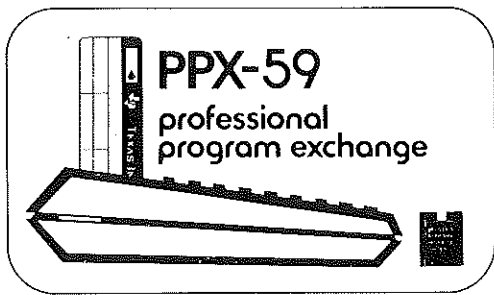
**Submission Checklist**

- Recorded Magnetic Cards
- Submission Abstract
- Program Description
- User Instructions
- Sample Problem
- Listing
- \_\_\_\_\_
- \_\_\_\_\_

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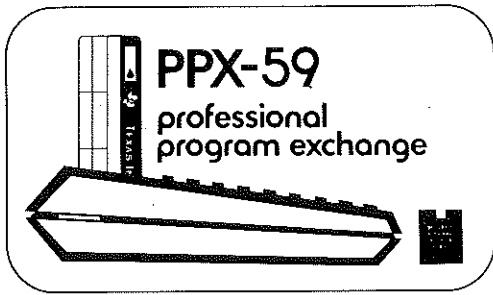


# TEXAS INSTRUMENTS Calculator Products Division

## Program Description

Program Title: <b>BLACKBODY PHOTON RADIANCE</b>	Rev.
<p>Method, Equations, Sketches, Limitations, References, Error Recovery:</p> <p>Planck's radiation law and associated Wien's displacement law are used as the basis for the program. The spectral photon radiance <math>Q_\lambda</math>, is given by</p> $Q_\lambda = \frac{2c}{\lambda^4} \frac{1}{e^{hc/\lambda kT} - 1} \quad \text{photons s}^{-1} \text{ m}^{-2} \mu\text{m}^{-1} \text{ sr}^{-1}$ <p>where <math>h</math> = Planck's constant, <math>c</math> = speed of light, <math>\lambda</math> = wavelength, <math>k</math> = Boltzmann's constant, <math>T</math> = temperature. The total photon radiance, <math>Q_t</math>, is given by</p> $Q_t = \frac{4k^3(1.202 \times 10^4)T^3}{h^3c^2} \quad \text{photons s}^{-1} \text{ m}^{-2} \text{ sr}^{-1}$ <p>The wavelength at maximum spectral photon radiance, <math>\lambda_{\text{max}}</math>, is</p> $\lambda_{\text{max}} = \frac{3669.7}{T_{\text{bb}}} \quad \mu\text{m}$ <p>The in-band photon radiance is computed using a rapidly-converging series expansion of the integral equation</p> $Q_{\Delta\lambda} = \int_{\lambda_1}^{\lambda_2} Q_\lambda d\lambda = Q_t \left( .416 \sum_{n=1}^3 \frac{1}{n^3} e^{-v_2} (v_2^2 + 2v_2 + 2) - e^{-v_1} (v_1^2 + 2v_1 + 2) \right)$ <p>where <math>v_1 = \frac{hcn}{\lambda_1 kT_{\text{bb}}}</math>, <math>v_2 = \frac{hcn}{\lambda_2 kT_{\text{bb}}}</math></p> <p>The computed quantities are accurate to at least three decimal places over the infrared spectrum.</p>	
<input type="checkbox"/> See Continuation Sheet	





TEXAS INSTRUMENTS  
Calculator Products Division

Sample Problem

Statement of Example

For a Blackbody at 295° k and  $\lambda_1$  of 7.65 microns and  $\lambda_2$  of 11.75 microns, find

$\lambda_{max}$ ,  $Q_{\Delta\lambda}$ ,  $Q_{\lambda}$ ,  $Q_{total}$ ,  $Q_{0-\lambda_1}/Q_t$ ,  $Q_{0-\lambda_2}/Q_t$ ,  $Q_{\Delta\lambda}/Q_t$

See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
	A	0.	T BB
295	R/S	295.	T BB
	B	0.	L LO
7.65	R/S	7.65	L LO
	C	0.	L HI
11.75	R/S	11.75	L HI
	2nd *B'	0.	Q 1
	R/S	.0392687962	Q 1
	2nd *C'	0.	Q 2
	R/S	.1815327186	Q 2
	2nd *A'	1.5813015 17	Q (L)
	2nd *D'	.1422639224	QFRA
		3.9055384 18	QTOT
		5.5561721 17	Q $\Delta$ L
	E	3.9055384 18	QTOT
	2nd *E'	1.2439661 01	LMAX

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



PPX-59 Professional Program  
 Exchange  
 Sample Problem (cont'd)

For TI use only

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
For a summary of the results:			
	A	295. T BB	
	B	7.65 L LO	
	C	11.75 L HI	
	D	.1422639224 QFRA	
	E	3.9055384 18 QTOT	
	2nd *A'	1.5813015 17 Q (L)	
	2nd *B'	3.9268796-02 Q 1	
	2nd *C'	1.8153272-01 Q 2	
	2nd *D'	1.4226392-01 QFRA	
		5.5561721 17 QTOT	
		3.4007527 07 Q ΔL	
	2nd *E'	1.2439661 01 LMAX	
Modes: (n)*--Printed only (n)--Displayed Briefly ( Pause ) n*--Printed and displayed			

# PPX-59 Professional Program Exchange

For TI use only

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
000	76	LBL		054	43	RCL		107	43	RCL	
001	11	A		055	03	03		108	18	18	
002	03	3		056	69	DP		109	69	DP	
003	07	7		057	06	06		110	06	06	
004	08	8		058	92	RTN		111	92	RTN	
005	00	0		059	42	STD		112	43	RCL	
006	01	1		060	03	03		113	02	02	
007	04	4		061	61	GTO		114	71	SBR	
008	01	1		062	13	C		115	89	#	
009	04	4		063	76	LBL		116	76	LBL	
010	69	DP		064	18	C'		117	77	GE	
011	04	04		065	03	3		118	71	SBR	
012	43	RCL		066	04	4		119	88	DMS	
013	01	01		067	08	8		120	97	DSZ	
014	69	DP		068	00	0		121	00	00	
015	06	06		069	00	0		122	77	GE	
016	92	RTN		070	03	3		123	42	STD	
017	42	STD		071	00	0		124	18	18	
018	01	01		072	00	0		125	61	GTO	
019	61	GTO		073	69	DP		126	17	B'	
020	11	A		074	04	04		127	76	LBL	
021	76	LBL		075	43	RCL		128	88	DMS	
022	12	B		076	19	19		129	01	1	
023	02	2		077	69	DP		130	04	4	
024	07	7		078	06	06		131	03	3	
025	08	8		079	92	RTN		132	08	8	
026	00	0		080	43	RCL		133	08	8	
027	02	2		081	03	03		134	55	+	
028	07	7		082	71	SBR		135	43	RCL	
029	03	3		083	89	#		136	07	07	
030	02	2		084	76	LBL		137	55	+	
031	69	DP		085	87	IFF		138	43	RCL	
032	04	04		086	71	SBR		139	01	01	
033	43	RCL		087	88	DMS		140	65	*	
034	02	02		088	97	DSZ		141	43	RCL	
035	69	DP		089	00	00		142	00	00	
036	06	06		090	87	IFF		143	54	)	
037	92	RTN		091	42	STD		144	42	STD	
038	42	STD		092	19	19		145	05	05	
039	02	02		093	61	GTO		146	53	(	
040	61	GTO		094	18	C'		147	43	RCL	
041	12	B		095	76	LBL		148	05	05	
042	76	LBL		096	17	B'		149	94	+/-	
043	13	C		097	03	3		150	22	INV	
044	02	2		098	04	4		151	23	LNK	
045	07	7		099	08	8		152	65	*	
046	08	8		100	00	0		153	53	(	
047	00	0		101	00	0		154	43	RCL	
048	02	2		102	02	2		155	05	05	
049	03	3		103	00	0		156	65	*	
050	02	2		104	00	0		157	53	(	
051	04	4		105	69	DP		158	43	RCL	
052	69	DP		106	04	04		159	05	05	
053	04	04									

83 GTO Ind  
 73 RCL Ind  
 84 DP Ind  
 74 SUM Ind  
 92 INV SBR

# PPX-59 Professional Program Exchange

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
160	85	+		213	69	DP		266	69	DP	
161	02	2		214	06	06		267	06	06	
162	54	)		215	92	RTN		268	42	STD	
163	85	+		216	76	LBL		269	21	21	
164	02	2		217	19	D*		270	92	RTN	
165	54	)		218	14	D		271	76	LBL	
166	55	÷		219	65	x		272	16	R*	
167	43	RCL		220	53	(		273	03	3	
168	00	00		221	15	E		274	04	4	
169	45	YX		222	54	)		275	05	5	
170	03	3		223	95	=		276	05	5	
171	65	x		224	42	STD		277	02	2	
172	93	.		225	22	22		278	07	7	
173	04	4		226	03	3		279	05	5	
174	01	1		227	04	4		280	06	6	
175	06	6		228	00	0		281	69	DP	
176	54	)		229	00	0		282	04	04	
177	44	SUM		230	07	7		283	43	RCL	
178	06	06		231	05	5		284	05	05	
179	43	RCL		232	02	2		285	22	INV	
180	06	06		233	07	7		286	23	LNK	
181	92	RTN		234	69	DP		287	75	-	
182	76	LBL		235	04	04		288	01	1	
183	89	#		236	43	RCL		289	95	=	
184	42	STD		237	22	22		290	35	1/X	
185	07	07		238	69	DP		291	65	x	
186	03	3		239	06	06		292	01	1	
187	42	STD		240	92	RTN		293	08	8	
188	00	00		241	76	LBL		294	08	8	
189	00	0		242	15	E		295	03	3	
190	42	STD		243	03	3		296	05	5	
191	06	06		244	04	4		297	05	5	
192	92	RTN		245	03	3		298	52	EE	
193	76	LBL		246	07	7		299	01	1	
194	14	D		247	03	3		300	08	8	
195	03	3		248	02	2		301	55	÷	
196	04	4		249	03	3		302	43	RCL	
197	02	2		250	07	7		303	03	03	
198	01	1		251	69	DP		304	45	YX	
199	03	3		252	04	04		305	04	4	
200	05	5		253	01	1		306	95	=	
201	01	1		254	05	5		307	69	DP	
202	03	3		255	02	2		308	06	06	
203	69	DP		256	01	1		309	92	RTN	
204	04	04		257	03	3		310	76	LBL	
205	43	RCL		258	52	EE		311	10	E*	
206	19	19		259	07	7		312	02	2	
207	75	-		260	65	x		313	07	7	
208	43	RCL		261	43	RCL		314	03	3	
209	18	18		262	01	01		315	00	0	
210	54	)		263	45	YX		316	01	1	
211	42	STD		264	03	3		317	03	3	
212	20	20		265	54	)		318	04	4	

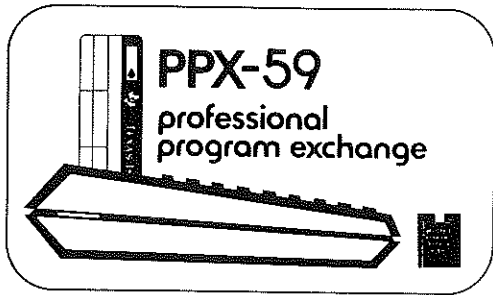
CODES  
 83 GTO Ind  
 84 Op Ind  
 92 INV SBR  
 64 POC Ind  
 74 SUM Ind

# PPX-59 Professional Program Exchange

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
319	04	4									
320	69	OP									
321	04	04									
322	03	3									
323	06	6									
324	06	6									
325	09	9									
326	93	.									
327	07	7									
328	55	÷									
329	43	RCL									
330	01	01									
331	95	=									
332	69	OP									
333	06	06									
334	92	RTN									

MERGED CODES

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



# TEXAS INSTRUMENTS Calculator Products Division

## Submission Abstract

Program Title <u>SPECTRAL RESPONSIVITY (RA)</u>	Rev. _____
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**Abstract of Program**

This program will calculate the spectral responsivity expected for a well-behaved photoconductor or photoresistor from the parameters of detector length in mils, detector width in mils, cutoff wavelength in microns, total quantum efficiency as a decimal fraction, carrier lifetime in seconds, bias current in milliamperes, detector resistance in Ohms, detector thickness in microns, excess donor or acceptor concentration in  $cm^{-3}$  according to the equation.

$$Ra = \frac{IR \eta \lambda^2}{lwt(N_D - N_A)}$$

**User Benefits:**

This program helps establish design parameters for a desired responsivity by varying detector parameters or will estimate the responsivity from a set of photoconductor parameters.

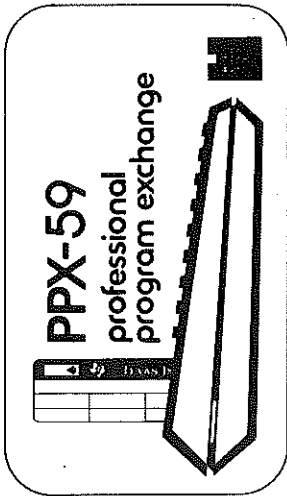
Category Number <u>74</u>	Required Progs. _____	Prog. Steps <u>288</u>	PC-100A Needed <input type="checkbox"/> Library Module ID _____ <input type="checkbox"/>
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# User Instructions

**Program Title** SPECTRAL RESPONSIVITY (R λ)

I	R	λ	N <sub>D</sub> -NA	R λ
l	W	λ	λ	τ

Partition (OP 17) Parenthesis Levels  t Register   
 479.59\*  
 Angular Mode SBR Levels  Absolute Addresses   
 (if applicable)  
 Library Module ID \* for TI-58 Operations   
 319.19

**LABELS (Op 08)**

INV	INZ	CE	CLR	Z=1	Z=2
CF	1/2	STO	RCL	SUM	Y*
EE	(	)	→	GTO	X
SBR	-	RST	+	R/S	·
+/-	=	CLR	INV	DP	EP
DB	DB*	DB*	SBR	DB*	DB*
EC	PD	IT	LOG	INT	INT*
DE	PAUSE	Z=1	NOP	OP	RAD
LD	Z=2	Z=*	Z	ORAD	STO*
TR	DMS	TR	TR	TR	TR*
TR*	TR*	TR*	TR*	TR*	TR*

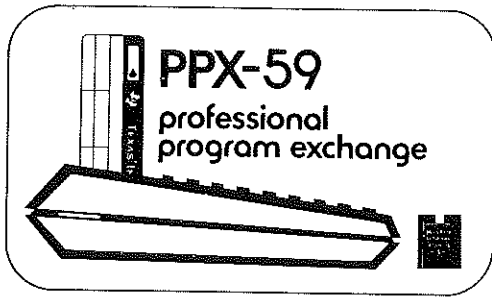
**USER DEFINED KEYS**

A	Length (mils)
B	Width (mils)
C	λ (microns)
D	λ (fraction)
E	τ (sec)
A'	I (milliamps)
B'	R (Ohms)
C'	λ (microns)
D'	N <sub>D</sub> -NA
E'	R λ

FLAGS	0	1	2	3	4	5	6	7	8	9
-------	---	---	---	---	---	---	---	---	---	---

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)	DATA REGISTERS (INV)
1	Enter program 1 & 2				0
2	Display Detector Length To update	new l	A R/S	Length (mils)* (new Length (mils))*	1 l
3	Display Detector Width To update	new w	B R/S	Width (mils)* (new Width (mils))* Width (cm)*	2 w
4	Display cutoff wavelength To update	new λ <sub>p</sub>	C R/S	λ <sub>p</sub> (microns)* new λ <sub>p</sub> (microns)*	3 λ
5	Display quantum efficiency To update	new λ	D R/S	(fraction)* new λ (fraction)*	4 λ
6	Display carrier lifetime To update	new τ	E R/S	(sec)* new τ (sec)*	5 τ
7	Display bias current To update	new I (milliamps)	*A' R/S	I (amps)* new I (amps)*	6 I
8	Display Detector Resistance To update	new R	*B' R/S	R (ohms)* New R (ohms)*	7 R

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



# TEXAS INSTRUMENTS Calculator Products Division

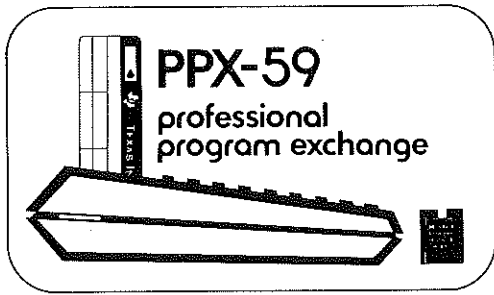
Continued From:  Program Description  User Instructions  Stmt. of Example

Program Title:	SPECTRAL RESPONSIVITY (R λ)	Rev.
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Step	Procedure	Enter	Press	Output/Mode
9	Display Detector Thickness To update	new	2nd *C' R/S	Thickness (microns)* new (microns)*
10	Display $N_A - N_D$ To update	New $N_D - N_A$	2nd *D' R/S	$N_D - N_A$ (cm <sup>-3</sup> )* new $N_D - N_A$ (cm <sup>-3</sup> )*
11	To calculate Spectral Responsivity		2nd *E'	Spectral Responsivity*

Note: \* - printed and displayed

( )\* - printed only.



TEXAS INSTRUMENTS  
Calculator Products Division

Sample Problem

Statement of Example

Determine the spectral responsivity of a detector of length of 2.7 mils, width of 3.4 mils, peak wavelength of 11 microns, N of .6,  $\tau$  of  $3 \times 10^{-7}$  sec., bias current of 10 milliamperes, resistance of 30 ohms, thickness of 10 microns, and  $N_D - N_A$  of  $1 \times 10^{15}$  #/cm.

See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
2.7	A	0. LGTH	
	R/S	2.7 LGTH	Length (mils)
		0.006858 LGTH	Length (cm)
3.4		0. WDTH	
	R/S	3.4 WDTH	Width (mils)
		0.008636 WDTH	Width (cm)
11		0. W-L	
	R/S	11. W-L	(microns)
.6		0. Q E	
	R/S	0.6 Q E	N (Fraction)
3 -07		0. T	
	R/S	3. -07 T	Carrier Lifetime
10		0. I	
	R/S	1. -02 I	Bias Current
30		0. R	
	R/S	30. R	Detector Resistance
10		0. THCK	
	R/S	10. THCK	Thickness (microns)
1 15		0. CONC	
	R/S	1. 15 CONC	$N_D - N_A$
	E'	5.0147159 04 RESP	Spectral Responsivity

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

Over



# PPX-59 Professional Program Exchange

For TI use only

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
000	76	LBL		052	92	RTN		104	69	DP	
001	11	A		053	42	STO		105	04	04	
002	25	CLR		054	02	02		106	43	RCL	
003	02	2		055	69	DP		107	04	04	
004	07	7		056	06	06		108	69	DP	
005	02	2		057	65	*		109	06	06	
006	02	2		058	93	.		110	92	RTN	
007	03	3		059	00	0		111	42	STO	
008	07	7		060	00	0		112	04	04	
009	02	2		061	02	2		113	69	DP	
010	03	3		062	05	5		114	06	06	
011	69	DP		063	04	4		115	98	ADV	
012	04	04		064	54	)		116	76	LBL	
013	43	RCL		065	42	STO		117	15	E	
014	01	01		066	12	12		118	25	CLR	
015	69	DP		067	69	DP		119	03	3	
016	06	06		068	06	06		120	07	7	
017	92	RTN		069	98	ADV		121	00	0	
018	42	STO		070	76	LBL		122	00	0	
019	01	01		071	13	C		123	00	0	
020	69	DP		072	25	CLR		124	00	0	
021	06	06		073	04	4		125	00	0	
022	65	*		074	03	3		126	00	0	
023	93	.		075	02	2		127	93	.	
024	00	0		076	00	0		128	69	DP	
025	00	0		077	02	2		129	04	04	
026	02	2		078	07	7		130	43	RCL	
027	05	5		079	00	0		131	05	05	
028	04	4		080	00	0		132	69	DP	
029	54	)		081	69	DP		133	06	06	
030	42	STO		082	04	04		134	92	RTN	
031	11	11		083	43	RCL		135	42	STO	
032	69	DP		084	03	03		136	05	05	
033	06	06		085	69	DP		137	69	DP	
034	98	ADV		086	06	06		138	06	06	
035	76	LBL		087	92	RTN		139	98	ADV	
036	12	B		088	42	STO		140	76	LBL	
037	25	CLR		089	03	03		141	16	A*	
038	04	4		090	69	DP		142	25	CLR	
039	03	3		091	06	06		143	02	2	
040	01	1		092	98	ADV		144	04	4	
041	06	6		093	76	LBL		145	00	0	
042	03	3		094	14	D		146	00	0	
043	07	7		095	25	CLR		147	00	0	
044	02	2		096	03	3		148	00	0	
045	03	3		097	04	4		149	00	0	
046	69	DP		098	00	0		150	00	0	
047	04	04		099	00	0		151	69	DP	
048	43	RCL		100	01	1		152	04	04	
049	02	02		101	07	7		153	43	RCL	
050	69	DP		102	00	0		154	06	06	
051	06	06		103	00	0		155	69	DP	

CODES

83 GTO Ind  
 84 Op Ind  
 92 INV SBR  
 64 Prd Ind  
 74 SUM Ind  
 06 Ind  
 06 Ind

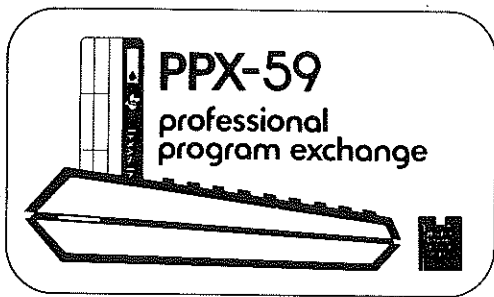
# PPX-59 Professional Program Exchange

For TI use only

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
157	92	RTN		209	92	RTN		262	65	*	
158	65	*		210	42	STO		263	43	RCL	
159	01	1		211	08	08		264	05	05	
160	52	EE		212	69	DP		265	55	+	
161	03	3		213	06	06		266	43	RCL	
162	94	+/-		214	98	ADV		267	11	11	
163	95	=		215	76	LBL		268	55	+	
164	42	STO		216	19	D*		269	43	RCL	
165	06	06		217	25	CLR		270	12	12	
166	69	DP		218	01	1		271	55	+	
167	06	06		219	05	5		272	43	RCL	
168	98	ADV		220	03	3		273	08	08	
169	76	LBL		221	02	2		274	55	+	
170	17	B*		222	03	3		275	43	RCL	
171	25	CLR		223	01	1		276	09	09	
172	03	3		224	01	1		277	55	+	
173	05	5		225	05	5		278	02	2	
174	00	0		226	69	DP		279	52	EE	
175	00	0		227	04	04		280	02	2	
176	00	0		228	43	RCL		281	03	3	
177	00	0		229	09	09		282	94	+/-	
178	00	0		230	69	DP		283	95	=	
179	00	0		231	06	06		284	69	DP	
180	69	DP		232	92	RTN		285	06	06	
181	04	04		233	42	STO		286	98	ADV	
182	43	RCL		234	09	09		287	92	RTN	
183	07	07		235	69	DP					
184	69	DP		236	06	06					
185	06	06		237	98	ADV					
186	92	RTN		238	92	RTN					
187	42	STO		239	76	LBL					
188	07	07		240	10	E*					
189	69	DP		241	03	3					
190	06	06		242	05	5					
191	98	ADV		243	01	1					
192	76	LBL		244	07	7					
193	18	C*		245	03	3					
194	25	CLR		246	06	6					
195	03	3		247	03	3					
196	07	7		248	03	3					
197	02	2		249	69	DP					
198	03	3		250	04	04					
199	01	1		251	43	RCL					
200	05	5		252	06	06					
201	02	2		253	65	*					
202	06	6		254	43	RCL					
203	69	DP		255	07	07					
204	04	04		256	65	*					
205	43	RCL		257	43	RCL					
206	08	08		258	03	03					
207	69	DP		259	65	*					
208	06	06		260	43	RCL					
				261	04	04					

MERGED CODES

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



# TEXAS INSTRUMENTS Calculator Products Division

## Submission Abstract

Program Title <b>BLACKBODY ENERGY RADIANCE</b>	Rev.
---	------

Abstract of Program

Computes total energy radiance, in-band energy radiance, and spectral energy radiance of a blackbody radiator at input temperature and wave-length band movements.

User Benefits:

Time Savings

Category Name <u>Optics</u>	Required Progs. _____	Prog. Steps <u>314</u>	Card Sides <u>2</u>	PC-100A Needed <input type="checkbox"/>
				Library Module ID <input type="checkbox"/>

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Signature \_\_\_\_\_ Date \_\_\_\_\_

Name Texas Instruments Tel. No. \_\_\_\_\_

Address \_\_\_\_\_

City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

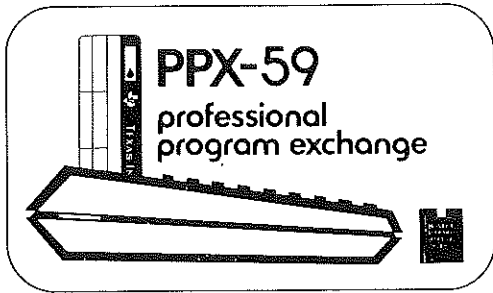
**Submission Checklist**

- Recorded Magnetic Cards
- Submission Abstract
- Program Description
- User Instructions
- Sample Problem
- Listing
- \_\_\_\_\_
- \_\_\_\_\_

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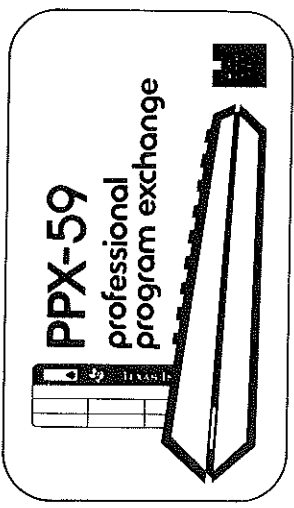
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# TEXAS INSTRUMENTS Calculator Products Division

## Program Description

<b>Program Title:</b> BLACKBODY ENERGY RADIANCE	<b>Rev.</b>
<p><b>Method, Equations, Sketches, Limitations, References, Error Recovery:</b></p> <p>Planck radiation law is used as a basis for this program. This spectral energy radiance, <math>H_\lambda</math>, is given by:</p> $H_\lambda = \frac{c_1 \lambda^{-5}}{e^{c_2/(\lambda T)} - 1} \quad \text{wattcm}^{-2} \text{ cm} \Delta\lambda^{-1}$ <p>where <math>c_1 = 2\pi^5 hc^2 = 3.7403 \times 10^{-2} \text{ watt cm}^2</math>  <math>c_2 = \frac{hc}{k} = 1.43848 \text{ cm deg (A)}</math></p> <p>(h = Planck constant, c = speed of light, x = wavelengths, k = Boltzmann's constant, T = Temperature.)</p> <p>The total energy radiance, <math>H_{\text{Total}}</math>, is given by:</p> $H_{\text{Total}} = \frac{c_1}{c_2^4} \cdot \frac{\pi^4}{15} \cdot T^4 = 5.67283 \times 10^{-12} T^4 \text{ watt cm}^{-2}$ <p>The in-band energy radiance is computed by:</p> $H_{\Delta\lambda} = \frac{c_1}{c_2^4} T^4 \left( \sum_{n=1}^{\infty} \frac{1}{n^4} [ (nx)^3 + 3(nx)^2 + 6nx + 6 ] e^{-nx} \right) \Bigg _{x_1}^{x_2}$ $\frac{H_{0-\lambda}}{H} = \frac{15}{\pi^4} \sum_{n=1}^{\infty} \frac{1}{n^4} [ (nx)^3 + 3(nx)^2 + 6nx + 6 ] e^{-nx}$ <p>These formulas are accurate to at least 3 decimal places over the infrared spectrum.</p>	
<input type="checkbox"/> See Continuation Sheet	



# User Instructions

**Program Title** BLACKBODY ENERGY RADIANCE

H <sub>1</sub>	H <sub>2</sub>	H <sub>Δλ</sub>	H <sub>T</sub>
λ short	λ long	HFRA	H <sub>T</sub> Total

Partition (OP 17) Parenthesis Levels  
 479 59\*  t Register

Angular Mode SBR Levels  
 (if applicable)  Absolute Addresses

Library Module ID \* for TI-58  
 319.19  Disturbs Pending Operations

**LABELS (Op 08)**

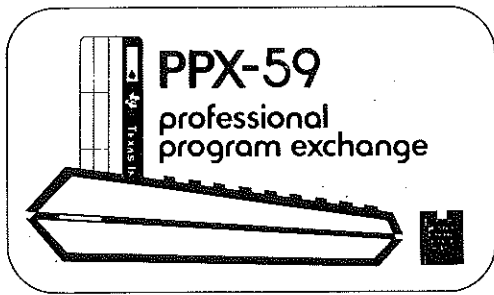
INV	IND	CE	CLR	Σ	Σ
√	V <sub>Σ</sub>	STO	RCL	SUM	7*
EE	LC	1	-	GTO	X
SBR	-	RST	+	R/S	0
4/-	≡	CLR	INV	log	OP
int	Prm	P=1	Σ	Σ	DM
Loc	Prd	Σ	Σ	Σ	Σ
log	Prps	Σ	Σ	Σ	Σ
10	Σ	Σ	Σ	Σ	Σ
10E	Σ	Σ	Σ	Σ	Σ
10E	Σ	Σ	Σ	Σ	Σ
10E	Σ	Σ	Σ	Σ	Σ

**USER DEFINED KEYS**

A	Temperature (°K)
B	λ short (μm)
C	λ long (μm)
D	H <sub>Δλ</sub> /H <sub>T</sub>
E	H <sub>T</sub> Total
A'	H <sub>O</sub> -λ <sub>1</sub> /H <sub>T</sub>
B'	H <sub>O</sub> -λ <sub>2</sub> /H <sub>T</sub>
C'	H <sub>Δλ</sub>
D'	H <sub>Δλ</sub>
E'	H <sub>T</sub>

FLAGS	0	1	2	3	4	5	6	7	8	9
-------	---	---	---	---	---	---	---	---	---	---

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)	DATA REGISTERS (INV)
1	Enter Program 1 & 2	New T	A R/S	Temperature * (New Temp)*	0 *dsz
2	Display Blackbody Temp To update	New λ short	B R/S	λ short * (New λ short) *	1 T
3	Display λ short To update	New λ long	C R/S	λ long * (New λ long) *	2 λ short
4	Display λ long To update		*B' 2nd	H <sub>1</sub> *	3 λ long
5	To compute H <sub>O</sub> -λ <sub>1</sub> /H <sub>T</sub>		*C' 2nd	H <sub>2</sub> *	4
6	To compute H <sub>O</sub> -λ <sub>2</sub> /H <sub>T</sub>		E	H <sub>T</sub> Total *	5 nX
7	To compute H <sub>T</sub> Total		D	H <sub>Δλ</sub> /H <sub>T</sub>	6 Σ
8	To compute H <sub>Δλ</sub> /H <sub>T</sub>		*D' 2nd	H <sub>Δλ</sub> *	7 λ Transfer
9	To compute H <sub>Δλ</sub>		*E' 2nd	H <sub>T</sub>	8
10	To Compute H <sub>T</sub>			H <sub>T</sub>	9
	Note: * - Printed and displayed ( ) * - Printed only				0
					18 H <sub>1</sub>
					19 H <sub>2</sub>



TEXAS INSTRUMENTS  
Calculator Products Division

Sample Problem

Statement of Example

Find  $H_{O-\lambda_1} / H_T$ ,  $H_{O-\lambda_2} / H_T$ ,  $H_{\Delta\lambda} / H_T$ ,  $H_{\Delta\lambda}$ ,  $H_{Total}$ , and  $H_{\lambda}$   
for a blackbody at 500°K between 7.65 microns and 11.75 microns.

See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)		COMMENT
500	A R/S	0. (500	TEMP TEMP)	
7.65	R/S	0. (7.65	L LO L LO)	
11.75	R/S	0. 11.75	L HI L HI	
	2nd *B'	.4482033943	H 1	
	2nd *C'	.7269106746	H 2	
	E	3.5455187-01	HTOT	
	D	2.7870728-01	HFRA	
	2nd *D'	9.8816189-02	H L	

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

Over

# PPX-59 Professional Program Exchange

For TI use only

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
000	76	LBL		050	02	2		100	00	0	
001	11	A		051	03	3		101	00	0	
002	03	3		052	02	2		102	00	0	
003	07	7		053	04	4		103	02	2	
004	01	1		054	69	DP		104	00	0	
005	07	7		055	04	04		105	00	0	
006	03	3		056	43	RCL		106	69	DP	
007	00	0		057	03	03		107	04	04	
008	03	3		058	69	DP		108	43	RCL	
009	03	3		059	06	06		109	02	02	
010	69	DP		060	92	RTN		110	71	SBR	
011	04	04		061	42	STO		111	89	π	
012	43	RCL		062	03	03		112	76	LBL	
013	01	01		063	69	DP		113	77	GE	
014	69	DP		064	06	06		114	71	SBR	
015	06	06		065	98	ADV		115	88	DMS	
016	92	RTN		066	92	RTN		116	97	DSZ	
017	42	STO		067	76	LBL		117	00	00	
018	01	01		068	18	C*		118	77	GE	
019	69	DP		069	02	2		119	42	STO	
020	06	06		070	03	3		120	18	18	
021	98	ADV		071	00	0		121	69	DP	
022	76	LBL		072	00	0		122	06	06	
023	12	B		073	00	0		123	98	ADV	
024	02	2		074	03	3		124	92	RTN	
025	07	7		075	00	0		125	76	LBL	
026	00	0		076	00	0		126	88	DMS	
027	00	0		077	69	DP		127	53	(	
028	02	2		078	04	04		128	01	1	
029	07	7		079	43	RCL		129	04	4	
030	03	3		080	03	03		130	03	3	
031	02	2		081	71	SBR		131	08	8	
032	69	DP		082	89	π		132	08	8	
033	04	04		083	76	LBL		133	55	÷	
034	43	RCL		084	87	IFF		134	43	RCL	
035	02	02		085	71	SBR		135	07	07	
036	69	DP		086	88	DMS		136	55	÷	
037	06	06		087	97	DSZ		137	43	RCL	
038	92	RTN		088	00	00		138	01	01	
039	42	STO		089	87	IFF		139	65	×	
040	02	02		090	42	STO		140	43	RCL	
041	69	DP		091	19	19		141	00	00	
042	06	06		092	69	DP		142	54	)	
043	98	ADV		093	06	06		143	42	STO	
044	76	LBL		094	98	ADV		144	05	05	
045	13	C		095	92	RTN		145	53	(	
046	02	2		096	76	LBL		146	43	RCL	
047	07	7		097	17	B*		147	05	05	
048	00	0		098	02	2		148	45	YX	
049	00	0		099	03	3		149	03	3	

MERGED CODES

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

# PPX-59 Professional Program Exchange

For TI use only

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
150	85	+	next →	200	03	3		250	02	2	
151	03	3		201	02	2		251	03	3	
152	65	x		202	01	1		252	07	7	
153	43	RCL		203	03	3		253	69	OP	
154	05	05		204	05	5		254	04	04	
155	33	X²		205	01	1		255	05	5	
156	85	+		206	03	3		256	93	.	
157	06	6		207	69	OP		257	06	6	
158	65	x		208	04	04		258	07	7	
159	43	RCL		209	43	RCL		259	02	2	
160	05	05		210	19	19		260	08	8	
161	85	+		211	75	-		261	03	3	
162	06	6		212	43	RCL		262	52	EE	
163	54	)		213	18	18		263	01	1	
164	65	x		214	95	=		264	02	2	
165	43	RCL		215	42	STO		265	94	+/-	
166	05	05		216	08	08		266	65	x	
167	94	+/-		217	69	OP		267	43	RCL	
168	22	INV		218	06	06		268	01	01	
169	23	LNx		219	98	ADV		269	45	Yx	
170	55	÷		220	92	RTN		270	04	4	
171	43	RCL		221	76	LBL		271	95	=	
172	00	00		222	19	D'		272	42	STO	
173	45	Yx		223	02	2		273	09	09	
174	04	4		224	03	3		274	69	OP	
175	65	x		225	00	0		275	06	06	
176	93	.		226	00	0		276	98	ADV	
177	01	1		227	07	7		277	92	RTN	
178	05	5		228	05	5		278	76	LBL	
179	04	4		229	02	2		279	10	E'	
180	54	)		230	07	7		280	02	2	
181	44	SUM		231	69	OP		281	03	3	
182	06	06		232	04	04		282	05	5	
183	43	RCL		233	43	RCL		283	05	5	
184	06	06		234	08	08		284	02	2	
185	92	RTN		235	65	x		285	07	7	
186	76	LBL		236	43	RCL		286	05	5	
187	89	π		237	09	09		287	06	6	
188	42	STO		238	95	=		288	69	OP	
189	07	07		239	69	OP		289	04	04	
190	03	3		240	06	06		290	43	RCL	
191	42	STO		241	98	ADV		291	05	05	
192	00	00		242	92	RTN		292	22	INV	
193	00	0		243	76	LBL		293	23	LNx	
194	42	STO		244	15	E		294	75	-	
195	06	06		245	02	2		295	01	1	
196	92	RTN		246	03	3		296	95	=	
197	76	LBL		247	03	3		297	35	1/X	
198	14	D		248	07	7		298	65	x	
199	02	2		249	03	3		299	03	3	

MERGED CODES

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



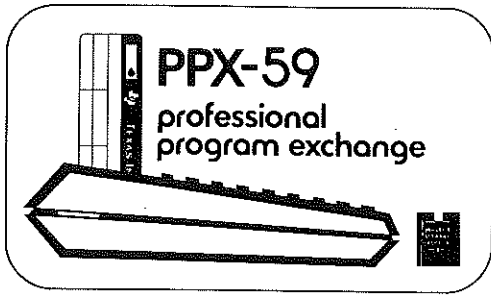
# PPX-59 Professional Program Exchange

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
300	07	7									
301	04	4									
302	00	0									
303	03	3									
304	55	÷									
305	43	RCL									
306	03	03									
307	45	YX									
308	05	5									
309	95	=									
310	69	DP									
311	06	06									
312	98	ADV									
313	92	RTN									

MERGED CODES

62	Per	Ind	72	STO	Ind	83	GTO	Ind
63	Cr	Ind	73	RCL	Ind	84	Op	Ind
64	Pr	Ind	74	SUM	Ind	92	INV	SBR





TEXAS INSTRUMENTS  
 Calculator Products Division

Submission Abstract

Program Title <b>DETECTIVITY (D*) AND RESPONSIVITY (R)</b>	Rev.
---	------

Abstract of Program

This program converts measured laboratory signals and noises from a standard reference blackbody test set to responsivity in volts/watt, detectivity in cm H <sup>1/2</sup>/watt, and Noise per Root Hertz.

*Doesn't work*

User Benefits:

Condensed calculation with increased accuracy

Category Name <u>Optics</u>	Required Progs. _____	Prog. Steps <u>298</u>	Card Sides <u>2</u>	PC-100A Needed <input type="checkbox"/>
				Library Module ID <input type="checkbox"/>

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Submission Checklist

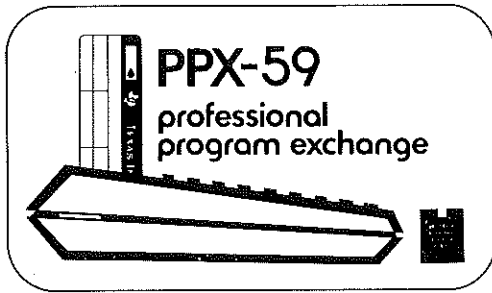
- Recorded Magnetic Cards
- Submission Abstract
- Program Description
- User Instructions
- Sample Problem
- Listing

Signature \_\_\_\_\_ Date \_\_\_\_\_  
 Name Texas Instruments Tel. No. \_\_\_\_\_  
 Address \_\_\_\_\_  
 City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

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TEXAS INSTRUMENTS  
 Calculator Products Division

**Program Description**

Program Title: <b>DETECTIVITY AND RESPONSIVITY</b>	Rev.
Method, Equations, Sketches, Limitations, References, Error Recovery:	
<p>The user supplied inputs include:</p> <ol style="list-style-type: none"> <li>1) detector width in thousandths of inches (in mils)</li> <li>2) detector length (in mils)</li> <li>3) signal flux density (in watts/cm<sup>2</sup>)</li> <li>4) amplifier gain (in volts/volt)</li> <li>5) amplifier or analyzer bandwidth (in Hertz)</li> <li>6) measured signal and noise values (in millivolts)</li> </ol> <p>Additional information calculated during the program and displayed on command includes:          square root of detector area (in cm) and detector noise per root Hz.</p> $\text{Responsivity} = \frac{V_s}{G} \cdot \frac{1}{J_{BB} \cdot \text{Area}}$ $\frac{v_n}{\sqrt{\Delta f}} = \frac{V_n}{G \sqrt{\Delta f}}$ $D^* = \frac{R \sqrt{\text{Area}}}{v_n}$	
<input type="checkbox"/> See Continuation Sheet	



# User Instructions

**Program Title**  
 Detectivity (D\*) & Responsivity (R)

GAIN	$\Delta f$	AREA	NOISE
L	W	J	SIGNAL
			D*

Partition (OP 17) Parenthesis Levels  
 479 59\*  t Register

Angular Mode SBR Levels  Absolute Addresses

Library Module ID \* for TI-58 319.19  Disturbs Pending Operations

**LABELS (Op 08)**

INV	INX	CE	CLR	Z-1	Z-2
VZ	VZ	STO	RCL	SUM	Z-2
EE	L	L	-	GTO	X
SBR	-	RST	+	R/S	*
+/-	=	CUR	INV	OP	OP
OP	OP	P-R	OP	OP	OP
OP	OP	Z-1	OP	OP	OP
OP	OP	Z-1	OP	OP	OP
OP	OP	Z-1	OP	OP	OP
OP	OP	Z-1	OP	OP	OP
OP	OP	Z-1	OP	OP	OP
OP	OP	Z-1	OP	OP	OP

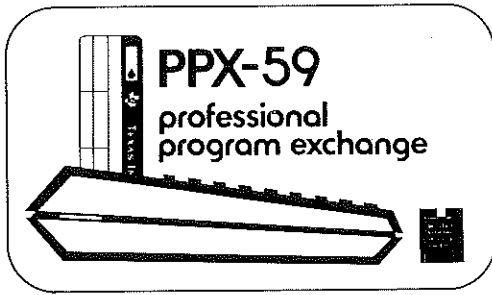
**USER DEFINED KEYS**

A	Length (mils)
B	Width (mils)
C	J (watts/cm <sup>2</sup> )
D	Sig (mV)
E	D*
A'	Gain
B'	Noise Bandwidth
C'	$\sqrt{\text{Area}}$
D'	Noise ( $\mu V$ )
E'	

FLAGS	0	1	2	3	4	5	6	7	8	9
-------	---	---	---	---	---	---	---	---	---	---

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)	DATA REGISTERS (INV)
1.	Enter Program 1 & 2				0
2.	Display Detector Length To update	New L	A R/S	Length (mils) * (New Length (mils) * (New Length (cm) *	1 Length (mils) 2 Width (mils) 3 J 4 Gain 5 $\Delta f$ 6 7 Signal 8 Noise 9 10 11 Length (cm) 12 Width (cm) 13 14 15 $\sqrt{\Delta f}$ 16 Area 17 18 Noise/Hz <sup>1/2</sup> 19 Area
3.	Display Detector Width To update	New W	B R/S	Width (mils) * (New Width (mils)) * (New Width (cm) *	
4.	Display Signal Flux Density To update	New J	C R/S	J * (New J) *	
5.	Display amplifier Gain To update	New Gain	*A' R/S	Gain * (New Gain) *	
6.	Display Amplifier Bandwidth To update	New Bwth	*B' R/S	Bandwidth * (New Bandwidth) *	
7.	Display Area		*C'	(Area) * $\sqrt{\text{Area}}$ *	

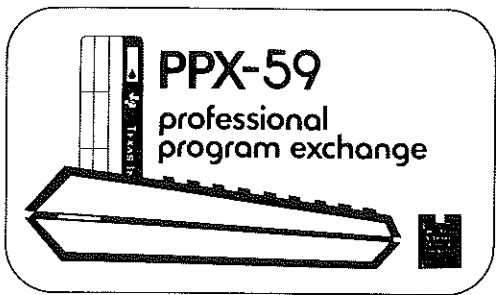
Modes: (n) \* —Printed only (n) —Displayed Briefly (Pause)  
 n\* —Printed and displayed



# TEXAS INSTRUMENTS Calculator Products Division

Continued From:  Program Description  User Instructions  Stmt. of Example

Program Title:				Rev.
DETECTIVITY (D*) AND RESPONSIVITY (R)				
8.	Display Signal To update	New Signal	$\frac{D}{R/S}$	Signal * (New Signal) * Responsivity *
9.	Display Noise	New Noise	$\frac{2^{nd} *D'}{R/S}$	Noise * (New Noise) * Noise/Hz <sup>1/2</sup> *
10.	To Compute Detectivity		E	Detectivity *
<p>Note: * – Printed and displayed ( ) * – Printed only</p>				



# TEXAS INSTRUMENTS Calculator Products Division

## Sample Problem

### Statement of Example

Find the Detectivity ( $D^*$ ) and Responsivity ( $R$ ) for a detector of length 2.0 mils, width 2.0 mils, and signal flux density of  $3.55542 \times 10^{-5}$ . The electronic gain is 5000, the noise bandwidth is  $3.8077 \times 10^4$ , signal of 600 mV, and a noise signal of 60 mV.

See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)		COMMENT
2.0	A R/S	0. (2.0 (.00508	LNTH LNTH) LNTH)	
2.0	R/S	0. (2.0 (.00508	WDTH WDTH) WDTH)	
3.55542-05	R/S	0. (3.55542-05	J J)	
5 04	R/S R/S	0.00 (5.04	GAIN GAIN)	
3.8077 04	R/S	0.00 (3.8077 04 1.9513329 02	BWTH BWTH)	
	R/S	(2.6709624-05 5.1681354-03	AREA)	
600	R/S R/S	0.00 (6.02 1.307865 04	SIG SIG) RESP	

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

Over

PPX-59 Professional Program  
 Exchange  
 Sample Problem (cont'd)

ENTER	PRESS	OUTPUT/MODE (see legend below)		COMMENT
60	R/S	0.00	NOIS	
	R/S	6.01	NOIS	
		6.1496427-09	N/HZ	
	E	1.0803805	D*	

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



# PPX-59 Professional Program Exchange

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
000	76	LBL		050	92	RTN		100	69	DP	
001	11	A		051	42	STO		101	04	04	
002	02	2		052	02	02		102	43	RCL	
003	07	7		053	69	DP		103	04	04	
004	03	3		054	06	06		104	69	DP	
005	09	9		055	65	X		105	06	06	
006	03	3		056	93	.		106	92	RTN	
007	07	7		057	00	0		107	42	STO	
008	02	2		058	00	0		108	04	04	
009	03	3		059	02	2		109	69	DP	
010	69	DP		060	05	5		110	06	06	
011	04	04		061	04	4		111	98	ADV	
012	43	RCL		062	95	=		112	76	LBL	
013	01	01		063	42	STO		113	17	B'	
014	69	DP		064	12	12		114	01	1	
015	06	06		065	69	DP		115	04	4	
016	92	RTN		066	06	06		116	04	4	
017	42	STO		067	98	ADV		117	03	3	
018	01	01		068	76	LBL		118	03	3	
019	69	DP		069	13	C		119	07	7	
020	06	06		070	02	2		120	02	2	
021	65	X		071	05	5		121	03	3	
022	93	.		072	00	0		122	69	DP	
023	00	0		073	00	0		123	04	04	
024	00	0		074	00	0		124	43	RCL	
025	02	2		075	00	0		125	05	05	
026	05	5		076	00	0		126	69	DP	
027	04	4		077	00	0		127	06	06	
028	95	=		078	69	DP		128	92	RTN	
029	42	STO		079	04	04		129	42	STO	
030	11	11		080	43	RCL		130	05	05	
031	69	DP		081	03	03		131	69	DP	
032	06	06		082	69	DP		132	06	06	
033	98	ADV		083	06	06		133	34	FX	
034	76	LBL		084	92	RTN		134	42	STO	
035	12	B		085	42	STO		135	15	15	
036	04	4		086	03	03		136	99	PRT	
037	03	3		087	69	DP		137	98	ADV	
038	01	1		088	06	06		138	92	RTN	
039	06	6		089	98	ADV		139	76	LBL	
040	03	3		090	76	LBL		140	18	C'	
041	07	7		091	16	A'		141	01	1	
042	02	2		092	02	2		142	03	3	
043	03	3		093	02	2		143	03	3	
044	69	DP		094	01	1		144	05	5	
045	04	04		095	03	3		145	01	1	
046	43	RCL		096	02	2		146	07	7	
047	02	02		097	04	4		147	01	1	
048	69	DP		098	03	3		148	03	3	
049	06	06		099	09	9		149	69	DP	

MERGED CODES

62	Pem	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

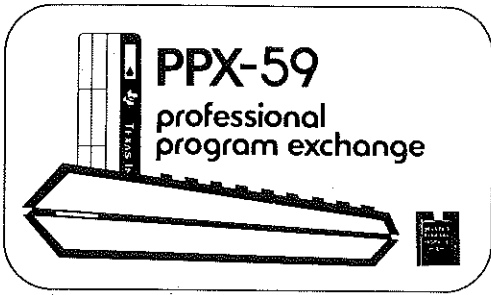
# PPX-59 Professional Program Exchange

For TI use only

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
150	04	04		200	43	RCL		250	15	15	
151	43	RCL		201	19	19		251	55	÷	
152	11	11		202	95	=		252	43	RCL	
153	65	*		203	42	STO		253	04	04	
154	43	RCL		204	17	17		254	95	=	
155	12	12		205	98	ADV		255	42	STO	
156	95	=		206	03	3		256	18	18	
157	42	STO		207	05	5		257	03	3	
158	19	19		208	01	1		258	01	1	
159	69	OP		209	07	7		259	06	6	
160	06	06		210	03	3		260	03	3	
161	34	FX		211	06	6		261	02	2	
162	42	STO		212	03	3		262	03	3	
163	16	16		213	03	3		263	04	4	
164	99	PRT		214	69	OP		264	06	6	
165	98	ADV		215	04	04		265	69	OP	
166	92	RTN		216	43	RCL		266	04	04	
167	76	LBL		217	17	17		267	43	RCL	
168	14	D		218	69	OP		268	18	18	
169	03	3		219	06	06		269	69	OP	
170	06	6		220	98	ADV		270	06	06	
171	02	2		221	92	RTN		271	98	ADV	
172	04	4		222	76	LBL		272	92	RTN	
173	02	2		223	19	D*		273	76	LBL	
174	02	2		224	03	3		274	15	E	
175	00	0		225	01	1		275	01	1	
176	00	0		226	03	3		276	06	6	
177	69	OP		227	02	2		277	05	5	
178	04	04		228	02	2		278	09	9	
179	43	RCL		229	04	4		279	00	0	
180	07	07		230	03	3		280	00	0	
181	69	OP		231	06	6		281	00	0	
182	06	06		232	69	OP		282	00	0	
183	92	RTN		233	04	04		283	69	OP	
184	42	STO		234	43	RCL		284	04	04	
185	07	07		235	08	08		285	43	RCL	
186	69	OP		236	69	OP		286	17	17	
187	06	06		237	06	06		287	65	*	
188	65	*		238	92	RTN		288	43	RCL	
189	01	1		239	42	STO		289	16	16	
190	52	EE		240	08	08		290	55	÷	
191	03	3		241	69	OP		291	43	RCL	
192	94	+/-		242	06	06		292	18	18	
193	55	÷		243	65	*		293	95	=	
194	43	RCL		244	01	1		294	69	OP	
195	04	04		245	52	EE		295	06	06	
196	55	÷		246	03	3		296	98	ADV	
197	43	RCL		247	94	+/-		297	92	RTN	
198	03	03		248	55	÷					
199	55	÷		249	43	RCL					

MERGED CODES

62	Per	Ind	72	STO	Ind	83	GTO	Ind
63	Trc	Ind	73	RCL	Ind	84	Op	Ind
64	Pro	Ind	74	SUM	Ind	92	INV	SBR



TEXAS INSTRUMENTS  
Calculator Products Division

Submission Abstract

Program Title BLACKBODY FLUX (SIGNAL)	Rev.
--	------

Abstract of Program

This program will calculate the total RMS modulated radiation from a reference blackbody used in standard test equipment.

User Benefits:

Replaces tabular data for various apertures at a fixed blackbody and ambient temperature for increased accuracy and flexibility (correct for uncontrolled ambient).

Category Name <u>Optics</u>	Required Progs. _____	Prog. Steps <u>215</u>	Card Sides <u>1</u>	PC-100A Needed <input type="checkbox"/>
				Library Module ID _____ <input type="checkbox"/>

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Submission Checklist

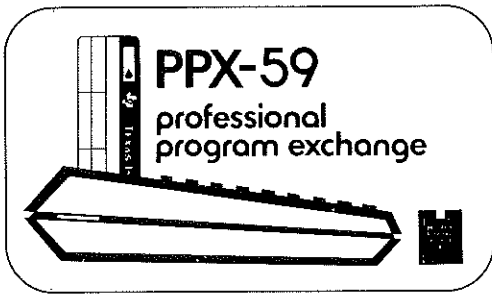
- Recorded Magnetic Cards
- Submission Abstract
- Program Description
- User Instructions
- Sample Problem
- Listing

Signature \_\_\_\_\_ Date \_\_\_\_\_  
 Name Texas Instruments Tel. No. \_\_\_\_\_  
 Address \_\_\_\_\_  
 City \_\_\_\_\_ State \_\_\_\_\_ Zip \_\_\_\_\_

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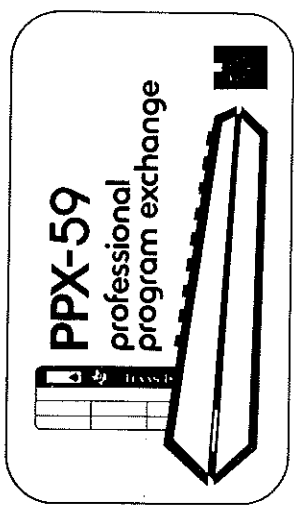
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TEXAS INSTRUMENTS  
Calculator Products Division

**Program Description**

Program Title: <p style="text-align: center;">BLACKBODY FLUX (SIGNAL)</p>	Rev.
<p>Method, Equations, Sketches, Limitations, References, Error Recovery:</p> <p>Parameters to be entered by the user are:</p> <ol style="list-style-type: none"> <li>1) Blackbody temperature in Kelvin</li> <li>2) Ambient temperature in Kelvin</li> <li>3) Reference blackbody source to detector distance in inches</li> <li>4) Blackbody aperture in square inches</li> <li>5) RMS factor (from Fourier integration of wave shape)</li> </ol> <p>Equations used by the program are:</p> $H = \sigma T^4$ $J \text{ Sig} = H_{\text{rms}} = \frac{(H_{\text{BB}} - H_{\text{AMB}}) (\text{Area})}{D^2} \times \text{RMS}$ $\sigma = 5.67283 \times 10^{-12}$	
<input type="checkbox"/> See Continuation Sheet	



# User Instructions

**Program Title** BLACKBODY FLUX (SIGNAL)

H <sub>BB</sub>	H <sub>AMB</sub>	RMS	
T <sub>BB</sub>	T <sub>AMB</sub>	DIST	AREA <sub>BB</sub> J SIG

Partition (OP 17) Parenthesis Levels  
 479 59\*  t Register

Angular Mode SBR Levels   
 (if applicable) Absolute Addresses

Library Module ID \* for TI-58 239.29   
 Disturbs Pending Operations

**LABELS (Op 08)**

INV	INT	CE	CLR	EXIT	X <sup>2</sup>
1/x	1/2	STD	RCL	SUM	Y <sup>x</sup>
EE	( )	+	GTO	X	
SBR	-	RST	+	R/S	•
+/-	=	CLR	INV	ENG	CP
2nd	7 <sup>th</sup>	P-R	3 <sup>rd</sup>	OS	CM <sub>1</sub>
1/x	Prd	1/x	Eng	1/x	Int
Eng	Pause	X=1	Ngp	Op	Rat
1/x	X=1	X+	X	Grad	ST <sub>1/2</sub>
1/x	DMS	π	1/x	White	Dis
1/x	Prd				

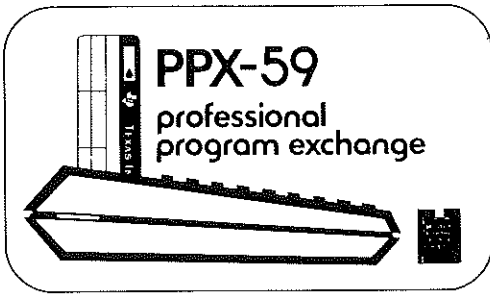
**USER DEFINED KEYS**

A	Temperature (BB)
B	Temperature (AMB)
C	Distance to BB
D	Area of BB
E	J Signal
A'	H <sub>BB</sub>
B'	H <sub>AMB</sub>
C'	RMS Factor
D'	
E'	

FLAGS	0	1	2	3	4	5	6	7	8	9
-------	---	---	---	---	---	---	---	---	---	---

STEP	PROCEDURE	ENTER	PRESS	OUTPUT/MODE (see legend below)	DATA REGISTERS (INV)
1.	Enter Program 1 & 2				0 J Signal
2.	Display Temperature Blackbody To update	New T <sub>BB</sub>	A R/S	Temperature BB * (NEW T <sub>BB</sub> ) *	1 T <sub>BB</sub>
3.	Display Temperature Ambient To update	New T <sub>AMB</sub>	B R/S	Temperature AMB * (NEW T <sub>AMB</sub> ) *	2 T <sub>AMB</sub>
4.	Display Distance Between Blackbody and Chopper To update	New Dist	C R/S	Distance * (New Distance) *	3 BB Distance
5.	Display Area of Detector to update	New Area	D R/S	Area * (New Area) *	4 Area BB
6.	Display RMS Factor To update	New RMS	*C' R/S	RMS Factor * (New RMS Factor) *	5 RMS Factor
7.	To H <sub>BB</sub>		*A' 2nd	H <sub>BB</sub> *	6 (H <sub>TOTAL</sub> ) BB
8.	To calculate H <sub>AMB</sub>		*B' 2nd	H <sub>AMB</sub> *	7 (H <sub>TOTAL</sub> ) AMB
9.	To calculate Blackbody Signal Flux		E	J Sig *	8

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



# TEXAS INSTRUMENTS Calculator Products Division

## Sample Problem

### Statement of Example

For a blackbody at  $500^{\circ}\text{K}$ , ambient temperature of  $295^{\circ}\text{K}$ , distance of 8 inches between detector and blackbody chopper, an RMS factor of .3535, and an area of  $6.553 \times 10^{-5}$  square inches, find the signal flux at the detector surface.

See Continuation Sheet

ENTER	PRESS	OUTPUT/MODE (see legend below)	COMMENT
500	A R/S	0. (500.	T BB T BB)*
295	R/S	0. (295.	T AB T AB)*
8	R/S	0. ( 8.	DIST DIST)*
6.553-02	R/S	0. (6.553-02	AREA AREA)*
.3535	R/S	0.00 3.535- 1	RMS RMS
	A'	3.5455187-01	H BB
	B'	4.2962331-02	H AB
	E	3.5899021-05	J SG

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

Over

# PPX-59 Professional Program Exchange

For TI use only

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
000	76	LBL		055	04	04		109	98	ADV	
001	11	R		056	43	RCL		110	92	RTN	
002	03	3		057	03	03		111	76	LBL	
003	07	7		058	69	DP		112	16	R'	
004	00	0		059	06	06		113	02	2	
005	00	0		060	92	RTN		114	03	3	
006	01	1		061	42	STO		115	00	0	
007	04	4		062	03	03		116	00	0	
008	01	1		063	69	DP		117	01	1	
009	04	4		064	06	06		118	04	4	
010	69	DP		065	98	ADV		119	01	1	
011	04	04		066	76	LBL		120	04	4	
012	43	RCL		067	14	D		121	69	DP	
013	01	01		068	01	1		122	04	04	
014	69	DP		069	03	3		123	43	RCL	
015	06	06		070	03	3		124	01	01	
016	92	RTN		071	05	5		125	45	YX	
017	42	STO		072	01	1		126	04	4	
018	01	01		073	07	7		127	65	X	
019	69	DP		074	01	1		128	05	5	
020	06	06		075	03	3		129	06	6	
021	98	ADV		076	69	DP		130	07	7	
022	76	LBL		077	04	04		131	02	2	
023	12	B		078	43	RCL		132	08	8	
024	03	3		079	04	04		133	03	3	
025	07	7		080	69	DP		134	52	EE	
026	00	0		081	06	06		135	01	1	
027	00	0		082	92	RTN		136	07	7	
028	01	1		083	42	STO		137	94	+/-	
029	03	3		084	04	04		138	54	)	
030	01	1		085	69	DP		139	42	STO	
031	04	4		086	06	06		140	11	11	
032	69	DP		087	98	ADV		141	69	DP	
033	04	04		088	76	LBL		142	06	06	
034	43	RCL		089	18	C'		143	98	ADV	
035	02	02		090	03	3		144	92	RTN	
036	69	DP		091	05	5		145	76	LBL	
037	06	06		092	02	2		146	17	B'	
038	92	RTN		093	08	8		147	02	2	
039	42	STO		094	03	3		148	03	3	
040	02	02		095	06	6		149	00	0	
041	69	DP		096	00	0		150	00	0	
042	06	06		097	00	0		151	01	1	
043	98	ADV		098	69	DP		152	03	3	
044	76	LBL		099	04	04		153	01	1	
045	13	C		100	43	RCL		154	04	4	
046	01	1		101	06	06		155	69	DP	
047	06	6		102	69	DP		156	04	04	
048	02	2		103	06	06		157	43	RCL	
049	04	4		104	92	RTN		158	02	02	
050	03	3		105	42	STO		159	45	YX	
051	06	6		106	06	06					
052	03	3		107	69	DP					
053	07	7		108	06	06					
054	69	DP									

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

# PPX-59 Professional Program Exchange

For TI use only

LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS	LOC	CODE	KEY	COMMENTS
160	04	4									
161	65	X									
162	05	5									
163	06	6									
164	07	7									
165	02	2									
166	08	8									
167	03	3									
168	52	EE									
169	01	1									
170	07	7									
171	94	+/-									
172	54	)									
173	42	STD									
174	12	12									
175	69	OP									
176	06	06									
177	98	ADV									
178	92	RTN									
179	76	LBL									
180	15	E									
181	02	2									
182	05	5									
183	00	0									
184	00	0									
185	03	3									
186	06	6									
187	02	2									
188	02	2									
189	69	OP									
190	04	04									
191	43	RCL									
192	11	11									
193	75	-									
194	43	RCL									
195	12	12									
196	54	)									
197	65	X									
198	43	RCL									
199	04	04									
200	65	X									
201	43	RCL									
202	06	06									
203	55	÷									
204	43	RCL									
205	03	03									
206	33	X <sup>2</sup>									
207	55	÷									
208	89	π									
209	52	EE									
210	95	=									
211	42	STD									
212	00	00									
213	69	OP									
214	06	06									
215	98	ADV									
216	92	RTN									

MERGED CODES

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





# BLACKBODY

- **BLACKBODY PHOTON RADIANCE**  
Computes wavelength of maximum photon radiance, total photon radiance, in-band photon radiance, and special photon radiance of blackbody radiator at input temperature and wavelength band limits.  
**TI-59 only.**
- **SPECTRAL RESPONSIVITY (R $\lambda$ )**  
Calculates the spectral responsivity expected for a well-behaved photoconductor or photoresistor from the parameters of detector length, detector width, cutoff wavelength, total quantum efficiency, carrier lifetime, bias current, detector resistance, detector thickness and excess donor acceptor concentration.  
**TI-58 or TI-59.**
- **BLACKBODY ENERGY RADIANCE**  
Total energy radiance, in-band radiance, and spectral energy radiance of a blackbody radiator at input temperature and wavelength band movements is computed.  
**TI-58 or TI-59.**
- **DETECIVITY (D\*) AND RESPONSIVITY (R)**  
Converts measured laboratory signals and noises from a standard reference blackbody test set to responsivity in volts/watt, and Noise per Root Hertz.  
**TI-58 or TI-59.**
- **BLACKBODY FLUX (SIGNAL)**  
Calculates the total RMS modulated radiation from a reference blackbody used in standard test equipment.  
**TI-58 or TI-59.**

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

**TEXAS INSTRUMENTS**  
INCORPORATED