

# The Cyc

*Articles by  
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Version 20090921TH

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**TEXAS INSTRUMENTS**  
**HOME COMPUTER**

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## 1. Using RANDOMIZE with seeds

**by Jacques Groslouis**

*September 20, 2009*

The purpose of this document is to describe an observed difference in using the RANDOMIZE function plus seed with TI Basic and with TI Extended Basic.

The TI Extended Basic manual<sup>1</sup> (page 151) describes the RANDOMIZE function as follows:

“The RANDOMIZE statement resets the random number generator to an unpredictable sequence. If RANDOMIZE is followed by a *numeric-expression*, the same sequence of random numbers is produced each time the statement is executed with that value for the expression. Different values give different sequences.”

The TI-99/4A *User’s Reference Guide*<sup>2</sup> (page II-95) describes the RANDOMIZE function in a bit more detail as follows:

“The RANDOMIZE statement is used in conjunction with the random number function (RND). When the RANDOMIZE statement is not used, the random number function will generate the same sequence of pseudo-random numbers each time the program is run. When the RANDOMIZE statement is used without a *seed*, a different and unpredictable sequence of random numbers is generated by the random number function each time the program is run. If you use the RANDOMIZE statement with a *seed* specified, then the sequence of random numbers generated by the random number function depends upon the value of the *seed*. If the same *seed* is used each time the program is run, then the same sequence of numbers is generated. If a different *seed* is used each time the program is run, then a different sequence of numbers is generated. The *seed* may be any numeric expression. The number actually used for the *seed* is the first two bytes of the internal representation of the number. ... Thus, it is possible that the same sequence of numbers may be generated even if you specify different *seeds*. For example, RANDOMIZE 1000 and RANDOMIZE 1099 produce the same first two bytes internally and thus the same sequence of numbers. If the *seed* you specify is not an integer, then the value used is INT(*seed*).”

Although these descriptions are similar in describing the results when a program containing the RANDOMIZE function is run with a seed and then run again with the same seed, its use with TI Extended Basic produces a peculiar result that is somewhat predictable.

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<sup>1</sup> [See \vendors\ti\phm\phm3026\phm3026.pdf for the manual. — Cyc Ed.]

<sup>2</sup> [See \vendors\ti\pha\pha2603\us\pha2603.pdf for the *URG*. — Cyc Ed.]

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The observed difference is that with TI Extended Basic the first random fraction generated by any specific seed from 0 to 99 is built from the same starting number, with only the first two digits in the random fraction changing. The same thing happens with the second random fraction generated but starting from a different number. This also happens with the third, fourth and the following random fractions. TI Basic does not seem to produce the same sequence of random fractions where only the first two digits change and the remaining digits remain unchanged. The remainder of this document will only deal with what has been observed with TI Extended Basic.

This table shows the first six random fractions generated using RANDOMIZE seeds of 0 to 6.

Seed	RND fraction					
	1	2	3	4	5	6
0	0.211324865	0.063675343	0.747072754	0.148079781	0.399281999	0.056075622
1	0.421324865	0.473675343	0.357072754	0.958079781	0.409281999	0.266075622
2	0.631324865	0.883675343	0.967072754	0.768079781	0.419281999	0.476075622
3	0.841324865	0.293675343	0.577072754	0.578079781	0.429281999	0.686075622
4	0.051324865	0.703675343	0.187072754	0.388079781	0.439281999	0.896075622
5	0.261324865	0.113675343	0.797072754	0.198079781	0.449281999	0.106075622
6	0.471324865	0.523675343	0.407072754	0.008079781	0.459281999	0.316075622
	.21	.41	.61	.81	.01	.21

Note that the random fractions in column 1 increase by .21 and that the other columns increase by .41, .61, .81 and .01 respectively with the remaining digits from the starting numbers staying the same. If the number created exceeds 1, then the leading digit is removed. In column 6 a difference of .21 is used again and the sequence then repeats with the next random fraction using .41, followed by .61, etc. For lack of a better name, this series of differences has been called "keys." Each column repeats the indicated sequence up to and including seed 99. Seed 100 generates a series of random fractions that are identical to those generated by seed 1. Starting with seed 101 the key becomes a four-digit decimal number added to the same bases, but this has not been investigated any further.

A list of starting numbers can be generated by creating an Extended Basic program using RANDOMIZE 0 and then repeating PRINT RND the desired number of times.

Except for determining the starting numbers, the above observations can be expressed as a formula that does not require the use of RANDOMIZE and RND:

$$\text{Random fraction} = \text{MOD} (\text{key} \times 10^{12} \times \text{seed} + \text{starting number}, 10^{14}) / 10^{14}$$

Some explanations of the formula:

The values for the variables *key*, *seed*, and *starting number* should be integers.

MOD ensures that the *random fraction*, after division by  $10^{14}$ , does not produce a number greater than one. The formula uses the MOD function as it is used in TI Multiplan; TI Extended Basic does not have a MOD function.

The two-digit *key* is multiplied by  $10^{12}$  to make it a 14-digit number. The keys are 21, 41, 61, 81, and 01.

The *starting number* is a 14-digit number and must correspond with the *n*th random fraction that is being calculated. Remember that the series of 5 keys are used in sequence and then repeat so that random fractions #1, #6 and #11 generated with any seed, all use key 21. So each starting number can be matched with its own key.

I first experimented by creating a TI Multiplan spreadsheet to generate a block of random fractions using the above formula with a series of starting numbers. I subsequently transferred this TI Multiplan spreadsheet to MS Excel because Excel calculates faster.

Since I had to prove that this method of generating random fractions actually worked, I decided to write an Extended Basic program (named RANDOM) that would generate some random fractions using the above formula — but without using RANDOMIZE and RND — and then generate the same random fractions using RANDOMIZE and RND. The program only displays lists of 16 random fractions in order to allow some space on the screen for descriptions of the options chosen. Accordingly, only 16 DATA statements have been included to store the 16 starting numbers and their related keys. The program contains two menu items under two options being one for generating random fractions using RANDOMIZE and RND and another for generating without using RANDOMIZE and RND. The two menu items under each option do the following:

RANDOM NUMBERS  
BY JACQUES GROSLOUIS

WITHOUT TI RANDOMIZE AND RND  
1 DISPLAY ADJACENT RANDOM NUMBERS FOR A SERIES OF 16 RANDOMIZE SEEDS

2 DISPLAY FIRST 16 RANDOM NUMBERS FOR A SPECIFIC SEED

USING TI RANDOMIZE AND RND  
3 DISPLAY ADJACENT RANDOM NUMBERS FOR A SERIES OF 16 RANDOMIZE SEEDS

4 DISPLAY FIRST 16 RANDOM NUMBERS FOR A SPECIFIC SEED

M THIS MENU P SET PRINTER YOUR CHOICE? (M1234PEND):M

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1. Generate two adjacent random fractions (between 1 to 16) for any of the seeds from 0 to 15.
2. Generate 16 random fractions for any one of the seeds from 0 to 15.

The program can also print the results of the menu choices individually or all together. These printing options are selected by entering **P** from the main menu. Entering **1** to **4** will access the selected option and entering **E** will end the program. The printer code is set to print to Fred Kaal's TI99PRINT PC program using a serial cable. This code can be changed to suit your printer.

```
MENU #1 RANDOM # (1-15)? : 1
RANDOM NUMBERS 1 AND 2
IN ALL THE SERIES FROM 0 TO
15. NOTE FIRST 2 DIGITS.
USES KEYS 21 AND 41
SEED RND # 1 # 2
0 . 2113248654 . 0636753429
1 . 421 . 4700000000000000
2 . 631 . 3000000000000000
3 . 841 . 2900000000000000
4 . 051 . 7000000000000000
5 . 261 . 1100000000000000
6 . 471 . 0500000000000000
7 . 681 . 9000000000000000
8 . 891 . 7400000000000000
9 . 001 . 2700000000000000
10 . 101 . 1000000000000000
11 . 311 . 1500000000000000
12 . 521 . 0200000000000000
13 . 731 . 9000000000000000
14 . 941 . 8000000000000000
15 . 151 . 3613248654 . 2136753429
PRESS ANY KEY TO CONTINUE
```

I also wrote a shorter program (named RNDGEN) that will generate up to 99 random fractions for any RANDOMIZE seed from 0 to 99 using an adaptation of the formula described above<sup>3</sup>.

In case you are wondering what prompted me to look into these RANDOMIZE peculiarities, it was a User Note in the August 1995 issue of *MICROpendium*<sup>4</sup> contained the following formula:

$$X(N+1) = 14389820420821 * X(N) + 21132486540519 \pmod{10^{14}}$$

where  $X^*(0)$  is an integer.

I could not understand this formula but recognized that the second 14-digit number resembles the first random fraction generated after using RANDOMIZE 0. This led to identifying other starting numbers and observing the differences in keys described above. I still do not know what is the significance of the first 14-digit number in this formula. None of the above observations deals with how random numbers are generated, but only presents an observed peculiarity when RANDOMIZE is used with a seed with TI Extended Basic.

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<sup>3</sup> [See \articles\grosloui\articles\random.dsk for the programs on disk. — Cyc Ed.]

<sup>4</sup> [See \pubs\micropen\mp-9512\mp-9512.pdf, 12:7:29. User Notes, XB RND not just for games. — Cyc Ed.]

## 1.1. Listing of RANDOM

```
100 ! SAVE DSK1.RANDOM
110 DIM SD(17),SY(17)
120 M$="M1234PEnd" :: PR$="R
S232.BA=9600" :: KY$="1" :: 
Y$="0"
130 IMAGE ### .##### .#
#####
140 IMAGE ### ### ##.#####
###
150 IMAGE ### #.#####
160 CALL CLEAR :: CALL BLUE
:: GOSUB 5000 :: CALL PAGE1
170 CALL TITLE3 :: CALL MENU
180 DISPLAY AT(24,3):"Your C
hoice? (";M$;") :M" :: ACCEPT
AT(24,28)SIZE(-1)VALIDATE("M1234PE")BEEP:M1$ :: N=POS(M
$,M1$,1)
190 ON N GOSUB 170,3000,4000
,6000,7000,9000,990
200 GOTO 170
990 END
1000 DATA 21,21132486540519
1010 DATA 41,06367534286618
1020 DATA 61,74707275413897
1030 DATA 81,14807978089956
1040 DATA 01,39928199914395
1050 DATA 21,05607562158814
1060 DATA 41,45921200806813
1070 DATA 61,20620870393992
1080 DATA 81,90393996647951
1090 DATA 01,31454693928290
1100 DATA 21,02893883466609
1110 DATA 41,07587168406508
1120 DATA 61,97877041643587
1130 DATA 81,56758322465446
1140 DATA 01,39310437991685
1150 DATA 21,87605285413904
3000 DISPLAY AT(1,1)ERASE AL
L:"MENU #1 RANDOM # (1-15)?:
"&KY$ :: ACCEPT AT(1,26)VALI
DATE(DIGIT)SIZE(-2):KY$ :: I
F KY$="" THEN 3000 ELSE KY=V
AL(KY$)
3010 IF KY>15 OR KY<1 THEN 3
000
3020 DISPLAY AT(2,1):"Random
Numbers";KY; "and";KY+1;"in
all the Series from 0 to 15.
Note first 2 digits."
3030 DISPLAY AT(5,1):"Uses K
eys";SY(KY-1); "and";SY(KY):"
Seed Rnd "#;KY; " #";KY+
1
3040 IF T AND 1 THEN OPEN #1
:PR$ :: PRINT #1:"Menu #1 RA
NDOMIZE Series 0 to 15":"See
d RND "#&STR$(KY)
&" RND "#&STR$(KY+1)
3050 FOR X=0 TO 15
3060 A=(SY(KY-1)*10^12*X+SD(
KY-1))/10^14
3070 A1=(SY(KY)*10^12*X+SD(K
Y))/10^14
3080 IF A>1 THEN A=A-1 :: GO
TO 3080
3090 IF A1>1 THEN A1=A1-1 :: :
GOTO 3090
3100 DISPLAY AT(X+7,1):USING
130:X,A,A1
3110 IF T AND 1 THEN PRINT #
1:X,A,A1
3120 NEXT X :: CALL ANYKEY :
: IF T AND 1 THEN CLOSE #1
3130 IF T AND 16 THEN 6000 E
LSE RETURN
4000 DISPLAY AT(1,1)ERASE AL
L:"MENU #2":RANDOMIZE Seed
(0-16)?:"&Y$ :: ACCEPT AT(2,
24)VALIDATE(DIGIT)SIZE(-2):Y
$"
4010 IF Y$="" THEN 4000 ELSE
Y=VAL(Y$)
4020 IF Y>16 OR Y<0 THEN 400
0
4030 DISPLAY AT(3,1):"These
are the 1st 16 random number
s generated if seed";Y;"is u
sed.":# Key Random Numb
ers"
4040 IF T AND 2 THEN OPEN #1
:PR$ :: PRINT #1:" Menu #2 R
ANDOMIZE "&STR$(Y):" #
Key # Random
#"
4050 FOR X=0 TO 15
```

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```
4060 B=(SY(X)*10^12*Y+SD(X))
/10^14
4070 IF B>1 THEN B=B-1 :: GO
TO 4070
4080 DISPLAY AT(X+7,1):USING
140:X+1,SY(X),B
4090 IF T AND 2 THEN PRINT #
1:X+1,SY(X),B
4100 NEXT X :: CALL ANYKEY :
: IF T AND 2 THEN CLOSE #1
4110 IF T AND 16 THEN 7000 E
LSE RETURN
5000 FOR X=0 TO 15
5010 READ SY(X),SD(X)
5020 NEXT X :: RETURN
6000 DISPLAY AT(1,1)ERASE AL
L:"MENU #3 RANDOM # (1-15)?:
"&KY$ :: ACCEPT AT(1,26)VALIDATE(DIGIT)SIZE(-2):KY$
6010 IF KY$="" THEN 6000 ELSE KY=VAL(KY$)
6020 IF KY>15 OR KY<1 THEN 6
000
6030 DISPLAY AT(2,1):"Random
Numbers";KY;"and";KY+1;"in
all the Series from 0 to 15.
Note first 2 digits."
6040 DISPLAY AT(6,1):"Seed
Rnd #";KY;" #";KY+1
6050 IF T AND 4 THEN OPEN #1
:PR$ :: PRINT #1:"Menu #3 RANDOMIZE Series 0 to 15":"See
d RND #"&STR$(KY)
& RND #&STR$(KY+1)
6060 FOR X=0 TO 15
6070 RANDOMIZE X
6080 FOR Y=1 TO KY-1 :: K=RND
D:: NEXT Y
6090 A=RND:: B=RND:: DISPLAY
AT(X+7,1):USING 130:X,A,B
6100 IF T AND 4 THEN PRINT #
1:X,A,B
6110 NEXT X :: CALL ANYKEY :
: IF T AND 4 THEN CLOSE #1
6120 IF T AND 16 THEN 4000 E
LSE RETURN
7000 DISPLAY AT(1,1)ERASE AL
L:"MENU #4":"RANDOMIZE Seed
(0-16)?:&Y$ :: ACCEPT AT(2,
24)VALIDATE(DIGIT)SIZE(-2):Y
```

```
$
7010 IF Y$="" THEN 7000 ELSE
Y=VAL(Y$)
7020 IF Y>16 OR Y<0 THEN 700
0
7030 DISPLAY AT(3,1):"These
are the 1st 16 random number
s generated if seed";Y;"is u
sed.":# Random Numbers"
7040 IF T AND 8 THEN OPEN #1
:PR$ :: PRINT #1:"Menu #4 RANDOMIZE "&Y$:#
Random #
7050 RANDOMIZE Y
7060 FOR X=0 TO 15
7070 A=RND:: DISPLAY AT(X+7,
1):USING 150:X+1,A
7080 IF T AND 8 THEN PRINT #
1:X+1,A
7090 NEXT X :: CALL ANYKEY :
: IF T AND 8 THEN CLOSE #1
7100 RETURN
9000 ! SET PRINTER
9010 DISPLAY AT(1,8)ERASE AL
L:"Print Set-Up": :"Printer
>Change as necessary":PR$ :::
ACCEPT AT(4,1)SIZE(-28)VALIDATE(UALPHA,DIGIT,".")BEEP:P
R$#
9020 DISPLAY AT(20,1):"If print 'All' pages is selected, program will run and print all pages in the following order 1 3 2 4."
9030 DISPLAY AT(6,1):"Set Pages To Print"
9040 DISPLAY AT(8,1):"Clear (Y/N)"
9050 ACCEPT AT(8,14)VALIDATE
("YN")SIZE(-1):Z$ :: IF Z$="Y" THEN T=0
9060 IF T AND 16 THEN DISPLAY
AT(9,3):"All (Y/N) Y" ELSE DISPLAY
AT(9,3):"All (Y/N) "
9070 ACCEPT AT(9,14)VALIDATE
("YN")SIZE(-1):Z$ :: IF Z$="Y" THEN T=T OR 31
9080 IF T AND 1 THEN DISPLAY
AT(10,5):"1 (Y/N) Y" ELSE
```

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```
DISPLAY AT(10,5):"1 (Y/N)"
9090 IF T AND 2 THEN DISPLAY
    AT(11,5):"2 (Y/N) Y" ELSE
DISPLAY AT(11,5):"2 (Y/N)"
9100 IF T AND 4 THEN DISPLAY
    AT(12,5):"3 (Y/N) Y" ELSE
DISPLAY AT(12,5):"3 (Y/N)"
9110 IF T AND 8 THEN DISPLAY
    AT(13,5):"4 (Y/N) Y" ELSE
DISPLAY AT(13,5):"4 (Y/N)"
9120 ACCEPT AT(10,14)VALIDAT
E("YN")SIZE(-1):Z$ :: IF Z$=
"Y" THEN T=T OR 1
9130 ACCEPT AT(11,14)VALIDAT
E("YN")SIZE(-1):Z$ :: IF Z$=
"Y" THEN T=T OR 2
9140 ACCEPT AT(12,14)VALIDAT
E("YN")SIZE(-1):Z$ :: IF Z$=
"Y" THEN T=T OR 4
9150 ACCEPT AT(13,14)VALIDAT
E("YN")SIZE(-1):Z$ :: IF Z$=
"Y" THEN T=T OR 8
9160 DISPLAY AT(17,4):"Chang
e pages? (Y/N) N" :: ACCEPT
AT(17,24)VALIDATE("YN")SIZE(
-1)BEEP:AN$ :: IF AN$="Y" TH
EN 9030
9170 IF T AND 16 THEN 3000 E
LSE RETURN
10000 SUB ANYKEY
10010 DISPLAY AT(24,2)BEEP:"Press Any Key to Continue"
10020 CALL KEY(3,K,S):: IF S
<1 THEN 10020
10030 SUBEND
10100 SUB MENU
10110 DISPLAY AT(5,1):"Witho
ut TI RANDOMIZE and RND":1
Display Adjacent Random
Numbers for a Series of
16 RANDOMIZE Seeds"
10120 DISPLAY AT(10,1):"2 Di
splay First 16 Random      Nu
mbers for a Specific      Se
ed"
```

```
10130 DISPLAY AT(14,1):"Usin
g TI RANDOMIZE and RND":3 D
isplay Adjacent Random      N
umbers for a Series of      1
6 RANDOMIZE Seeds"
10140 DISPLAY AT(19,1):"4 Di
splay First 16 Random      Nu
mbers for a Specific      Se
ed"
10150 DISPLAY AT(23,1):"M Th
is Menu P Set Printer"
10160 SUBEND
11000 SUB PAGE1
11010 CALL TITLE3
11020 DISPLAY AT(5,1):"This
program explores some pecul
arities in the use of the R
ANDOMIZE statement and will
create series of random"
11030 DISPLAY AT(9,1):"numbe
rs without using the RANDO
MIZE statement or RND funct
ion. For comparison the s
ame random numbers can"
11040 DISPLAY AT(13,1):"be c
reated using RANDOMIZE and
RND. Output can also be sent
to a printer."
11090 CALL ANYKEY :: SUBEND
29245 SUB TITLE3
29250 ! SHORT TITLE SCREEN
29255 DISPLAY AT(1,8)ERASE A
LL:"Random Numbers" :: CALL
CHAR(95,"00FF"):: CALL HCHAR
(2,10,95,14)
29260 DISPLAY AT(3,6):"By Ja
cques Groslouis" :: CALL HCH
AR(4,8,95,20)
29265 SUBEND
29505 SUB BLUE
29510 ! SWITCHES DISPLAY TO
WHITE ON BLUE; JLS 7/88
29515 CALL SCREEN(5):: FOR L
=0 TO 14 :: CALL COLOR(L,16,
1):: NEXT L :: SUBEND
```