

Integer Base Conversion on Handheld Programmable Calculators

An efficient algorithm that converts integers between different number systems is implemented on two handheld programmable calculators, using either RPN or AOS

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Base conversion is an important tool for the computer programmer, engineering designer, and mathematician. Many problems related to computer program development involve conversion of numbers between binary, octal, decimal, and hexadecimal bases. Problems related to number theory require conversion between these and other arbitrary bases.

The conversion of a number from base a to base b is generally a 2-step procedure accomplished by first converting from base a to base 10, and then converting from base 10 to

base b . Normally, an algorithm involving division is used for the first step and a different algorithm involving multiplication is used for the second step. The algorithm versions presented achieve high efficiency by using a single algorithm that does both conversions.* The 55-step HP 67/97 calculator program compares with a similar 135-step program available in the HP library. The 105-step TI 58/59 calculator program compares with a less general program available in the TI library that requires 179 steps and converts only from base 10 to a base between 2

and 299. A well written Texas Instruments' AOS™ (algebraic operating system) program requires approximately twice as many steps as a well written reverse polish notation (RPN) program.

All standard handheld programmable calculators operate in decimal mode. Therefore, one digit is required to represent a single digit number for bases 2 through 10, two digits are required for bases 11

*The algorithm and the HP 67/97 program were developed by Cass R. Lewart; James Mockler wrote the TI 58/59 version.

through 100, etc. For example, to represent $2F7_{16}$ the calculator will display, or expect as input, 21507. A routine within the program computes the number of decimal digits required for presentation in any given base. On output, the inverse conversion has to be performed mentally by separating the readout into groups of 1, 2, 3, or more digits. Any integer argument and any positive integer base larger than 1 can be handled by the program within the limits of the calculator accuracy and display size. Note that the two coded programs (Tables 1 and 2) could be run, with only slight modifications, on other programmable calculators using either RPN or AOS.

HP 67/97 Calculator Conversion

The example presented converts 12345_{10} to $(?)_{16}$ and then to $(?)_{10}$.
(1) Key in integer (number) to be converted, eg, 12345.

(2) Press ENTER ↑.

(3) Key in present base, eg, 8.

(4) Press ENTER ↑.

(5) Key in desired base, eg, 16.

(6) Press A.

(7) Calculator displays 1041405 or $14E5_{16}$.

(8) To convert $14E5_{16}$ to base 10, press R/S.

(9) Calculator displays 5349.

TI 58/59 Calculator Conversion

Used as an example of the keying sequence is the conversion of $2F7_{16}$ to $(?)_{10}$ and then to $(?)_{2}$.

(1) Key in integer (number) to be converted, eg, 21507.

(2) Press A.

(3) Key in present base, eg, 16.

(4) Press B.

(5) Key in desired base, eg, 2.

(6) Press C.

(7) Calculator then displays 101110111₂.

(8) To convert 101110111₂ to base 10, press R/S.

(9) Calculator displays 759.

TABLE 1
HP 67/97 Conversion
Program Listing

Step	Key	HP 67 Code
01	LBL A	31 25 11
	STO 0	33 00
	R ↓	35 53
	ENT ↑	41
	GSB 3	31 22 03
	GSB 0	31 22 00
	RCL 0	34 00
	GSB 3	31 22 03
	RCL 0	34 00
10	LBL 0	31 25 00
	STO 1	33 01
	R ↓	35 53
	STO 2	33 02
	R ↓	35 53
	STO 3	33 03
	STO 6	33 06
	0	00
	STO 4	33 04
	1	01
20	STO 5	33 05
	LBL 1	31 25 01
	RCL 3	34 03
	X = 0?	31 51
	GTO 2	22 02
	RCL 1	34 01
	STO ÷ 3	33 81 03
	RCL 3	34 03
	INT	31 83
	STO 3	33 03
30	X	71
	—	51
	RCL 1	34 01
	X ↔ Y	35 52
	X < 0?	31 71
	+	61
	RCL 5	34 05
	X	71
	STO + 4	33 61 04
	RCL 2	34 02
40	STO × 5	33 71 05
	GTO 1	22 01
	LBL 2	31 25 02
	RCL 4	34 04
	RTN	35 22
	RCL 6	34 06
	RTN	35 22
	LBL 3	31 25 03
	1	01
	—	51
50	LOG	31 53
	INT	31 83
	1	01
	+	61
	10*	32 53
	RTN	35 22

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TABLE 2
TI 58/59 Base Conversion Program Listing

Step	Code	Key	Step	Code	Key
000	76	LBL	060	43	RCL
	11	A		09	09
	32	X $\leftrightarrow$ T		95	=
	91	R/S		44	SUM
	76	LBL		07	07
	12	B		69	OP
	42	STO		29	29
	01	01		00	0
	10	E'		32	X $\leftrightarrow$ T
	42	STO		22	INV
010	02	02	070	67	EQ
	91	R/S		90	LST
	76	LBL		97	DSZ
	13	C		06	06
	42	STO		98	ADV
	03	03		17	B'
	10	E'		76	LBL
	42	STO		98	ADV
	04	04		43	RCL
	02	2		07	07
020	42	STO	080	42	STO
	06	06		08	08
	76	LBL		32	X $\leftrightarrow$ T
	19	D'		43	RCL
	00	0		03	03
	42	STO		42	STO
	07	07		02	02
	42	STO		43	RCL
	09	09		04	04
	32	X $\leftrightarrow$ T		42	STO
030	76	LBL	090	01	01
	90	LST		19	D'
	55	+		76	LBL
	43	RCL		17	B'
	02	02		43	RCL
	95	=		07	07
	53	(		91	R/S
	29	CP		43	RCL
	85	+		08	08
	32	X $\leftrightarrow$ T		91	R/S
040	54	)	100	76	LBL
	59	INT		10	E'
	32	X $\leftrightarrow$ T		75	-
	22	INV		01	1
	59	INT		95	=
	65	x		28	LOG
	43	RCL		59	INT
	02	02		85	+
	65	x		01	1
	53	(		95	=
050	43	RCL		22	INV
	01	01		28	LOG
	45	Y*		92	RTN

Summary

Two relatively short programs for HP 67/97 and TI 58/59 handheld programmable calculators use a highly efficient algorithm to convert integer arguments between any two arbitrary bases. Main applications of the programs are for computer pro-

gram development and debugging, and for solving problems in number theory.

Bibliography

HP 67/97 Owners Handbook, Hewlett-Packard Co, Corvallis, Ore, June 1976
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OEM's: Why Create Software For Protocol Conversion When We Have It Available Now?

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