Manual

Sectn48

Version 2.0

Contents

CONTENTS 2
1. COPYRIGHT AND DISCLAIMER OF WARRANTY 3
2. DESCRIPTION 3
3. CO-ORDINATE SYSTEM AND SIGNS 3
4. OVERVIEW 4
5. COMMAND REFERENCE 4
6. THEORY 9
7. EXAMPLES 10
A. INSTALLATION 13
B. CHARACTERISTICS 13
C. AUTHOR 13

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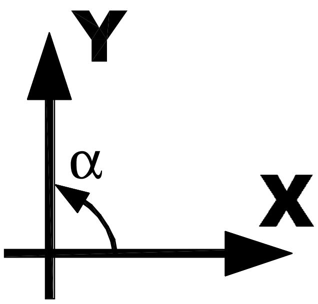
2. Description

The Sectn48 library is an application for the Hewlett Packard 48G series calculators[1]. It is designed to calculate the properties of cross-sections.
Sectn48 can calculate almost all the characteristic properties of such a cross-section like the area, the centre of area, the moment of inertia etc. Sectn48 can do this also for non-solid and oddly shaped cross-sections.
What’s more, Sectn48 can even calculate properties of a fictional (i.e. elastic) cross-section, that is, a cross-section composed of two materials. An example of this is a cross-section of a reinforced concrete beam. This was one of the main reasons for developing the Sectn48 library.
Sectn48 provides all of this through an easy to use interface. Additional features include a built-in plotter to check the correctness of the geometry of the cross-section and a section wizard[2].
Sectn48 is completely written in SysRPL.

3. Co-ordinate system and signs

Sectn48 uses an X-Y co-ordinate system where the positive X-direction is to the right and the positive Y-direction is upwards. Angles are positive counter-clockwise. Below the positive directions are drawn.



Note:
Since units are not supported with arrays on the HP48 you have to be careful about the values you enter. The implied units *must* be compatible for meaningful results. For instance if you enter X and Y co-ordinates in meters you have to enter the area[3] in square meters.

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[1] Please note that you should use version 2.0 only on a G series. Failing to do so could result in a “Memory Lost” event.
[2] Only available in version 2.0W
[3] Used for fictional cross-section calculations.

4. Overview

The Sectn48 library menu consists of seven commands. These commands will be explained shortly below.

- SSECT — Calculates properties of a cross-section
- ESECT — Calculates properties of an fictional (i.e. elastic) cross-section
- SSPLT — Plots the cross-section
- ESPLT — Plots the fictional (i.e. elastic) cross-section
- WZRDm[4] — Provides wizards for “standard sections”
- CFGRm — Gives the Sectn48 configuration options
- ABOUTSectn48 — The about screen with the version number

The (S/E)SECT and (S/E)SPLT commands take their arguments from the stack in the form of real arrays and real numbers.
The basic idea is to describe a cross-section with a 2-column matrix where the first column contains the X-co-ordinates and the second column contains the Y-co-ordinates. The co-ordinates should describe a closed polyline.
For the calculation of properties of fictional cross-sections additional information is required. This should be provided in the form of the ratio of some material property and an array with X and Y co-ordinates and the precise area of the second material at this point.

5. Command reference

SSECT

Standard section command: The SSECT command calculates properties of a cross-section.

Level 1	→	**Level 20**	**Level 19**	…	**Level 1**
$[[\text{matrix}]]_s$	→	$[[\text{matrix}]]_s$	A	…	α’

Affected by Flags:

Userflag 40	clear:	results to stack
	set:	enter browser, only marked results to stack
Userflag 43	clear:	condensed output
	set:	comprehensive output

Output:
With Userflag 43 set, the calculated properties are (from level 19 to level 1):

In the main x,y co-ordinate system (reference point: (0,0))

A	:	area
Xc	:	x-co-ordinate of “centre of area”
Yc	:	y-co-ordinate of “centre of area”
Sx	:	Static moment of area (reference: X-axis)
Sy	:	Static moment of area (reference: Y-axis)
Ix	:	Moment of inertia (reference: X-axis)
Iy	:	Moment of inertia (reference: Y-axis)
Ip	:	Polar moment of inertia (reference point: (0,0))

[4] Only available in the 2.0W version.

Ixy : Centrifugal moment of inertia (reference: X and Y-axis)
I1 : Main moment of inertia (reference: X or Y-axis rotated over α)
I2 : Main moment of inertia (reference: X or Y-axis rotated over α)
α : Angle of rotated (from X and Y axis) co-ordinate system for main moments of inertia

In the translated x',y' co-ordinate system (reference point: (Xc,Yc))
Ix' : Moment of inertia (reference: X'-axis)
Iy' : Moment of inertia (reference: Y'-axis)
Ip' : Polar moment of inertia (reference point: (Xc,Yc))
Ix'y' : Centrifugal moment of inertia (reference: X' and Y'-axis)
I1' : Main moment of inertia (reference: X' or Y'-axis rotated over α')
I2' : Main moment of inertia (reference: X' or Y'-axis rotated over α')
α' : Angle of rotated (from X' and Y' axis) co-ordinate system for main moments of inertia

Note that the tag of I1 and I1' (when necessary) will be enhanced by an indicator:
X (reference is X-axis), Y (reference is Y-axis), 1Q (reference is axis in first quadrant, rotated over α (or α') from X-axis) or 2Q (reference is axis in second quadrant, rotated over α (or α') from Y-axis).

With Userflag 43 clear, the calculated properties are (from level 5 to level 1):

In the main x,y co-ordinate system (reference point: (0,0))
A : area
Xc : x-co-ordinate of "centre of area"
Yc : y-co-ordinate of "centre of area"

In the translated x',y' co-ordinate system (reference point: (Xc,Yc))
Ix' : Moment of inertia (reference: X'-axis)
Iy' : Moment of inertia (reference: Y'-axis)

Remarks:
The [[matrix]]$_s$ is a {n 2} real matrix with column 1 as x-co-ordinates and column 2 as y-co-ordinates where the co-ordinates should describe a closed polyline (first row of [[matrix]]$_s$ equals last row of [[matrix]]$_s$). The [[matrix]]$_s$ should have at least 3 rows ($n \geq 3$).
Positive area is described counter-clockwise, negative area is described clockwise. This can be used to calculate the properties of non-solid cross-sections (see *Examples*).

ESECT

Imaginary section command: The ESECT command calculates properties of a fictional (i.e. elastic) cross-section. This cross-section consists of two (!) materials. An example would be a cross-section of a reinforced concrete beam. Note that by the nature of the calculation the area of the second material should be small compared to that of the main material (see *Theory*). It is also understood that the second material is enclosed by the main material (n-1 in formulas, see *Theory*). The ESECT command uses the SSECT command internally.

Level 3	Level 2	Level 1	→
n	[[matrix]]$_{m2}$	[[matrix]]$_s$	→

Level 10	Level 9	Level 8	Level 7	…	Level 1
n	[[matrix]]$_{m2}$	[[matrix]]$_s$	Ai	…	Iy'i

Affected by Flags:

Userflag 40	clear:	results to stack
	set:	enter browser, only marked results to stack
Userflag 43	clear:	condensed output
	set:	comprehensive output

Output:
With Userflag 43 set, the calculated properties are (from level 7 to level 1):

In the main x,y co-ordinate system (reference point: (0,0))
Ai : fictional area
Xci : fictional x-co-ordinate of "centre of area"
Yci : fictional y-co-ordinate of "centre of area"
Ixi : fictional moment of inertia (reference: X-axis)
Iyi : fictional moment of inertia (reference: Y-axis)
In the translated x',y' co-ordinate system (reference point: (Xci,Yci))
Ix'i : fictional moment of inertia (reference: X'-axis)
Iy'i : fictional moment of inertia (reference: Y'-axis)

With Userflag 43 clear, the calculated properties are (from level 5 to level 1):

In the main x,y co-ordinate system (reference point: (0,0))
Ai : fictional area
Xci : fictional x-co-ordinate of "centre of area"
Yci : fictional y-co-ordinate of "centre of area"
In the translated x',y' co-ordinate system (reference point: (Xci,Yci))
Ix'i : fictional moment of inertia (reference: X'-axis)
Iy'i : fictional moment of inertia (reference: Y'-axis)

Remarks:
n is the ratio between the material properties of the second material (i.e. steel reinforcement bars) and the main material (i.e. concrete). For elastic cross-sections this material property would be the modulus of elasticity (i.e. $n_e = E_{steel}/E_{conc}$).
The $[[matrix]]_{m2}$ is a {n 3} real matrix with column 1 as x-co-ordinates, column 2 as y-co-ordinates and column 3 the areas of the second material. The $[[matrix]]_{m2}$ can have any number of rows ($n \geq 1$).
The $[[matrix]]_s$ is a {n 2} real matrix with column 1 as x-co-ordinates and column 2 as y-co-ordinates where the co-ordinates should describe a closed polyline (first row of $[[matrix]]_s$ equals last row of $[[matrix]]_s$). The $[[matrix]]_s$ should have at least 3 rows ($n \geq 3$).
Positive area is described counter-clockwise, negative area is described clockwise. This can be used to calculate the properties of non-solid cross-sections (see *Examples*).

SSPLT

Standard section plot command: The SSPLT command plots the polyline of a cross-section.

Level 1	→	Level 1
$[[matrix]]_s$	→	$[[matrix]]_s$

Affected by Flags:

Userflag 41	clear:	normal plot
	set:	plot is rotated 90 degrees clockwise
Userflag 42	clear:	plot only to ABUFF (stack grob)
	set:	plot to ABUFF and PICT

Remarks:
After plotting the program waits for a keystroke to resume the normal stack display, the only exception is the OFF key (rightshift ON).
The $[[\text{matrix}]]_s$ is a {n 2} real matrix with column 1 as x-co-ordinates and column 2 as y-co-ordinates where the co-ordinates should describe a closed polyline (first row of $[[\text{matrix}]]_s$ equals last row of $[[\text{matrix}]]_s$). The $[[\text{matrix}]]_s$ should have at least 3 rows ($n \geq 3$).
Positive area is described counter-clockwise, negative area is described clockwise. This can be used to calculate the properties of non-solid cross-sections (see *Examples*).

ESPLT

Imaginary section plot command: The ESPLT command plots a fictional (i.e. elastic) cross-section. This cross-section consists of two (!) materials. An example would be a cross-section of a reinforced concrete beam. The second material is plotted as a cross.

Level 2	Level 1	→	Level 2	Level 1
$[[\text{matrix}]]_{m2}$	$[[\text{matrix}]]_s$	→	$[[\text{matrix}]]_{m2}$	$[[\text{matrix}]]_s$

Affected by Flags:

Userflag 41	clear:	normal plot
	set:	plot is rotated 90 degrees clockwise
Userflag 42	clear:	plot only to ABUFF (stack grob)
	set:	plot to ABUFF and PICT

Remarks:
After plotting the program waits for a keystroke to resume the normal stack display, the only exception is the OFF key (rightshift ON).
The $[[\text{matrix}]]_{m2}$ is a {n 3} real matrix with column 1 as x-co-ordinates, column 2 as y-co-ordinates and column 3 the areas of the second material. The $[[\text{matrix}]]_{m2}$ can have any number of rows ($n \geq 1$).
The $[[\text{matrix}]]_s$ is a {n 2} real matrix with column 1 as x-co-ordinates and column 2 as y-co-ordinates where the co-ordinates should describe a closed polyline (first row of $[[\text{matrix}]]_s$ equals last row of $[[\text{matrix}]]_s$). The $[[\text{matrix}]]_s$ should have at least 3 rows ($n \geq 3$). Positive area is described counter-clockwise, negative area is described clockwise.

WZRDm

Wizard menu: The WZRDm command provides an easy menu-based interface to assemble “standard sections”.

Level 1	→	Level 1
	→	

Affected by Flags:
No

Usage:
Currently the WZRDm menu provides wizards for the following types of sections:

- Triangle
- Rectangle
- Rectangular box
- Trapezoid
- Circle (approx)
- Circular ring (approx)
- Angle
- Channel
- T-beam
- I-beam

Remarks:
Since the WZRDm menu provides grob menulabels the section wizards are easily recognised. The menukeys of the WZRDm menu provide three types of actions: *unshifted, left-shifted* and *right-shifted*. These actions are explained below:

Keypress	Unshifted	Left-shifted	Right-shifted
Action:	Run wizard	SSECT	SSPLT

CFGRm

Configuration menu: The CFGRm command provides an easy menu-based interface to modify the behaviour of the SSECT, ESECT, SSPLT and ESPLT commands.

Level 1	→	Level 1
	→	

Affected by Flags:
No, however it affects flags (Userflag 40,41,42 and 43)

Usage:
The CFGRm menu provides four menukeys which can be toggled on or off. The state of the menulabels will be explained below.

Menulabel	Toggled on	Toggled off
CMPR	Userflag 43 set: comprehensive output	Userflag 43 clear: condensed output
BRWS	Userflag 40 set: browse results	Userflag 40 clear: results to stack
ROT	Userflag 41 set: rotate plot	Userflag 41 clear: default plot
→PICT	Userflag 42 set: export plot to PICT	Userflag 42 clear: plot only to stack

ABOUTSectn48

About command: The ABOUTSectn48 command shows the about message of the Sectn48 library.

Level 1	→	**Level 1**
	→	

Affected by Flags:
No

Remarks:
The current version, year of production and the name of the author are shown.

6. Theory

Underneath a couple of formulas are shown which are used to describe the properties of a fictional cross-section, used by the ESECT command (the ones used for the SSECT command can be found in most textbooks). Note that all the properties of the second material are marked by: $_{m2}$.

$$Ai = A + (n-1) \cdot \sum A_{m2}$$

$$Xci = \frac{Xc \cdot A + (n-1) \cdot \sum A_{m2} \cdot X_{m2}}{Ai} \qquad Yci = \frac{Yc \cdot A + (n-1) \cdot \sum A_{m2} \cdot Y_{m2}}{Ai}$$

$$Ixi = Ix + (n-1) \cdot \sum A_{m2} \cdot Y_{m2}^2 \qquad Iyi = Iy + (n-1) \cdot \sum A_{m2} \cdot X_{m2}^2$$

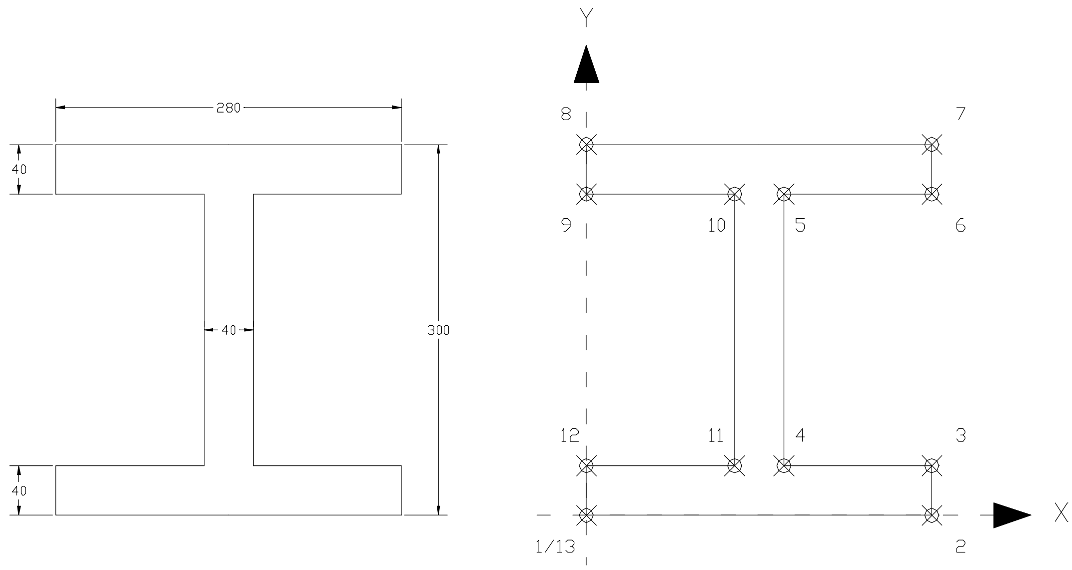
$$Ix'i = Ixi - Ai \cdot Yci^2 \qquad Iy'i = Iyi - Ai \cdot Xci^2$$

7. Examples

In the next section some examples are provided to familiarise you with the Sectn48 library.

Example 1

Below an example of an I-profile is shown.



To calculate the properties of this cross-section you have to enter the X and Y co-ordinates of the cross-section. Since the area is positive you have to work counter-clockwise. I have chosen the intersection of the X and Y axis on the bottom left of the cross-section. This is entirely free, however a reasonable choice lightens the work!
In this example I start from point 1 (and finish there also). This is also free (I could have started at point 8, but then would have had to finish there).

Having agreed on all this, you have to enter the following ({13 2} sized) array on the HP48:

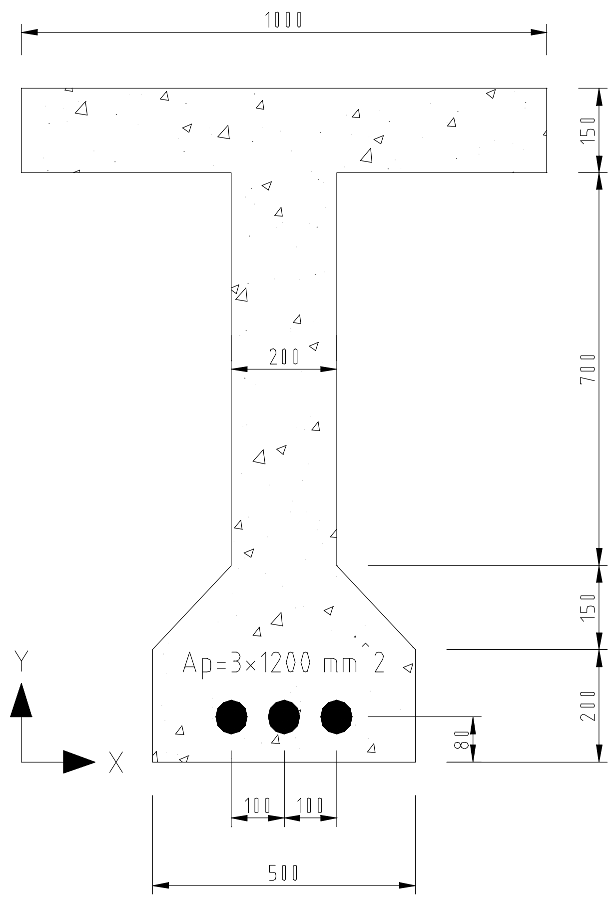
```
[ [   0   0 ] [ 280   0 ] [ 280  40 ] [ 160  40 ] [ 160 260 ]
  [ 280 260 ] [ 280 300 ] [   0 300 ] [   0 260 ] [ 120 260 ]
  [ 120  40 ] [   0  40 ] [   0   0 ] ]
```

With this array on level 1 of the stack you can execute the SSECT command and, depending on your version of the library and its current configuration, after a slight pause you will either enter a browser (a screen-wide choose box), see the output displayed on line 1 to 7 or just see the tagged results appear on the stack.

If you want to check the geometry of the entered cross-section you can execute the SSPLT command.

Example 2

This example shows the necessary input for the calculation of the elastic properties of a post-stressed concrete T-beam. This T-beam is drawn below with the dimensions in millimetres.



To calculate the properties of the elastic cross-section we have to know the modulus of elasticity of the concrete and the steel. For this example we take $E_{steel} = 2.0*10^5$ [MPa] and $E_{concrete}$ = 33500 [MPa]. Thus the value of n_e is $2.0*10^5$ / 33500 = 5.97.
If we enter everything in meters we have to know A_p in meters too. So, 3*1200 [mm^2] equals 3*.0012 [m^2].

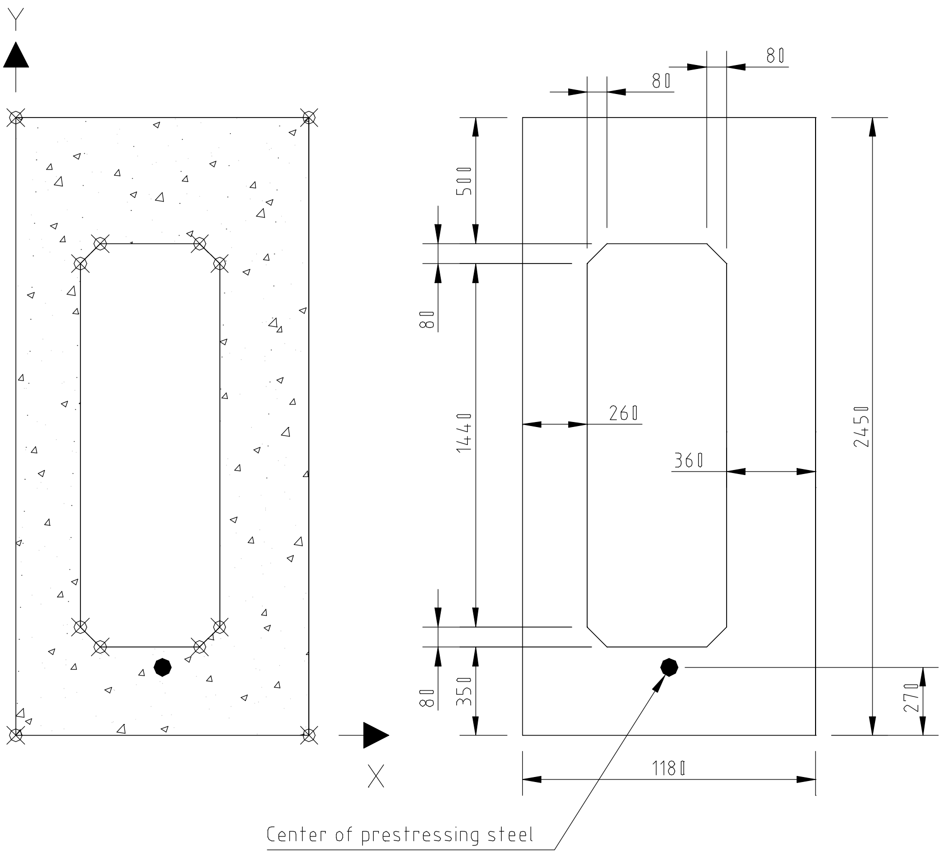
The input for the ESECT command is:

Level 3:
```
5.97
```
Level 2:
```
[ [ .4 .08 .0012 ] [ .5 .08 .0012 ] [ .6 .08 .0012 ] ]
```
Level 1:
```
[ [ .25 0 ] [ .75 0 ] [ .75 .2 ] [ .6 .35 ] [ .6 1.05 ]
  [ 1 1.05 ] [ 1 1.2 ] [ 0 1.2 ] [ 0 1.2 ] [ 0 1.05 ]
  [ .4 1.05 ] [ .4 .35 ] [ .25 .2 ] [ .25 0 ] ]
```

The same input can be used for the ESPLT command (although there is no level 3 argument needed).

Example 3

This example shows the necessary input for the calculation of the elastic properties of a non-solid pre-stressed concrete beam. This pre-stressed concrete beam is drawn below with the dimensions in millimetres.



To calculate the properties of the elastic cross-section we have to know the modulus of elasticity of the concrete and the steel. For this example we take $E_{steel} = 2.0*10^5$ [MPa] and $E_{concrete}$ = 33500 [MPa]. Thus the value of n_e is $2.0*10^5$ / 33500 = 5.97.
If we enter everything in meters we have to know A_p in meters too. So, let us say that A_p is 18900 [mm^2] equals 0.0189 [m^2].

The input for the ESECT command is:

Level 3:
```
5.97
```
Level 2:
```
[ [ .59 .27 .0189 ] ]
```
Level 1:
```
[ [ 0 0 ] [ 1.18 0 ] [ 1.18 2.45 ] [ 0 2.45 ] [ 0 0 ]
  [ .26 .43 ] [ .26 1.87 ] [ .34 1.95 ] [ .74 1.95 ]
  [ .82 1.87 ] [ .82 .43 ] [ .74 .35 ] [ .34 .35 ]
  [ .26 .43 ] [ 0 0 ] ]
```

For the level 1 argument you have to remember that positive area is described counter-clockwise, negative area clockwise. The same input can be used for the ESPLT command (although there is no level 3 argument needed).

A. Installation

The Sectn48 library can be installed in any available port on the calculator. However, it works fastest from a non-covered port (port 0 or 1). To install the Sectn48 library on your calculator do the following:

- Transfer the library to your calculator and place the library on the stack
- Place the port number you wish to store the library in on the stack
- Press the STO button
- Warmstart the calculator (press ON and C simultaneously) or shut it off and then turn it on again
- Purge the variable which still contains the library

If any of this gives you problems you should read the HP manual!

B. Characteristics

Sectn48	Description
Version	2.0/2.0W
Library number	1600 (decimal)
Size (bytes)	5704.5 (2.0) 8828 (2.0W)
Checksum	#1082d (2.0) #22386d (2.0W)
Systemflags used	none
Userflags used	40,41,42,43
Language used	Sys-RPL

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