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TABLE OF CONTENTS

1. INTRODUCTION

2. STARTING THE PROGRAM

3. THE MAIN WINDOW

4. USING STK

5. SELECTING THE DATA

6. THE OUTPUT WINDOW

7. PROGRAM AND ROUTINES DESCRIPTION

1. INTRODUCTION

The SPARK MODEL program has been developed to evaluate and compute the main characteristics of a Space Solar Power system. The software has been written for a user with some experience in the SSP issues.
In the present manual the following convention are assumed:

in **bold** the names of input and output files
in *italic* the titles of the dialog windows
in `courier` the labels of the input and output fields.

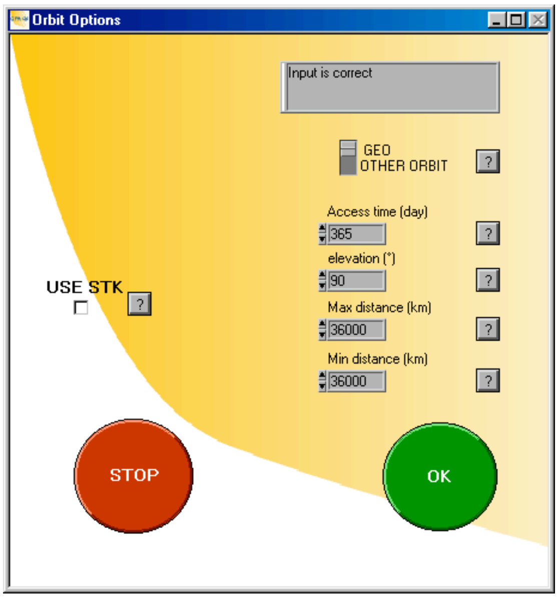
The SPARK MODEL program has been developed with the software LABVIEW 5.1 of National Instruments with the operating system Windows NT, the program has been successfully tested also with Windows 2000 and Windows 98. The program has a graphical user interface, optimised, following ESA request, for a screen resolution of 1024x768 pixels.
To employ all the options of the SPARK MODEL program it is required to have installed the STK 4.3 program from AGI, available freely for the research institutions. AGI suggests, for the installation and execution of STK a minimum disk space of 300MB and 128MB of RAM, but for the present application a Pentium III with 800MHz clock and 256MB RAM is a minimum suggested requirement. For any question and problem about STK contact support@stk.com or visit www.stk.com web page.
Warning: the SPARK MODEL program reads the paths of the executable file of STK and of the report files folder from a text file called **path.txt**, you should edit this file writing the right paths for your system (e.g. C:\Program files\AGI\stk\4.3\bin4.3\stk.exe and C:\stk\user1).
The input data for the calculation performed by SPARK MODEL program are stored in ASCII files (**filename.txt**) and reflect the present technological knowledge for the various elements (e.g. photovoltaic cells). This data format allows the user to keep updated these files with the new technological improvements.
Warning: after any modification these files should be stored in the same directory they were before and with the same name and structure (data fields are separated with tab).

2. STARTING THE PROGRAM

You can start the SPARK MODEL program double clicking on its icon.
The program displays a main window and several dialog windows used to get input parameters and output the results of calculation. In the almost every window there are two round buttons: clicking on the green one you proceed with the calculations, with the red one you quit the program. In the input windows to the right of every data filed you can see a small grey button with a question mark ?, clicking on it you can read a brief description of the command.
After a welcome screen the program asks you if you want to open an old project or to create a new one. To select the files the standard "Save as…" and "Open" dialog windows are used. The projects are stored in ASCII files with the spark extension (e.g. **projectname.spark**).
Each time the program is executed three files are generated:

- the project (with the **.spark** extension by default) which stores all the input data
- the output file (the string **_output.dat** is added to the project name e.g. **projectname_output.dat**) which stores the relevant input and the output data.
- the loss table file (the string **_loss.dat** is added to the project name e.g. **projectname_loss.dat**) which stores the power lost in each step of the project.

If you create a new project the following dialog window is opened:



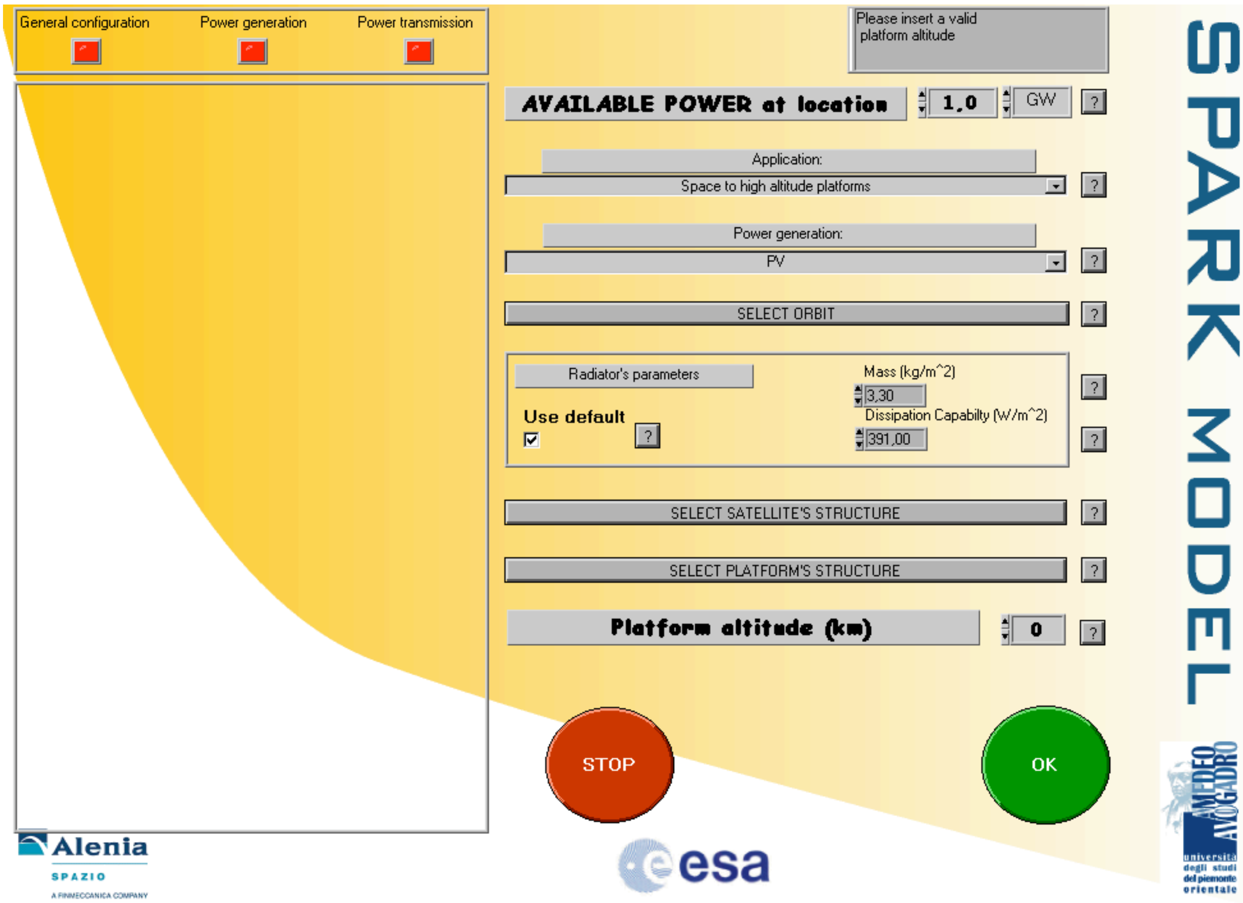
With the check box on the left (`USE STK`) you can choose if you want to input the orbital parameters for the solar power satellite or to use the STK program (checked); the parameters you can input are:

- `Access time (day)` is the time, in a year, during which the satellite can deliver power to the ground station; the time is expressed in days
- `Elevation (°)` is the minimum elevation angle of the satellite seen from the ground station. This angle should be greater than zero; to avoid an excessive spreading of the beam on the receiving area it should not be too small.
- `Max distance (km)` is the maximum distance between the satellite and the ground station.
- `Min distance (km)` is the minimum distance between the satellite and the ground station.

With the switch on the right, labelled `GEO OTHER ORBIT`, you can select a geostationary orbit, in this case you can't modify the parameters, or manually input all of them. All these controls are visible only if you uncheck the `USE STK` checkbox.
The grey box on the top right displays error messages if the chosen values are not valid, in this case your are not allowed to proceed with the calculations. A similar box is present in all the input windows.

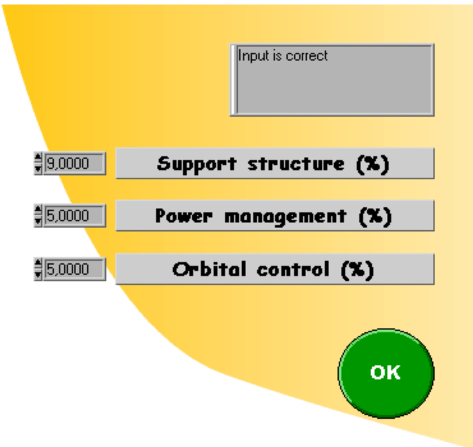
If you open an existing project all the input windows described later are automatically filled with the values of the chosen project, but you can freely modify all of them.

3. THE MAIN WINDOW



The main window of the SPARK MODEL program is shown above.
The right part of the window contains the input controls:

- `AVAILABLE POWER at location` is the total power delivered to the final application, you can select the unit of measurement from watts to gigawatts.
- `Application` is the kind of application you want to study, there are three possible choices: Space to Earth, Space to space and Space to high altitude platforms.
- You can select the `Power generation` system between photovoltaic cells and sun pumped laser.
- The button `SELECT ORBIT` calls STK, the SPARK MODEL program displays a window with a summary of the tasks to be performed with STK. This window will be better described later.
- The `Radiator's parameters` group includes three commands: the `Use default` checkbox allows you to choose if you want to use default values for dissipator's characteristics or to manually input them. The two parameters are `Mass` and `Dissipation capability`. If the operating temperature of an element is known, these values are ignored and the dissipation capability is calculated directly from the temperature itself.
- The button `SELECT SATELLITE'S STRUCTURE` opens a dialog window you can use to input the percentage in mass of the satellite due to three elements: `Support structure`, `Power management` and `Orbital control`.



- The button SELECT PLATFORM'S STRUCTURE opens the same dialog window. In this you can use it to input the percentage in mass of the platform due to the same three elements.
- Platform altitude is the altitude over the sea level of the atmospheric platform. This control, together with the previous one, is visible only if you select space-to-platform application.

The input process is split into three main sections:
1) the general configuration that includes all the choices made within the main window
2) the power generation section
3) the power transmission section

When each one of these steps has been completed the corresponding red "led" on the top left of the main window turns to green.
During the input process in the left part of the main window you can read the parameters you have already chosen.

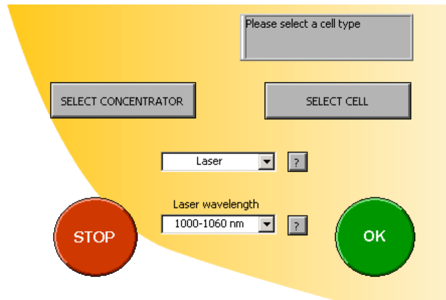
4. USING STK

It this manual it is assumed you know how to use the STK program. The SPARK MODEL program reads the access time, the elevation angle and the distances from two output reports of STK. In this chapter are listed only the tasks required to create these reports. The same tasks are listed in the help window that appears when you click on the SELECT ORBIT button.
You have to create a scenario or to open one with one satellite and one facility. The orbit of the satellite should be circular and should be computed over an year period to average the seasonal effects. In the satellite lighting constraints select direct sun. In the facility constraint dialog select the minimum elevation angle to avoid an excessive spreading of the beam on the receiving area. Select the facility and compute access with the satellite.
Warning: do not select the satellite and compute access with the facility because it would give a wrong value for the elevation angle.
Create the access report and the AER (Azimuth Elevation Range) report and save them in the folder written in the second line of **path.txt** file in the data folder.
Warning: use always the names **access.dat** for the access report and **dist.dat** for the AER report.
The recorded reports are automatically renamed by the SPARK program with a progressive number that depends on the date of creation.
When the four values has been read the instruction window is automatically closed and you can also close STK.

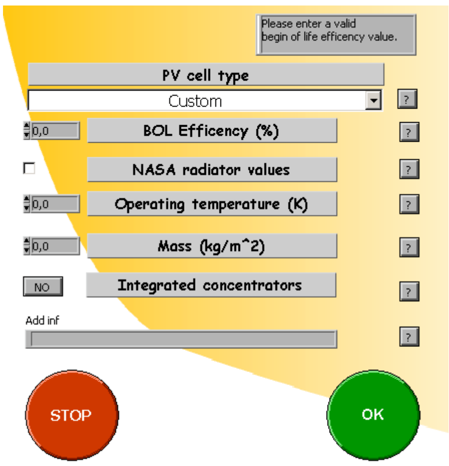
5. SELECTING THE DATA

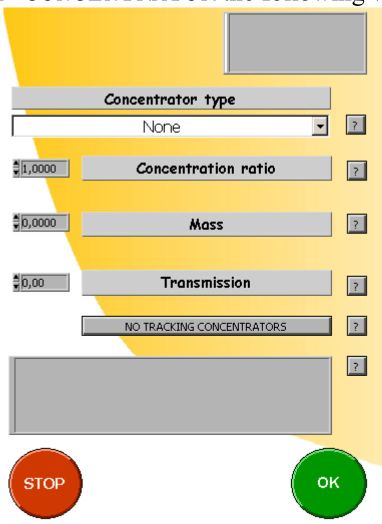
The program opens several different input windows according to the options selected in the main window.

With space-to-Earth or space-to-space application and photovoltaic power generation the following windows are displayed:

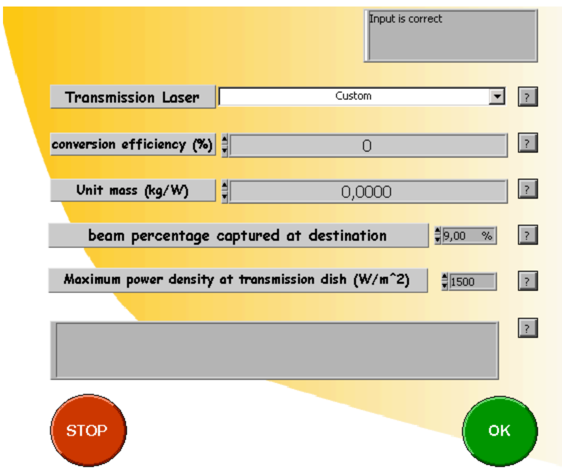


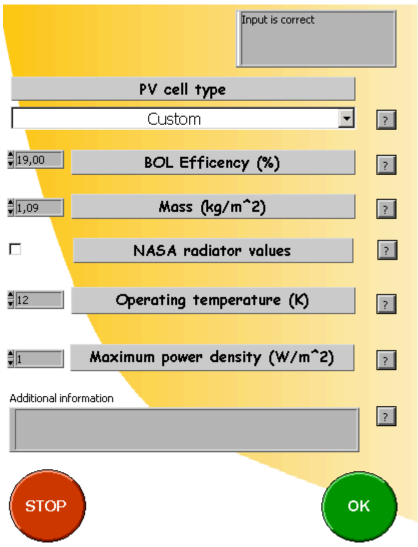
In this window you can select the kind of beam used to transfer energy, selecting laser you can also choose the wavelength band. There are two bands matching two minima of atmospheric absorption.
Clicking on `SELECT CELL` and `SELECT CONCENTRATOR` the following windows are displayed:



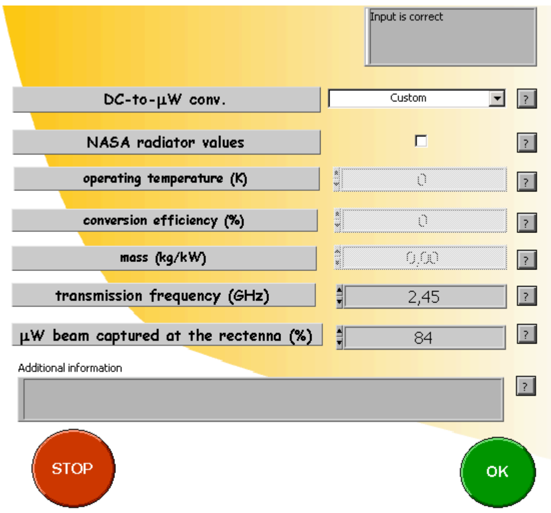


When the laser beam option is selected the following windows appear:

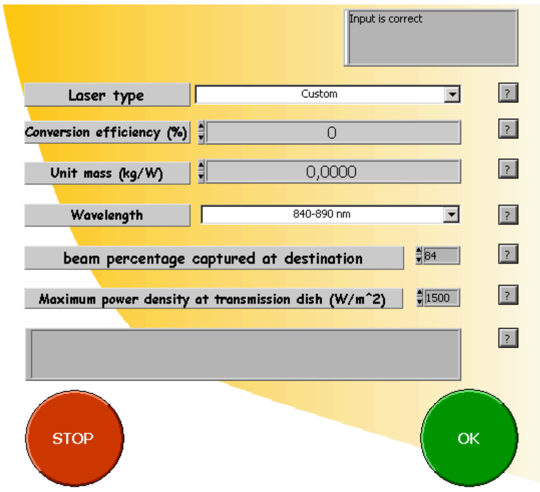


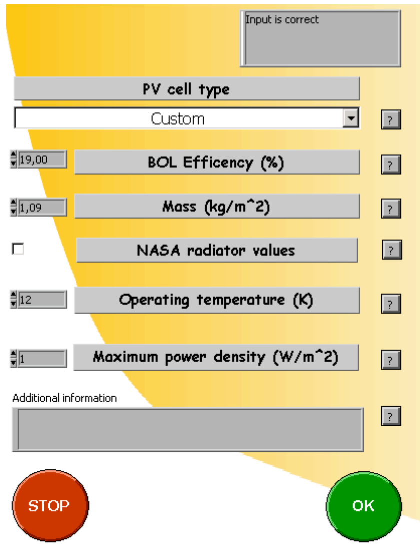


When the microwave beam option is selected the following window appears:

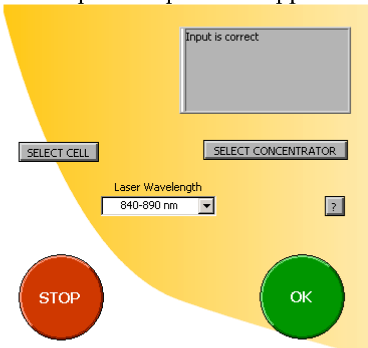


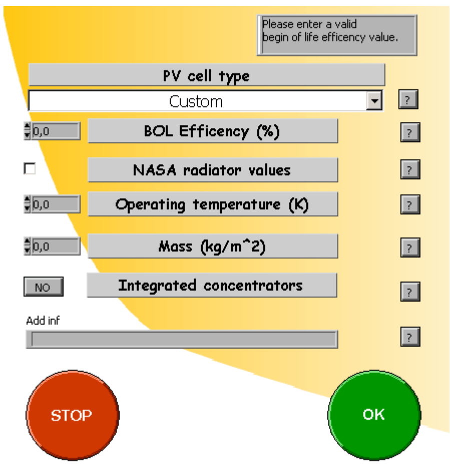
With laser power production and space-to-Earth or space-to-space application the following windows are displayed:

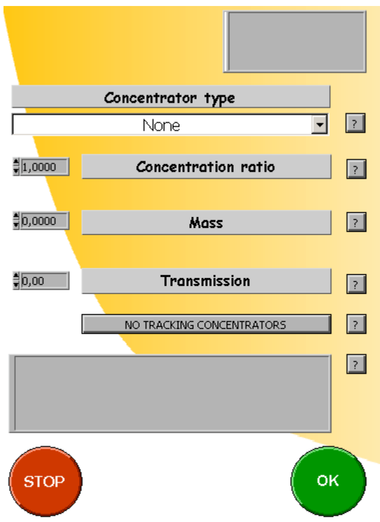


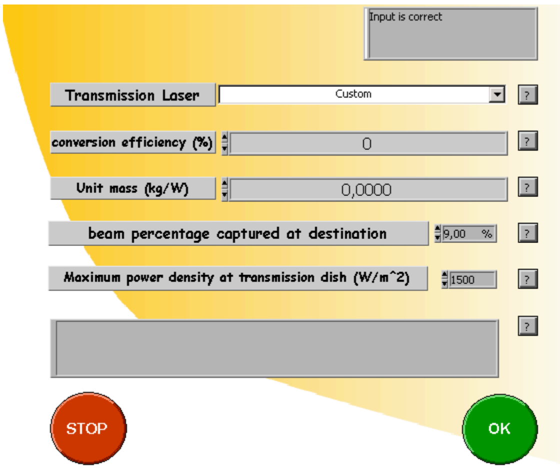


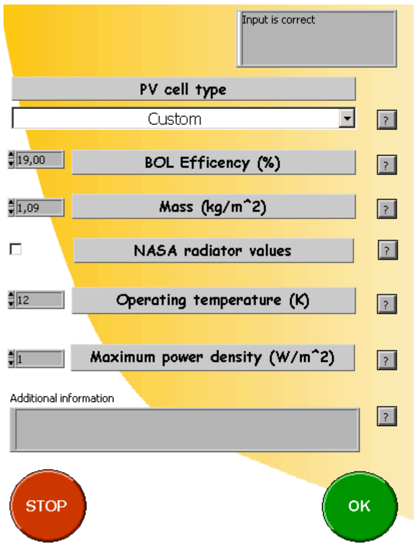
With Space-to-platform application and photovoltaic power generation

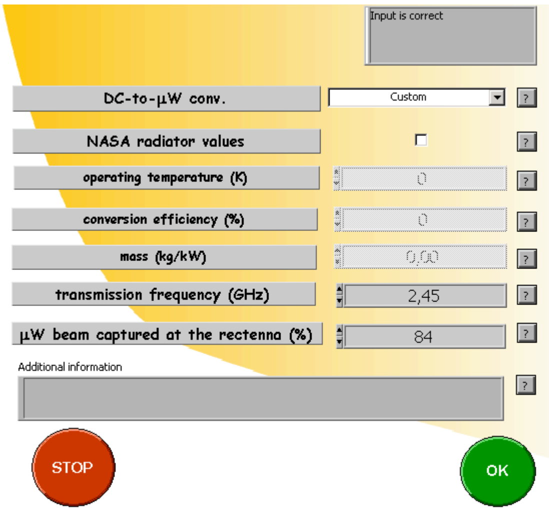




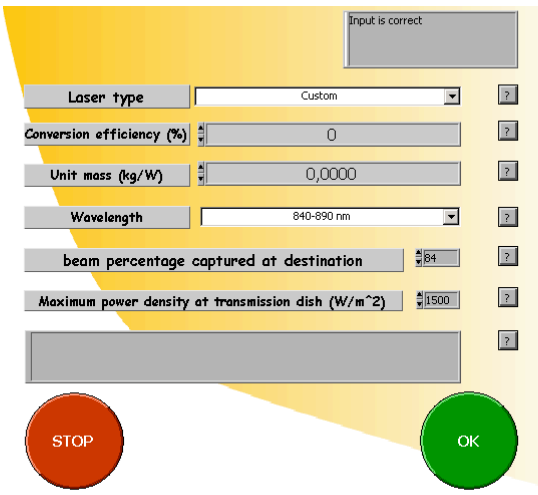


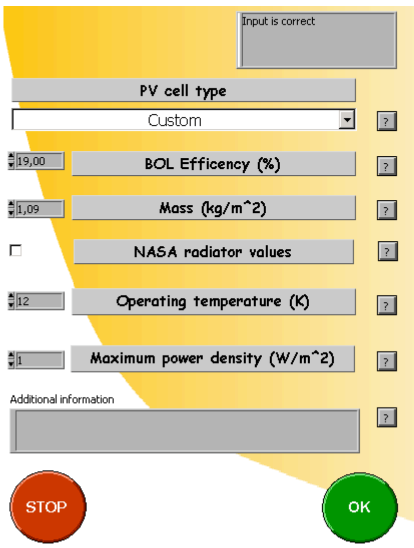


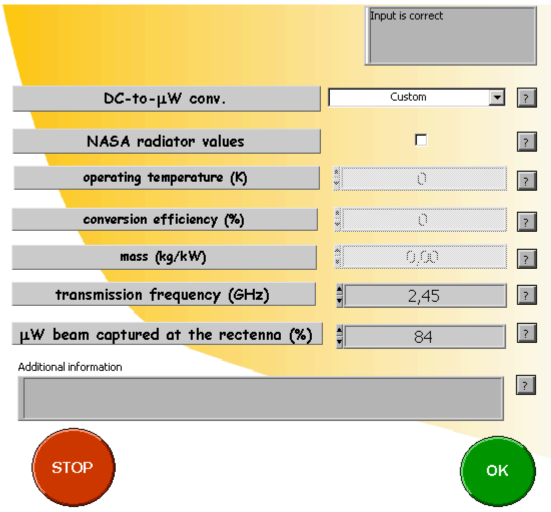




With Space-to-platform application and laser power generation

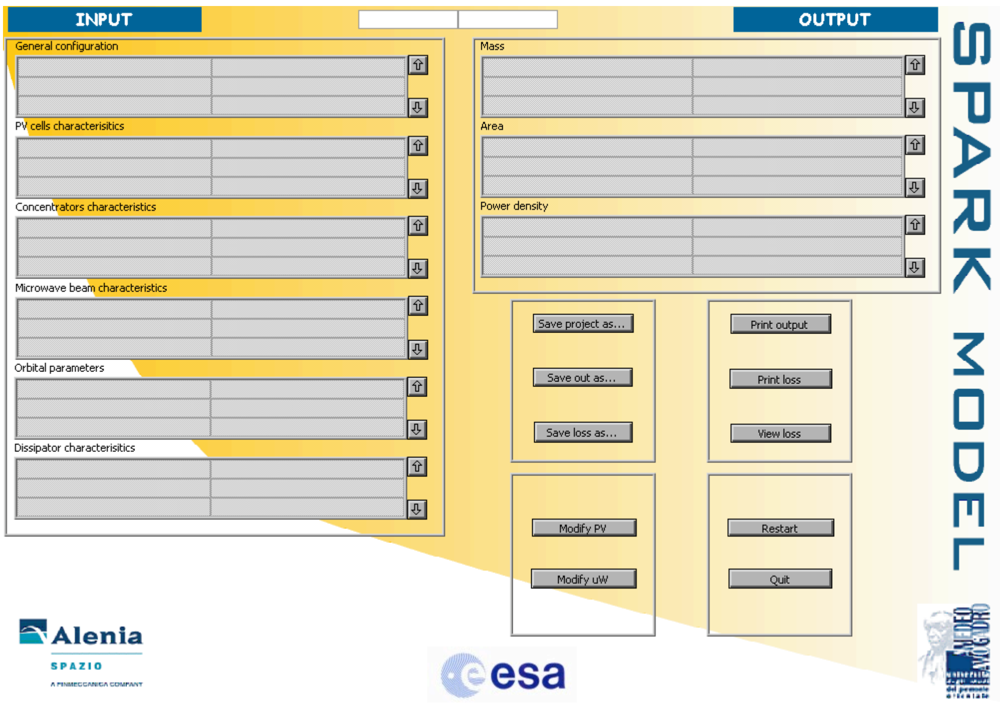






In all these windows, with the pop-up menu, you can select from different databases the device you want to use (e.g. the cell type) or, if present, select `Custom` and manually digit the data. If you select a device from the database you can't modify the data. If the data are not physically achievable (e.g. efficiency greater than 100%) the top right grey box displays an error message and you can't proceed in the input process until you write an allowed value. In the bottom grey box you can read additional information about the device you selected or, if you select `Custom` type, you can write your own comments that will appear in the output file.
In some windows there is also a checkbox labelled `NASA radiator values`, when checked the radiator specific mass from NASA Fresh Look (April 4, 1997) will be used in the following calculations, otherwise the specific mass will be calculated from the chosen operating temperature.

6. THE OUTPUT WINDOW



There are five different output windows according to the chosen configuration; all of them have the same structure. In the left part are displayed all the input parameters grouped for device, in each group you can scroll the lines

using the little up and down arrow buttons. In the right part there are the grouped output values: masses and surfaces of the elements of the SSP and power density on the receiving station.
In all the output windows are also present some buttons for saving and printing functions, for the program management.
`Save project as`… allows to save the project with a user chosen file name and path.
`Save out as`… allows to save the output data with a user chosen file name and path.
`Save loss as`… allows to save the loss table output with a user chosen file name and path.

`Print output` allows to print the output data using notepad program.
`Print loss` same as before for the loss table.

`View loss` shows on the screen the loss table.

In the different windows some buttons labelled `Modify`… allow you to recalculate output changing only the selected device. (e.g. `Modify uW` allows to modify the characteristics of the microwave generator)

`Restart` button allows you to restart the program with a new project.
`Quit` button has the obvious meaning.

7. PROGRAM AND ROUTINES DESCRIPTION

This section presents the program and main routines definition in terms of inputs, outputs and their functional relationships.

Fig. 7.1 presents the program routines while Fig 7.2 (a,b,c) contains the program logical flow

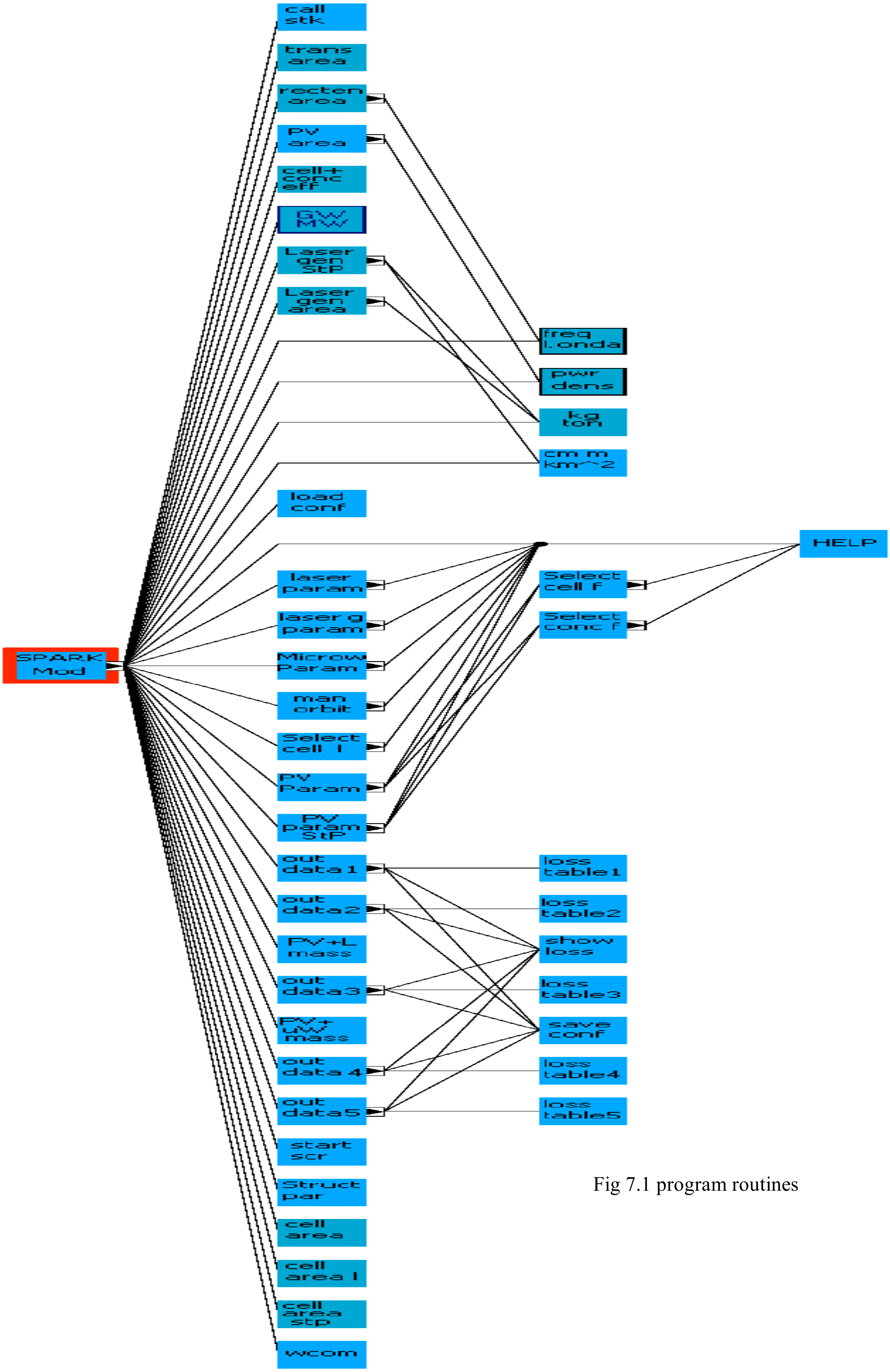


Fig 7.1 program routines

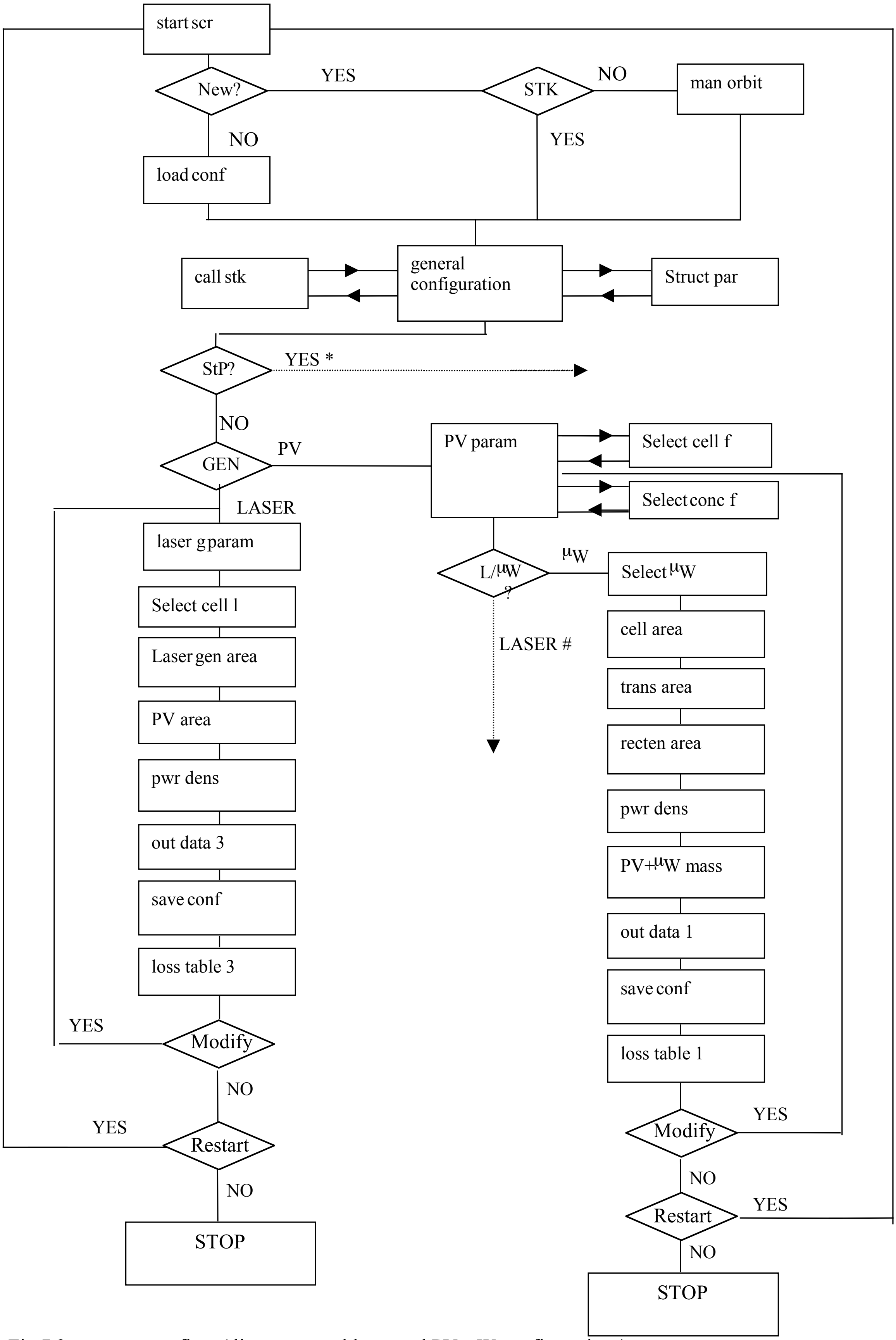


Fig 7.2- a program flow (direct pumped laser and PV-μW configurations)

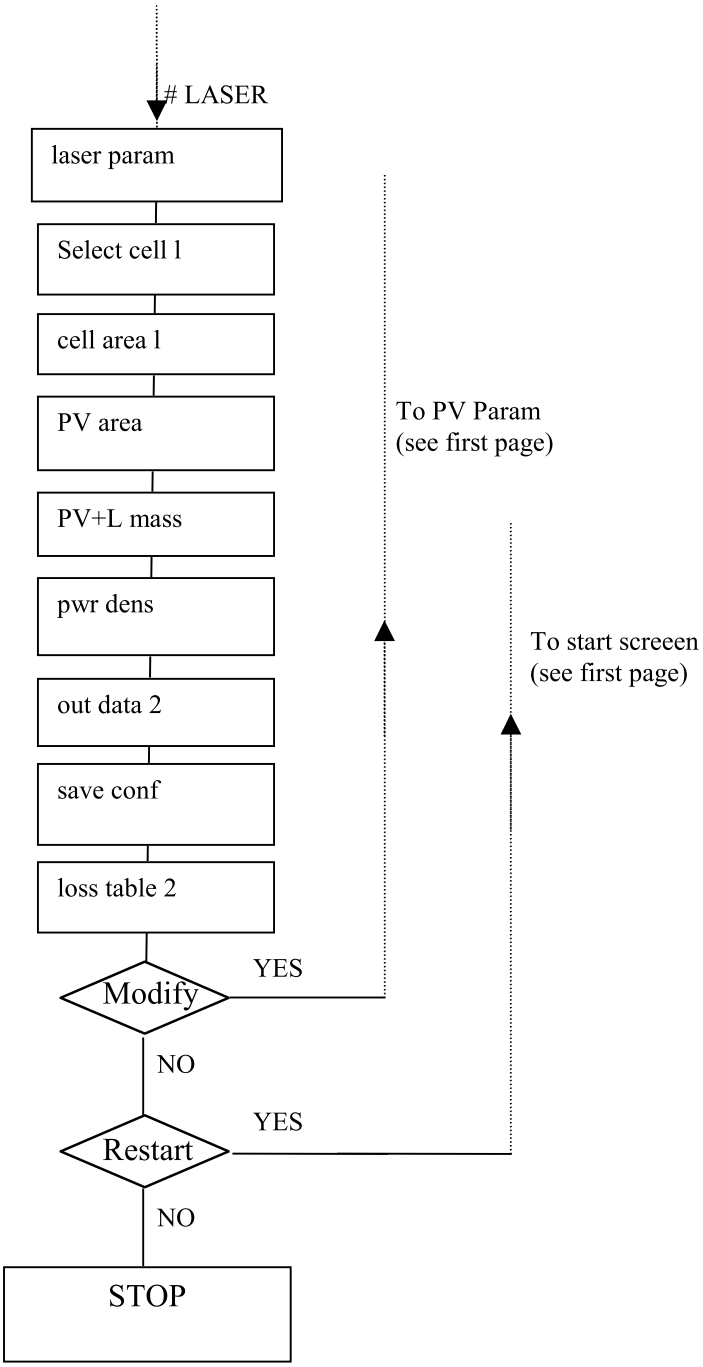


Fig 7. 2 b program flow (PV-Laser configuration)

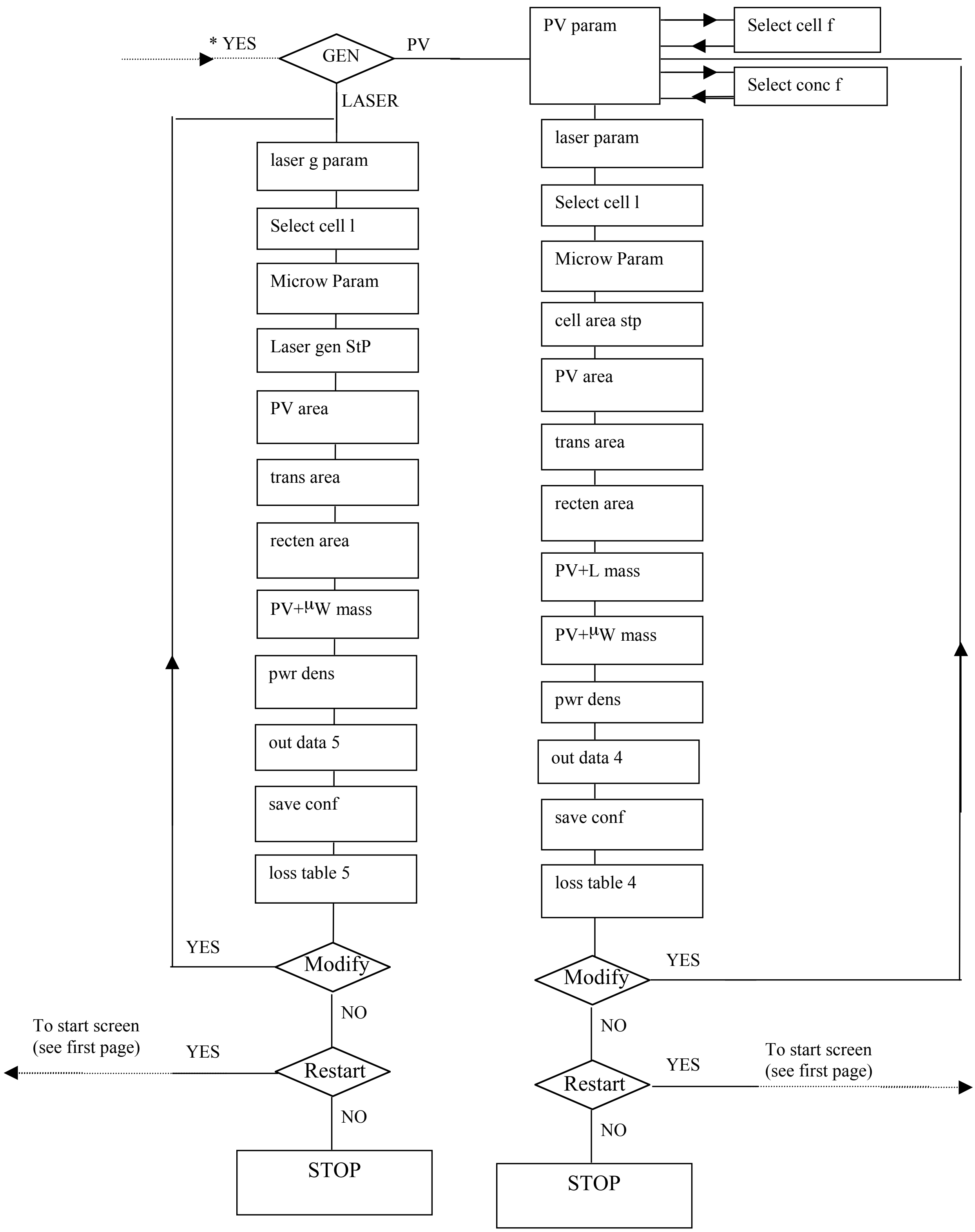


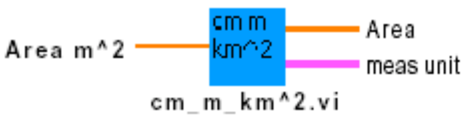
Fig 7.2- c program flow (space-platform-ground configuration)

1. **Call_STK** (call_STK.vi)

This VI calls the external program STK that calculates the satellite orbit

- access: satellite access time (day/year)
- Elevation: satellite elevation (deg)
- max distance: satellite max distance from ground receiving plant
- min distance: satellite min distance from ground receiving plant

2. **Cm_m_km**^2 (cm_m_km^2.vi)



This VI converts an area expressed in square meters into cm^2 or km^2, according to the area value itself

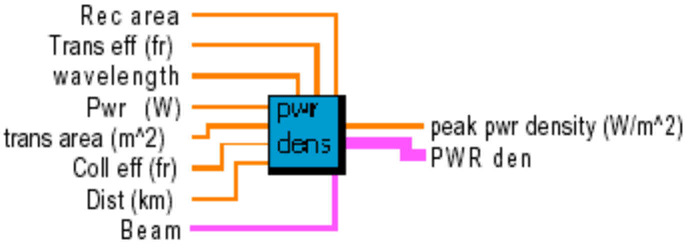
3. freql.onda (da freq a lung d'onda.vi)

This VI calculates the wavelength starting from the frequency

- f: Frequency
- Lunghezza d'onda : Wave length = $3 * 10^8 / f$

Where $3 * 10^8$ m/sec= C = velocity of light

4. **pwrdens** (densita` di potenza.vi)



This VI calculates the power density in the receiver center and the average power density at destination

- Pwr (W): transmitted power = P_t
- Wavelength: wavelenght = L
- Trans eff (fr): atmospheric efficiency (loss)
- Rec area: rectenna area
- Beam: in case laser is used, defines the wavelenght: 0→ 865 nm
  1→1.03 µm
- Dist (km): distance Km = D
- Coll eff (fr): geometric collection efficiency
- trans area (m^2): transmitting area = A_t

- peak pwr density (W/m^2): power density at rectenna center
- PWR den: vector including Average pwr density, Peak pwr density, 2nd peak pwr density, 2nd peak radius

Peak pwr density = $((A_t * P_t)/(L^2 * D^2)) * \text{Trans eff}$

Average power density = (Trans eff * Coll eff * P_t) / Rec area

2nd peak pwr density = peak pwr density * 0.0175

2nd peak radius = $1.635 * L*D/(\text{sqrt}(A_t/\pi)$

5. **trans-area** (diametro ant trasm mod.vi)

This VI calculates the transmitting antenna area

• atm trans (fract)	Atmospheric efficiency (loss)=atm
• eff.gen. (fraz):	μw generation efficiency = n
• op.temp. (°K)	Operating temperature = T
• Trans diameter km:	Transmitting area diameter = D_t
• power density on transmitti...	RF power density = denspot
• Pwr on rectenna (W):	Power at rectenna = Psurec
• Trans area m^2:	Transmitting area = A_t

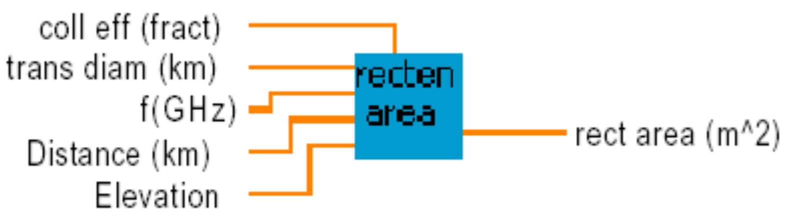
denspot= $(n/(1-n))*(5.67*T^4*10^{-8})$ ($5.67*10^{-8}$ is the stefan-Boltzmann constant)

A_t = Pant/denspot

D_t= sqrt((4* A_t)/π)

Psurec=(0.98*atm)*Pant (0.98 = beam forming antenna efficiency)

6. recten area (diametro della rectenna_mod.vi)



Thi VI calculates the rectenna area

• trans diam (km):	transmitting source diameter = D_t
• coll eff (fract)	geometric collection efficiency = eta
• Elevation:	elevation angle = E
• Distance (km):	distance = D
• f(GHz):	frequency
• rect area (m^2):	rectenna area

tau=sqrt(ln(1/(1-eta)))

Dr=((4*L*D*tau)/(3.1416*Dt))/1000

r e c = D * s i n (a t a n (D r / D)) / s i n (E - a t a n (D r /D)) D

L= wave length = 3 * 10^8/ f
Dt = spacetenna diameter
Dr = Rectenna Diameter

7. Cell+concef (eff_con eff nota_mod.vi)

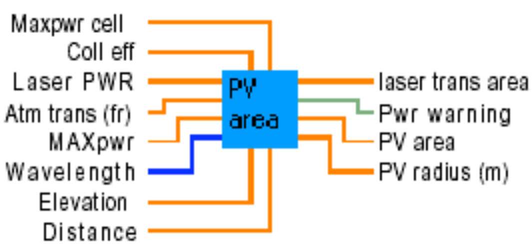
Thi VI calculates the efficency of the array formed by PV cells and concentrators

- cel eff (%) — cell efficiency =eff
- Conc ratio: — concentration ratio
- trasm Eff (fract) — concentrator effciency

- PV eff(fract) — cells+concentrators efficiency

ndec = log (Conc ratio)
PV eff = (eff+(0.02*ndec))* trasm Eff
(the PV efficiency increases of about 2% for each decade of concentrion ratio; then the overall efficiency is degraded due the concentrator efficiency)

8. Ground PV area (Ground_PV_area.vi)



This VI calculates the area of the ground PV array for laser power transmission

- Laser PWR: Laser generated power

- Coll eff: geometric collection efficiency = eta
- Maxpwr cell max power density allowed by selected PV cell
- Distance: distance = Dist
- Elevation: elevation angle = E
- Wavelenght wavelenght: selection : 0→ 865 nm = L
  1→1.03 µm = L
- MAXpwr: Max power density allowed by laser optics
- Atm trans (fr): atmospheric effciency (loss)

- laser trans area: laser transmitting area = At
- Pwr warning alert that the peak power density is greater than the maximum allowed by selected ground Pvcells, the fpcos spot at receiver is then enlarged
- PV area: ground PV area
- PV radius (m): ground PV area radius = Rec

Tau =sqrt((ln(1/(1-eta)))
Ar = $(\text{tau}*L*\text{Dist})^2/\text{At}$
Dr = Sqrt (Ar/π)
Rec = Dist*sin(atan(Dr/Dist))/sin(E-atan(Dr/Dist))
PV area = $\pi * \text{Rec}^2$

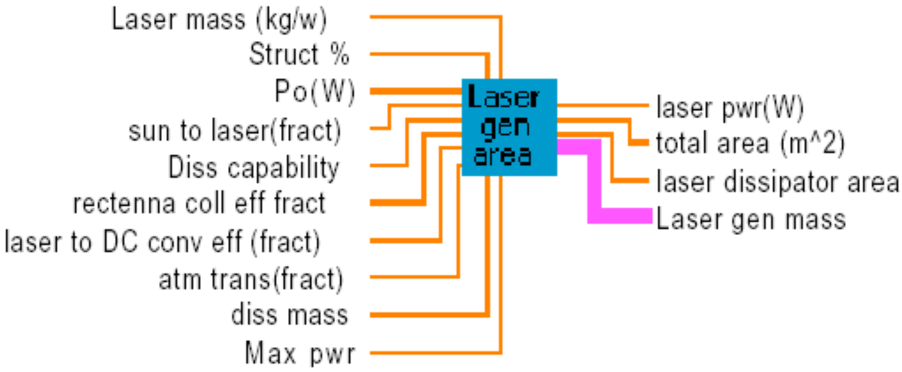
9. GW_MW_kW (GW_MW_kW.vi)

This VI converts a power expressedn in W, kW, MW or GW into W

10. kg_ton_tons (kg_ton_tons.vi)

This VI converts a mass expressed in tons into kg, according to the mass value itself

11. lasergen_area (lasegen_area.vi)

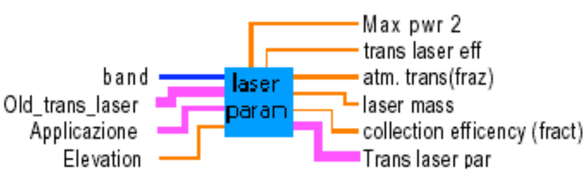


This Vi provide laser section sizing for Direct solar pumped laser configuration

Po(W):	Power required at end user = Po
Struct %:	Structural part percentage
Laser mass (kg/w):	laser mass per generated watt
Max pwr:	Max power density allowed by laser optics
diss mass:	thermal dissipator mass per area (Kg/m^2)
atm trans(fract):	atmosphere efficiency (loss)= atm
laser to DC conv eff (fract):	Ground PV cells conversion efficiency= cell
rectenna coll eff fract:	ground geometric collection fraction = coll
Diss capability	dissipation capability for m^2
sun to laser(fract):	sun to laser conversion efficiency = laser
laser pwr(W)	Laser generated power = Plaser
total area (m^2)	Laser area = Suptot
laser dissipator area:	Thermal dissipators area
Laser gen mass	Array including : overall mass, laser section mass, dissipator mass

Suptot=Po/(1350*laser*cell*atm*coll);
Plaser=Suptot*1350*laser;
Pinlaser=Suptot*1350;
Laser dissipator area = (laser * Pinlaser)/ Diss capability
laser mass = Plaser *laser mass
Laser diss. Mass = laser dissipator area * diss mass
Mirror mass (if mirrors are used)= (Plaser/Max pwr)* mirror unit mass (Kg/m^2)
Total mass = (laser mass+Laser diss.Mass+Mirror mass)*Struct%+(laser mass+Laser diss Mass+Mirr.mass)

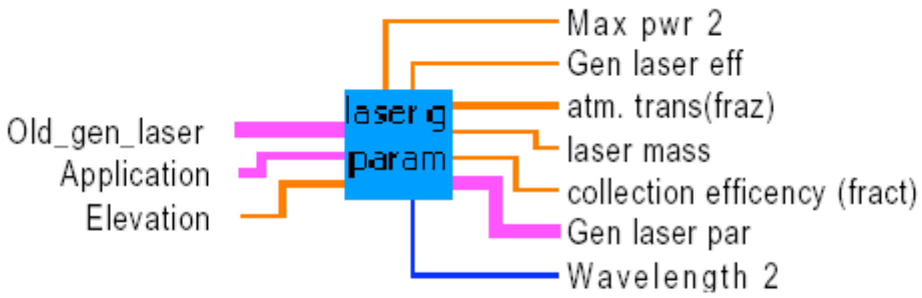
12. **Laser parameters** (laser_param_dati_file.vi)



- band: laser bandwith
- Applicazione type of application (space to earth, space to platform, space to space)
- Old_trans_laser : previously saved laser parameters array
- Elevation elevation angle

- Max pwr 2 Max power density allowed by optical system
- trans laser eff DC to Laser conversion efficiency
- atm. trans(fraz) atmospheric absorbtion
- laser mass mass per transmitted watt (Kg/W)
- collection efficiency (fract) ground geometric collection fraction
- Trans laser par Arrays laser characteristics

13. **Laser g param** (Laser_sun_pump_dati_file.vi)

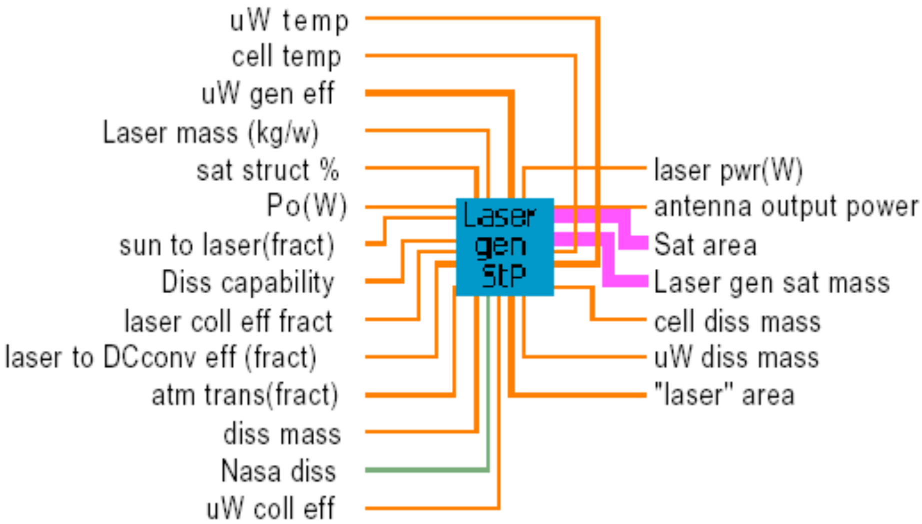


With this vi, the user can select from a data base the transmission laser type or manually input several parameter

- Application type of application (space to earth, space to platform, space to space)
- Old_trans_laser : previously saved laser parameters array
- Elevation elevation angle

- Max pwr 2 Max power density allowed by optical system
- gen laser eff Laser generation efficiency
- atm. trans(fraz) atmospheric absorption
- laser mass mass per transmitted watt (Kg/W)
- collection efficiency (fract) ground geometric collection efficiency
- Gen laser par Arrays of laser characteristics
- Wavelenght2 wave length

14. **Lasergen_area_Stp** (Lasergen_area_Stp.vi)



This Vi provides sizing for laser and µW sections in the "space – platform- ground" application

• Po(W):	Power required at end user = Po
• Sat Struct %:	Structural part percentage
• Laser mass (kg/w):	laser mass per generated watt
• diss mass:	thermal dissipator mass per area (Kg/m^2)
• atm trans(fract):	atmosphere efficiency (loss)= atm
• laser to DC conv eff (fract):	Ground PV cells conversion efficiency= cell
• laser coll eff fract:	laser collection PV efficiency = laserce
• Diss capability	dissipation capability for m^2
• sun to laser(fract):	sun to laser conversion efficiency = laser
• µw gen eff	µw generation efficiency =DC to µw
• µw coll eff:	ground geometric collection efficiency laser pwr(W) =µwce
• cell temp	Platform PV cell operative temperature
• uW temp	Platform RF section operative temperature = uWT
• NASA diss:	NASA RF section operative temperature

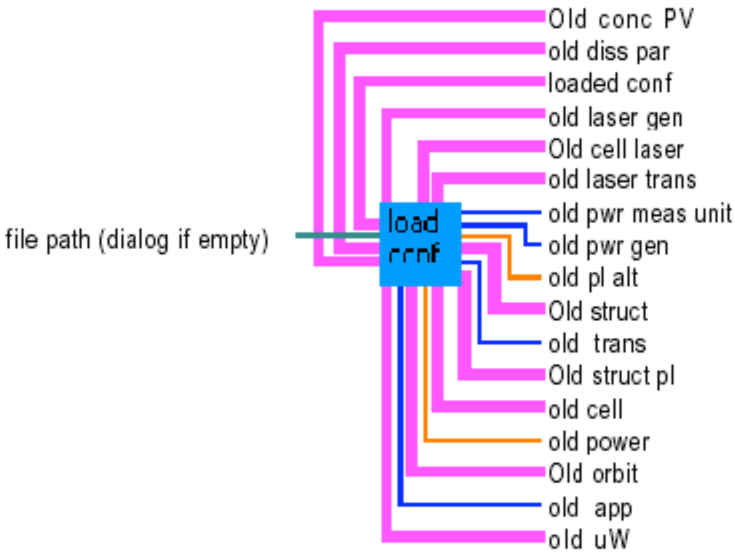
• laser pwr(W)	Laser generated power = Plaser
• antenna output power	RF antenna power = Pant
• Sat area	array including laser area, platform PV area (Suptot)
• Laser gen sat mass	array including: laser section mass, laser dissipator mass, total satellite mass
• cell diss mass	mass of platform PV cells dissipator
• uW diss mass	mass of platform RF section dissipator
• "laser" area	laser area

Suptot=Po/(1350*laser*laserce*cell*cable*DCtouW*uWce*atm*uWtoDC*antenna);
Plaser=Suptot*1350*laser;
Pinlaser=Suptot*1350;
Pincell=Plaser*laserce;
PinuW=Pincell*cell*cable;
Pant=PinuW*DCtouW*antenna;
Celldiss=10^(2.94-0.00624*CellT+2.4e-6*CellT^2);
uWdiss=10^(2.94-0.00624*uWT+2.4e-6*uWT^2);
cable = 0.92 cable efficiency (loss)
antenna = 0.98 antenna efficiency (loss)

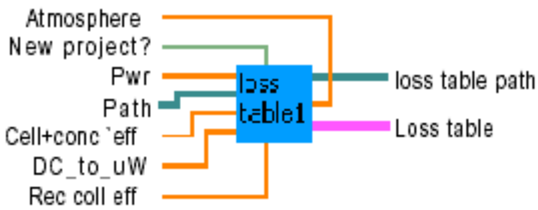
laser section mass = Plaser *Laser mass (Kg/W)
Laser diss. Mass = laser* Pinlaser/Diss capability * diss mass
Mirror mass (if mirrors are used)= (Plaser/Max pwr)* mirror unit mass (Kg/m^2)
Laser gen sat mass = (laser mass+Laser diss.Mass+Mirror mass)*Struct%+(laser mass+Laser diss Mass+Mirr.mass)

cell diss mass= cell*Pincell*Celldiss
uW diss mass = DC to μw PinμW* μWdiss

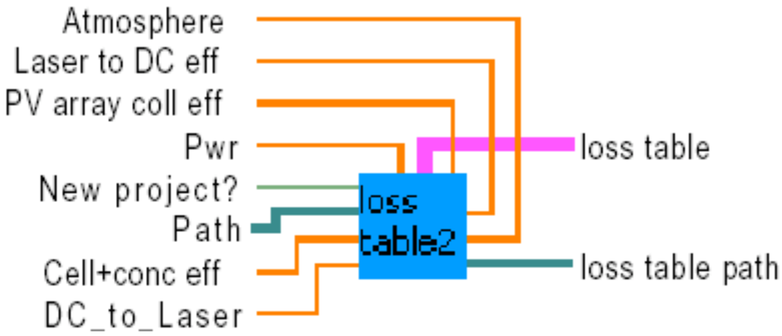
15. **Load_conf** (load_conf.vi)



This vi loads last saved configuration data

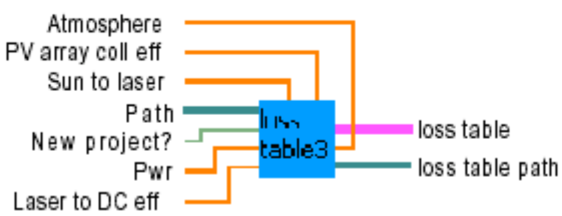


17. **Loss_table2** (loss_table2.vi)



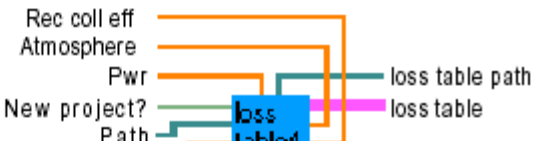
This VI writes in a file the power percentage lost in every step for the PV-laser configuration

18. **Loss_table3** (loss_table3.vi)

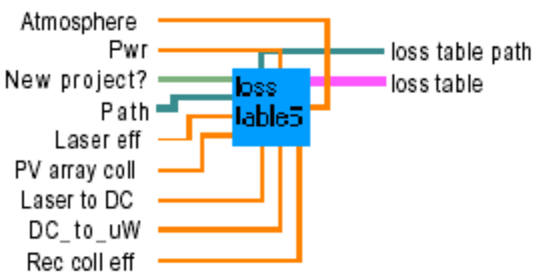


This VI writes in a file the power percentage lost in every step for the Direct-pumped laser configuration

19. **Loss_table4** (loss_table4.vi)

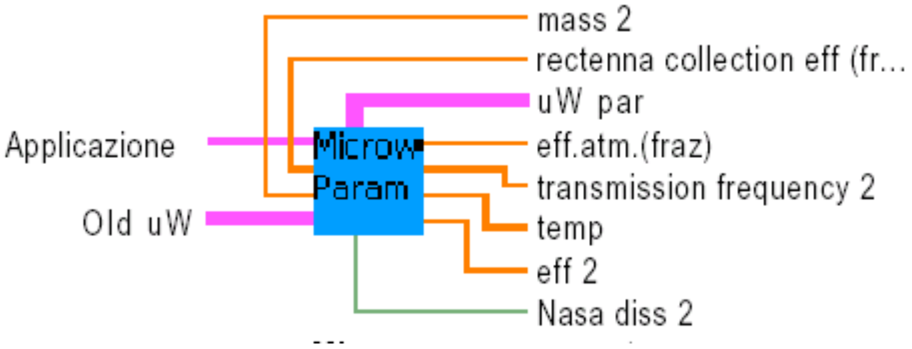


20. Loss_table5 (loss_table5.vi)



This VI writes in a file the power percentage lost in every step for the dierct pumped laser -platform configuration

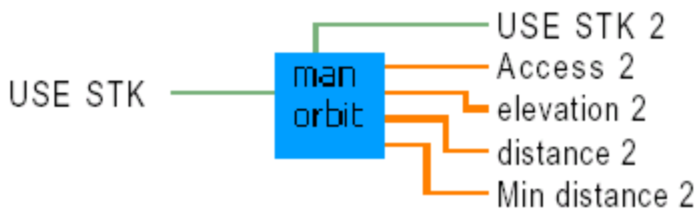
21. Microwave Parameters (Microwave_param_dati_file.vi)



With this VI the user can select from a database the microwave generator type or manually input parameters

• Applicazione:	type of application
• Old uW	last saved µw data file
• eff.atm.(fraz)	atmospheric efficiency (loss)
• transmission frequency 2	trasmission frequency
• temp	operative temperature
• eff 2	RF section efficiency
• Nasa diss 2	NASA used operative temperature values
• mass 2	mass/power
• uW par rectenna collection eff (fr...	ground rectenna collection efficiency
• uW par	µw parameters array

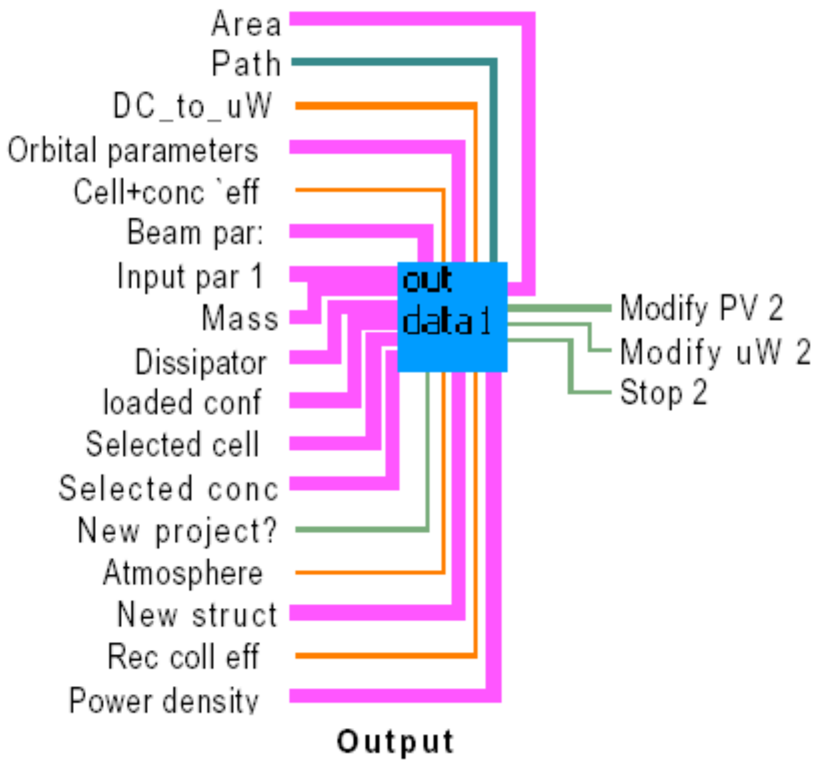
22. **Orbit Options** (orbit_manual.vi)



This VI calls the STK program

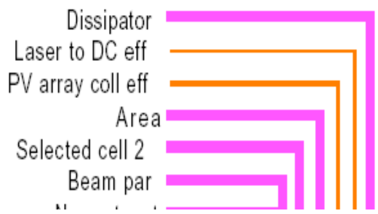
• Access 2	access time (days/year)
• elevation 2	elevation angle with respetc to ground station
• distance 2	max distance
• Min distance 2	minimum distance

23. **Output Data1** (Output_data1.vi)

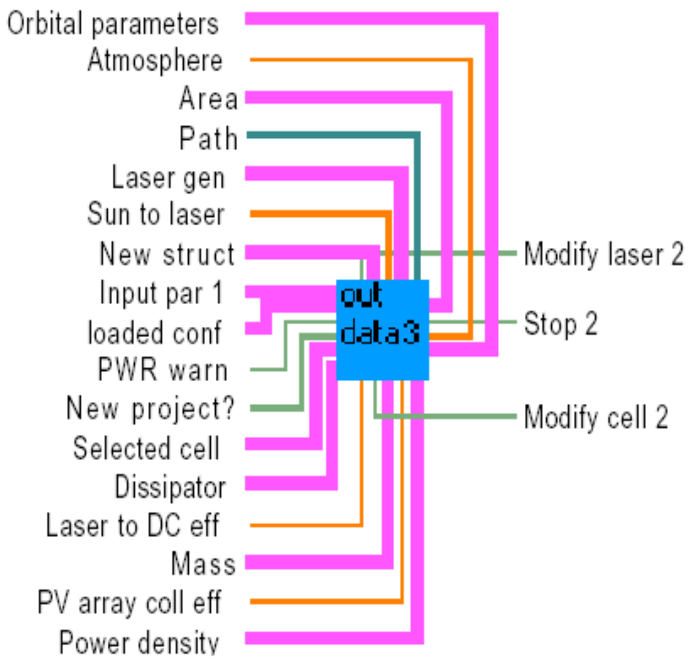


This VI writes in a file the Input and Output Data for the PV-µw configuration

24. **Output Data2** (Output_data2.vi)

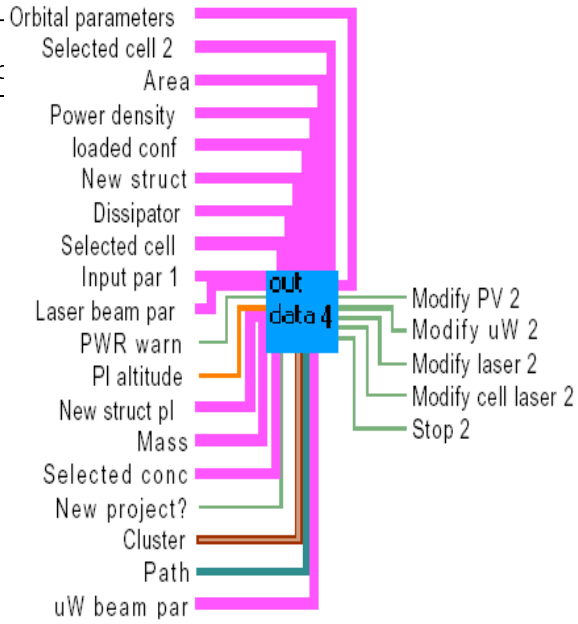


25. **Output Data3** (Output data3.vi)



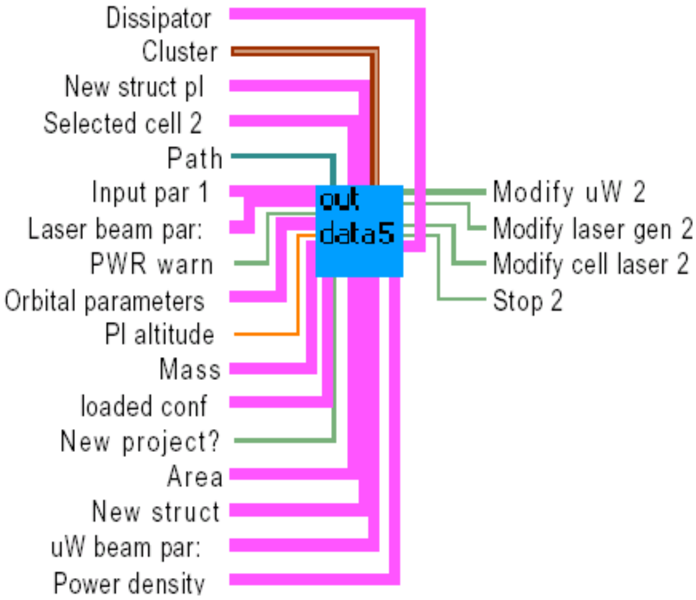
26. **Output I**

This VI writes in a file the Input and Output Data for the direct pumped laser configuration



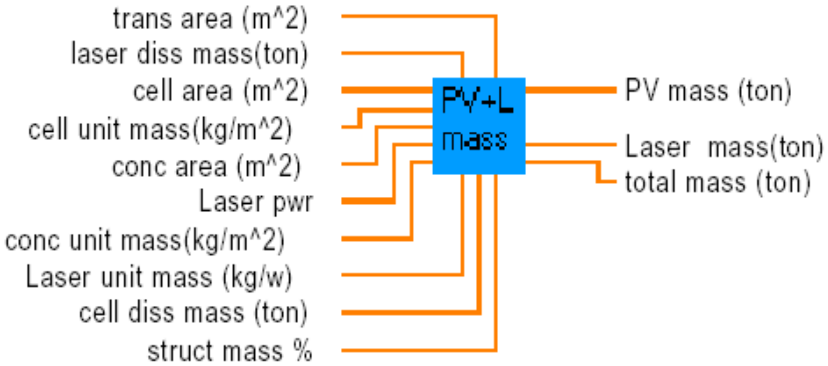
This VI writes in a file the Input and Output Data for the Pv-laser -platform configuration

27. Output Data5 (Output_data5.vi)



This VI writes in a file the Input and Output Data for the dierct pumped laser -platform configuration

28. **Pesi_Pv+Laser** (Pesi_Pv+Laser.vi)

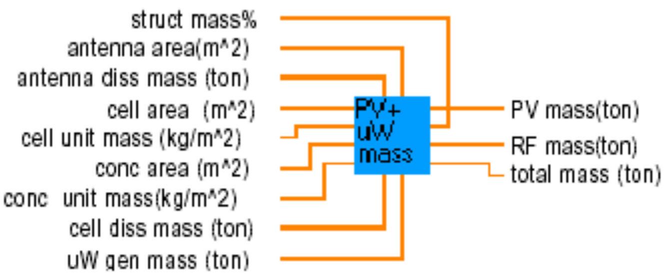


This VI calculate the mass of PV and laser sections in the PV-laser configuration

• cell area (m^2)	PV cells area
• laser diss mass(ton)	mass of laser section dissipators
• trans area (m^2)	Laser area
• struct mass %	structural part mass percentage
• cell diss mass (ton)	mass of PV section dissipators
• Laser unit mass (kg/w)	laser mass/watt
• conc unit mass(kg/m^2)	concentrators mass/area
• Laser pwr	emitted laser power
• conc area (m^2)	concentrators area
• cell unit mass(kg/m^2)	PV cells mass/area

• PV mass (ton)	PV section overall mass (includes dissipators and concentrators)
• Laser mass(ton)	Laser section overall mass
• total mass (ton)	

29. **Pesi_Pv+uW** (pesi_PV+uW.vi)

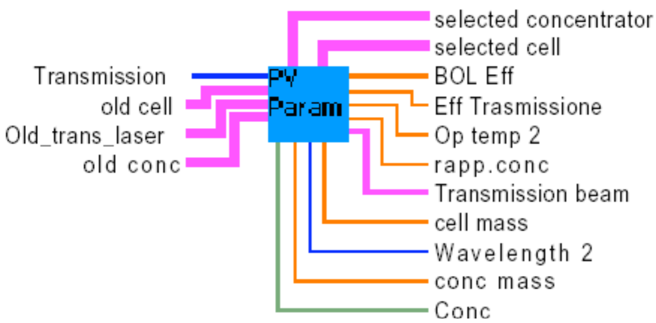


This VI calculates the masses of power generation and power transmission systems

- struct mass % — structural part mass percentage
- antenna area(m^2) — antenna area
- antenna diss mass (ton) — mass of RF section dissipators
- cell area (m^2) — PV cells area
- cell unit mass(kg/m^2) — PV cells mass/area
- conc area (m^2) — concentrators area
- conc unit mass(kg/m^2) — concentrators mass/area
- cell diss mass (ton) — mass of PV section dissipators
- Laser unit mass (kg/w) — laser mass/watt
- uW gen mass (ton) — μw generator section mass

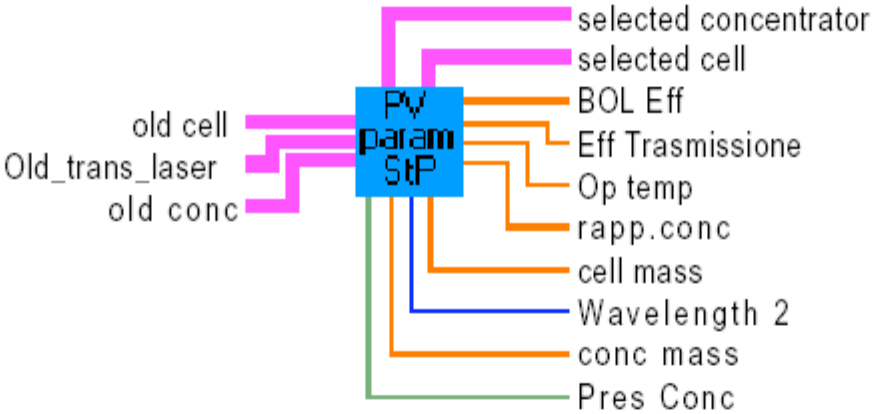
- PV mass (ton) — PV section overall mass (includes dissipators and concentrators)
- RF mass(ton) — RF section overall mass
- total mass (ton)

30. **Photovoltaic Parameters** (PV_param_pop_up.vi)



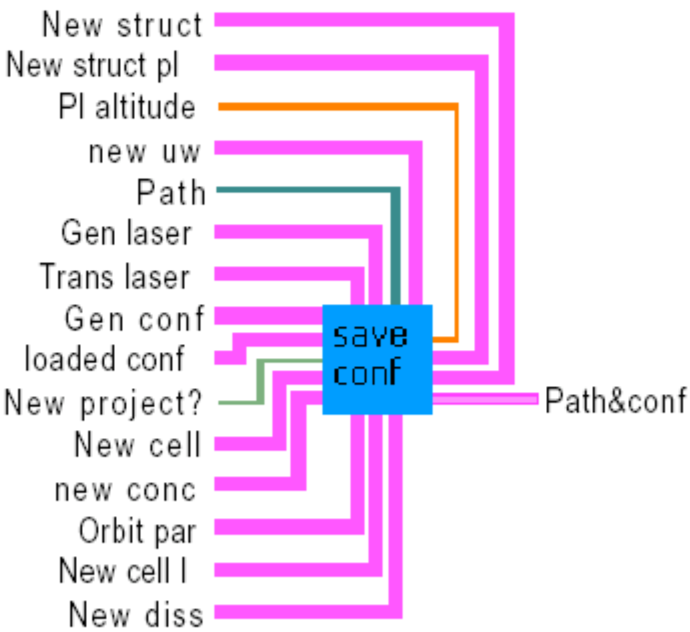
Whit this VI the user can select the power transmission system, the cell and the concentrator

31. **Photovoltaic parameters** (PV_Param_Stp.vi)

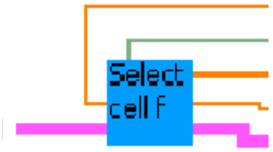


With th s VI the user can select the values for PV cells, Laser and concentrators in the Space to platform configuration

32. **save_conf** (save_conf.vi)

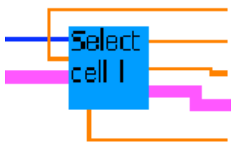


33. This Vi saves into a file all input data



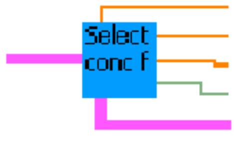
Whit this VI the user can select a PV cell type for solar acquisition from a database and manually modify several parameters

34. **Select** cell (select_cell_laser.vi)



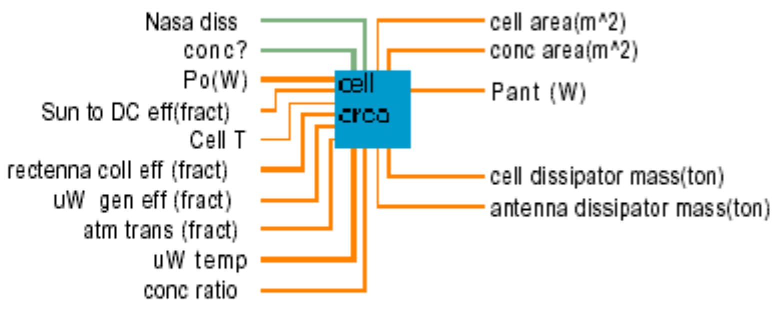
Whit this VI the user can select a PV cell type for laser acquisition from a database and manually modify several parameters

35. **Select Concentrator** (select_conc_dati_file.vi)



Whit this VI the user can select a concentrator type from a database and manually modify several parameters

36. **Cell area** (Superficie celle Dt output rapp_conc_mod.vi)



This VI calculates the PV area for PV-µw configuration, and the dissipators mass

- Po(W) — Power required at end user = Po
- conc? — Use of concentrator ?
- Nasa diss — NASA value for RF section operative temperature
- conc ratio — concentration ratio
- uW temp — µw generator operative temperature = µwT
- atm trans (fract) — Atmosphere efficiency (loss) = atm
- uW gen eff (fract) — µw generation efficiency = n
- rectenna coll eff (fract) — rectenna geometric collection efficiency = conv
- Cell T — PV cells operative temperature CellT
- Sun to DC eff(fract) — PV cells efficiency =cell

- cell area(m^2) — space PV cells area
- conc area(m^2) — concentrators area
- Pant (W) — RF power
- cell dissipator mass(ton) — PV section dissipators mass =
- antenna dissipator mass(ton) — RF section dissipators mass

Ptrasm=Po/(n*antenna*atm*conv*RFtoDC*Cable);
RF to DC =0.89
Cable = 0.92
Antenna = 0.98
Suptot=(Ptrasm/(cell*1350));
Pant=Suptot*1350*cell*n*Cable*antenna;
Pinant=Suptot*1350*cell*Cable;

uWdiss=10^(2.94-0.00624*uWT+2.4e-6*uWT^2);

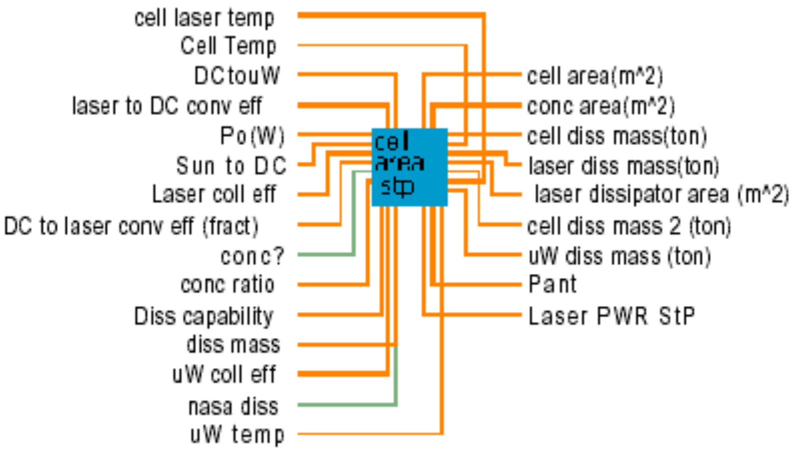
Celldiss=10^(2.94-0.00624*CellT+2.4e-6*CellT^2);

37. **Laser Cell Surface Area** (Superficie celle laser.vi)

• Po(W)	Power required at end user = Po
• conc?	Use of concentrator ?
• laser to DC conv eff fract	ground laser to DC conversion efficiency =lasertoDC
• Cell temp	PV cells operative temperature CellT
• conc ratio	concentrationr ratio
• diss mass	laser dissipator mass/area
• atm trans(fract)	Atmosphere efficiency (loss) = atm
• DC to laser conv eff (fract)	Laser efficiency = n
• rectenna coll eff fract	ground station geometric collection efficiency = conv
• Diss capability	max laser optic dissipation capability
• sun to DC(fract)	PV section eficiency
• cell area(m^2)	space PV cells area
• conc area(m^2)	concentrators area
• Pout_celle (W)	space PV section output power =Ptrasm
• laser pwr(W)	laser emitted power = Plaser
• laser dissipator area	
• cell diss mass(ton)	PV section dissipators mass
• laser diss mass(ton)	laser section dissipators mass

```
Ptrasm=Po/(n*atm*conv*LasertoDC*Cable);
Suptot=(Ptrasm/(cell*1350));
Plaser=Suptot*1350*cell*n*Cable;
Pinlaser=Suptot*1350*cell*Cable;
Celldiss=10^(2.94-0.00624*CellT+2.4e-6*CellT^2);
Cable=0.92
```

38. **Cell Surface Area** (superficie celle Stp.vi)



This VI provides sizing for space PV in the PV-laser – platform configuration

• Po(W)	Power required at end user = Po
• laser to DC conv eff	ground laser to DC conversion efficiency =lasertoDC
• DCtouW	platform µw generation efficiency
• Cell Temp	PV cells operative temperature CellT
• cell laser temp	platform PV cells operative temperature
• uW temp	platform µw section operative temperature
• nasa diss	NASA operative temperature value
• uW coll eff	rectenna geometric collection efficiency
• diss mass	laser dissipator mass/area
• Diss capability	max laser optic dissipation capability
• conc ratio	concentrationr ratio
• conc?	Use of concentrator ?
• DC to laser conv eff (fract)	Laser efficiency = n
• Laser coll eff	platform PV cell efficiency
• Sun to DC	space PV section eficiency
• cell area(m^2)	space PV cells area
• conc area(m^2)	concentrators area
• cell diss mass(ton)	space PV section dissipators mass
• laser diss mass(ton)	laser section dissipators mass
• laser dissipator area (m^2)	area of laser dissipators
• cell diss mass 2 (ton)	platform PV dissipator mass
• uW diss mass (ton)	platform RF section dissipator mass
• Pant	platform radiated power
• Laser PWR StP	laser emitted power

```
Poutcell=Po/(DCtoL*antenna*atm*Lce*LasertoDC*Cable^2*DCtouW*atm*uWce*uWtoDC);
Suptot=(Poutcell/(suntoDC*1350));
Pinlaser=Suptot*1350*suntoDC*Cable;
Pincell2=Pinlaser*DCtoL*Lce;
PinuW=Pincell2*LasertoDC*Cable;
```

```
Pant=PinuW*DCtouW*antenna;
Plaser=Suptot*1350*suntoDC*DCtoL*Cable;
uWdiss=10^(2.94-0.00624*uWT+2.4e-6*uWT^2);
Celldiss=10^(2.94-0.00624*CellT+2.4e-6*CellT^2);
```