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User Manual of the TASK/EQ Code

Contents

1 How to run TASK/EQ

1.1 Start TASK/EQ

Move to the task/eq directory and run the eq code by entering the file name. In order to distinguish it from command names, it should be full path name or ./file_name for the file in the present directory.

```
cd eq

./eq
```

1.1.1 Graphic setting

At the beginning of the task code run, graphic settings are requested.

The first inquiry is the resolution of the graphic output. Enter a one character and hit return.

0: no graphic output; graphic data can be saved in a file

1: 512x380

2: 640x475

3: 768x570

4: 896x665

5: 1024x760

6: 1280x950

7-9: obsolete; to be deleted

The second inquiry is a one-character command to define the output of graphic data.

C: continue without graphic output

F: save graphic data to a file; the file name to be used will be asked

O: option setting; paper size, screen title, file output are inquired

H: help for one character command input at each end of page

Q: quit; terminate the code

Graphic setting can be skipped by defining a environmental variable GSGDP.

export GSGDP="5c"

1.1.2 Menu input

After the graphic setting, the TASK component EQ show a menu and accept a line of command input, one character command or parameter change.

- Typical one character command (the first character of a line, both upper- and lower-case work)

  P: change parameter as a namelist input with group name eq

  V: show input parameters

  R: start a run after initialization

  C: continue the run

  G: graphic output mode

  S: save present status data

  L: load previously save status data

  Q: quit the component

- Parameter change

  – You can change the input parameters listed in eqinit.f90 with a form similar to a component of the namelist input; for example

  ```
  rr=3.D0
  pn(1)=0.5D0, pn(2)=0.4D0, pn(3)=0.1D0
  pn=0.5D0,0.4D0,0.1D0
  modelg=3
  knameq='eqdata.ITER'
  ```

  – A input line including a character "=" is considered as a parameter change.

1.2 Input parameter

The input parameters and their default values are defined in eqinit.f90. The sequence of parameter setting is as follows.

1. The default parameters are defined in eqinit.f90.

2. At the beginning of executing eq, if there exists a namelist file eqparm or eqparm.nl, the component reads the namelist file. The namelist file has a form

```
&eq
 rr=3.D0
&end
```

3. During the operation of the eq component, input parameters can be changed through the menu interface. The command line input like `rr=3.D0` or the namelist input through"P" command changes the input parameters.

1.3 Save graphic data

Entering "G" command for the menu input, the graphic command input is prompted. The graphic command, a sequence of characters, depends on the TASK component. "X" command is to exit the graphic menu and go back to the main menu.

The graphic output is page base. After drawing a page, a key input is waited on the graphic window, unless "0" graphic mode is chosen at the beginning of component operation.

Following key inputs are acceptable:

C or Return key : continue operation

F: open graphic file and start to save following pages

S: save this page, open graphic file if not yet opened

Y: save this page

N: do not save this page

X: switch on/off of saving pages

B: switch on/off the bell sound at the end of drawing page

D: dump a bitmap of this page to a file and draw it in a new window

K: keep this page without erase and overdraw the next page

O: change options (page size, page title, file save)

H: help, show this information

Q: quit the component after confirmation

The graphic date is composed of ASCII-text data, and machine-independent. It can be viewed, converted to EPS file or PS file, and printed on a postscript printer. The recommended extension of the graphic date file is ".gs".

1.4 View and convert the graphic data

The graphic data file of GSAF graphic library can be viewed on the X11 screen, converted to EPS file, PS file and SVG file, printed in a postscript printer.

gsview: view on a X-window screen

gstoeps: convert selected pages to separate EPS files

gstops: convert selected pages to a combined postscript file

gstosvg: convert selected pages to separate SVG files

gsprint: print on a postscript printer

The available options of these commands are

usage: gsxxxx [-atbrcmgz] [-s ps] [-e pe] [-p np] [filename]

-a : show all page

-s ps : show from page ps [1]

-e pe : show until page pe [999]

-p np : combine np pages on a sheet [1]

-t : keep original page title

-b : no page title

-r : rotate figure, valid for gstops/eps

-c : color figure, valid for gstops/eps (default)

-z : gray figure, valid for gstops/eps

-m : monochrome figure, valid for gstops/eps

-g : gouraud shading, valid for gstops/eps

filename : if not specified, prompted

The EPS file using gouraud shading cannot be edited by Adobe Illustrator.

2 Structure of TASK/EQ

2.1 Support directories

The following directories in a component directory includes:

in/ test input files eq.inITER...

parm/ test parameter files, eqparm...

mod/ module files (generated during compiling fortran files)

2.2 Source file name

File name of main components

eqcomm.f: Definition of variable module, allocation of arrays

eqmain.f: Initialization, read paramater file, start menu, and termination.

eqmenu.f: Show menu, and accept command input

eqinit.f: Set default values of input parameters

eqparm.f: Read input parameters (at present, in eqinit.f)

eqview.f: Show input parameters (at present, in eqinit.f)

eqcalc.f: Solve fixed-boundary equilibrium

eqcalq.f: calculate rectangular mesh data

eqfile.f: Save and load equilibrium data

eqgout.f: Graphic output

3 Run examples

Example 1:

start eq from xterm window

```
./eq
```

graphic setting

```
5
```

```
c
```

run equilibrium solver

```
r
```

show results by graphics

```
g
```

show fixed boundary solution calculated by eqcalc

```
c
```

input ten carriage returns to show a sequence of graphs

show equilibrium mesh data calculated by eqcalq

```
s
```

input ten carriage returns to show a sequence of graphs

exit graphics and return to main menu

```
x
```

change paramter: elongation 1.5

```
rkap=1.5
```

run equilibrium solver again

```
r
```

show results by graphics

```
g
```

show equilibrium mesh data calculated by eqcalq

```
s
```

input ten carriage returns to show a sequence of graphs

exit graphics and return to main menu

```
x
```

quit eq run

```
q
```

Example 2:

copy parm/eqparm.ITER eqparm

```
cp parm/eqparm .
```

run eq

```
./eq
```

graphic setting with graphic data output

```
5
```

```
f
```

```
eq.gs
```

```
c
```

run equilibrium solver

```
r
```

show results by graphics

```
g
```

```
c
```

```
s
```

```
x
```

quit eq run

```
q
```

view graphic data

```
gsview eq.gs
```

```
5
```

```
c
```

to show all pages

```
0
```

quit gsview

```
CTRL-D
```

Example 3:

remove eqparm if exists

```
rm eqparm
```

start run copy in/eq.inITER .

```
./eq <in/eq.inITER >eq.outITER
```

convert all graphic data to a ps file

```
gstops -ab gsdata.ITER >eq.ITER.ps
```

(macos only) view ps file and save it to pdf file

```
open eq.ITER.ps
```

4 Input parameters

```
C     $Id$
C
C     ****** DEFAULT PARAMETERS ******
C
C     ======( DEVICE PARAMETERS )======
C
C        RR    : Plasma major radius                              (m)
C        RA    : Plasma minor radius                              (m)
C        RB    : Wall minor radius                                (m)
C        RKAP  : Plasma shape elongation
C        RDLT  : Plasma shape triangularity *
C        BB    : Magnetic field at center                         (T)
C        Q0    : Safety factor at center
C        QA    : Safety factor on plasma surface
C        RIP   : Plasma current                                  (MA)
C        FRBIN : (RB_inside-RA)/(RB_outside-RA)
C
      RR    = 3.D0
      RA    = 1.D0
      RB    = 1.2D0
      RKAP  = 1.D0
      RDLT  = 0.D0
C
      BB    = 3.D0
      Q0    = 1.D0
      QA    = 3.D0
      RIP   = 3.D0
C
      FRBIN = 1.D0
      RBRA  = RB/RA
C
```

```
C     ======( PLASMA PARAMETERS )======
C
C        NSMAX : Number of particle species
C        PA    : Mass number
C        PZ    : Charge number
C        PN    : Density at center                    (1.0E20/m**3)
C        PNS   : Density on plasma surface            (1.0E20/m**3)
C        PTPR  : Parallel temperature at center              (keV)
C        PTPP  : Perpendicular temperature at center         (keV)
C        PTS   : Temperature on surface                      (keV)
C        PU    : Toroidal rotation velocity at center        (m/s)
C        PUS   : Toroidal rotation velocity on surface       (m/s)
C        RHOITB: rho at ITB (0 for no ITB)
C        PNITB : Density increment at ITB             (1.0E20/Mm*3)
C        PTITB : Temperature increment at ITB                (keV)
C        PUITB : Toroidal rotation velocity increment at ITB  (m/s)
C
      NSMAX = MIN(2,NSM)
C
         PA(1)   = AME/AMP
         PZ(1)   =-1.0D0
         PN(1)   = 1.0D0
         PNS(1)  = 0.0D0
         PTPR(1) = 5.0D0
         PTPP(1) = 5.0D0
         PTS(1)  = 0.05D0
         PU(1)   = 0.D0
         PUS(1)  = 0.D0
         RHOITB(1)= 0.D0
         PNITB(1)= 0.D0
         PTITB(1)= 0.D0
         PUITB(1)= 0.D0
C
      IF(NSM.GE.2) THEN
         PA(2)   = 1.0D0
         PZ(2)   = 1.0D0
         PN(2)   = 1.0D0
         PNS(2)  = 0.0D0
         PTPR(2) = 5.0D0
         PTPP(2) = 5.0D0
         PTS(2)  = 0.05D0
         PU(2)   = 0.D0
         PUS(2)  = 0.D0
         RHOITB(2)= 0.D0
         PNITB(2)= 0.D0
         PTITB(2)= 0.D0
         PUITB(2)= 0.D0
      ENDIF
C
      DO NS=3,NSM
         PA(NS)   = 1.0D0
         PZ(NS)   = 1.0D0
         PN(NS)   = 0.0D0
         PNS(NS)  = 0.0D0
         PTPR(NS) = 5.0D0
         PTPP(NS) = 5.0D0
         PTS(NS)  = 0.0D0
         PU(NS)   = 0.D0
         PUS(NS)  = 0.D0
         RHOITB(NS)= 0.D0
         PNITB(NS)= 0.D0
         PTITB(NS)= 0.D0
```

```
         PUITB(NS)= 0.D0
      ENDDO
C
C     ======( PROFILE PARAMETERS )======
C
C
C        PROFN1: Density profile parameter (power of rho)
C        PROFN2: Density profile parameter (power of (1 - rho^PROFN1))
C        PROFT1: Temperature profile parameter (power of rho)
C        PROFT2: Temperature profile parameter (power of (1 - rho^PROFN1))
C        PROFU1: Rotation profile parameter (power of rho)
C        PROFU2: Rotation profile parameter (power of (1 - rho^PROFN1))
C
      DO NS=1,NSM
         PROFN1(NS)= 2.D0
         PROFN2(NS)= 0.5D0
         PROFT1(NS)= 2.D0
         PROFT2(NS)= 1.D0
         PROFU1(NS)= 2.D0
         PROFU2(NS)= 1.D0
      END DO
C
C     ======( MODEL PARAMETERS )======
C
C        MODELG: Control plasma geometry model
C                   0: Slab geometry
C                   1: Cylindrical geometry
C                   2: Toroidal geometry
C                   3: TASK/EQ output geometry
C                   4: VMEC output geometry
C                   5: EQDSK output geometry
C                   6: Boozer output geometry
C        MODELN: Control plasma profile
C                   0: Calculated from PN,PNS,PTPR,PTPP,PTS,PU,PUS; 0 in SOL
C                   1: Calculated from PN,PNS,PTPR,PTPP,PTS,PU,PUS; PNS in SOL
C                   7: Read from file by means of WMDPRF routine (DIII-D)
C                   8: Read from file by means of WMXPRF routine (JT-60)
C                   9: Read from file KNAMTR (TASK/TR)
C        MODELQ: Control safety factor profile (for MODELG=0,1,2)
C                   0: Parabolic q profile (Q0,QA,RHOMIN,RHOITB)
C                   1: Given current profile (RIP,PROFJ0,PROFJ1,PROFJ2)
C
      MODELG= 2
      MODELN= 0
      MODELQ= 0
C
C        RHOMIN: rho at minimum q (0 for positive shear)
C        QMIN  : q minimum for reversed shear
C        RHOEDG: rho at EDGE for smoothing (1 for no smooth)
C
      RHOMIN = 0.D0
      QMIN   = 1.5D0
      RHOEDG = 1.D0
C
C     ======( GRAPHIC PARAMETERS )======
C
C        RHOGMN: minimum rho in radial profile
C        RHOGMX: maximum rho in radial profile
C
      RHOGMN = 0.D0
      RHOGMX = 1.D0
C
```

```
C     ======( MODEL PARAMETERS )======
C
C        KNAMEQ: Filename of equilibrium data
C        KNAMWR: Filename of ray tracing data
C        KNAMWM: Filename of full wave data
C        KNAMFP: Filename of Fokker-Planck data
C        KNAMFO: Filename of File output
C        KNAMPF: Filename of profile data
C        KNAMEQ2:Filename of addisional equilibrium data
C
      KNAMEQ = 'eqdata'
      KNAMWR = 'wrdata'
      KNAMWM = 'wmdata'
      KNAMFP = 'fpdata'
      KNAMFO = 'fodata'
      KNAMPF = 'pfdata'
      KNAMEQ2= 'eqdata2'
C
      NRMAXPL= 100
      NSMAXPL= NSMAX
C
      IDEBUG = 0
C
C     *** PROFILE PARAMETERS ***
C
C        PP0   : Plasma pressure (main component)              (MPa)
C        PP1   : Plasma pressure (sub component)               (MPa)
C        PP2   : Plasma pressure (increment within ITB)        (MPa)
C        PROFP0: Pressure profile parameter
C        PROFP1: Pressure profile parameter
C        PROFP2: Pressure profile parameter
C
C        PPSI=PP0*(1.D0-PSIN**PROFR0)**PROFP0
C    &       +PP1*(1.D0-PSIN**PROFR1)**PROFP1
C    &       +PP2*(1.D0-(PSIN/PSIITB)**PROFR2)**PROFP2
C
C        The third term exists for RHO < RHOITB
C
      PP0    = 0.001D0
      PP1    = 0.0D0
      PP2    = 0.0D0
      PROFP0 = 1.5D0
      PROFP1 = 1.5D0
      PROFP2 = 2.0D0
C
C        PJ0   : Current density at R=RR (main component) : Fixed to 1
C        PJ1   : Current density at R=RR (sub component)       (arb)
C        PJ2   : Current density at R=RR (sub component)       (arb)
C        PROFJ0: Current density profile parameter
C        PROFJ1: Current density profile parameter
C        PROFJ2: Current density profile parameter
C
C      HJPSI=-PJ0*(1.D0-PSIN**PROFR0)**PROFJ0
C     &               *PSIN**(PROFR0-1.D0)
C     &      -PJ1*(1.D0-PSIN**PROFR1)**PROFJ1
C     &               *PSIN**(PROFR1-1.D0)
C     &      -PJ2*(1.D0-PSIN**PROFR2)**PROFJ2
C     &               *PSIN**(PROFR2-1.D0)
C
C        The third term exists for RHO < RHOITB
C
      PJ0    = 1.00D0
```

```
      PJ1    = 0.0D0
      PJ2    = 0.0D0
      PROFJ0 = 1.5D0
      PROFJ1 = 1.5D0
      PROFJ2 = 1.5D0
C
C        FF0   : Current density at R=RR (main component) : Fixed to 1
C        FF1   : Current density at R=RR (sub component)       (arb)
C        FF2   : Current density at R=RR (sub component)       (arb)
C        PROFF0: Current density profile parameter
C        PROFF1: Current density profile parameter
C        PROFF2: Current density profile parameter
C
C      FPSI=BB*RR
C     &      +FF0*(1.D0-PSIN**PROFR0)**PROFF0
C     &      +FF1*(1.D0-PSIN**PROFR1)**PROFF1
C     &      +FF2*(1.D0-PSIN**PROFR2)**PROFF2
C
C        The third term exists for RHO < RHOITB
C
      FF0    = 1.0D0
      FF1    = 0.0D0
      FF2    = 0.0D0
      PROFF0 = 1.5D0
      PROFF1 = 1.5D0
      PROFF2 = 1.5D0
C
C        PT0   : Plasma temperature (main component)           (keV)
C        PT1   : Plasma temperature (sub component)            (keV)
C        PT2   : Plasma temperature (increment within ITB)     (keV)
C        PTSEQ : Plasma temperature (at surface)               (keV)
C        PROFTP0: Temperature profile parameter
C        PROFTP1: Temperature profile parameter
C        PROFTP2: Temperature profile parameter
C
C        TPSI=PTSEQ+(PT0-PTSEQ)*(1.D0-PSIN**PROFR0)**PROFTP0
C    &       +PT1*(1.D0-PSIN**PROFR1)**PROFTP1
C    &       +PT2*(1.D0-PSIN/PSIITB)**PROFR2)**PROFTP2
C    &       +PTSEQ
C
C        The third term exits for RHO < RHOITB
C
      PT0    = 1.0D0
      PT1    = 0.0D0
      PT2    = 0.0D0
      PTSEQ  = 0.05D0
C
      PROFTP0 = 1.5D0
      PROFTP1 = 1.5D0
      PROFTP2 = 2.0D0
C----
C        PV0   : Toroidal rotation (main component)             (m/s)
C        PV1   : Toroidal rotation (sub component)              (m/s)
C        PV2   : Toroidal rotation (increment within ITB)       (m/s)
C        PROFV0: Velocity profile parameter
C        PROFV1: Velocity profile parameter
C        PROFV2: Velocity profile parameter
C
C        PVSI=PV0*(1.D0-PSIN**PROFR0)**PROFV0
C    &       +PV1*(1.D0-PSIN**PROFR1)**PROFV1
C    &       +PV2*(1.D0-(PSIN/PSIITB)**PROFR2)**PROFV2
C
```

```
C        The third term exits for RHO < RHOITB
C
      PV0    = 0.0D0
      PV1    = 0.0D0
      PV2    = 0.0D0
      PROFV0 = 1.5D0
      PROFV1 = 1.5D0
      PROFV2 = 2.0D0
C
C        PNOEQ : Plasma number density(constant)
C
      PNOEQ  = 1.D20
C
C        PROFR0: Profile parameter
C        PROFR1: Profile parameter
C        PROFR2: Profile parameter
C        RHOITB: Normalized radius SQRT(PSI/PSIA) at ITB
C
      PROFR0 = 1.D0
      PROFR1 = 2.D0
      PROFR2 = 2.D0
C
C        OTC   : Constant OMEGA**2/TPSI
C        HM    : Constant                                    (Am)
C
      OTC = 0.15D0
      HM  = 1.D6
C
C     *** MESH PARAMETERS ***
C
C        NSGMAX: Number of radial mesh points for Grad-Shafranov eq.
C        NTGMAX: Number of poloidal mesh points for Grad-Shafranov eq.
C        NUGMAX: Number of radial mesh points for flux-average quantities
C        NRGMAX: Number of horizontal mesh points in R-Z plane
C        NZGMAX: Number of vertical mesh points in R-Z plane
C        NPSMAX: Number of flux surfaces
C        NRMAX : Number of radial mesh points for flux coordinates
C        NTHMAX: Number of poloidal mesh points for flux coordinates
C        NSUMAX: Number of boundary points
C        NRVMAX: Number of radial mesh of surface average
C        NTVMAX: Number of poloidal mesh for surface average
C
      NSGMAX = 32
      NTGMAX = 32
      NUGMAX = 32
C
      NRGMAX = 33
      NZGMAX = 33
      NPSMAX = 21
C
      NRMAX  = 50
      NTHMAX = 64
      NSUMAX = 65
C
      NRVMAX = 50
      NTVMAX = 200
C
C     *** CONTROL PARAMETERS ***
C
C        EPSEQ  : Convergence criterion for equilibrium
C        NLPMAX : Maximum iteration number of EQ
C        EPSNW  : Convergence criterion for newton method
```

```
C        DELNW  : Increment for derivative in newton method
C        NLPNW  : Maximum iteration number in newton method
C
      EPSEQ  = 1.D-6
      NLPMAX = 20
      EPSNW  = 1.D-2
      DELNW  = 1.D-2
      NLPNW  = 20
C
C        MDLEQF : Profile parameter
C            0: given analytic profile  P,J_tor,T,Vph + Ip
C            1: given analytic profile  P,F           + Ip
C            2: given analytic profile  P,J_para      + Ip
C            3: given analytic profile  P,J_para
C            4: given analytic profile  P,q
C            5: given spline profile    P,J_tor,T,Vph + Ip
C            6: given spline profile    P,F           + Ip
C            7: given spline profile    P,J_para      + Ip
C            8: given spline profile    P,J_para
C            9: given spline profile    P,q
C
      MDLEQF = 0
C
C        MDLEQA : Rho in P(rho), F(rho), q(rho),...
C            0: SQRT(PSIP/PSIPA)
C            1: SQRT(PSIT/PSITA)
C
      MDLEQA = 0
C
C        MDLEQC : Poloidal coordinate parameter
C            0: Poloidal length coordinate
C            1: Boozer coordinate
C
      MDLEQC = 0
C
C        MDLEQX : Free boundary calculation
C            0: Given PSIB and RIPFC
C            1: PSIB adjusted after loop for given RR,RA,RKAP,RDLT
C            2: PSIB adjusted eqch loop for given RR,RA,RKAP,RDLT
C
      MDLEQX = 0
C
C        MDLEQV : Order of extrapolation of psi in the vacuum region
C                 if positive, wall is linearly extended from plasma surface
C                 if negative, wall is extraporated by polynomials
C
      MDLEQV = 3
C
C        NPRINT: Level print out
C            0: no print
C            1: print first and last loop
C            2: print all loop
C
      NPRINT= 0
C
C        RGMIN: Minimum R of computation region [m]
C        RGMAX: Maxmum  R of computation region [m]
C        ZGMIN: Minimum Z of computation region [m]
C        ZGMAX: Maxmum  Z of computation region [m]
C        ZLIMP: Position of upper X points
C        ZLIMM: Position of lower X points
C
```

```
      RGMIN = 1.5D0
      RGMAX = 4.5D0
      ZGMIN =-2.0D0
      ZGMAX = 2.0D0
      ZLIMM =-2.5D0
      ZLIMP = 2.5D0
C
C        PSIB(0:5): Multipole moments of poloidal flux PSIRZ on boundary
C
      PSIB(0) =  2.0D0
      PSIB(1) =  0.5D0
      PSIB(2) =  0.D0
      PSIB(3) =  0.D0
      PSIB(4) =  0.D0
      PSIB(5) =  0.D0
C
C        NPFCMAX : Number of poloidal field coils (PFXs)
C        RIPFC(NPFC) : PFC coil current    [MA]
C        RPFC(NPFC)  : PFC coil position R [m]
C        ZPFC(NPFC)  : PFC coil position Z [m]
C        WPFC(NPFC)  : PFC coil width      [m]
C
      NPFCMAX = 0
      DO NPFC=1,NPFCM
         RIPFC(NPFC) = 0.D0
         RPFC(NPFC)  = 3.D0
         ZPFC(NPFC)  =-1.75D0
         WPFC(NPFC)  = 0.75D0
      ENDDO

      MODEFW=0 ! dangerous setting
      MODEFR=0 ! dangerous setting
```