Operator DEFI_FONC_ELEC

1 Goal

To define a function of time intervening in the calculation of the forces of Laplace.

These forces are exerted on a principal driver (being based on a grid *Aster*) acting with one or more secondary drivers (not resting necessarily on grids *Aster*); these drivers are traversed by intensities of current of short-circuit. The expression of the force of Laplace is composed of the product of a function of time due itself to the products of the intensities of current and of a function of space due to the relative position of the drivers.

Product a structure of data of the type `function`.

2 Syntax

```
F [function] = DEFI_FONC_ELEC (

    ◊  FREQ   =  /    Fr,                                   [R]
                 /   50. ,                                  [DEFECT]
    ◊  SIGNAL =  /   'COMPLETE',                            [DEFECT]
                 /   'CONTINUOUS',
    ♦  /  ♦  COURT     =   (_F (
                              ♦  INTE_CC_1       =  I1,     [R]
                              ♦  TAU_CC_1        =  τ1 ,    [R]
                              ♦  /  PHI_CC_1     =  ϕ1 ,    [R]
                                 /  INTC_CC_1    =  IC1,    [R]
                              ♦  INTE_CC_2       =  I2,     [R]
                              ♦  TAU_CC_2        =  τ2 ,    [R]
                              ♦  /  PHI_CC_2     =  ϕ2 ,    [R]
                                 /  INTC_CC_2    =  IC2,    [R]
                              ◊  INST_CC_INIT    =  Ti,     [R]
                              ♦  INST_CC_FIN     =  tf,     [R]
                           ),),
       /  ♦  COUR_PRIN =   (_F (
                              ♦  INTE_CC_1       =  I1,     [R]
                              ♦  TAU_CC_1        =  τ1 ,    [R]
                              ♦  /  PHI_CC_1     =  ϕ1 ,    [R]
                                 /  INTC_CC_1    =  IC1,    [R]
                              ◊  INTE_RENC_1     =  I1R,    [R]
                              ◊  TAU_RENC_1      =  τ1R ,   [R]
                              ◊  PHI_RENC_1      =  ϕ1R ,   [R]
                              ♦  INST_CC_INIT    =  Ti,     [R]
                              ♦  INST_CC_FIN     =  tf,     [R]
                              ◊  INST_RENC_INIT  =  /  shooting, [R]
                                                    /  0. ,
  [DEFECT]
                              ◊  INST_RENC_FIN   =  /  tfR,   [R]
                                                    /  0. ,
  [DEFECT]
                            ),),
          ♦  COUR_SECO =   (_F (
                              ♦  INTE_CC_2       =  I2,     [R]
                              ♦  TAU_CC_2        =  τ2 ,    [R]
                              ♦  /  PHI_CC_2     =  ϕ2 ,    [R]
                                 /  INTC_CC_2    =  IC2,    [R]
                              ◊  INTE_RENC_2     =  I2R,    [R]
                              ◊  TAU_RENC_2      =  τ2R ,   [R]
                              ◊  PHI_RENC_2      =  ϕ2R ,   [R]
                              ◊  DIST            =  /  D,   [R]
                                                    /  1. ,
  [DEFECT]
                            ),),
    ◊  INFORMATION  =  /   1,
  [DEFECT]
                 /   2,
    )
```

3 Operands

The treated data can be divided into two groups:

- those concerning one **only** secondary driver, generally in a position **unspecified** compared to the principal driver but with **several** time intervals. These time intervals can be continuous between them (case of the same current with characteristics different from one interval to another) or discontinuous (case of one or more resets at various levels of intensity keyword factor COURT),
- those concerning one or **several** possibly parallel and/or infinite secondary drivers with **one** time interval corresponding to the short-circuit and **possibly** a second time interval corresponding to a reset (keywords factors COUR_PRIN and COUR_SECO).

One can notice that:

- in the second group of data, the characteristics of the currents crossing the secondary drivers are separately treated those of the currents crossing the principal driver (with the keyword COUR_SECO that one can repeat several times),
- all the cases treated by the second group of data can be treated by the first group. However in the case of current crossing several secondary drivers, the operator should then be repeated DEFI_FONC_ELEC with the keyword COURT as many times as there are drivers secondary (and of the same for AFFE_CHAR_MECA and CALC_VECT_ELEM).

3.1 Operand FREQ

```
◊  FREQ  =  /  50. ,
            /  Fr,
```

Frequency of the current in Hertz (50.0 by defaults).

3.2 Operand SIGNAL

```
◊  SIGNAL =
```

Specify the way of calculating of the electric function of time:

/	'COMPLETE'	all the terms of the electric function are taken into account,
/	'CONTINUOUS'	one does not take into account the periodic terms of the electric function.

3.3 Keyword `COURT`

♦ / ♦ `COURT = (_F (`

♦ `INTE_CC_1 = I1` effective intensity of the current of short-circuit, crossing the principal driver (in Amps),

♦ `TAU_CC_1 =` $\tau 1$ time-constant of the current of short-circuit, crossing the principal driver (in seconds),

♦ / `PHI_CC_1 =` $\phi 1$ dephasing (in degrees) of the principal current (current of short-circuit),

/ `INTC_CC_1 = IC1` intensity of first peak of the principal current (in Amps), amounts giving a dephasing,

♦ `INTE_CC_2 = I2` effective intensity of the current of short-circuit, crossing the secondary driver (in Amps),

♦ `TAU_CC_2 =` $\tau 2$ time-constant of the current of short-circuit, crossing the secondary driver (in seconds),

♦ / `PHI_CC_2 =` $\phi 2$ dephasing (in degrees) of the secondary current (current of short-circuit),

/ `INTC_CC_2 = IC2` intensity of first peak of the secondary current (in Amps), amounts giving a dephasing,

◊ `INST_CC_INIT = Ti` initial moment of an interval of current, by default, equal to the final moment of the preceding interval (the intervals are then continuous),

♦ `INST_CC_FIN = tf` final moment of an interval of current

`), ),`

3.4 Keyword COUR_PRIN

```
/ ♦ COUR_PRIN = (_F (
```

♦ `INTE_CC_1 = I1`	effective intensity of the current of short-circuit, crossing the principal driver (in Amps),
♦ `TAU_CC_1 =` $\tau 1$	time-constant of the current of short-circuit, crossing the principal driver (in seconds),
♦ / `PHI_CC_1 =` $\phi 1$	dephasing (in degrees) of the principal current (current of short-circuit),
/ `INTC_CC_1 = IC1`	intensity of first peak of the principal current (in Amps), amounts giving a dephasing,
◊ `INTE_RENC_1 = I1R`	effective intensity of the current of reset, crossing the principal driver (in Amps),
◊ `TAU_RENC_1 =` $\tau 1R$	time-constant of the current of short-circuit, crossing the secondary driver (in seconds),
◊ `PHI_RENC_1 =` $\phi 1R$	dephasing (in degrees) of the principal current of reset,
♦ `INST_CC_INIT = Ti`	initial moment of the current of short-circuit,
♦ `INST_CC_FIN = tf`	final moment of the current of short-circuit,
◊ `INST_RENC_INIT = / shooting, / 0. ,`	initial moment of the current of reset,
◊ `INST_RENC_FIN = / tfR / 0. ,`	final moment of the current of reset,

```
), ),
```

Note:

By default, t_{iR} *and* t_{fR} *are worthless and there is no current of reset.*

3.5 Keyword COUR_SECO

```
/ ♦ COUR_SECO = (_F (
```

♦ `INTE_CC_2 = I2` effective intensity of the current of short-circuit, crossing the secondary driver (in Amps),

♦ `TAU_CC_2 =` $\tau 2$ time-constant of the current of short-circuit, crossing the secondary driver (in seconds),

♦ / `PHI_CC_2 =` $\phi 2$ dephasing (in degrees) of the secondary current (current of short-circuit),

/ `INTC_CC_2 = IC2` intensity of first peak of the secondary current (in Amps), amounts giving a dephasing,

◊ `INTE_RENC_2 = I2R` effective intensity of the current of reset, crossing the secondary driver (in Amps),

◊ `TAU_RENC_2 =` $\tau 2R$ time-constant of the current of reset, crossing the secondary driver (in seconds),

◊ `PHI_RENC_2 =` $\phi 2R$ dephasing (in degrees) of the secondary current of reset,

◊ `DIST = / D,` distance (in meters) from an infinite secondary driver
`/ 1. ,` and parallel with the principal driver.

`), ),`

Note:

Not credit in the other cases and taken with 1 . by default to neutralize its action in the calculation of the force of LAPLACE.

3.6 Operand INFORMATION

◊ `INFORMATION =` Specify the options of impression on the file `MESSAGE`.

`1 =` pas d' impression (option by default),

`2 =` impression of the parameters plus the list of the first 10 values in the order ascending of the parameter.

4 Expression of the calculated function

4.1 Data of the first group

In the case of given first group, with N occurrences of the keyword factor `COURT` correspondent with N time intervals, arguments entered to K[ième] occurrence of the keyword factor are affected index (k) that is to say:

$$I_1^{(k)}, \tau_1^{(k)}, \phi_1^{(k)}, I_2^{(k)}, \tau_2^{(k)}, \phi_2^{(k)}, t_1^{(k)}, t_f^{(k)}$$

4.1.1 Complete signal

The expression of the calculated function is:

$$F(t) = 4.10^{-7} I_1^{(k)} I_2^{(k)} \times \left[\cos(2\pi\, fr(t - t_r^{(k)}) + \phi_1^{(k)}) - \cos\phi_1^{(k)} e^{-\frac{t - t_r^{(k)}}{\tau_1^{(k)}}} \right] \times \left[\cos(2\pi\, fr(t - t_r^{(k)}) + \phi_2^{(k)}) - \cos\phi_2^{(k)} e^{-\frac{t - t_r^{(k)}}{\tau_2^{(k)}}} \right]$$

4.1.2 Continuous signal

$$F(t) = 4.10^{-7} I_1^{(k)} I_2^{(k)} \times \left[\frac{1}{2} \cdot \cos(\phi_2^{(k)} - \phi_1^{(k)}) + \cos\phi_1^{(k)} \times \cos\phi_2^{(k)} \times e^{-\left(\frac{1}{\tau_1^{(k)}} + \frac{1}{\tau_2^{(k)}}\right)(t - t_r^{(k)})} \right]$$

for $t \in \left[t_i^{(k)}, t_f^{(k)}\right], k = 1, N$
with $t_r^{(k)}$ defined by:

$$\begin{aligned} t_r^{(1)} &= t_i^{(1)} \\ t_r^{(k)} &= t_r^{(k-1)} \quad \text{si} \quad t_i^{(k)} = t_f^{(k-1)}, \quad k = 2, N \\ t_r^{(k)} &= t_i^{(k)} \quad \text{si} \quad t_i^{(k)} > t_f^{(k-1)}, \quad k = 2, N \end{aligned}$$

$F(t) = 0$ if $t_i^{(k)} > t_f^{(k-1)}$ and $t \in \left[t_f^{(k-1)}, t_i^{(k)}\right], k = 2, N$

or if $t > t_f^{(N)}$

4.2 Data of the second group

In the case of given of the second group, with an occurrence of the keyword COUR_PRIN (a principal current) and N occurrences of the keyword factor COUR_SECO (N secondary currents), arguments entered to $k^{ième}$ occurrence of COUR_SECO are assigned to the index (k) that is to say: $I_2^{(k)}, \tau_2^{(k)}, \Phi_2^{(k)}, d^{(k)}$ and possibly $I_{2R}^{(k)}, \tau_{2R}^{(k)}, \Phi_{2R}^{(k)}$.

4.2.1 Case or t belongs to the first interval of current

4.2.1.1 Complete signal

The expression of the calculated function becomes then: if $t \in [t_i, t_f]$

$$F(t)=4.10^{-7} \times I_1 \cdot \left[\cos\left(2\pi \cdot fr \cdot (t-t_i)+\Phi_1\right)-\cos(\Phi_1)\cdot e^{-\frac{t-t_i}{\tau_1}}\right]$$
$$\times \sum_{k=1,N} \frac{I_2^{(k)}}{d^{(k)}}\left[\cos\left(2\pi \cdot fr \cdot (t-t_i)+\Phi_2^{(k)}\right)-\cos(\Phi_2^{(k)})\cdot e^{-\frac{t-t_i}{\tau_2^{(k)}}}\right]$$

4.2.1.2 Continuous signal

$$F(t)=4.10^{-7}\cdot I_1$$
$$\times \sum_{k=1,N} \frac{I_2^{(k)}}{d^{(k)}}\left[\frac{1}{2}\cos\left(\Phi_2^{(k)}-\Phi_1^{(k)}\right)+\cos(\Phi_1)\cdot\cos(\Phi_2^{(k)})\cdot e^{-\left(\frac{1}{\tau_1}+\frac{1}{\tau_2^{(k)}}\right)(t-t_i)}\right]$$

4.2.2 Case where t belongs to the second interval of current (reset)

4.2.2.1 Complete signal

The expression of the calculated function becomes then: if $t \in [t_{iR}, t_{fR}]$

$$F(t)=4.10^{-7}\cdot I_{1R} \left[\cos\left(2\pi f_r (t-t_{iR})+\Phi_{1R}\right)-\cos(\Phi_{1R})\cdot e^{-\frac{t-t_{iR}}{\tau_{1R}}}\right]$$
$$\left[\cos\left(2\pi f_r (t-t_{iR})+\Phi_{2R}^{(k)}\right)-\cos(\Phi_{2R}^{(k)})\cdot e^{-\frac{t-t_{iR}}{\tau_{2R}^{(k)}}}\right]$$

NB: one must have $t_{iR} > t_f$ and $t_{iR} \neq 0$

4.2.2.2 Continuous signal

$$F(t)=4.10^{-7}\cdot I_{1R} \times \sum_{k=1,N} \frac{I_{2R}^{(k)}}{d^{(k)}}\left[\frac{1}{2}\cos\left(\Phi_{2R}^{(k)}-\Phi_{1R}^{(k)}\right)+\cos(\Phi_{1R})\cdot\cos(\Phi_{2R}^{(k)})\cdot e^{-\left(\frac{1}{\tau_{1R}}+\frac{1}{\tau_{2R}^{(k)}}\right)(t-t_{iR})}\right]$$

Moreover:
When there is reset: $F(t)=0$ if $t\in[t_f, t_{iR}]$ or if $t>t_{fR}$
When there is not reset: $F(t)=0$ if $t>t_f$

5 Examples of function of current

5.1 With data of the two groups

Definition of functions of currents using as well the data of the first group as of the second group.

Case of two-phase short-circuit during 0.5 second with reset from 1.5 to 2 seconds of intensity $20\,kA$, of worthless and time-constant intensity and phase 0.2 second before reset $15\,kA$ after reset.

- Data of the first group:

```
f1 =   DEFI_FONC_ELEC   (
         COURT = (_F (INTE_CC_1=  20.E3,    TAU_CC_1      =    0.2,
                      PHI_CC_1     =   0. ,     INTE_CC_2     =   20.E3,
                      TAU_CC_2     =   0.2,     PHI_CC_2      =  180. ,
                      INST_CC_INIT =   0. ,     INST_CC_FIN   =    0.5,
                  ),

                 _F (INTE_CC_1   =  15.E3,    TAU_CC_1      =    0.2,
                      PHI_CC_1     =   0. ,     INTE_CC_2     =   15.E3,
                      TAU_CC_2     =   0.2,     PHI_CC_2      =  180. ,
                      INST_CC_INIT =   1.5,     INST_CC_FIN   =    2.0,
                 ),),
                          )
```

- Data of the second group:

```
f2 =   DEFI_FONC_ELEC   (
COUR_PRIN = (_F (   INTE_CC_1        =  20.E3,    TAU_CC_1      =   0.2,
                    PHI_CC_1         =   0. ,     INTE_RENC_1   =  15.E3,
                    TAU_RENC_1       =   0.2,     PHI_RENC_1    =   0. ,
                    INST_CC_INIT     =   0. ,     INST_CC_FIN   =   0.5,
                    INST_RENC_INIT   =   1.5,     INST_RENC_FIN=   2.0,
             ),),
COUR_SECO = (_F (   INTE_CC_2     =  20.E3,       TAU_CC_2      =    0.2,
                    PHI_CC_2     = 180. ,         INTE_RENC_2   =   15.E3,
                    TAU_RENC_2   =   0.2,         PHI_RENC_2    =  180. ,
             ),),
                          )
```

5.2 With only of the data of the first group

Definition of functions of currents using **strictly** data of the first group.

Case of two-phase short-circuit during 1 second, worthless phase, 0.2 second and stage time-constant of intensity of $20\,kA$ during 0.5 second, of $15\,kA$ between 0.5 second and 0.7 second, of $10\,kA$ between 0.7 second and 1 second.

```
f1 =   DEFI_FONC_ELEC   (
         COURT = (_F (INTE_CC_1=  20.E3,    TAU_CC_1     =    0.2,
                    PHI_CC_1     =   0. ,     INTE_CC_2    =   20.E3,
                    TAU_CC_2     =   0.2,     PHI_CC_2     =  180. ,
                    INST_CC_INIT =   0. ,     INST_CC_FIN  =    0.5,
                 ),
                _F (INTE_CC_1    =  15.E3,    TAU_CC_1  =    0.2,
                    PHI_CC_1     =   0. ,     INTE_CC_2 =   15.E3,
                    TAU_CC_2     =   0.2,     PHI_CC_2  =  180. ,
                    INST_CC_FIN  =   0.7,
                 ),
                _F (INTE_CC_1    =  10.E3,    TAU_CC_1  =    0.2,
                    PHI_CC_1     =   0. ,     INTE_CC_2 =   10.E3,
                    TAU_CC_2     =   0.2,     PHI_CC_2  =  180. ,
                    INST_CC_FIN  =   1.0,
                ),),
                          )
```

5.3 With preferentially of the data of the second group

Definition of functions of using current **preferentially** data of the second group.

To express the interaction of two drivers with the studied phase, the use of data of the first group would result in defining two functions F_1 and F_2 (by two calls to `DEFI_FONC_ELEC`) and two loads `ch1` and `ch2`.

The data of the second group make it possible to be limited to only one function.

Case of three-phase short-circuit during 1 second of intensity 20 kA, phase 45 degrees, time-constant 0.2 second with phases parallel and infinite apart 2 meters.

```
f1 =   DEFI_FONC_ELEC   (
       COUR_PRIN = (_F (   INTE_CC_1     =  20.E3,    TAU_CC_1      =
0.2,
                         PHI_CC_1     =  45. ,     INST_CC_INIT =  0. ,
                         INST_CC_FIN  =   1. ,
                         ),),
       COUR_SECO = (_F (   INTE_CC_2 =   20.E3,      TAU_CC_2  =  0.2,
                          PHI_CC_2 =  165. ,        DIST      =  2. ,
                     ),
                    _F ( INTE_CC_2 =    20.E3,     TAU_CC_2  =    0.2,
                         PHI_CC_2  =  - 75. ,         DIST      =  - 2. ,
                     ),),
                          )
```

One will find examples of `DEFI_FONC_ELEC` in CAS-tests SDNL101A, SDLL102A and SDLL102B.