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ARTERE : description of data files

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Contents

1 How data files are organized

Data files include *records* and *comments*, as detailed hereafter.

1.1 Records

Each record may span over any number of lines. However, each line must not be more than 130 character long. Each record ends up with a semicolon (;).

Each record includes a certain number (at least one) of *fields*. A field is either a real number (numeric field) or a string of characters (character field).

Two successive fields must be separated by at least one space. Similarly, there must be at least one space between the last field of a record and the semicolon that terminates that record.

Only the first 20 characters of a field are read; the remaining of the string is just ignored, without warning. It is thus highly recommended not to have more than 20 characters in a field.

Numeric fields are written in free format : the usual ways of writing numbers (with or without a dot, with or without an exponent, exponent denoted by `E` or `D`, etc.) are accepted.

Any character field must not include more than some number of characters, specified in the documentation. According to one of the above rules, this number is smaller or equal to 20. If this limit is exceeded, the programs stops with an error message.

Uppercase letters are significant within a character field (i.e. two fields that differ by the uppercase/lowercase spelling are different).

If a character field includes a space or a slash (/), it must be enclosed with quotes ('). In between the two quotes, the leading spaces are significant while the trailing ones are ignored. An empty string of character is denoted by ' '.

The first field of each record is a character field which indicates the type of the record. The use of quotes is never needed for those fields, which never include spaces.

Some records have optional fields, necessarily located at the end of the record.

An element such as a line, a transformer, etc. may be defined several times successively in the data files. In this case, the last record read supersedes the previous ones. A message is given at the time the records are translated into internal variables, indicating that the element is redefined.

Records may be distributed over any number of data files, which will be read sequentially. The order in which the records are placed inside the data files does not matter, except when an element is defined several times, for the above mentioned reasons. This allows to create an “incremental” data file, describing the modifications with respect to a base case defined in a previously loaded data file.

1.2 Comments

There are three ways to insert comments in the data files:

1. a line in which the first non blank character is an exclamation mark (!) : the 80 characters that follow this symbol are memorized by the program and reproduced on output files;
2. a line in which the first non blank character is a # : this line is simply ignored by the program;
3. anything written after the semicolon that terminates a record and before the end of the line is also ignored.

Note that a comment need not be terminated by a semicolon since it may not span over several lines. If several lines are needed to write the comment, each of them must start with a ! or a #.

Empty lines are just ignored.

2 Buses, loads and shunt compensation

2.1 BUS record

Specifies the base voltage, the load and the shunt compensation at a bus.

* type of record : BUS
* NAME (max 8 characters) : name of the bus
* VNOM : base voltage, in kV. VNOM is used to set in per unit the parameters of the lines and transformers incident to the bus
* PLOAD : active power load, en MW
* QLOAD : reactive power load, en Mvar
* BSHUNT : nominal reactive power, in Mvar, of the shunt compensation treated as constant admittance. This is the reactive power produced under a 1 pu voltage. A positive (resp. negative) value corresponds to a capacitor (resp. an inductor)
* QSHUNT : nominal reactive power, in Mvar, of the shunt compensation treated as constant power in load flow computation. A positive (resp. negative) value corresponds to a capacitor (resp. an inductor).

It is mandatory to declare all buses through BUS records. If the program subsequently finds a bus not described by a BUS record, it stops on error.

3 Lines

3.1 Model

Lines and cables are represented by a pi equivalent as shown in Fig. 1. Series capacitors are also represented by this scheme with R and C set to zero and X to a negative value.

3.2 LINE record

The LINE record describes a line, a cable or a series capacitor, modelled as represented in Fig. 1.

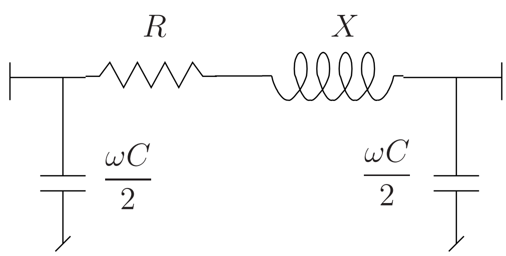

Figure 1: line or cable equivalent

* type of record : LINE
* NAME (max 20 characters) : name of the line
* FROM_BUS (max 8 characters) : name of the "from" bus (the line orientation is arbitrary)
* TO_BUS (max 8 characters) : name of the "to" bus
* R : resistance R, in Ω
* X : reactance X, in Ω
* WC/2 : half shunt susceptance $\omega C/2$, in μS
* SNOM : nominal apparent power, in MVA. This value should be set to zero if one does not want to specify this power; this will be interpreted as an infinite power.
* BR : on/off status of the line breakers. A zero value indicates that the breakers are open at both ends; any other value means that both breakers are closed.

All lines are memorized, even those which are out of service. A line out of service is not involved in the equations (it appears in the output results with a zero power flow) but it can be put back into service.

It is not allowed to have a line connecting two buses with different base voltages (as defined by the VNOM fields of their BUS records).

To have a line connected through a single end, declare the open end as a bus and set the BR parameter to 1.

4 Switches

4.1 SWITCH record

The SWITCH record allows to create a direct connection between two buses.

* type of record : SWITCH

* NAME (max 20 characters) : name of the switch

* FIRST_BUS (max 8 characters) : name of the first bus (the choice is arbitrary)

* SECOND_BUS (max 8 characters) : name of the second bus

* BR : on/off status of the switch. A zero value indicates that the switch is open; any other value means that it is closed.

All switches are memorized, even those which are open. An open switch is not involved in the equations (it appears in the output results with a zero power flow) but it can put back into service.

It is not allowed to have a switch connecting two buses with different base voltages (as defined by the VNOM fields of their BUS records).

5 Transformers

5.1 Model

Transformers are represented by the equivalent shown in Fig. 2. B_1 or B_2 can represent the magnetizing reactance. Normally one of these two parameters is zero. n (resp. ϕ) is the magnitude (resp. the phase angle) of the transformer ratio.

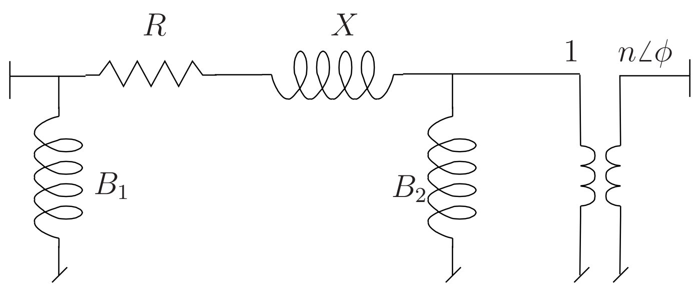

Figure 2: transformer equivalent

Three pairs of voltages have to be considered in the modelling of a transformer:

- V_{B1}, V_{B2} : the *base* voltages at the corresponding terminal buses, used to translate the parameters in per unit values

- V_{N1}, V_{N2} : the *nominal* voltages at the corresponding terminal buses

- V_{r1}, V_{r2} : the open-circuit voltages corresponding to the transformer ratio.

ARTERE requires that all parameters are in per unit on the (V_{B1}, V_{B2}) base voltages.

Now, the R, X, B_1, B_2 parameters of Fig. 2 are often provided by the manufacturer in per unit on the V_{N1} base voltage. The corresponding per unit values on the V_{B1} base voltage are given by:

$$\begin{aligned}
R_{baseV_{B1}} &= R_{baseV_{N1}}(\frac{V_{N1}}{V_{B1}})^2 \\
X_{baseV_{B1}} &= X_{baseV_{N1}}(\frac{V_{N1}}{V_{B1}})^2 \\
B_{1\ baseV_{B1}} &= B_{1\ baseV_{N1}}(\frac{V_{B1}}{V_{N1}})^2 \\
B_{2\ baseV_{B1}} &= B_{2\ baseV_{N1}}(\frac{V_{B1}}{V_{N1}})^2
\end{aligned}$$

The transformer ratio is equal to

$$n = \frac{V_{r2}}{V_{r1}}$$

and on the (V_{B1}, V_{B2}) base voltage it becomes :

$$n = \frac{V_{r2}V_{B1}}{V_{r1}V_{B2}}$$

Note that the V_{B1}, V_{B2} voltages are not passed on to the program, which assumes that the user has expressed the transformer parameters on these base voltages. These voltages must coincide with the base voltages declared at both terminal buses (through the BUS records), which cannot be checked by the program.

The transformer can have its tap position adjusted automatically so as to maintain a voltage in a range $[V^0 - \epsilon, V^0 + \epsilon]$ where V^0 is the setpoint and ϵ half the deadband. This corresponds to in-phase regulating transformers. The regulated bus can be either the left or the right bus in Fig. 2. When the tap position (and hence the ratio n) of the transformer varies, the R, B_1, B_2 and ϕ parameters remain constant, while X may vary if desired. Piece-wise linear variations of n and X with the tap position may be specified.

In the load flow computation, in-phase regulating transformers are adjusted in between the iterations of the Newton method, as soon as the equations are solved with a specified precision. Each transformer is moved by one position at a time.

A transformer can also have its tap position adjusted automatically so as to maintain the active power flow in a branch in a range $[P^0 - \epsilon, P^0 + \epsilon]$ where P^0 is the setpoint and ϵ half the deadband. This corresponds to phase-shifting regulating transformers. When the tap position of the transformer varies, the R, B_1 and B_2 parameters remain constant, while X as well as n

may vary if desired[1]. Piece-wise linear variations of X, n and ϕ with the tap position may be specified.

In the load flow computation, phase-shifting regulating transformers are adjusted in between the iterations of the Newton method, as soon as the equations are solved with a specified precision. Each transformer is moved by one position at a time.

5.2 Associated records

A transformer with fixed ratio should be described by a TRANSFO record. It can be also described by a TRFO record in which some fields are not used.

An in-phase regulating transformer can be represented either by a combination of TRANSFO and LTC-V records or by a TRFO record. In the former case, a constant but nonzero ϕ can be specified while in the latter case, $\phi = 0$ is assumed.

A phase-shifting regulating transformer must be represented by a combination of TRANSFO and PHSHIFT-P records.

Any transformer cannot be controlled by more than one LTC-V or PHSHIFT-P record, otherwise the program stops.

All transformers are memorized, even those which are out of service. A transformer out of service is not involved in the equations (it appears in the output results with a zero power flow) but it can be put back into service.

5.3 TRANSFO record

* type of record : TRANSFO
* NAME (max 20 characters) : name of transformer
* FROM_BUS (max 8 characters) : name of the bus on the “1” side of the ideal transformer (cf Fig. 2)
* TO_BUS (max 8 characters) : name of the bus on the “n” side of the ideal transformer (cf Fig. 2)
* R : resistance R, in % on the (V_{B1}, SNOM) base
* X : reactance X, in % on the (V_{B1}, SNOM) base
* B1 : susceptance B_1, in % on the (V_{B1}, SNOM) base. This is normally a negative value. It can be set to zero

[1] to account for the fact that in some phase-shifting transformers, n varies with the phase angle shift ϕ

* B2 : susceptance B_2, in % on the (V_{B1}, SNOM) base. This is normally a negative value. It can be set to zero

* N : ratio n, in % on the (V_{B1}, V_{B2}) base

* PHI : phase angle ϕ, in degrees

* SNOM : apparent nominal power of the transformer, in MVA. This value must not be zero

* BR : on/off status of the transformer breakers. A zero value indicates that the breakers are open at both ends; any other value means that both breakers are closed.

To have a transformer connected through a single end, declare the opened end as a bus and set the BR parameter to 1.

5.4 LTC-V record

The LTC-V record describes an in-phase voltage regulator. It has mandatory and optional fields.

5.4.1 Mandatory fields

The mandatory fields are as follows:

* type of record : LTC-V

* NAME (max 20 characters) : name of transformer. This name must be defined in a TRANSFO record, otherwise the program stops

* CON_BUS (max 8 characters) : name of the bus whose voltage is controlled by adjusting the transformer ratio n. This must be one of the two terminal buses of the transformer, otherwise the program stops

* NFIRST : the ratio n, in %, corresponding to the first tap position

* NLAST : the ratio n, in %, corresponding to the last tap position

* NBPOS : the number of tap positions

* TOLV : the ϵ tolerance (or half deadband), in per unit

* VDES : the desired voltage at the controlled bus, in per unit. As long as the controlled voltage differs from VDES by less than TOLV, the tap position remains unchanged

* TEMPIN : not used by ARTERE
* TEMPUL : not used by ARTERE.

When an LTC-V record is provided, the ratio given by the N field of the TRANSFO record is adjusted to match the closest tap position. The so obtained ratio is used as initial value.

5.4.2 Optional fields

The optional fields are used to specify individual values of n and X for all or for some tap positions. There are 3 fields per tap position, as follows:

* POS : number of the tap position. POS must be larger or equal to 1, otherwise the program stops
* REAC : reactance X, in % on the (V_{B1}, SNOM) base
* RATIO : ratio n, in %.

If no optional field is specified, n varies linearly in between NFIRST and NLAST, while X remains constant.

If optional fields are provided:

- the NFIRST, NLAST and NBPOS fields of the LTC-V record are ignored;
- the X field of the TRANSFO record is also ignored.

If optional fields are used, data must be provided for at least two tap positions, otherwise the program stops.

The first field relates to tap position No 1; hence, the first POS field must be equal to 1, otherwise the program stops.

Data must be specified by increasing value of the tap position number. If the value does not increase from one POS field to the next, the program stops.

The last POS field gives the total number of tap positions. As already mentioned, this value supersedes the NBPOS field.

The ratio n may either decrease or increase with the tap position number, but it must not do both. In other words, the values given by the successive RATIO fields must vary monotonically, otherwise the program stops. Therefrom the program determines in which direction the tap must be moved to correct a given voltage deviation.

On the ohter hand, the values in the REAC fields need not vary monotonically with the tap position.

At tap positions not specified in the data, the values of n and X are obtained by linear interpolation. This is illustrated in Fig. 3. In this example, data are specified for tap positions 1, 4, 5 and 8 (black dots) and are interpolated for positions 2, 3, 6 and 7 (white dots). Thus, the corresponding LTC-V record has $9 + (4 \times 3) = 21$ fields. Note that n increases monotonically with the tap position but not X.

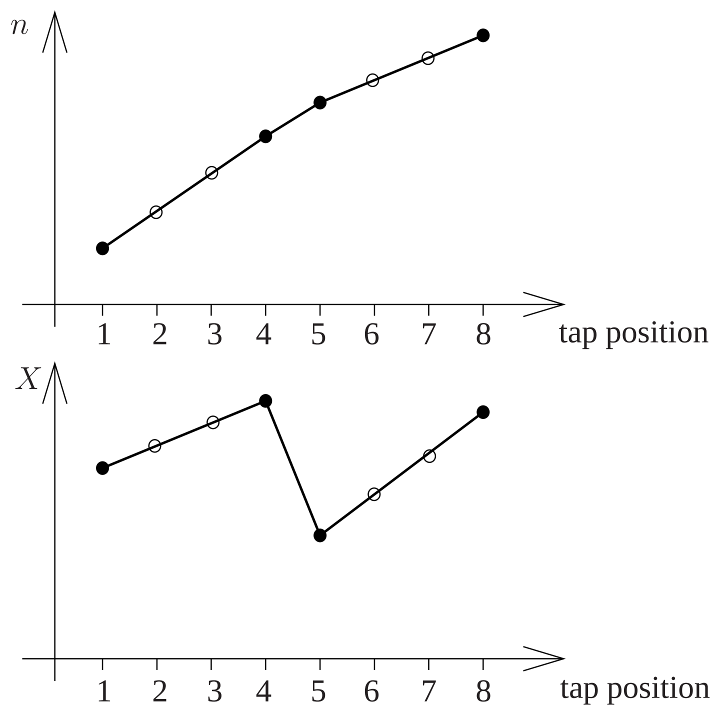

Figure 3: Example of interpolation of n and X

5.5 TRFO record

The TRFO record is a simplified variant of the TRANSFO and LTC-V records combined. n vary linearly with the tap position while X is constant. B_2 and ϕ are zero.

* type of record : TRFO
* NAME (max 20 characters) : name of transformer
* FROM_BUS (max 8 characters) : name of the bus on the “1” side of the ideal transformer (cf Fig. 2)
* TO_BUS (max 8 characters) : name of the bus on the “n” side of the ideal transformer (cf Fig. 2)

* CON_BUS (max 8 characters) : name of the bus whose voltage is controlled by adjusting the transformer ratio n. This must be one of the two terminal buses of the transformer, otherwise the program stops. An empty or blank string of characters[2] is used to indicate that no voltage is controlled, i.e. the transformer ratio is fixed

* R : resistance R, in % on the (V_{B1}, SNOM) base

* X : reactance X, in % on the (V_{B1}, SNOM) base

* B : susceptance B, in % on the (V_{B1}, SNOM) base. This is normally a negative value. It can be set to zero

* N : ratio n, in % on the (V_{B1}, V_{B2}) base

* SNOM : apparent nominal power of the transformer, in MVA. This value must not be zero

* NFIRST : ratio n, in %, corresponding to the first tap position

* NLAST : ratio n, in %, corresponding to the last tap position

* NBPOS : the number of tap positions

* TOLV : tolerance ϵ (or half deadband) of the voltage control, in per unit

* VDES : the setpoint voltage at the controlled bus, in per unit. As long as the controlled voltage differs from VDES by less than TOLV, the tap position remains unchanged

* BR : on/off status of the transformer breakers. A zero value indicates that the breakers are open at both ends; any other value means that both breakers are closed.

To have a transformer connected through a single end, declare the opened end as a bus and set the BR parameter to 1.

5.6 PSHIFT-P record

The PSHIFT-P record describes a phase-shifting regulator aimed at maintaining the active power flow in a branch near some setpoint value.

The PSHIFT-P record has mandatory and optional fields.

[2] enclosed within quotes !

5.6.1 Mandatory fields

The mandatory fields are as follows:

* type of record : PSHIFT-P
* CONTRFO (max 20 characters) : name of the controlled transformer whose phase shift is changed. This name must be defined in a TRANSFO record. If the transformer does not exist, the record is ignored with a warning message
* MONBRANCH : name of the branch in which the active power flow P is monitored and maintained close to a setpoint value. P is the active power leaving the "from" bus and entering the branch. If the branch does not exist, the program stops
* PHAFIRST : the phase shift ϕ, in degrees, corresponding to the first tap position
* PHALAST : the phase shift ϕ, in degrees, corresponding to the last tap position
* NBPOS : number of tap positions
* SIGN : an indication of the direction in which the phase shift ϕ (not the tap position !) must be changed to reach the objective. A value of 1 indicates that ϕ must be <u>in</u>creased to <u>in</u>crease the active power flow in the monitored branch. A value of -1 indicates that it must be decreased. Any other value is refused and causes the program to stop.
* PDES : the setpoint value of the active power flow, in MW
* TOLP : the tolerance ϵ, in MW
* TEMPIN : not used by ARTERE
* TEMPUL : not used by ARTERE.

ARTERE performs a sensitivity analysis to determine how the tap changer has to be moved. If this analysis yields a direction opposite to what is specified in SIGN, a warning is issued and the value of SIGN is ignored. On output, when it produces an updated data file with the system state, ARTERE sets SIGN to the value corresponding to its sensitivity analysis.

When an PHSIFT-P record is provided, the phase shift given by the PHI field of the TRANSFO record is adjusted to match the closest tap position. The so obtained phase angle is used as initial value.

5.6.2 Optional fields

The optional fields are used to specify individual values of n, X and ϕ for all or for some tap positions. There are 4 fields per tap position, as follows:

* POS : number of the tap position. POS must be larger or equal to 1, otherwise the program stops
* REAC : reactance X, in % on the (V_{B1}, SNOM) base
* RATIO : ratio n, in %
* PHASE : phase shift ϕ, in degrees.

If no optional field is specified, ϕ varies linearly between PHAFIRST and PHALAST, while X and n remain constant. If optional fields are provided:

- the PHAFIRST, PHALAST and NBPOS fields of the PHSIFT-P record are ignored;
- the X and N fields of the TRANSFO record are also ignored.

If optional fields are used, data must be provided for at least two tap positions, otherwise the program stops.

The first field relates to tap position No 1; hence, the first POS field must be equal to 1, otherwise the program stops.

Data must be specified by increasing value of the tap position number. If the value does not increase from one POS field to the next, the program stops.

The last POS field gives the total number of tap positions. As already mentioned, this value supersedes the NBPOS field.

The phase angle ϕ may either decrease or increase with the tap position number, but it must not do both. In other words, the values given by the successive PHASE fields must vary monotically, otherwise the program stops.

On the other hand, the values in the REAC and RATIO fields need not vary monotonically.

At tap positions not specified in the data, the values of n and X are obtained by linear interpolation, similarly to what is shown in Fig. 3. The PHSHIFT-P record corresponding to that figure has $9 + (4 \times 4) = 25$ fields.

6 Generators

In ARTERE, generators are represented through the so-called PV or PQ buses. Note that there can be only one generator per bus. In the same way, a bus cannot simultaneously have a generator and a static var compensator.

If, initially, the generator is specified as PV, lower and upper limits of reactive generation are monitored. If the limit is violated, the generator bus is converted to the PQ type and the limit is enforced. A generator at its upper (resp. lower) reactive limit reverts to PV type if the voltage becomes greater (resp. smaller) than the imposed voltage. Note that these reactive limits only affect the load flow computation; the QSS simulation uses distinct models.

A generator can be specified PQ, in which case there is no testing of limits.

In ARTERE, following a change imposed by the user (for instance, a change in load or generation, or a generator outage) the resulting active power imbalance can be compensated by adjusting the generator active powers according to some participation factors (see user guide) *before* running a new sequence of Newton iterations. In this power rescheduling, the limits on the active power of a generator (turbine limits) can be taken into account.

6.1 GENER record

In load flow computation, generators are described by GENER records, as follows.

* type of record : GENER
* NAME (max 10 characters) : name of the generator
* CON_BUS (max 8 characters) : name of the bus to which the generator is connected
* MON_BUS (max 8 characters) : not used by ARTERE. To be set to CON_BUS
* P : active power production, in MW
* Q : reactive power production, in Mvar
* VIMP : imposed voltage, in per unit. If VIMP is zero, the generator is treated as a PQ bus with the reactive power production set at the Q value. Otherwise, it is treated as a PV bus and the Q field is ignored
* SNOM : nominal apparent power, in MVA. This parameter must not be zero if one is willing to model the generator in detail (i.e. through a GROUP3 record) in the dynamic simulation
* QMIN : lower reactive power limit, in Mvar
* QMAX : upper reactive power limit, in Mvar
* BR : on/off status of the generator breaker. A zero value indicates that the breaker is open, any other value means that it is closed.

All generators are memorized, even those which are out of service. A generator out of service is not involved in the equations (it appears in the output results with a zero power output) but it can put back into service in the dynamic simulation.

6.2 TURLIM record

The following records are used to specify the minimum and maximum active power of a generator.

* type of record : TURLIM
* GENER (max 10 characters) : name of the generator of concern. If this generator does not exist, the record is ignored with a warning message
* PMIN : minimum active power generation, in MW
* PMAX : maximum active power generation, in MW
* TAU : not used by ARTERE.

7 Static var compensators

7.1 Model

The block diagram of an SVC is shown in Fig. 4. Note that this model is used in both load flow computations and QSS simulations.

Let j be the *observed* bus (i.e. whose voltage is regulated) and i the *controlled* bus (i.e. where the shunt susceptance varies). i and j can be any of the buses, in particular they can coincide. However, normally, j is a transmission EHV bus and i the bus behind the EHV/MV transformer.

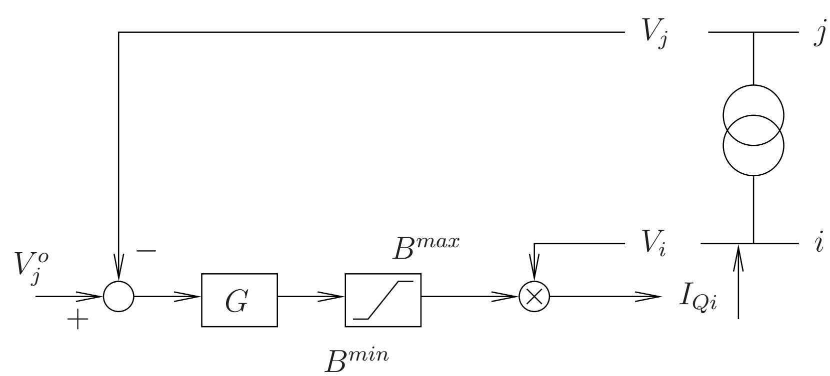

Figure 4: static var compensator

We have $I_{Pi} = 0$ while I_{Qi} takes on one of the following forms:

$$
\begin{aligned}
& I_{Qi} &=& \; G(V_j^0 - V_j)V_i & (1)\\
\text{or} \quad & I_{Qi} &=& \; B^{max} V_i & (2)\\
\text{or} \quad & I_{Qi} &=& \; B^{min} V_i & (3)
\end{aligned}
$$

7.2 SVC record

* type of record : SVC
* NAME (max 10 characters) : name of the compensator
* CON_BUS (max 8 characters) : name of the controlled bus (where the shunt susceptance shunt varies)
* MON_BUS (max 8 characters) : name of the monitored bus (whose voltage is regulated)
* V0 : voltage setpoint V^0, in pu
* Q0 : reactive power setpoint, in Mvar. Used for the load flow computation only. If V0 is set to zero, the compensator is treated in the load flow as a PQ bus, with P = 0 and Q = Q0, and no limit is tested. If V0 is nonzero, the Q0 field is ignored
* SNOM : nominal reactive power, in Mvar
* BMAX : maximal nominal reactive power, in Mvar. This is the power produced by the compensator under a 1 per unit voltage, when B is at the maximal value B^{max}
* BMIN : minimal nominal reactive power, in Mvar. This is the power produced by the compensator under a 1 per unit voltage, when B is at the minimal value B^{min}. A negative value if the compensator consumes power, as is usually the case
* G : gain G, in pu on the (V_B, SNOM) base, where V_B is the base voltage at the controlled bus
* BR : on/off status of the compensator breaker. A zero value indicates that the breaker is open, any other value means that it is closed.

8 Slack bus

In the load flow computation, the slack bus is used as phase angle reference and to compensate for unknown values of the network losses.

8.1 SLACK record

The SLACK record allows to specify which bus is the slack bus. A generator must be connected to this bus.

* type of record : SLACK
* AT_BUS (max 8 characters) : name of the bus of concern

9 Initial and computed voltages

A LFRESV record specifies the voltage magnitude and phase angle at a bus. This voltage is either an initial value specified for the load flow computation or the output of the load flow computation. In the latter case, these records are generated by ARTERE itself (see menu “Outputs - dump records on file”).

* type of record : LFRESV
* BUS (max 8 characters) : name of the bus of concern
* MODULE : voltage magnitude, in per unit
* PHASE : voltage phase angle, in radian.

In the absence of LFRESV record, the ARTERE computation initializes the bus voltage to 1 pu and 0 degrees, respectively.

10 Zones

10.1 Definition

A zone is defined as a set of buses. The zone can include any bus, in particular, the branches connecting the buses in a zone need not make up a connected sub-system. Different zones can overlap, i.e. a bus may belong to several zones.

Zones are used both to define outputs (such as the power consummed or produced in an area) and to apply actions (such as increasing the load in an area).

10.2 BUSPART record

The BUSPART record specifies that a bus belongs to a zone; it also allows to specify active and reactive participation factors for that bus. For a given zone, there are as many BUSPART records as there are buses in the zone.

The participation factors are used when applying actions to the system or are involved in some automatic devices. The interpretation of these numbers depends on the particular action or automatic device.

* type of record : BUSPART
* ZONE (max 8 characters) : name of zone to which the bus belongs. The zones are created as different zone names are discovered while BUSPART records are being read
* BUS (max 8 characters) : name of the bus of concern
* PARTP : active power participation factor
* PARTQ : reactive power participation factor.

11 Cuts

11.1 Definition

A cut is a set of branches with an indication of the monitored extremity and the direction of power flow.

A cut is used to display the total power flowing in the set of branches. A typical example is the total active power flowing in a corridor comprizing several transmission lines.

11.2 BRAPART record

The BRAPART record specifies that a branch belongs to a cut; it also allows to specify the end through which the cut passes and the direction of the power flow. For a given cut, there are as many BRAPART records as there are branches in the cut.

* type of record : BRAPART
* CUT (max 20 characters) : name of the cut to which the branch belongs. The cuts are created as differents cut names are discovered while BRAPART records are being read
* BRANCH (max 20 characters) : name of the branch of concern
* BUS (max 8 characters) : name of the ending bus. This must be one of the branch extremities, otherwise the program stops
* ORIENT : +1 to indicate that the considered power is the one *entering* the branch (thus leaving BUS), -1 to indicate that it is *going out* of the line (thus flowing towards BUS). Any other value causes the program to stop.

12 Computation control parameters

ARTERE relies on the Newton(-Raphson) method to solve the power flow equations. At the k-th iteration, the following indices are computed:

$\epsilon_P = \max_i |f_i(\mathbf{v}^{(k)}, \boldsymbol{\theta}^{(k)}) - P_i^o|$ the largest absolute mismatch of the active power equations

$\epsilon_Q = \max_i |g_i(\mathbf{v}^{(k)}, \boldsymbol{\theta}^{(k)}) - Q_i^o|$ the largest absolute mismatch of the reactive power equations

$\epsilon_S = \max_i \sqrt{(f_i(\mathbf{v}^{(k)}, \boldsymbol{\theta}^{(k)}) - P_i^o)^2 + (g_i(\mathbf{v}^{(k)}, \boldsymbol{\theta}^{(k)}) - Q_i^o)^2}$ the largest apparent power mismatch.

The problem is considered solved once :

- both ϵ_P and ϵ_Q are below specified thresholds
- all controls on transformer ratios and phase shifts are satisfied, and
- all generators and SVCs are within their reactive limits.

while ϵ_S is used to check that the solution is accurate enough to :

- "freeze" the Jacobian matrix (in order to save some computing time)
- check the generator and SVC reactive power limits and enforcing the latter if needed
- adjust the transformer ratios and phase shifter angles to control voltage magnitudes and active power flows, as specified in the data.

Finally, the iterations can be stopped as soon as there is an indication of divergence, in order to save computing time, especially when analysing a large set of severe contingencies. To this purpose the quadratic index :

$$\varphi(k) = \sum_i \sqrt{(f_i(\mathbf{v}^{(k)}, \boldsymbol{\theta}^{(k)}) - P_i^o)^2 + (g_i(\mathbf{v}^{(k)}, \boldsymbol{\theta}^{(k)}) - Q_i^o)^2}$$

is monitored. Under normal convergence conditions, φ decreases from one iteration to the next. Therefore, the increase in φ is used to detect divergence. The algorithm stops at the iteration k such that :

$$\varphi(k) > 1.1\,\varphi(k-1)$$

However, this test is skipped at any iteration k that follows the switching of generators or SVCs under limit, or the adjustment of transformer ratios and phase shifter angles. Indeed, these adjustments cause increases in φ that have nothing to do with divergence.

12.1 Records

The records detailed herafter are used to control the computation itself. They all start with the $ symbol to distinguish them from the records describing the network components. They all have a single field, as detailed hereafter. The default value is assigned by ARTERE in case the record is missing.

* type of record : $TOLAC

* value of ϵ_P, in MW, below which active power flow equations are considered solved. Default value : 0.1 MW

* type of record : $TOLREAC

* value of ϵ_Q, in Mvar, below which reactive power flow equations are considered solved. Default value : 0.1 Mvar

* type of record : $NBITMA

* maximum number of iterations. If this number is exceeded, the computation stops. Default value : 20

* type of record : $MISBLOC

* value of ϵ_S, in MVA, below which the Jacobian is kept constant. Set this parameter to zero to update the Jacobian at every iteration. Default value : 10 MVA

* type of record : $MISADJ

* value of ϵ_S, in MVA, below which the transformer ratios and phase shifter angles are adjusted to control voltage magnitudes and active power flows, respectively. Set this parameter to zero to skip the adjustment. Default value : 10 MVA

* type of record : $PLIM

* a 1 indicates that active power limits specified in TURLIM records should be enforced; otherwise, generators are not active power limited. Default value : 1

* type of record : $DIVDET

* a 1 indicates that the divergence test based on the φ index should be activated during the iterations. If it is not activated, and divergence takes place, the algorithms stops when the maximum number of iterations is reached. Default value : 0