Field	RAWX Key	Description
	rate10, rate11, rate12	Each RATEn = 0.0 (bypass check for this branch; this branch will not be included in any examination of circuit loading) by default. Refer to activity RATE.
STATUS	stat	Switching device status 0 - Open 1 - Closed 2 - Stuck closed STATUS = 1 by default
NSTAT	nstat	Switching device normal status 0 - Open 1 - Closed 2 - Stuck closed NSTAT = 1 by default
METERD	met	Metered end
STYPE	stype	Switching device type 1 - Generic connector 2 - Circuit breaker 3 - Disconnect switch
NAME	name	System switching device name

System Switching Device data input is terminated with a record specifying a from bus number of zero.

1.13. Transformer Data

Each ac transformer to be represented in PSSE is introduced through transformer data record blocks that specify all the data required to model transformers in power flow calculations, with one exception. That exception is an optional set of ancillary data, transformer impedance correction tables, which define the manner in which transformer impedance changes as off-nominal turns ratio or phase shift angle is adjusted. Those data records are described in Transformer Impedance Cor.

Both two-winding and three-winding transformers are specified in transformer data record blocks. Two-winding transformers require a block of four data records. Three-winding transformers require five data records.

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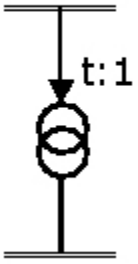
Transformer 	t_1: t_2:	t = t_1 / t_2; transformer turns ratio winding 1 turns ratio in kV or pu on bus voltage base or winding voltage base winding 2 turns ratio in kV or pu on bus voltage base or winding voltage base

Figure 1-9 shows the transformer winding configurations.

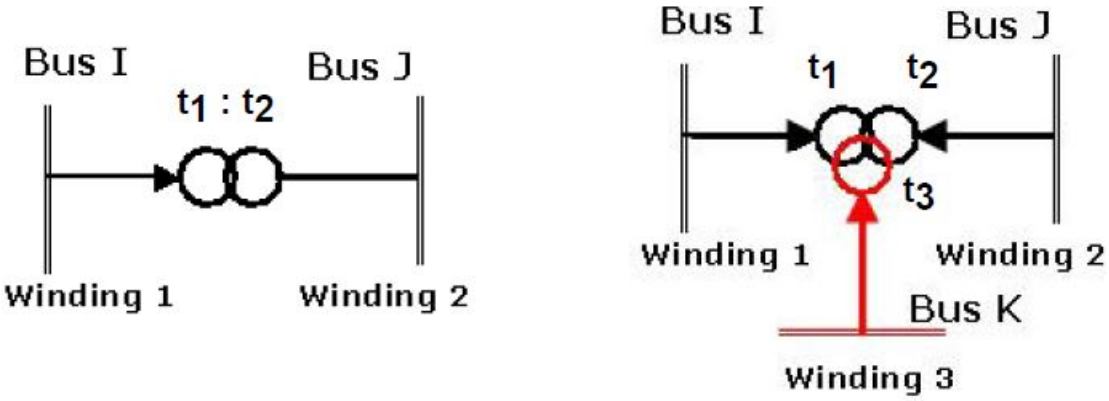


Figure 1.6. Two and Three-winding Transformer Configurations Related to Data Records

RAW Format

The five record transformer data block for three-winding transformers has the following format:

```
I,J,K,CKT,CW,CZ,CM,MAG1,MAG2,NMETR,'NAME',STAT,O1,F1,...,O4,F4,VECGRP,ZCOD

R1-2,X1-2,SBASE1-2,R2-3,X2-3,SBASE2-3,R3-1,X3-1,SBASE3-1,VMSTAR,ANSTAR

WINDV1,NOMV1,ANG1,RATE11...RATE121,COD1,CONT1,NODE1,RMA1,RMI1,

WINDV2,NOMV2,ANG2,RATE12...RATE122,COD2,CONT2,NODE2,RMA2,RMI2,

WINDV3,NOMV3,ANG3,RATE13...RATE123,COD3,CONT3,NODE3,RMA3,RMI3,
```

The four-record transformer data block for two-winding transformers is a subset of the data required for three-winding transformers and has the following format:

```
I,J,K,CKT,CW,CZ,CM,MAG1,MAG2,NMETR,'NAME',STAT,O1,F1,...,O4,F4,VECGRP

R1-2,X1-2,SBASE1-2
```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WINDV1,NOMV1,ANG1,RATE11...RATE121,COD1,CONT1,NODE1,RMA1,RMI1,

WINDV2,NOMV2

RAWX Data Table Format

```
"transformer":{
    "fields":["ibus", "jbus", "kbus", "ckt", "cw", "cz", "cm",
        "mag1", "mag2", "nmet", "name", "stat",
        "o1", "f1", "o2", "f2", "o3", "f3", "o4", "f4",
        "vecgrp", "zcod", "r1_2", "x1_2", "sbase1_2",
        "r2_3", "x2_3", "sbase2_3", "r3_1", "x3_1",
        "sbase3_1", "vmstar", "anstar",
        "windv1", "nomv1", "ang1",
        "wdg1rate1", "wdg1rate2", "wdg1rate3", "wdg1rate4",
        "wdg1rate5", "wdg1rate6", "wdg1rate7", "wdg1rate8",
        "wdg1rate9", "wdg1rate10", "wdg1rate11", "wdg1rate12",
        "cod1", "cont1", "node1", "rma1", "rmi1", "vma1", "vmi1",
        "ntp1", "tab1", "cr1", "cx1", "cnxa1",
        "windv2", "nomv2", "ang2",
        "wdg2rate1", "wdg2rate2", "wdg2rate3", "wdg2rate4",
        "wdg2rate5", "wdg2rate6", "wdg2rate7", "wdg2rate8",
        "wdg2rate9", "wdg2rate10", "wdg2rate11", "wdg2rate12",
        "cod2", "cont2", "node2", "rma2", "rmi2", "vma2", "vmi2",
        "ntp2", "tab2", "cr2", "cx2", "cnxa2",
        "windv3", "nomv3", "ang3",
        "wdg3rate1", "wdg3rate2", "wdg3rate3", "wdg3rate4",
        "wdg3rate5", "wdg3rate6", "wdg3rate7", "wdg3rate8",
        "wdg3rate9", "wdg3rate10", "wdg3rate11", "wdg3rate12",
        "cod3", "cont3", "node3", "rma3", "rmi3", "vma3", "vmi3",
        "ntp3", "tab3", "cr3", "cx3", "cnxa3"],
    "data":[
        [101, 151, 0, "T1", 2, 2, 1,
         0.171, -0.102, 2, "", 1,
         1, 0.32, 2, 0.39, 3, 0.14, 4, 0.15,
         "Dyn1", null, 0.001, 0.0091, 1200.0,
         null, null, null, null, null,
         null, null, null,
         21.6, 21.6, 0.0,
         1200.0, 1100.0, 1000.0, 0.0,
         0.0, 0.0, 0.0, 0.0,
         0.0, 0.0, 0.0, 0.0,
         1, 101, 0, 22.68, 20.52, 1.05, 0.95,
         25, 0, 0.00021, 0.00051, 0.0,
         500.0]

        ...

        [3008, 3012, 3010, "2", 2, 1, 1,
         2.1E-04, -1.2E-04, 1, "", 2,
         5, 0.8, 3, 0.05, 2, 0.1, 1, 0.05,
```


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```
        "D1y0y0", 0, 5.15E-3, 0.5, 20.0,
        9.2E-3, 0.8, 15.0, 3.75E-3, 0.41667,
        25.0, 0.98625, -30.5021,
        230.0, 230.0, 0.0,
        20.0, 18.0, 14.0, 0.0,
        0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0,
        0, 0, 0, 1.1, 0.9, 1.1, 0.9,
        33, 0, 0.0, 0.0, 0.0,
        230.0, 230.0, 0.0,
        15.0, 13.0, 9.0, 0.0,
        0.0, 0.0, 0.0, 0.0,
        0.0, 0.0, 0.0, 0.0,
        0, 0, 0, 1.1, 0.9, 1.1, 0.9,
        33, 0, 0.0, 0.0, 0.0,
        21.6, 21.6, 30.0,
        25.0, 19.0, 16.0,
        0.0, 0.0, 0.0,
        0.0, 0.0, 0.0,
        0.0, 0.0, 0.0,
        0, 0, 0, 1.1, 0.9, 1.1, 0.9,
        33, 0, 0.0, 0.0, 0.0]
    ]
}
```

Note: The above RAWX example includes both a 2-winding and a 3-winding data row example. The 2-winding example skips several trailing fields at the end of the record.

Control parameters for the automatic adjustment of transformers and phase shifters are specified on the third record of the two-winding transformer data block, and on the third through fifth records of the three-winding transformer data block. All transformers are adjustable and the control parameters may be specified either at the time of raw data input or subsequently via activity CHNG or the transformer *[Spreadsheets]*. Any two-winding transformer and any three-winding transformer winding for which no control data is provided has default data assigned to it; the default data is such that the two-winding transformer or three-winding transformer winding is treated as locked.

Refer to Transformer Sequence Numbers and Three-Winding Transformer Notes for additional details on the three-winding transformer model used in PSSE.

When specifying a two-winding transformer between buses I and J with circuit identifier CKT, if a nontransformer branch between buses I and J with a circuit identifier of CKT is already present in the working case, it is replaced (i.e., the nontransformer branch is deleted from the working case and the newly specified two-winding transformer is then added to the working case).

All data items on the first record are specified for both two- and three-winding transformers except for ZCOD, which is specified only for three-winding transformers.

Field	RAWX Key	Description
I	ibus	The bus number, or extended bus name enclosed in single quotes (refer to Extended Bus Names), of the bus to which Winding 1 is connected. The transformer's magnetizing admittance is modeled on Winding 1. Winding 1 is the only winding of a two-winding transformer for which tap ratio or phase shift angle may be ad-

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Field	RAWX Key	Description
		justed by the power flow solution activities; any winding(s) of a three-winding transformer may be adjusted. No default is allowed
J	jbus	The bus number, or extended bus name enclosed in single quotes, of the bus to which Winding 2 is connected. No default is allowed
K	kbus	The bus number, or extended bus name enclosed in single quotes, of the bus to which Winding 3 is connected. Zero is used to indicate that no third winding is present (i.e., that a two-winding rather than a three-winding transformer is being specified). K = 0 by default.
CKT	ckt	One- or two-character uppercase non-blank alphanumeric transformer circuit identifier; the first character of CKT *must not* be an ampersand ( ), at sign (@), or asterisk (*); refer to Multi-Section Line Grouping Data and Section 6.15.2, Outage Statistics Data File Contents. CKT = '1' by default.
CW	cw	The winding data I/O code defines the units in which the turns ratios WINDV1, WINDV2 and WINDV3 are specified (the units of RMAn and RMIn are also governed by CW when |CODn| is 1 or 2): • 1 for off-nominal turns ratio in pu of winding bus base voltage • 2 for winding voltage in kV • 3 for off-nominal turns ratio in pu of nominal winding voltage, NOMV1, NOMV2 and NOMV3 CW = 1 by default.
CZ	cz	The impedance data I/O code defines the units in which the winding impedances R1-2, X1-2, R2-3, X2-3, R3-1 and X3-1 are specified: • 1 for resistance and reactance in pu on system MVA base and winding voltage base • 2 for resistance and reactance in pu on a specified MVA base and winding voltage base • 3 for transformer load loss in watts and impedance magnitude in pu on a specified MVA base and winding voltage base In specifying transformer leakage impedances, the base voltage values are always the nominal winding voltages that are specified on the third, fourth and fifth records of the transformer data block (NOMV1, NOMV2 and NOMV3). If the default NOMVn is not specified, it is assumed to be identical to the winding n bus base voltage.

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Field	RAWX Key	Description
		CZ = 1 by default.
CM	cm	The magnetizing admittance I/O code defines the units in which MAG1 and MAG2 are specified: • 1 for complex admittance in pu on system MVA base and Winding 1 bus voltage base • 2 for no load loss in watts and exciting current in pu on Winding 1 to two MVA base (SBASE1-2) and nominal Winding 1 voltage, NOMV1. CM = 1 by default.
MAG1, MAG2	mag1, mag2	The transformer magnetizing admittance connected to ground at bus I. When CM is 1, MAG1 and MAG2 are the magnetizing conductance and susceptance, respectively, in pu on system MVA base and Winding 1 bus voltage base. When a non-zero MAG2 is specified, it should be entered as a negative quantity. When CM is 2, MAG1 is the no load loss in watts and MAG2 is the exciting current in pu on Winding 1 to two MVA base (SBASE1-2) and nominal Winding 1 voltage (NOMV1). For three-phase transformers or three-phase banks of single phase transformers, MAG1 should specify the three-phase no-load loss. When a non-zero MAG2 is specified, it should be entered as a positive quantity. MAG1 = 0.0 and MAG2 = 0.0 by default.
NMETR	nmet	The nonmetered end code of either 1 (for the Winding 1 bus) or 2 (for the Winding 2 bus). In addition, for a three-winding transformer, 3 (for the Winding 3 bus) is a valid specification of NMETR. NMETR = 2 by default
NAME	name	Alphanumeric identifier assigned to the transformer. NAME may be up to forty characters and may contain any combination of blanks, uppercase letters, numbers and special characters. NAME *must* be enclosed in single or double quotes if it contains any blanks or special characters. NAME *must* be unique within all non-transformer and transformer branches. NAME is blank by default
STAT	stat	Transformer status of one for in-service and zero for out-of-service. In addition, for a three-winding transformer, the following values of STAT provide for one winding out-of-service with the remaining windings in-service: • 2 for only Winding 2 out-of-service • 3 for only Winding 3 out-of-service • 4 for only Winding 1 out-of-service STAT = 1 by default

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Field	RAWX Key	Description
Oi	o1, o2, o3, o4	An owner number (1 through 9999). Each transformer may have up to four owners. By default, O1 is the owner to which bus I is assigned and O2, O3, and O4 are zero.
Fi	f1, f2, f3, f4	The fraction of total ownership assigned to owner Oi; each Fi must be positive. The Fi values are normalized such that they sum to 1.0 before they are placed in the working case. Each Fi is 1.0 by default
VECGRP	vecgrp	Alphanumeric identifier specifying vector group based on transformer winding connections and phase angles. VECGRP value is used for information purpose only. VECGRP is 12 blanks by default
ZCOD	zcod	Method to be used in deriving actual transformer impedances in applying transformer impedance adjustment tables: • 0 apply impedance adjustment factors to winding impedances • 1 apply impedance adjustment factors to bus-to-bus impedances ZCOD = 0 by default ZCOD value is used only for three winding transformers. It is not used for two winding transformers. For three winding transformers, winding impedances are the equivalent T-model impedances Z1, Z2 and Z3; and the bus-to-bus impedances are impedances Z12, Z23 and Z31. For three winding transformers and bus-to-bus impedance correction factors, only one of the three windings must be adjustable (only one of COD1, COD2 and COD3 can be non-zero).

The first three data items on the second record are read for both two- and three-winding transformers; the remaining data items are used *only* for three-winding transformers:

Field	RAWX Key	Description
R1-2, X1-2	r1_2, x1_2	The measured impedance of the transformer between the buses to which its first and second windings are connected. When CZ is 1, they are the resistance and reactance, respectively, in pu on system MVA base and winding voltage base. When CZ is 2, they are the resistance and reactance, respectively, in pu on Winding 1 to 2 MVA base (SBASE1-2) and winding voltage base. When CZ is 3, R1-2 is the load loss in watts, and X1-2 is the impedance magnitude in pu on Winding 1 to 2 MVA base (SBASE1-2) and winding voltage base. For three-phase transformers or three-phase banks of single phase transformers, R1-2 should specify the three-phase load loss.

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Field	RAWX Key	Description
		R1-2 = 0.0 by default, but no default is allowed for X1-2.
SBASE1-2	sbase1-2	The Winding 1 to 2 three-phase base MVA of the transformer. SBASE1-2 = SBASE (the system base MVA) by default.
R2-3, X2-3	r2_3, x2_3	The measured impedance of a three-winding transformer between the buses to which its second and third windings are connected; ignored for a two-winding transformer. When CZ is 1, they are the resistance and reactance, respectively, in pu on system MVA base and winding voltage base. When CZ is 2, they are the resistance and reactance, respectively, in pu on Winding 2 to 3 MVA base (SBASE2-3) and winding voltage base. When CZ is 3, R2-3 is the load loss in watts, and X2-3 is the impedance magnitude in pu on Winding 2 to 3 MVA base (SBASE2-3) and winding voltage base. For three-phase transformers or three-phase banks of single phase transformers, R2-3 should specify the three-phase load loss. R2-3 = 0.0 by default, but no default is allowed for X2-3.
SBASE2-3	sbase2_3	The Winding 2 to 3 three-phase base MVA of a three-winding transformer; ignored for a two-winding transformer. SBASE2-3 = SBASE (the system base MVA) by default.
R3-1, X3-1	r3_1, x3_1	The measured impedance of a three-winding transformer between the buses to which its third and first windings are connected; ignored for a two-winding transformer. When CZ is 1, they are the resistance and reactance, respectively, in pu on system MVA base and winding voltage base. When CZ is 2, they are the resistance and reactance, respectively, in pu on Winding 3 to 1 MVA base (SBASE3-1) and winding voltage base. When CZ is 3, R3-1 is the load loss in watts, and X3-1 is the impedance magnitude in pu on Winding 3 to 1 MVA base (SBASE3-1) and winding voltage base. For three-phase transformers or three-phase banks of single phase transformers, R3-1 should specify the three-phase load loss. R3-1 = 0.0 by default, but no default is allowed for X3-1.
SBASE3-1	sbase3_1	The Winding 3 to 1 three-phase base MVA of a three-winding transformer; ignored for a two-winding transformer. SBASE3-1 = SBASE (the system base MVA) by default.
VMSTAR	vmstar	The voltage magnitude at the hidden star point bus; entered in pu. VMSTAR = 1.0 by default.
ANSTAR	anstar	The bus voltage phase angle at the hidden star point bus; entered in degrees. ANSTAR = 0.0 by default

All data items on the third record are read for both two- and three-winding transformers:

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Field	RAWX Key	Description
WINDV1	windv1	When CW is 1, WINDV1 is the Winding 1 off-nominal turns ratio in pu of Winding 1 bus base voltage; WINDV1 = 1.0 by default. When CW is 2, WINDV1 is the actual Winding 1 voltage in kV; WINDV1 is equal to the base voltage of bus I by default. When CW is 3, WINDV1 is the Winding 1 off-nominal turns ratio in pu of nominal Winding 1 voltage, NOMV1; WINDV1 = 1.0 by default.
NOMV1	nomv1	The nominal (rated) Winding 1 voltage base in kV, or zero to indicate that nominal Winding 1 voltage is assumed to be identical to the base voltage of bus I. NOMV1 is used in converting magnetizing data between physical units and per unit admittance values when CM is 2. NOMV1 is used in converting tap ratio data between values in per unit of nominal Winding 1 voltage and values in per unit of Winding 1 bus base voltage when CW is 3. NOMV1 = 0.0 by default
ANG1	ang1	The winding one phase shift angle in degrees. For a two-winding transformer, ANG1 is positive when the winding one bus voltage leads the winding two bus voltage; for a three-winding transformer, ANG1 is positive when the winding one bus voltage leads the T (or star) point bus voltage. ANG1 must be greater than -180.0° and less than or equal to +180.0°. ANG1 = 0.0 by default.
RATE1n	wdg1rate1, wdg1rate2, wdg1rate3, wdg1rate4, wdg1rate5, wdg1rate6, wdg1rate7, wdg1rate8, wdg1rate9, wdg1rate10, wdg1rate11, wdg1rate12	
COD1	cod1	The transformer control mode for automatic adjustments of the Winding 1 tap or phase shift angle during power flow solutions: • 0 - for fixed tap and fixed phase shift • ±1 - for voltage control • ±2 - for reactive power flow control • ±3 - for active power flow control • ±4 - for control of a dc line quantity (valid only for two-winding transformers) • ±5 - for asymmetric active power flow control If the control mode is entered as a positive number, automatic adjustment of this transformer winding is enabled when the corresponding adjustment is activated

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Field	RAWX Key	Description
		during power flow solutions; a negative control mode suppresses the automatic adjustment of this transformer winding. COD1 = 0 by default.
CONT1	cont1	The bus number, or extended bus name enclosed in single quotes (refer to Extended Bus Names), of the bus for which voltage is to be controlled by the transformer turns ratio adjustment option of the power flow solution activities when COD1 is 1. CONT1 should be non-zero only for voltage controlling transformer windings. CONT1 may specify a bus other than I, J, or K; in this case, the sign of CONT1 defines the location of the controlled bus relative to the transformer winding. If CONT1 is entered as a positive number, or a quoted extended bus name, the ratio is adjusted as if bus CONT1 is on the Winding 2 or Winding 3 side of the transformer; if CONT1 is entered as a negative number, or a quoted extended bus name with a minus sign preceding the first character, the ratio is adjusted as if bus |CONT1| is on the Winding 1 side of the transformer. CONT1 = 0 by default.
NODE1	node1	A node number of bus CONT1. The bus section of bus CONT1 to which node NODE1 is connected is the bus section for which voltage is to be controlled by the transformer turns ratio adjustment option of the power flow solution activities when COD1 is 1. NODE1 should be non-zero only for voltage controlling transformer windings. If bus CONT1 is not in a substation, NODE1 must be specified as 0. NODE1 = 0 by default.
RMA1, RMI1	rma1, rmi1	When |COD1| is 1, 2, 3, or 5, the upper and lower limits, respectively, of one of the following: • Off-nominal turns ratio in pu of Winding 1 bus base voltage when |COD1| is 1 or 2 and CW is 1; RMA1 = 1.1 and RMI1 = 0.9 by default. • Actual Winding 1 voltage in kV when |COD1| is 1 or 2 and CW is 2. No default is allowed. • Off-nominal turns ratio in pu of nominal Winding 1 voltage (NOMV1) when |COD1| is 1 or 2 and CW is 3; RMA1 = 1.1 and RMI1 = 0.9 by default. • Phase shift angle in degrees when |COD1| is 3 or 5. No default is allowed. Not used when |COD1| is 0 or 4; RMA1 = 1.1 and RMI1 = 0.9 by default.
VMA1, VMI1	vma1, vmi1	When |COD1| is 1, 2, 3, or 5, the upper and lower limits, respectively, of one of the following: • Voltage at the controlled bus (bus |CONT1|) in pu when |COD1| is 1. VMA1 = 1.1 and VMI1 = 0.9 by default. • Reactive power flow into the transformer at the Winding 1 bus end in Mvar when |COD1| is 2. No default is allowed.

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Field	RAWX Key	Description
		• Active power flow into the transformer at the Winding 1 bus end in MW when |COD1| is 3 or 5. No default is allowed. Not used when |COD1| is 0 or 4. VMA1 = 1.1 and VMI1 = 0.9 by default.
NTP1	ntp1	The number of tap positions available; used when COD1 is 1 or 2. NTP1 must be between 2 and 9999. NTP1 = 33 by default.
TAB1	tab1	The number of a transformer impedance correction table if this transformer winding's impedance is to be a function of either off-nominal turns ratio or phase shift angle (refer to Transformer Impedance Correction Tables), or 0 if no transformer impedance correction is to be applied to this transformer winding. TAB1 = 0 by default. For three winding transformers, these impedance correction factors are applied to the equivalent T-model impedance Z1 when ZCOD=0 and to the bus-to-bus impedance Z12 when ZCOD=1.
CR1, CX1	cr1, cx1	The load drop compensation impedance for voltage controlling transformers entered in pu on system base quantities; used when COD1 is 1. CR1 + j CX1 = 0.0 by default
CNXA1	cnxa1	Winding connection angle in degrees; used when COD1 is 5. There are no restrictions on the value specified for CNXA1; if it is outside of the range from -90.0 to +90.0, CNXA1 is normalized to within this range. CNXA1 = 0.0 by default.

The first two data items on the fourth record are read for both two- and three-winding transformers; the remaining data items are used *only* for three-winding transformers:

Field	RAWX Key	Description
WINDV2	windv2	When CW is 1, WINDV2 is the Winding 2 off-nominal turns ratio in pu of Winding 2 bus base voltage; WINDV2 = 1.0 by default. When CW is 2, WINDV2 is the actual Winding 2 voltage in kV; WINDV2 is equal to the base voltage of bus J by default. When CW is 3, WINDV2 is the Winding 2 off-nominal turns ratio in pu of nominal Winding 2 voltage, NOMV2; WINDV2 = 1.0 by default.
NOMV2	nomv2	The nominal (rated) Winding 2 voltage base in kV, or zero to indicate that nominal Winding 2 voltage is assumed to be identical to the base voltage of bus J. NOMV2 is used in converting tap ratio data between values in per unit of nominal Winding 2 voltage and values in per unit of Winding 2 bus base voltage when CW is 3. NOMV2 = 0.0 by default.
ANG2	ang2	The winding two phase shift angle in degrees. ANG2 is ignored for a two-winding transformer. For a three-winding transformer, ANG2 is positive when the winding

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Field	RAWX Key	Description
		two bus voltage leads the T (or star) point bus voltage. ANG2 must be greater than -180.0° and less than or equal to +180.0°. ANG2 = 0.0 by default.
RATE2n	wdg2rate1, wdg2rate2, wdg2rate3, wdg2rate4, wdg2rate5, wdg2rate6, wdg2rate7, wdg2rate8, wdg2rate9, wdg2rate10, wdg2rate11, wdg2rate12	Winding 2's twelve three-phase ratings, entered in either MVA or current expressed as MVA, according to the value specified for XFRRAT specified on the first data record (refer to Case Identification Data). Each RATEn2 = 0.0 (bypass loading limit check for this transformer winding) by default.
COD2	cod2	The transformer control mode for automatic adjustments of the Winding 2 tap or phase shift angle during power flow solutions: • 0 - for fixed tap and fixed phase shift • ±1 - for voltage control • ±2 - for reactive power flow control • ±3 - for active power flow control • ±5 - for asymmetric active power flow control If the control mode is entered as a positive number, automatic adjustment of this transformer winding is enabled when the corresponding adjustment is activated during power flow solutions; a negative control mode suppresses the automatic adjustment of this transformer winding. COD2 = 0 by default.
CONT2	cont2	The bus number, or extended bus name enclosed in single quotes (refer to Extended Bus Names), of the bus for which voltage is to be controlled by the transformer turns ratio adjustment option of the power flow solution activities when COD2 is 1. CONT2 should be non-zero only for voltage controlling transformer windings. CONT2 may specify a bus other than I, J, or K; in this case, the sign of CONT2 defines the location of the controlled bus relative to the transformer winding. If CONT2 is entered as a positive number, or a quoted extended bus name, the ratio is adjusted as if bus CONT2 is on the Winding 1 or Winding 3 side of the transformer; if CONT2 is entered as a negative number, or a quoted extended bus name with a minus sign preceding the first character, the ratio is adjusted as if bus |CONT2| is on the Winding 2 side of the transformer. CONT2 = 0 by default.

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Field	RAWX Key	Description
NODE2	node2	A node number of bus CONT2. The bus section of bus CONT2 to which node NODE2 is connected is the bus section for which voltage is to be controlled by the transformer turns ratio adjustment option of the power flow solution activities when COD2 is 1. NODE2 should be non-zero only for voltage controlling transformer windings. If bus CONT2 is not in a substation, NODE2 must be specified as 0. NODE2 = 0 by default.
RMA2, RMI2	rma2, rmi2	When |COD2| is 1, 2, 3, or 5, the upper and lower limits, respectively, of one of the following: • Off-nominal turns ratio in pu of Winding 2 bus base voltage when |COD2| is 1 or 2 and CW is 1; RMA2 = 1.1 and RMI2 = 0.9 by default. • Actual Winding 2 voltage in kV when |COD2| is 1 or 2 and CW is 2. No default is allowed. • Off-nominal turns ratio in pu of nominal Winding 2 voltage (NOMV2) when |COD2| is 1 or 2 and CW is 3; RMA2 = 1.1 and RMI2 = 0.9 by default. • Phase shift angle in degrees when |COD2| is 3 or 5. No default is allowed. Not used when |COD2| is 0. RMA2 = 1.1 and RMI2 = 0.9 by default.
VMA2, VMI2	vma2, vmi2	When |COD2| is 1, 2, 3, or 5, the upper and lower limits, respectively, of one of the following: • Voltage at the controlled bus (bus |CONT2|) in pu when |COD2| is 1. VMA2 = 1.1 and VMI2 = 0.9 by default. • Reactive power flow into the transformer at the Winding 2 bus end in Mvar when |COD2| is 2. No default is allowed. • Active power flow into the transformer at the Winding 2 bus end in MW when |COD2| is 3 or 5. No default is allowed. Not used when |COD2| is 0. VMA2 = 1.1 and VMI2 = 0.9 by default
NTP2	ntp2	The number of tap positions available; used when COD2 is 1 or 2. NTP2 must be between 2 and 9999. NTP2 = 33 by default
TAB2	tab2	The number of a transformer impedance correction table if this transformer winding's impedance is to be a function of either off-nominal turns ratio or phase shift angle (refer to Transformer Impedance Correction Tables), or 0 if no transformer impedance correction is to be applied to this transformer winding. TAB2 = 0 by default.

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Field	RAWX Key	Description
		For three winding transformers, these impedance correction factors are applied to the equivalent T-model impedance Z2 when ZCOD=0 and to the bus-to-bus impedance Z23 when ZCOD=1.
CR2, CX2	cr2, cx2	The load drop compensation impedance for voltage controlling transformers entered in pu on system base quantities; used when COD2 is 1. CR2 + j CX2 = 0.0 by default.
CNXA2	cnxa2	Winding connection angle in degrees; used when COD2 is 5. There are no restrictions on the value specified for CNXA2; if it is outside of the range from -90.0 to +90.0, CNXA2 is normalized to within this range. CNXA2 = 0.0 by default.

The fifth data record is specified only for three-winding transformers:

Field	RAWX Key	Description
WINDV3	windv3	When CW is 1, WINDV3 is the Winding 3 off-nominal turns ratio in pu of Winding 3 bus base voltage; WINDV3 = 1.0 by default. When CW is 2, WINDV3 is the actual Winding 3 voltage in kV; WINDV3 is equal to the base voltage of bus K by default. When CW is 3, WINDV3 is the Winding 3 off-nominal turns ratio in pu of nominal Winding 3 voltage, NOMV3; WINDV3 = 1.0 by default.
NOMV3	nomv3	The nominal (rated) Winding 3 voltage base in kV, or zero to indicate that nominal Winding 3 voltage is assumed to be identical to the base voltage of bus K. NOMV3 is used in converting tap ratio data between values in per unit of nominal Winding 3 voltage and values in per unit of Winding 3 bus base voltage when CW is 3. NOMV3 = 0.0 by default
ANG3	ang3	The winding three phase shift angle in degrees. ANG3 is positive when the winding three bus voltage leads the T (or star) point bus voltage. ANG3 must be greater than -180.0° and less than or equal to +180.0°. ANG3 = 0.0 by default
RATE3n	wdg3rate3, wdg3rate2, wdg3rate3, wdg3rate4, wdg3rate5, wdg3rate6, wdg3rate7, wdg3rate8, wdg3rate9, wdg3rate10, wdg3rate11, wdg3rate12	Winding 3's twelve three-phase ratings, entered in either MVA or current expressed as MVA, according to the value specified for XFRRAT specified on the first data record (refer to Case Identification Data). Each RATEn3 = 0.0 (bypass loading limit check for this transformer winding) by default.
COD3	cod3	The transformer control mode for automatic adjustments of the Winding 3 tap or phase shift angle during power flow solutions:

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Field	RAWX Key	Description
		• 0 - for fixed tap and fixed phase shift • ±1 - for voltage control • ±2 - for reactive power flow control • ±3 - for active power flow control • ±5 - for asymmetric active power flow control If the control mode is entered as a positive number, automatic adjustment of this transformer winding is enabled when the corresponding adjustment is activated during power flow solutions; a negative control mode suppresses the automatic adjustment of this transformer winding. COD3 = 0 by default
CONT3	cont3	The bus number, or extended bus name enclosed in single quotes (refer to Extended Bus Names), of the bus for which voltage is to be controlled by the transformer turns ratio adjustment option of the power flow solution activities when COD3 is 1. CONT3 should be non-zero only for voltage controlling transformer windings. CONT3 may specify a bus other than I, J, or K; in this case, the sign of CONT3 defines the location of the controlled bus relative to the transformer winding. If CONT3 is entered as a positive number, or a quoted extended bus name, the ratio is adjusted as if bus CONT3 is on the Winding 1 or Winding 2 side of the transformer; if CONT3 is entered as a negative number, or a quoted extended bus name with a minus sign preceding the first character, the ratio is adjusted as if bus |CONT3| is on the Winding 3 side of the transformer. CONT3 = 0 by default
NODE3	node3	A node number of bus CONT3. The bus section of bus CONT3 to which node NODE3 is connected is the bus section for which voltage is to be controlled by the transformer turns ratio adjustment option of the power flow solution activities when COD3 is 1. NODE3 should be non-zero only for voltage controlling transformer windings. If bus CONT3 is not in a substation, NODE3 must be specified as 0. NODE3 = 0 by default.
RMA3, RMI3	rma3, rmi3	When |COD3| is 1, 2, 3, or 5, the upper and lower limits, respectively, of one of the following: • Off-nominal turns ratio in pu of Winding 3 bus base voltage when |COD3| is 1 or 2 and CW is 1; RMA3 = 1.1 and RMI3 = 0.9 by default. • Actual Winding 3 voltage in kV when |COD3| is 1 or 2 and CW is 2. No default is allowed. • Off-nominal turns ratio in pu of nominal Winding 3 voltage (NOMV3) when |COD3| is 1 or 2 and CW is 3; RMA3 = 1.1 and RMI3 = 0.9 by default.

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Field	RAWX Key	Description
		• Phase shift angle in degrees when |COD3| is 3 or 5. No default is allowed. Not used when |COD3| is 0. RMA3 = 1.1 and RMI3 = 0.9 by default
VMA3, VMI3	vma3, vmi3	When |COD3| is 1, 2, 3, or 5, the upper and lower limits, respectively, of one of the following: • Voltage at the controlled bus (bus |CONT3|) in pu when |COD3| is 1. VMA3 = 1.1 and VMI3 = 0.9 by default. • Reactive power flow into the transformer at the Winding 3 bus end in Mvar when |COD3| is 2. No default is allowed. • Active power flow into the transformer at the Winding 3 bus end in MW when |COD3| is 3 or 5. No default is allowed. Not used when |COD3| is 0. VMA3 = 1.1 and VMI3 = 0.9 by default
NTP3	ntp3	The number of tap positions available; used when COD3 is 1 or 2. NTP3 must be between 2 and 9999. NTP3 = 33 by default
TAB3	tab3	The number of a transformer impedance correction table if this transformer winding's impedance is to be a function of either off-nominal turns ratio or phase shift angle (refer to Transformer Impedance Correction Tables), or 0 if no transformer impedance correction is to be applied to this transformer winding. TAB3 = 0 by default For three winding transformers, these impedance correction factors are applied to the equivalent T-model impedance Z3 when ZCOD=0 and to the bus-to-bus impedance Z31 when ZCOD=1.
CR3, CX3	cr3, cx3	The load drop compensation impedance for voltage controlling transformers entered in pu on system base quantities; used when COD3 is 1. CR3 + j CX3 = 0.0 by default
CNXA3	cnxa3	Winding connection angle in degrees; used when COD3 is 5. There are no restrictions on the value specified for CNXA3; if it is outside of the range from -90.0 to +90.0, CNXA3 is normalized to within this range. CNXA3 = 0.0 by default

Transformer data input is terminated with a record specifying a Winding 1 bus number of zero.

1.13.1. Three-Winding Transformer Notes

The transformer data record blocks described in Transformer Data provide for the specification of both two-winding transformers and three-winding transformers. A three-winding transformer is modeled in PSSE as a grouping of three two-winding transformers, where each of these two-winding transformers models one

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