

VTs & CCVTs - SYSTEM PROTECTION

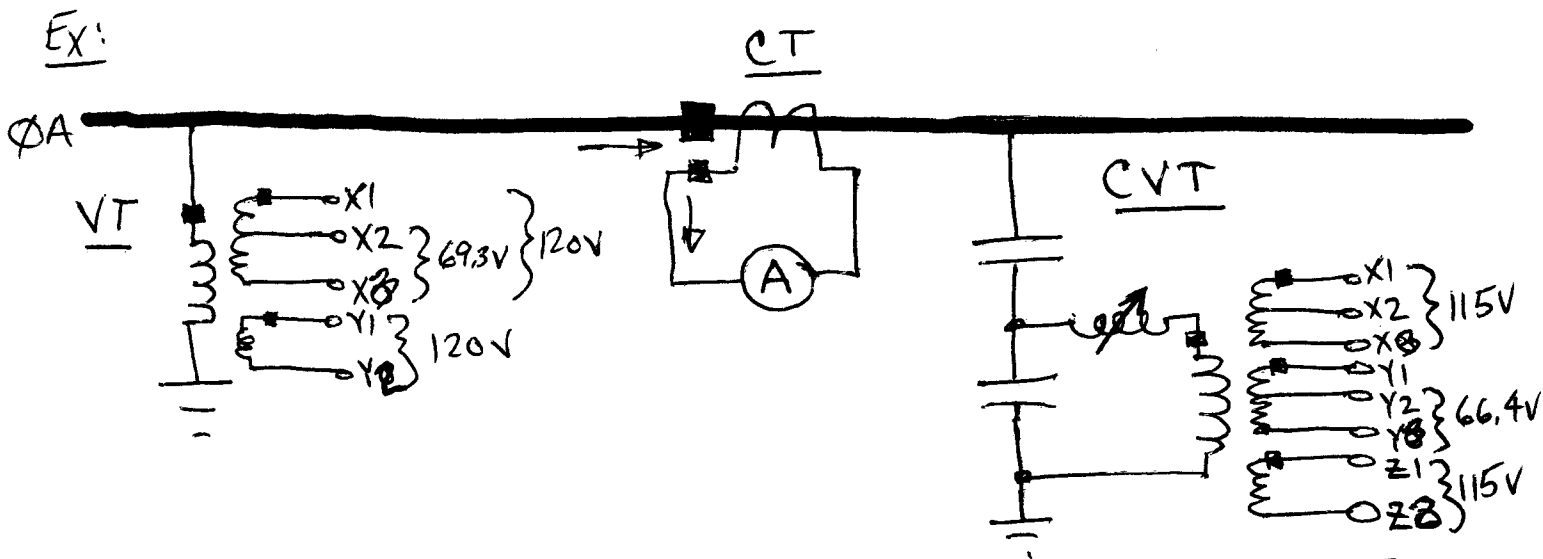
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Instrument transformers - used to "step down" primary voltages and currents to lower standard levels.

- Current: 0-5 A - CT

Voltage: X1-X3: 0-120V
X2-X3: 0-69.3V } Voltage Transformer (VT)

X1-X3: 0-115V
X2-X3: 0-66.4V } CVT or CCVT



Note that "PT" designation is obsolete - new ~~IEEE~~ designation is "VT". Economics usually point to use of CVT or CCVT for voltages above 69-KV, VTs for lower voltages.

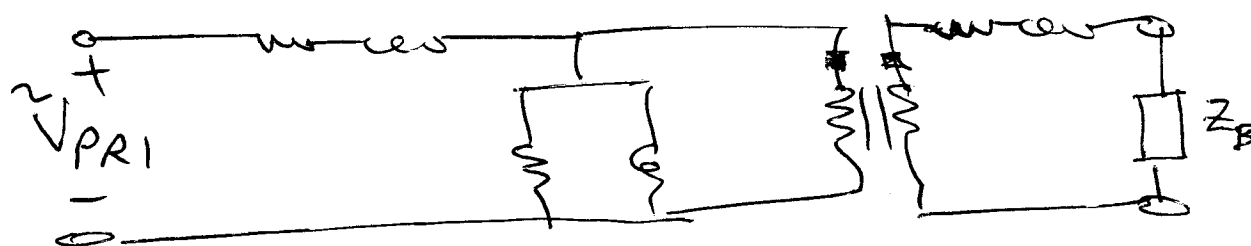
Note that linear couplers, which produce a secondary voltage proportional to the primary current, were in vogue for a while in the 50's & 60's but never caught on. Used mainly in bus differential schemes. Requires special relays (voltage instead of current input) - this additional cost hobbled it. (See p. 35, Blackburn 2nd Ed.)

VTs and CCVTs will ^{usually} not experience overvoltage situations (except for ferroresonance) and so the extreme core saturation problems of the CT are not an issue, especially for system protection.

If VT or CCVT is to be used for metering, however, then accuracy is an issue.

1.2R accuracy class - relaying
0.3 accuracy class - metering

VT:



CCVT:

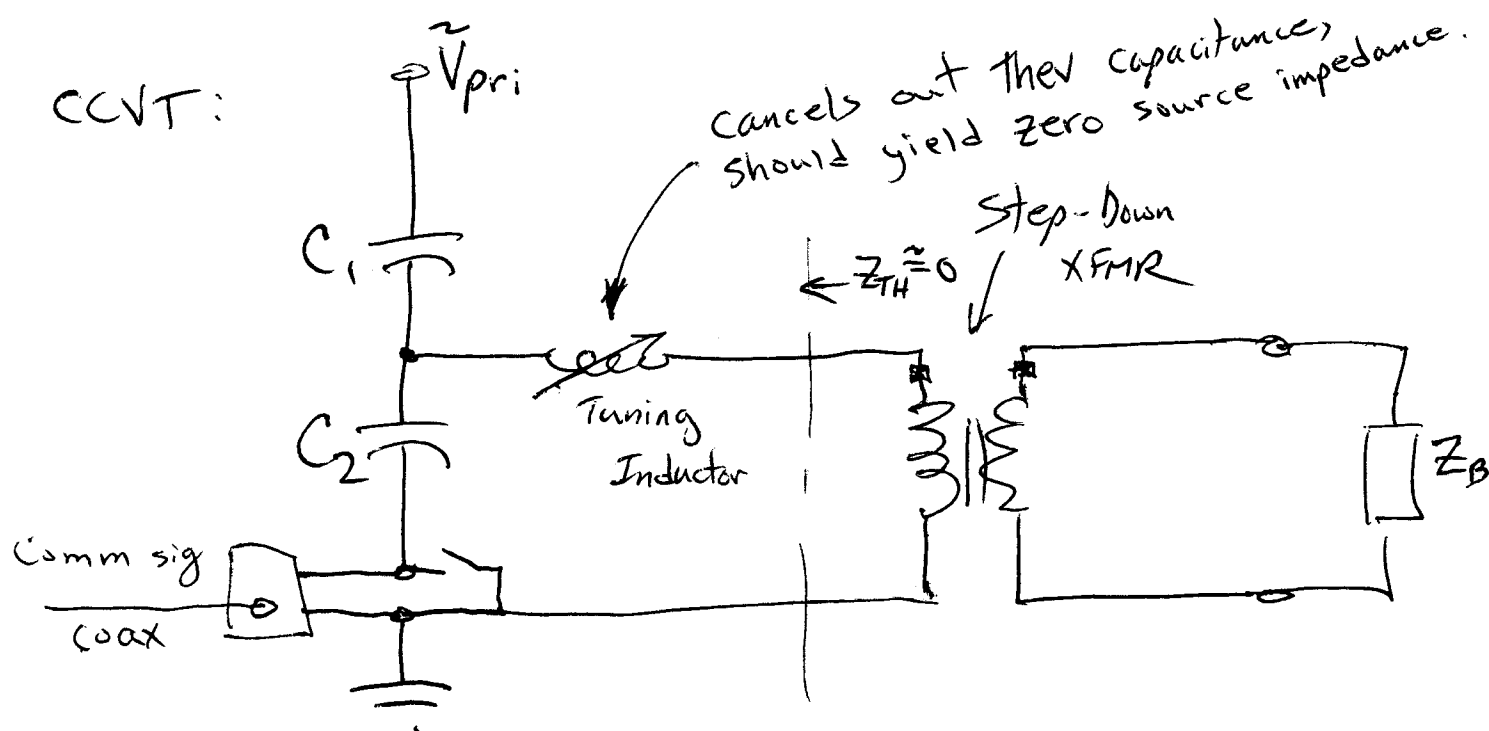


Table 3
Voltage Ratings and Marked Ratios

Nominal System Voltage (Note 1) (kV)	Maximum System Voltage (kV)	Maximum Rated Voltage (Note 2) (kV)	Performance Reference Voltage (Note 3) (Volts)	Marked Ratio (Note 3)	
				Lower Ratio	Higher Ratio
Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
34.5	38	22	20 125	175:1	300:1
46	48.3	28	27 000	240:1	400:1
69	72.5	42	40 250	350:1	600:1
115	121	70	69 000	600:1	1000:1
138	145	84	80 500	700:1	1200:1
161	169	98	92 000	800:1	1400:1
230	242	140	138 000	1200:1	2000:1
345*	362	209	207 000	1800:1	3000:1
500*	550	317	287 500	2500:1	4500:1
735-765*	800	462	431 250	3750:1	6250:1

*These typical "nominal" voltages are in accordance with Section 2 of American National Standard Preferred Voltage Ratings for Alternating-Current Electrical Systems and Equipment Operating at Voltages above 230 Kilovolts Nominal, C92.2-1976.

NOTES:

(1) These values correspond to the preferred nominal system voltages given in American National Standard Voltage Ratings for Electric Power Systems and Equipment (60 Hz), C84.1-1977, except for the 345-, 500-, and 765-kV ratings.

(2) These values are the phase-to-ground voltages corresponding to the maximum voltage of the tolerable zone for voltages at substations and on transmission systems given in American National Standard C84.1-1977.

(3) For CCVTs in this table that have a double ratio achieved by means of a tap in the secondary winding(s), the nonpolarity end of the winding shall be the common terminal. Application of performance reference voltage between the high-voltage terminal and the ground terminal will result in 115 volts across the secondary windings having the lower ratio.

3.2 Unusual Service Conditions

(1) Altitudes above 3300 feet (1000 meters). For CCVTs applied at altitudes greater than 3300 feet (1000 meters), the dielectric strength correction factors given in Table 2 should be applied.

(2) Gas-insulated substations.

(3) High-voltage power cable systems.

4. Ratings

4.1 General

4.1.1 Voltage Ratings and Marked Ratios. Voltage ratings and marked ratios shall be as listed in Table 3.

4.1.2 Dielectric Strength Requirements

4.1.2.1 Dielectric Strength of the Capacitor Divider. The dielectric strength of the capacitor divider shall be in accordance with Table 3 of American National Standard Requirements for Power Line Coupling Capacitors, C93.1-1972.

4.1.2.2 Dielectric Strength of the Electromagnetic Unit

4.1.2.2.1 Dielectric Strength of the Intermediate-Voltage Circuit. The dielectric strength of

the electromagnetic unit at the intermediate-voltage terminal shall be equal to the appropriate capacitor divider dielectric test values as specified in Table 3 of American National Standard C93.1-1972 multiplied by the ratio $C_1/(C_1 + C_2)$. The sparkover voltage of protective equipment, such as gaps, may be lower than the dielectric strength rating.

4.1.2.2.2 Dielectric Strength of the Secondary Circuit. The secondary windings of the intermediate-voltage transformer and the reactive element of any auxiliary equipment to be connected to the secondary winding(s) shall withstand a test voltage of four times normal operating voltage for 1 minute and a power-frequency rms dielectric test voltage of 2.5 kV for 1 minute between the secondary circuit and ground and between secondary windings.

4.1.3 Capacitance and Dissipation Factor of the Capacitor Divider

4.1.3.1 Prior to Dielectric Tests. The stack capacitance at rated power frequency shall not differ from the nominal nameplate value by more than -5% or +10%.

4.1.3.2 After Dielectric Tests. The capacitance at rated power frequency shall differ from that measured

Table 4
Burdens for Accuracy Rating

Burdens*			Characteristics on 120-Volt Basis			Characteristics on 69.3-Volt Basis		
Designation	Volt-Amperes	Power Factor	Resistance (ohms)	Inductance (henries)	Impedance (ohms)	Resistance (ohms)	Inductance (henries)	Impedance (ohms)
M	35	0.20	82.3	1.07	411	27.4	0.356	137
W	12.5	0.10	115.2	3.04	1152	38.4	1.01	384
X	25	0.70	403.2	1.09	576	134.4	0.364	192
Y	75	0.85	163.2	0.268	192	54.4	0.0894	64
Z	200	0.85	61.2	0.101	72	20.4	0.0335	24
ZZ	400	0.85	30.6	0.0503	36	10.2	0.0168	12

* These burden designations have no significance at frequencies other than 60 Hz.

prior to the dielectric tests by less than the equivalent of one capacitor element. The dissipation factor at rated power frequency shall not differ from that measured prior to the dielectric tests by more than 0.1%.

NOTE: The purpose of checking the dissipation factor is to check the uniformity of the production method and effectiveness of the processing cycle.

4.1.4 Radio-Influence Voltage. The maximum radio-influence voltage of a CCVT shall be in accordance with Table 4 of American National Standard C93.1-1972.

4.1.5 Short-Time Overvoltage Operation. The CCVT shall be capable of withstanding 140% of performance reference voltage for 1 minute.

"Capable of withstanding" shall be interpreted to mean that, after being subjected to this duty, the CCVT shall show no damage and shall be capable of meeting the requirements of this standard.

4.1.6 Burdens

4.1.6.1 Burdens for Accuracy Rating. Burdens for accuracy rating purposes shall be expressed in volt-amperes at a specified lagging power factor as listed in Table 4, at one of the voltages given as follows:

Burdens are based on two secondary voltages, 120 volts and 69.3 volts, and rated power frequency. The burden designations and the same physical burdens are used in applying accuracy ratings to CCVTs irrespective of the exact secondary voltages resulting from the voltage applied to the high-voltage terminal and ratios. For example, for those CCVTs having ratios that result in secondary voltages of 115 or 66.4 volts at performance reference voltage, the actual volt-amperes for a designated burden is reduced to 91.8% of the values listed in Table 4.

4.1.6.2 Burdens for Transient Response Rating. Burdens for transient response rating purposes shall be

expressed in volt-amperes at a specified lagging power factor. Burdens are based on a 120-volt secondary voltage and rated power frequency. The burden shall consist of two impedances connected in parallel as in Fig. 1. One impedance shall be a pure resistance (R_p) and the other (R_s plus X_s) shall have a lagging power factor of 0.5. The inductive reactor shall be of the air-core type.

Burden values for transient response tests shall be 100% of the CCVT maximum rated accuracy class winding volt-amperes and 25% of the maximum rated accuracy class winding volt-amperes at 0.85 power factor. Burdens for CCVTs rated ZT or ZZT are shown in Table 5.

4.1.7 Thermal Burden Rating. The thermal burden rating of a CCVT shall be specified in terms of the maximum burden that the CCVT can carry continuously at maximum rated voltage without exceeding the temperature rise, above a 30°C ambient, permitted by the dielectric materials used in construction.

Each winding, including the primary winding of a

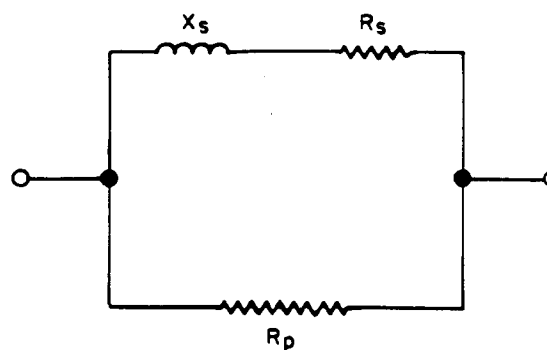


Fig. 1
Circuit Diagram of Burden to Be
Used for Transient Response Test

Table 6
Accuracy Class Limits for Relaying Service

Accuracy Class	Limits of Ratio Correction Factor		Limits of Phase Angle
	Minimum	Maximum	
1.2R	0.988	1.012	± 63 minutes (± 18 milliradians)

4.2 Relaying Service CCVTs. The CCVT shall be within the limits of ratio correction factor and phase angle from zero burden to accuracy burden rating.

4.2.1 Accuracy Class. Accuracy class and corresponding limits of ratio correction factor and phase angle shall be as shown in Table 6 and Fig. 2.

4.2.2 Allowable Variation in Ratio Correction Factor and Phase Angle with Operating Conditions

4.2.2.1 Voltage Variations. The limits of ratio correction factor and phase angle for variations in ap-

plied voltage with constant linear burden shall be as shown in Table 7.

4.2.2.2 Frequency Variations. Over the range of 58 Hz through 62 Hz, the ratio correction factor shall be within the limits of 0.95 to 1.05 and the phase angle shall be within the limits of $\pm 5^\circ$ degrees (± 87 mrad) from the 60-Hz values.

4.3 Metering Service CCVTs. The CCVT shall be within the limits of ratio correction factor and phase angle from zero burden to accuracy burden rating.

4.3.1 Accuracy Classes. Accuracy classes and corresponding limits of ratio correction factor and phase angle shall be as shown in Fig. 3. A metering service CCVT shall be assigned an accuracy class rating for each of the burdens for which it is designed.

4.3.2 Allowable Variation in Ratio Correction Factor and Phase Angle with Operating Conditions

4.3.2.1 Voltage Range. A CCVT shall remain within its metering accuracy class limits when operating continuously between 90% of performance reference voltage and maximum rated voltage.

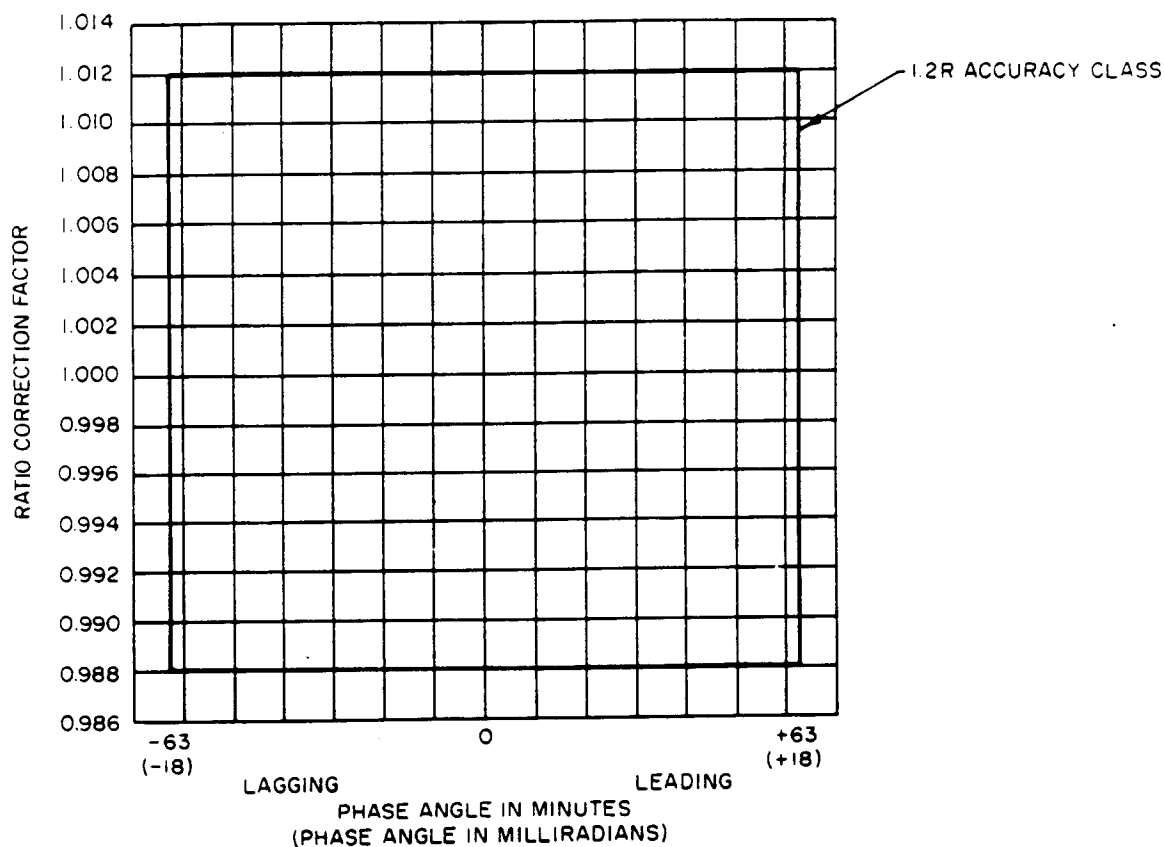


Fig. 2
Limits for Accuracy Class 1.2R for
Coupling Capacitor Voltage Transformers for
Relaying Service

Table 7
Limits of Ratio Correction Factor and
Phase Angle with Voltage Variations

Applied Voltage	Ratio Correction Factor Limits	Phase Angle Limits
90% performance reference voltage to maximum rated voltage	Accuracy class limits	Accuracy class limits
25% performance reference voltage	0.97 to 1.03	$\pm 3^\circ (\pm 52 \text{ mrad})$
5% performance reference voltage	0.95 to 1.05	$\pm 5^\circ (\pm 87 \text{ mrad})$

4.3.2.2 Temperature Range. A CCVT shall remain within its metering accuracy class limits over the ambient temperature range specified in 3.1.

4.3.2.3 Interrelation of Voltage and Temperature. The provisions of 4.3.2.1 and 4.3.2.2 shall be considered simultaneous effects.

5. Testing

5.1 General

5.1.1 Test Conditions. Units shall be tested as specified in 5.1.1.1 through 5.1.1.4.

5.1.1.1 The ambient temperature range for testing shall be from $+10^\circ\text{C}$ through $+40^\circ\text{C}$, with $+20^\circ\text{C}$ as the reference temperature.

5.1.1.2 The test units shall be new and in clean, dry condition.

5.1.1.3 The test units shall be mounted vertically.

5.1.1.4 The sequence of testing shall be optional, except where otherwise noted.

5.1.2 Production (Routine) Tests. The following production tests shall be performed by the manufacturer on each CCVT:

- (1) Capacitance and dissipation factor (see 5.2.1)
- (2) Dielectric (see 5.2.2)
- (3) Accuracy (see 5.2.3)
- (4) Polarity (see 5.2.4)
- (5) Protective-gap setting (see 5.2.5)

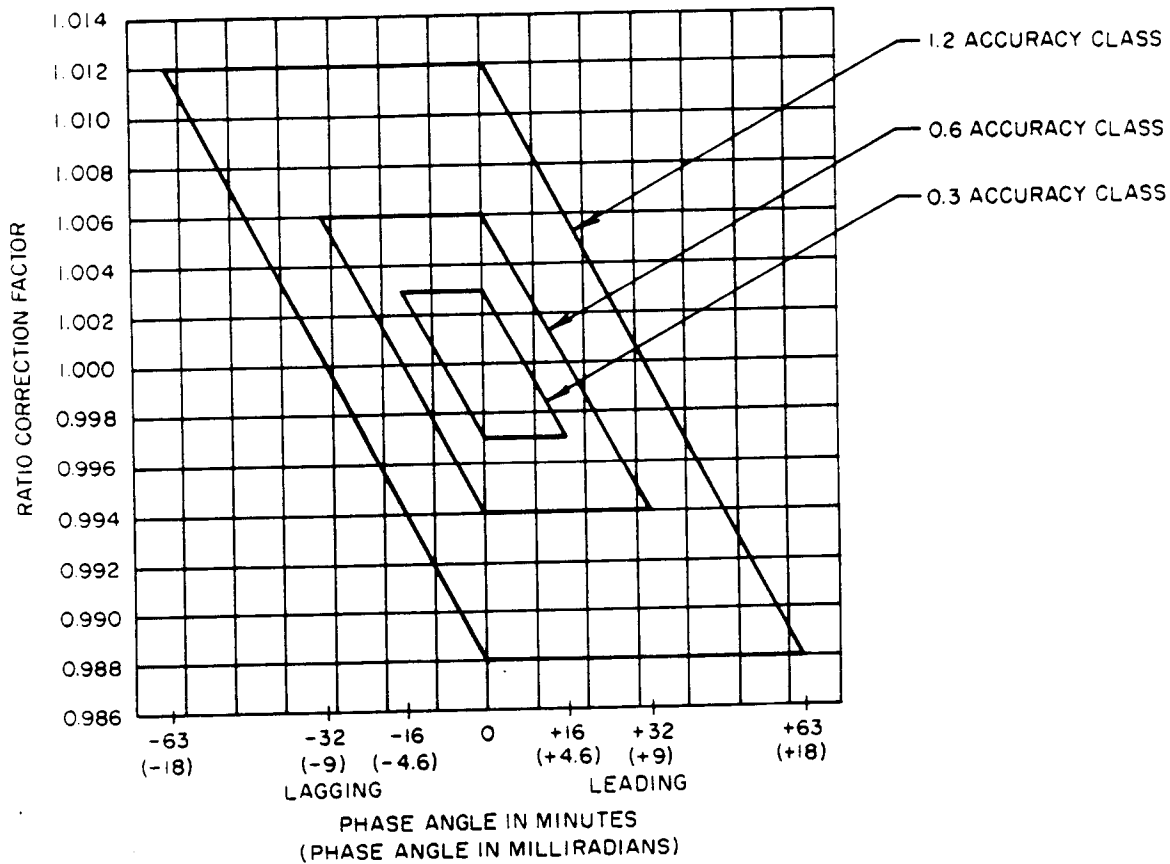


Fig. 3
Limits for Accuracy Classes 0.3, 0.6, and 1.2 for
Coupling Capacitor Voltage Transformers for
Metering Service

Appendixes

(These Appendixes are not a part of American National Standard Requirements for Power-Line Coupling Capacitor Voltage Transformers, C93.2-1976, but are included for information purposes only.)

Appendix A

Coupling Capacitor Voltage Transformer Circuit Diagram

A typical diagram of a coupling capacitor voltage transformer with carrier coupling accessories is shown in Fig. A1. Note, however, that electromagnetic unit overvoltage protective gaps and ferroresonance suppression networks are not included in this diagram.

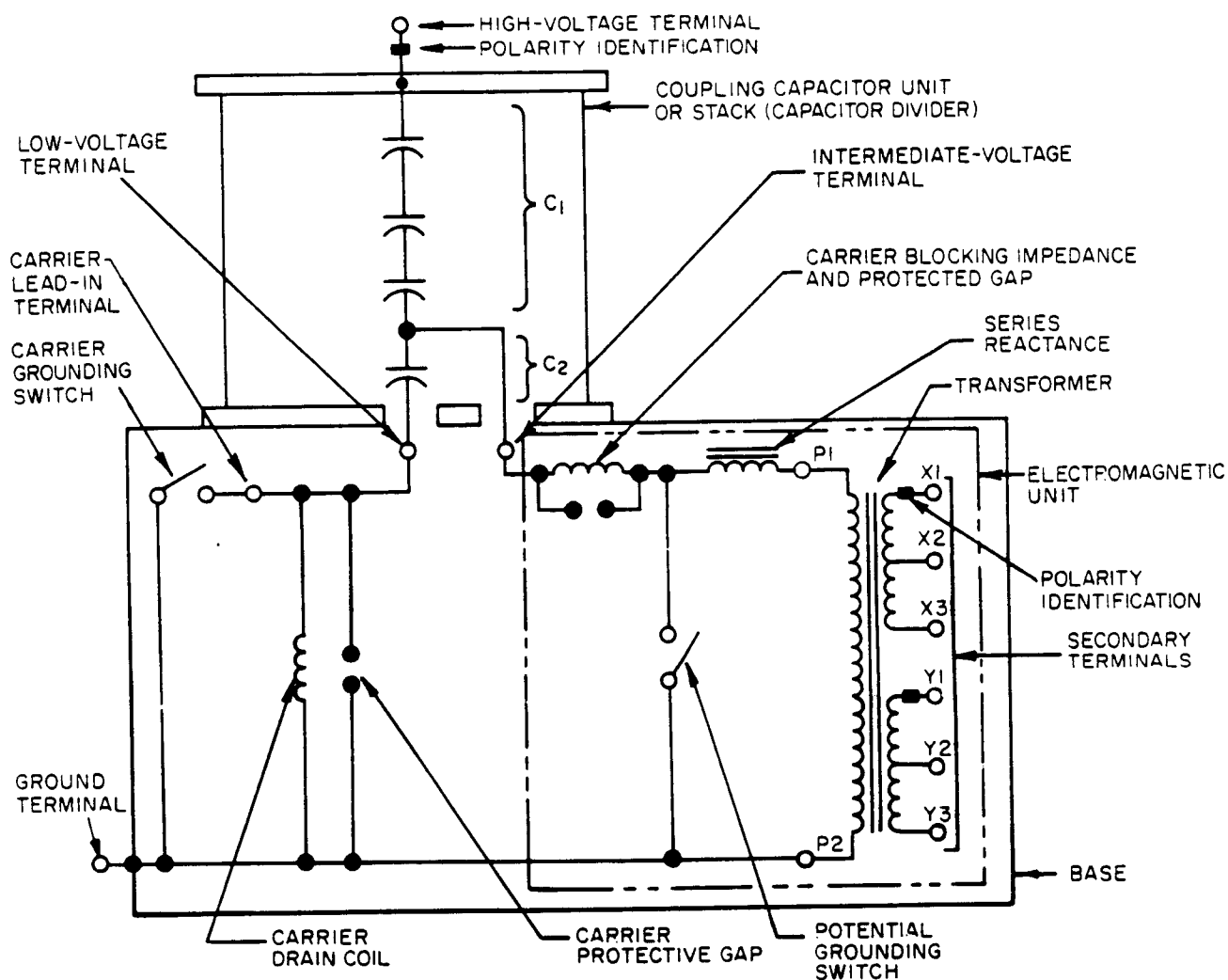


Fig. A1
Typical Diagram of Coupling Capacitor Voltage Transformer
with Carrier Coupling Accessories