

September, 1990  
Supersedes DB 41-347, pages 1-6,  
dated July, 1988  
Mailed to: E, D, C/41-300A

Single Phase  
Device Number: 87

## Types HU, HU-1, HU-4 Instantaneous Variable Percentage Relays

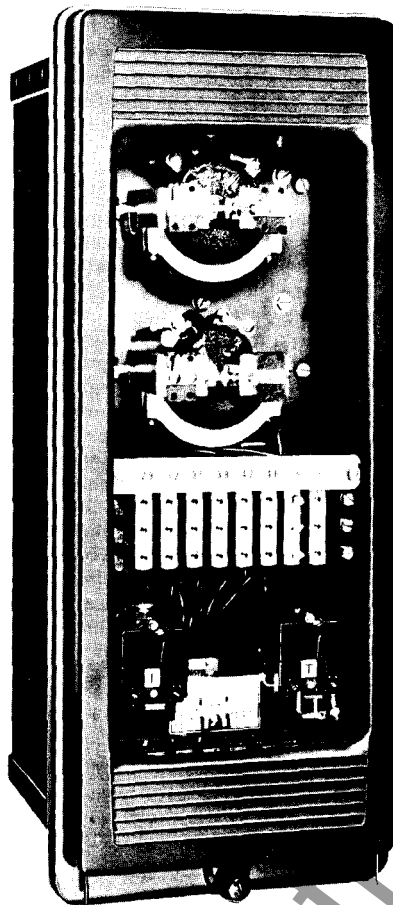


Figure 1

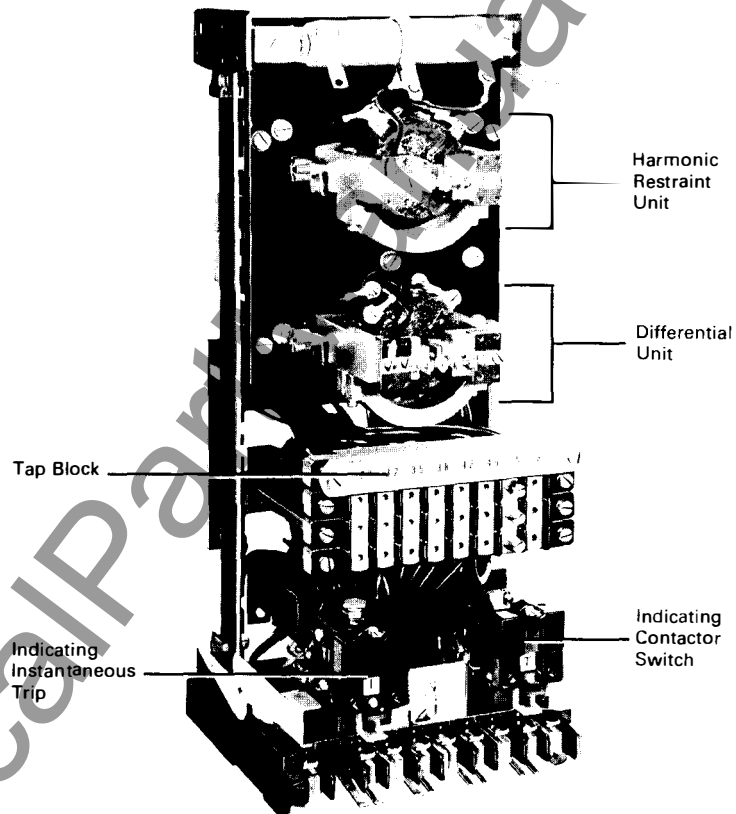


Figure 2

### Application

Types HU, HU-1, and HU-4 relays are high speed differential units with two, three, or four restraint circuits respectively; all incorporating a harmonic restraint circuit to prevent false tripping on magnetizing inrush currents associated with transformer energization.

All are designed with a variable ratio characteristic which provides high sensitivity at low current magnitudes with an increase in percentage ratio at higher currents. Each of the relays then, will detect light internal faults within the transformer and, at the same time, prevent false tripping on heavy external fault currents which may cause variation in the current transformer performance at high currents. This is particularly desirable when severe saturation of current transformers occurs due to the dc component of asymmetrical short circuits.

The harmonic restraint feature of these relays prevents false tripping on magnetizing inrush currents which appear at the relay as an internal fault. Such inrush currents are rich in harmonics, with the second harmonic being predominant. Since this second harmonic is always present in magnetizing inrush currents and not in internal fault current waves the harmonic restraint unit will not close its contacts unless second harmonic content is less than 15 percent of the fundamental. Normal application of these relays is:

- 2-Winding Transformer: Type HU
- 3-Winding Transformer: Type HU-1
- 4-Winding Transformer: Type HU-4
- 4-Circuit Bus: Type HU-4

The HU relay has two restraint transformers and is for use with 2-winding transformer protection. The HU-1 has a third restraint transformer and is used for three winding application. The HU-4 has four restraint cir-

cuits, and may be applied to three-winding transformers with a tertiary winding, or a transformer and bus section combination.

The Type HU-4 may be applied to any bus circuit where the external fault current through the bus is twenty times tap value secondary current or less—e.g., 100 amperes on the 5 ampere tap. Occasionally an auxiliary current balance transformer is used on the line side of the power transformer to adjust the current transformer secondary currents to the bus sections included in the protected zone.

Taps are supplied to compensate for main current transformer mismatch. The relays are available with a sensitivity of either 0.30 or 0.35 times tap setting. The 30% sensitivity relay satisfactorily handles up to 15% mismatch (e.g.,  $\pm 10\%$  transformer tap changing, plus 5% current transformer mismatch). The 35% unit handles up to 20% mismatch. See Figures 4, 5, 9, and 10.

## Features

1. High security due to variable ratio characteristic — The relay detects light internal faults with the transformer and at the same time prevents false tripping on heavy external faults which may cause variation in the current transformer performance at high currents.
2. Fast operating speed limits fault damage to the protected transformer. With the continuing trend toward larger and more costly power transformers, the user is best suited to apply protective relays offering the fastest operating speeds.
3. Greater security during external faults — Faults external to the transformer produce large magnitude through currents which cause unsymmetrical saturation to the current transformers on each side of the power transformer. The higher designed burden of the HU relay's operating coil forces the "strong" CT on one side of protected power transformer to more effectively support the "weak" CT on the other side as desired for secure operation.
4. Second harmonic filter circuits are used to prevent false tripping of the relays during magnetizing inrush current at start-up — The HU relays use the filtered input for the instantaneous unit as well as the main differential unit. Therefore, the instantaneous unit can be set more sensitively, still being secure from false trips due to second harmonic inrush.
5. The type HU relays are designed thermally to allow currents of 2.5 to 3.4 times tap value.

## Operation

### External Fault Conditions

With the relay connected as shown in Figure 3a, external fault currents will flow in the restraint transformers of the differential unit. If the line current transformers are below saturation and with correct tap settings, no effective current flows in the operating transformer of the relay. Hence, a contact opening torque is produced in the differential polar unit.

On heavy external faults where a main transformer saturates, current will flow in the operating circuit of the relay. Under these conditions the harmonic restraint unit may close its contacts depending on the harmonics present in the false operating current. Operation of the differential unit is prevented by its variable percentage characteristic, since a large differential current is required to close the contacts during heavy external faults.

### Internal Fault Conditions

On internal faults the restraint of the differential unit is proportional to the largest restraint current flowing. The sum of the two restraint currents flows into the operating transformer, producing an excess of operating torque, and the differential unit operates. (See Figure 3b.)

If the internal fault is fed from one source only, the fault current flows in one restraint transformer and the operating transformer. An excess of operating torque is again produced to operate the differential unit.

On heavy internal faults, the Instantaneous Indicating Trip Unit will operate before the main differential unit. Since this unit is connected to an air gap transformer, essentially only the sine wave component of an internal fault is applied to the IIT unit. The dc component is bypassed by the transformer primary. For example, an internal fault with a first peak of 28 times tap value (50% dc component) is reduced to 14 times tap value (dc component absent) in the transformer secondary. As the IIT unit is set to operate at 10 times rms tap value, it will just operate under these conditions.

The varistor is connected across the dc side of the restraint rectifier of the harmonic restraint unit to prevent excessive voltage peaks from appearing across the rectifiers caused by transformer action of the polar unit coils during heavy internal faults.

When a magnetizing inrush wave is applied to the relay, the dc component of the wave is bypassed by the air gap operating transformer. The other components of the inrush wave are fed into the filter circuits. The "block" and "pass" characteristics of the filter circuits feed the second harmonic component of the wave into the restraint coil of the polar unit, and the other components into the operating coil. The polar unit will not close its contacts unless the second harmonic content is less than 15% of the fundamental component. The Indicating Instantaneous Trip will not operate on inrush.

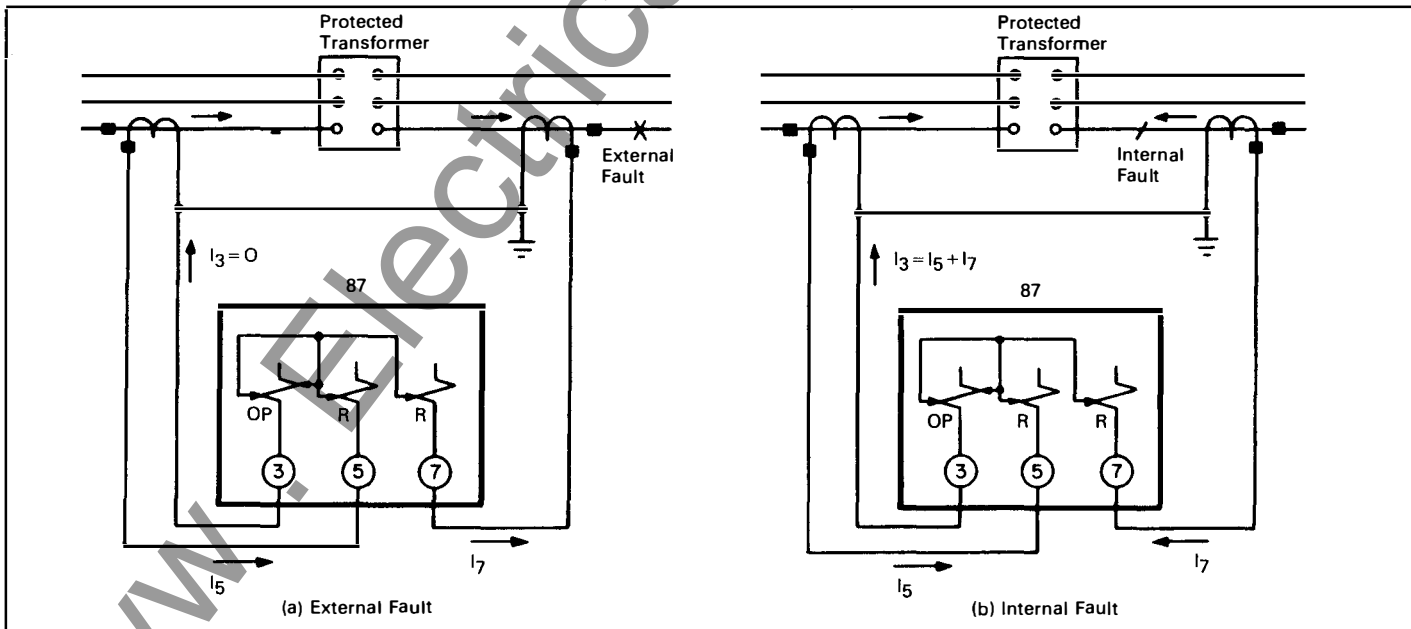


Figure 3: HU-4 simplified external connections showing current distribution for external and internal faults.

## Characteristics

Single phase, 60 hertz, spst-cc contacts

### Operating Time

See Figure 6.

### Restraint Circuits

Two in HU, three in HU-1, 4 in HU-4; plus one harmonic restraint and one operating circuit in each.

### Ratio Taps

2.9, 3.2, 3.5, 3.8, 4.2, 4.6, 5.0, 8.7 amperes.

### Variable Percentage Characteristics

HU, HU-1: See Figures 8 and 10

### Minimum Trip

30% or 35% of tap value.

### Performance

See Figures 6 and 7.

### Relay Settings

Select the ratio in matching taps. No other settings are required. To calculate the required tap settings and check current transformer performance, follow the steps outlined on pages 31-34 of Application Data 41-300.

The HU-4 relay is applicable to circuits where the current transformer ratio error is 10% or less with maximum symmetrical external fault current flowing, or with eight times relay tap current flowing.

Taps are provided in the relay restraint and operating circuits to compensate for main current transformer mismatch. These taps are rated in terms of secondary amperes with the ratings mentioned under "Ratio Taps."

Effective unbalance should not exceed the values indicated by the 15% mismatch curve, Figure 4, or 20% mismatch curve, Figure 5.

## Energy Requirements

Tap	Continuous Rating	Pf Angle ①	Volt-Amperes②		
			At Tap Value	8 Times Tap Value	20 Times Tap Value
Each Restraint Circuit					
2.9	10	71	.88	50	191
3.2	12	70	.89	51	211
3.5	13	66	.90	51	203
3.8	14	65	.91	53	220
4.2	15	58	.91	53	235
4.6	16	57.5	.91	55	248
5.0	18	52.5	.92	59	280
8.7	22	30	1.28	94	340
Operating Circuit					
2.9	10	35	2.26	76	487
3.2	12	34	2.30	78	499
3.5	13	33	2.30	81	504
3.8	14	33	2.30	83	547
4.2	15	31	2.30	84	554
4.6	16	30	2.40	88	598
5.0	18	29	2.50	92	640
8.7	22	23	3.18	132	850

① Degrees current lags voltage at tap value current.

② Voltage taken with Rectox type voltmeter.

## Sensitivity

Relays are available with either 0.30 or 0.35 times tap rating.

The 30% sensitivity relay will accommodate up to 15% mismatch; and the 35% unit will handle as much as 20% mismatch. See Figure 8 for comparison of the 30% and 35% sensitivity.

### Indicating Contactor Switch (ICS)

Has 0.2 and 2.0 ampere taps. Will close 30 amperes and carry this long enough to trip circuit breaker.

## Indicating Instantaneous Trip (IIT)

### HU, HU-1

Set to operate at 10 times rms tap value. Will close 30 amperes and carry long enough to trip a circuit breaker.

### HU-4

Set to operate at 15 times rms tap value. Will close 30 amperes and carry long enough to trip a circuit breaker.

### Thermal Capability

One-second thermal rating: 300 amperes. Thermal capacities for short times other than one second may be calculated on the basis of time being inversely proportional to the square of the current.

**Differential Voltage Characteristic  
With Pickup of 0.30 Times Tap**

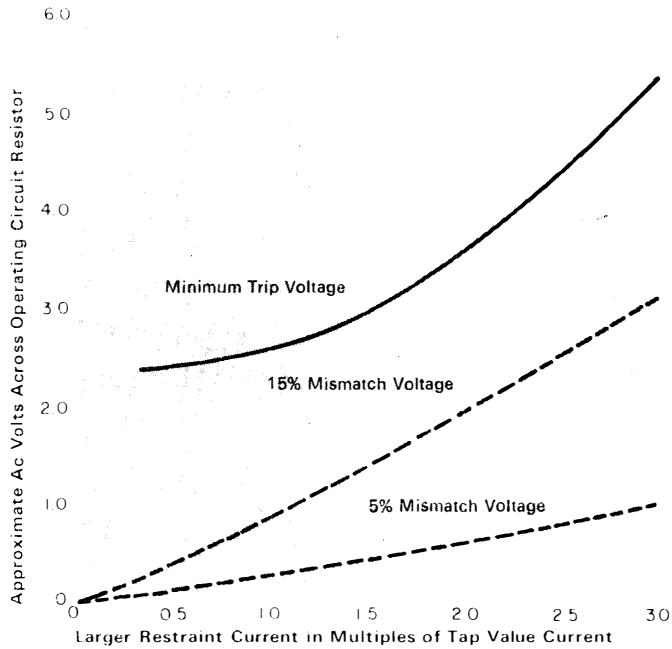


Figure 4

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**Differential Voltage Characteristic  
With Pickup of 0.35 Times Tap**

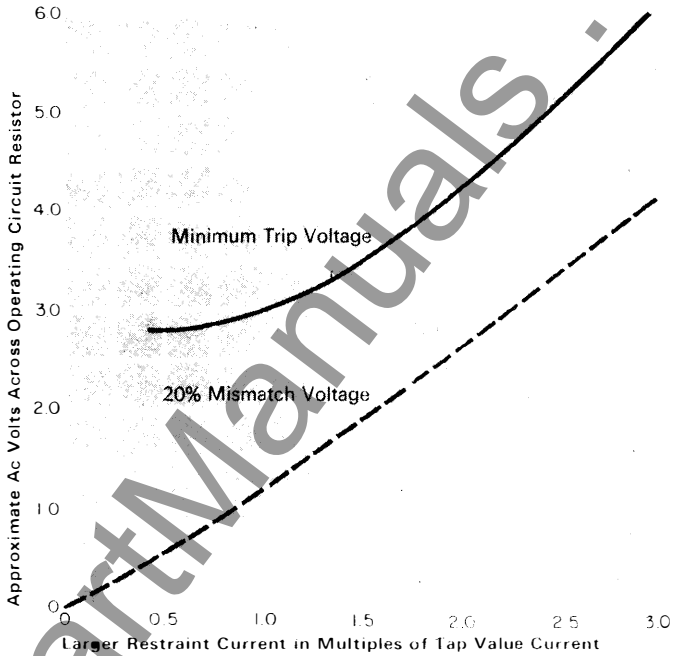


Figure 5

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**Operating Time Curve (60 Hz Base)**

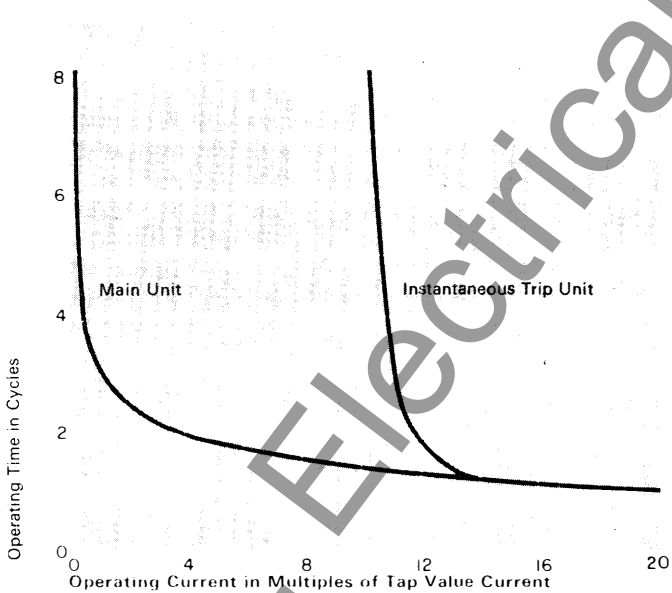


Figure 6

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**Frequency Response Curve**

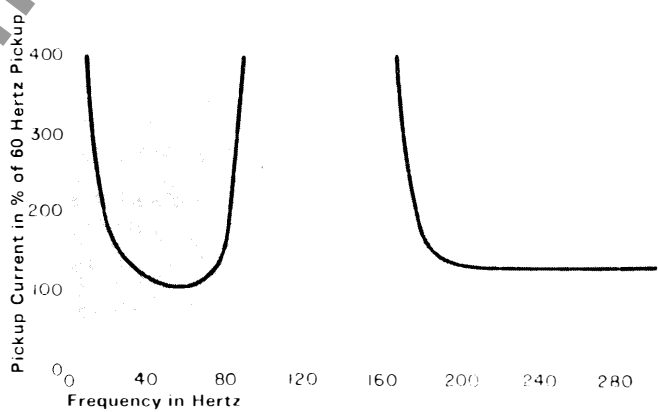


Figure 7

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## Comparison of the Differential Characteristic of HU and HU-1 Differential Unit With Pickups of 0.30 and 0.35 Times Tap

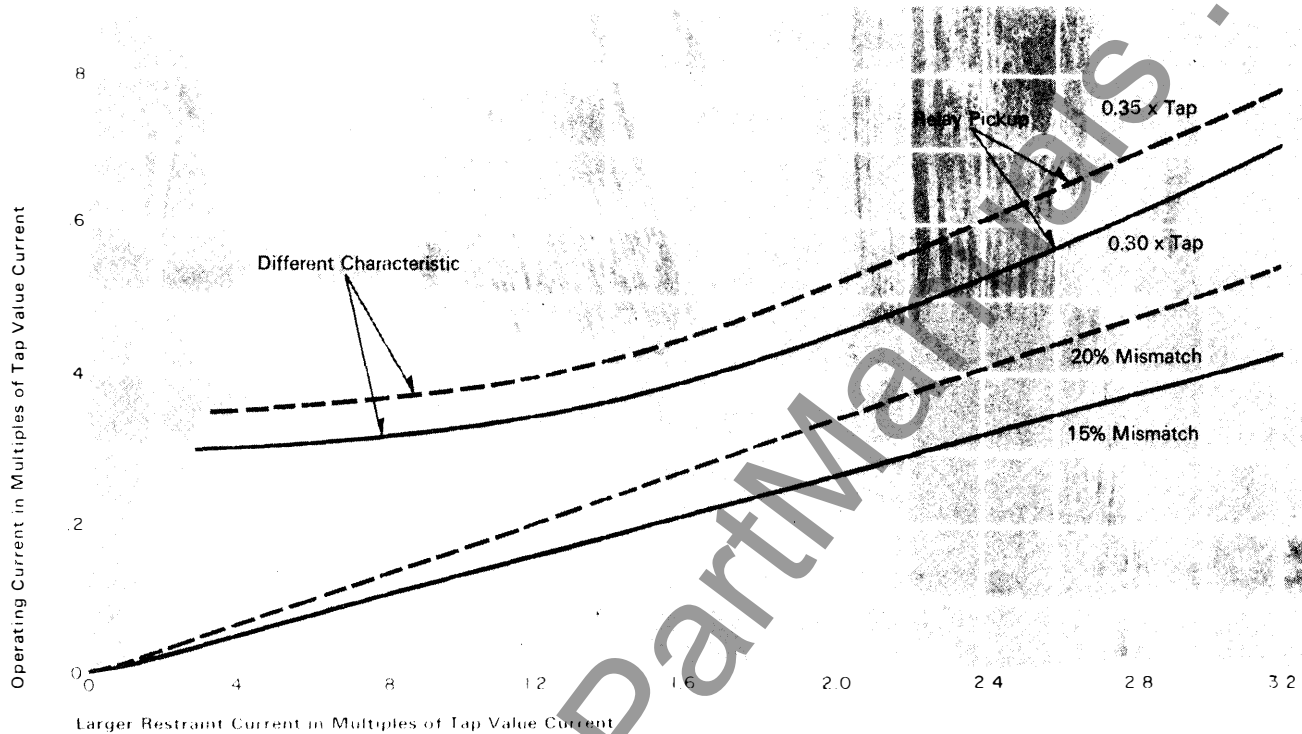


Figure 8

4/1136

## Typical Differential Characteristic of HU-4 Differential Unit

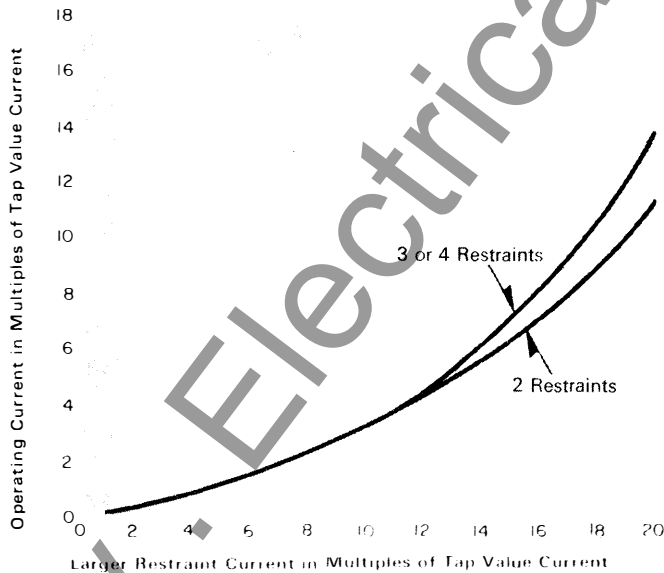


Figure 9

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## Typical Differential Characteristic of HU and HU-1 Differential Unit

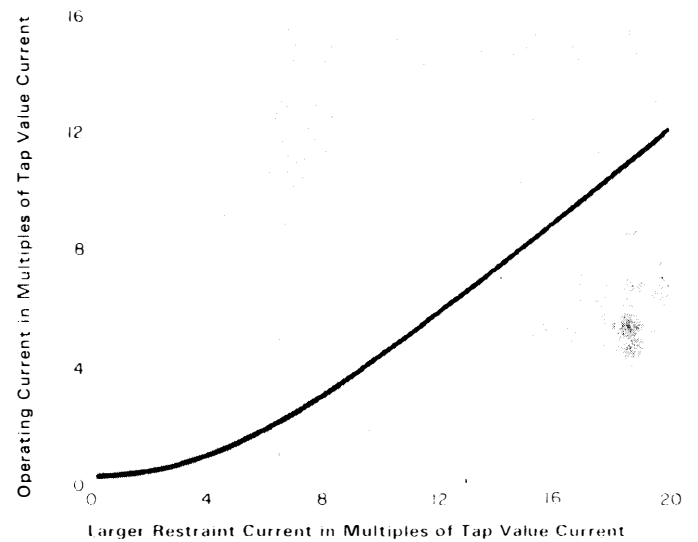


Figure 10

4/1050

**Descriptive Bulletin**  
**41-305E**

Page 6

**Further Information**

List Prices: PL 41-020

Technical Data: TD 41-025

Application Data: AD 41-301E

Instructions: IL 41-347.1

Renewal Parts: RPD 41-938

Flexitest Case Dimensions: DB 41-076

Contactors Switches: DB 41-081

Other Protective Relays:

Application Selector Guide, TD 41-016





December, 1990  
Supersedes TD 41-020, Types HU, HU-1,  
HU-4 on page 68, dated November, 1987  
Mailed to: E, D, C/41-300A

Single Phase

## Types HU, HU-1 HU-4 Instantaneous Variable Percentage Relays

### High Speed Variable Percentage Differential, Single Phase, 15% Second Harmonic Restraint (Dev 87, DB 41-347)

Type	Application	Contacts	Frequency, Hertz	Indicating Contactor Switch③	Sensitivity	Rating: Amperes Ac	Relay Data		
							Internal Schematic	Style Number	Case Size
HU ②	2-winding transformer	Spst-cc	60	0.2/2.0 Amps dc	30%	2.9-8.7	184A762	290B346A09⑤	FT-31
		Dpst-cc			30%		185A036	290B346A21⑤	
		Spst-cc Dpst-cc			35% 35%		184A762 185A036	1962 553 1963 125	
HU-1 ②	3-winding transformer	Spst-cc	60	0.2/2.0 Amps dc	30%	2.9-8.7	184A736	290B346A10⑤	FT-31
		Dpst-cc			30%		185A037	290B346A22⑤	
		Spst-cc			30%		184A736	1957 938	
HU-4 ②	4-restraint transformer and bus	Dpst-cc	60	0.2/2.0 Amps dc 1.0 Amp dc	30% 35%	2.9-8.7	188A542	292B804A23⑤	FT-42
							188A542	292B804A22	
							848A772	292B804A24	

### Test Unit for HU, HU-1, HU-4 Relays (DB 41-818E)

Type	Rectifier	Rating Dc			Nominal Input Rating	Rectifier Data		
		1-Second	Maximum Reverse Volts	Maximum Reverse Current		Internal Schematic	Case Outline Drawing	Style Number
TRB-1	304F	30 Amps	300	4 milli- amps	125 volts ac	184A234	184A117 (Fig. 2)	407C275G03

⑤ Denotes item available from stock.

① 50-Hertz relays and auxiliaries can be supplied at same price. Order "Similar to Style Number . . . . ., except 50 Hertz".

③ ICS: Indicating Contactor Switch (dc current operated) having seal-in contacts and indicating target which are actuated when the ICS coil is energized at or above pickup current setting. Suitable for dc control voltages up to and including 250 volts dc. Two current ranges available: (1) 0.2/2.0 amps dc, with tapped coil. (2) 1.0 amp dc, without taps.

Rating of ICS unit used in specific types of relays is shown in price tables. All other ratings must be negotiated.

When ac current is necessary in a control trip circuit, the ICS unit can be replaced by an ACS unit.

The ACS unit may be supplied in place of an ICS unit at no additional cost. Specify system voltage rating on order.