INSTRUCTIONS

TYS3B56H12E2XB019
Scheme: Directional Comparison Hybrid
Phase Functions: Distance
Ground Functions: Distance
Time Curve: Extremely Inverse

Introduction

These instructions, GEK-99347 together with GEK-90656, constitute the complete instructions for the TYS3B56H12E2XB019.

Description

This relay has the following differences from the standard TYS relay described in GEK-90656.

This relay has an extremely inverse time curve.

You will find substitute pages attached.

Please replace	with
page CS-9 of GEK-90656	page CS-9 of GEK-99347
page CS-12 of GEK-90656	page CS-12 of GEK-99347
page CS-15 of GEK-90656	page CS-15 of GEK-99347
page CS-16 of GEK-90656	page CS-16 of GEK-99347
page MO-6 of GEK-90656	page MO-6 of GEK-99347
page AT-3 & 4 of GEK-90656	page AT-3 & 4 of GEK-99347
page SP-3 of GEK-90656	page SP-3 of GEK-99347

All other descriptions, calculations, testings and drawings shown in GEK-90656 apply equally to the TYS3B56H12E2XB019.

IM, Overcurrent Supervision

The IM function uses positive-, negative- and zero-sequence currents for the operating quantity. It is used for numerous purposes, including supervision of the MB blocking functions. The setting is made in per-unit current, where rated current, I_N, (1 or 5 amperes) is used as the base.

This function should be set to its minimum setting of 0.05 per-unit current. This setting establishes the MB blocking function current supervision that cooordinates with the IØØ settings suggested above. The setting is made using switches located on the board of the ADM112 module, Figure MO-3.

I_1, Line Pickup Supervision

The I_1 function operates from positive-sequence current and is provided for use as part of the line pickup scheme (see Logic Description in the SCHEME DESCRIPTION section for details). The setting is made in per-unit current where rated current, I_N, (1 or 5 amperes) is the base.

$$I_1 \text{ setting} = I_1/I_N \quad (7)$$

I_1 should be set no greater than 2/3 of the minimum fault current for an internal three-phase fault at the relay location.

Assuming simultaneous reclosing at both ends, if the minimum fault current is greater than the maximum load current across the line, the I_1 setting can be reduced to provide greater coverage of the line. For this case, a setting of 110% of the maximum load current is proposed. If the I_1 function can be set with a pickup of at least 110% of the maximum load current, contact converter CC5 can be energized continuously to bypass coordinating timer TL7 (see Logic Description) to obtain faster tripping.

If sequential reclosing is used, or if there is no automatic reclosing, then I_1 can be set below load current, and CC5 can be energized continuously to bypass timer TL7. If high-speed simultaneous reclosing is used and I_1 is set below full-load current, then TL7 should **not** be continuously bypassed; otherwise tripping might be initiated when picking up a loaded line.

If a power transformer is energized when the line is reclosed, CC5 should not be continuously energized to bypass TL7 if I_1 can pick up on the transformer-inrush current. A conservative approach to determine if I_1 will pick up on the transformer inrush is to calculate the steady-state positive-sequence current for a three-phase through fault just on the other side of the transformer; i.e., at the transformer bushings. If I_1 will pick up for this fault, then TL7 should not be bypassed.

The I_1 function is set using the switches located on the board of the ABM11(-) module, Figure MO-2.

OPTIONAL OVERCURRENT FUNCTIONS

The following optional overcurrent functions must be set:

IPT - Pilot tripping (0.1-1.0 per unit, 0.05 step)

IDT - Direct tripping (0.8-8.0 per unit, 0.2 step)

TOC - Time overcurrent (0.2-2.4 per unit, 0.2 step)
Time dial (0.5-10, 0.5 step)

IPT, Pilot Tripping

IPT uses zero-sequence current with positive-sequence restraint ($I_O - K_T I_1$). The setting is made in per-unit current, where rated current, I_N, (1 or 5 amperes) is used as the base, and it is actually in terms of $3 \times (I_O - K_T I_1)$. Positive-sequence current restraint is used to increase the security of the function by making it less sensitive to steady-state unbalances, error currents, etc. It also reduces the number of external faults that will be detected, thus increasing the overall security of the relaying scheme.

TABLE CS-I

Fault Loc	I_1	$0.3\times3\times I_1$	I_0	$3\times I_0$	Operate Signal $3\times I_0-0.3\times3\times I_1$	Load
Able	2.75	2.48	0.52	1.56	−0.92	Y
Baker	2.88	2.59	1.00	3.00	0.41	Y
Able*	2.57	2.31	0.43	1.29	−1.02	Y
Baker*	2.96	2.66	0.92	2.76	0.10	Y
Able**	2.02	1.82	0.42	1.26	−0.56	Y
Baker**	2.12	1.91	1.10	3.30	1.39	Y
Able	1.65	1.49	0.54	1.62	0.13	N
Baker	1.24	1.12	1.06	3.18	2.06	N
Able*	1.25	1.13	0.45	1.35	0.22	N
Baker*	1.30	1.17	1.01	3.03	1.86	N
Able**	1.37	1.23	0.43	1.29	0.06	N
Baker**	1.14	1.03	1.13	3.39	2.36	N

*Breaker D open **Breaker E open

For two-terminal line applications, IPT should be set to its minimum setting of 0.1 per-unit for lines less than 100 miles long and 0.15 per-unit for lines greater than 100 miles in length, to compensate for the increased charging current. IPT must be set higher than IPB at the remote terminal, to assure coordination. The setting is made using the switches located on the board of the CTM12(-) module, Figure MO-6.

For three-terminal line applications, the coordination margins indicated by the suggested IPT and IPB settings given here may, in the worst case, have to be doubled. For two- or three-terminal applications, such as cable circuits, where the zero-sequence charging current is significant, the magnitude of charging current should be calculated to establish an adequate coordination margin.

IDT, Direct Trip

The IDT function is used to provide direct tripping for single-line-to-ground (SLG) faults. The setting is made in per-unit current, where rated current, I_N, (1 or 5 amperes) is used as the base. IDT uses zero-sequence current with positive-sequence current restraint for the operating quantity. Positive-sequence current restraint is used to provide secure operation during steady-state unbalances, error currents, and for external faults. The function can be directionally controlled by the NT function if so desired. In general, directional control should be used when the operating current for a fault behind the function is much greater than the operating current for a fault at the remote terminal of the transmission line. IDT pickup is established by determining the maximum positive value of:

$$\text{Operate Signal} = 3\times|I_0|-0.3\times3\times|I_1| \quad (8)$$

If IDT is directionally controlled by NT then the operate signal need only be calculated for faults at the remote end of the line. If IDT is not directionally controlled, then it will be necessary to calculate the quantity for faults directly behind the relaying terminal as well as at the remote end of the line. The IDT pickup setting in per unit is then the maximum operate signal plus a margin of 25% of the ($3\times|I_0|$) used in determining the maximum value of the operate signal, all divided by the rated current, I_N; i.e.,

$$\text{IDT setting} = \frac{\{3\times|I_0|-0.3\times3\times|I_1|+0.25\times(3\times|I_0|)\}}{I_N} \quad (9)$$

The IDT pickup is set using the switches located on the front panel of the CTM12(-) module, Figure MO-6. Directional control of IDT is implemented via a link located on the board of the CTM12(-) module, Figure MO-6. It is also possible, via the same link, to disable IDT altogether.

TOC, Time Overcurrent

The TOC function is used to provide time-delayed backup tripping for SLG faults. The TOC function has a very-inverse-time characteristic and uses zero-sequence current as the operating quantity. The setting is made in per-unit current, where rated current, I_N, (1 or 5 amperes) is used as the base.

$$\text{TOC setting} = 3 \times I_0/I_N \qquad (10)$$

The TOC function can be directionally controlled by the NT function if so desired, (link on CTM12(-) board, Figure MO-6); directional control should be considered if it becomes difficult to coordinate the TOC functions with similar functions in adjacent line sections. The pickup and time-dial setting for the TOC function should be selected to provide coordination with similar functions in adjacent line sections. Both settings are made using the switches located on the front panel of the CTM12(-) module, Figure MO-6.

WORKED EXAMPLE (overcurrent functions)

The system of Figure CS-3 will be used and the overcurrent functions at Station Able will be set.

IPB, Pilot Blocking

Set the IPB function to 0.05 per-unit current, using the switches located on the board of the ADM112 module, Figure MO-3.

IØØ, MT Overcurrent Supervision

Set the IØØ function to 0.1 per-unit current, using the switches located on the front panel of the ETM114 module, Figure MO-8.

IM, Overcurrent Supervision

Set the IM function to 0.05 per-unit current, using the switches located on the board of the ADM112 module, Figure MO-3.

I_1, Line Pickup Supervision

From Figure CS-3, the three-phase fault current for a fault just in front of the relay at Station Able is 26.6 amperes, whereas the load current is 2.71 amperes. Assume that more-sensitive protection is required than would be obtained with the proposed setting of 2/3 of the minimum fault current for a fault at the relay. A setting of 110% of the load current of 2.71 amperes will therefore be used.

$$I_1 \text{ setting} = \frac{1.1 \times 2.71}{5} = 0.59 \text{ per unit}$$

Use the nearest setting of 0.6 per unit, and make this setting using the switches located on the board of the ABM11(-) module, Figure MO-2.

WORKED EXAMPLE, continued (optional overcurrent functions)

IPT, Pilot Tripping

Set the IPT function to 0.1 per-unit current, using the switches located on the board of the CTM12(-) module, Figure MO-6 (assume the line length is less than 100 miles).

IDT, Direct Trip

The quantities listed in Table CS-I were calculated using the system of Figure CS-3 and for the conditions noted.

From the data, it can be seen that the maximum value of the operate signal is 2.36, and that it is obtained for a fault at Station Baker, with no load flow and with Breaker E open. Knowing this, the pickup setting for IDT can be calculated using equation (9) above.

$$IDT\ setting = \frac{\{3.39 - 1.03 + 0.25 \times 3.39\}}{5}$$
$$= 0.64\ per\ unit$$

Use the next higher available setting of 0.8 per unit, and make this setting using the switches located on the front panel of the CTM12(-) module, Figure M0-6.

Further examination of the above calculated data will show that the value of the operate signal for faults at the bus at Station Able is much less than the value obtained for faults at Station Baker; consequently directional control is not required. Set IDT directional control to the OUT position, using the link located on the board of the CTM12(-) module, Figure MO-6.

<u>TOC, Time Overcurrent</u>

It is assumed that TOC will be directionally controlled, and that maximum sensitivity is desired in order to provide protection for high-resistance ground faults; therefore the minimum pickup setting of 0.2 per unit will be used. A time-dial setting of 2.0 will be used. Both of these settings can be made using the switches located on the front panel of the CTM12(-) module, Figure M0-6. Set the directional control to the IN position via the link located on the board of the CTM12(-) module, Figure M0-6.

OUT-OF-STEP-BLOCKING

The out-of-step-blocking circuitry is described in the overall Logic Description, and the characteristic is illustrated in Figure SD-1, both in the SCHEME DESCRIPTION section. The following settings must be made:

a. MOB characteristic timer setting (32°-124°, 4° step)
b. Switch OSB-1 setting (IN/OUT)
c. Switch OSB-2 setting (IN/OUT)

MOB Characteristic Timer Setting

The MOB characteristic timer setting is dependent on the characteristic timer setting made on the MT functions at the same terminal of the transmission line. Use the following settings:

MT timer setting	MOB timer setting
90 degrees	72 degrees
105 degrees	84 degrees
120 degrees	100 degrees

The MOB characteristic timer setting is made using the switches located on the board of the UTM111 module, Figure MO-16.

Switch OSB-1 Setting

Logic switch OSB-1 can be used to block channel tripping, and to block tripping by the zone 1, zone 2, and zone 3 functions. Line pickup tripping, and tripping by IDT and ITOC, will be left in service if this switch is set to the right (IN) position. The switch is located on the front panel of the ULM257 module, Figure MO-11.

Switch OSB-2 Setting

Logic switch OSB-2 can be used to block all tripping when it is set to the right (IN) position. The switch is located on the front of the ULM257 module, Figure MO-11.

WORKED EXAMPLE (out-of-step blocking)

<u>MOB Characteristic Setting</u>

The characteristic timer setting for the MT functions in this example has been determined to be 105°, consequently the MOB characteristic timer should be set to 84°. Make this setting, using the switches located on the board of the UTM111 module, Figure M0-16.

SETTINGS LIST B (Worked Example)

TYS3 PHASE AND GROUND DISTANCE BLOCKING SCHEME SETTING LIST

Module Location	Module Setting	Adjustment	Description	Setting Location	
ZC	ABM11(-)	I_1	Line PU supervision	on board	0.6
ZC	ABM11(-)	KV	Pos.-seq. volt comp	on board	0
ZC	ABM11(-)	K	MB zero-seq.curr.comp	on board	2.2
ZC	ABM11(-)	r	MB reach setting	front panel	31.6Ω
ZG	ADM112	IM BIAS	Overcurrent supervision	on board	0.05
ZG	ADM112	IPB BIAS	Pilot blocking supervision	on board	0.05
Y	AFM12(-)/13(-)	(ZR1) r	Zone 1 reach (M1/MG1)	front panel	9.0Ω
Y	AFM12(-)/13(-)	K0	Zero-seq.curr.comp (M1/MG1)	on board	3.0
S	AFM12(-)	(ZRT) r	Overreaching reach (MT/MTG)	front panel	28.6Ω
S	AFM12(-)	K0	Zero-seq.curr.comp (MT/MTG)	on board	3.2
W	ETM111	PHA - VP	MG1 characteristic	on board	MHO (ON)
W	ETM111	PHA - VP	REACTANCE = OFF	on board	MHO (ON)
W	ETM111	PHA - VP	MHO = ON	on board	MHO (ON)
P	ETM114	IØØ	MT overcurrent supervision	front panel	0.1
2N	IOM112	VDC	Contact conv. volt.	on board	125
ZA	ISM11(-)	$ØZ_1$	Pos.-seq. reach ang.	front panel	85°
ZA	ISM11(-)	$ØZ_0$	Zer.-seq. reach ang.	front panel	75°
* K	ULM225	TL1	Trip integrator	on board	4
* K	ULM225	TL16	Weak Infeed	on board	4
H	ULM234	TIMER II	TL2	front panel	0.2
H	ULM234	TIMER III	TL3	front panel	0.5
H	ULM257	OSB-1	OSB option	front panel	OUT
H	ULM257	OSB-2	OSB option	front panel	IN
M	UTM111	MT	MT char. timer	on board	105°
M	UTM111	MTG	MTG char. timer	on board	105°
M	UTM111	MB	MB char. timer	on board	95°
M	UTM111	MOB	MOB char. timer	on board	84°
M	UTM111	MG1	MG1 supervision	on board	MHO
ZE	VMM11(-)	II	Zone 1 ext. factor	front panel	1.4

Optional functions, when included

ZJ	CTM12(-)	TD	TOC time dial	front panel	2.0
ZJ	CTM12(-)	TOC PU	TOC pickup	front panel	0.2
ZJ	CTM12(-)	DT PU	IDT pickup	front panel	0.8
ZJ	CTM12(-)	PT PU	IPT pickup	on board	0.1
ZJ	CTM12(-)	ITOC DIR CON	TOC directional cont.	on board	IN
ZJ	CTM12(-)	IDT DIR CON	IDT directional cont.	on board	OUT

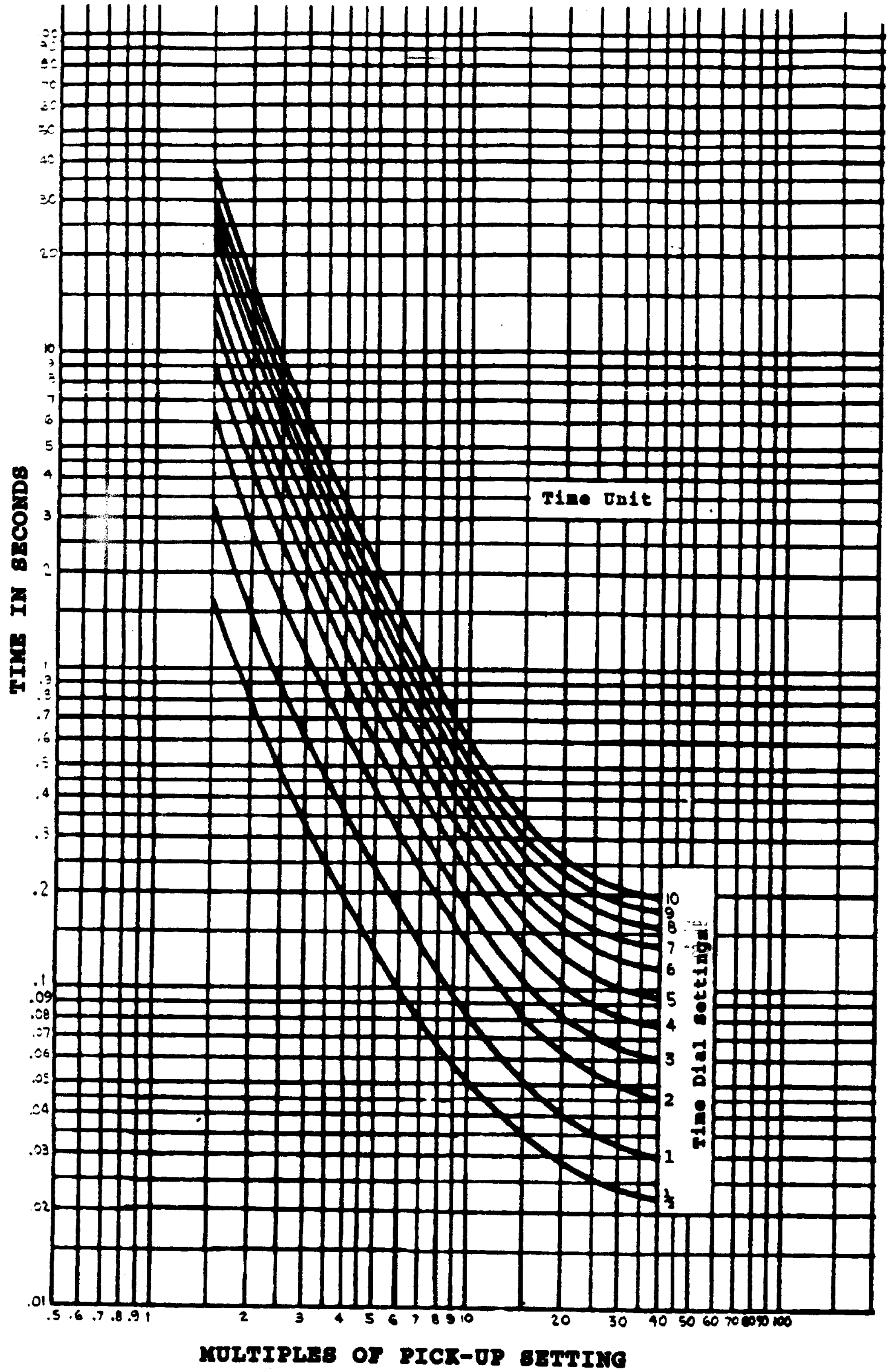

Figure CS-4 (0286A2770 [1]) Time Curve Characteristics

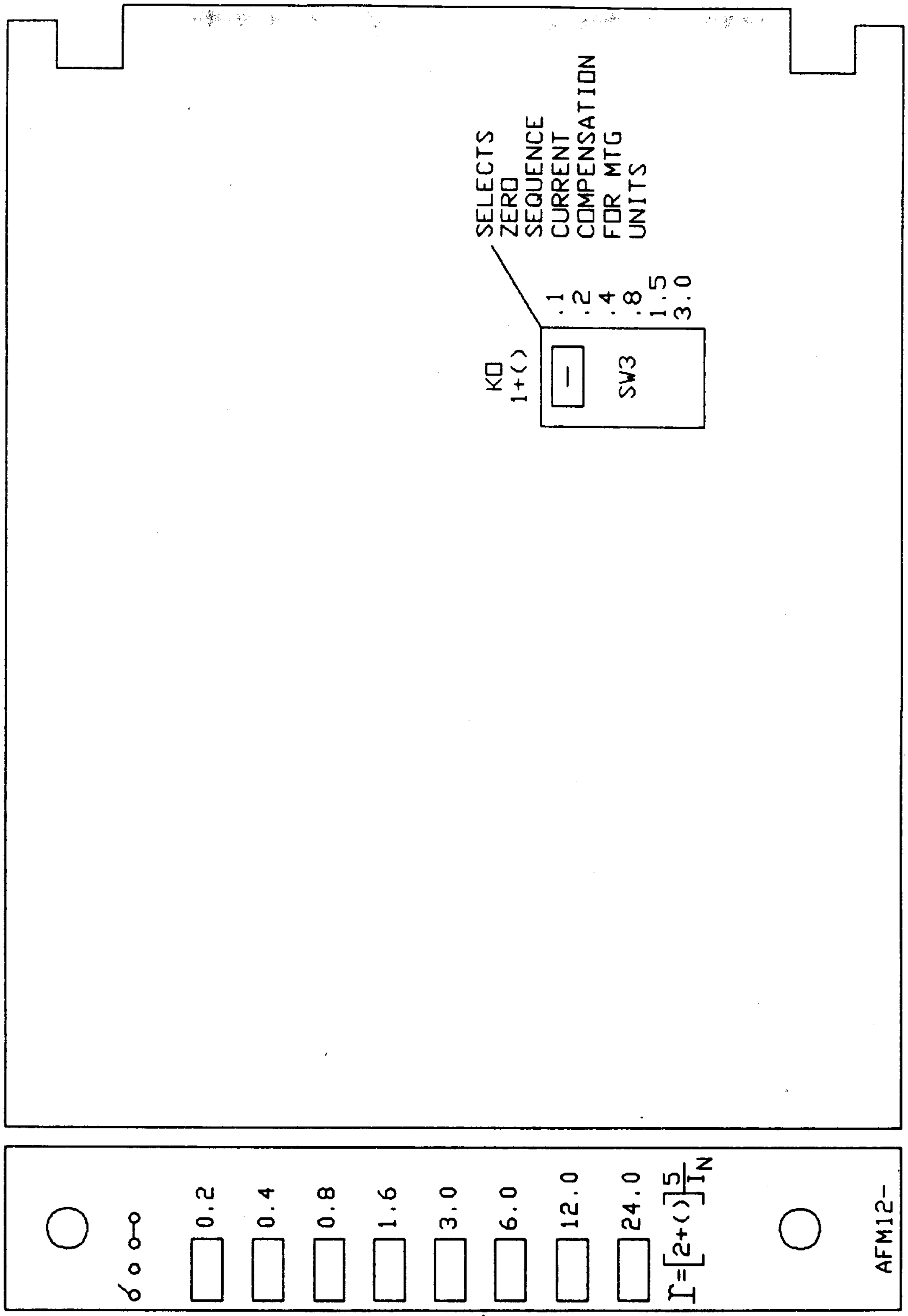

Figure MO-5 (0285A9988-2) Front Panel and Internal Switch, AFM12(-) Module

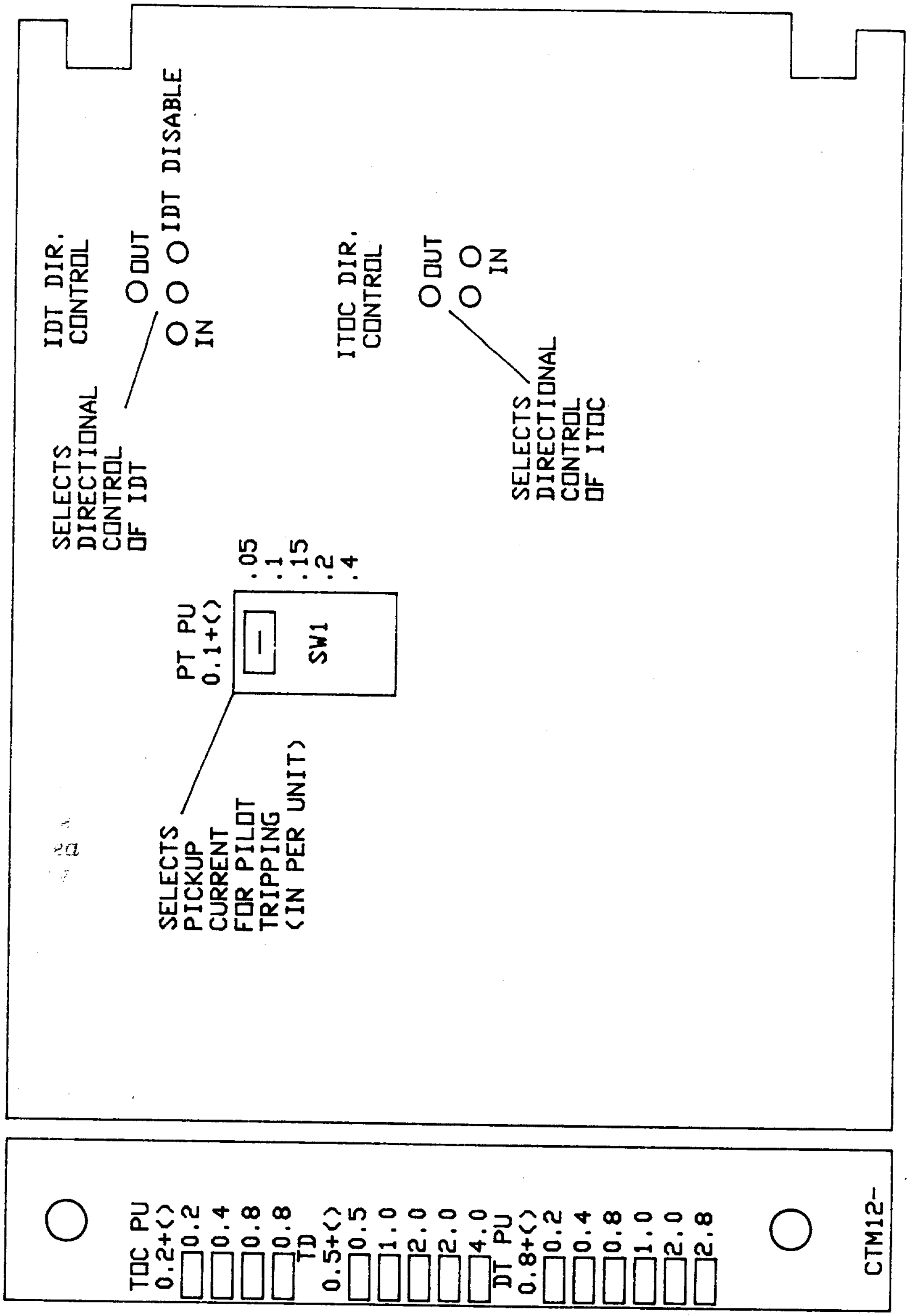

Figure MO-6 (0286A2803) Front Panel & Internal Switch & Links, CTM12(-) Module

TABLE AT-II

MODULE NAME	LOCATION	SWITCH NAME	SETTING	RANGE
ABM11(-)	ZC	r	6.0	(2 TO 50 Ω)
AFM12(-)	S	r	3.0	(2 TO 50 Ω)
AFM12(-)	Y	r	3.0	(1 TO 25 Ω) †
OR				
AFM13(-)	Y	r	2.5	(0.1 TO 2.5 Ω) †
CTM12(-)	ZJ	TOC PU TD DT PU	0.6 1.0 4.0	(0.2 TO 2.4 PU) (0.5 TO 10 PU) (0.8 TO 8.0 PU)
ETM114	P	IØ-Ø	0.1	(0.1 to 1.0 PU)
ISM11(-)	ZA	$ØZ_1$ $ØZ_0$	85° 85°	(50° TO 85°) (50° TO 85°)
ULM234	H	TIMER II TIMER III	0.0 0.0	(0 TO 3.1 SEC) (0 TO 3.1 SEC)
ULM257	F	OSB-1 OSB-2	OPEN OPEN	
VMM11(-)	ZE	II	1.0	(1 TO 10) × ZONE 1

† Refer to the specific model number and the Nomenclature Selection Guide (INTRODUCTION section) to determine which range has been supplied.

Place the front-panel switches on the modules in the appropriate positions to obtain the settings listed in Table AT-II.

GENERAL INSTRUCTIONS

1. Remove the upper-right blank module and insert a card extender (GE #0138B7406G1) in this location (B in Figure MO-1). The oscilloscope ground should be connected to pin 1 of this card for all tests.

   Place the test source in rated-frequency position. Turn on the power supply and check that the green LED on the PSM21(-) module (see Figure MO-14) is lit. If the LED is not lit, refer to the SERVICING section.

2. The following tests are intended to verify the operation of the measuring units. If it is desired to check outputs or targets, refer to the logic diagram.

3. In the following tests, a LOW is defined as approximately 0 volt and a HIGH is defined as approximately 10 volts.

4. Where two numbers are shown: xx(yy), xx is the value to be used for relays rated 5 amperes, and (yy) is the value to be used for relays rated 1 ampere.

5. If the test source is an electronic type and one (or more) current source is not used for a particular test, that source must be set to " zero" in addition to being turned OFF. Also, these current sources should only be switched with the current set at, or near, zero (0).

6. <u>All phase angles of test sources are shown relative to phase A voltage</u>. A (+) phase angle refers to the referenced-quantity leading phase A

voltage. A (−) phase angle refers to the referenced-quantity lagging phase A voltage.

7. All test voltages are phase-to-ground measurements, unless otherwise specified.

LEVEL-DETECTOR TESTS

Fault-Detector Test

1. Make the connections shown in Figure AT-1 with relay input Y connected to BH1 (or TP9 for post-installation testing). Connect the oscilloscope input to card-extender Pin 25. Set the oscilloscope for external trigger.

2. Set current I_{OP} to 0.5 (0.1) ampere rms. Close the pushbutton test switch for approximately one (1) second. When the pushbutton test switch opens, the oscilloscope trace should go HIGH momentarily, after which it should return to LOW.

3. Increase I_{OP} to 2.25 (0.45) amperes rms and repeat test 2. The oscilloscope trace should remain HIGH except when the pushbutton test switch is closed.

IM Detector Test

1. With the connections as shown in Figure AT-1, move the oscilloscope input to card-extender Pin 23. Increase I_{OP} until the oscilloscope trace goes from LOW to HIGH. At this point the current should be between 0.16 (0.032) and 0.201 (0.04) ampere rms.

IPB Detector Test

1. With the connections as shown in Figure AT-1, move the oscilloscope input to card-extender Pin 22. Increase I_{OP} until the oscilloscope trace goes from LOW to HIGH. At this point the current should be between 0.253 (0.05) and 0.308 (0.062) ampere rms.

TOC Detector Test

1. Set the "ITOC DIR. CONTROL" link, located on the CTM12(-) module, Figure MO-6, to the "OUT" position.

2. With the connections as shown in Figure AT-1, move the oscilloscope input to card-extender Pin 28. Increase I_{OP} until the oscilloscope trace goes from LOW to HIGH. At this point the current should be between 2.9 (0.59) and 3.3 (0.66) amperes rms.

3. Restore the "ITOC DIR. CONTROL" link to the "IN" position.

IDT Detector Test

1. Using the "DT PU" switch located on the front panel of the CTM12(-) module, Figure MO-6, set the "IDT" function to 0.8 PU.

2. Set the "IDT DIR. CONTROL" link, located on the board of the CTM12(-) module, Figure MO-6, to the "OUT" position.

3. With the connections as shown in Figure AT-1, move the oscilloscope input to card-extender Pin 19. Increase I_{OP} until the oscilloscope trace goes from LOW to HIGH. At this point the current should be between 5.5 (1.10) and 5.9 (1.18) amperes rms.

4. Reset the "IDT" function to 4.0 PU and restore the "IDT DIR. CONTROL" link to the "IN" position.

IPT Detector Test

1. With the connections as shown in Figure AT-1, move the oscilloscope input to card-extender Pin 21. Place a temporary jumper between Pins 25 and 60 of the card extender.

   <u>NOTE</u>: Pin 60 is connected to the +12VDC supply of the TYS.

OVERCURRENT-FUNCTION-SETTING RANGES

TABLE SP-III

FUNCTION	OVERCURRENT-FUNCTION SETTING RANGE IN AMPS $I_N=5$	$I_N=1$	RESOLUTION $I_N=5$	$I_N=1$
Pilot Tripping (IPT)	0.5 to 5.0	0.1 to 1.0	0.25	0.05
Pilot Blocking (IPB)	0.25 to 3.78	0.05 to 0.75	0.125	0.025
Time Overcurrent (ITOC)	1.0 to 12.0	0.2 to 2.4	1.0	0.2
Istantaneous Overcurrent (IDT)	4.0 to 40	0.8 to 8.0	1.0	0.2

TOC TIME DIAL

TABLE SP-IV

TIME-DIAL-FUNCTION SETTING IN MULTIPLE OF PICKUP CURRENT FUNCTION	RANGE	RESOLUTION
TOC Time Dial (TD)	0.5 to 10	0.5

SUPERVISION-FUNCTION-SETTING RANGES

TABLE SP-V

FUNCTION		RANGE IN AMPS $I_N=5$	$I_N=1$	RESOLUTION $I_N=5$	$I_N=1$
Overcurrent Supervision	(IM)	0.25 to 3.78	0.05 to 0.75	0.125	0.025
Line Pickup	(I_1)	1.05 to 16	0.2 to 3.2	1.0	0.2
MT Overcurrent Supervision	(IØ-Ø)	0.5 to 5.0	0.1 to 1.0	0.5	0.1

COMPENSATION-FACTOR-SETTING RANGES

TABLE SP-VI

FUNCTION		RANGE	RESOLUTION
Positive-Sequence Voltage	(K_V)	0.0 to 0.45	0 .15
Zero-Sequence Current, MB	(K)	1.0 to 7.0	0.1
Zero-Sequence Current, MG1/MTG	(K_0)	1.0 to 7.0	0.1

REPLICA-IMPEDANCE-ANGLE SETTING

The replica impedance angle is adjustable from 50° to 85° in 5° steps with a switch mounted on the front panel of the ISM11(-) module, Figure MO-9.

ADJUSTABLE LOGIC TIMERS

TABLE SP-VII

TIMER	RANGE	RESOLUTION	DESCRIPTION
TL1	0-15.75 ms	0.25 ms	Trip Integrator
TL2†	0 - 3.1 sec	0.1 sec	Zone Two
TL3†	0 - 3.1 sec	0.1 sec	Zone Three
TL16	0 - 126 ms	2.0 ms	Weak Infeed

† Can be defeated by setting the front-panel mounted switches to the 'OUT' position

ACCURACY

Distance Measuring Units	Reach: ± 5% of setting at angle of maximum reach and rated current
	Angle of Maximum Reach: ± 3° of setting
Zone Timers	± 3% of setting

CURRENT SENSITIVITY

The current sensitivity for the phase distance units is determined from:

$$I_{\theta\theta} Z_{R1} = \frac{(0.905)(RM)}{(1 - X)}$$

WHERE:
- $I_{\theta\theta}$ is the phase - phase current at relay (e.g., $I_A - I_B$)
- Z_{R1} is the positive-sequence relay reach
- RM is a design constant (see Table SP-VIII below)
- X is the actual reach / nominal reach

TABLE SP-VIII

REACH RANGES	RM
(0.1 - 2.5) $(5/I_N)$	0.25
(1 - 25) $(5/I_N)$	1
(2 - 50) $(5/I_N)$	1