INSTRUCTIONS

TYS3B56P13E2XB020

PERMISSIVE SCHEME WITH GROUND DISTANCE AND GROUND DIRECTIONAL OVERCURRENT FUNCTIONS

INTRODUCTION

Together, books GEK-100603 and GEK-90658 form the instructions for the TYSX020.

DESCRIPTION

The TYSXO2O is similar to the TYS3 Directional Comparison Permissive with Phase Distance and Ground Distance Functions, except that Zone 1 and Zone 2 Reach Ranges have been extended to 0.2 - 50 ohms. The standard TYS is 1 - 24 ohms.

ATTACHMENTS

For the TYSX020, these insertable pages supersede the corresponding text, tables and figures of GEK-90658.

Pages 1 through 6 (Table of Contents, showing GEK-100603 pages to the right, and applicable GEK-90658 pages to the left)
CS-1 through CS-9, CS-14, CS-15
Figures MO-1, M0-4, MO-5, MO-13
Tables AT-I and AT-II
Pages AT-5 through AT-7
Pages PT-3 through PT-7
Figure SE-1 (pages SE-4 through SE-10)
Pages SP-2, SP-5, SP-6

Note: In the event that the pages of GEK-90658 not applicable to the TYSX020 are to be removed from the binder, it is important that pages such as CS-10, CS-16, MO-9, AT1 through AT-4, PT-1, PT-2, SE-3, SE-11, SP-1 of GEK-90658 be retained, rather than being removed along with the superseded pages.

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b. MG1 zero-sequence current compensation, K0 (1-7, 0.1 step)
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MTG Zero-Sequence Current Compensation, K_0

The MTG zero-sequence current compensation factor, K_0, is a function of the positive- and zero-sequence impedances of the transmission line to be protected:

$$K_0 = \frac{Z_{0L}}{Z_{1L}} \qquad (1)$$

Where:

Z_{0L} = zero-sequence impedance of the line

Z_{1L} = positive-sequence impedance of the line

The setting is made using switches located on the board of the AFM133 module (position S), Figure MO-4 in the MODULES section.

MG1 Zero-Sequence Current Compensation, K_0

The MG1 zero-sequence current compensation factor, K_0, is a function of the positive- and zero-sequence impedances of the transmission line to be protected:

$$K0 = \frac{0.95 \times Z_{0L}}{Z_{1L}} \qquad (2)$$

Where:

Z_{0L} = zero-sequence impedance of the line

Z_{1L} = positive-sequence impedance of the line

The setting is made using switches located on the board of the AFM133 module (position Y), Figure MO-4.

Positive-Sequence Angle of Maximum Reach, ϕZ_1

The positive-sequence angle-of-maximum-reach adjustment is common to all of the distance functions (MT, MTG, M1, MG1 and MB) and should be set to the angle that is just larger than the angle of the positive-sequence impedance of the transmission line on which the TYS system is applied. Use 85° for line angles greater than 85°. The setting is made using a switch located on the front panel of the ISM11(-) module, Figure MO-10.

Zero-sequence Angle of Maximum Reach, ϕZ_0

The zero-sequence angle-of-maximum-reach adjustment is common to the ground distance functions (MTG, MG1) and to the MB function and should be set to the angle that is just larger than the angle of the zero-sequence impedance of the transmission line on which the TYS system is applied. The setting is made using a switch located on the front panel of the ISM11(-) module, Figure MO-10.

MT and MTG Reach and Characteristic Shape, M1 and MG1 Reach, Reach Extension Factor, Timer II and III Settings

A given reach for either MT/MTG or M1/MG1 is made by selecting two separate settings on the front panel of the associated AFM133 module. The AFM133 module associated with MT/MTG is located in position "S" of the TYS chassis, and the AFM133 module associated with M1/MG1 is located in position "Y" of the TYS chassis. The dip switches associated with the "r" setting can be positioned to obtain a range of 2Ω to 50Ω, with a resolution of 0.2Ω. The rotary switch associated with the "MULT" setting can be positioned to 1, 0.25, or 0.1. The actual reach is:

$$\text{actual reach} = (r)\,(\text{MULT}),$$

which results in an actual range of 0.2Ω to 50Ω. Maximum sensitivity will be achieved if the lowest MULT is used, but faster operating time will be obtained for higher fault currents if the highest MULT is used. Select the highest MULT value possible if current sensitivity is not a problem. Current sensitivity may be calculated using the equations given in the SPECIFICATIONS section.

When a "MULT" setting is selected, the rotary switch on the front panel must be set to this value <u>and</u> the link labeled "MULT" located on the board of the same module must be set to this value. In addition, there are three other settings that must be made on different modules that are directly related to the above reach settings.

The link labeled "MULT" on the board of the VMM115 module must be set to the same value selected for the rotary switch on the AFM133 module associated with M1/MG1 (located in position "Y"). The dip switch labeled "0(1) SUP" on the board of the AFM217 module must be set equal to 0.1/MULT, where MULT is the reach multiplier set on the front panel rotary switch of the AFM133 module associated with M1/MG1 (located in position "Y"). The dip switch labeled "0(T) SUP" must be set equal to 0.1/MULT, where MULT is the reach multiplier set on the front panel rotary switch of the AFM133 module associated with MT/MTG (located in position "S"). Both "0(1) SUP" and "0(T) SUP" have a setting range of 0.1 to 1.5, with a resolution of 0.03. The actual setting is equal to 0.1 plus the sum of the switch toggles set to the "right" position.

The overreaching functions are always used with the pilot channel to provide high-speed protection for faults anywhere on the transmission line. To this purpose, they must be set to reach beyond the remote terminal of the line. The overreaching functions should never be set less than 125% of the line impedance, but can be set longer than this to provide improved performance or to control timers (II and III) so that time-delayed backup tripping can be provided, independent of the pilot trip.

The first timer (II) can be used to provide zone 2 protection in conjunction with the zone 1 functions by extending the zone 1 reach to zone 2 when this timer times out.

The second timer (III) works directly with the overreaching functions and can be used to:

a. initiate zone 3 tripping if the zone 1 functions are used in the extended-reach mode to provide zone 2 backup.

b. initiate zone 2 tripping if the zone 1 functions are not used in the extended-reach mode for 2nd zone backup.

Each timer is set or disabled using switches located on the front panel of the ULM234, Figure MO-11 in the MODULES section.

It follows from the above discussion that it is necessary to decide how many zones of backup protection are to be used in a particular application.

If it is acceptable to extend the reach of the 1st zone functions, up to three zones of protection can be provided:

a. The 1st zone functions would be set to reach no more than 90% of the transmission line impedance. The zone 1 reach setting is made using switches located on the front panel of the AFM133 module (position Y), Figure MO-4.

b. The zone 1 reach-extension factor would be set to give the desired 2nd zone reach. For example, a zone 2 reach equal to 125% of the protected line can be obtained with the reach-extension setting set as close as possible to 125/90 or 1.39. The reach extension setting is made using switches located on the front panel of the VMM11(-) module, Figure MO-13 in the MODULES section. The zone timer switch (II) labeled OUT on the ULM234 Module, figure MO-11, would be set to the left (IN) position.

c. Third (3rd) zone protection would be obtained by setting the overreaching functions (if possible) to reach beyond the remote terminal of any line that emanates from the bus at the remote terminal of the line to be protected. The reach setting is made using switches located on the front panel of the AFM133 module (position S), Figure MO-4. Zone timer III on the ULM234 Module, Figure MO-11, would be set to 3rd zone time, and its switch, labeled OUT, would be set to the left (IN) position. If 3rd zone backup protection is not required, set the zone timer III switch to the right (OUT) position and select a reach setting for the overreaching functions that is at least 10% larger than the selected 2nd zone reach.

If it is not acceptable to extend the 1st zone functions in reach, only two zones of protection can be provided:

a. The 1st zone functions would be set to reach 90% of the transmission line impedance.

b. The zone timer (II) switch would be set to the right (OUT) position.

c. The overreaching functions would be set with a suitable 2nd zone reach, keeping in mind the 125% minimum-setting limitation proposed earlier. Set the zone timer switch (III) labeled OUT to the left (IN) position. If zone 2 backup protection is not desired, set the zone timer switch (III) to the right (OUT) position.

After a reach setting has been selected for the overreaching functions, it is desirable to check that the selected reach setting has not exceeded allowable limits. The maximum allowable reach setting that can be made is dependent on the impedance angle of the transmission line, the maximum load flow (minimum load impedance) across the line, and the characteristic shape selected for the distance functions. Three different characteristic shapes can be selected (see Figure CS-1 for details). Larger maximum

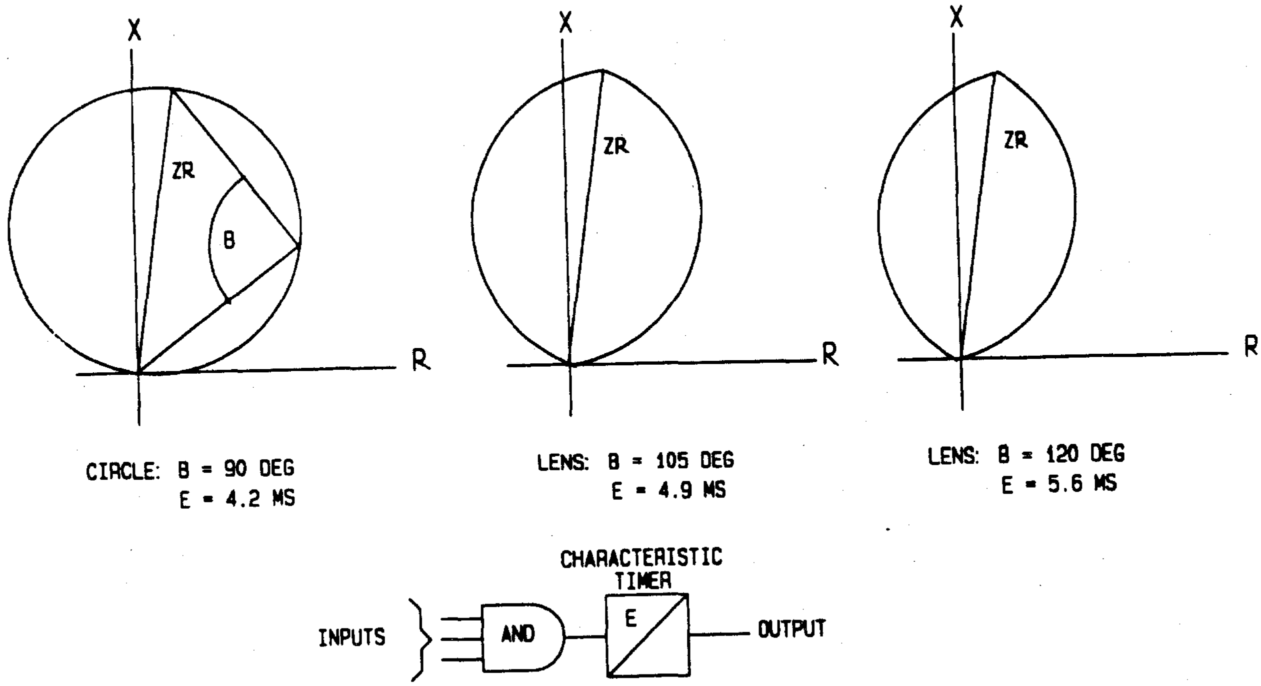


Figure CS-1 (0285A9991-1) Phase Distance Functions Characteristic Shapes

reaches can be used if the characteristic is made more lenticular, but at a slight increase in operating time because the characteristic timer setting must be increased to obtain the lenticular shape. To get the best possible operating time, a circular characteristic should be used whenever possible.

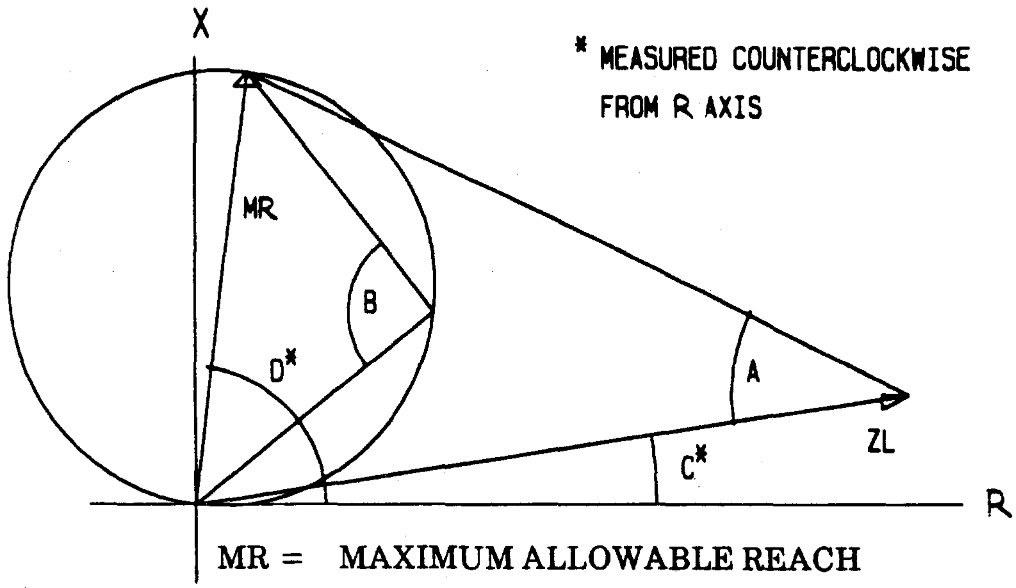
The maximum allowable reach setting can be easily calculated if the maximum load flow across the line is known. Please refer to Figure CS-2 for details.

The criterion used for establishing the maximum allowable reach is based on maintaining a 40° angular margin between the angle A and the characteristic angle B; i.e., B > A by 40°. With this margin maintained, the functions will be secure from operation as a result of load because the blocks created at the input to the characteristic timer (see Figure CS-1) due to load will be approximately 2 milliseconds less than the timer pickup setting.

Please note that the settings described above are predicated on using the overreaching functions as part of the stepped distance backup protection. If this function is not required as part of the backup, the best possible performance will be obtained from the pilot scheme if the reach of the overreaching functions is set as large as possible, but not larger than the maximum allowable reach described in equation (3) in Figure CS-2.

Ground Zone 1 Characteristic, Mho or Reactance

The ground zone 1 functions can be set to operate with a variable mho or reactance characteristic. When operated with a reactance characteristic, the function is supervised by the MTG overreaching functions. The reactance characteristic will provide more resistance coverage than will the variable mho, but slightly slower operating times will be



MR = MAXIMUM ALLOWABLE REACH

$$MR = \frac{SIN(A) \times ZL}{SIN(180 - A - E)} \qquad (3)$$

Where:

A = 50 for circle (B=90)
A = 65 for lens (B=105)
A = 80 for lens (B=120)
ZL = |Minimum load impedance (maximum load current)|

C = load impedance angle
D = Relay positive-sequence angle of maximum reach;use next higher angle above the positive-sequence impedance line angle
E = |D−C|

Figure CS-2 (0285A9992-1) Overreaching Function Load Coordination

experienced for zone 1 trips because of the necessity of the mho supervision.

Characteristic selection is made via three switches that are located on the board of the ETM111 module, Figure MO-9. The variable mho characteristic is selected when the switches are in the ON position. With the switches in the OFF position, the reactance characteristic is selected.

Directional supervision of the reactance characteristic is made via dip switch settings on the board of the UTM111 module, Figure MO-16.

When each of the ØA, ØB, and ØC "MG-1 SUP" switches are set to the "REACT" position, the zone 1 function is supervised by MTG. When the reactance characteristic is selected on the ETM111 module, the "MG-1 SUP" switches must be set to REACT. When the mho characteristic is selected on the ETM111 module, the "MG-1 SUP" switches must be set to MHO.

WORKED EXAMPLE (distance tripping functions)

As an example of the settings to be made on the distance functions, consider the typical transmission line shown in Figure CS-3 and assume that three zones of protection are to be used in the TYS system located at Station Able. To accomplish this, the 1st zone functions will be increased in reach following zone 2 time to provide zone 2 protection, and, for 3rd zone protection, the overreaching functions will be set, if possible, to reach beyond the remote ends of

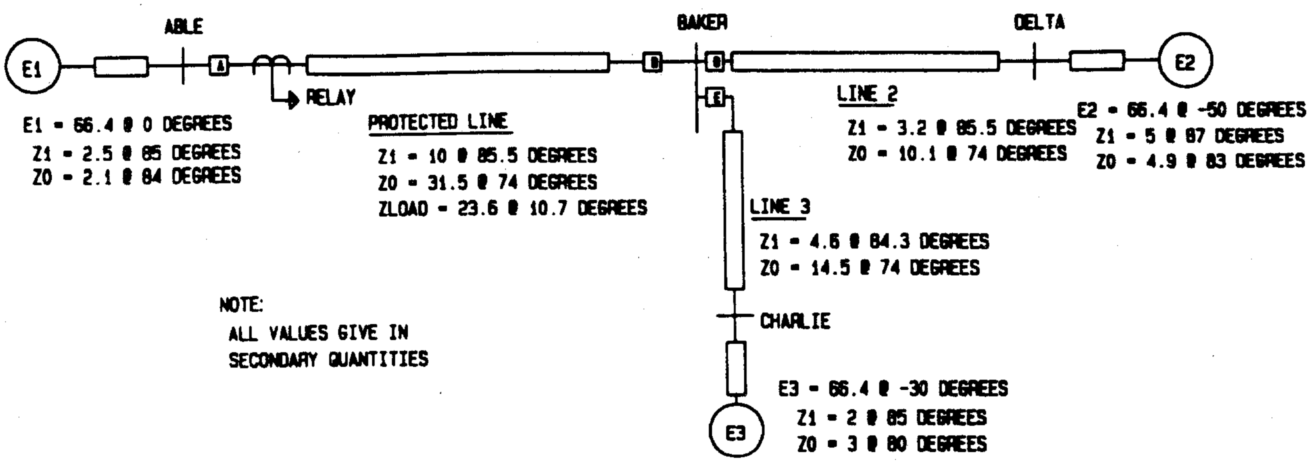


Figure CS-3 (0285A9993) Typical Transmission System

the lines emanating from Station Baker to Station Charlie and Station Delta.

Positive-Sequence Angle of Maximum Reach, ϕZ_1

Set the positive-sequence angle of maximum reach (ϕZ_1) to 85°, using the switch located on the front panel of the ISM11(-) module, Figure MO-10.

Zero-Sequence Angle of Maximum Reach, ϕZ_0

Set the zero-sequence angle of maximum reach (ϕZ_0) to 75° using the switch located on the front panel of the ISM11(-) module, Figure MO-10.

MTG Zero-Sequence Current Compensation, K_0

From equation (1) above:

$$K_0 = 31.5/10 = 3.15$$

The nearest setting is 3.2. Set K0 for MTG to 3.2, using the switches located on the board of the AFM133 module (position S), Figure MO-4.

MG1 Zero-Sequence Current Compensation, K_0

From equation (2) above:

$$K_0 = (0.95 \times 31.5)/10 = 2.99$$

The nearest setting is 3.0. Set K_0 for MG1 to 3.0, using the switches located on the board of the AFM133 module (position Y), Figure MO-4.

M1 and MG1 Reach

Set the zone 1 functions to reach 90% of the positive-sequence impedance of the transmission line.

$$ZR1 = 0.9 \times 10 = 9 \text{ ohms}$$

Set "MULT" = 1, using the rotary switch on the front panel of the AFM133 module located in position "Y". Set "r" = 9 ohms, using the dip switches on the front panel of the same module. Set "MULT" = 1, using the link located on the board of the same module. Refer to Figure MO-4 for the locations of these settings. The reach of both M1 and MG1 is established with these settings.

Set "MULT" = 1, using the link located on the board of the VMM115 module. Set "0(1) SUP" = 0.1/1 = 0.1, using the switch on the board of the AFM217 module.

Second Zone Reach (extension factor), Timer II

Zone 2 protection will be provided by increasing the reach of the zone 1 functions (M1 and MG1) following a 2nd zone time delay set on timer II. The timer is started by

MB Reach

The reach of the blocking functions will be established using equation (5) above because the reach of the overreaching functions at Station Able (28.6 ohms) is greater than twice the positive-sequence impedance of the line:

MB Reach = $(28.6-10)\times 1.7 = 31.6$ ohms

Set 31.6 ohms, using the "r" switches located on the front panel of the ABM11(-) module, Figure MO-2.

Zero-Sequence Current Compensation Factor, K

The MB zero-sequence compensation factor is calculated using equation (6) above:

$$K = \frac{(31.5-10)}{10} = 2.15$$

The nearest available setting is 2.2. Set 2.2, using the switches located on the board of the ABM11(-) module, Figure MO-2.

MB Characteristic Timer

Set the MB characteristic timers for 95°, using the switches located on the board of the UTM111 module, Figure MO-16.

OVERCURRENT FUNCTIONS

The following overcurrent functions must be set:

IPB - Pilot blocking (0.05-0.755 per unit, 0.025 step)

IØØ - MT overcurrent supervision (0.1-1.0 per unit, 0.1 step)

IM Overcurrent supervision (0.05-0.755 per unit, 0.025 step)

I1 - Line pickup (0.2-3.2 per unit, 0.2 step)

IPB, Pilot Blocking

IPB uses zero-sequence current with positive-sequence restraint ($I_0 - K_B I_1$). It is used to supervise the NB function. The setting is made in per-unit current, where rated current, I_N, (1or 5 amperes) is used as the base, and it is actually in terms of $3x(I_0 - K_B I_1)$. IPB should be set to its minimum setting of 0.05 per-unit current. The setting is made using the switches located on the board of the ADM112 module, Figure MO-3.

IØØ, MT Supervision

IØØ is not a separate overcurrent function but rather an input to the MT phase distance function comparator, however it acts just like an overcurrent function to establish trip level supervision of MT. IØØ uses delta current for the operating quantity (i.e., $I_A - I_B$ for the ØA-B MT function), but its setting is based on phase current. The setting is made in per-unit current, where rated current, I_N (1 or 5 amperes) is used as the base. IØØ must coordinate with IM at the remote terminal since IM provides overcurrent supervision of the MB blocking functions. For two terminal applications, IØØ should be set for its minimum value of 0.1 per-unit current. For three terminal applications, the coordination margin should be doubled by increasing the IØØ setting to 0.2. Both of these recommended settings are based on the IM setting suggested below. The setting is made using the switches located

For the balance of the text of the CALCULATION OF SETTINGS section, please refer to pages CS-8 - CS-13 of GEK-90658.

MODULES

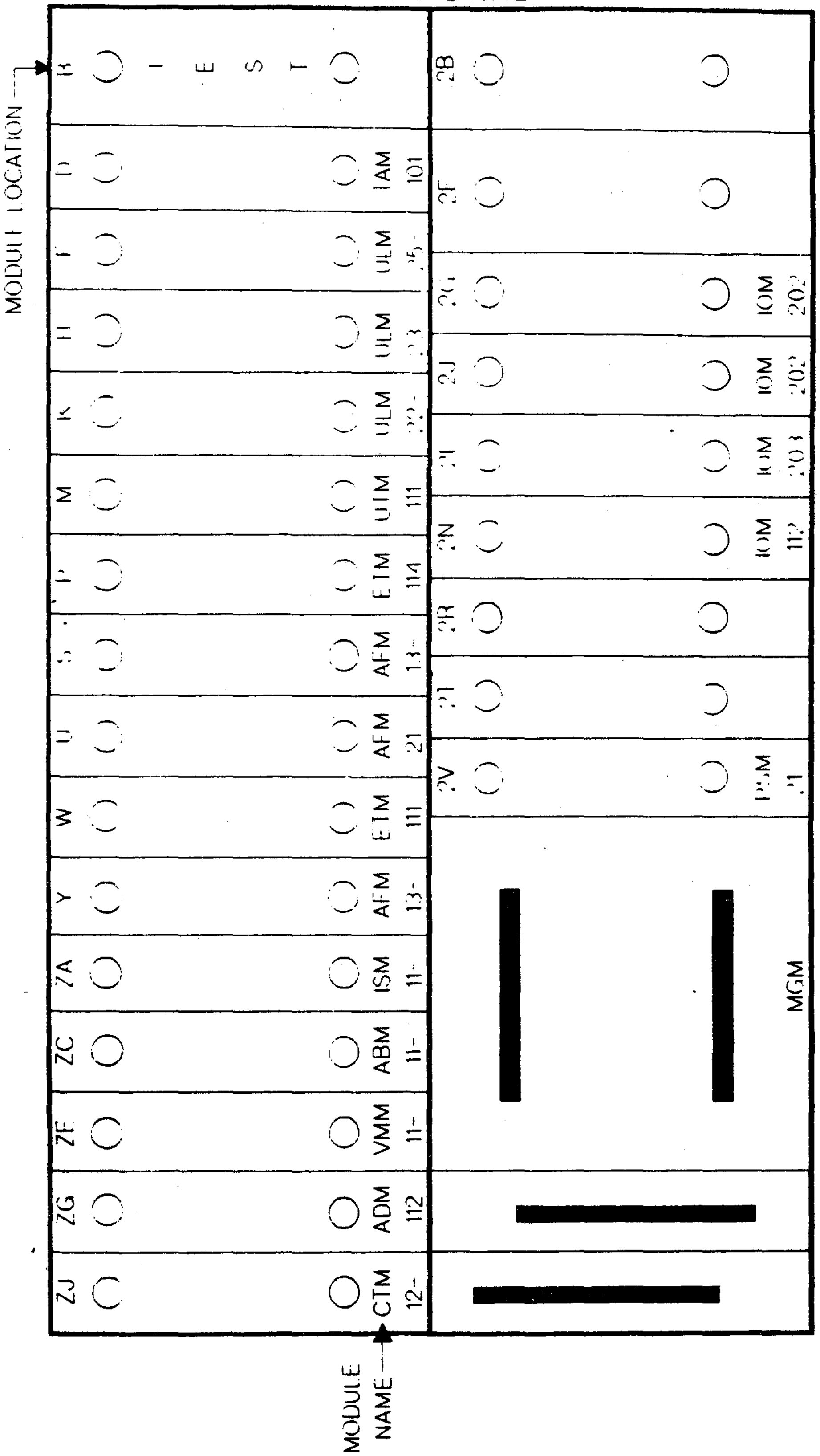


Figure MO-1 (0285A5468) Module Location
Phase and Ground Distance Permissive

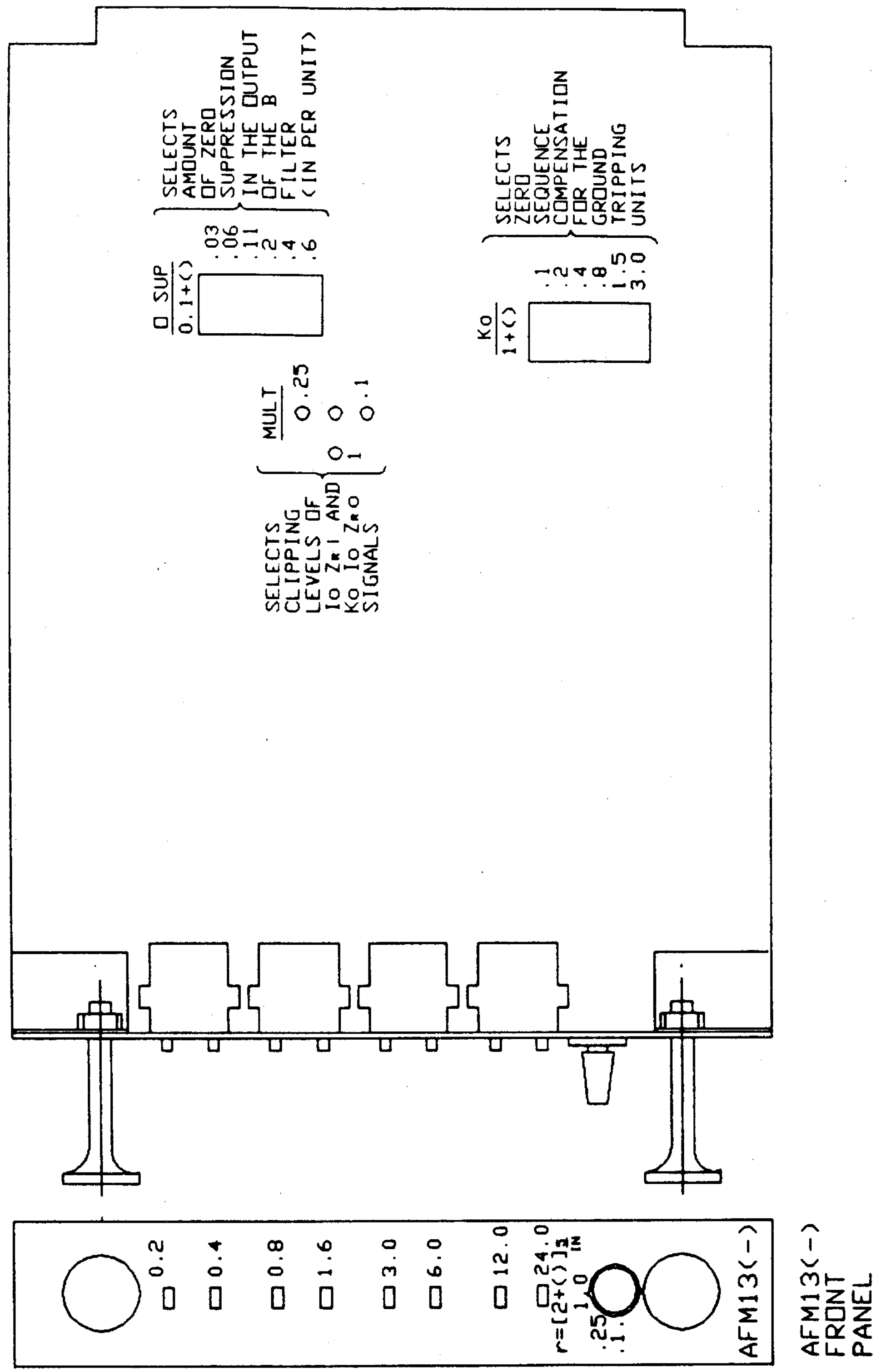


Figure MO-4 (0285A5469) Front Panels and Internal Switch, AFM13(-) Module

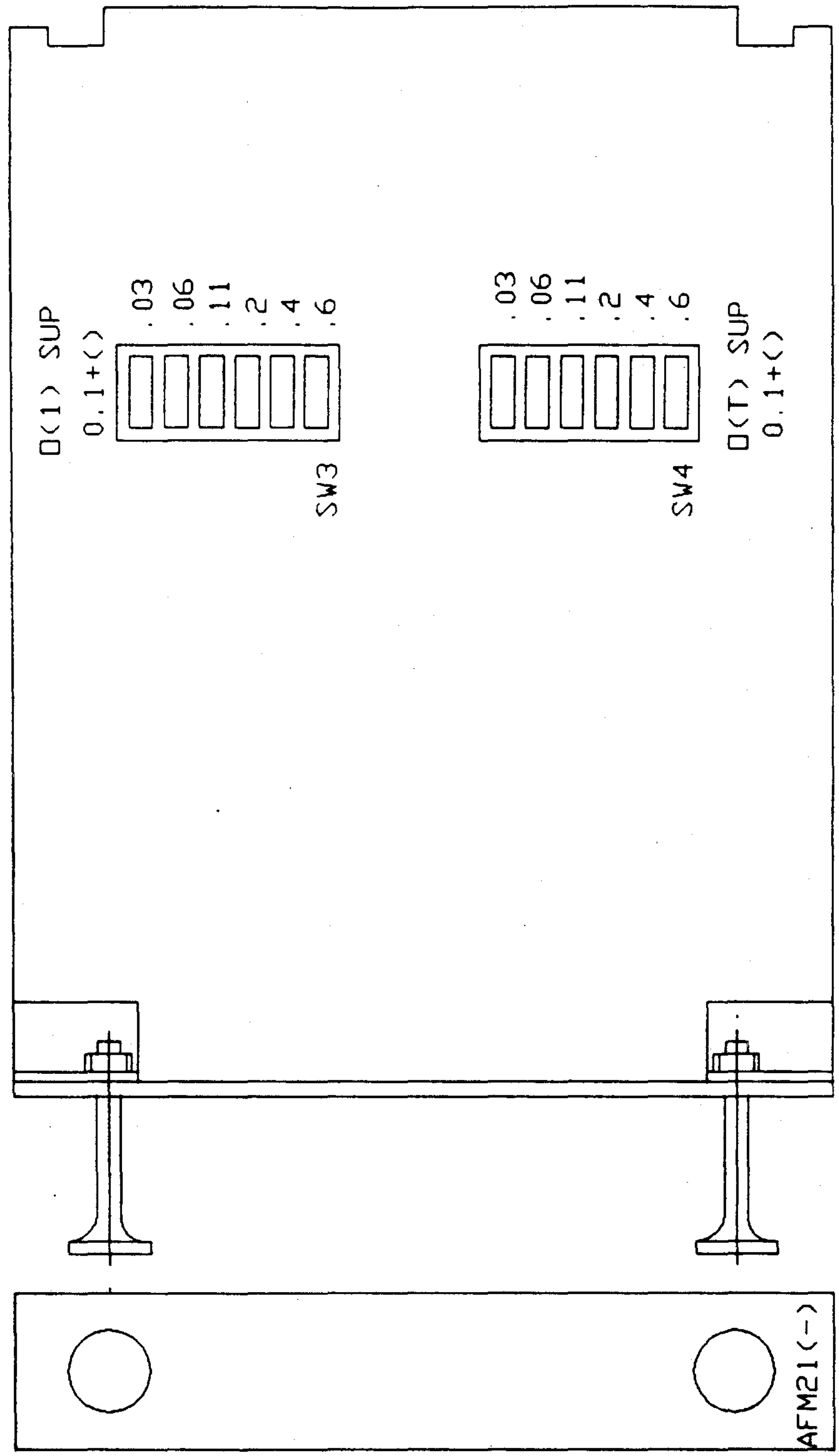


Figure MO-5 (0285A5470) Internal Switches and Links, AFM21(-) Module

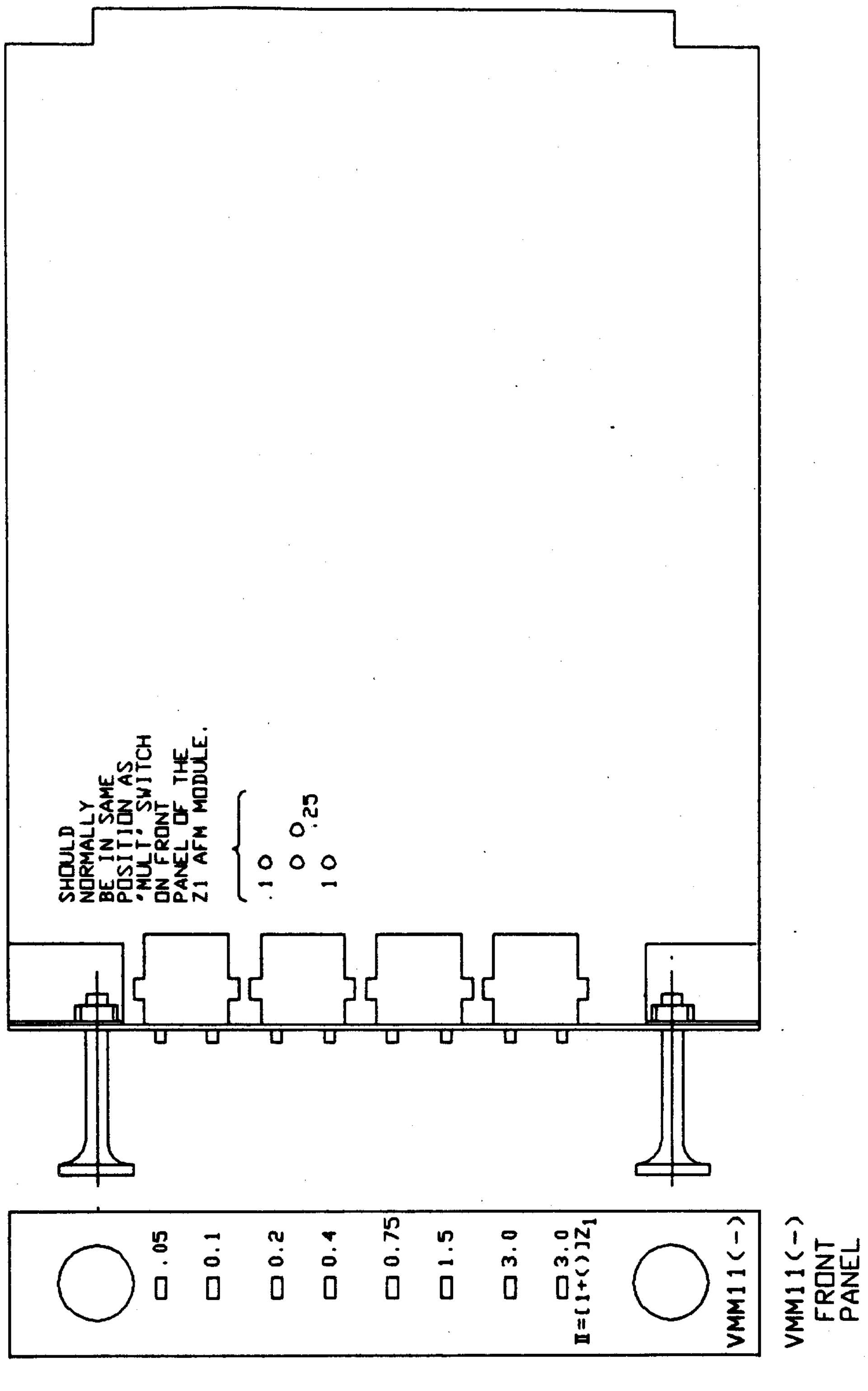


Figure MO-13 (0285A5471) VMM115 Module

TABLE AT-I

MODULE NAME	LOCATION	LINK/ SWITCH NAME		SETTING
ABM11(-)	ZC	K	(SWITCH)	1.0
		K_V	(SWITCH)	0.3
		I_1	(SWITCH)	0.2
ADM112	ZG	IPB BIAS	(SWITCH)	0.05
		IM BIAS	(SWITCH)	0.05
AFM133†	Y	K0	(SWITCH)	4.0
AFM133	S	0 SUP	(SWITCH)	0.1
	S	MULT	(LINKS)	1.0
AFM217	U	O(I) SUP	(SWITCH)	0.1
	U	O(T) SUP	(SWITCH)	0.1
CTM12(-)	ZJ (OPTION)	IDT DIR. CONTROL	(LINK)	"IN"
		ITOC DIR. CONTROL	(LINK)	"IN"
		PT PU	(SWITCH)	0.5
ETM111	W	PHA - VP	(SWITCH)	"ON"
		PHB - VP	(SWITCH)	"ON"
		PHC - VP	(SWITCH)	"ON"
IOM112	2N	DC PWR SUP SOURCE	(LINK)	RATED
TAM101	D (OPTION)	LOGIC VOLT	(LINK)	12 VDC
		SW4	(SWITCH)	AS REQ'D
ULM227	K	TL1	(SWITCH)	0.0
		TL16	(SWITCH)	0.0
UTM111	M	MG1	(SWITCH)	MHO
		MT	(SWITCH)	90°
		MTG	(SWITCH)	90°
		MOB	(SWITCH)	124°
		MB	(SWITCH)	80°
		FREQ.	(SWITCH)	RATED
VMM115	ZE	MULT	(LINK)	1.0

† Refer to the specific model number, the Nomenclature Selection Guide (**INTRODUCTION** section) and Table AT-II to determine which range has been supplied.

TABLE AT-II

MODULE NAME	LOCATION	SWITCH NAME	SETTING	RANGE
ABM11(-)	ZC	r	6.0	(2 TO 50 Ω)
AFM133	Y	r	3.0	(0.2 TO 50 Ω)
AFM133	Y	MULT	1.0	(0.1 TO 2.5 Ω)
CTM12(-)	ZJ	TOC PU	0.6	(0.05 TO 0.6 PU)
		TD	1.0	(0.5 TO 10)
		IDT PU	4.0	(0.4 TO 4.0 PU)
ETM114	P	Iø - ø	0.1	(0.1 to 1.0 U)
ISM11(-)	ZA	$øZ_1$	85°	(50 TO 85°)
		$øZ_0$	85°	(50 TO 85°)
ULM234	H	TIMER II	0.0	(0 TO 3.1 SEC)
		TIMER III	0.0	(0 TO 3.1 SEC)
ULM258	F	OSB-1	OPEN	
		OSB-2	OPEN	
VMM11(-)	ZE	II	1.0	(1 TO 10) ×ZONE 1

I1 Detector Test

1. With the connections as shown in Figure AT-1, move the oscilloscope input to card-extender Pin 24. 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.

V1 DETECTOR TEST

1. With the connections as shown in Figure AT-2, move the oscilloscope input to card-extender Pin 26. Set angle VA = 0°, VB = −120° and VC = +120° or −240°. Set voltage VA, VB and VC to 67 volts rms.

2. Reduce the three-phase voltage, simultaneously, until the oscilloscope trace goes from LOW to HIGH. At this point the voltage should be between 48.5 and 51.5 volts rms.

NEGATIVE-SEQUENCE DIRECTIONAL TESTS

NT Test

1. With the connections as shown in Figure AT-3, move the oscilloscope input to card-extender Pin 18. Connect the relay input "Y" to BH1 (TP9 for post-installation testing). Set angle VA = 0°, VB = −120° and VC = +120° or −240°. Set voltage VA, VB and VC to 67 volts rms.

2. Set angle I_{OP} = −85°. Reduce voltage VA to 30 volts rms and slowly increase I_{OP} until the trace on the scope goes from LOW to HIGH. At this point current I_{OP} should be less than 1.0 ampere rms.

3. Change angle I_{OP} to +95° and check that the oscilloscope trace does not go HIGH as I_{OP} is increased up to 10 (2) amperes rms.

NB Test

1. With the angle I_{OP} set to +95°, move the oscilloscope input to card-extender Pin 14. Reduce I_{OP} to 1.0 (0.2) amperes rms and check that the oscilloscope trace is HIGH.

2. Change angle I_{OP} to −85° and check that the oscilloscope trace is LOW.

REACH TESTS

M1 Test

1. With the connections as shown in Figure AT-4 for the appropriate phases and function to be tested, set angle VA = 0°, VB = −120° and VC = +120° or −240°. Set voltage VA, VB and VC to 67 volts rms. Set the phase angle of I_{OP} to the values indicated in Table AT-III.

TABLE AT-III

Volts RMS	I Degrees
26 - 30	−25
32 - 37	−55
26 - 30	−85

2. Set I_{OP} to 10 (2) amperes rms. Simultaneously reduce the voltage of the faulted phases and check that the appropriate pin on the card extender goes from LOW to HIGH within the voltage limits given in Table AT-III.

MT Tests

1. With the connections as shown in Figure AT-4 for the appropriate phases and function to be tested, set angle VA = 0°, VB = −120° and VC = +120° or −240°. Set voltage VA, VB and VC to 67 volts rms. Set the phase angle of I_{OP} to the values indicated in Table AT-IV.

2. Set I_{OP} to 10 (2) amperes rms. Simultaneously reduce the voltage of the faulted phases and check that the appropriate pin on the card extender

TABLE AT-IV

Volts RMS	I Degrees
26 - 30	−25
32 - 37	−55
26 - 30	−85

goes from LOW to HIGH within the voltage limits given in Table AT-IV.

MG1 Tests

1. With the connections as shown in Figure AT-6 for the appropriate phase and function to be tested, set angle VA = 0°, VB = −120° and VC = +120° or −240°. Set voltage VA, VB and VC to 67 volts rms. Set the phase angle of I_{OP} to the values indicated in Table AT-V.

TABLE AT-V

Volts RMS	I Degrees
34 - 39	−55
40 - 47	−85
34 - 39	−115

2. Set I_{OP} to 7.5 (1.5) amperes rms. Reduce the voltage of the faulted phase and check that the appropriate pin on the card extender goes from LOW to HIGH within the voltage limits given in Table AT-V.

MTG Tests

1. With the connections as shown in Figure AT-6, for the appropriate phase and function to be tested, set angle VA = 0°, VB = −120° and VC = +120° or −240°. Set voltage VA, VB and VC to 67 volts rms. Set the phase angle of I_{OP} to the values indicated in Table AT-VI.

2. Set I_{OP} to 7.5 (1.5) amperes rms. Reduce the voltage of the faulted phase and check that the appropriate pin on the card extender goes from LOW to HIGH within the voltage limits given in Table AT-VI.

TABLE AT-VI

Volts RMS	I Degrees
34 - 39	−55
40 - 47	−85
34 - 39	−115

MB Tests

1. With the connections as shown in Figure AT-3 for the appropriate phase to be tested, set angle VA = 0°, VB = −120° and VC = +120° or −240°. Set voltage VA, VB and VC to 67 volts rms. Set the phase angle of I_{OP} to the values indicated in Table AT-VII.

TABLE AT-VII

Volts RMS	I Degrees
50 - 58	+65
52 - 60	+95
50 - 58	+125

2. Set I_{OP} to 5 (1) amperes rms. Simultaneously reduce the three-phase voltage and check that the appropriate pin on the card extender goes from LOW to HIGH within the voltage limits given in Table AT-VII.

MOB Tests

1. Change the MOB timer setting to 60°. This is accomplished by means of a switch located on the board of the UTM111 module, Figure MO-16, which is found in location "M".

2. With the connections as shown in Figure AT-8, connect the oscilloscope input to card-extender Pin 27. Set angle VA = 0°, VB = −120° and VC = +120° or −240°. Set voltage VA, VB and VC to 67 volts rms. Set the phase angle of I_{OP} to the values indicated in Table AT-VIII.

3. Set I_{OP} to 10 (2) amperes rms. Simultaneously reduce the voltage of the faulted phases until the trace on the oscilloscope, Pin 27, goes from LOW to HIGH (First Pulse) within the voltage

TABLE AT-VIII

Volts RMS	I Degrees
35 - 41	−25
35 - 41	−85

limits given in Table AT-VIII. Move the oscilloscope input to card-extender Pin 45 and check that it also has changed from LOW to HIGH.

4. Connect the oscilloscope input to card-extender Pin 8, 9 or 10, determined by the phases that are being tested. Continue to reduce the voltage of the faulted phases until the trace on the oscilloscope goes from LOW to HIGH. Also, check that the trace on the oscilloscope from card-extender Pin 45 remained HIGH.

5. Increase the voltage of the faulted phases back to 67 volts rms and check that the traee on the oscilloscope from card-extender Pin 45 returned to a LOW.

6. Reset the MOB timer to its pre-test position. (See Table AT-I)

SETTINGS LIST A (Blank Form)

TYS3 PHASE AND GROUND DISTANCE PERMISSIVE SCHEME SETTING LIST

Module Location	Module	Adjustment	Description	Switch Location	Setting
ZC	ABM11(-)	I_1	Line PU supervision	on board	
	ABM11(-)	KV	Pos. seq. volt. comp.	on board	0
	ABM11(-)	K	MB zero seq. curr. comp.	on board	
	ABM11(-)	r	MB reach setting	front panel	
ZG	ADM112	IM BIAS	Overcurrent supervision	on board	0.05
	ADM112	IPB BIAS	Pilot blocking	on board	
Y	AFM133	r	Zone 1 reach (M1/MG1)	front panel	
	AFM133	MULT	Reach multiplier	front panel	
	AFM133	MULT	Clip level	on board	
	AFM133	KO	Zero seq.curr.comp(M1/MG1)	on board	
S	AFM133	r	Overreaching (MT/MTG) reach	front panel	
	AFM133	MULT	Reach multiplier	front panel	
	AFM133	MULT	Clip level	on board	
	AFM133	K0	Zero seq.curr.comp(MT/MTG)	on board	
U	AFM217	0(1) SUP	Zone 1: zero suppression	on board	
	AFM217	0(T) SUP	Zone 2: zero suppression	on board	
W	ETM111	PHA - VP	MG1 Characteristic	on board	
	ETM111	PHB - VP	REACTANCE = OFF	on board	
	ETM111	PHC - VP	MHO = ON	on board	
P	ETM114	Iøø	MT overcurrent supervision	front panel	
ZN	IOM112	VDC	Contact conv. volt.	on board	
ZA	ISM11(-)	$øZ_1$	Pos. seq. reach ang.	front panel	
	ISM11(-)	$øZ_0$	Zer. seq. reach ang.	front panel	
K	ULM227	TL1	Trip integrator	on board	
H	ULM234	TIMER II	Zone ( ) timer	front panel	
	ULM234	TIMER III	Zone ( ) timer	front panel	
F	ULM258	OSB-1	OSB option	front panel	
	ULM258	OSB-2	OSB option	front panel	
M	UTM111	MT	MT char. timer	on board	
	UTM111	MTG	MTG char. timer	on board	
	UTM111	MB	MB char. timer	on board	
	UTM111	MOB	MOB char. timer	on board	
	UTM111	MG1-SUP	MG1 supervision	on board	
ZE	VMM115	II	Zone 1 ext. factor	front panel	
	VMM115	MULT	Zero suppression	on board	

Optional overcurrent functions (when included)

Module Location	Module	Adjustment	Description	Switch Location	Setting
ZJ	CTM12(-)	TD	TOC time dial	front panel	
	CTM12(-)	TOC PU	TOC pickup	front panel	
	CTM12(-)	DT PU	IDT pickup	front panel	
	CTM12(-)	PT PU	IPT pickup	on board	
	CTM12(-)	ITOC DIR CON	TOC directional cont.	on board	
	CTM12(-)	IDT DIR CONT	IDT directional cont.	on board	

SETTINGS LIST B (*Worked Example*)
TYS3 PHASE AND GROUND DISTANCE PERMISSIVE SCHEME SETTING LIST

Module Location	Module	Adjustment	Description	Switch Location	Setting
ZC	ABM11(-)	I1	Line PU supervision	on board	*0.6*
	ABM11(-)	KV	Pos. seq. volt. comp.	on board	*0*
	ABM11(-)	K	MB zero seq. curr. comp.	on board	*2.2*
	ABM11(-)	r	MB reach setting	front panel	*31.6Ω*
ZG	ADM112	IM BIAS	Overcurrent supervision	on board	*0.05*
	ADM112	IPB BIAS	Pilot blocking	on board	*0.05*
Y	AFM133	r	Zone 1 reach (M1/MG1)	front panel	*9Ω*
	AFM133	MULT	Reach multiplier	front panel	*1*
	AFM133	MULT	Clip level	on board	*1*
	AFM133	K0	Zero seq.curr.comp(M1/MG1)	on board	*3.0*
S	AFM133	r	Overreaching (MT/MTG) reach	front panel	*28.6Ω*
	AFM133	MULT	Reach multiplier	front panel	*1*
	AFM133	MULT	Clip level	on board	*1*
	AFM133	K0	Zero seq.curr.comp(MT/MTG)	on board	*3.2*
U	AFM217	0(1) SUP	Zone 1: zero suppression	on board	*0.1*
	AFM217	0(T) SUP	Zone 2: zero suppression	on board	*0.1*
W	ETM111	PHA - VP	MG1 characteristic	on board	MHO (ON)
	ETM111	PHB - VP	REACTANCE = OFF	on board	MHO (ON)
	ETM111	PHC - VP	MHO = ON	on board	MHO (ON)
P	ETM114	Iøø	MT overcurrent supervision	front panel	*0.1*
ZN	IOM112	VDC	Contact conv. volt.	on board	*125*VDC
ZA	ISM11(-)	øZ_1	Pos. seq. reach ang.	front panel	*85°*
	ISM11(-)	øZ_0	Zer. seq. reach ang.	front panel	*75°*
K	ULM227	TL1	Trip integrator	on board	*4.0* ms
H	ULM234	TIMER II	Zone ( ) Timer	front panel	*0.2* sec
	ULM234	TIMER III	Zone ( ) Timer	front panel	*0.5* sec
F	ULM258	OSB-1	OSB option	front panel	*IN*
	ULM258	OSB-2	OSB option	front panel	*IN*
M	UTM111	MT	MT char. timer	on board	*105°*
	UTM111	MTG	MTG char. timer	on board	*105°*
	UTM111	MB	MB char. timer	on board	*95°*
	UTM111	MOB	MOB char. timer	on board	*84°*
	UTM111	MG1-SUP	MG1 supervision	on board	*MHO*
ZE	VMM115	II	Zone 1 ext. factor	front panel	*1.4*
	VMM115	MULT	Zero suppression	on board	*1*

Optional overcurrent functions (when included)

Module Location	Module	Adjustment	Description	Switch Location	Setting
ZJ	CTM12(-)	TD	TOC time dial	front panel	*2.0*
	CTM12(-)	TOC PU	TOC pickup	front panel	*0.05*
	CTM12(-)	DT PU	IDT pickup	front panel	*0.7*
	CTM12(-)	PT PU	IPT pickup	on board	*0.1*
	CTM12(-)	ITOC DIR CON	TOC directional cont.	on board	*IN*
	CTM12(-)	IDT DIR CON	IDT directional cont.	on board	*OUT*

the operation of the MT overreaching functions. Assume that zone 2 reach is to be 125% of the protected line, and that a zone 2 time of 0.2 seconds is required.

$$Z_2 = 1.25 \times 10 = 12.5 \text{ ohms}$$

$$\text{Reach Extension Factor} = \frac{Z2}{Z1} = \frac{12.5}{9}$$

$$= 1.39$$

The nearest available setting for the reach multiplier is 1.40. Set 1.4, using switches located on the front panel of the VMM115 module, Figure MO-13.

Set the 0.2-second Zone 2 time delay and set the timer switch labeled OUT, to the left (IN) position, using the switches marked TIMER II and located on the front panel of the ULM234 module, Figure MO-11.

<u>MT and MTG Reach (Overreaching) and Characteristic Shape, Timer III</u>

If the MT and MTG overreaching functions are to reach beyond the remote terminals of the lines emanating from Station Baker, the effects of infeed at Station Baker must be taken into account in establishing a reach setting. Fault studies were run with and without load flow for the system shown in Figure CS-3, and it was established that the maximum apparent impedance seen by the relays at Station Able was:

Z = 22.9 ohms, for a single-line-to-ground fault at Station Charlie (no load)

The studies showed that the apparent impedance seen with load flow was less than the value given above.

It is proposed that the MT overreaching functions be set with a reach that is 25% greater than the maximum apparent impedance seen by the functions, and that timer III be set to pick up in 3rd zone time of 0.5 seconds.

$$ZRT = 1.25 \times 22.9 = 28.6 \text{ ohms.}$$

It is next necessary to check the maximum allowable reaches that are permitted for the conditions given in Figure CS-3. From equation (3) above and from the system data given in Figure CS-3, the following maximum reaches can be calculated (use a relay angle of maximum reach of 85°):

MR = 21.9 ohms with 90° circle
MR = 32.8 ohms with 105° lens
MR = 50 ohms (maximum available) with 120° lens

To obtain the reach of 28.6 ohms calculated above, the overreaching functions must be set with a 105° lens characteristic. Set "MULT" = 1, using the rotary switch on the front panel of the AFM133 module located in position "S". Set "r" = 28.6 ohms, using the dip switches on the front panel of the same module, and "MULT" = 1, using the link located on the board of the same module. Refer to Figure MO-4 for the locations of these settings. The reach of both MT and MTG is established with these settings.

Set "0(T) SUP" = 0.1/1 = 0.1, using the switch on the board of the AFM217 module.

Set the 105° lens characteristic for MT and MTG, using the respective switches located on the board of the UTM111 module, Figure MO-16.

Set the 3rd zone timer to 0.5 second, and set the timer switch, labeled OUT to the left (IN) position, using the switches marked TIMER III and located on the front panel of the ULM234 module, Figure MO-11.

<u>Note</u>: if 3rd zone protection is not required, the overreaching functions can be set with a circular (90°) characteristic, but the reach must be reduced to 21.9 ohms.

<u>Ground Zone 1 (MG1) Characteristic</u>

The variable mho characteristic will be used for the zone 1 ground distance functions in this application.

Select the mho characteristic, using the switches located on the board of the ETM111 module, Figure MO-7.

Select the mho supervision, using the switch located on the board of the UTM111 module, Figure MO-16.

Distance Function Sensitivity

If required, the sensitivity of the distance functions can be found using the calculated settings and the procedures defined in the SPECIFICATIONS section of this instruction book.

REVERSE-REACHING BLOCKING FUNCTIONS, MB

The following settings must be made:

a. MB Reach (2Ω-50Ω, 0.2Ω step)
b. Zero-sequence current compensation, K (1-7, 0.1 step)
c. Characteristic timer setting (80°, 95°, 110°)
d. Positive-sequence voltage compensation, KV (0-0.3, 0.15 step)

MB Reach

The reach of the reverse-reaching blocking functions is dependent on the reach of the overreaching functions at the remote end of the line. The following settings are proposed:

a. If the MT reach at the remote terminal is less than twice the positive-sequence impedance of the line,

$$\text{MB Reach} = (\text{MT reach}) \times 0.85 \quad (4)$$

b. If the MT reach at the remote terminal is greater than twice the positive-sequence impedance of the line,

$$\text{MB Reach} = (\text{MT reach} - Z_{1L}) \times 1.7 \quad (5)$$

Where: Z_{1L} = positive-sequence impedance of line.

The MB reach is set using the switches located on the front panel of the ABM11(-) module, Figure MO-2.

Zero-Sequence Current Compensation Factor, K

The zero-sequence current compensation factor, K, is a function of the positive- and zero-sequence impedances of the transmission line to be protected:

$$K = (Z_{0L} - Z_{1L})/Z_{1L} \quad (6)$$

Where:
Z_{0L} = zero-sequence impedance of line.
Z_{1L} = positive-sequence impedance of line.

The MB zero-sequence current compensation factor is set using the switches located on the board of the ABM11(-) module, Figure MO-2.

MB Characteristic Timer Setting

The characteristic timer settings for the blocking functions should be set 10° less than the characteristic timer setting of the overreaching functions at the remote terminal of the line. The characteristic timer setting is made using the switches located on the board of the UTM111 module, Figure MO-16.

Positive-Sequence Voltage Compensation Factor, KV

The positive-sequence voltage compensation factor, KV, should be set to zero (0). The setting is made using the switches located on the board of the ABM11(-) module, Figure MO-2.

WORKED EXAMPLE (distance blocking functions)

The system of Figure CS-3 will be used. The blocking functions at Station Baker will be set to coordinate with the settings selected above for the overreaching functions at Station Able.

tolerance given in Table PT-I for the particular value of test current.

$$I = \text{"I1" PU} \times I_N \times 3 \qquad (6)$$

WHERE:
"I1" PU is the per-unit setting on the board of the ABM11(-) module, Figure MO-2
I_N is the rated relay current (1 or 5 amperes)
I is the nominal pickup current

FD

The fault detector may be tested using the same method as specified under ACCEPTANCE TESTING since there are no customer settings on this function.

REACH TESTS

M1

Use the connections shown in Figure AT-4 for the appropriate phases and function to be tested.

Set the current and voltage phase angles per Table PT-II.

TABLE PT-II

Phase AB	I_{OP}	$-(\theta - 30)°$
Phase BC	I_{OP}	$-(\theta + 90)°$
Phase CA	I_{OP}	$(150 - \theta)°$
V_A		$0°$
V_B		$-120°$
V_C		$+120°$

Where: θ is the setting of "ϕZ_1" on the front panel of the ISM11(-) module, Figure MO-9

The recommended test currents for this test are given in Table PT-III.

The nominal operating voltage for M1, at the angle of maximum reach, is given in Equation 7.

$$V_{NOM} = \frac{ZR1 \times 2 \times I_{TEST}}{\sqrt{3}} \qquad (7)$$

WHERE:
V_{NOM} is the phase-to-ground pickup voltage
I_{TEST} is the test current
ZR1 is the reach setting "r" times the multiplier setting "MULT" found on the front panel of the AFM133 module, Figure MO-4, found in location "Y"

TABLE PT-III

$I_N = 5$	
ZR1 or "r"(Ω)	I_{TEST}(amps)
0.2 - 2.5	10
1 - 6	10
6 - 12	5
12 - 20	3
20 - 25	2
25 - 50	1
$I_N = 1$	
ZR1 or "r"(Ω)	I_{TEST}(amps)
0.5 - 125†	2
5 - 30	2
30 - 60	1
60 - 100	0.6
100 - 125	0.4
125 250	0.2

NOTE: The switch marked "II" mounted on the front panel of the VMM11(-) module, Figure MO-13, should be set to 1 (all switches to left) when testing the M1 function.

The applied three-phase voltage should be initially set to a value greater than the nominal operating voltage and the current should be increased slowly to the recommended test value. The voltage of the faulted phases should be slowly lowered, simultaneously, until the trace on the oscilloscope steps from LOW to HIGH. The actual operating voltage should be within the tolerances given in Table PT-I for the value of test current used.

To check the M1 function at other angles, refer to the TYSTEST computer program provided in the SOFTWARE section of this manual.

MT

Use the connections shown in Figure AT-4 for the appropriate phases and function to be tested.

Set the current and voltage phase angles per Table PT-II.

The recommended test currents for this test are given in Table PT-IV.

TABLE PT-IV

$I_N = 5$ ZRT or "r"(Ω)	I_{TEST}(amps)
0.2 - 2.5	10
1 - 6	10
6 - 12	5
12 - 20	3
20 - 25	2
25 - 50	1

$I_N = 1$ ZRT or "r"(Ω)	I_{TEST}(amps)
0.5 - 125	2
5 - 30	2
30 - 60	1
60 - 100	0.6
100 - 125	0.4
125 250	0.2

The nominal operating voltage for MT, at the angle of maximum reach, is given in Equation 8.

$$V_{NOM} = \frac{ZRT \times 2 \times I_{TEST}}{\sqrt{3}} \qquad (8)$$

WHERE:

V_{NOM} is the phase-to-ground pickup voltage
I_{TEST} is the test current
ZRT is the reach setting "r" times the multiplier setting "MULT" found on the front panel of the AFM133 module, Figure MO-4, found in location "S".

The applied three-phase voltage should be initially set to a value greater than the nominal operating voltage and the current should be increased slowly to the recommended test value. The voltage of the faulted phases should be slowly lowered, simultaneously, until the trace on the oscilloscope steps from LOW to HIGH. The actual operating voltage should be within the tolerances given in Table PT-I for the value of test current used.

To check the MT function at other angles, refer to the TYSTEST computer program provided in the SOFTWARE section of this manual.

MG1

Use the connections shown in Figure AT-6, for the appropriate phase and function to be tested.

Set the current and voltage phase angles per TABLE PT-V.

TABLE PT-V

Phase AN	I_{OP}	$-(\theta)^\circ$
Phase BN	I_{OP}	$-(\theta + 120)^\circ$
Phase CN	I_{OP}	$(120 - \theta)^\circ$
V_A		0°
V_B		-120°
V_C		$+120^\circ$

Where θ, the phase angle of I_{OP}, is determined by the following expression:

$$ZG = \left|r\right| \times \left[\left(\frac{2}{3}\right)\angle\phi Z_1 + \left(\frac{K_0}{3}\right)\angle\phi Z_0\right|$$

$$ZG = |ZG| \angle\theta \qquad (9)$$

WHERE:

ϕZ_1 is the positive-sequence impedance characteristic angle setting, found on the front panel of the ISM11(-) module, Figure MO-10
ϕZ_0 is the zero-sequence impedance characteristic angle setting, found on the front panel of the ISM11(-) module

"r" is the nameplate reach setting (located on the front panel of the AFM13(-) module, Figure MO-4, and found in location "Y") times the multiplier setting "MULT"

K_0 is the zero-sequence current compensation factor, found on the board of the AFM133 module, location "Y"

The nominal operating voltage for MG1, at the angle of maximum reach is given in Equation 10.

$$V_{NOM} = I_{TEST} \times |ZG| \qquad (10)$$

WHERE : V_{NOM} is the phase-to-ground pickup voltage

I_{TEST} is the test current

ZG is the reach as determined above (equation 9)

NOTE: The switch marked "II", mounted on the front panel of the VMM11(-) module, Figure MO-13, should be set to 1 (all switches to left) when testing the MG1 function.

The applied three-phase voltage should be initially set to a value greater than the nominal operating voltage and the current should be increased slowly to the recommended test value shown in Table PT-VI. The voltage of the faulted phase should be slowly lowered, until the trace on the oscilloscope steps from LOW to HIGH. The actual operating voltage should be within the tolerances given in TABLE PT-I for the value of test current used.

NOTE: The test currents indicated in Table PT-VI should only be used as guidelines. The maximum amount of test current that can be applied to obtain a favorable test result is determined by several factors, e.g. MG1 reach setting, K_0 setting, etc. Therefore, to make certain that the maximum allowable test current has not been exceeded, refer to the TYSTEST computer program furnished in the SOFTWARE section of this manual.

To check the MG1 function at other angles, refer to the TYSTEST computer program provided in the SOFTWARE section of this manual.

TABLE PT-VI

$I_N = 5$	
ZR1 or "r"(Ω)	I_{TEST}(amps)
0.1 - 2.5	10
1 - 6	10
6 - 12	5
12 - 20	3
20 - 25	2
25 - 50	1
$I_N = 1$	
ZR1 or "r"(Ω)	I_{TEST}(amps)
0.5 - 12.5	2
5 - 30	2
30 - 60	1
60 - 100	0.6
100 - 125	0.4
125 - 250	0.2

MTG

Use the connections shown in Figure AT-6, for the appropriate phase and function to be tested.

Set the current and voltage phase angles per TABLE PT-V, where θ, the phase angle of I_{OP}, is determined by the following expression:

$$ZG = \left|r\right| \times \left|\left(\frac{2}{3}\right)\angle\phi Z_1 + \left(\frac{K_0}{3}\right)\angle\phi Z_0\right|$$

$$ZG = |ZG| \angle\theta \qquad (11)$$

WHERE:

ϕZ_1 is the positive-sequence impedance characteristic angle setting, found on the front panel of the ISM11(-) module, Figure MO-10

ϕZ_0 is the zero-sequence impedance characteristic angle setting, found on the front panel of the ISM11(-) module

"r" is the nameplate reach setting, (located on the front panel of the AFM133 module,

Figure MO-5, found in location "S") times the multiplier setting "MULT"
K_0 is the zero-sequence current compensation factor, found on the board of the AFM133 module, location "S"

The nominal operating voltage for MTG, at the angle of maximum reach, is given in Equation 12.

$$V_{NOM} = I_{TEST} \times |ZG| \qquad (12)$$

WHERE:
V_{NOM} is the phase-to-ground pickup voltage
I_{TEST} is the test current
ZG is the reach as determined above (Equation 11)

The applied three-phase voltage should be initially set to a value greater than the nominal operating voltage and the current should be increased slowly to the recommended test value shown in Table PT-VII. The voltage of the faulted phase should be slowly lowered, until the trace on the oscilloscope steps from LOW to HIGH. The actual operating voltage should be within the tolerances given in TABLE PT-I for the value of test current used.

TABLE PT-VII

$I_N = 5$ ZRT or "r"(Ω)	I_{TEST}(amps)
0.1 - 2.5	10
1 - 6	10
6 - 12	5
12 - 20	3
20 - 25	2
25 - 50	1

$I_N = 1$ ZRT or "r"(Ω)	I_{TEST}(amps)
0.5 - 12.5	2
5 - 30	2
30 - 60	1
60 - 100	0.6
100 - 125	0.4
125 - 250	0.2

<u>NOTE</u>: The test currents indicated in Table PT-VII should only be used as guidelines. The maximum amount of test current that can be applied to obtain a favorable test result is determined by several factors, e.g. MTG reach setting, K_0 setting, etc. Therefore, to make certain that the maximum allowable test current has not been exceeded, refer to the TYSTEST computer program furnished in the SOFTWARE section of this manual.

To check the MTG function at other angles, refer to the TYSTEST computer program provided in the SOFTWARE section of this manual.

MB

Use the connections shown in Figure AT-3 for the appropriate phase to be tested.

Set the current and voltage phase angles per Table PT-VIII.

TABLE PT-VIII

Phase A I_{OP}	Lead by	$360 - (\theta B + 180)°$
Phase B I_{OP}	Lag by	$120 - [360 - (\theta B + 180)]°$
Phase C I_{OP}	Lead by	$[360 - (\theta B + 180)] + 120°$
V_A		0°
V_B		-120°
V_C		+120°

Where θB, the phase angle of I_{OP}, is determined by the following expression:

$$ZB = \left(\frac{r}{1-K_v}\right)\times\left|\left(1+\frac{0.1\times K_v}{3}\right)\angle\phi Z_1+\left(\frac{K}{3}\right)\angle\phi Z_0\right|$$

$$ZB = |ZB| \angle \theta B \qquad (13)$$

WHERE:
ϕZ_1 is the positive-sequence impedance characteristic angle setting, found on the front panel of the ISM11(-) module, Figure MO-10.
ϕZ_0 is the zero-sequence impedance characteristic angle setting, found on the front panel of the ISM11(-) module.

"r" is the nameplate reach setting located on the front panel of the ABM11(-) module, Figure MO-2.
K is the zero-sequence current compensation factor, found on the board of the ABM11(-) module.
K_V is the positive-sequence voltage compensation factor, found on the board of the ABM11(-) module.

The nominal operating voltage for MB, at the angle of maximum reach in the blocking direction (θB + 180°), is given in Equation 14.

$$V_{NOM} = I_{TEST} \times |ZB| \quad (14)$$

WHERE:
V_{NOM} is the phase-to-ground pickup voltage
I_{TEST} is the test current
ZB is the reach in the blocking direction, as determined above (Equation 13)

Set voltage VA, VB and VC to 67 volts rms. Set the current to the value shown in Table PT-IV. Simultaneously reduce the three-phase voltage, and check that the appropriate pin on the card extender goes from LOW to HIGH. The actual operating voltage should be within the tolerances given in Table PT-I for the value of test current used.

NOTE: The test currents indicated in Table PT-IV should only be used as guidelines. The maximum amount of test current that can be applied to obtain a favorable test result is determined by several factors, e.g. MB reach setting, K setting, K_V setting, etc. Therefore, to make certain that the maximum allowable test current has not been exceeded, refer to the TYSTEST computer program furnished in the SOFTWARE section of this manual.

To check the MB function at other angles, refer to the TYSTEST computer program provided in the SOFTWARE section of this manual.

MOB

The MOB function can be tested with specific settings for a particular application by the same method as specified under ACCEPTANCE TESTING. To determine the required values for Table AT-XIV, refer to the TYSTEST computer program provided in the SOFTWARE section of this manual.

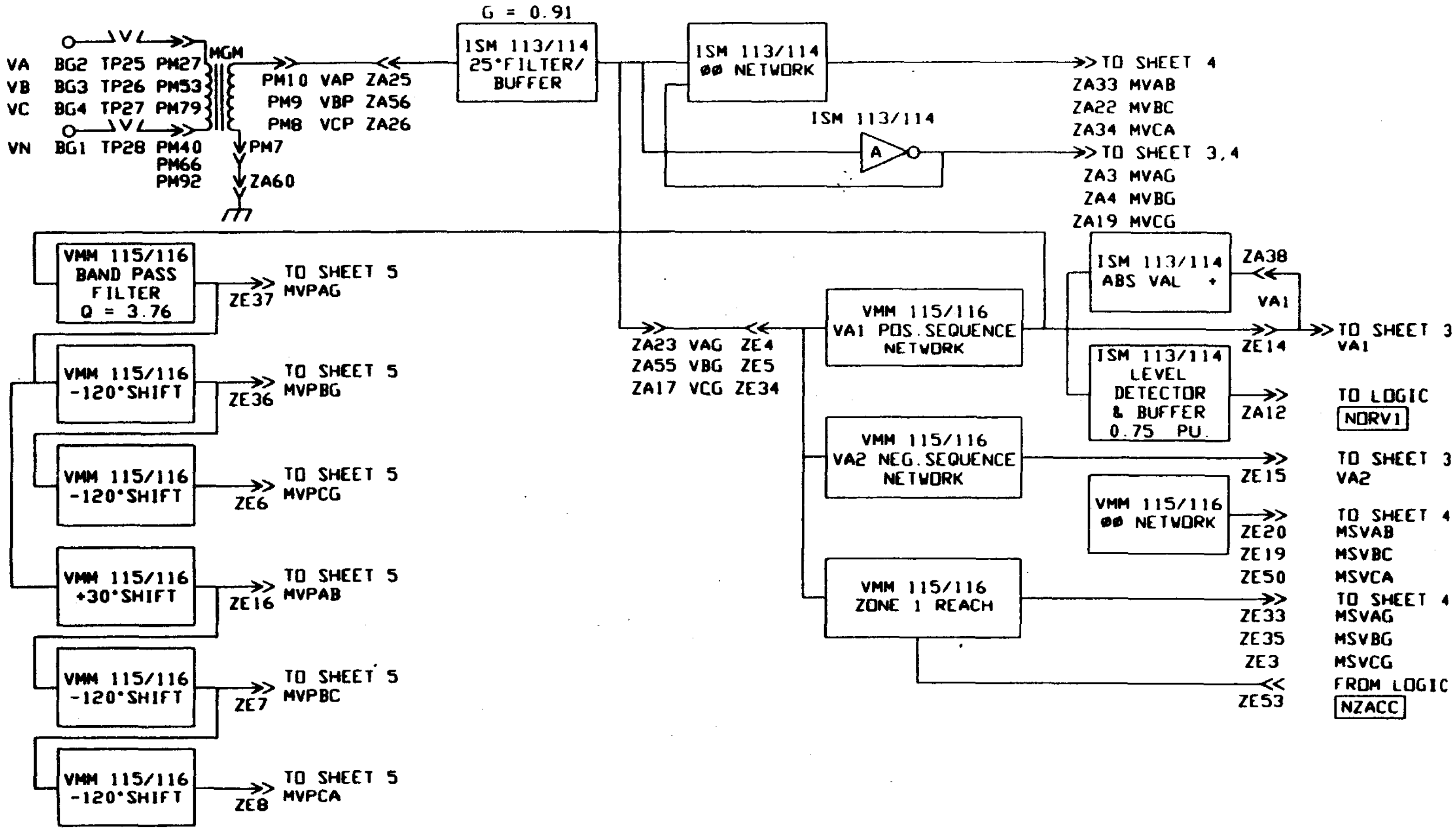


Figure SE-1 (0215B8420 Sh.1) Measuring Functions Block Diagram

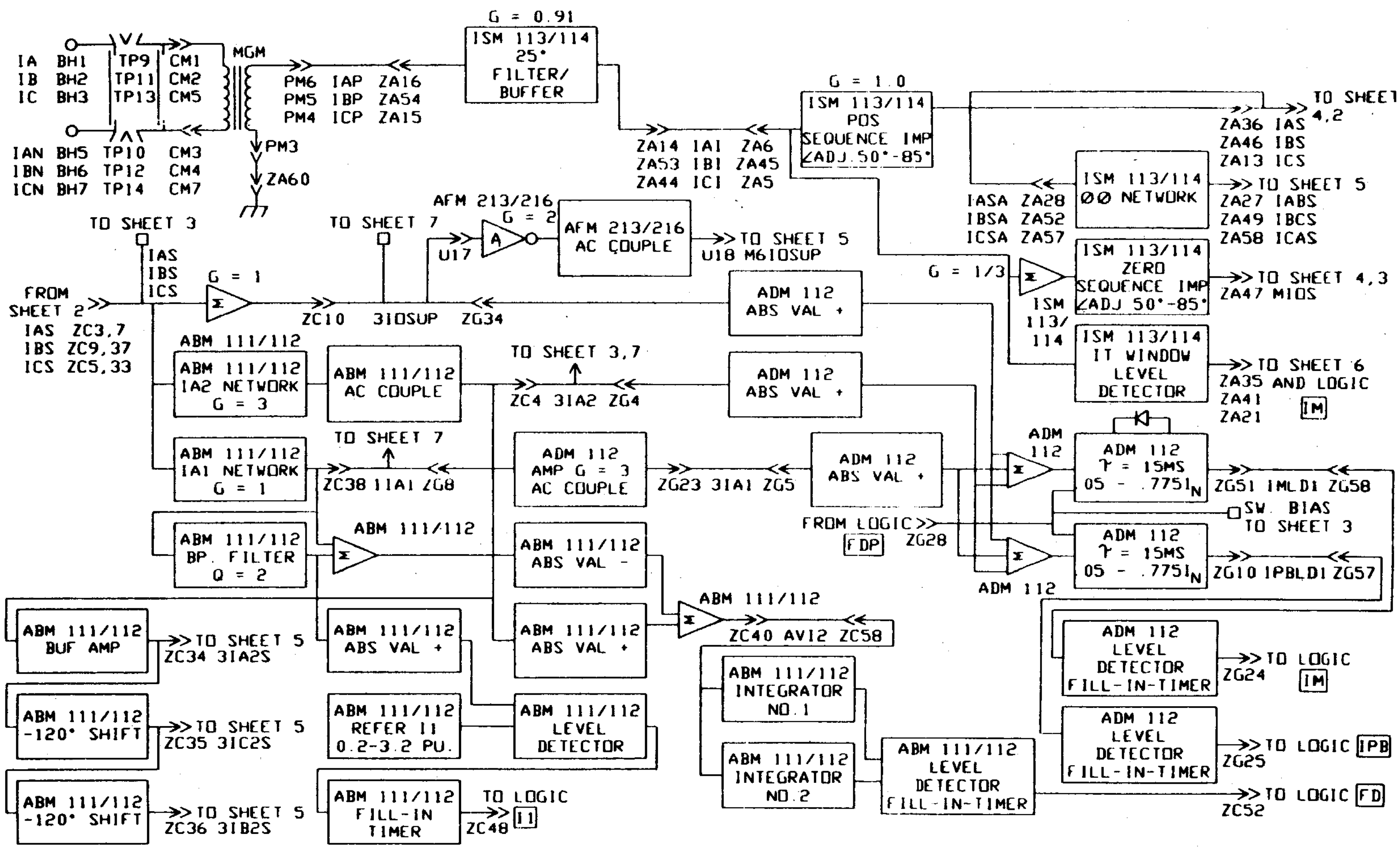


Figure SE-1 (0215B8420 Sh.2) Measuring Functions Block Diagram

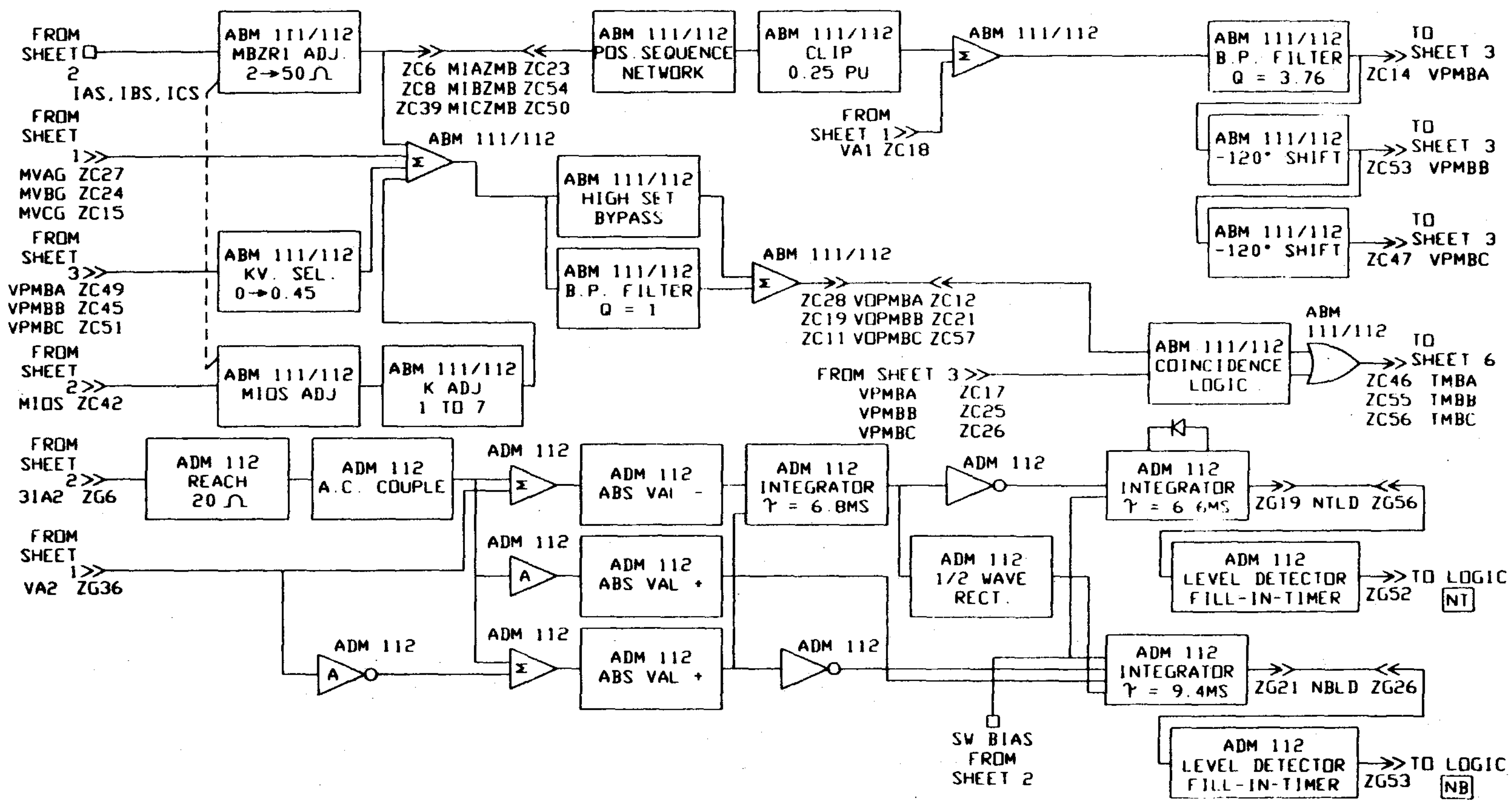


Figure SE-1 (0215B8420 Sh.3) Measuring Functions Block Diagram

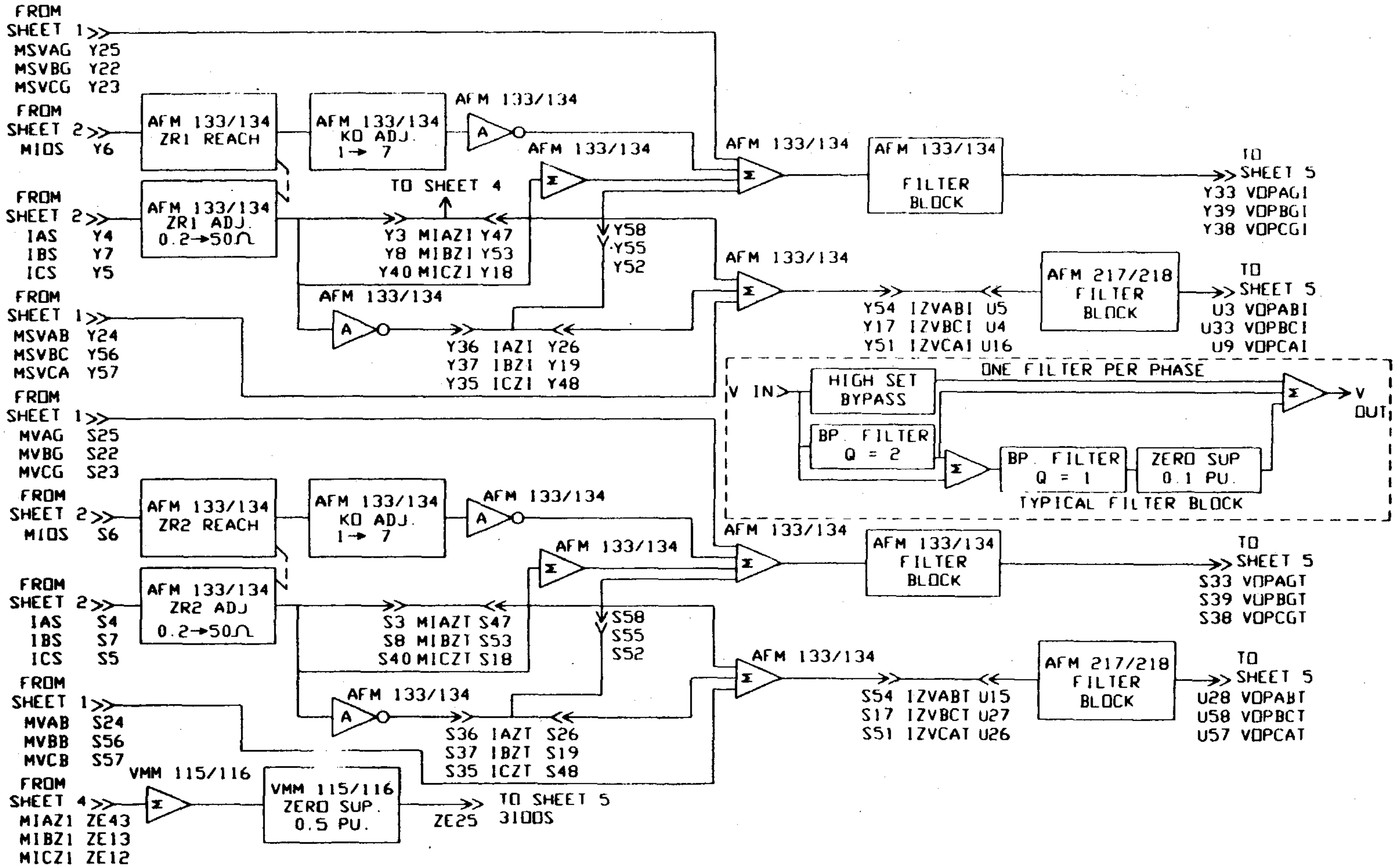


Figure SE-1 (0215B8420 Sh.4) Measuring Functions Block Diagram

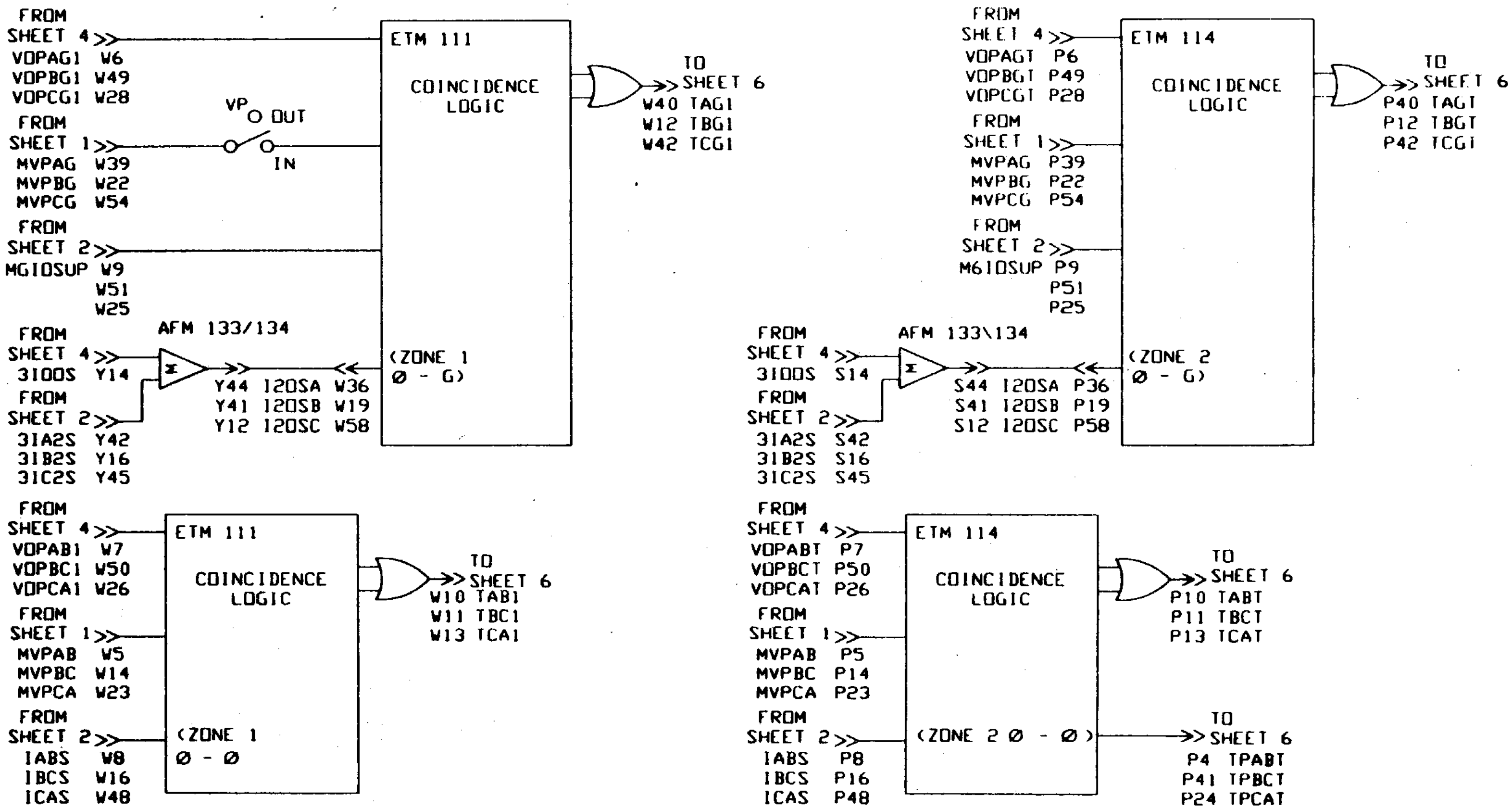


Figure SE-1 (0215B8420 Sh.5) Measuring Functions Block Diagram

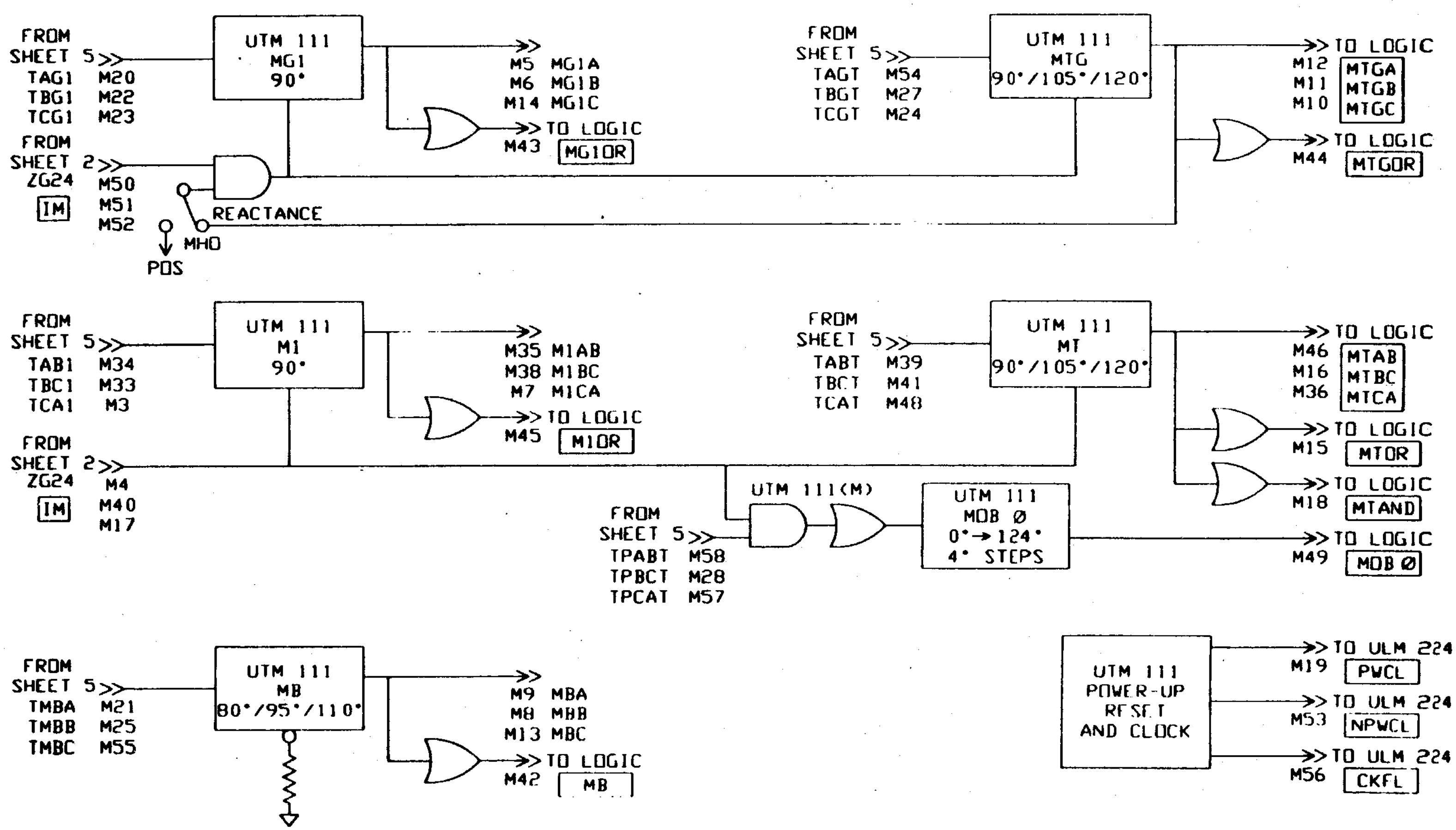


Figure SE-1 (0215B8420 Sh.6) Measuring Functions Block Diagram

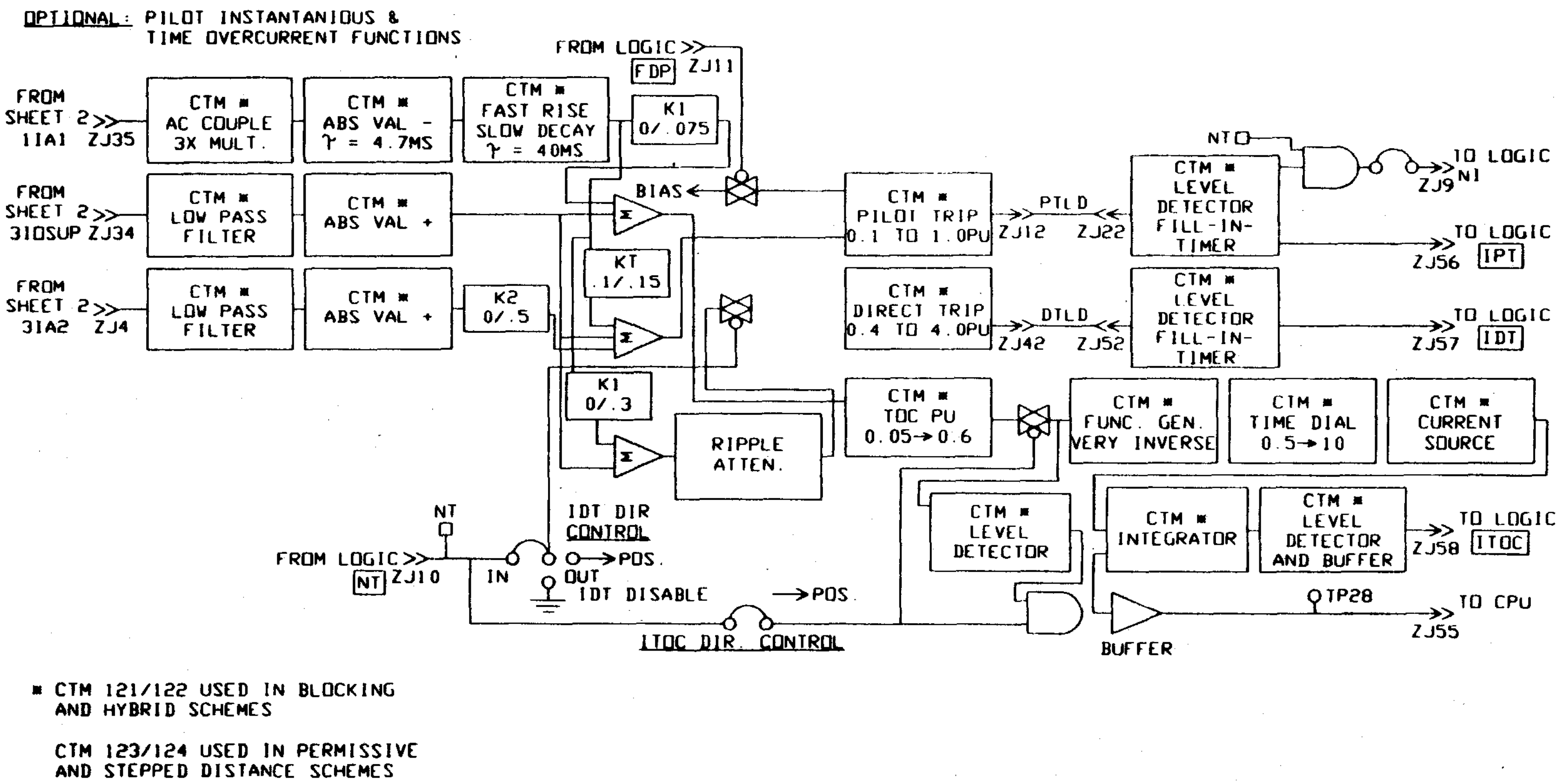


Figure SE-1 (0215B8420 Sh.7) Measuring Functions Block Diagram

CONTACT DATA

Trip Outputs	Continuous rating = 3 amperes Make and carry for tripping duty: (per ANSI C37.90) = 30 amps Break 180 VA resistive at 125/250 VDC Break 60 VA inductive at 125/250 VDC
Thyristor Outputs	Same as trip contacts except no interrupting rating
Auxiliary Outputs (including Alarms)	Continuous rating = 3 amperes Make and carry for 30 seconds = 5 amperes Break 25 watts inductive at 125/250 VDC Make and Carry continuously 50 watts Maximum of 250 volts or 0.5 ampere
DLA and Channel Control Contacts	10 watts 250 VDC maximum, 0.5 amp maximum

REACH-SETTING RANGES

TABLE P-I

FUNCTION	MEASURING UNIT	MULT	RANGE IN OHMS $I_N=5$	RANGE IN OHMS $I_N=1$	RESOLUTION $I_N=5$	RESOLUTION $I_N=1$
Zone 1	M1	0.1	0.2 to 5.0	1.0 to 5.0	0.02	0.1
	M1	0.25	0.5 to 12.5	2.5 to 62.5	0.05	0.25
	M1	1.0	2.0 to 50	10 to 250	0.2	1.0
Zone 2	MT	0.1	0.2 to 5.0	1.0 to 5.0	0.02	0.1
	MT	0.25	0.5 to 12.5	2.5 to 62.5	0.05	0.25
	MT	1.0	2.0 to 50	10 to 250	0.2	0.5
Blocking	MB		2.0 to 50	10 to 250	0.2	1.

REACH EXTENSION FACTOR

TABLE SP-II

FUNCTION	MEASURING UNIT	RANGE	RESOLUTION
Zone 1	M1	(1 - 10) × Zone 1	0.05

EXAMPLE:

For the phase pair A - B unit and:
$Z_{R1} = 3$
$RM = 1$
$X = 0.95; (1 - X) = 0.05$ (5% pull back)

$$I_A\text{-}I_B = \frac{(.905)}{(.05)(3)} = 6.03$$

For a phase - phase fault:
$I_A\text{-}I_B = 2I_A = 6.03$
$I_A = 3.015$

For a three-phase fault:
$I_A\text{-}I_B = \sqrt{3}\ I_A = 6.03$
$I_A = 3.48$

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

$$(I_\theta - I_0)\, Z_{R1} + I_0\, K_0\, Z_{R0} = \frac{(0.905)(RM)}{(1 - X)}$$

To use this formula, the ratio of I_0 to I_θ must be known or assumed.

WHERE:
I_θ is the phase current at relay
I_0 is the zero-sequence current at relay
Z_{R1} is the positive-sequence relay reach
Z_{R0} is the zero-sequence relay reach ($Z_{R1} = Z_{R0}$)
K_0 is the zero-sequence current compensation factor
RM is a design constant (see Table SP-VIII)
X is the actual reach / nominal reach

EXAMPLE:

$I_\theta = 3I_0$

$K_0 = 3$

$X = 0.95;\ (1 - X) = 0.05$ {5% pull back}

$\frac{2}{3}\, I_\theta Z_{R1} + I_\theta Z_{R1} = (18.1)(RM)$

If $Z_{R1} = 3$ and $RM = 1$, then

$\frac{5}{3}(I_\theta)(3) = 18.1$

$I_\theta = 3.62$ amps

DIMENSIONS

Height	14 inches (356 millimeters) 8 rack units
Width	19.1 inches (484 millimeters) Standard 19 inch rack
Depth	16 inches (406 millimeters)

WEIGHT

Standard rack-mounted unit weighs approximately 45 pounds (20 kilograms)