Application Note

1MAC104496-AP Rev A August 2015

PPMV – DA Application Solutions

Matching MCO and MMCO Protection Functions in Relion® Relays

Objective and Scope

This application note can be used whenever replacing legacy ABB MCO (single phase) and MMCO (three phase) phase microprocessor based relays with Relion® micro-processer based relays that have the programmable curve feature (i.e., REF615 ANSI relay). It describes the process for translating all over-current settings for each type of MCO/MMCO relay to Relion® within its specified ranges. For the MCO/MMCO relays this consists of tap (minimum pickup current), time dial and instantaneous trip (IT) settings. The Relion® settings include nominal CT *Secondary current, Curve parameters*, *Pickup value*, *Time multiplier*, *Trip delay time*, and *Operating curve type* (always 'programmable'). The values for the Relion® programmable curve parameters are based on characteristics defined in the test object library of Omicron® Test Universe 3.00 [2]. For MCO/MMCO time dials settings greater than 15 the parameters for the near equivalent CO/COM curves from the Omicron® test object library were re-used with a correction factor applied to the Time Multiplier setting to overcome the setting range limitation of the REF615. The only exception being the CO-5 relay since curve parameter 'B' was out of range in the Relion® relay. In this case the curve parameters were determined using the Curvegen tool in the ABB WinECP setting software.

Contact customer support regarding any of the following:

- To fine tune curves
- Request graphical curve comparisons
- Determine parameters for inverse reset curves (upstream relays with no immediate reset capability, typically electro-mechanical relays)
- IT setting is above 200A (additional settings and logic required)

Matching the Curve Type and Time Dial

The inverse time over-current curve characteristics for each type of MCO/MMCO relay was closely approximated using the 'Programmable*' Operating curve type* selectable setting in the 51P-1 function of the REF615 relay. The *Curve parameters* setting values (A, B, C and E) in Table 1 (time dial ≤ 15) and Table 2 (15 < time dial ≤ 63) define the characteristics of the programmable curves in accordance with the following equation:

$$t[s] = \left(\frac{A}{\left(\frac{I}{I>}\right)^{c} - E} + B \right) \cdot k \qquad (1)$$

I> Measured current
I set *Pickup value*
k set *Time multiplier*

For time dial settings less than or equal to 15 the MCO/MMCO time dial setting can be matched directly in the REF615 by substituting the values into the *Time Multiplier* setting 'k' of equation. For time dial settings greater than 15 and less than or equal to 63, the time dial setting is divided by a correction factor (5.5) to match the Time Multiplier (equation 2).

$$Time\ Multiplier_{REF615} = \frac{Time\ Dial}{Correction\ factor} \qquad (2)$$

where,

Correction factor = 1 (Time Dial ≤ 15)
Correction factor =5.5 (15 < Time Dial ≤ 63)

Table 1: REF615 ANSI curve parameters for MCO/MMCO type relays (Time Dial ≤ 15)

Relay Type	Curve Parameters			
	A	B	C	E
MCO/MMCO-2	0.0310	0.0050	1.00	0.7
MCO/MMCO-5	0.5740	0.3420	1.00	1.1
MCO/MMCO-6	0.0280	0.0330	1.00	1.2
MCO/MMCO-7	0.1300	0.0220	1.00	0.8
MCO/MMCO-8	0.1720	0.0200	1.00	1.3
MCO/MMCO-9	0.1150	0.0130	1.00	1.4
MCO/MMCO-11	0.8820	0.0050	2.00	1.0

Table 2: REF615 ANSI curve parameters for MCO/MMCO type relays (15 <Time Dial ≤ 63)

Relay Type	Curve Parameters			
	A	B	C	E
MCO/MMCO-2	0.1052	0.0262	0.80	1.0
MCO/MMCO-5	1.32	0.5672	0.31	1.0
MCO/MMCO-6	0.3164	0.1934	1.40	1.0
MCO/MMCO-7	0.0094	0.0366	0.02	1.0
MCO/MMCO-8	5.8480	0.1654	2.00	1.0
MCO/MMCO-9	4.1200	0.0958	2.00	1.0
MCO/MMCO-11	5.5700	0.0280	2.00	1.0

Matching the Tap and Instantaneous Trip

A relay tap setting value equal to or greater than 0.25 can be divided by the nominal CT *Secondary current* setting (1 or 5 A) to match the *Pickup value* of the 51P-1 function in the REF615 (equation 2). For tap values less than 0.25A the *Secondary current* setting must be 1A. In this case the tap value would be equal to the *Pickup value*.

Instantaneous trip setting values (≤ 200 A) can also be divided by the nominal CT *Secondary current* to match the *Pickup value* of the 50P-1/2/3 functions in the REF615 (equation 3). However, if the *Secondary current* setting is 1A then the maximum instantaneous unit trip setting value that can be matched is 40A. For Instantaneous trip values exceeding 200A a *Pickup value mult* setting along with additional logic are required. Contact customer support if needed.

$$Pickup\ value_{REF615} = \frac{Tap\ setting}{I_n} \qquad (3)$$

$$Pickup\ value_{REF615} = \frac{Inst\ trip\ setting}{I_n} \qquad (4)$$

where,

$I_n = Secondary\ current\ setting$ (1 or 5 A) $_{REF615}$

$I_n = 1A\ ; Tap\ setting < 0.25A$

$I_n = 5A\ ; Tap\ setting\ \geq 0.25A$ (Typical)

Example 1 (Typical)

For this example, the protection functions of a MCO/MMCO-11 relay (Time Dial = 15) will be matched in a REF615 ANSI relay. Curve data was derived theoretically from equation (1) using the parameters in Table I (curve 7) from Instruction Leaflet 41-120B. The tap setting and instantaneous trip unit settings were chosen at 4A and 40A respectively allowing a typical nominal CT *Secondary current* setting of 5A. The REF615 settings (Figures 1, 2 & 3) are determined as follows:

Operating Curve type and parameters:

Operating curve type = Programmable

From Table 1 (for MMCO-11 relay) the *Curve parameter* setting values are:

Curve parameter A = 0.8820
Curve parameter B = 0.0050
Curve parameter C = 2.00
Curve parameter E = 1.0

Refer to figure 4 for 5 for graphical comparison and percent deviation between REF615 and MMCO-11 curve.

Secondary current and Pickup value (Inverse time over-current):

From equation 3:

$$I_n = 5A\ ; Tap\ setting\ \geq 0.25A \quad \textit{(Tap setting =4A)}$$

$$Pickup\ value_{REF615} = \frac{Tap\ setting}{I_n} = \frac{4A}{5A} = 0.80$$

Time Multiplier:

Time multiplier setting = Time Dial = 15.00 (Correction factor = 1)

Pickup value (Instantaneous):

From equation 4:

$$Pickup\ value_{REF615} = \frac{Inst\ trip\ setting}{I_n} = \frac{40A}{5A} = 8.00$$

Trip delay time = 20 ms (Minimum setting)

Current (3I,CT)(Current (IA,IB,IC,CT)					
Current (IA,IB,IC,CT)					
Secondary current	(In)	5A			
Primary current		600.0	A	1.0	6000.0

Figure 1 – Analog input current (CT) settings for Example 1.

PHLPTOC1(51P-1): 1					
51P-1					
Operation		enable			
Num of pickup phases		1 out of 3			
Minimum trip time		20	ms	20	60000
Reset delay time		20	ms	0	60000
Measurement mode		DFT			
Curve parameter A		**0.8820**		0.0086	120.0000
Curve parameter B	**(Table 1)**	**0.0050**		0.0000	0.7120
Curve parameter C		2.00		0.02	2.00
Curve parameter D		29.10		0.46	30.00
Curve parameter E		1.0		0.0	1.0
Setting Group 1					
Pickup value	**(Equation 3)**	**0.80**	xIn	0.05	5.00
Pickup value mult		1.0		0.8	10.0
Time multiplier	**(Time Dial)**	**15.00**		0.05	15.00
Trip delay time		40	ms	40	200000
Operating curve type		**Programmable**			
Type of reset curve		Immediate			

Figure 2 – 51P-1 function protection settings (Inverse time over-current) for Example 1.

PHIPTOC1(50P-3): 1					
50P-3					
Operation		**enable**			
Num of pickup phases		1 out of 3			
Reset delay time		20	ms	0	60000
Setting Group 1					
Pickup value	**(Equation 4)**	**8.00**	xIn	1.00	40.00
Pickup value mult		1.0		0.8	10.0
Trip delay time	**(Inst trip time)**	20	ms	20	200000

Figure 3 – 50P-3 function protection settings (Instantaneous over-current) for Example 1.

(M)MCO Curve	Time Dial (D)
(M)MCO-11	15

REF615 Programmable Curve Coefficients - (M)MCO

A	B	C	E
0.8820	0.0050	2.00	1.0

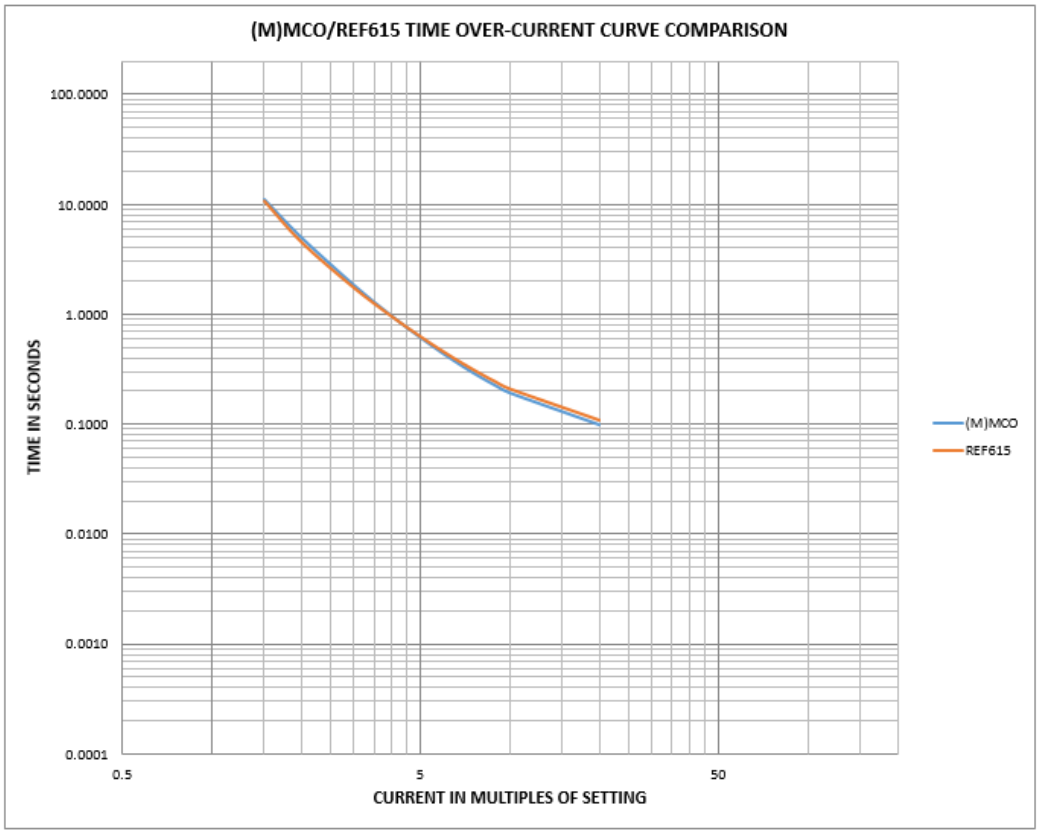

Figure 4 – Graphical comparison between MMCO-11 (Time Dial = 15) and REF615 programmable curve for Example 1.

PERCENT DEVIATION

CO(M) CURVE VS. EQUIVALENT REF615 PROGRAMMABLE CURVE

Multiples of Pickup	CO(M)	REF615	Δ
	Time (Seconds)		%
1.5	5.40	4.8263	10.62%
2	3.25	3.0842	5.10%
3	2.30	2.2382	2.69%
4	2.00	1.9710	1.45%
5	1.84	1.8441	-0.22%
6	1.75	1.7713	-1.22%
7	1.70	1.7248	-1.46%
8	1.65	1.6928	-2.38%
9	1.63	1.6696	-2.33%
10	1.62	1.6521	-2.29%
20	1.55	1.5860	-2.04%
40	1.53	1.5618	-1.83%

Figure 5 – Percent deviation between MMCO-11 (Time Dial = 15) and REF615 programmable curve for Example 1.

Example 2 (Typical)

For this example, the protection functions of a MCO/MMCO-11 relay (Time Dial = 63) will be matched in a REF615 ANSI relay. Curve data was derived theoretically from equation (1) using the parameters in Table I (curve 7) from Instruction Leaflet 41-120B. In this case *Curve parameters* from Table 2 (near equivalent CO/COM curves) were used to overcome the *Time Multiplier* range limitation in the REF615. The tap setting and instantaneous trip unit settings were chosen at 6A and 60A respectively allowing a typical nominal CT *Secondary current* setting of 5A. The REF615 settings (Figures 6, 7 & 8) are determined as follows:

Operating Curve type and parameters:

Operating curve type = Programmable

From Table 2 (for MMCO-11 relay) the *Curve parameter* setting values are:

Curve parameter A = 5.5700
Curve parameter B = 0.0280
Curve parameter C = 2.00
Curve parameter E = 1.0

Refer to figure 9 for 10 for graphical comparison and percent deviation between REF615 and MMCO-11 curve.

Secondary current and Pickup value (Inverse time over-current):

From equation 3:

$$I_n = 5A\ ;Tap\ setting\ \geq 0.25A \quad \textit{(Tap setting =6A)}$$

$$Pickup\ value_{REF615} = \frac{Tap\ setting}{I_n} = \frac{6A}{5A} = 1.20$$

Time Multiplier:

From equation 2:

Correction factor = 5.5; Time Dial > 15 (Time Dial = 63)

$$Time\ Multiplier_{REF615} = \frac{Time\ Dial}{Correction\ factor} = \frac{63}{5.5} = 11.45$$

Pickup value (Instantaneous):

From equation 4:

$$Pickup\ value_{REF615} = \frac{Inst\ trip\ setting}{I_n} = \frac{60A}{5A} = 12.00$$

Trip delay time = 20 ms (Minimum setting)

Current (3I,CT)(Current (IA,IB,IC,CT)					
Current (IA,IB,IC,CT)					
Secondary current	(In)	5A			
Primary current		600.0	A	1.0	6000.0

Figure 6 – Analog input current (CT) settings for Example 2.

PHLPTOC1(51P-1): 1					
51P-1					
Operation		enable			
Num of pickup phases		1 out of 3			
Minimum trip time		20	ms	20	60000
Reset delay time		20	ms	0	60000
Measurement mode		DFT			
Curve parameter A		**5.5700**		0.0086	120.0000
Curve parameter B	(Table 2)	**0.0280**		0.0000	0.7120
Curve parameter C		2.00		0.02	2.00
Curve parameter D		29.10		0.46	30.00
Curve parameter E		1.0		0.0	1.0
Setting Group 1					
Pickup value	(Equation 3)	**1.20**	xIn	0.05	5.00
Pickup value mult		1.0		0.8	10.0
Time multiplier	(Equation 2)	**11.45**		0.05	15.00
Trip delay time		40	ms	40	200000
Operating curve type		**Programmable**			
Type of reset curve		Immediate			

Figure 7 – 51P-1 function protection settings (Inverse time over-current) for Example 2.

PHIPTOC1(50P-3): 1					
50P-3					
Operation		**enable**			
Num of pickup phases		1 out of 3			
Reset delay time		20	ms	0	60000
Setting Group 1					
Pickup value	(Equation 4)	**12.00**	xIn	1.00	40.00
Pickup value mult		1.0		0.8	10.0
Trip delay time	(Inst trip time)	20	ms	20	200000

Figure 8 – 50P-3 function protection settings (Instantaneous over-current) for Example 2.

(M)MCO Curve	Time Dial (D)
(M)MCO-11	63

REF615 Programmable Curve Coefficients - (M)MCO			
A	B	C	E
5.5700	0.0280	2.00	1.0

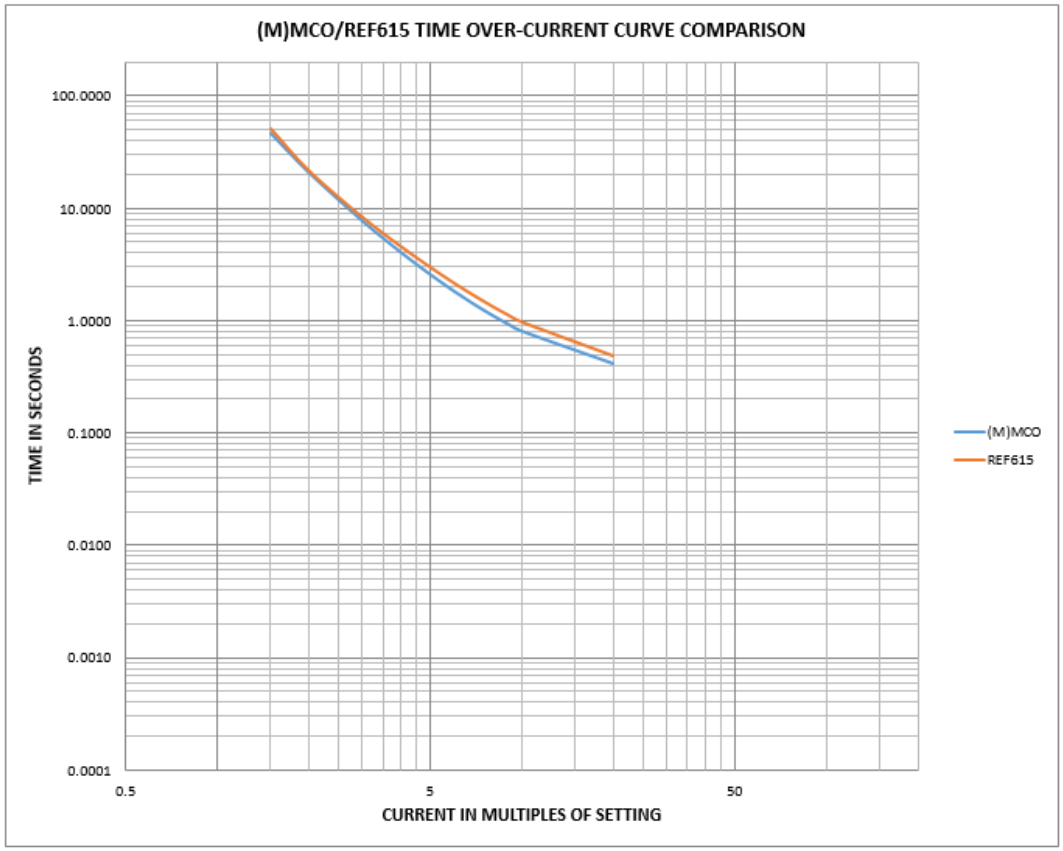

Figure 9 – Graphical comparison between MMCO-11 (Time Dial = 63) and REF615 programmable curve for Example 2.

PERCENT DEVIATION

(M)MCO CURVE VS. EQUIVALENT REF615 PROGRAMMABLE CURVE

Multiples of Pickup	(M)MCO	REF615	Δ
	Time (Seconds)		%
1.5	46.5938	51.0249	-9.51%
2	20.8688	21.5242	-3.14%
3	7.6976	8.2849	-7.63%
4	4.0688	4.5702	-12.32%
5	2.5754	2.9771	-15.60%
6	1.8195	2.1424	-17.75%
7	1.3847	1.6491	-19.09%
8	1.1120	1.3328	-19.86%
9	0.9296	1.1177	-20.23%
10	0.8018	0.9648	-20.32%
20	0.4105	0.4804	-17.03%

Figure 10 – Percent deviation between MMCO-11 (Time Dial = 63) and REF615 programmable curve for Example 2.

Reference list

/1/ Type MCO Microprocessor Overcurrent Relay Instruction Leaflet 41-120B

/2/ Omicron® Test Universe 3.00 Software -Test Object Library: MCO/MMCO curve parameters

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Revision A, 08/2015

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