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MSC Technical Note

Reduced Voltage Motor Starters
Pumps P4 and P5

Overview

This tech note concerns the reduced voltage motor starters installed in the motor control centers (MCC's) at a research laboratory facility, specifically cooling tower pumps P4 and P5.

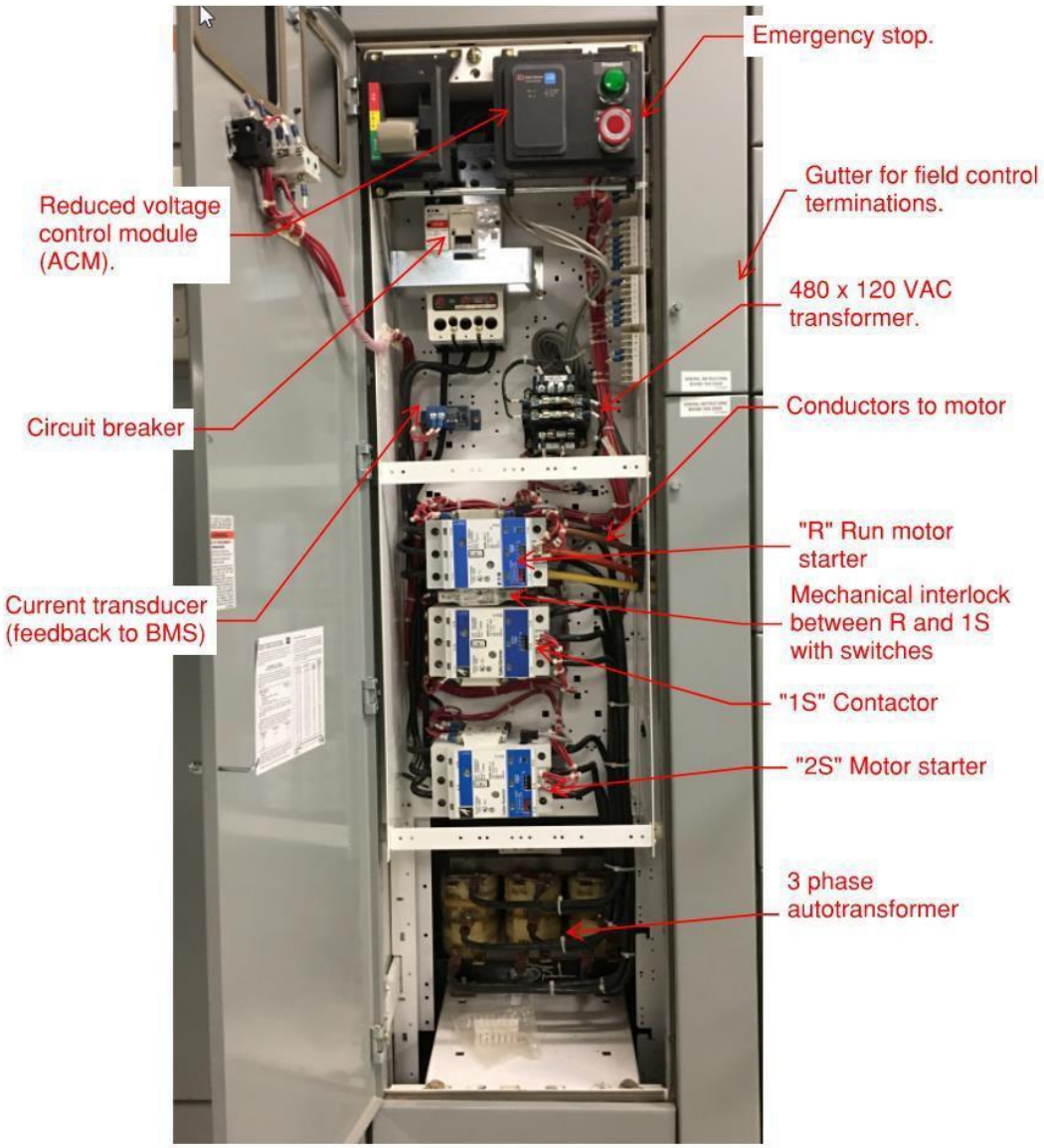
The complaint from the BAS contractor was that pump P5, when selected to run, would immediately trip on startup. The electrical contractor investigated and replaced one of the two motor starters; however, the pump continued to trip. We (MSC) meggar tested the 60 HP motor and found it to be in good electrical condition which directed our attention to the control side. The problem turned out to be incorrect dip switch settings on both motor starters and the control module (ACM).

Technical explanation

On this project, any motors 60 HP and larger, not controlled by a VFD, require reduced voltage starting to reduce inrush current and shock on the fan or pump. Reduced voltage starting can be accomplished by many methods. There are seven reduced voltage starting methods available on the Cutler Hammer (Eaton) MCC's but this Tech Note will focus on the *Autotransformer with two starters and one contactor (parallel)* method used on this project.

As can be seen on the attached wiring diagram and the photo in Fig. 1, there are two 3-pole motor starters and one 3-pole contactor installed in the bucket along with the reduced voltage control module and the autotransformer (down low in the bucket). The two starters and the control module each have dip switches that have to be set to allow the system to function correctly.

Fig 1


Emergency stop.
Gutter for field control terminations.
Reduced voltage control module (ACM).
480 x 120 VAC transformer.
Circuit breaker
Conductors to motor
"R" Run motor starter
Current transducer (feedback to BMS)
Mechanical interlock between R and 1S with switches
"1S" Contactor
"2S" Motor starter
3 phase autotransformer

The dip switch settings for pumps P4 and P5 (both 60 HP, 460/3/60, 1.15 SF (service factor) motors) are as follows.

1. Motor starters (both starters are to be set the same).

   a. *Dip switch 8:*
   This sets the reset method. Set dip switch to 0 (down) for manual reset.

RESET METHOD	POSITION 8
MANUAL (Non-automatic. Wait 5 minutes)	0
AUTOMATIC (Reset time is based on protection class)	1

   b. *Dip switch settings #7 and #6:*
   These two dip switches set the overload class. Set dip switch #7 to 0 (down) and dip switch #6 to 1 (up). This sets the overload class to 20. Class 10 is typically used for artificially cooled motors (submersible pumps), Class 20 is used for general purpose applications and Class 30 is used for high inertia loads. The trip class means that at six (6) times the FLA of the motor, a class 20 device will trip in approximately 6-20 seconds.

OVERLOAD CLASS	POSITION 7	POSITION 6
10	0	0
20	0	1
30	1	0
NONE	1	1

   c. *Dip switches #5 through #1:*
   Dip switches #5 through #1 set the overload range used to protect the motor from overload. In this case, the motor has a full load amp (FLA) rating of 69 amps. The dip switch settings below correspond to an amp range of 66.6 – 73.2 amps for a motor with a 1.15-1.25 service factor. The dip switch numbers are in descending order from left to right and are shown that way in the setting table

from the IOM cut and pasted below. In the photo above, note that dip switch #1 is just barely visible on the right.

i. DS-5 = 1
ii. DS-4 = 0
iii. DS-3 = 1
iv. DS-2 = 0
v. DS-1 = 0

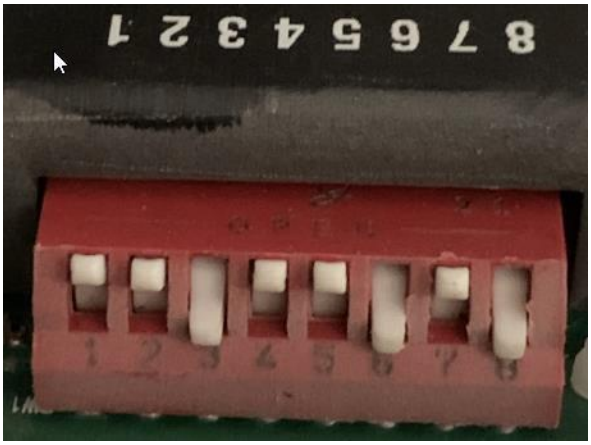
TABLE V - SIZE 4 CURRENT RANGE

Column A Service Factor 1.15 to 1.25 Min.		Max.	Column B Service Factor 1.0 Min.		Max.	Trip Rating (Amps)	DIP Switch Setting* (Positions 54321)
9.9	-	10.8	10.8	-	11.7	12.4	00000
10.9	-	11.9	11.8	-	12.9	13.6	00001
12.0	-	13.1	13.0	-	14.2	15.0	00010
13.2	-	14.4	14.3	-	15.6	16.5	00011
14.5	-	15.8	15.7	-	17.2	18.1	00100
15.9	-	17.4	17.3	-	18.9	19.9	00101
17.5	-	19.2	19.0	-	20.9	21.9	00110
19.3	-	21.1	21.0	-	22.9	24.1	00111
21.2	-	23.2	23.0	-	25.2	26.5	01000
23.3	-	25.6	25.3	-	27.8	29.1	01001
25.7	-	28.1	27.9	-	30.6	32.1	01010
28.2	-	30.9	30.7	-	33.6	35.3	01011
31.0	-	34.1	33.7	-	37.0	38.8	01100
34.2	-	37.5	37.1	-	40.8	42.7	01101
37.6	-	41.3	40.9	-	44.9	47.0	01110
41.4	-	45.4	45.0	-	49.4	51.7	01111
45.5	-	50.0	49.5	-	54.3	56.9	10000
50.1	-	54.9	54.4	-	59.7	62.6	10001
55.0	-	60.5	59.8	-	65.7	68.8	10010
60.6	-	66.5	65.8	-	72.3	75.7	10011
66.6	-	73.2	72.4	-	79.6	83.3	10100
73.3	-	80.7	79.7	-	87.7	91.6	10101
80.8	-	88.7	87.8	-	96.4	101	10110
88.8	-	97.5	96.5	-	105	111	10111
97.6	-	106	106	-	116	122	11000
107	-	117	117	-	127	134	11001
118	-	129	128	-	135	147	11010
130	-	135		-		162	11011

*ALL SETTINGS NOT SHOWN ARE EQUIVALENT TO 00000

Replace the arc box cover securely after making selections.

2. ACM control module:
The ACM is the reduced voltage control module which controls when and how the transition from reduced voltage to full voltage occurs. This is set through a series of eight (8) dip switches labeled 1 through 8 on the back of the module. Care must be taken to ensure that the switches are set in the correct direction as the writing on the switch block is extremely small and the literature is a bit confusing.



WPONI Advantage controller dip switch settings (WPBRV1, reset button only)

Dip switch number	DS-1	DS-2	DS-3	DS-4	DS-5	DS-6	DS-7	DS-8
New setting	Open	Open	Closed	Open	Open	Closed	Open	Closed
New setting description	4 Seconds			Trans time strt-run	Time	Autotransformer with R and 2S in parallel		

a. *Dip switches #1, #2 and #3:*
The combination of these three switches sets the time duration for the transition from start to run. This time setting will be the selected time the motor runs in the start mode before the transition to run when dip switch #4 is open, or the maximum time allowed for transition from start to run when dip switch #4 is closed. The combination of open and closed for dip switches 1 through 3 respectively sets the timing for 4 seconds.

b. *Dip switch #4 and #5; Both set to open:*
The time setting set by dip switches 1, 2 and 3 will be the selected time the motor runs in the start mode before the transition to run when dip switch #4 is open, or the maximum time allowed for transition from start to run when dip switch #4 is closed. Dip switch #5 tells the controller to transition from start to run based on time (dip switch #5 open) or based on current (dip switch #5 closed).
Different combinations of the switch settings for dip switches #4 and #5 are described below.

i. *Dip switch #4 open with dip switch #5 open (time):*
Tells the controller to transition the motor from start to run based on time only at the expiration of the time period set by dip switches 1,2 and 3 above.

ii. *Dip switch #4 closed; dip switch #5 open (time):*
Tells the controller to trip if the transition has not occurred within the set time period.

iii. *Dip switch #4 open; switch #5 closed (current):*
Tells the controller to transition from start to run at the end of the time period regardless of the current draw. The transition may have occurred if

the motor amp draw dropped below the overload setting, but if not, it forces the transition from start to run at the end of the time period.

iv. *Dip switch #4 closed; dip switch #5 closed (current):*
Tells the controller to trip the motor controller if the transition from start to run hasn't completed (by current) within the time period set by dip switches 1,2, and 3.

c. *Dip switches #6, #7 and #8; set to closed, open, closed respectively:*
The setting of these three switches tells the reduced voltage controller, what type of reduced voltage starting it is controlling. There are seven possible selections to choose from (Wye/Delta, part winding start, etc.). Pumps P4 and P5 were supplied as autotransformer with two starters in parallel and one contactor. Other selections for different hardware are discussed in the Cutler Hammer (Eaton) literature and will not be discussed here.

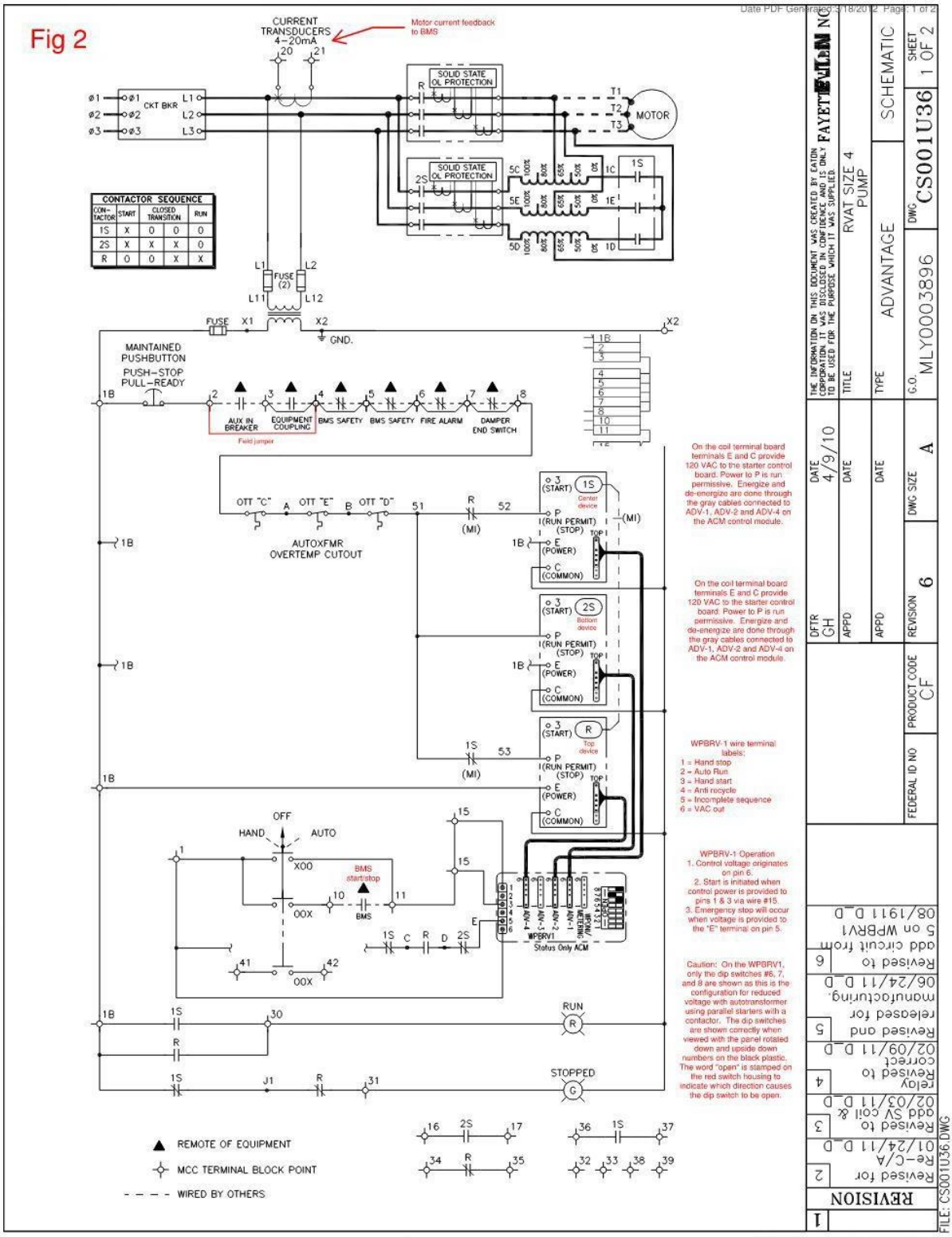
The sequence of operation is as described below. Refer to the wiring diagram shown in Fig 2 below and specifically the contactor sequence table.

1. The BMS provides an input command to the ACS (reduced voltage controller) by closing terminal 10 to terminal 11 which provides voltage to terminals #1 and #3 on the ACM.
2. Provided that no voltage is present on pin #5 (E) on the ACM, the ACM energizes 1S contactor and 2S motor starter and the delay timer starts. Motor overload protection is provided by the 2S motor starter.
3. The motor starts at a reduced voltage (65% of 460 VAC in this case) and a corresponding reduced amperage, progresses through inrush and begins to rotate as follows.
    a. With the 1S contactor closed, the autotransformer is connected in a Wye configuration.
    b. 65% of the voltage value travels to the motor from the 65% tap on the autotransformer.
    c. 35% of the voltage value travels through the remainder of the autotransformer and is dissipated as heat.
    d. The autotransformer is protected from overheating by embedded thermostats in each phase that are wired in series to interrupt control power to terminal 51 in the event of an overheating condition. These are labeled OTT-C, OTT-E and OTT-D on the control drawing. These are not visible when viewed from the front of the bucket.
4. At the expiration of the delay time period (in this case, 4 seconds), the ACM moves to the closed transition portion of the sequence. Note that the time required for transition from start through transition to run is quite fast but an exact time value is not in the literature. This is called closed transition (vs open transition) because power continues to flow to the motor to maintain rotation and avoid a reoccurrence of inrush current during the transition from start to run. During closed transition the following sequence occurs.

a. The 1S contactor is de-energized. This opens the common center point connection of the Wye connected autotransformer.
b. Starter 1S remains energized. Power flows from the 1S starter through the first 35% of the autotransformer windings to the motor. For this brief period of time, the 35% portion of the winding of the autotransformer is in effect an undersized conductor, but it supplies enough power to maintain rotation.
c. Starter R is energized. At this point, both starters 1S and R are energized in parallel and power is flowing to the motor through both paths (not equally).
d. The motor accelerates to full speed.

5. The ACM moves to the run stage of the process and the following occurs.
    a. Starter 1S is deenergized and supply power is removed from the autotransformer. Caution: voltage is still present on all autotransformer terminals when in run mode due to the permanent connection to the motor conductors
    b. The motor continues to run at full speed.
    c. Overload protection is provided by the Run motor starter.

Fig 2


Date PDF Generated: 3/18/2012 Page: 1 of 2
CURRENT TRANSDUCERS 4-20mA
Motor current feedback to BMS
CKT BKR
SOLID STATE OL PROTECTION
MOTOR
CONTACTOR SEQUENCE
FUSE (2)
MAINTAINED PUSHBUTTON
PUSH-STOP
PULL-READY
AUX IN BREAKER
EQUIPMENT COUPLING
BMS SAFETY
BMS SAFETY
FIRE ALARM
DAMPER END SWITCH
AUTOXFMR OVERTEMP CUTOUT
OFF
HAND
AUTO
BMS start/stop
WPBRV1
Status Only ACM
RUN
STOPPED
REMOTE OF EQUIPMENT
MCC TERMINAL BLOCK POINT
WIRED BY OTHERS
On the coil terminal board terminals E and C provide 120 VAC to the starter control board. Power to P is run permissive. Energize and de-energize are done through the gray cables connected to ADV-1, ADV-2 and ADV-4 on the ACM control module.
On the coil terminal board terminals E and C provide 120 VAC to the starter control board. Power to P is run permissive. Energize and de-energize are done through the gray cables connected to ADV-1, ADV-2 and ADV-4 on the ACM control module.
WPBRV-1 wire terminal labels:
1 = Hand stop
2 = Auto Run
3 = Hand start
4 = Anti recycle
5 = Incomplete sequence
6 = VAC out
WPBRV-1 Operation
1. Control voltage originates on pin 6.
2. Start is initiated when control power is provided to pins 1 & 3 via wire #15.
3. Emergency stop will occur when voltage is provided to the "E" terminal on pin 5.
Caution: On the WPBRV1, only the dip switches #6, 7, and 8 are shown as this is the configuration for reduced voltage with autotransformer using parallel starters with a contactor. The dip switches are shown correctly when viewed with the panel rotated down and upside down numbers on the black plastic. The word "open" is stamped on the red switch housing to indicate which direction causes the dip switch to be open.
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TITLE
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SCHEMATIC
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G.O.
MLY0003896
DWG
CS001U36
SHEET
1 OF 2
DFTR GH
DATE 4/9/10
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DATE
DWG SIZE A
REVISION 6
PRODUCT CODE CF
FEDERAL ID NO
REVISION
1
2 Revised for Re-C/A 01/24/11 D_D
3 Revised to add SV coil & 02/03/11 D_D
4 Revised to relay 02/09/11 D_D
5 Revised and released for manufacturing. 06/24/11 D_D
6 Revised to add circuit from 5 on WPBRV1 08/19/11 D_D
FILE: CS001U36.DWG

Technical notes

1. If at any time, voltage is supplied to terminal #5 (E terminal), the ACM will immediately de-energize both starters and the contactor.
2. Starter R and contactor 1S are mechanically and electrically interlocked to prevent simultaneous operation.
3. The current transducer (connected to conductors #20 and #21) provides an analog signal to the BMS for reference only.
4. Conductors #41 and #42 which are connected to the Hand/Off/Auto switch, provide indication only to the BMS that the HOA switch is not in auto.
5. The wiring diagram included here is specific to pumps P4 and P5. Other loads 60 HP and above (not operated by a VFD) are also equipped for reduced voltage start (supply and exhaust fans). While these loads operate the same as P4 and P5 on the power side, additional devices are included on the control side. The correct wiring diagram number is listed on the nameplate in each bucket.
6. It is imperative that each starter and/or contactor be connected to the correct terminal on the ACM via the gray communication cable.

General notes

1. None

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