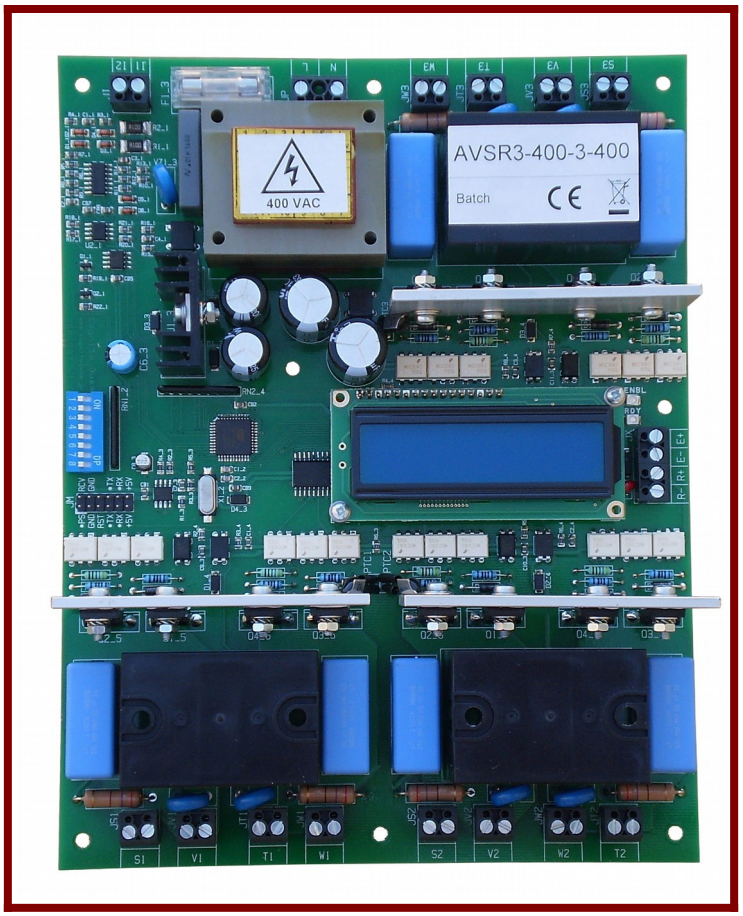
AVSR3
Triple Switch Autocalibrating Variable Step Regulator
v1.0



Installation and Operation Manual

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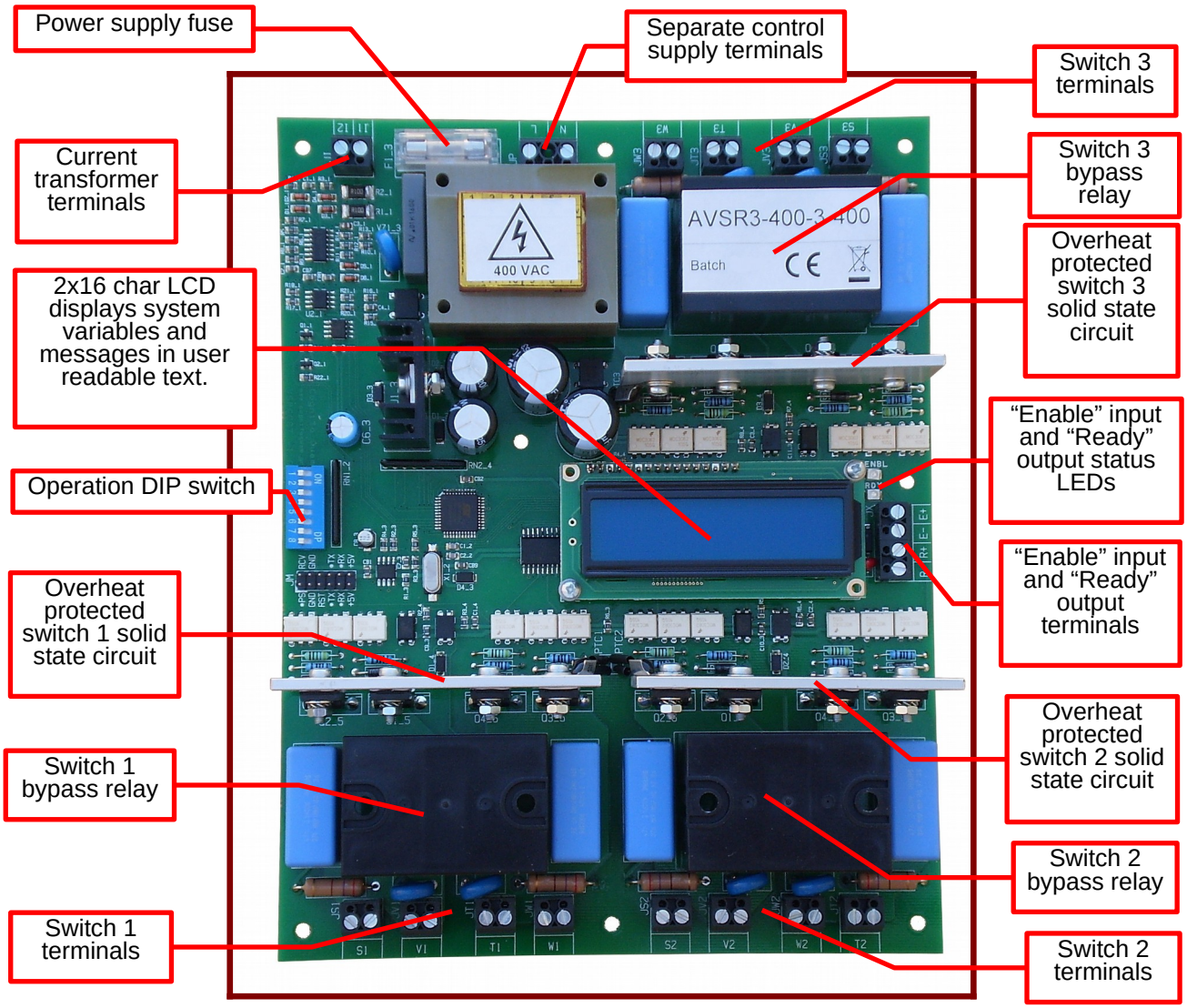
1. Introduction

This manual covers the installation and operation of the AVSR3 v1.0 triple switch autocalibrating variable step power factor regulator. Version 1 uses a LCD to display user-friedly text messages and introduces new external control modes via the “Enable” and “Ready” I/O (Input/Output) pair.

The AVSR3 employs variable step technology to compensate reactive current in up to seven steps. It features three 25 A solid state switches to connect three compensating capacitor banks in and out of the single- or three- phase line system. At installation no adjustments are required as each capacitor size is detected automatically making AVSR3 commissioning purely “wire-up-and-play”. The current is detected with a current transformer in one of the lines and the sampling period is selectable from 5 to 30 seconds.

The manual goes through the required installation steps after a technical overview.



The AVSR3 regulator

WARNING!

As the voltages involved are of a dangerous level, ALL connections must be made with the power OFF and by QUALIFIED personnel.

2. Overview

The AVSR3 is designed for most standard single- and three- phase line systems, 3x<25 Ar compensating operation. The characterizing features are as follows:

- **Variable compensating capacitance step** is any combination of the three driven banks, effectively realizing an up to 7 step system,
- **Autocalibration function** corrects all errors and detects the current transformer phase shift and each capacitor bank size. No other adjustment is needed,
- **Separate, galvanically isolated control supply** terminals can be connected directly to the line or a separate control power line,
- **Enabling bit I/O pair** allows for integration in a supervisory system or connection to an external master in a number of functional modes,
- **Current detection** by standard 5 A secondary current transformer (CT). The transformer phase shift is detected at autocalibration and, as such, the CT can be placed in any of the phase lines,
- **Current is measured** by detecting its phase and magnitude,
- **Zero crossing type solid state relays** ensure that each capacitor is switched in when the line voltage equals the capacitor voltage thus eliminating capacitor inrush current and extending capacitor service life,
- **Switch bypass relays** minimize solid state switch losses,
- **Overheat protected** solid state circuits switch each 25 A compensating capacitor in and out of the line at every sampling instant,
- **DIP switch selectable sampling time** of 5, 10, 20 and 30 seconds,
- **DIP switch selectable forced state** turns the switch on or off regardless of current value,
- **2x16 character LCD** shows system state, variable and error messages,
- **Isolated control circuit** enhances safety and noise immunity,
- **Protection** against line overvoltages, faults and power circuit overheating.

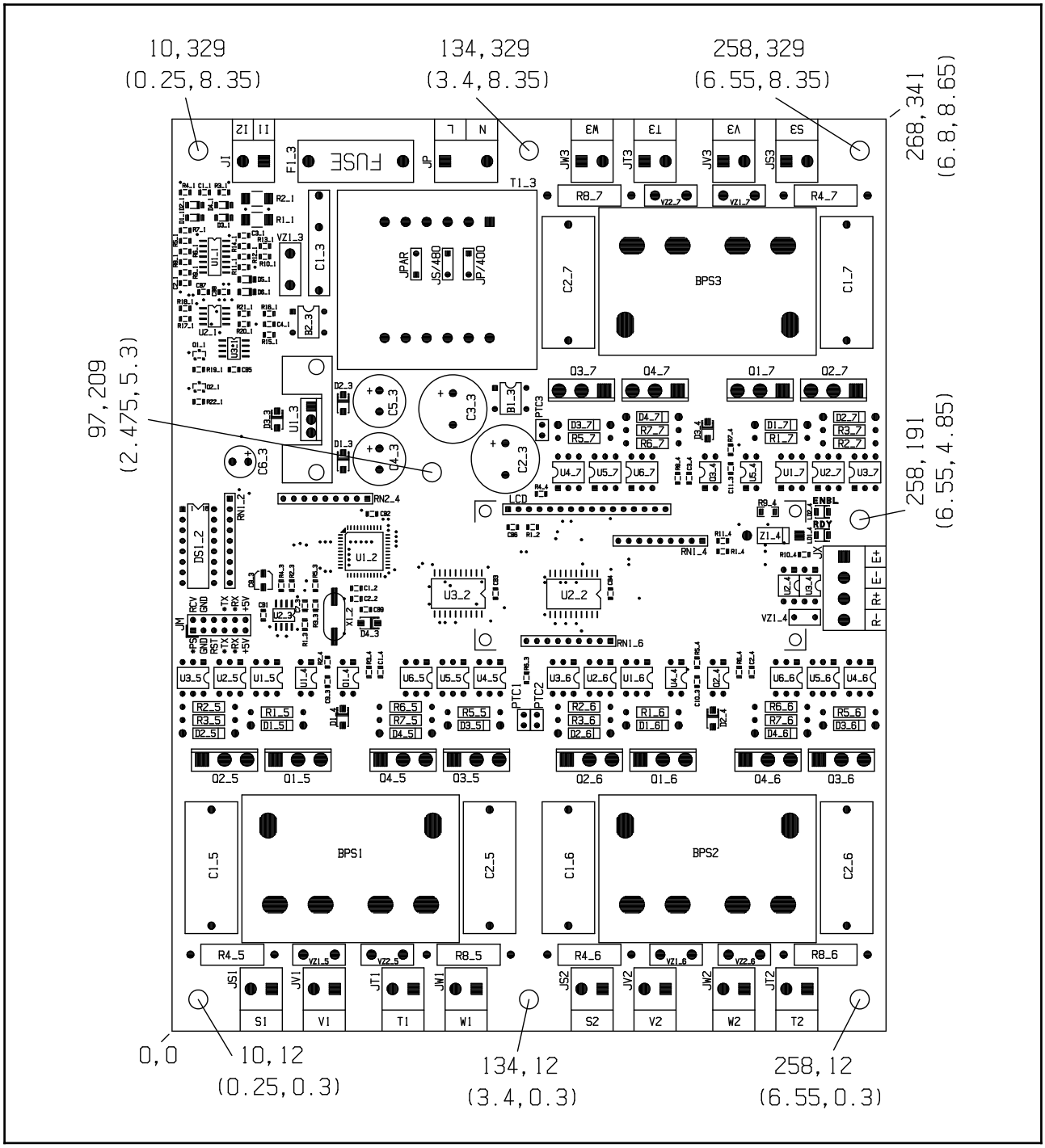
The table summarizes the maximum capacitor size which can be handled by each switch, “ccc” being the model control supply voltage:

AVSR3 Capacitor Sizes per Model			
Model	**Line System**	**Maximum Capacitor Size, KVAr**	**Recommended Capacitor Size, KVAr**
AVSR3-115-1-115	1x115 VAC, 50-60 Hz	2,8	2,5
AVSR3-ccc-1-230	1x230 VAC, 50-60 Hz	5,7	5,0
AVSR3-ccc-3-230	3x230 VAC, 50-60 Hz	9,9	7,5
AVSR3-ccc-3-400	3x400 VAC, 50-60 Hz	17,2	15,0
AVSR3-ccc-3-480	3x480 VAC, 50-60 Hz	20,7	15,0

The recommended capacitor size is the nearest standard size allowing for a minimum 10% safety and capacitor tolerance margin.

3. Mechanical dimensions and support

The AVSR3 board is designed to be mounted on a flat surface such as the back plate or the door inside of an electrical cabinet. The eight support holes are of 4 mm diameter.



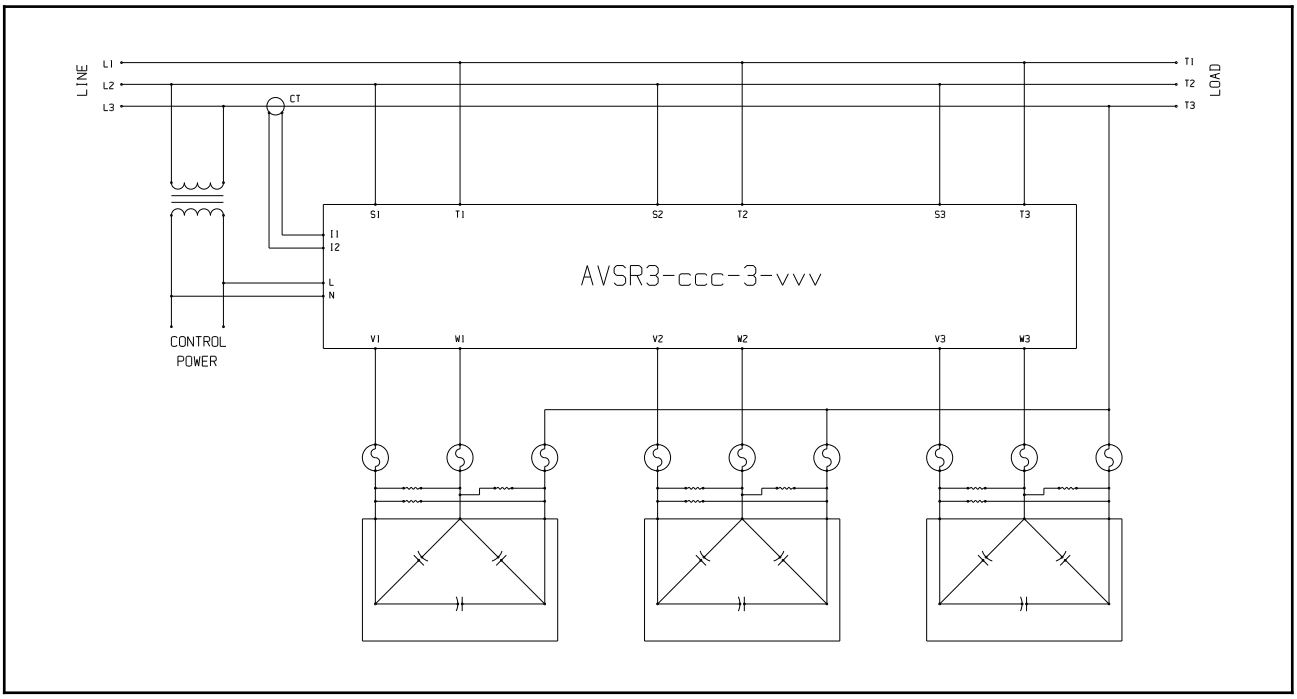
AVSR3 dimensions and support hole centers. Shown in millimeters and inches in parentheses.

4. Connection overview

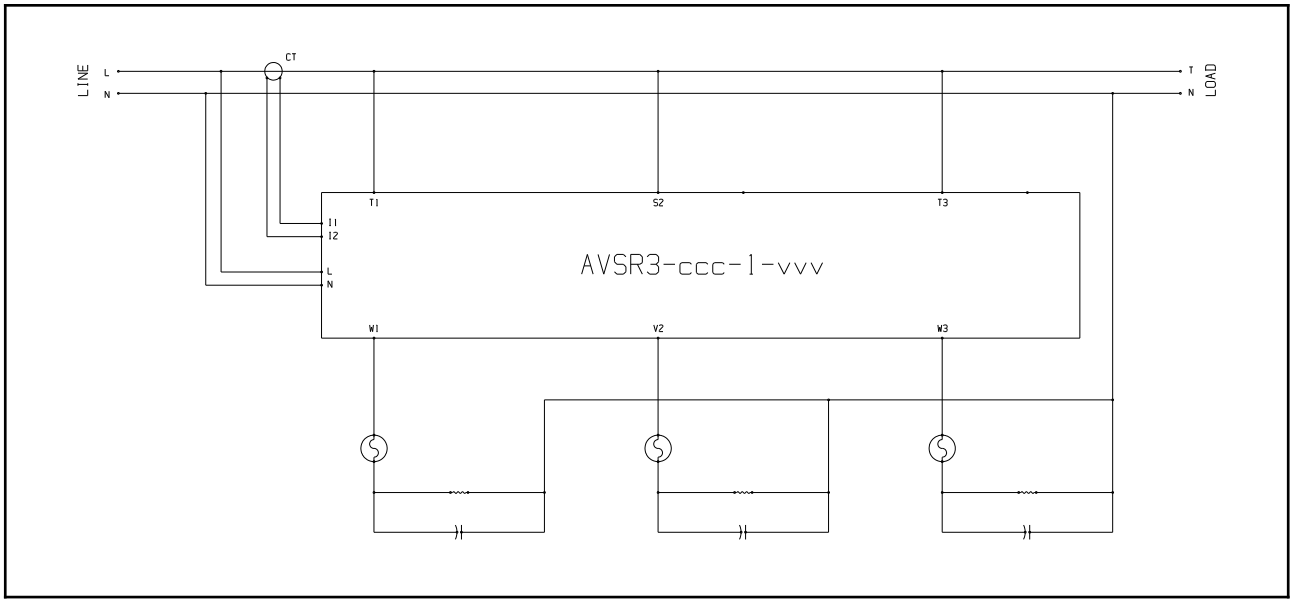
Each unit is connected at the line, output and control connections. The table summarizes the connections:

AVSR3 Connection Overview		
Single Phase Models, Position	**Three Phase Models, Position**	**Description**
T1	S1, T1	Switch 1 line voltage input, 2x16 A terminal.
S2	S2, T2	Switch 2 line voltage input, 2x16 A terminal.
T3	S3, T3	Switch 3 line voltage input, 2x16 A terminal.
I1, I2	I1, I2	Current transformer 5A secondary input.
W1	V1, W1	Compensating capacitor 1 input, 2x16 A terminal.
V2	V2, W2	Compensating capacitor 2 input, 2x16 A terminal.
W3	V3, W3	Compensating capacitor 3 input, 2x16 A terminal.
N, L	N, L	Control supply input.
E-, E+	E-, E+	Enable control input. 24 V/15 mA current sink type.
R-, R+	R-, R+	Ready control output. Uncommitted 35 V/20 mA optotransistor.

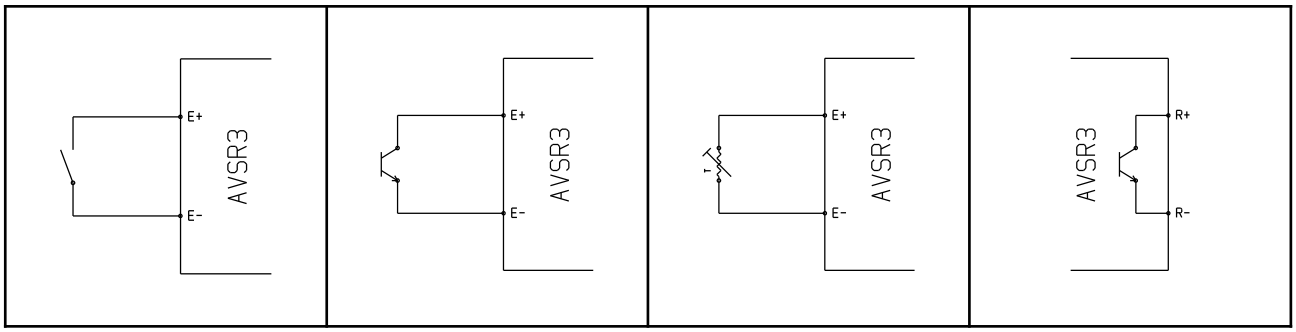
Larger than 10 A line and capacitor connections are effected by using two conductors at the respective twin terminals.



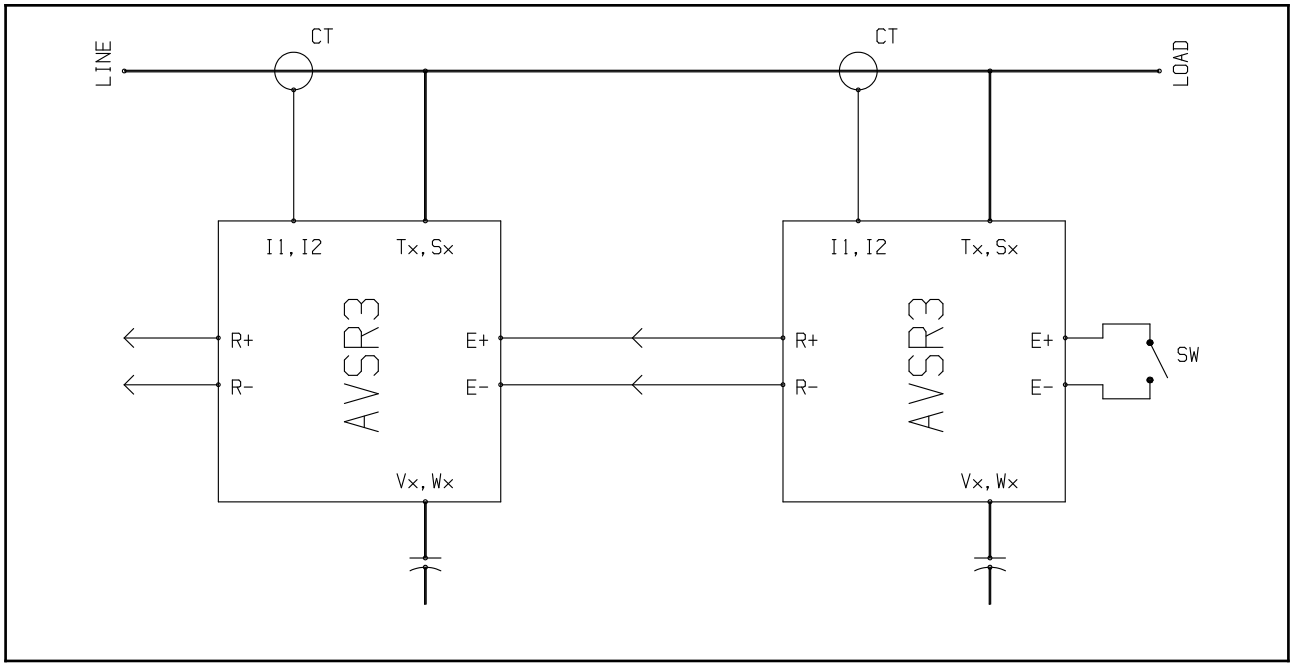
Typical three-phase power factor correction AVSR3 system. (Model number “ccc” refers to the AVSR3 control voltage and “vvv” to the installation line voltage). The AVSR3 is powered by a separate control supply, as provided by the shown isolation transformer. The current transformer (CT) phase shift is detected at autocalibration and can be placed in any phase line. In the presence of significant line harmonics, the capacitors must be protected by detuning chokes.



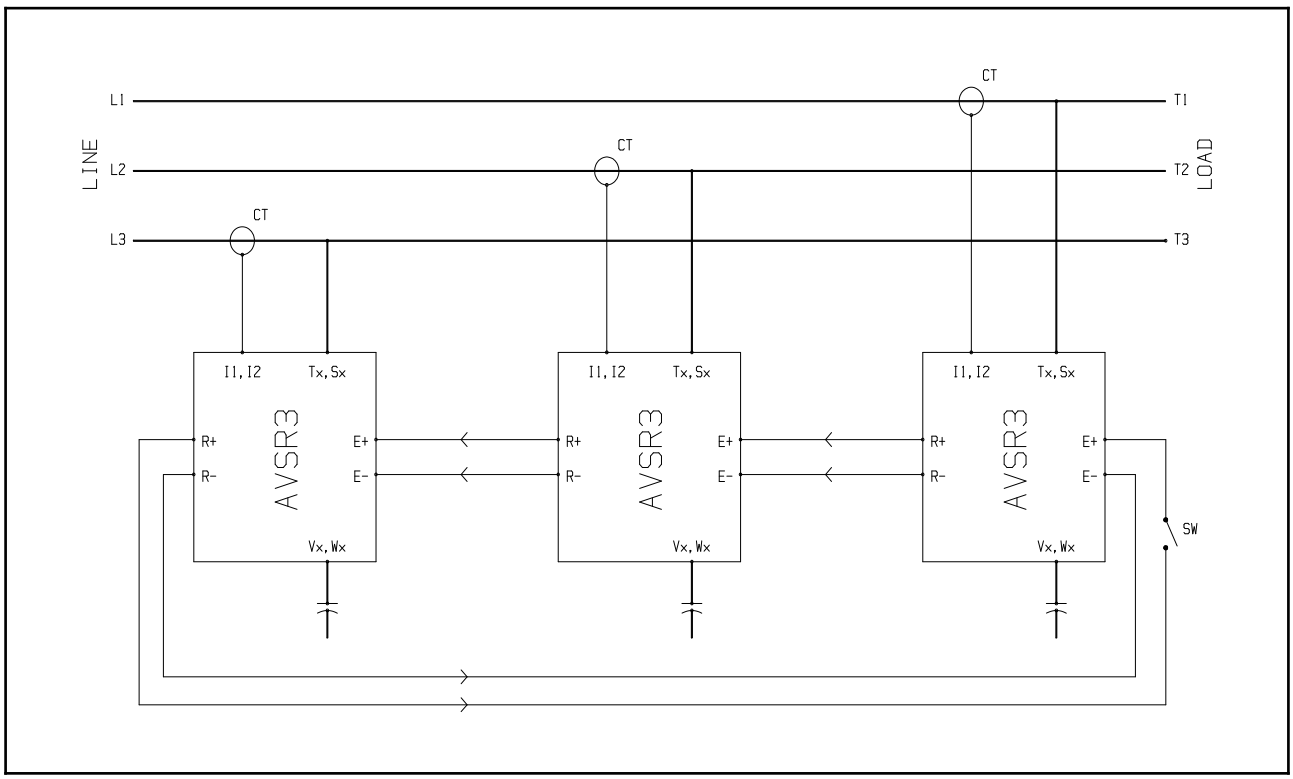
Typical single-phase power factor correction AVSR3 systems. (Model number “ccc” refers to the AVSR3 control voltage and “vvv” to the installation line voltage). In this example the AVSR3 is powered from the line. The current transformer (CT) phase shift is detected at autocalibration and can be placed in either the line or the neutral. In the presence of significant line harmonics, the capacitors must be protected by detuning chokes.



AVSR3 enable input connection (from left to right) to a switch or relay contacts, optotransistor and thermistor. The system is enabled with the switch closed or the optotransistor conducting current. The AVSR3 output (right) is an uncommitted optotransistor and is on when the system is ready (Standard I/O mode) or enabling the next connected AVSR3 (Tandem and Interlock modes) as set at DIP switch positions 5 and 8.



Tandem mode connection. Each AVSR3 detects its own capacitor bank contribution and enables the next unit when all its switches are on. The general enable switch SW enables the first unit nearest to the load.



Interlock mode connection. Three single phase AVSR3s controlling the individual phases in a three-phase system. While one unit switches a capacitor in/out, the others wait for the enabling signal to switch their capacitors on/off. The group is enabled/disabled via switch SW.

The control supply is protected by a 250 mA (AVSR3-115-x-xxx models) or 100 mA fuse.

5. Setting the DIP switch options

The AVSR3 operating parameters are selected by setting the positions at the DIP switch.

Position 1 activates the switches for testing purposes. The table summarizes the available options:

AVSR3 DIP switch forced activation setting	
Position 1	**Description**
OFF	Normal operation. The switches are activated as a result of normal operation.
ON	Forced activation state. All switches are activated regardless of other settings or operational conditions enabling power circuit testing.

Position 2 disables automatic CT phase handling for testing or using with regenerative lines. The table summarizes the available options:

AVSR3 DIP switch automatic CT phase setting	
Position 2	**Description**
OFF	Normal operation. An out-of-range CT phase current is automatically handled and corrected.
ON	An out-of-range CT phase current is handled as an error. Such an error is caused when the CT is inversely connected or in the presence of regenerative currents.

The measurement sampling period is selected by DIP switch positions 3 and 4:

AVSR3 DIP switch sampling period settings		
Position 3	**Position 4**	**Sampling period, s**
OFF	OFF	5
OFF	ON	10
ON	OFF	20
ON	ON	30

The measurement sampling period is chosen after considering the monitored process dynamics. For most practical purposes switching at 5 s taxes the bypass relays unnecessarily.

Position 5 selects the “Enable”-”Ready” pair alternative modes:

AVSR3 DIP switch“Enable”-”Ready” pair alternative mode setting	
Position 5	**Description**
OFF	Standard mode. The “Ready” control output is on during normal operation and is off during autocalibration and while the AVSR3 is in the Quiet state. The “Enable” input enables normal operation.
ON	Alternative modes set at Position 8.

Position 6 sets the autocalibration mode:

AVSR3 DIP switch autocalibration setting	
Position 6	**Description**
OFF	Normal operation.
ON	System autocalibration is enabled. Autocalibration starts after reenabling the system at position 7.

Position 7 enables system operation:

AVSR3 DIP switch enable setting	
Position 7	**Description**
OFF	System is enabled via the “Enable” control input.
ON	System is enabled regardless of the “Enable” control input state.

Position 8 selects one of the vailable alternative modes for the “Enable”-”Ready” I/O pair:

AVSR3 DIP switch“Enable”-”Ready” pair alternative modes	
Position 8	**Description**
OFF	Tandem mode. The “Ready” output is on when all switches are activated. The “Enable” input enables normal operation. Allows for the connection of two or more units in tandem, ie each “Ready” output driving the “Enable” input of the next unit to realize systems with more switches/capacitor banks. Group control is effected via the “Enable” input of the first unit.
ON	Interlock mode. The “Ready” output is off when the “Enable” input is off or while any of the switches changes state. Allows for systems using a weak common current return path (typically the neutral of a three phase line) to minimize line disturbances. The units sharing the common path (typically three single phase AVSR3s controlling the individual phases of a three phase load) are connected in a ring, ie each “Ready” output driving the “Enable” input of the next unit in the ring. Group control is effected via a series switch in one of the “Enable” inputs.

6. AVSR3 operation

The variable step technology provides for different capacitor banks of any size to correct power factor in practically any arbitrary minimum step and correction range size. At every sampling instant, the controller calculates the required compensation step and connects or disconnects a combination of banks whose sum is equal or closest to the calculated step value. In the AVSR3, three banks are used and, if sized as x1, x2 and x4 multiples of the smallest required step, provide seven steps of compensating operation.

Each capacitor bank size is autodetected during AVSR3 installation. The autocalibrating function detects all internal errors and offsets, measures the current transformer phase shift and the individual capacitor bank sizes. The measured parameters are then used during normal operation ensuring accurate, effective and dependable performance. Following autocalibration no other adjustment is required making AVSR3 installation quick and error-free.

On power up the AVSR3 displays the “Hello World!” message, checks the integrity and valid operational state of the various subsystems and waits to be enabled either by an external “Enable” control input or at DIP switch position 7.

While in normal operation, the AVSR3 reads the line period, the bit inputs, the current magnitude and phase and, after averaging them, calculates the reactive component. Following this and depending on the various parameter values the outputs are driven. Capacitor banks are always switched largest first and one at a time. Current measurement is suspended during bank switching to exclude any transient effects. Switch activation/deactivation happens at every sampling instant as set at the DIP switch between 5 and 30 s.

In the event of a power circuit overheating, the failing switch is deactivated until power is removed. This is done after a number of attempts over a period of time (see Operation parameters below) to ensure that the associated temperature sensor was not triggered by noise or other similar event. (Overheating is normally the result of switch bypass relay failure and in such a case the worn relay must be replaced).

In the case of an error or fault condition, the AVSR3 enters the idle state (banks are turned off) and displays the associated error message. The system recovers when the cause is removed or reboots in the case of unrecoverable errors. If the error condition persists or another one occurs, the AVSR3 will again display the associated error message and wait to recover or reboot depending on the error type.

In standard mode, the “Ready” control output signals normal operation to an external master and is off with any of the switches overheated and while the AVSR3 is in the Quiet state. Alternatively, in tandem mode the “Ready” output is on when all three banks are switched in and, as such, enable the next unit in line. In interlock mode, the “Ready” output goes off when the unit is disabled or at bank switch-overs. The “Enable” input in this mode allows for short disabling signals which in essense preserve switch state while another unit in the group is switching in or out a capacitor bank.

7. Displayed messages

During operation the AVSR3 display shows system variables, status messages and/or error conditions. The table summarizes the displayed messages during AVSR3 operation:

AVSR3 operation messages	
Message	**Description**
Welcome display sequence	Power-up message. The welcome message (“Welcome!”) and AVSR3 hardware and software version/release numbers (“AVSR3 7-3-1.0”) are shown.
“No config”	No parameters, the AVSR3 will load backed-up or default values.
“All outputs on”	All switches are activated via DIP switch position 1.
“Running', “Idle”, “Disabled”, “Quiet”	Current AVSR3 running status.
“Low load”	Low load current. The AVSR3 is disabled when the current magnitude is less than the associated parameter (see below, Operation parameters).
“Static I/O”, “Tandem I/O”, “Interlock I/O”	Current “Enable”-”Ready” pair I/O control mode as set via DIP switch positions 5 and 8.
“Uncalibrated”	Uncalibrated system. The AVSR3 must be calibrated for proper operation.
Overheated switches	List of currently overheated switches
“Bad line freq”	Out-of-range line frequency. Measured line frequency is outside the 45-65 Hz range, usually as a result of line noise or extensive harmonic content. System will resume normal operation when the line frequency is again within this range.
“Bad input”	Absent or corrupted line voltage or current inputs. The AVSR3 will resume normal operation when the inputs return to their normal states.
“Bad processing”	Non-recoverable internal processing error. The AVSR3 will reboot.
“Out-of-range CT”	Out-of-range current transformer (CT) input, typically caused by regenerative currents or inversely connected CT. (This error is enabled at DIP switch position 2). The AVSR3 will resume normal operation when the CT input returns to its normal range.
“Bad memory”	Non-recoverable internal flash memory error. The AVSR3 halts operation.
Active switches/banks page	Individual switch states and percentage of total capacity are shown in rotation with the power factor, current and power data display.
Power factor data page	Current line and load power factor are shown in rotation with the active switch, current and power data messages. The power factor value is appended with an “L” or “C” indicating inductive or capacitive PF respectively
Current data page	Current line and load apparent current is shown in rotation with the active switch, power factor and power data messages. When the CT ratio parameter equals one (factory default, see Operation Parameters below), current is displayed as read at the CT secondary otherwise referred to the CT primary.
Power data page	Current line and load power data are shown in rotation with the active switch, power factor and line/load data messages. Power data are shown only when the CT ratio parameter is set to a value other than one.
Calibration step	The current calibration step is displayed during autocalibration.

8. Autocalibration

AVSR3 autocalibration is performed by enabling the system externally via the “Enable” control input or via DIP switch position 7 with DIP switch position 6 on. During autocalibration the various internal errors and offsets are detected as well as the connected capacitor bank sizes and CT phase.

To do this no load should be active in the line throughout this process.

Autocalibration is done in six stages:

1. Internal error and offset detection with “Pre ADC offset” and “ADC offset” being displayed.
2. Switch 1 is closed and capacitor bank 1 is measured with “Pre capacitor 1” and “Capacitor 1” being displayed.
3. Switch 2 is closed and capacitor bank 2 is measured with “Pre capacitor 2” and “Capacitor 2” being displayed.
4. Switch 3 is closed and capacitor bank 3 is measured with “Pre capacitor 3” and “Capacitor 3” being displayed.
5. All switches are closed to test line capacity and measure CT phase with “Pre CT phase” and “CT phase angle” being displayed.
6. The autocalibration parameters are saved and backed-up with “Saving/backup” being displayed.

Following this, DIP switch position 6 must be set in the OFF position to avoid a new autocalibration cycle starting at the next enable command. Autocalibration can be performed at any time (with no load present!) and can be canceled by removing the enable input/command (“Enable” input or DIP switch position 7).

9. Operation parameters

AVSR3 operation is controlled under a number of parameters which are set during factory testing:

AVSR3 operation parameters	
Parameter	**Description**
A/D offset	Set during autocalibration. Set to zero.
Capacitor bank sizes	Set during autocalibration. Set to zero.
CT phase offset	Set during autocalibration. Set to zero.
Inversely connected CT	Set during autocalibration. Set to no CT inversion.
Idle time	Idle time with switches off following an error or at start-up. Set to 5 seconds.
Time between switch changes	Time allowing capacitor current to settle after a switch changes state. During this time no other switch changes take place. Set to 1 second.
Bypass delay	Time for switch bypass relay contacts to settle. Set to 0.4 seconds.
Low current limit	Current limit above which the AVSR3 operates. If zero, the smallest capacitor bank size is used. Set to zero.
Compensation factor	Factor to undercompensate reactive currents so that a minimum inductance is always present in the line. Set to 0.95, in effect targets the 0.95 to 1 PF inductive range.
Current factor	Factor to convert A/D count to current in Amps. Set at factory calibration.
CT ratio	Current transformer ratio to calculate load/line Amps. Set to 1 referring the detected current to the CT secondary.
KVA factor.	Factor to convert detected current to KVA. The CT ratio parameter must be set accordingly to display line/load power values. Set at factory calibration to indicate nominal power with a unit CT ratio (e.g. 0.690 for a 3x400 VAC line).
Time to retry after overheated switch	Following the detection of an overheated switch, the switch will be retested after a time for a number of times. Set to 15 minutes.
Overheat recovery tries	Number of tries to recover after overheat detection. Set to 3.
Overheat error clearance	Time to clear overheat error history following successful switch operation. Set to one hour.
Interlock mode time-out	Disabling input time-out in interlock mode. AVSR3 operation is disabled after this. Set to 3 seconds.
Data page display time	Duration of each rotating data page display. Set to 3 seconds.
Welcome message duration	Duration of power-up welcome display. Set to 3 seconds.
Announcement message duration	Duration of interrupting message display. Set to 3 seconds.
LCD display contrast	PWM value driving LCD contrast input. Set to 128/255.
LCD display backlight	PWM value driving LCD backlight LED. Set to 255/255.

The above parameters can also be set via the available on demand avsr3_jobs.exe monitoring PC software.

10. AVSR3 maintenance

The AVSR3 should periodically be checked for conduction voltage drop across the line and capacitor terminals.

With the switches activated (DIP position 1 ON), the voltage between the S1-V1, T1-W1, S2-V2, T2-W2, S3-V3 and T3-W3 terminals should be such that the conducted current by the thyristors does not overheat them, typically well under 1 Vrms. If near or above, the respective bypass relay is suspect and, depending on the conducted capacitor current, the increased switch losses may overheat the switch power circuit.

In such a case or after the power circuit has overheated (“Overheated switches” display showing) the relevant relay must be replaced by a new unit.

11. Recycling information

This product has been designed to be readily recyclable under most jurisdictions. For further information contact us at Cognito Quam Electrotechnologies Ltd, 22 Pigis Ave, Melissia, Athens, Greece 15127, Tel/fax: +30.210.8049475, e-mail: weee@cognitoquam.gr.

Dispose of in accordance with locally applicable laws and regulations.