Information Sheet

Features of the STC3000 Thyristor Stacks and their Application

Caledon

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Introduction

The STC3000 range are 3-phase AC thyristor stacks which operate in phase angle (cycle chopping) mode, or soft start burst fire mode (burst fire but with a phase angle ramped start to the burst). These types of control are aimed at applications where the load is transformer coupled, or has a low resistance when cold, requiring the current to be limited. Other applications are where voltage or current must be controlled eg in the generation of a gas plasma, 50Hz induction heating, or power supplies for induction heating at other frequencies. For more information on the different firing techniques, and general application of thyristors, see our information sheet 'Using Thyristors in Heating Control Applications'.

A number of features have been introduced in the STC3000 range to simplify and enhance their application. This information sheet is intended to highlight a few. For detailed information on how to use the stack see the manual.

The Configuration Menu

The stacks are fitted with a 2 x 16 character LCD display, for initial configuration and subsequent monitoring during operation. The configuration menu is quite short. It is not going to take you a day to find out how to use it and set it up! Indeed, we will supply the stack fully configured to your requirements. What the menu does, is to make it very easy to adjust a few important parameters to exactly meet a requirement. For example:-

Within the limits of the hardware the control range for voltage and current can be adjusted as required. This for example enables you to commission the stack on a 415V supply, but then change it for use on a 380V supply. The input control signal will still control over the full range of voltage. Alternatively, if you wish to control load current, you could adjust a 125A stack so that it controlled over 0-100A to match your load more accurately.

You can easily change the load parameter that is controlled, eg from Voltage to Voltage^2 or Current, and experiment to find the optimum solution for your requirement.

In burst fire mode you can change the cycle time, or the number of cycles over which the soft start ramps up.

The Operating Display

In operation the display indicates a number of flags to indicate the operating status (eg the presence of supplies), and displays load currents, voltage and power. It also enables setting of 'local' setpoints, normally used for limit setpoints such as current limit. As the display is on the front of the stack, which is locked away in a control panel it is mainly intended for commissioning and fault finding. The use of digital communications can make all this information available to the operator on a remote PC or plc based display, eliminating the need for ammeters, voltmeters etc.

Setpoint Facilities

The STC3000 has comprehensive control and limit setpoint facilities. It has two analogue inputs, so that one can be used as the control setpoint (from a temperature controller) and one as an adjustable limit setpoint. Alternatively, if only fixed limit setpoints are required they may be set up 'locally' on the display and stored in EEPROM in the stack. Independent current, voltage and power limit setpoints are provided. A local control setpoint is also provided, enabling operation of the stack without an external control signal (sometimes useful when commissioning or fault finding). Switching between 'local' and 'remote' setpoints is by digital inputs. This means that you could start a process on a local fixed setpoint, and then transfer to automatic control by remote setpoint when operation was under way. The limit setpoints are activated / deactivated by digital inputs.

Switching between Operating (Firing) Modes

The stack may be switched between operating in phase angle mode and soft start burst fire mode simply by toggling a digital input. This can be useful because phase angle mode enables current or voltage limit/control and smooth operation, but causes harmonic distortion and a poor power factor. On the other hand burst fire control offers good power factor and minimum distortion, but causes rapid changes in load current/voltage and cannot be used for voltage or current control. For example, in applications with back-up generators you might wish to use phase angle control when powered by the generator to avoid problems with the generator speed / frequency control, often experienced with burst fire loads, but revert to burst fire for mains operation to improve power factor and minimise waveform distortion. When using heater elements with low cold resistance you might wish to use phase angle control and current limit at low temperatures, and switch to burst fire control at higher temperatures.

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Current, Voltage and Power Measurements

The stack uses separate, true RMS measurements of the 3 load currents, line and load voltage. True RMS or instantaneous measurements are important in phase angle mode, as the waveforms are non-sinusoidal, and serious errors would be introduced by average reading measurements. The use of a powerful microprocessor enables accurate calculation of derived variables such as V^2, I^2 or power. An error is introduced in measurements of power on unbalanced 3-wire loads, because we have to calculate power by multiplying RMS values of voltage and current, but normally this is not excessive. This error is not introduced on balanced loads, 4-wire star or 6-wire loads. Using the microprocessor we are able to calculate power when operating in burst fire mode - a parameter it is very difficult to measure using conventional meters!

Digital Inputs and Outputs

For convenience the digital inputs are designed to be compatible with either pull up or pull down 24V DC logic systems, or can be activated by a contact closure in relay logic systems. The digital outputs can be used as either pull up or pull down in 24V DC logic systems, or to activate a relay coil. One relay output with volt free contacts is provided to indicate an alarm condition.

Communications

Digital communications are becoming ever more popular. With a stack like the STC3000 which used digital technology at its heart, they become a really powerful feature that can be used to significantly enhance the end user's experience and simplify installation and commissioning.

In a typical application a furnace might have overall plc control, with an LCD touchscreen or similar user interface. Communications to the stack would immediately make possible the display of accurate measurements of load and line voltage, current and power, and diagnostics relating to operating conditions, such as fuse failure etc.

Without much more difficulty the stack can be completely controlled using the digital communications, eliminating the need for analogue control signals between temperature controller / plc and stack, and hard wiring of digital I/O. For the OEM, PLC control software only has to be written and de-bugged once. Hard wiring has to be repeated and tested on every installation!

Information can also potentially be made available via modem for remote logging or diagnostics.

The stacks are provided as standard with Modbus RTU slave emulation, using a galvanically isolated RS422 / 485 communications port (single or twin twisted pair as required). Galvanic isolation helps eliminate noise problems, and more particularly prevents gross problems on the communications wiring from penetrating into the stack (like becoming 'live'!). The Modbus protocol is a real workhorse, supported by many equipment suppliers and low cost hardware. Other fieldbus types are not forgotten however, and through the use of AnyBus® technology the stacks can be supplied equipped with DeviceNet, Profibus DP, and potentially many other fieldbus interfaces.

Feedback and Limit Modes

V^2 control is commonly used for heating applications, because for a given load resistance the load power is proportional to V^2. Using power control, account is also taken of variations in the element resistance. I^2/V^2 transfer is used with heaters with low cold resistance. When the heaters are cold the control signal controls the $current^2$, but as the elements heat up the voltage across them increases, until the normalised $voltage^2$ across them is greater than the normalised $current^2$ through them. At this point the control signal switches to controlling $voltage^2$. By normalised voltages and currents we mean scaled so that 0-100% corresponds to the voltage and current span of the stack (supply voltage and operating current, see under configuration menu).

When operating in burst fire mode, closed loop control of the output is not used, because although the power output can be calculated, the effective sample rate, limited by the burst fire cycle period could lead to control instability. Open loop control with modification of the cycle period in inverse proportion to the square of the line voltage is therefore adopted, which in practice gives close correlation with true V^2 control. If you wish to switch between burst fire and phase angle modes, and wish the load power to remain more or less constant during the change over, you should choose compensated control in burst fire mode and V^2 feedback in phase angle mode.

Voltage limit is not available in burst fire mode, as by definition the voltage in the 'on' period is the same as the line voltage. Current limit is however available, and if the current limit setpoint is exceeded in the 'on' burst, the stack will 'phase back' to limit the current. At the end of the 'on' period the stack switches off in the normal way, and the procedure repeats in the next 'on' burst. An intelligent algorithm is incorporated to eliminate current overshoot after the first burst where current limit activated. During current limit in burst fire mode the measurement of load power remains reasonably accurate, but the 'on' period does not automatically increase to compensate for the loss in power created by the limit action.

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