Technical Note 133

ACH580 E-Clipse bypass overview

Advanced features

Since the introduction of variable frequency drives, some form of auxiliary device has been available to disconnect, or "bypass", the drive and connect the motor across the line in case of drive failure. Early forms (Figure 1) of this bypass device were strictly electro-mechanical, providing interlocking contactors to isolate the drive and line-connect the motor. Over time, the need for a more sophisticated approach to this bypass concept became apparent, and ABB introduced its E-Clipse bypass (Figure 2) product to service this demand.

Originally introduced in 2008 following the release of the ACH550, the first iteration of the E-Clipse bypass set a new standard for intelligent bypass control in a traditional HVACR application. 15+ years later, this product continues to evolve with the introduction of the ACH580, including full compatibility with the Ultra-low harmonic (ULH) version of the drive.

This paper introduces the reader to the advanced features of the E-Clipse bypass and contrasts these with the limited features of the "classic" or "traditional" electro-mechanical bypass.

Below is a summary with links to more detailed discussions of each feature:

- Classic bypass schematic – traditional 3-contactor design
- Intelligent bypass schematic – E-Clipse 2-contactor design
- Advanced stand-alone user interface
- Three-phase switch mode power supply
- Pass-through I/O
- Configurable safety annunciation
- Intelligent bypass mode
- Communications
- Override modes
- Proof-of-flow
- Number of contactors

Classic bypass schematic – traditional 3-contactor design

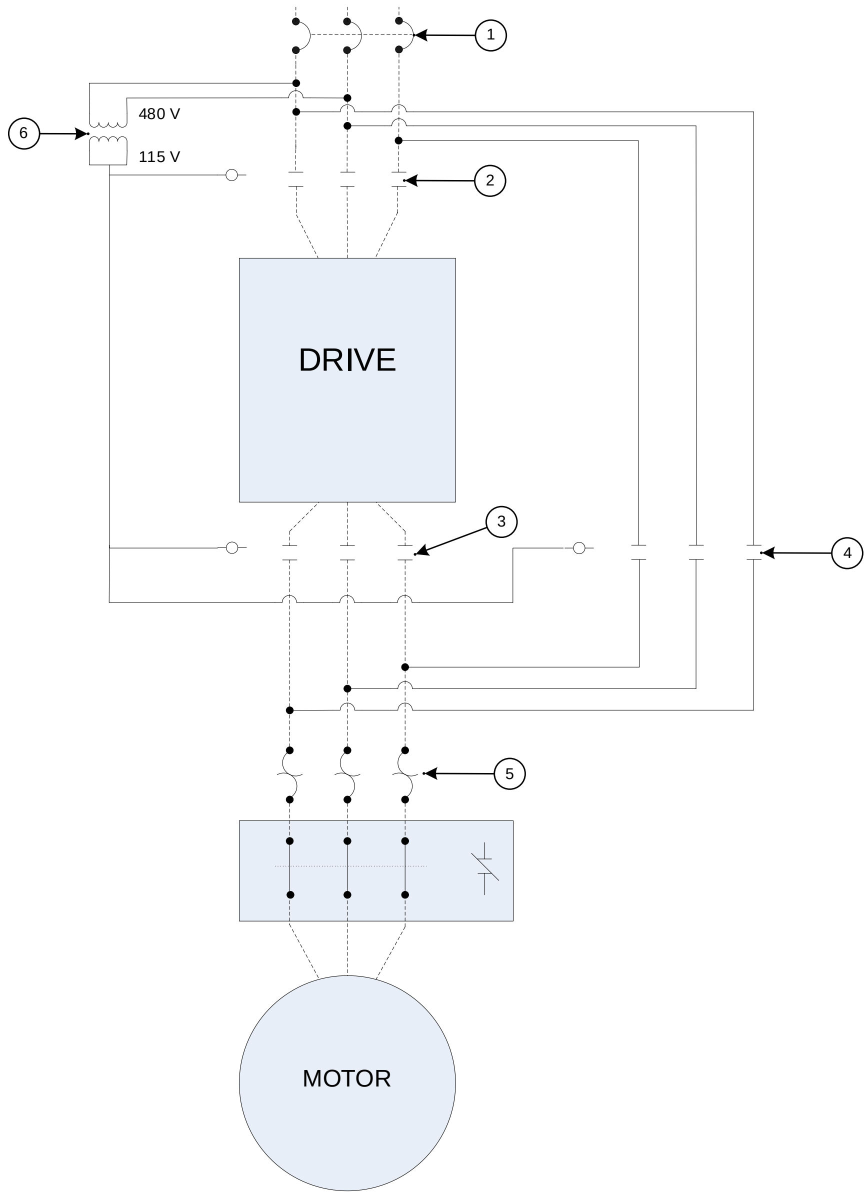

Figure 1 Classic bypass

1. Input circuit breaker
2. VFD input (3rd) contactor
3. VFD output contactor
4. Bypass contactor
5. Motor overload
6. Control power transformer

Intelligent bypass schematic – E-Clipse 2-contactor design

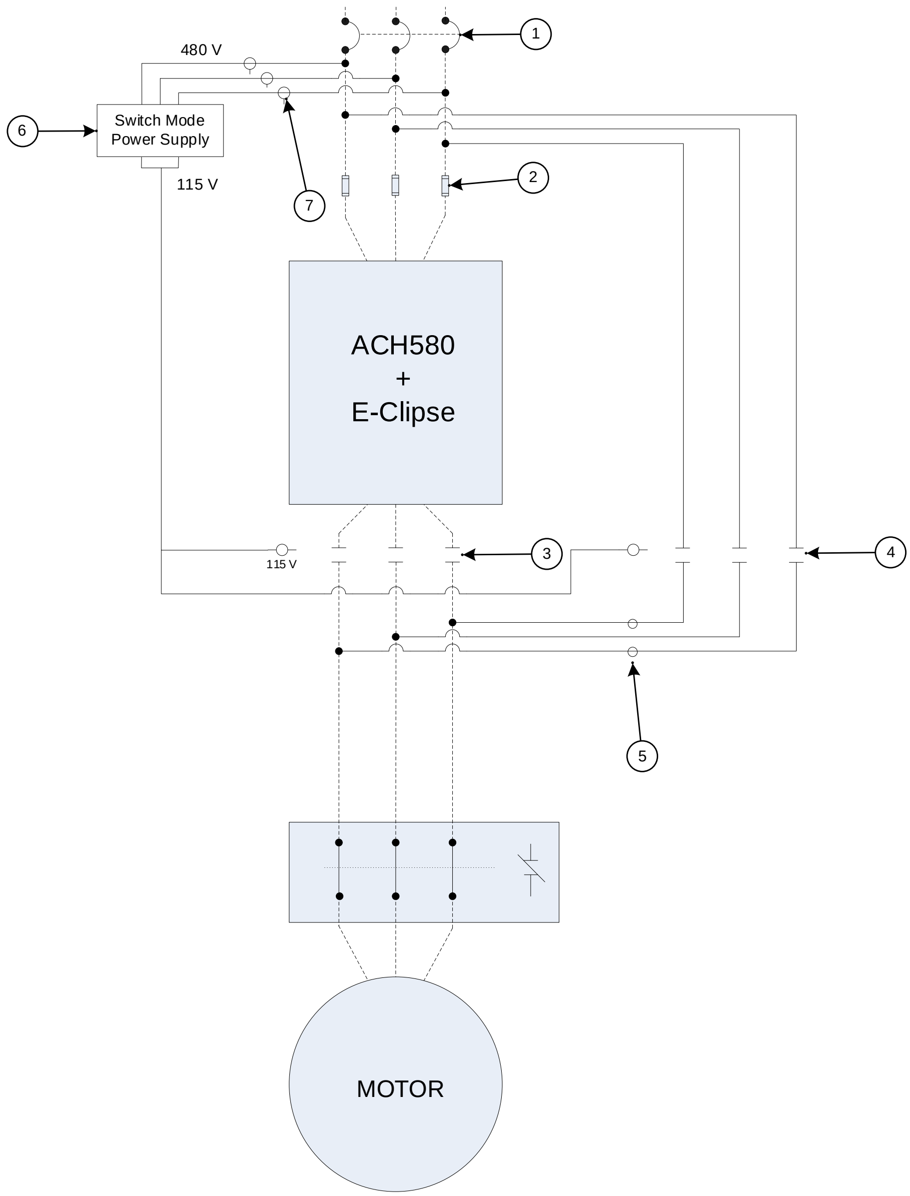

Figure 2 E-Clipse bypass

1. Input circuit breaker
2. VFD input fuses
3. VFD output contactor
4. Bypass contactor
5. Bypass-mode current sensors
6. Switch mode power supply
7. 3-phase line voltage measurement

Advanced stand-alone user interface

One of the most visible enhancements of the E-Clipse bypass is its independent user interface which provides the following features:

- 2-line LCD display supporting intuitive programming and diagnostic feedback
- 9-button membrane keypad providing easy access to bypass sytem configuration and control
- 4 status multi-color LEDs clearly indicating the system operating state
- Allows continued operation in bypass mode in the event of VFD failure

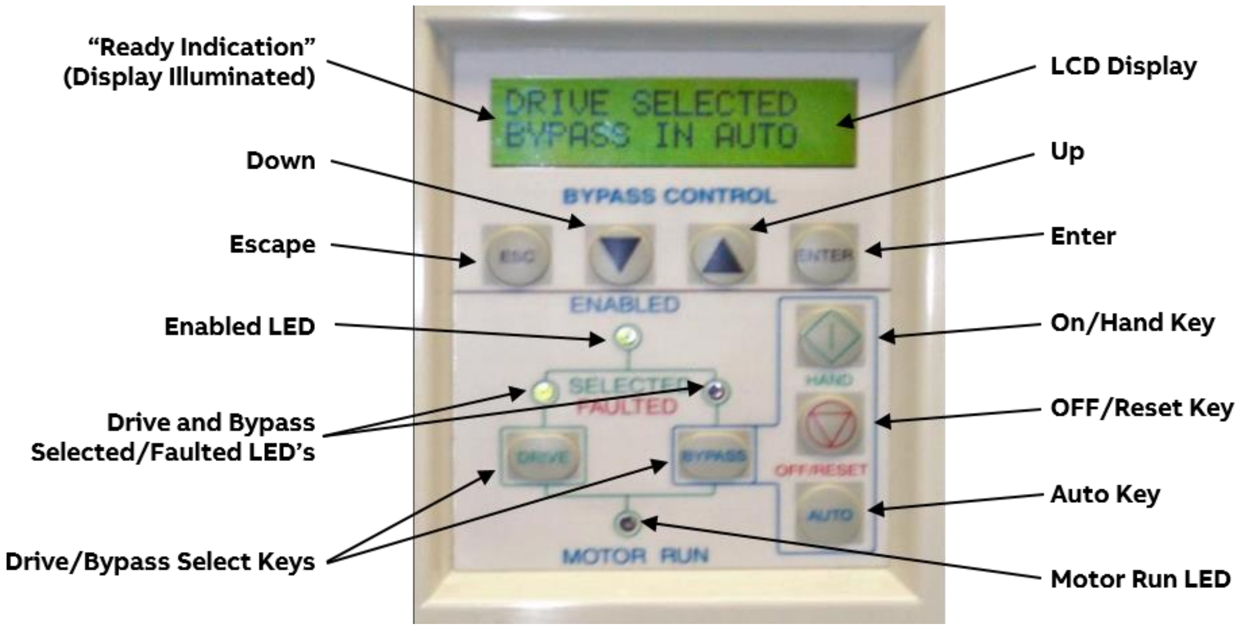

Figure 3 E-Clipse control panel

Three-phase switch mode power supply

Rather than a simple control power transformer found in a classic bypass system (Figure 1, item 6), the E-Clipse system incorporates an MOV-protected, advanced switch mode power supply (Figure 2, item 6). This power supply has significant advantages over a control power transfer by managing input power disturbances without passing these on to the contactors, such as +30%, -35% voltage fluctuation tolerances and single-phase conditions. Under these transient line conditions, high or low, as well as phase loss, and very brief generator transfers, contactor control can be maintained, allowing trip-free operation of the system, and minimizing contactor cycling (chatter). A robust power supply design is critical for reliable drive-mode operation, as the output contactor must be kept closed while the drive is controlling the motor.

This well-regulated control of coil voltage to the contactors permits characterization of their pick-up and hold currents. With this information integrated into the E-Clipse controller, common contactor failure modes such as welded contacts or failure to close can be detected and annunciated to the user. These annunciations make troubleshooting safer and simpler than a "classic" bypass.

Pass-through I/O

In addition to the ACH580's standard 6 digital inputs, 3 relay outputs, 2 analog inputs and 2 analog outputs, the E-Clipse bypass also provides 6 additional digital inputs and 5 additional Form-C relay outputs, for a combined total of 24 "pass-through" I/O.

So-called "pass-through" I/O is a term used to describe hardware that may have underlying functionality an application does not require. For example, a common system configuration might designate the ACH580's Analog Input 1 as frequency reference, and the bypass' DI1 as the start/stop source. This is what is meant by "underlying functionality".

Contrast this with an application that takes full advantage of control over the communications channel. Here, the same control inputs would not be required at the drive or bypass. However, the hardware itself is still available to the user over communications and may take the place of an additional I/O module in the control contractor's cabinet that might otherwise be required.

If, for example, a rooftop application had an additional temperature sensor or auxiliary contact required at the controller but not required in the VFD application, these inputs can still be landed locally at the drive or bypass and then accessed remotely by the automation system, thus avoiding an additional I/O module, or pulling additional wiring back to the main controller. This is the power of "pass-through" I/O.

Configurable safety annunciation

The E-Clipse bypass features 4 separate safety inputs. When in use, a warning message is annunciated on the bypass display to alert the user of their status. In addition to a default warning of "INTERLOCK x", user-selectable names can be assigned to each safety, e.g. "OVERPRESSURE", "VIBRATION TRIP" or "FREEZESTAT". As well, this status is accessible by a building automation system over the communication channel.

This is a significant advantage over a classic bypass design, providing clear and visible feedback to the user as to what input is preventing normal operation of the system. Having remote access to this status over communications further elevates the importance of this feature, enabling remote and safer troubleshooting.

Intelligent bypass mode

With its independent intelligent controller, the E-Clipse bypass system is uniquely designed to manage the bypass system with or without the VFD. For example, with access to the VFD's fault status, auto-transfer to bypass mode can be configured to only occur on certain faults, and not allowed on others. This way if the VFD faulted because of a motor related issue, bypass mode will not be allowed. With a classic style bypass, whether auto or manual transfer, bypass mode can be engaged even if the VFD knows there is a problem with the motor. Similarly, with the E-Clipse bypass-mode operation is inhibited if the bypass hasn't detected successful operation in drive-mode during commissioning, ensuring that proper motor rotation has been confirmed (first start in drive mode required).

With its line voltage measurement, the bypass can detect and annunciate a phase-loss condition to the user. As well, it will permit single-phase operation in drive-mode, but inhibit bypass mode with this condition.

With its bypass-mode current feedback measurement, UL-listed motor overload protection and energy measurement are still possible, even with VFD removed or otherwise offline.

Finally, as an independent controller managing all communications in the system, access to bypass-specific control and status continues to be available to the automation system, even without an operational VFD.

Communications

In an E-Clipse bypass system, the ACH580's embedded fieldbus channel (RS-485) is pre-configured for Modbus communications, as this is the primary interface between the bypass controller and the VFD. Therefore, the bypass controller functions as the communication "proxy" for all communications in the application.

For embedded communications (RS-485 based), the following protocols are supported:

- Modbus RTU
- Johnson Controls N2
- BACnet MS/TP
- Siemens GP1 (FLN)

In addition to acting as the ACH580 proxy for these protocols, the bypass controller can be separately configured to enable bypass-specific points over communications. Consult the E-Clipse user manual for more information.

ABB F-series module are also supported on the E-Clipse controller:

- FLON-01 (LonWorks)
- FENA-21 (Modbus/TCP, Ethernet/IP, Profinet)
- FBIP-21 (BACnet/IP)
- FMBT-21 (Modbus/TCP)
- FEIP-21 (Ethernet/IP)
- FPNO-21 (Profinet)

Note that the ACH580-based E-Clipse system does optionally support an F-series module installed on the ACH580 and a separate communications channel landed at the bypass controller, in unique applications where control and monitoring may be handled with different systems.

Regarding additional bypass-related information available over communications, it's worth highlighting some of the key benefits this provides, with some examples for BACnet MS/TP.

Access to additional pass-through I/O over BACnet MS/TP has already been mentioned above. But in addition to these hardware points, there are very useful binary value objects that provide bypass-related status, such as bypass fault state, system operating mode (drive or bypass) and bypass run status, which signals to the automation system that the bypass is running in bypass mode. Monitoring drive versus bypass status over BACnet provides multiple advantages. First, there is the cost savings of using BACnet, as there is no need to wire a bypass aux contact back to the automation system. Second, having a building automation system throw an alarm to continuously remind the facility management team that the package is in bypass mode, can save considerable energy costs. Unfortunately, sometimes when drives are temporarily put into bypass mode, that drive package is forgotten about and what was supposed to be a couple days of bypass operation becomes weeks, months, or even longer in bypass – resulting in significantly higher energy consumption.

As well, there are BACnet analog value objects that provide valuable bypass operating data for both status and diagnostics, such as bypass-mode output current, bypass operating mode (hand/off/auto), last fault and PCB (printed circuit board) temperature. Trending the PCB temperature is a way to verify the package is properly cooled (i.e. cooling fan is operating) or if preventative maintenance (cleaning) is required. Another set of useful analog value objects are the separate phase-to-phase line voltages. With this information, it's possible to remotely access line voltage measurements without requiring specialized test equipment and PPE. The ACH580 E-Clipse bypass package eliminates the need for submetering on HVACR equipment.

Override modes

The E-Clipse bypass is designed for life safety applications by leveraging Override mode. Two override modes are available: one which is "standard" and not configurable, designed to meet the intent of UL864/UUKL. The other is configurable and designed to offer flexibility in applications where an Authority Having Jurisdiction (AHJ) has additional requirements.

With Override 1, the motor is connected across the line through the bypass contactor. Once activated, the system ignores all commands from either the drive or bypass keypads, as well as the communication channel. Low priority safeties are ignored in this mode, while high priority safeties are followed. The system will always respond to the bypass' electronic motor overload protection in this mode. Upon release of the Override 1 command, the system will return to its prior operating state and normal control is restored.

Override 2 is much more configurable than Override 1. In this mode, the system can be configured to run the motor with the drive, across the line, or stopped with both contactors opened. As well, there is an option to switch from drive to bypass control if the VFD faults. As with Override 1, the system does not respond to commands from either the drive or bypass keypads. Finally, Override 2 offers the flexibility to select which faults, safeties and enables continue to be observed in this mode. The system will always respond to the bypass' electronic motor overload protection in this mode. Upon release of the Override 2 command, the system will return to its prior operating state and normal control is restored.

Proof-of-flow

Another feature made possible by the bypass' independent current measurement is the ability to provide underload, or proof-of-flow, detection in either drive or bypass mode, eliminating the need for an external current transducer. The drive's underload detection is configured separately from the bypass', and its underload status is shared with the bypass. A single BACnet object can be monitored, or a relay output can be configured to indicate a “system” proof-of-flow status if an underload is detected in either the drive or the bypass, thus simplifying integration into the building automation system. Monitoring proof-of-flow over BACnet allows for reduced installation costs. Troubleshooting is simplified with the bypass display having its own annunciation of underload status.

Number of contactors

Figure 1 (item 2) compared to Figure 2 shows that modern HVACR bypasses have one less contactor. Originally with the classic 3-contactor design, the industry used that contactor to provide isolation on the input side of the drive. That isolation would aid situations when a shorted internal drive component (i.e. diode, capacitor, IGBT) would continuously trip the circuit breaker (Figure 1, item 1). Opening the input contactor (assuming it had not become welded shut) would prevent that shorted component from tripping the breaker, thus allowing bypass operation. With changes to UL508C and UL61800-5-1 along with their safety related requirements, fuses installed in front of drives became the new standard. The fuses eliminated the need for the input contactor, as the fuse would open and provide the necessary isolation if there had been a shorted internal drive component.

In the past, some individuals also used the input contactor to provide input isolation to service/replace the drive while the package was operating in bypass mode. However, modern appreciation of safety and associated risks of working on a live cabinet (arc flash) and not being down-stream of a true locked-out tagged-out disconnect device, has made that practice obsolete and not recommended.

With everything above said, there are still some in the industry who desire the concept of an input contactor, and others who push the sale of an input contactor. To meet the intent of that request, the E-Clipse bypass is available with an optional input isolation switch (+F267). An isolation switch, a higher reliability component than a contactor, makes for a more robust system and still provides input side isolation if desired during troubleshooting. Note that if an internal drive component did fail in a shorted state, the input fuse(s) would still open and allow bypass operation. Even if not all three fuses opened, there is no need to open the service switch for bypass operation or for general equipment/facility protection during bypass operation. Fuses will open if a circuit or component could be unsafe, as the ACH580 drive meets UL61800-5-1.

Summary

This technical note is a review of the differences between a “classic” or “traditional” 3-contactor electro-mechanical bypass and ABB’s advanced E-Clipse 2-contactor bypass. Additional insight is given into the many benefits these advanced features provide in a bypass system under control of the E-Clipse bypass. In particular, the advantages afforded by the switch mode power supply and its ability to ride-through line quality issues are discussed, as well as the benefits of precise contactor control and diagnostics. On-board voltage and current measurements introduce a much higher level of functionality in the bypass mode of operation not previously available in legacy bypass designs.