UPS EXTERNAL MAINTENANCE BYPASS

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INTRODUCTION

Purpose: The purpose of this e-Guide is to provide an introduction to the application and use of a UPS External Maintenance Bypass.

Objectives: This paper will allow the reader to:

1. Understand the difference between the UPS internal and External Maintenance Bypass and the function of both.
2. Understand the difference between a make-before-break and a break-before-make External Maintenance Bypass.
3. Understand the three types of make-before-break bypasses and their application.
   a. Two Breaker Bypass
   b. Three Breaker Bypass
   c. Four Breaker Bypass
4. Understand which of the three different bypass types provide the greatest flexibility to future reconfiguration of the UPS and electrical system without interruption to the critical load.
5. Understand the function and purpose of an SKRU (Solenoid Key Release Unit) and Kirk-Key interlocks.
6. Understand the proper procedure for transferring a UPS to and from an external make-before-break bypass.
7. Understand the most common error resulting in dropping the critical load when manipulating an external make-before-break bypass.

TECHNICAL DISCUSSION

UPS Models

UPS modules come in two distinct models: dual-input design or single-input design. At one time in the 3-phase UPS history, the only design available was dual-input. As the UPS capacity (kVA rating) came down in size, the single-input was the most popular for UPS applications less than 150 kVA because it reduced the cost of the electrical installation. However, the single-input design forfeits the redundancy and reliability factor of the overall UPS installation design that a dual input UPS provides.

Internal Maintenance Bypass: The purpose of the internal maintenance bypass, contained within the sheet metal cabinet of the UPS module, is to provide a redundant power path through the UPS directly from the line-side source to the connected load.

The internal maintenance bypass, depending on the UPS manufacturer, will allow about 90-95% of preventative maintenance to be performed on the UPS module without interruption to the critical load.

Most but not all repairs can be accomplished with an internal maintenance bypass. Not all UPS manufacturers include this type of redundant bypass source in their UPS module designs.

External Maintenance Bypass: The purpose of the External Maintenance Bypass is to allow a fully redundant electrical power path around the UPS system to the connected mission critical load. This external bypass allows complete isolation of the UPS module from the electrical power source for scheduled maintenance or emergency repair without interruption to the critical load.

There are some services or repairs that can be provided with a fully isolated UPS module that cannot be performed on a UPS equipped with an internal maintenance bypass:

1. The input and output terminal lugs can be retorqued without electrocution.
2. The UPS static switch can be repaired, removed or replaced.
3. The UPS's internal bypass switches, fuses, or circuit breakers can be removed, repaired or replaced.
4. The market demands for a small UPS footprint places components closely tiered from the front to the back of the UPS module. Some repairs require the disassembly of the front of the UPS to gain access to components.
5. The UPS module can be started and tested on a limited basis (with no additional load applied after a repair, maintenance, or calibration) prior to being placed on-line with the mission critical load.

Two types of External Maintenance Bypass Schemes:

Make-Before-Break means that power derived on the output of the UPS module is met by a secondary bypass power source so that the connected load is transferred from one source to the other without any power aberration or interruption to the load.

Break-Before-Make means that the power derived on the output of the UPS module is turned off before a secondary bypass power source is connected to the load. The connected load will be turned off and then on each time a transfer is made between two sources.

A Break-Before-Make bypass scheme is usually utilized with single-phase UPS systems that have a 120/208V input and a 120/240V output.

The goal of the majority of UPS applications is to have an external bypass scheme that provides a Make-Before-Break transfer. If the external Make-Before-Break maintenance bypass design and application is properly applied, the UPS system can be physically removed and replaced without interruption to the connected load.

The secret to a Make-Before-Break bypass design is matching the sinusoidal wave form of the UPS output to the external bypass source.

Scenario:

If you have a UPS that is a 480V, 3-Phase, 3-wire plus ground with a UPS output of 208V, 3-phase, 3-wire, + neutral, + ground, and the external bypass source is derived from the same 480V source, you will be thwarted in your Make-Before-Break bypass scheme because of the unmatched voltages.

Solution:

Installing a transformer on the bypass line that supplies power to the input of the External Maintenance Bypass based on the exact specifications of the UPS module's internal transformer.

Three basic Make-Before-Break External Maintenance Bypass Designs:

1. Two Breaker Bypass
    a. Single Input UPS
    b. Dual Input UPS
2. Three Breaker Bypass
    a. Single Input UPS
    b. Dual Input UPS
3. Four Breaker Bypass
    a. Dual Input UPS

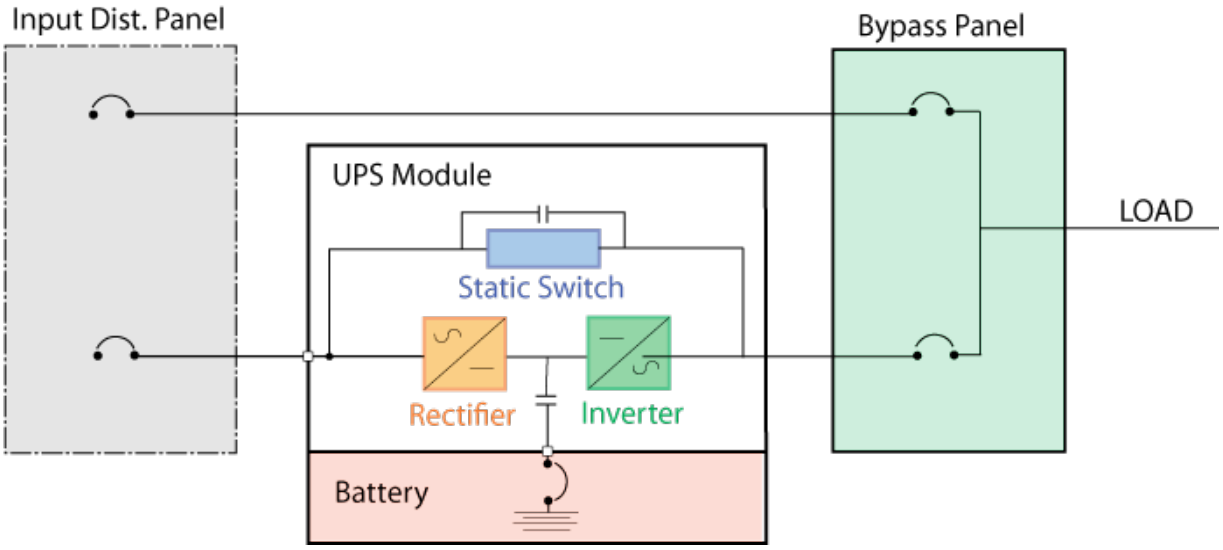
Each of the three designs brings unique benefits, though they may vary from one UPS installation to another.

The best time to apply an External Maintenance Bypass is at the time of the original installation of the UPS system. An External Maintenance Bypass can be installed after the original UPS installation, but it is more difficult and expensive. An External Maintenance Bypass installation will always require the mission critical load connected to the UPS to be shut down for a period of time.

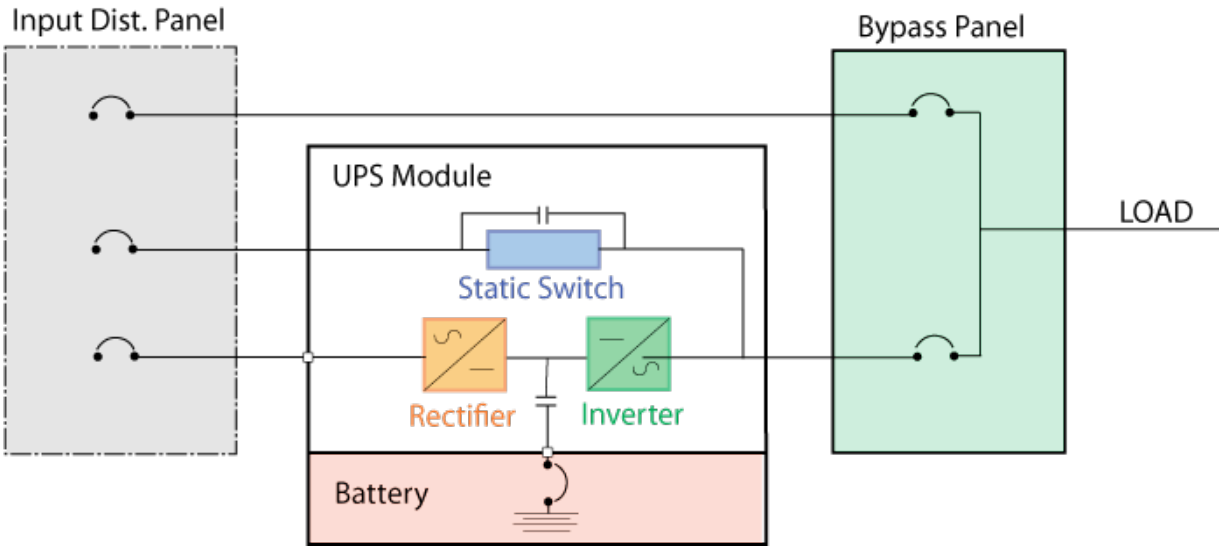
How long will the UPS be shut down? Every site and application is different. This paper offers no easy answer.

Below are five simple, single-line diagrams of the three typical bypass types applied to a single input UPS and dual input UPS.

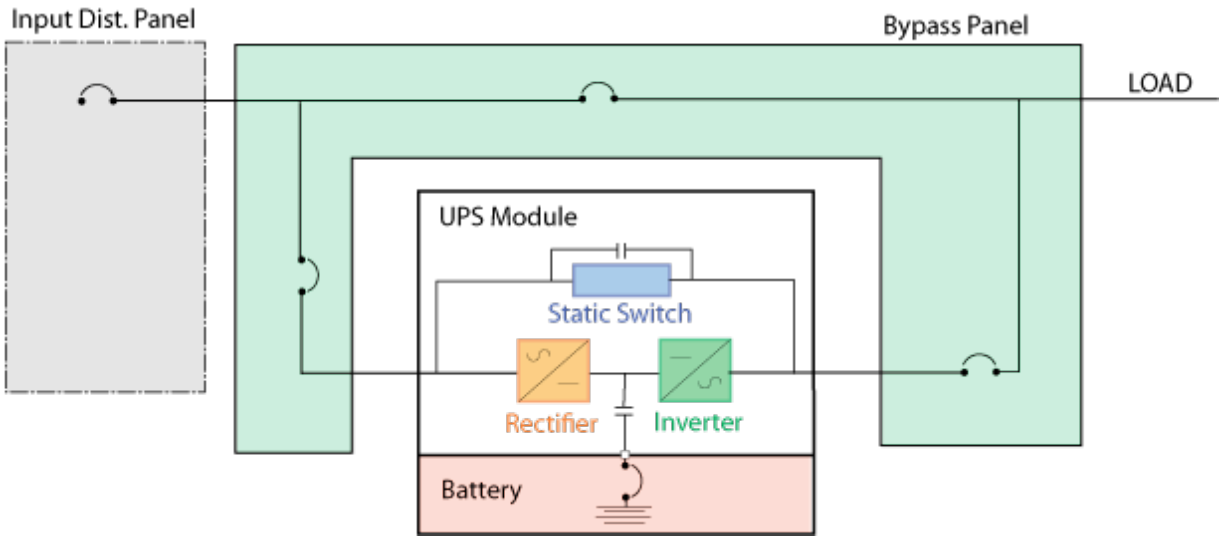
1a. 2-Breaker Bypass with a Single Input UPS



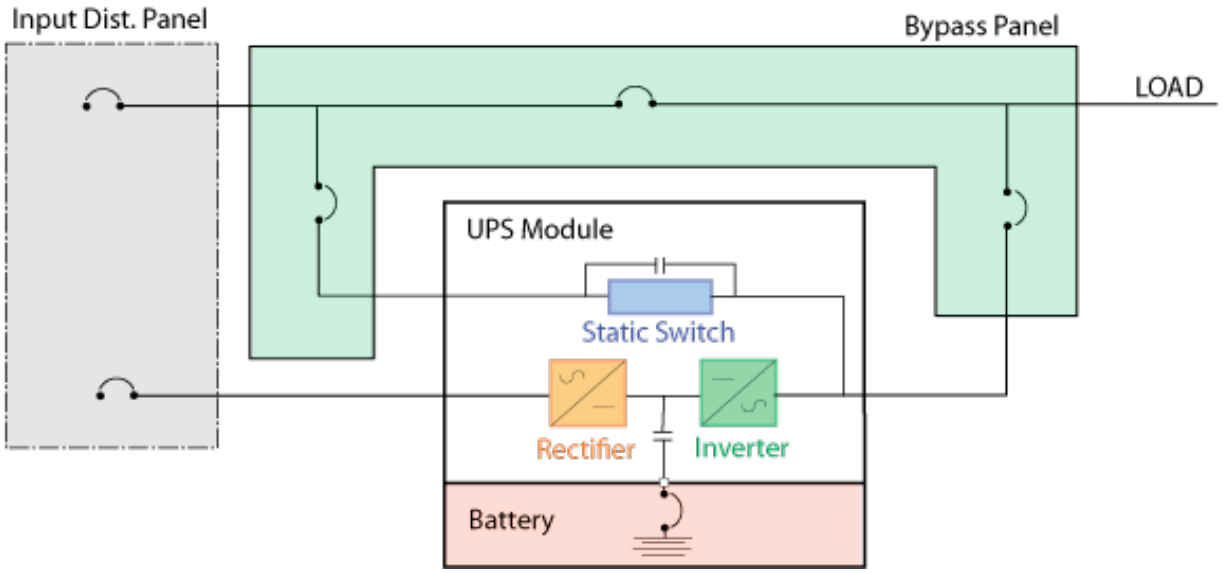
1b. 2-Breaker Bypass with a Dual Input UPS



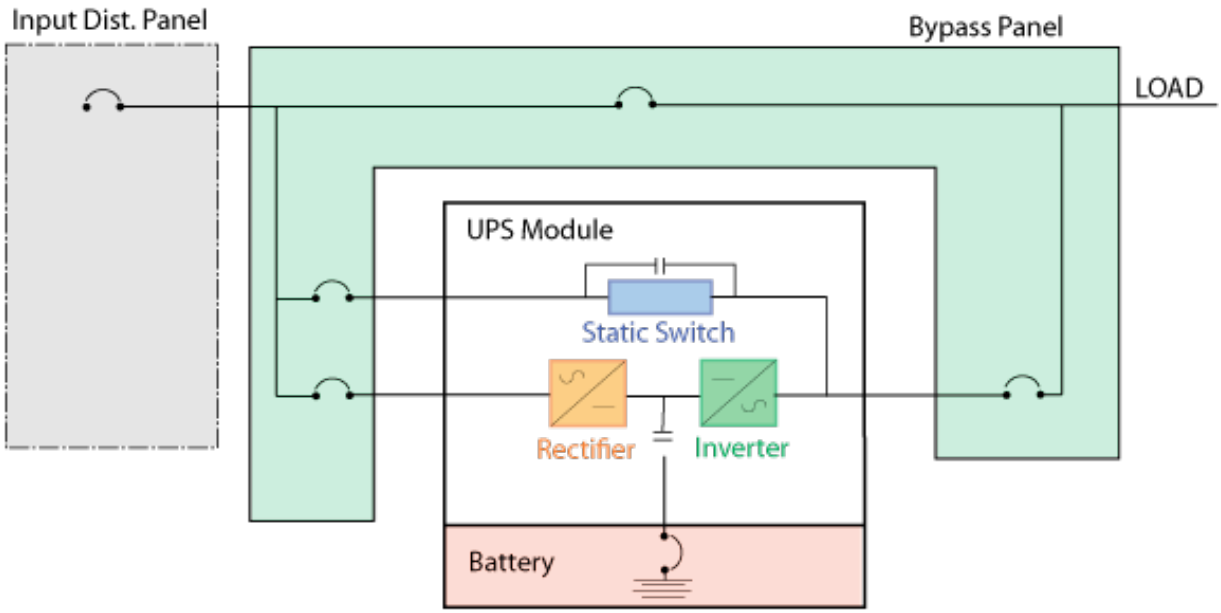
2a. 3-Breaker Bypass with a Single Input UPS



2b. 3-Breaker Bypass with a Dual Input UPS



3a. 4-Breaker Bypass with a Dual Input UPS



The bypass configurations that provide maximum flexibility in future electrical reconfigurations are the bypass schemes represented by the diagrams A1, A2, and B2, especially when one considers possible failure and repair of the line-side circuit breakers that feed the UPS and the External Maintenance Bypass.

There are several major components of the UPS External Make-Before-Break Maintenance Bypass:

1. UPS Reserve and/or Input Circuit Breaker: These circuit breakers bring input power to the UPS module. In normal UPS operation, this breaker(s) is "normally closed."
2. UPS Output Breaker: This provides a means of disconnect and over-current protection to the supply side of the UPS module. In normal UPS operation, this breaker is "normally closed."
3. External Bypass Breaker: The bypass circuit breaker permits the wrapping of electrical power around the UPS module. In normal UPS operation, this breaker is "normally open."
4. Kirk-Key Interlocks: Kirk-Key Interlocks is a term for locks and keys for sequential control of equipment and machinery to ensure safe operation.
5. SKRU (Solenoid Key Release Unit): This electrical solenoid is physically attached to the External Maintenance Bypass cabinet. Its function is to hold, without releasing, the brass key to the Kirk-Key lock installed on the External Bypass Breaker. The SKRU releases the brass key for use when the UPS module has successfully been placed into internal bypass mode.
6. Indicator Light (option): This option is an integrated part of the External Maintenance Bypass enclosure and illuminates when the UPS module is successfully placed into "internal bypass mode."
7. Permissive "Black Push Button" Key Release: The extracting of the Kirk-Key held by the SKRU has to be an intentional operation and requires two hands. One hand presses the Black Push Button and the other hand turns and releases the Kirk-Key held by the SKRU. The Kirk-Key will release only when the UPS module is safely in the "Internal Bypass" mode.

8. Breaker Labeling: For clarity, each of the breakers of the External Maintenance Bypass needs to be clearly labeled. It is a benefit to the installing electrician if the manufacturer utilizes some type of tape labeling within the enclosure to identify the breakers when the external sheet metal cover(s) are removed.
9. Printed Written Instructions: A clearly printed set of instructions should be attached to the External Maintenance Bypass enclosure explaining sequential step-by-step safe operation.
10. NEMA-1 Enclosure: This enclosure type is designed for indoor use. It can come in a wall-mounted or free-standing enclosure.

Several manufacturers produce a line-up-and-match External Bypass Cabinet to sit adjacent to the UPS module that utilizes control wiring instead of Kirk-keys to control sequential operation of the external bypass. In any case, the cabinet can be accessorized with a step-down transformer, output distribution panels, or breakers. These cabinets can often reduce the overall footprint needed for an external bypass, and they have "curb appeal."

When considering a manufacturer's line-up-and-match bypass cabinet, keep in mind the importance of maintaining the ability to physically remove and replace the UPS module without interruption to the critical load. With a line-up-and-match bypass cabinet, it may be impossible to switch manufacturer if dissatisfied with the current choice.

Operational errors of External Maintenance Bypass resulting in a dropped load include:

1. Operating the bypass under the influence of adrenaline. Do not operate the External Maintenance Bypass without a clear head, normal pulse, and steady hand. Do not operate the External Maintenance Bypass unless you are absolutely clear in your head how the UPS electrical system as a whole works from the line side circuit breakers to the External Maintenance Bypass to the connected mission critical load.
2. Not waiting for your field service technician to arrive on-site to manipulate the External Maintenance Bypass. This person manipulates these devices day in and day out, and they should be able to execute the operation safely and easily. With that said, I have seen professionals mess up the operation and drop the load because they were over-confident and made assumptions. Short cuts are your enemy. Follow your written procedure.

   Though discouraged, it is not uncommon for someone to open the upstream line-side feeder breaker to the External Maintenance Bypass Breaker as an extra precaution during "normal UPS operation." This can only be done with schemes shown in A1, A2, and B2. The operator must verify the line-side feeder breaker to the External Maintenance Bypass Breaker is in the closed position. If not, the risk is that no power is on the External Maintenance Bypass Breaker when closed, and the UPS Output Breaker is opened. The net result is the computer room goes silent…the worst sort of quiet is heard.
3. There is no Kirk-Key or inhibitor on the UPS Input Breaker in a 3 or 4-Breaker bypass configuration. If the UPS is on its internal bypass and the UPS Output Breaker is closed, then opening the UPS Input Breaker will bring down the UPS load. Read No.1 again. When in doubt, DON'T.

Application Scenario

True Story: A UPS was installed with an External Maintenance Bypass and all was well in the world. One day, a need arose to place the critical load on the External Maintenance Bypass. The UPS load was 60-70% of the UPS capacity and there was no need for concern. The External Maintenance Bypass was operated correctly according to the step-by-step instructions. The step of closing the external bypass breaker was executed, and instantly, the critical load was dropped with the external bypass breaker tripping open.

The operator of the bypass was stunned to silence just like the computer room. Once the IT Director and Facilities Manager were peeled off of the ceiling and resuscitated, the dust settled and a diagnosis was completed. It was determined that the "external bypass breaker" had failed.

In retrospect, when the UPS system was commissioned, the whole system was tested, manipulated, transferred to and from without a resistive load. On this particular sad day, the external bypass breaker saw its first test under load and failed.

When circuit breakers less than 600 amps are tested, they are batch tested. One breaker out of a pre-set number is pulled from the production line and put through its paces to verify manufacturing specifications. Not every one is tested.

There are two ways to avoid this scenario. One, have the circuit breakers bench tested and certified prior to installation into an External Maintenance Bypass. This adds cost and will delay delivery of the system a few days. The other option is to utilize a resistive load bank to test the entire UPS system at the time of commissioning and start-up. Make sure that the external bypass breaker is seen to carry 100% of the load indicated in the UPS design rating. If you have a failure of the circuit breaker at this time, your only angst will be scrambling to get a new tested breaker installed to meet your schedule.

In short, pick a supplier who understands your budget, application, UPS and bypass options, commissioning, and ongoing service options. As a bonus, maybe that person will have a soothing voice to help you in your adrenaline moments.

CONCLUSION

In the mid to late 1980's, Computer Air/Power Systems (CAPS) provided an External Maintenance Bypass with 3-Phase UPS systems about 50-60% of the time. Today, an External Maintenance Bypass is supplied 97% of the time.

What changed? The market place has changed dramatically since 1982, the year CAPS was first founded. The internet now connects companies in real time to suppliers, customers, financial institutions, and all other entities. If the utility source of electricity is interrupted, the financial impact on the bottom line begins. Each business has its own level of pain and loss when the computing operation of the company goes silent. When a company loses electrical power today, that company disappears from planet earth in the eyes of a customer attempting an internet purchase. If that isn't painful enough, turn off the electrical power to the executive email server. You are getting the picture.

Every business has a cost associated with failure of their infrastructure or the success and profitability of the same. The proper selection of the External Maintenance Bypass configuration, installation, testing, and operator training is crucially important to ensuring your mission critical equipment and revenue stream are uninterrupted.