

Application Note

Introduction to Creating Your Own Splice Recipes

This Application Note will introduce the basics of creating a fusion splice recipe with the FSM-100 series fusion splicing machines. It is not an exhaustive index of all details involved in creation of a fusion splice recipe and is not intended to encompass the full capability of the FSM-100 Series of Fusion Splicers.

A good fusion splice recipe is comprised of a combination of parameters and settings which, when built into a splice mode, form the instructions the splicer uses to create the desired end product. These instructions tell the fusion splicer how to handle the fiber as it executes the multiple stages of a fusion splice process.

Initial Considerations

The specifications for both the completed fusion splice and fibers used in said splice are the drivers for the specifics of a fusion splice recipe. When creating a splice mode, there are many things to account for including: *Are the fibers similar or dissimilar? What are the core, cladding, coating, and mode field diameters? Which way is the signal traveling? What are the fibers' numerical aperture? What is the polarization maintaining design of the fiber? etc.* As there are various details to cover, it is helpful to categorize:

1. What machine capabilities/functions are available?

See Table 1 below for an outline of functionality differences between the FSM-100P+, 100P, 100M+, and 100M models. If end view capabilities are required, then a 100P+ or 100M+ model is necessary. If rotational capabilities are required, then either a 100P+ or 100P model is necessary.

Table 1 — Comparison of FSM-100 Models

FEATURES	NO ROTATIONAL ALIGNMENT	ROTATIONAL ALIGNMENT
No End View Imaging, Limited Z-Stage Travel, Fiber Diameters <500 µm	FSM-100M	FSM-100P
End View Imaging, Extended Z-Stage Travel, Fiber Diameters >500 µm	FSM-100M+	FSM-100P+

2. What are the specifications of the fiber?

Fiber specifications affect splice mode parameters, test and measurement methods, and finished splice estimation. Specifically, for splice mode parameters, fiber specifications will affect V-groove clamping, Z-stage position, electrode position and movement, arc power, and arc time to name a few. Fiber specifications will also affect fiber preparation, test instrument setup, and data interpretation. Optimizing the estimation parameters for certain fiber types is also required. Knowing the key splice mode parameters which require modification from splice combination to combination is crucial to successful splice optimizations.

3. Environmental factors such as humidity, temperature, altitude, and barometric pressure

Environmental characteristics can have a negative impact on splice quality. Humidity primarily affects arc power due to the presence of varying levels of moisture. Humidity may require an increase in arc power since water molecules can absorb heat produced by the arc. A decrease in pressure will require a higher arc power due to the corresponding lower density of air molecules – the inverse of both is also true. This can be overcome by maintaining a regular arc calibration schedule. Environmental control is of key concern in high tensile strength splice applications as well.

If you have additional questions or inquiries, please contact AFL Technical Support at 1-800-866-3602.

Application Note

Introduction to Creating Your Own Splice Recipes (cont.)

Building a Splice Mode

In order to get started creating a splice mode, use the following steps as a guide to help you get started:

1. From the Ready screen, press the [MENU] button, press [SELECT] to enter the Select Splice Mode screen, and scroll to a blank splice mode (Figures 1 and 2) that will hold the splice recipe.

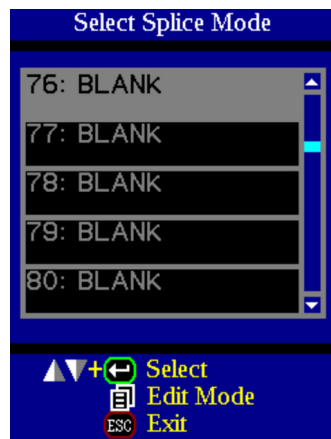


Figure 1 — Select a Blank Splice Mode

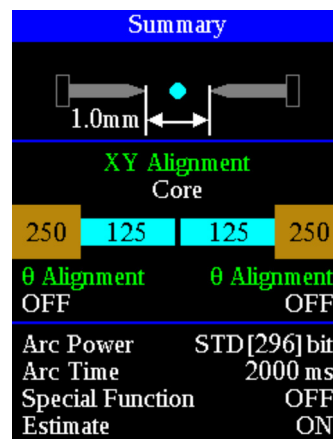


Figure 2 — Splice Mode Summary

2. Press the [MENU] button to edit the splice mode – when pressed, you will be informed that no parameters exist for this mode and will be prompted to choose a fiber type (Figure 3). If there is not an exact match, choose the closest match and proceed to dial in the rest of the parameters in the Edit Splice Mode menu (Figure 4).

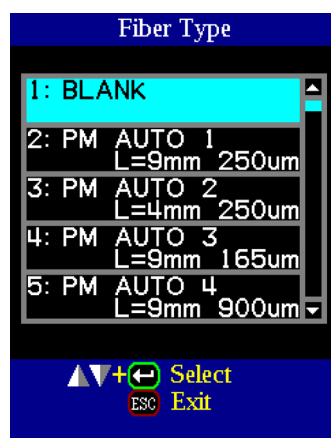


Figure 3 — Select a Blank Splice Mode

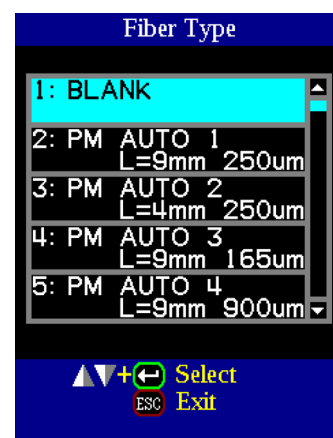


Figure 4 — Starting page of "Edit Splice Mode" menu

If you have additional questions or inquiries, please contact AFL Technical Support at 1-800-866-3602.

Application Note

Introduction to Creating Your Own Splice Recipes (cont.)

3. Choose the operating mode for building your set of parameters (**Figure 5**).

- Full mode provides the full array of options that the splicer offers for maximum control – most used operating mode
- Basic mode pares back the available options, specifically if only a few parameters are being changed or if it is a relatively simple splice.
- Fiber Shaping mode operates best in tandem with the Fiber Processing Software (FPS), developed by AFL, to control and expand the capabilities of the FSM-100 and LZM-100 Series Splicers. “Fiber Shaping” mode runs most closely in conjunction with the “Special Functions” option on page 6-C to create ball lenses, end caps, specialty tapers, and other components.

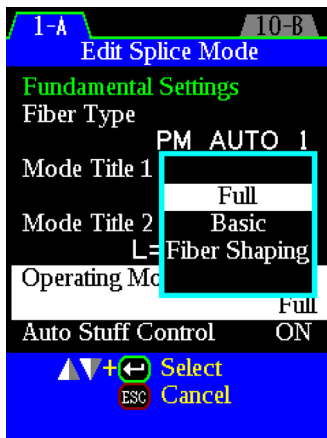


Figure 5 — Choose an Operating Mode



Figure 6 — Input fiber information

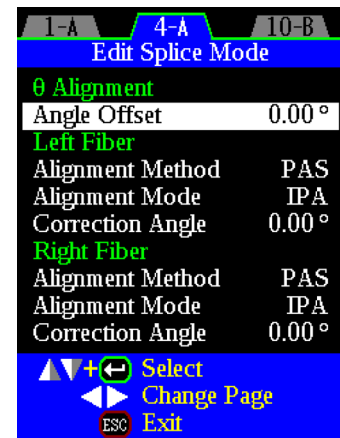


Figure 7 — Theta-Alignment

- Before changing any parameters, navigate to pages 2-A and 2-B (**Figure 6**) to input all fiber dimension and placement information. This information will inform the splicer the size of each fiber and how it will be placed in the V-grooves. Also, how close each fiber end is to the center, between the electrode tips.
- Proceed to the Theta-Alignment settings on pages 4-A through 4-C (**Figure 7**). FSM-100M/M+ users, skip this section. The parameters in this section allow you to control the method and mode of how the fibers are rotationally aligned.
 - For example, you may change the Alignment Method to P-Meter if you want to use a light source and power meter to align the fibers instead of PAS. You might use the Power Meter alignment method for aligning fibers that could be difficult for the PAS method to align. For example, you may be aligning fibers that have a very low contrast between the indices of refraction for the core and the cladding or fibers that have an unknown/irregular brightness intensity profile.
 - When using the PAS Alignment Method, it is important to select the correct Reference Method and Reference Model from page 4-C. The Reference Method tells the splicer if similar or dissimilar fibers are being spliced together, and the Reference Model gives you the option to tell the splicer what general profile to look for and compare the two fibers against.
 - When using Same Fiber, the splicer will analyze one fiber and then rotate the other fiber until the profiles match.
 - When using Diff Fiber, the splicer will independently develop a profile for both fibers and then align them to the best of its ability based on the Reference Model you choose.
 - When choosing a reference model, if you know one or both of your fibers, select the reference model that correlates with each fiber. Refer to the Instruction Manual for more information on IPA Data Learning and generating reference models.

If you have additional questions or inquiries, please contact AFL Technical Support at 1-800-866-3602.

Application Note

Introduction to Creating Your Own Splice Recipes (cont.)

6. Proceed to the spatial and optical alignment settings in pages 5-A and 5-B (**Figure 8**).

- Similar to the Theta-Alignment method discussion from step 5), the XY alignment method can be switched between PAS, P-Meter, and OFF. Again, this can be particularly helpful for fibers that do not have a known or well-defined profile, allowing the power meter to interpret the lowest measured loss as indicating optimal alignment of the cores.
- Choosing between Core, Cladding, Auto, or Manual as an alignment mode may require some experimentation, but as a general rule it depends on the concentricity of the core and cladding as well as cladding geometry. Very often, the cladding is quicker to align. For very high-quality fiber it can infer quite accurate core alignment, however in most cases there is no substitute for the accuracy and precision of true core-alignment.
 - Additionally, if you are splicing fiber that has high eccentricity of the core relative to the cladding, be sure to enable ECF (Eccentricity Correction Function) after selecting Core alignment mode. This allows users to align the cores of fibers having poor core-to-cladding concentricity while allowing the claddings to remain misaligned to accommodate the fibers' geometrical asymmetry and eliminate smearing of the cores as the fibers melt together.

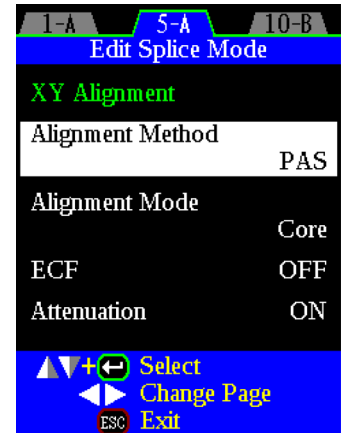


Figure 8 — XY Spatial Alignment

7. Proceed to the arc control settings in pages 6-A through 6-C (**Figures 9 and 10**).

- Prefuse is the arc that heats up the fibers before they are stuffed together. If Prefuse Power is set too high or Prefuse Time is set too long, the fibers are exposed to excessive heat and may incur high splice losses. Conversely, if Prefuse Power is set too low, or Prefuse Time is set too short, the stuffing action may introduce axial offsets due to inadequate melting of the fibers.
- Overlap is the amount that the fibers are stuffed together. In general, this value should increase or decrease as Prefuse Power and Prefuse Time increase or decrease. If Overlap is set to too large of a value and Prefuse Time/Power is set too low, the fibers will not be soft enough to stay aligned at the joint and may bend, chip, or break as they are pushed together. This will result in either a poor splice or a failure to successfully splice.
- When determining the fusing parameters, it's important to note that the Main Arc Time is the total amount of time that the arc is discharging. Prefuse Time is simply the beginning portion of the main arc. You will likely need to do some experimentation in order to determine the fusing power and fuse time that is best for your splice.
 - **Example:** If Main Arc Time is 2000 ms and Prefuse Time is 50 ms, then the arc "fires up" for 50 ms before the fibers touch, and then continues arcing for 1950 ms after the fibers are pushed together.
- For example, if you are splicing dissimilar MFD/NA fibers, you may want to lower the Main Arc Power and increase the Main Arc Time. The goal of this change would be to allow the MFD of the smaller fiber to expand and meet the larger fiber's MFD while not expanding the MFD of the larger fiber. As previously mentioned, you may need to experiment in order to reach optimal results based on your particular constraints.

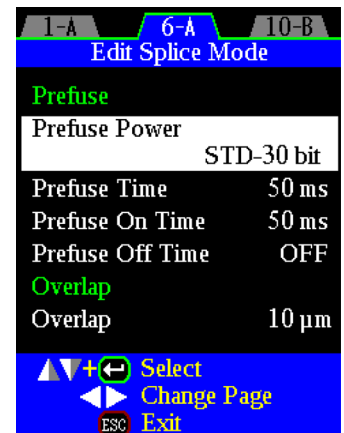


Figure 9 — Set Prefuse Power/Time

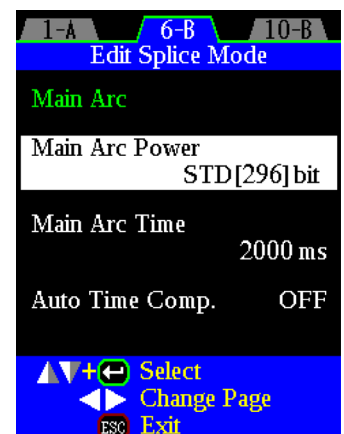


Figure 10 — Main Arc

If you have additional questions or inquiries, please contact AFL Technical Support at 1-800-866-3602.

Application Note

Introduction to Creating Your Own Splice Recipes (cont.)

8. Proceed to the estimation settings in pages 7-A through 8-A. FSM-100M/M+ users will not have page 8, and FSM-100P/P+ users who have selected IPA, IPA2, or End-View can navigate to page 8-B/C (**Figure 11**) to further view and adjust estimation settings.

- The main adjustments that are likely to be made in the estimation settings are:
 - Axis Offset – If you’re splicing fibers that need to be aligned by the cladding, it’s important to make sure that the axis offset method matches the alignment method in order to get accurate estimations.
 - MFD Mismatch – In keeping with the prior example regarding dissimilar MFD fibers, if you’re splicing dissimilar MFD fibers, enable the warm splice image or cold splice image to incorporate the MFD Mismatch contribution to the estimated splice loss.
- For FSM 100P/P+ users who are aligning PM fibers, you can choose the readout of angular alignment estimation based on the measurement setup that you are using. For example, you may have a PER meter set up to measure the effects of the splice on transmitted polarization states. In that case, it would be more helpful to estimate Deg & PER than Deg & CT.

9. Proceed to the error settings in pages 10A-10B (**Figure 12**).

- In most cases the factory error thresholds function quite well as a starting point. When you’re building a recipe, however, the error limit pages are where you go to fine-tune the sensitivity of your splice recipe.
 - For example, if you have found a working splice recipe, but you need very strict quality control on the splices that are deemed “acceptable,” turn down the Error Limit Thresholds such as Loss Limit, Fiber Angle Limit, and Arc Center Limit to make your recipe more sensitive.
- The same applies to the splice defect sensitivity settings on page 10-B (**Figure 13**). Some types of fiber appear to have formed a defect such as a bubble or a hot spot at the joint during the splice – even when they have been spliced correctly and measure little to no loss. This can be normal, depending on the designs of the fibers spliced. In this situation, first verify that it is a good splice, and either reduce the sensitivity to that defect or turn it off altogether.

Wrapping Up

Taking these guidelines as a starting point, continue to experiment with changes to different parameters to observe the effect each change has. Use that information to determine the way that parameter changes affect the splice outcome. Consider supplemental tools to developing optimal splice recipes as well. The Fiber Processing Software (FPS) is beneficial for quicker and more accurate data collection and optimization efforts. See the AFL [Fiber Processing Software webpage](#) for more details.

These introductory steps will get you started with the process of developing a splice recipe. The Instruction Manual offers further detail as to the function and effect of each parameter in splice mode setup.

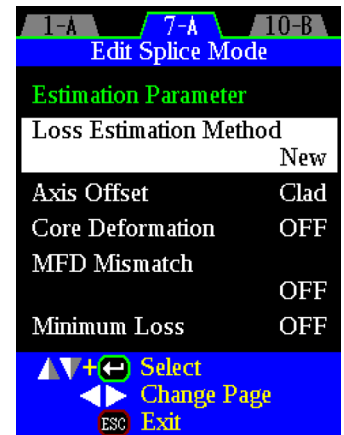


Figure 11 — Loss Estimation

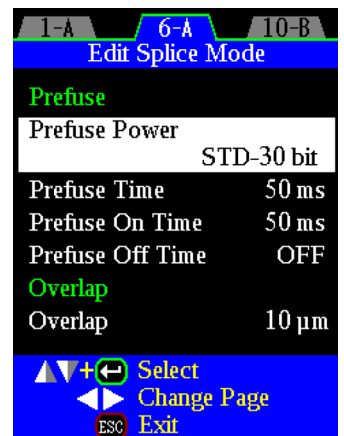


Figure 12 — Error Limit Threshold

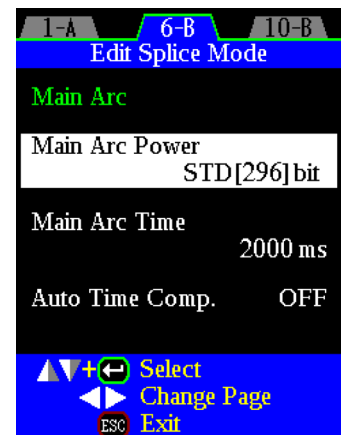


Figure 13 — Splice Defect Sensitivity

If you have additional questions or inquiries, please contact AFL Technical Support at 1-800-866-3602.