

Available Source Capacity Calculation and Configuration

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Introduction

Qualified Persons



WARNING

Only qualified persons who are knowledgeable in the installation, operation, and maintenance of overhead and underground electric distribution equipment, along with all associated hazards, may install, operate, and maintain the equipment covered by this publication. A qualified person is someone who is trained and competent in:

- The skills and techniques necessary to distinguish exposed live parts from nonlive parts of electrical equipment
- The skills and techniques necessary to determine the proper approach distances corresponding to the voltages to which the qualified person will be exposed
- The proper use of special precautionary techniques, personal protective equipment, insulated and shielding materials, and insulated tools for working on or near exposed energized parts of electrical equipment

These instructions are intended only for such qualified persons. They are not intended to be a substitute for adequate training and experience in safety procedures for this type of equipment.

Read this Instruction Sheet

NOTICE

Thoroughly and carefully read this instruction sheet and all materials included in the product's instruction handbook before installing or operating an IntelliTeam SG Automatic Restoration System. Become familiar with the Safety Information on page 4. The latest version of this publication is available online in PDF format at sandc.com/en/support/product-literature/.

Retain this Instruction Sheet

This instruction sheet is a permanent part of the IntelliTeam SG Automatic Restoration System. Designate a location where users can easily retrieve and refer to this publication.

Proper Application



WARNING

The software in this publication is only intended for a specific application. See Specification Bulletin 1044-31.

Warranty

The warranty and/or obligations described in S&C's Price Sheet 150, "Standard Conditions of Sale—Immediate Purchasers in the United States," (or Price Sheet 153, "Standard Conditions of Sale—Immediate Purchasers Outside the United States"), plus any special warranty provisions, as set forth in the applicable product-line specification bulletin, are exclusive. The remedies provided in the former for breach of these warranties shall constitute the immediate purchaser's or end user's exclusive remedy and a fulfillment of the seller's entire liability. In no event shall the seller's liability to the immediate purchaser or end user exceed the price of the specific product that gives rise to the immediate purchaser's or end user's claim. All other warranties, whether express or implied or arising by operation of law, course of dealing, usage of trade or otherwise, are excluded. The only warranties are those stated in Price Sheet 150 (or Price Sheet 153), and THERE ARE NO EXPRESS OR IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. ANY EXPRESS WARRANTY OR OTHER OBLIGATION PROVIDED IN PRICE SHEET 150 (OR PRICE SHEET 153) IS GRANTED ONLY TO THE IMMEDIATE PURCHASER AND END USER, AS DEFINED THEREIN. OTHER THAN AN END USER, NO REMOTE PURCHASER MAY RELY ON ANY AFFIRMATION OF FACT OR PROMISE THAT RELATES TO THE GOODS DESCRIBED HEREIN, ANY DESCRIPTION THAT RELATES TO THE GOODS, OR ANY REMEDIAL PROMISE INCLUDED IN PRICE SHEET 150 (OR PRICE SHEET 153).


End User License Agreement

The end user is granted a nontransferable, non-sublicensable, nonexclusive license to use the IntelliTeam® Designer software, IntelliLink® Setup Software, IntelliTeam SG Automatic Restoration software, and/or other software furnished with the IntelliTeam SG Automatic Restoration System only upon acceptance of all the terms and conditions of the seller's end-user license agreement set forth in Price Sheet 155.


Safety Information

Understanding Safety-Alert Messages


Several types of safety-alert messages may appear throughout this instruction sheet. Become familiar with these types of messages and the importance of these various signal words:

 **DANGER**

“DANGER” identifies the most serious and immediate hazards that will result in serious personal injury or death if instructions, including recommended precautions, are not followed.

 **WARNING**

“WARNING” identifies hazards or unsafe practices that can result in serious personal injury or death if instructions, including recommended precautions, are not followed.

 **CAUTION**

“CAUTION” identifies hazards or unsafe practices that can result in minor personal injury if instructions, including recommended precautions, are not followed.

NOTICE


“NOTICE” identifies important procedures or requirements that can result in product or property damage if instructions are not followed.

Following Safety Instructions

If any portion of this instruction sheet is not understood and assistance is required, contact the nearest S&C Sales Office or S&C Authorized Distributor. Their telephone numbers are listed on S&C’s website **sandc.com**, or call the S&C Global Support and Monitoring Center at 1-888-762-1100.

NOTICE

Read this instruction sheet thoroughly and carefully before installing or operating the IntelliTeam SG Automatic Restoration System.



Replacement Instructions and Labels

If additional copies of this instruction sheet are required, contact the nearest S&C Sales Office, S&C Authorized Distributor, S&C Headquarters, or S&C Electric Canada Ltd.

It is important that any missing, damaged, or faded labels on the equipment be replaced immediately. Replacement labels are available by contacting the nearest S&C Sales Office, S&C Authorized Distributor, S&C Headquarters, or S&C Electric Canada Ltd.

Before restoring load on a faulted circuit from an alternate source, the IntelliTeam system must know the available capacity of the alternate source. The available capacity takes into account capacity limitations resulting from circuit equipment and wires, existing loads already fed by that alternate source, and in some cases distributed generation installations. With this information the IntelliTeam system can reliably prevent overloading the alternate source during restoration events.

The IntelliTeam software has two different operation methods: the IntelliTeam SG Automatic Restoration System and the IntelliTeam II Automatic Restoration System. The IntelliTeam II system is compatible with older systems and is most effective on a typical radial-feeder configuration. The IntelliTeam SG system includes the **Rapid Self-Healing** feature and is compatible with systems that have distributed generation and load flowing in both directions on the circuit.

The calculation of available source capacity and the related configuration are different for the two IntelliTeam system methods. The following step-by-step instructions cover the IntelliTeam II and IntelliTeam SG systems separately.

IT-II mode uses a result-propagated method of calculating available source capacity. As the available source capacity is calculated, it uses the result determined at the upstream team to help determine the result at the downstream team. The final result given to the normally open tie switch has been continually propagated and updated from the Source/Sub switch to each mid-circuit main-line switch and finally to the tie switch.

The available source capacity calculation used by **IT-II** mode uses only the **Maximum Capacity** configuration setting and the optional settings associated with the **Real-time Feeder Loading** feature.

STEP 1. Configure the **Maximum Capacity** setting.

The user-configurable **Maximum Capacity** setting is the maximum load (in amperes) a team member can carry because of limitations such as conductor size and device rating. This must be configured separately for each team in which the switch is a member. See Figure 1.



Figure 1. The **Setup>Restoration>IntelliTeam SG>Team 1** screen **Maximum Capacity** setting.

Providing the **Maximum Capacity** setting for each team allows a distribution engineer to configure a switch location to support different capacities in each direction. This has obvious applications, such as actual switch capacity and wire size. However, other, less-obvious applications make this feature even more powerful because independent capacity settings can address unique circuit conditions.

See S&C Instruction Sheet 1044-584, “IntelliTeam® SG Automatic Restoration System: *Maximum Capacity Setup and Configuration*,” for information about configuring the **Maximum Capacity** setting.

STEP 2. Configure the **Real-time Feeder Loading** feature (if applicable).

Parameters associated with Real-time Feeder Loading are the **Maximum Source Capacity**, **Default Source Segment Loading** and **Real-time Feeder Loading Valid Timer** settings. These settings are only configured at the team member closest to the substation. This is the team member configured as the Source/Sub or Tie/Sub switch.

Use of the **Real-time Feeder Loading** feature is optional in the IntelliTeam II system. When these parameters are not configured (left at default settings), the IntelliTeam II system uses the **Maximum Capacity** setting associated with the first switch outside the substation as the maximum source capacity. In this case, loading between the substation and the first switch will not be included in the available source capacity calculation.

When using the **Real-time Feeder Loading** feature, four settings must be configured. Three settings are on the *Setup>Restoration>IntelliTeam SG>External Loading* screen. The fourth setting is configured through the SCADA system. See Figure 2.



Figure 2. The *Setup>Restoration>IntelliTeam SG>External Loading* screen.

(a) Configure the **Maximum Source Capacity** setting.

The **Maximum Source Capacity** setting is the maximum feeder capacity (in amperes) as viewed from the substation end of the feeder. Configure this value to represent the maximum three-phase average load the feeder can carry at any time.

(b) Configure the **Default Source Segment Loading** setting.

The **Default Source Segment Loading** setpoint is the estimated peak three-phase average load (in amperes) of the source-side segment between the substation-feeder breaker and first IntelliTeam system team member. Configure this value to represent the estimated maximum load to be used in the event real-time feeder loading data are not available or valid.

- (c) Configure the **Real-time Feeder Loading Valid Timer** setting.

The **Real-time Feeder Loading Valid Timer** starts counting when SCADA receives real-time feeder loading data. Configure this setting to a period longer than the interval the SCADA system will use when sending loading data. If the loading data are not updated within the configured interval (in minutes), rather than continue to use a value that may no longer represent real-time feeder loading, the loading calculations will default to using the **Default Source Segment Loading** value.

- (d) Configure the SCADA system to supply source loading data.

All IntelliTeam system products include the **Real-Time Feeder Loading** DNP analog output point. This point can be mapped on the *Setup>Point Mapping>Analog Output Points* screen for access by the SCADA system. The SCADA system should load this analog output with the total averaged three-phase feeder loading (in amperes), measured at the source breaker.

The SCADA system should be configured to send a DNP Analog Output Block (Object 41) with either a 32-bit value (Variation 1) or a 16-bit value (Variation 2) to the analog output point number mapped for the **Real-Time Feeder Loading** value to the RTU address of the team member closest to the substation. This is the team member configured as the Source/Sub or Tie/Sub switch.

The *Setup>Point Mapping>Analog Output Points* screen, shown in Figure 3, has the configuration parameters for analog output points. Map these points to make them available in the SCADA system.

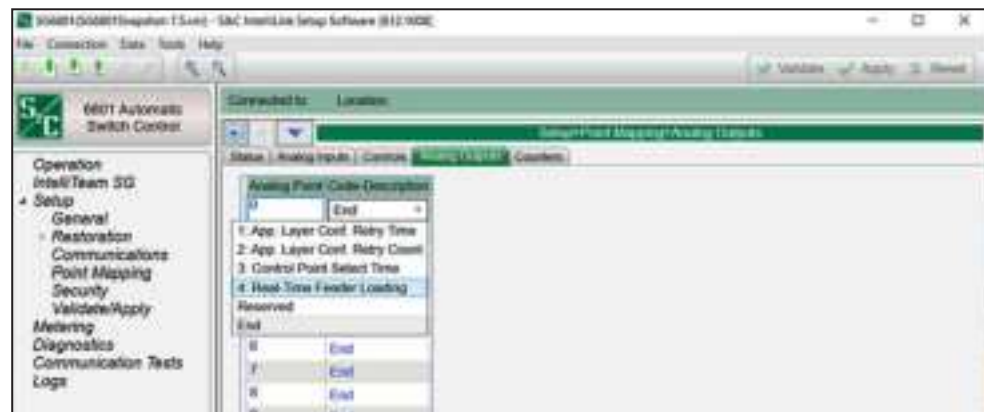


Figure 3. The *Setup>Point Mapping>Analog Outputs* screen.

Analog Point

This is the point number the SCADA system will use when operating the analog output.

Code-Description

These are the point codes representing specific analog outputs that may be assigned to individual SCADA point numbers. Setting a Code-Description point code to the **End** setting defines the end of the configured points list and the maximum number of analog output points that can be returned.

Result using the Real-time Feeder Loading feature

When the **Real-time Feeder Loading** feature is used, the available source capacity is calculated at the Source/Sub or Tie/Sub switch as follows:

- When SCADA receives an analog output with the present real-time feeder loading, if the **Maximum Source Capacity** setting is greater than the present real-time feeder loading, the available capacity is the **Maximum Source Capacity** setting minus the present real-time feeder loading. If the **Maximum Source Capacity** setting is less than the present real-time feeder loading, the available source capacity is 0.
- When SCADA has not received the present real-time feeder loading within the **Real-time Feeder Loading Valid Timer** setting, if the **Maximum Source Capacity** setting is greater than the **Default Source Segment Loading** setting plus the three-phase average real-time loading measured at the switch, the available source capacity is the **Maximum Source Capacity** setting minus the **Default Source Segment Loading** setting minus the three-phase average real-time loading measured at the switch. If the **Maximum Source Capacity** setting is less than the **Default Source Segment Loading** setting plus the three-phase average real-time loading measured at the switch, the available source capacity is 0.

See examples of the **IT-II** mode calculation process for determining the available source capacity in the “Examples/Use Cases” section on page 20.

The IntelliTeam SG system uses a netlist and runners to distribute data throughout the system, allowing the available source capacity calculation to include data beyond the directly adjacent teams and incorporate contributions from additional sources.

The available source capacity calculation used by the IntelliTeam SG system uses the following configuration parameters:

- Primary voltage classification
- Maximum capacity
- Real-time feeder loading
 - Maximum source capacity
 - Default source segment loading
 - Real-time feeder loading valid timer
- Default DG load contribution
- Transfer trip
- Overload permitted
- Restore to overload plus max capacity

Complete the following steps to fully configure available source capacity calculations for the various circuit scenarios:

STEP 1. Configure the **Primary Voltage Classification** setting.

During capacity calculations for a circuit, any one device may use the data associated with devices throughout the circuit. If the circuit includes primary voltage transformation midway on the main line, the scale of these data will not be wholly consistent. In other words, some of the data might be associated with devices on the other side of a step-down transformer.

To handle the presence of a step-down transformer, a scale factor derived from the local and remote system voltage classifications must be used to scale these data to represent local values. To do this, the IntelliTeam SG runner distributes the system voltage classification of each device on the circuit to all other devices.

It is critical that the user configures the **Line kV to 120 Vac Base Ratio** and **System Phase-to-Phase Voltage** settings correctly in the corresponding products. Incorrect settings will result in incorrect circuit capacities.

It is important that the primary voltage classification is set correctly, even on systems where no step-down transformer is installed, because in the IntelliTeam SG system the loading distributed throughout the teams is in units of kVA. Each team member converts the kVA units to simple amps to represent values related to the local system voltage.

IntelliRupter® Fault Interrupter

For the IntelliRupter fault interrupter, the associated configuration settings are **System Frequency** and **System Phase-to-Phase Voltage**. See Figure 4.

The screenshot shows the configuration interface for the IntelliRupter Fault Interrupter. The left sidebar contains a tree view with categories like Operation, Setup, Protection, and Diagnostics. The main area is titled 'Setup>General>Site-Related' and displays a list of configuration parameters. A red box highlights the 'System Frequency' and 'System Phase-to-Phase Voltage' settings.

Parameter	Value	Default
Pole 1 Phase Label (1 char)	1	
Pole 2 Phase Label (1 char)	2	
Pole 3 Phase Label (1 char)	3	
Phase Rotation	123	(Default 123)
Direction 1 (Direction 2)	X-Y	(Default X-Y)
Label for Direction 1 (6 char limit)	Dir1	
Label for Direction 2 (6 char limit)	Dir2	
Normal Power Flow	X-Y	(Default X-Y)
System Type	Auto (auto)	(Default Auto (auto))
System Frequency	60 Hz	
System Phase-to-Phase Voltage	12.47 kV	(Range: 4.00-40.00 Step: 0.01 Default: 12.47)
Voltage Reporting	Phase to Ground	(Default Phase to Ground)
Voltage Reporting Base	kV	(Default (kV) 133)
Backup Voltage Limit	10 %	(Range: 0-100 Step: 1 Default: 10)
Power Factor Sign Convention	EC	(Default EC)
Maximum Interrupting Current	12.5 kA	(Default 12.5 kA)
Use Last Used Poles First in Closing Profiles	No	(Default No)
Frequency Difference Threshold	Disrupt	(Range: 0-1.0 Step: 0.1 Default: Disrupt)

Figure 4. The Setup>General>Site-Related screen for the IntelliRupter fault interrupter.

System Frequency

Select the **System Frequency** setting, either the **60-Hz** or **50-Hz** option.

System Phase-to-Phase Voltage

Enter the value of the **System Phase-to-Phase Voltage** setting in kV. (Range: 4.00-40.00; Step: 0.01 kV; Default: 12.47)

6800-Series Products

For the 6800 Series Automatic Switch Control, the associated parameters are the **Line kV to 120 Vac Base Ratio**, the **Voltage Transformer Wiring**, and the **Nominal Operating Frequency** settings. See Figure 5.

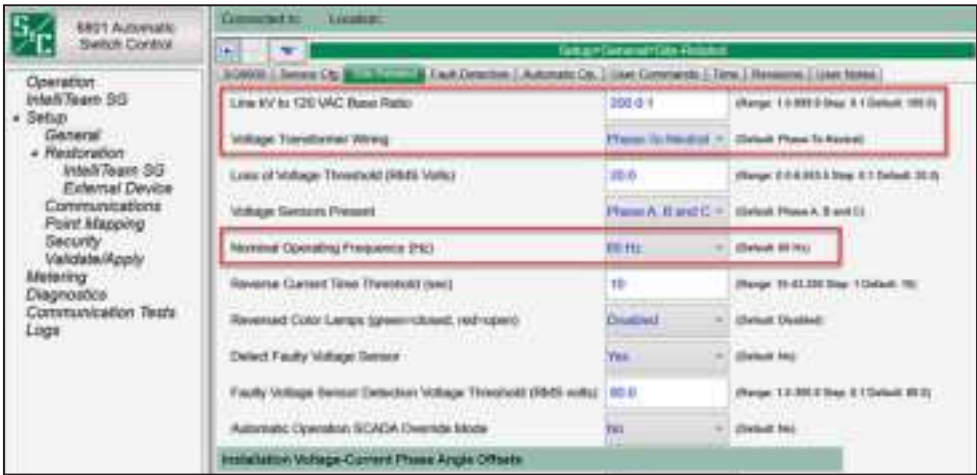


Figure 5. The 6801 Control Setup>General>Site-Related screen.

Line kV to 120 Vac Base Ratio

This is the voltage step-down ratio of all customer-load transformers on the feeder. The switch control records, displays, and manipulates voltages normalized on a 120-Volt or 240-Volt base. This setting is the conversion ratio from line voltage to base voltage. (Range: 1.0-999.9; Step: 0.1; Default: 100.0)

Enter the ratio for transformers wired the same way (phase to phase or phase to neutral) as the value entered for the **Voltage Transformer Wiring** setting in the following examples:

Example 1—For a four-wire, wye, multi-grounded, 24.9-kV, phase-to-phase primary distribution system with phase-to-neutral connected customer single-phase transformers rated 14,400/120 Volts, enter a ratio of 120:1 and select the **Phase-To-Neutral** setting for the **Voltage Transformer Wiring** setpoint.

Example 2—For a three-wire, wye, 12-kV, phase-to-phase primary distribution system with phase-to-phase connected customer transformers rated 12,000/120 Volts, enter a ratio of 100:1 and select the **Phase-To-Phase** setting for the **Voltage Transformer Wiring** setpoint.

Voltage Transformer Wiring

This configures the switch control for customer-voltage reporting. The control uses this information when calculating kvars. For delta voltage reporting, select the **Phase-To-Phase** setting for this setpoint. For wye voltage reporting, select the **Phase-To-Neutral** setpoint. (Default: Phase-To-Neutral)

Nominal Operating Frequency

Set this to the nominal operating frequency in Hertz for the distribution system. (Default: 60 Hz)

IntelliNode™ Interface Module

For the IntelliNode module, the associated configuration parameters are the **System Frequency** and the **System Phase-to-Phase Voltage** setpoints. See Figure 6.

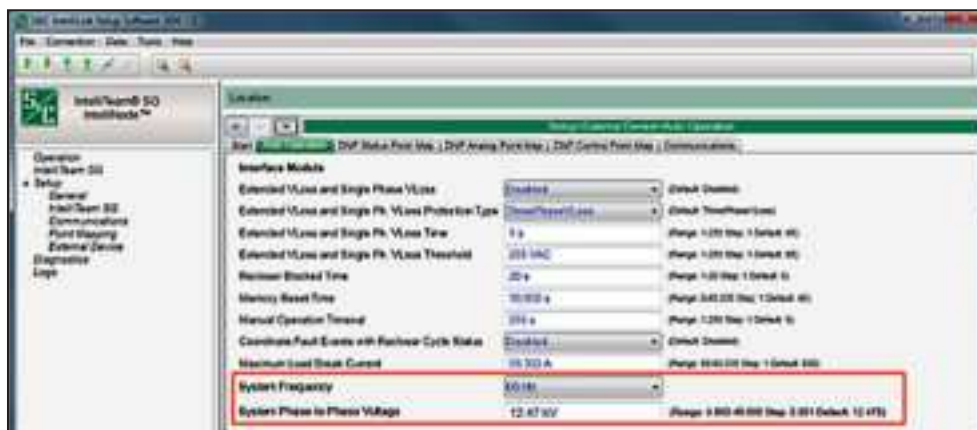


Figure 6. The IntelliNode module **Settings>External Device>Auto Operation** screen.

System Frequency

Select the **System Frequency** setpoint, either the 60-Hz (default) or 50-Hz option.

System Phase-to-Phase Voltage

Enter the **System Phase-to-Phase Voltage** setting in kV. (Range: 4.00-40.00; Step: 0.01 kV; Default: 12.47)

STEP 2. Configure the **Switch Maximum Capacity** setting.

Configuring maximum capacity at each switch and in each team for the IntelliTeam SG system is similar to, and has the same purpose as, configuring the **IT-II** mode, described in Step 1 on page 6. Instead of configuring the **Maximum Capacity** setting on the various team setup screens in IntelliLink® Setup Software, for the IntelliTeam SG system, the **Switch Maximum Capacity** value is entered in the IntelliTeam® Designer application on the *Netlist Configuration>Team Member Attributes* screen. See Figure 7 on page 14.

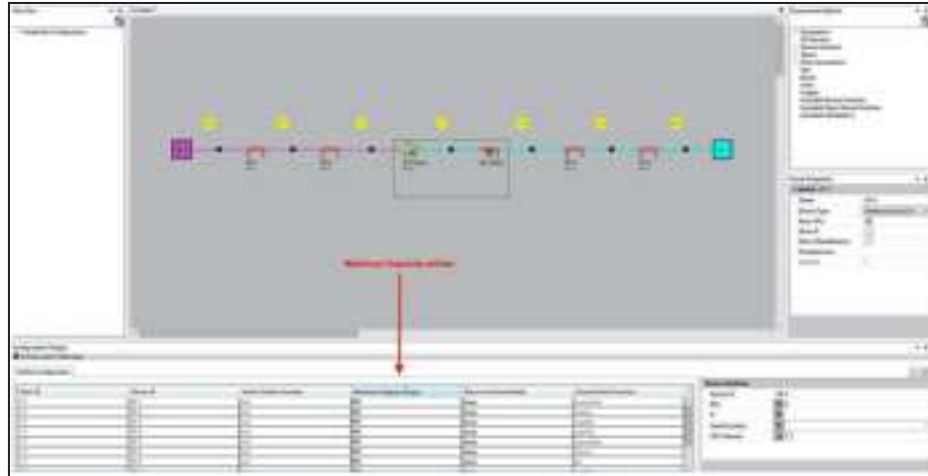


Figure 7. The IntelliTeam Designer software Substation Attribute tab.

See S&C Instruction Sheet 1044-584, “IntelliTeam® SG Automatic Restoration System: *Maximum Capacity Setup and Configuration*,” for information about configuring the **Maximum Capacity** setting.

STEP 3. Configure the **Maximum Capacity** setting.

When enabled, the maximum capacity of the feeder source is used in all IntelliTeam SG system available source capacity calculations. Configure the **Maximum Capacity** setting in the IntelliTeam Designer application on the *Netlist Configuration>Substation Attributes* screen. See Figure 8.



Figure 8. The Maximum Capacity entry in the IntelliTeam Designer software.

Set Max Capacity As Disabled

Checking this check box prevents maximum capacity from being a factor in available source capacity calculations.

Maximum Capacity

The **Maximum Source Capacity** threshold is defined as the maximum load a source can carry before it is considered to be in an **Overload** condition. (This is disabled when the Set Max Capacity As Disabled check box is checked.)

Note: This setting must be used with the **Default Source Segment Loading** setting on the *Setup>Restoration>IntelliTeam SG>External Loading* screen in the IntelliLink software for the **Real-time Feeder Loading** feature to be available. See Figure 9 on page 15.



Figure 9. The Setup>Restoration>IntelliTeam SG>External Loading screen.

STEP 4. Configure the **Real-Time Feeder Loading** feature (if applicable).

Configuring the parameters associated with the **Real-time Feeder Loading** feature for the IntelliTeam SG system has the same purpose as configuration for the IntelliTeam II system. See Step 2 on page 7.

- Be sure the **Maximum Source Capacity** setting is enabled from Step 3 on page 14.
- Configure the **Default Source Segment Loading** setting in IntelliLink software.

The **Default Source Segment Loading** setting is the estimated peak three-phase average load (in amperes) of the source-side segment between the substation-feeder breaker and first IntelliTeam team member. Configure this value to represent the estimated maximum load to use in the event real-time feeder loading data are not available or valid.

- Configure the **Real-Time Feeder Loading Valid Timer** setting in IntelliLink software.

The **Real-Time Feeder Loading Valid Timer** setting starts counting when real-time feeder loading data are received through SCADA. Configure this parameter to a period longer than the interval the SCADA system will use when sending loading data. If the loading data are not updated within the configured interval (in minutes), rather than continuing to use a value that may no longer represent real-time feeder loading, the loading calculations will default to using the **Default Source Segment Loading** value.

- Configure the SCADA system to deliver source loading.

All IntelliTeam products include the DNP Analog Output point **Real-Time Feeder Loading**. This point can be mapped on the Setup>Point Mapping>Analog Outputs screen for access by the SCADA system. The SCADA system should load this analog output with the total averaged three-phase feeder loading (in amperes), measured at the source breaker.

Configure the SCADA system to send a DNP Analog Output **Block** value (Object 41) with either a 32-bit value (Variation 1) or a 16-bit value (Variation 2) to the analog output point number that was mapped to the **Real-Time Feeder Loading** setting and the RTU address of the team member closest to the substation. This is the team member configured as the Source/Sub switch or Tie/Sub switch.

The *Setup>Point Mapping>Analog Outputs* screen, shown in Figure 10, contains configuration parameters for analog output points. Map the **Real-Time Feeder Loading** analog output point to make that available from the SCADA system.

Analog Point: This is the analog point number the SCADA system will use when sending the analog output.

Code-Description: These are the point codes representing specific analog outputs that may be assigned to individual SCADA point numbers. Setting a **Code-Description** point code to the **End** setting defines the end of the configured points list and the maximum number of analog outputs that can be returned.



Figure 10. The *Setup>Point Mapping>Analog Outputs* screen.

STEP 5. Configure the **Default DG Load Contribution** setting (if distributed generation is present).

When distributed generation is present on the system and is included in the IntelliTeam SG System's feeder configuration, the **Default DG Load Contribution** setting can be used at the team member directly associated with the distributed generation to include a static distributed generation load contribution value in the available source-capacity calculation. Set this value to the current in amperes the distributed generation is typically contributing to the distribution system under normal conditions. This value will be included in all capacity calculations. See Figure 11 on page 18.

However, including real-time loading data from the distributed generation in the available source-capacity calculation will result in much more accurate source capacity being used by the IntelliTeam SG system. This is preferred. When the team device directly associated with the distributed generation is an IntelliNode/Info-Only module that is actively polling the distributed generation for real-time loading data, the **Default DG Load**

Contribution setting in the IntelliNode module should be set to zero (Disabled) so the real-time loading data received from the distributed generation is included in all available source capacity calculations instead.

When the **Default DG Load Contribution** setting is a non-zero value and the distributed generation device is teamed with an IntelliNode/Info-Only module, the IntelliTeam SG system uses the configured value as the amount of current flowing from the distributed generation into the distribution system, even if real-time data is actively being polled from the distributed generation. When the **Default DG Load Contribution** setting is zero (the default), the IntelliTeam SG system uses loading polled by the IntelliNode/Info-Only module from the distributed generation as the current the distributed generation is contributing to the distribution system.

The **Default DG Load Contribution** setting is most useful when the team member directly associated with, or teamed with, the distributed generation is an IntelliRupter fault interrupter, IntelliNode module, or a 6800 Series switch control. These devices do not poll the distributed generation for real-time loading data. Using the **Default DG Load Contribution** setting in these cases, if set correctly, will allow customer load between the team device and the distributed generation to be accounted for in the available source capacity calculation. For example, if the **Default DG Load Contribution** setting was 80 amps, but the IntelliRupter fault interrupter, IntelliNode module, or 6800 Series switch control outside the distributed generation measured 25 amps in the direction of the mainline circuit, the available source capacity calculation would use 80 amps as the distributed generation load contribution.

If the **Default DG Load Contribution** setting is lower than its actual contribution to the grid, as seen by the directly associated IntelliRupter fault interrupter, IntelliNode module, or 6800 Series switch control, the value used in the available source capacity calculation will instead be the three-phase current measured at the IntelliRupter fault interrupter, IntelliNode module, or 6800 Series switch control. For example, if the **Default DG Load Contribution** setting was set to 0 but the IntelliRupter fault interrupter outside the distributed generation measured 25 amps going in the direction of the mainline circuit, the available source capacity calculation would use 25 amps as the distributed generation contribution.

The **Default DG Load Contribution** setting is only configurable in the IntelliTeam Designer application on the *Netlist Configuration>Team Member Attributes* screen accessed from the **Distributed Generation Attributes** tab. (Range: 0-1000 A; Default: 0, meaning this is disabled and not used by the IntelliTeam system) See Figure 11 on page 18.

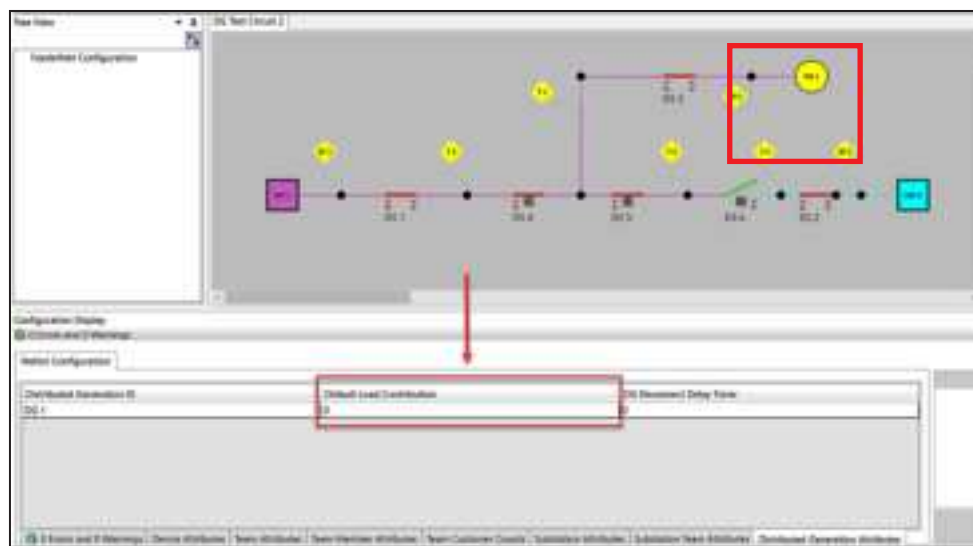


Figure 11. The IntelliTeam Designer Default Load Contribution field.

The **Default DG Contribution** setting is read-only on the IntelliLink software screen. To view the configured value, go to the *Setup>Restoration>IntelliTeam SG>Distributed Generation* screen. See Figure 12.



Figure 12. The Setup>Restoration>IntelliTeam SG>Distributed Generation screen.

Note: The value configured in the **Default DG Load Contribution** setting will only appear on the device teamed with the distributed generation. All other devices on the circuit will display “Disabled.”

See S&C Instruction Sheet 1044-578, “IntelliTeam® SG Automatic Restoration System: *Distributed Generation Setup and Configuration*,” for information about configuring an IntelliTeam SG system with distributed generation.

STEP 6. Configure the **Transfer Trip** setting (if applicable).

If the **Transfer Trip** feature of the IntelliTeam SG system is used to isolate distributed generation and prevent islanding load, the available source capacity calculation will be affected. The **Integrated Extended Load** setting the IntelliTeam SG system calculation uses will take into account all circuit loads and distributed generation load contributions as well as **Transfer Trip** operations that will remove those distributed generation load contributions.

Note: The **Transfer Trip** feature is optional for the IntelliTeam SG system. The **Transfer Trip** feature should only be used when distributed generation is present on the system.

See S&C Instruction Sheet 1044-579, “IntelliTeam SG Automatic Restoration System: *Remote Transfer Trip Setup and Configuration*,” for information about configuring the **Transfer Trip** feature in an IntelliTeam SG system with distributed generation.

One use of the **Transfer Trip** feature is to allow the user to disconnect distributed generation from a feeder immediately prior to that feeder being used to restore load on an adjacent faulted circuit. This **Transfer Trip** operation is only performed if the IntelliTeam SG system restoration logic determines the restoration will be successful and will not overload the circuit.

In this scenario, when calculating the available source capacity of the circuit used to restore load, the internal logic will search for **Transfer Trip** requests configured in the remote transmit list. If a **Transfer Trip** request is found that targets a device on the alternate source circuit, the logic will determine the integrated extended load of the alternate source circuit with the knowledge the distributed generation and any associated load will be disconnected.

If the calculated available source capacity of the alternate source circuit is sufficient to carry the restored load, the **Transfer Trip** operation will be executed prior to closing the normally open tie switch. If the calculated available source capacity is not sufficient, the distributed generation and the load will remain online, and the restoration process will need to look elsewhere for an adequate alternate source.

STEP 7. Configure the **Overload Permitted** and the **Restore to Overload plus Max Capacity** settings (Post Restoration Load Management (PRLM) only).

Leave the **Overload Permitted** and the **Restore to Overload plus Max Capacity** settings at their default values unless using the **Post Restoration Load Management** feature. Configuring the **Overload Permitted** setting and enabling the **Restore to Overload plus Max Capacity** feature will result in an available source capacity calculation that increases the **Maximum Source Capacity** setting by the **Overload Permitted** value. When the **PRLM** feature is not in use, this may unnecessarily overload the alternate source circuit indefinitely.

Post restoration load management is beyond the scope of this application guide. Consult S&C for details on configuration and use of post restoration load management if it is a necessary feature for the system.

See examples of the IntelliTeam SG system calculation process for determining the available source capacity in the “Examples/Use Cases” section on page 20.

Calculating Available Source Capacity in the IntelliTeam II System

The result-propagated method of calculating the available source capacity used by the IntelliTeam II system involves three key values:

- **Extended Load**—This is the two-minute, three-phase average load measured at each team switch. The value includes loading in the adjacent downstream team and all load extending beyond this team.
- **Local Capacity**—This is the initial available capacity calculated at a specific team member, taking into account the **Maximum Capacity** setting of the local switch and the extended load measured at this switch.
- **Real Capacity**—This is the final available capacity calculated at a specific team member, comparing the local capacity with the real capacity of the upstream team. The lesser of the two will be the real capacity for the adjacent downstream team.

This calculation occurs continuously along the circuit and therefore propagates the actual real capacity of the alternate source circuit to the normally open team member.

This example uses the following Maximum Capacity configuration and circuit loading. See Figure 13.

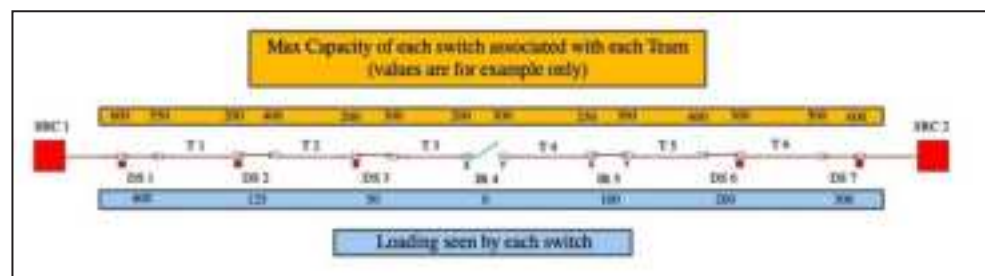


Figure 13. The Maximum Capacity settings and circuit loading.

Example 1: IntelliTeam II System

In this example, the **Real-Time Feeder Loading** feature is not being used. See Figure 14.

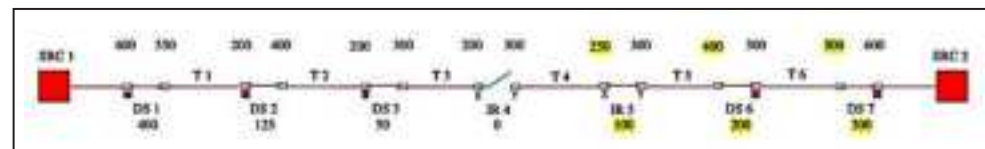


Figure 14. The Real-time Feeder Loading feature is not in use.

At DS7, use the **Maximum Capacity** setting configured for the team on the downstream side of switch DS7, team T6. Switch DS7 is configured for 500 amps on the team T6 side. Subtract the extended load seen by switch DS7 from the maximum capacity: $500 - 300 = 200$ amps of available source SRC2 capacity. Team T6 has 200 amps of real capacity.

At switch DS6, use the **Maximum Capacity** setting for the team on the downstream side of switch DS6, team T5, which is 400 amps. Subtract the switch DS6 extended load from the maximum capacity: $400 - 200 = 200$ amps. Switch DS6 has 200 amps of local capacity. Compare the switch DS6 local capacity with the upstream team T6 real capacity. In this case, they are the same, 200 amps. Team T5 has 200 amps of real capacity.

At switch IR5, use the **Maximum Capacity** setting for the team on the downstream side of switch IR5, team T4, which is 250 amps. Subtract the switch IR5 extended load from the maximum capacity: $250 - 100 = 150$ amps. Switch IR5 has 150 amps of local capacity. Compare the switch IR5 local capacity with the upstream team T5 real capacity. 150 is less than 200, so use the lesser. Team T4 has 150 amps of real capacity.

Effectively, alternate source circuit SRC2 has an available capacity of 150 amps it can offer to SRC1 circuit. The normally open tie switch IR4 holds this available capacity for immediate use should an outage occur. The available capacity is continuously updated in this manner as this calculation process constantly repeats itself.

Example 2: IntelliTeam II System

In this example, the necessary parameters have been configured so the **Real-Time Feeder Loading** feature is used, and the SCADA system has been configured to send feeder loading to the first team member outside the substation.

This circuit is the same as Example 1 but includes use of the **Real-Time Feeder Loading** feature. See Figure 15.

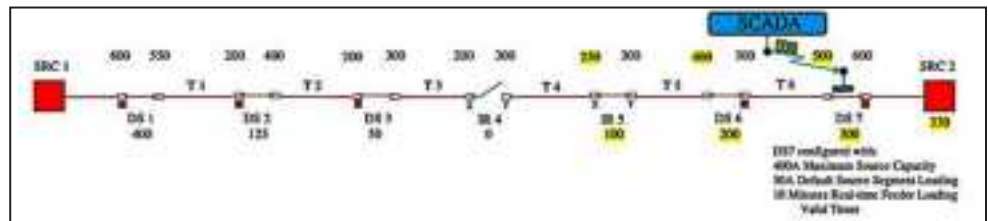


Figure 15. The Real-Time Feeder Loading feature being used.

The **Maximum Source Capacity** setting is 400 amps in switch DS7 for source SRC2. The **Default Source Segment Loading** setting is 50 amps for the estimated peak loading on the line between source SRC2 and switch DS7. The **Real-Time Feeder Loading Valid Timer** setting is 10 minutes in switch DS7, so the available source capacity calculation will use the **Default Source Segment Loading** setting if the SCADA system is unable to refresh the real-time value in switch DS7 within the 10-minute interval.

The last feeder loading value sent from the SCADA system to switch DS7 five minutes ago was 330 amps. The initial available capacity of source SRC2 is therefore the maximum source capacity of 400 minus 330, or 70 amps of available source capacity.

At switch DS7, use the switch **Maximum Capacity** setting for the team on the downstream side of switch DS7, team T6. Switch DS7 is configured for 500 amps on the team T6 side. Subtract the extended load measured at switch DS7 from the maximum capacity: $500 - 300 = 200$ amps of local capacity for team T6. Compare this local capacity with the upstream capacity of 70 amps for source SRC2. The real capacity of team T6 will be the lesser of the two, or 70 amps.

At switch DS6, use the switch **Maximum Capacity** setting for the team on the downstream side of switch DS6, team T5, which is 400 amps. Subtract the switch DS6 extended load from the Maximum Capacity: $400 - 200 = 200$ amps. Switch DS6 has 200 amps of local capacity. Compare the team T5 local capacity with the upstream team T6 real capacity of 70 amps. Again, 70 is the lesser of the two, so team T5 has 70 amps of real capacity.

At switch IR5, use the switch **Maximum Capacity** setting for the team on the downstream side of switch IR5, team T4, which is 250 amps. Subtract the switch IR5 extended load from the maximum capacity: $250 - 100 = 150$ amps. Team T4 has 150 amps of local capacity. Compare the team T4 local capacity with the upstream team T5 real capacity of 70 amps. 70 is less than 150, so again use the lesser 70 amps for the real capacity of team T4.

The result is the alternate source circuit SRC2 has an available capacity of 70 amps it can offer to the SRC1 circuit. The normally open tie switch IR4 holds this available capacity for immediate use should an outage occur. The available capacity is continuously updated in this manner as this calculation process constantly repeats itself.

If the SCADA system was unable to send the real-time loading data within the last 10 minutes, the calculation would use the **Default Source Segment Loading** value instead. In this case, the available source capacity would be calculated as the maximum source capacity minus the default source segment loading minus the extended load measured at switch DS7, or $400 - 50 - 300 = 50$ amps of available source capacity.

The 50 amps of source capacity would be used in the calculation because it propagated the real capacity toward the normally open tie switch. The result would now be 50 amps of capacity source SRC2 could offer to source SRC1 if it were needed instead of 70 amps.

Use of the **Real-time Feeder Loading** feature can be important if the substation has limited capacity or there is significant load between the substation and the first team switch.

Examples for calculating the available source capacity in IT-SG

The distributed data method the IntelliTeam SG system uses to calculate the available source capacity uses a view of loading that goes beyond the extended load used by the IntelliTeam II system. The IntelliTeam SG system method allows the capacity calculation to include data beyond the directly adjacent teams and incorporate all circuit data at once. It is performed using the **Integrated Extended Load** feature.

The **Integrated Extended Load** feature is a method of load accumulation that integrates loading throughout the circuit, current flow directionality, and contributions from distributed generation. **Transfer Trip** operations that remove contributions and loading are also taken into account.

Using the **Integrated Extended Load** feature allows the IntelliTeam SG system to calculate available source capacity for all situations, including:

- Simple and complex circuits
- Circuits with one or more distributed generation installations
- Circuits with currents flowing in multiple directions
- **Transfer Trip** operations during the restoration event
- Real-time substation loading provided by SCADA
- Use of default source segment loading

- Substation and line device capacities of differing values
- Mid-circuit step-down transformation
- Entire circuits or just portions of the circuit

The logic follows these steps to calculate the available source capacity using the **Integrated Extended Load** feature:

- STEP 1.** Determine which **Transfer Trip** messages will be sent to this alternate source feeder.
- STEP 2.** Add all team local loads on the feeder and subtract the total of all distributed generation contribution that will remain on the feeder. If necessary, use distributed generation default contributions, both in determining team local load to add and the distributed generation contribution to subtract.
- STEP 3.** Subtract local load of any team that will be removed by a **Transfer Trip** operation going to an isolating switch. If necessary, determine local load using the distributed generation default contribution.
- STEP 4.** Subtract the result from substation capacity and verify remaining capacity is not exceeded by the requested load to be restored. Save this calculated capacity for later comparison.
- STEP 5.** On the main line from the substation to the selected tie switch, look for switches with a maximum capacity configured that is lower than that of any upstream device or the substation maximum capacity.
- STEP 6.** For any of these switches, subtract the downstream **Integrated Extended Load** value (repeat Steps 2 and 3, but only from this switch outward) from the switch's **Maximum Capacity** setting. Verify this capacity remaining is not exceeded by the requested load to be restored. Save this calculated capacity for later comparison.
- STEP 7.** Compare the saved calculated capacities. Use the lowest of the saved capacities as the true capacity of the circuit.

Example 3: IntelliTeam SG System

A very simple example to start with. See Figure 16.

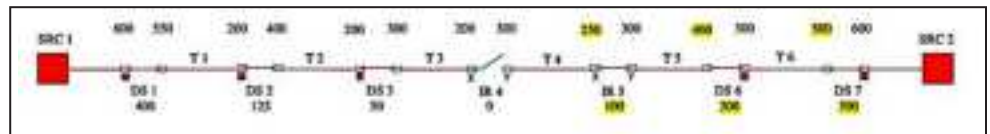


Figure 16. The Source Maximum Capacity setting is disabled.

When the source **Maximum Source Capacity** setting is disabled, the source capacity used is 500 amps from the team T6 side of switch DS7.

Using the Integrated Extended Load method, the capacity calculation is:

1. N/A (no distributed generation or **Transfer Trip** operation)
2. $(300-200)+(200-100)+(100-0) = 100+100+100 = 300$ A
3. N/A (no team load being removed by a **Transfer Trip** operation)
4. $500-300 = 200$ A capacity for the source SRC2 circuit
5. Switch DS6 has lower capacity at 400 A
6. Repeat 2 and 3 for switch DS6

Repeating the calculation for switch DS6:

1. $(200-100)+(100-0) = 100+100 = 200$ A
2. N/A
3. $400-200 = 200$ A capacity for SRC2 circuit
4. Switch IR5 has yet a still lower capacity at 250 A
5. Repeat 2 and 3 for switch IR5

Repeating the calculation for switch IR5:

1. $(100-0) = 100$ A
2. N/A
3. $250-100 = 150$ A capacity for SRC2 circuit
4. N/A (no further switches on circuit)
5. N/A
6. Compare the capacities found, 200 A, 200 A and 150 A. The capacity calculated at switch IR5 is the lowest at 150 A, therefore the available source capacity of source SRC2 is 150 amps.

When the source **Maximum Capacity** setting is enabled, the available source capacity calculation will ensure the source is not overloaded during a restoration event. In this calculation the source **Maximum Capacity** setting is 400 amps.

Using the **Integrated Extended Load** method, the capacity calculation is:

1. N/A (no distributed generation or **Transfer Trip** operation)
2. $(300-200)+(200-100)+(100-0) = 100+100+100 = 300$ A
3. N/A (no team load being removed by a **Transfer Trip** operation)
4. $400-300 = 100$ A capacity for source SRC2 circuit
5. Switch IR5 has lower capacity at 250 A
6. Repeat 2 and 3 for switch IR5

Repeating the calculation for switch IR5:

1. $(100-0) = 100$ A
2. N/A
3. $250-100 = 150$ A capacity for source SRC2 circuit
4. N/A (no further switches on circuit)
5. N/A

- Compare the capacities found, 100 A and 150 A. The capacity calculated at switch DS7 is the lowest at 100 amps, therefore the available source capacity of source SRC2 is 100 amps.

Example 4: IntelliTeam SG System

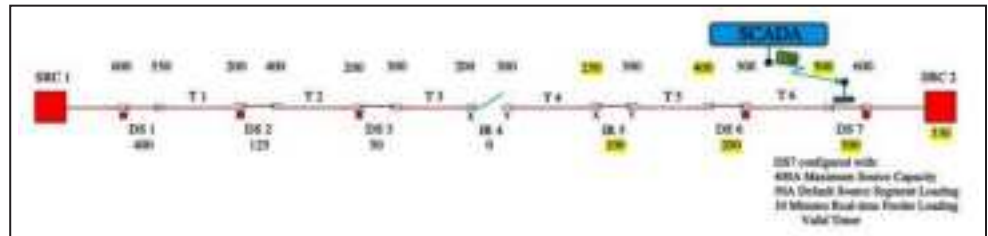


Figure 17. The Real-Time Feeder Loading feature is used.

In this example, the **Real-Time Feeder Loading** feature is added so load between the source and the first team switch is accounted for in the available source capacity calculation. See Figure 17.

The **Maximum Source Capacity** setting is 400 amps in switch DS7 for source SRC2. The **Default Source Segment Loading** setting is 50 amps for the estimated peak loading on the line between source SRC2 and switch DS7. The **Real-Time Feeder Loading Valid Timer** setting is 10 minutes in switch DS7, so the available source capacity calculation will use the **Default Source Segment Loading** setting if the SCADA system is unable to refresh the real-time value in switch DS7 within the 10-minute interval.

Using the **Integrated Extended Load** method, the capacity calculation is:

- N/A (no distributed generation or **Transfer Trip** operation)
- $(330-300)+(300-200)+(200-100)+(100-0) = 30+100+100+100 = 330$ A
- N/A (no team load being removed by a **Transfer Trip** operation)
- $400-330 = 70$ A capacity for source SRC2 circuit
- Switch IR5 has lower capacity at 250 A
- Repeat 2 and 3 for switch IR5

Repeating the calculation for switch IR5:

- $(100-0) = 100$ A
- N/A
- $250-100 = 150$ A capacity for source SRC2 circuit
- N/A (no further switches on circuit)
- N/A
- Compare the capacities found, 70 A and 150 A. The capacity calculated at switch DS7 is the lowest at 70 amps, so the available source capacity of source SRC2 is 70 amps.

If the SCADA system was unable to send the **Feeder Loading** value within the last 10 minutes, the calculation would use the **Default Source Segment Loading** setting instead. The substation loading would be assumed to be the extended load at switch DS7 plus the **Default Source Segment Loading** setting, or $300+50 = 350$ amps of circuit loading. The capacity calculation would now be the following:

Using the **Integrated Extended Load** feature, the capacity calculation is:

1. N/A (no distributed generation or **Transfer Trip** operation)
2. $(350-300)+(300-200)+(200-100)+(100-0) = 50+100+100+100 = 350$ A
3. N/A (no team load being removed by a **Transfer Trip** operation)
4. $400-350 = 50$ A capacity for source SRC2 circuit
5. Switch IR5 has lower capacity at 250 A
6. Repeat 2 and 3 for switch IR5

Repeating the calculation for switch IR5:

1. $(100-0) = 100$ A
2. N/A
3. $250-100 = 150$ A capacity for SRC2 circuit
4. N/A (no further switches on circuit)
5. N/A
6. Compare the capacities found, 50 A and 150 A. The capacity calculated at DS7 is the lowest at 50 amps, so the available source capacity of SRC2 is 50 amps.

Example 5: IntelliTeam SG System

The previous IntelliTeam SG system examples are fairly simple and do not illustrate the full capabilities associated with the **Integrated Extended Load** feature calculation process. To do that, the circuit needs to include a distributed generation installation. See Figure 18.

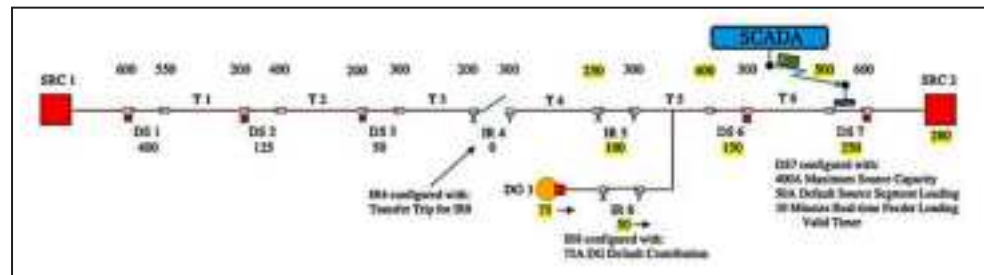


Figure 18. This circuit includes distributed generation.

In this example, distributed generation is contributing 75 amps to the circuit. 50 amps of that is feeding team T5 load, reducing the current flow from the utility substation to 280 amps. Team switch IR8 is an IntelliRupter fault interrupter and does not poll the distributed generation for real-time loading. Instead, the **Default DG Load Contribution** setting is configured for 75 amps in switch IR8.

As with Example 4, the source **Maximum Source Capacity** setting is 400 amps in switch DS7 for source SRC2. The **Default Source Segment Loading** setting is 50 amps for the estimated peak loading on the line between source SRC2 and switch DS7. The **Real-Time Feeder Loading Valid Timer** setting is 10 minutes.

When a fault occurs in team T2, and subsequent isolation, normally open tie switch IR4 must calculate the available source capacity of the source SRC2 circuit. In this example, switch IR4 is configured to request a **Transfer Trip** operation from the point of interconnect switch IR8, so distributed generation DG1 is disconnected from the circuit before the restoration occurs. See Figure 19.

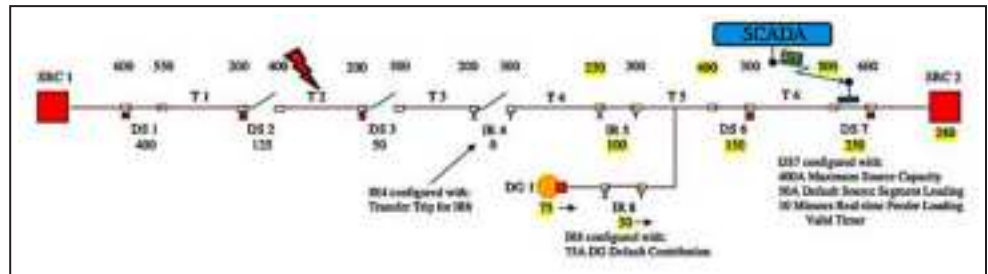


Figure 19. Distributed generation is discontinued before restoration is started.

Using the **Integrated Extended Load** feature, the capacity calculation is:

1. Switch IR4 will **Transfer Trip** operate switch IR8
2. $(280-250)+(250-150)+(150+50-100)+(100-0)+(75-50) = 30+100+100+100+25 = 355$ A
3. $355-25 = 330$ A (distributed generation team load of 25 amps will be removed by the **Transfer Trip** operation)
4. $400-330 = 70$ A capacity for the source SRC2 circuit
5. Switch IR5 has lower capacity at 250 A
6. Repeat 2 and 3 for switch IR5

Repeating the calculation for switch IR5:

1. $(100-0) = 100$ A
2. N/A
3. $250-100 = 150$ A capacity for the source SRC2 circuit
4. N/A (no further switches on circuit)
5. N/A
6. Compare the capacities found, 70 A and 150 A. The capacity of 70 amps is lower, so the available source capacity of the source SRC2 is 70 amps.

Switch IR4 now knows the 50 amps of switch T3 load being requested to restore can be carried by the source SRC2 circuit after the distributed generation is removed. Switch IR4 then issues the **Transfer Trip** command to switch IR8 to disconnect the distributed generation. See Figure 20.

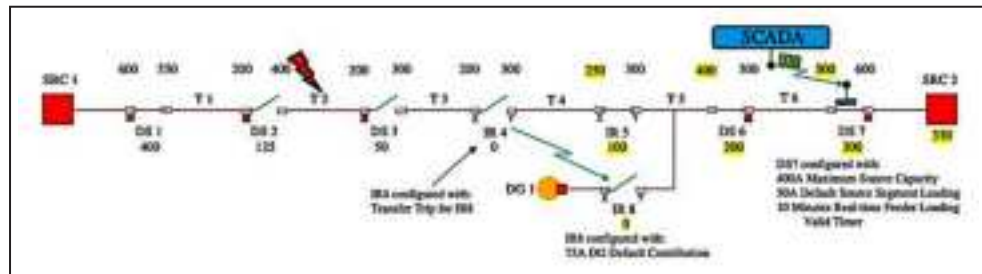


Figure 20. The Transfer Trip command is issued to switch IR8.

When the **Transfer Trip** operation has been verified, switch IR4 closes to restore the unfaulted team T3 load. See Figure 21.

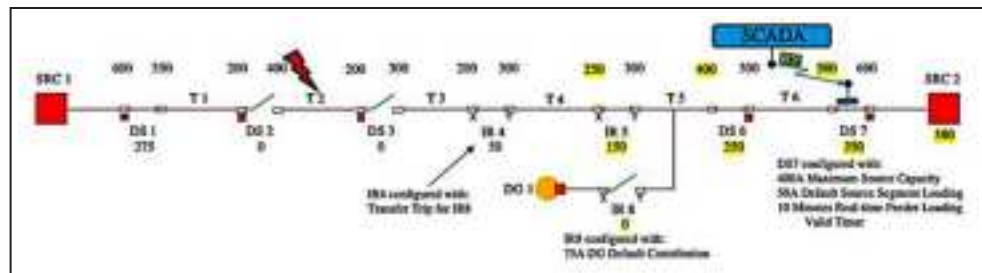


Figure 21. Switch IR4 closes to restore the unfaulted team T3 load.