Current Status:

Slight degradation was visible in delivered maximum power since two years,
but this was assumed to be caused by dirty panels

However, at the detailed check of all strings after replacing the burned panels on the westside some string voltages at the southside were lower than expected

After more measurements it became clear that „11 thirds“ of the panels deliver no power

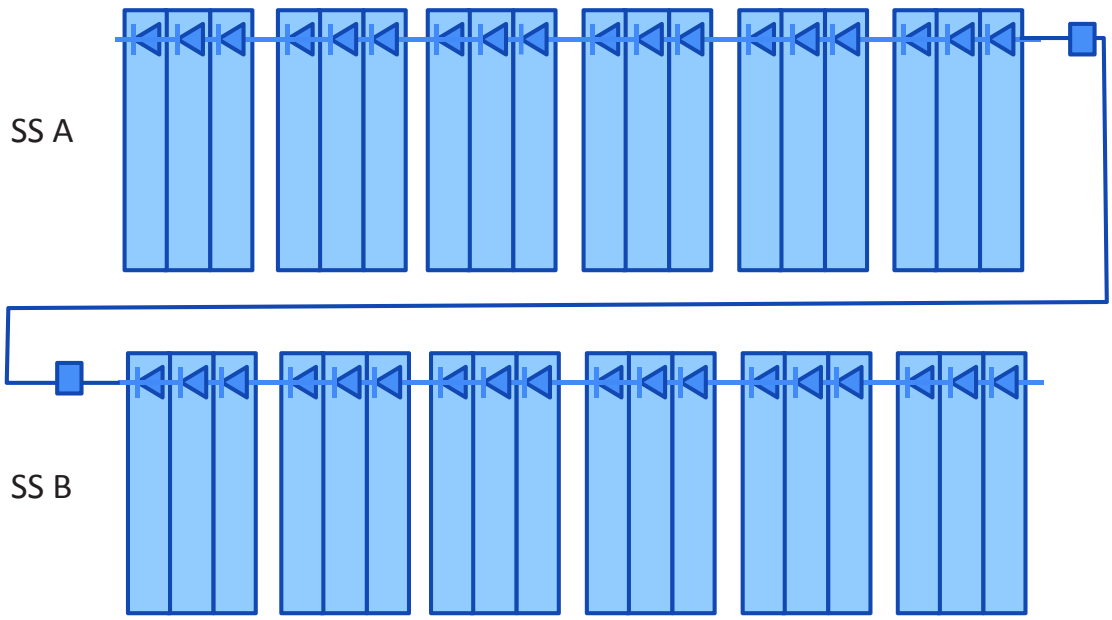
A special check for the possibility of shorted bypass diodes showed that there are no shorts
Only substring A has at least one open bypass diode and could not be verified therefore

This leaves only open connections or broken cells as failuremode

Multiple thermographic checks showed some suspect panels,
but this is not 100% accurate without special equipment

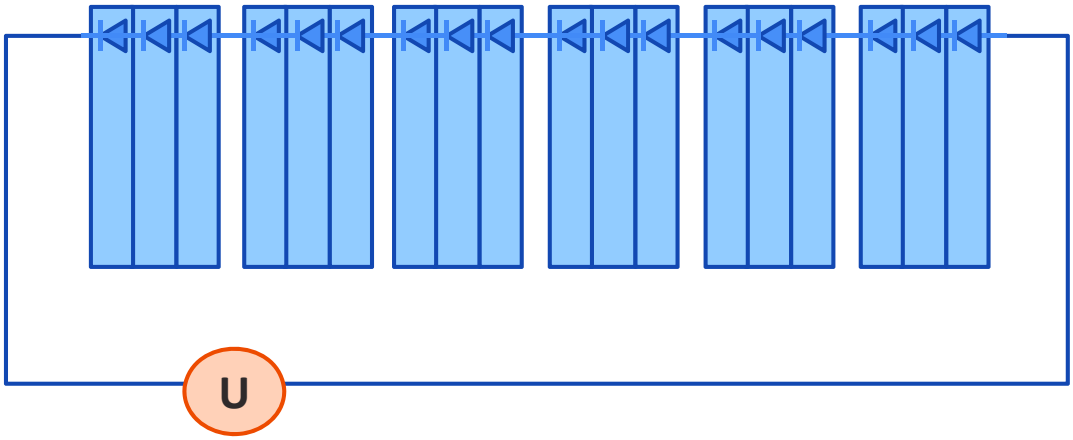
Configuration:

For easier troubleshooting each inverter string is built from two „substrings“
Typically 6 Panels, only one substring has 9 panels



Substring Voltage Measurement:

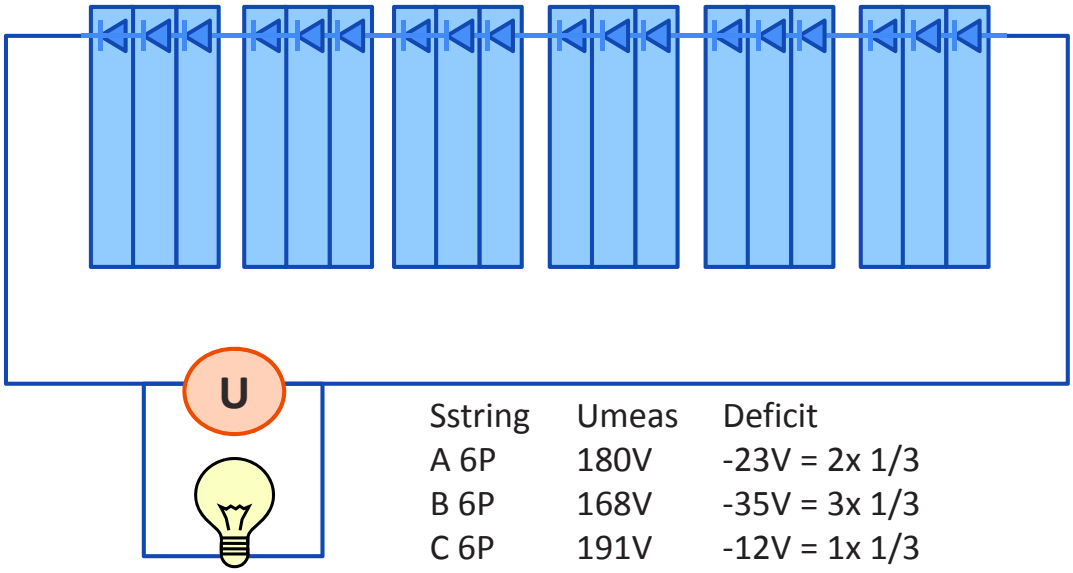
Outside sunny, no shading
Voltage on substring measured with **no load**



Sstring	Umeas	Deficit
A 6P	198V	-6V
B 6P	190V	-14V
C 6P	192V	-12V
D 6P	204V	Reference, assumed good
E 6P	197V	-7V
F 9P	310V	+4V

Substring Voltage Measurement:

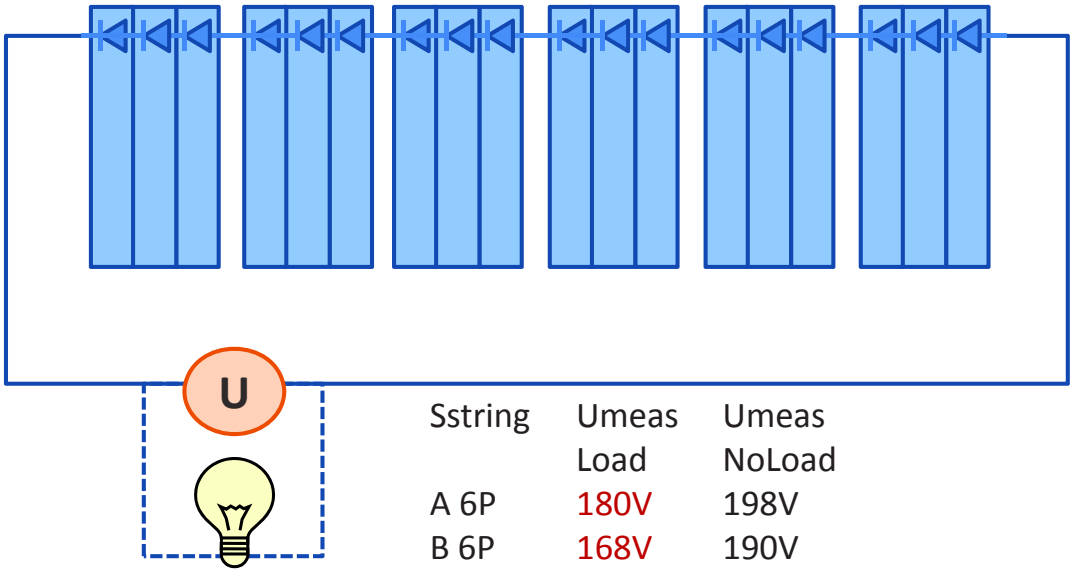
Outside sunny, no shading
Voltage on substring measured **with 40 W lightbulb as load**



Sstring	Umeas	Deficit
A 6P	180V	-23V = 2x 1/3
B 6P	168V	-35V = 3x 1/3
C 6P	191V	-12V = 1x 1/3
D 6P	203V	Reference, assumed good
E 6P	170V	-33V = 3x 1/3
F 9P	284V	-21V = 2x 1/3

Substring Voltage Measurement:

Outside sunny, no shading
Voltage on substring measured with **40 W lightbulb as load & no load**
Comparison of Voltages



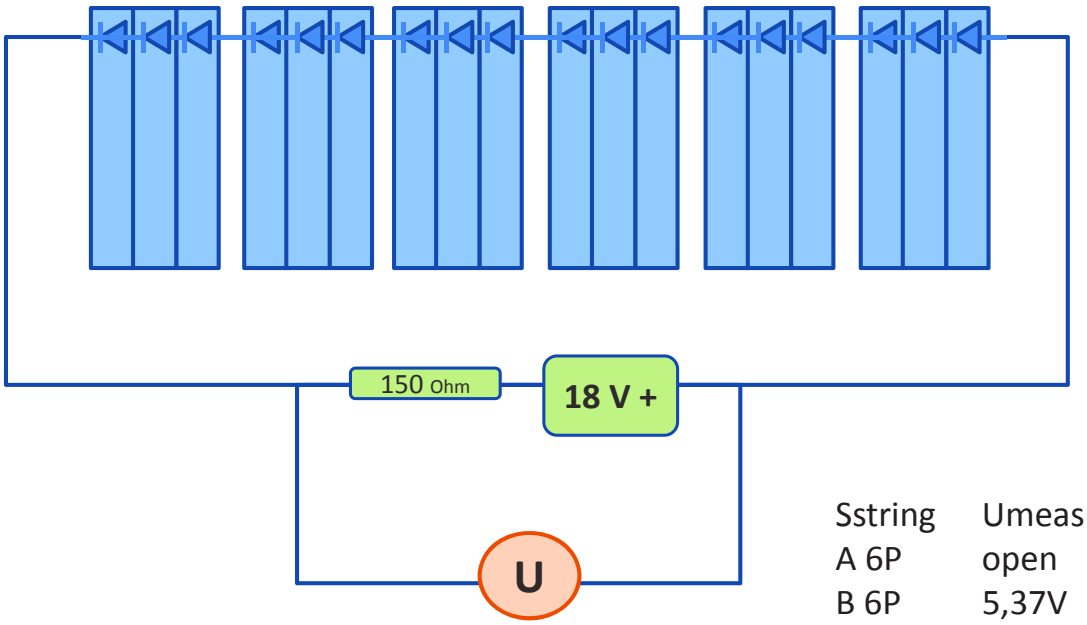
Sstring	Umeas Load	Umeas NoLoad
A 6P	180V	198V
B 6P	168V	190V
C 6P	191V	192V
D 6P	203V	204V
E 6P	170V	197V
F 9P	284V	310V

Diode Measurement:

Outside completely dark

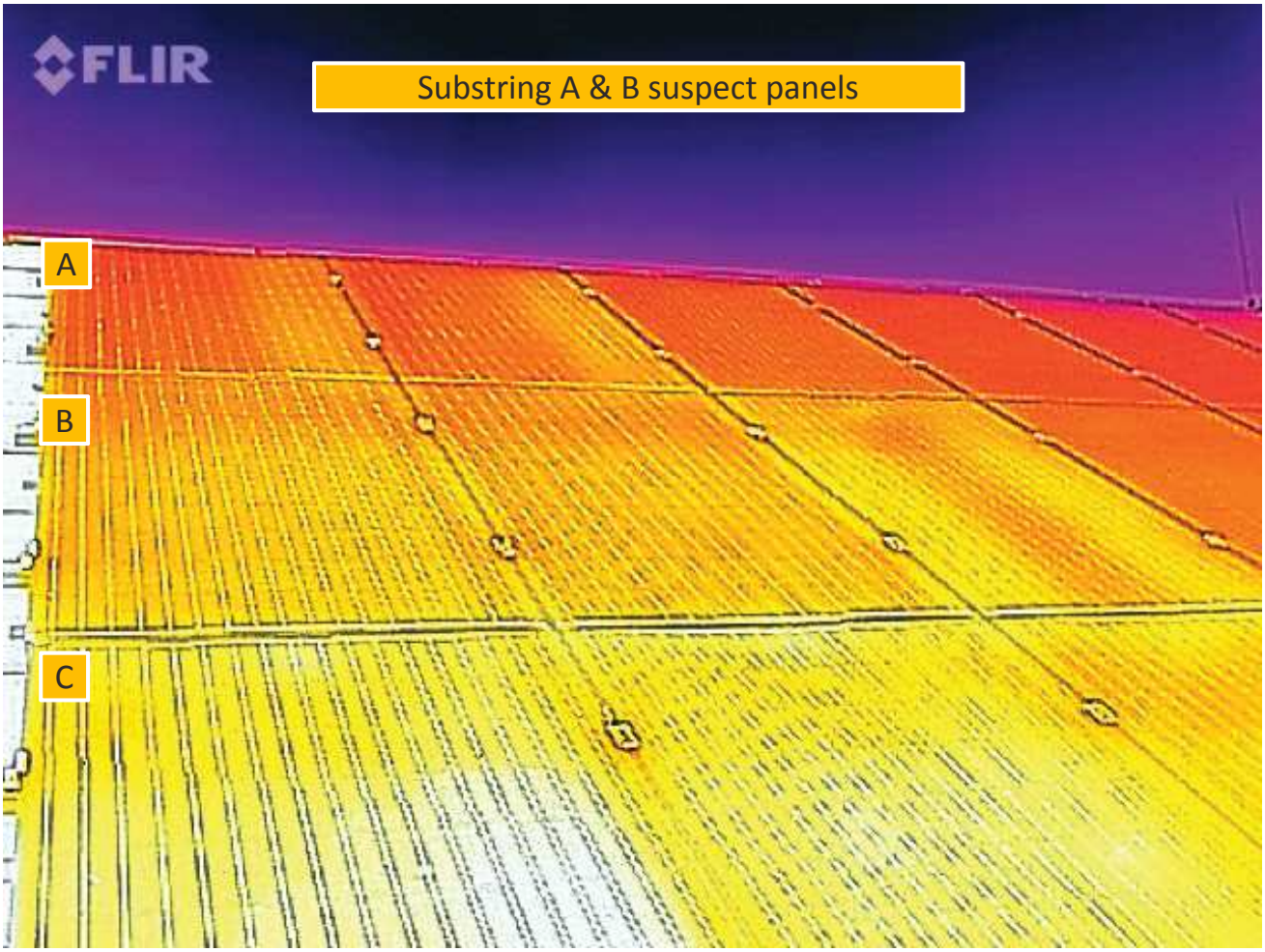
Bypass Diode Voltages on substring measured with auxiliary power

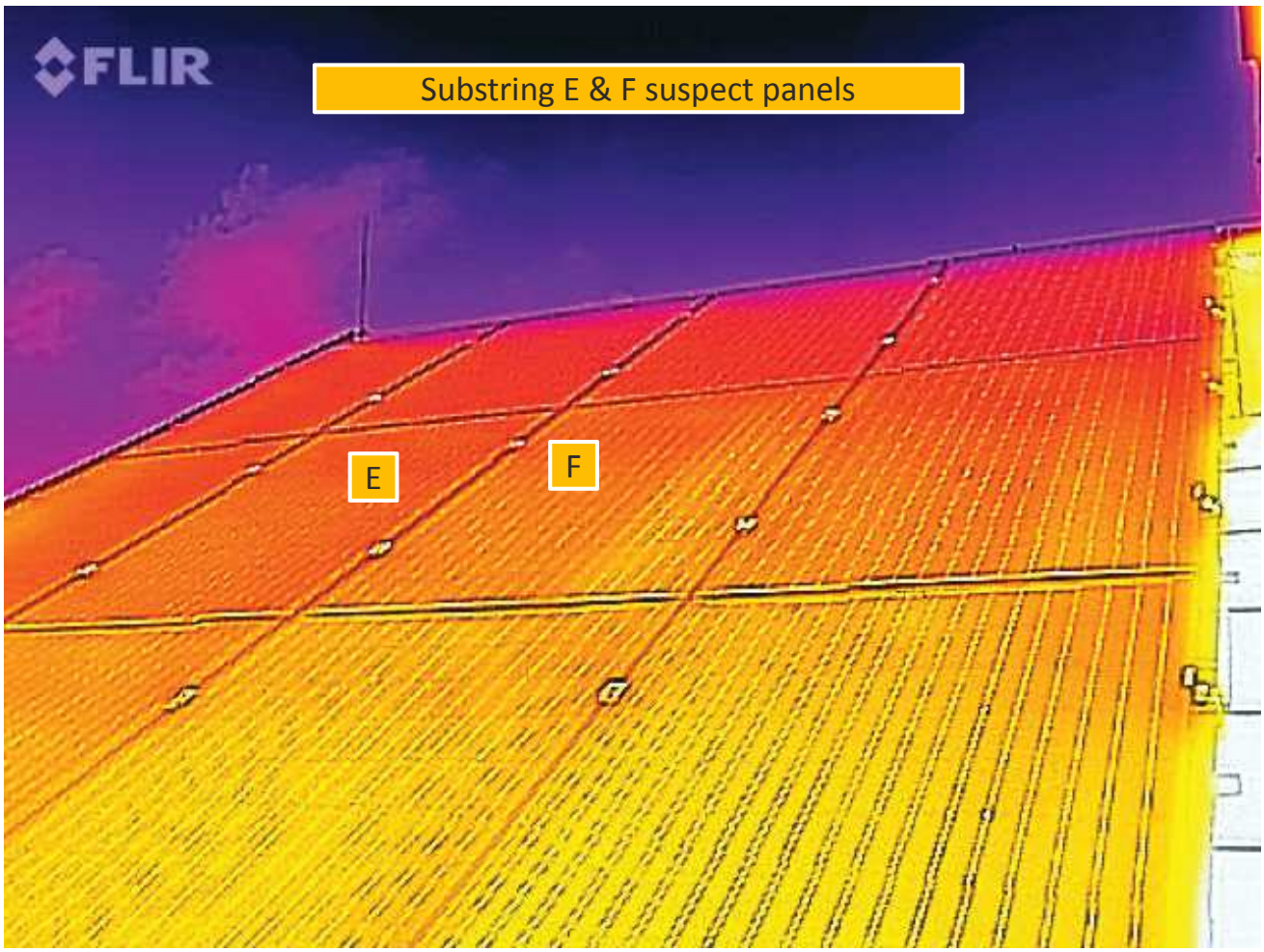
Typically 0,295 V per Diode at about 80mA

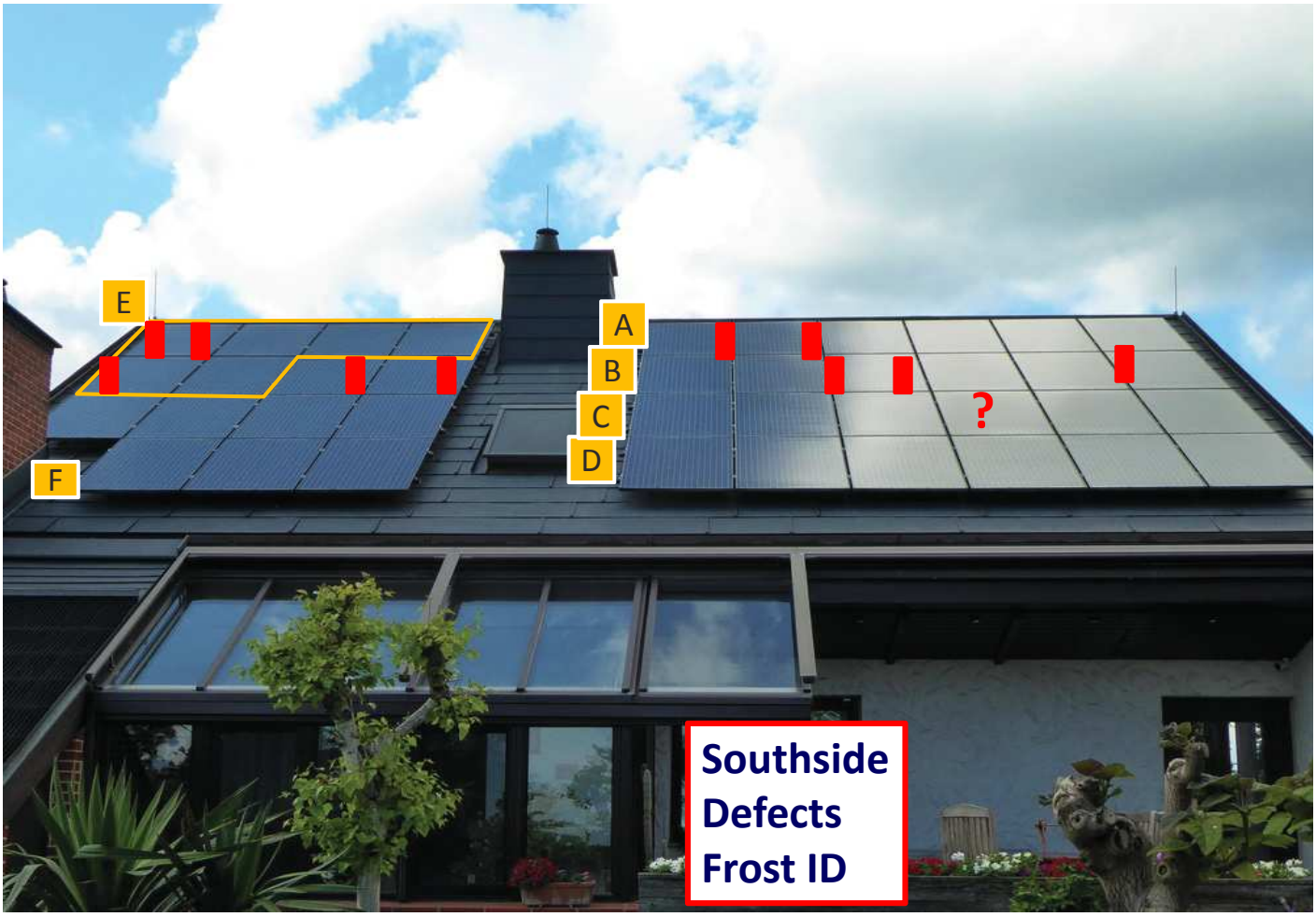


Sstring	Umeas	
A 6P	open	Defective
B 6P	5,37V	OK
C 6P	5,32V	OK
D 6P	5,30V	OK
E 6P	5,32V	OK
F 9P	7,82V	OK


E
A
B
C
D
F
Southside
Defects
Thermal ID


FLIR
Substring A & B suspect panels
A
B
C


FLIR
Substring E & F suspect panels
E
F


E
A
B
C
D
F
?
Southside
Defects
Frost ID

Actions:

As there is at least one open bypass diode inhibiting further checks,
Substring A will be dismounted and each panel will be checked in detail,
Thermographic checks show there two suspect panels

A Winter day with a perfect frost layer and full sun verified results
of thermographic check, (except SS C,D in the shadow)

Current estimate is that 9 panels are partial defective (33% to 66%)
11x 33% = 900 WP Performance loss

This means about 1000 KWh less per year !