



UNIVERSITÀ DI PISA

di DIPARTIMENTO DI
INGEGNERIA
DELL'INFORMAZIONE

INGENiArs

SpaceWire & SpaceFibre Conference 2022

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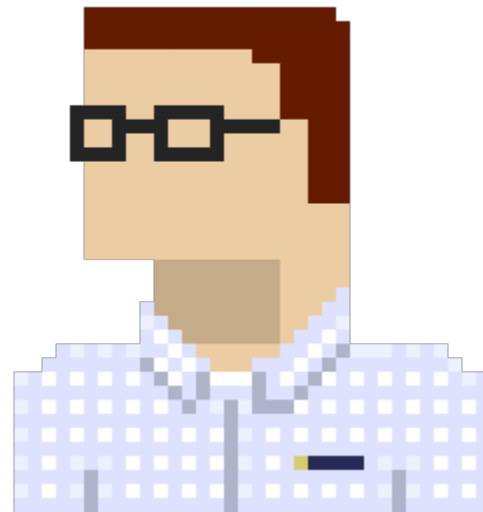
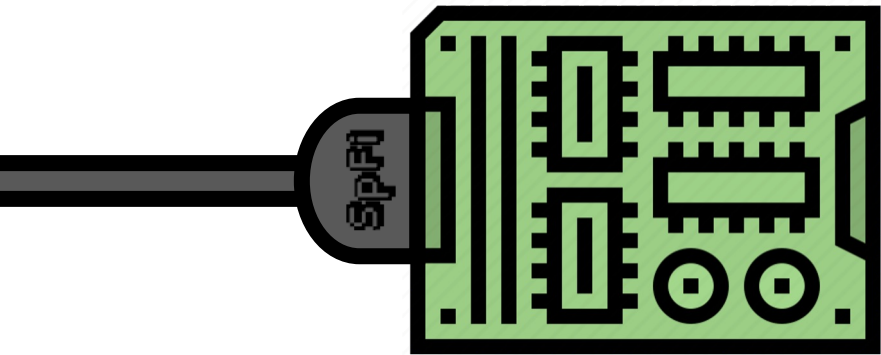
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Eye Diagram Analyser for Space High-Speed Serial Links: a Tool for Evaluating Signal Integrity in SpaceFibre Links.

John's Case



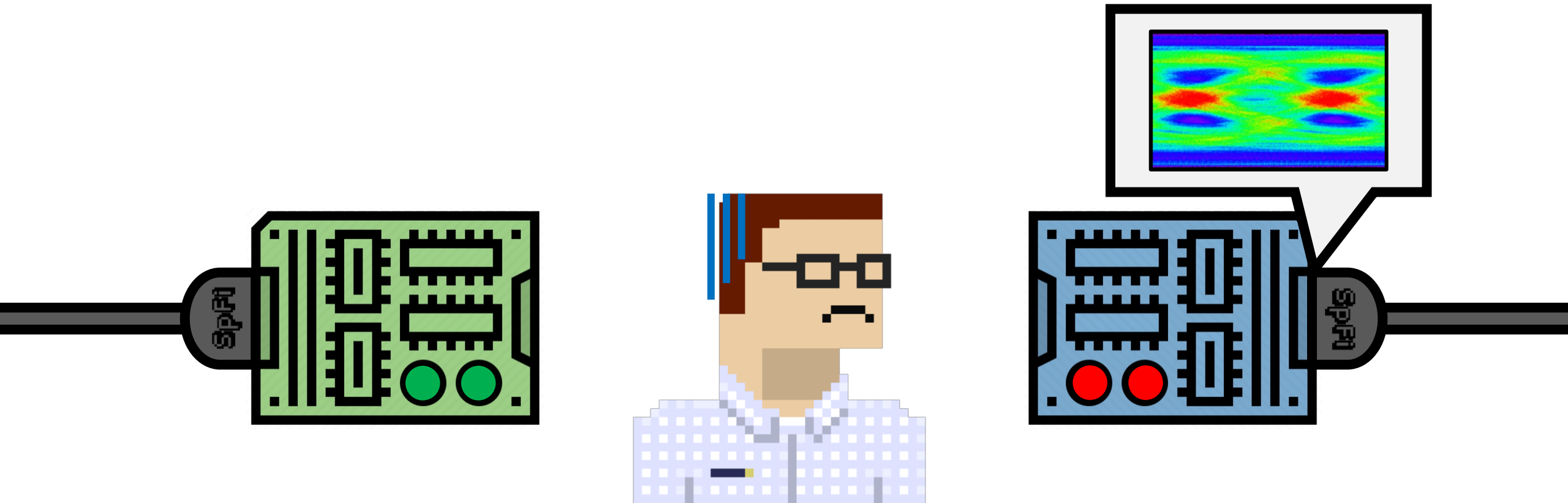
John's Case



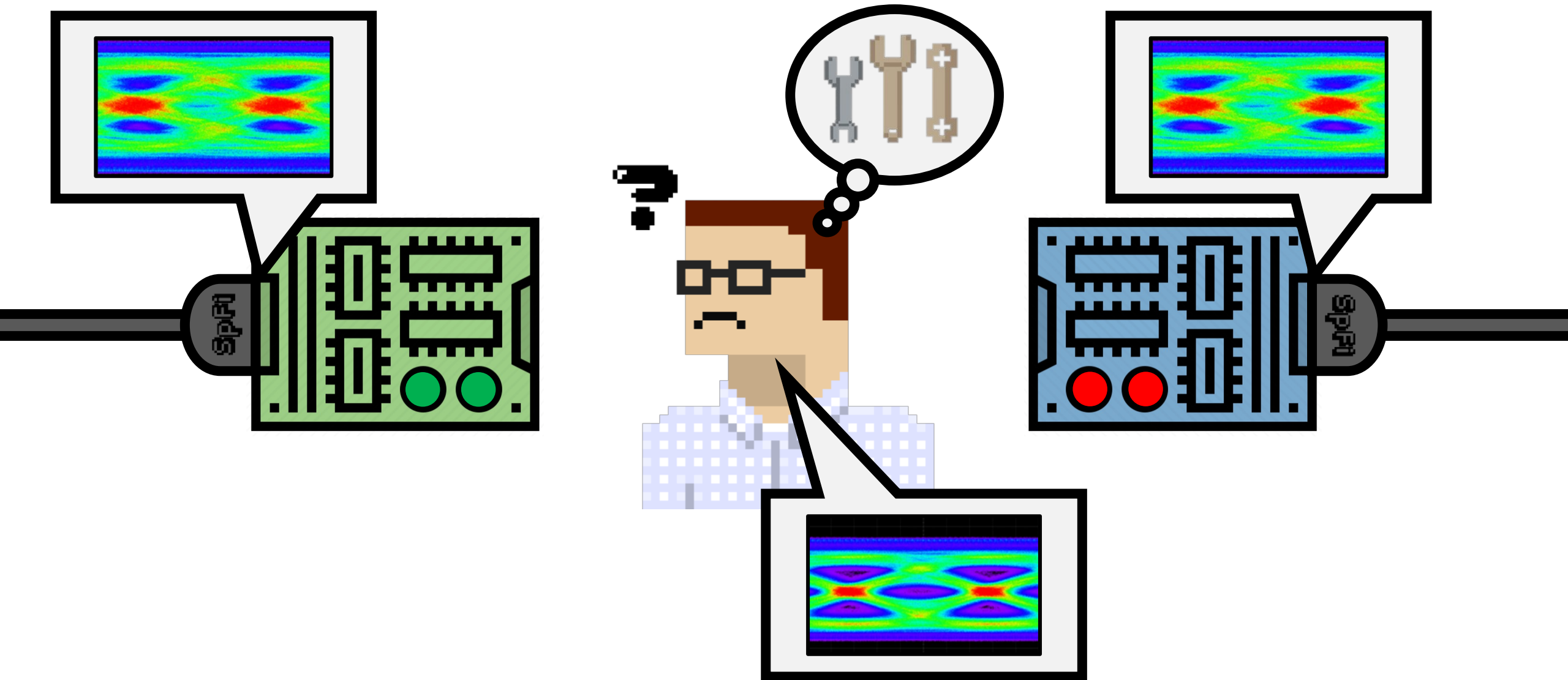
John's Case

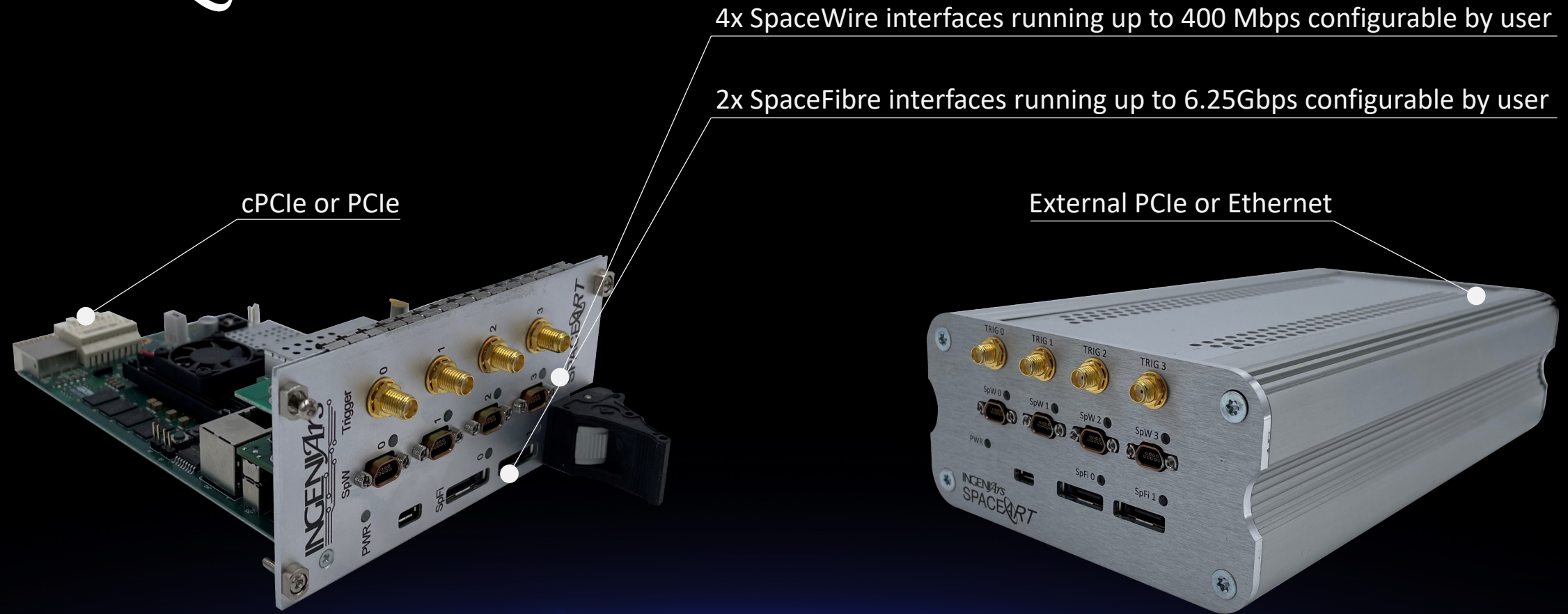


John's Case



John's Case





SpaceWire & SpaceFibre Analyzer Real Time

- 4x SpaceWire interfaces running up to 400 Mbps configurable by user
- 2x SpaceFibre interfaces running up to 6.25Gbps configurable by user
- 8 Virtual Channels per SpaceFibre interface
- Dynamic data-rate selection
- Real-time packet generation
- Processing and consumption through PCIe communication
- Statistical Eye diagram acquisition for post RX-Equalization margin analysis
- 4x user configurable trigger inputs/outputs
- SpaceWire/SpaceFibre bridging
- Selectable hardware packet generator and consumer to allow the easy saturation of the SpaceFibre link
- Time-tagging of the received SpW/SpFi packets
- Advanced Error injection/Word replacement capability to facilitate conformance testing of the system under-test
- Simple yet powerful graphical user interface
- Options for host PC interface: Gigabit Ethernet; Compact PCIe; PCIe
- Easy user interface to check the status of each SpaceWire and SpaceFibre link (including standard flags and link/data rate measurement)
- Trace memory of 8192 words (or more on request) to analyse protocol-specific features such as: flow-control, acknowledgement & frame re-transmission
- Programmable via software API for test automation and advanced processing (C/C++; LabVIEW; more options on request)

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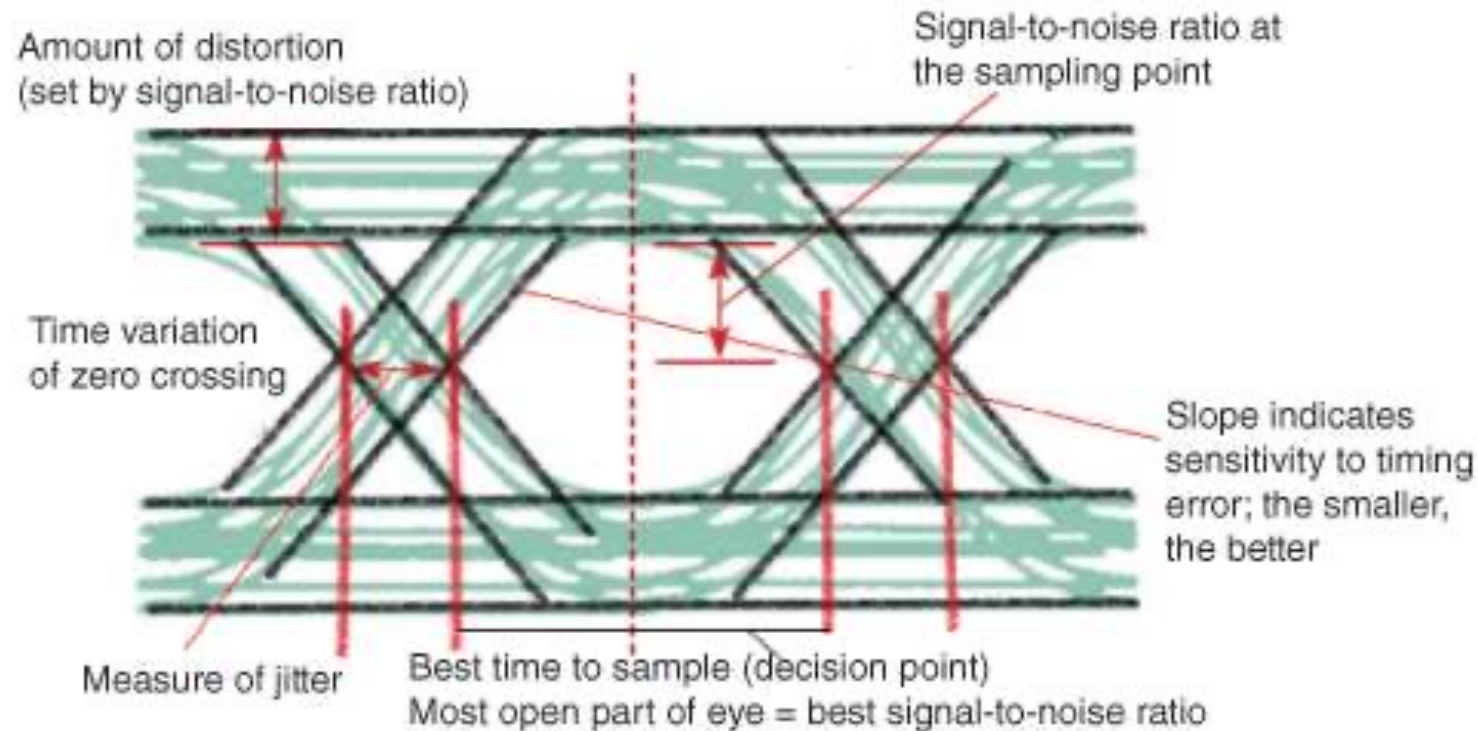


Up to 6.25 Gbps SL or 20 Gbps ML

ACTUAL CHALLENGES FOR SIGNAL INTEGRITY

Eye Diagram Analysis

Immediate VISUAL inspection of complex signal characteristics



Timing

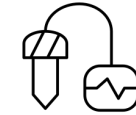


Amplitude

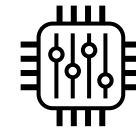
Eye Diagram Analysis (Caveats)



Instrument cost



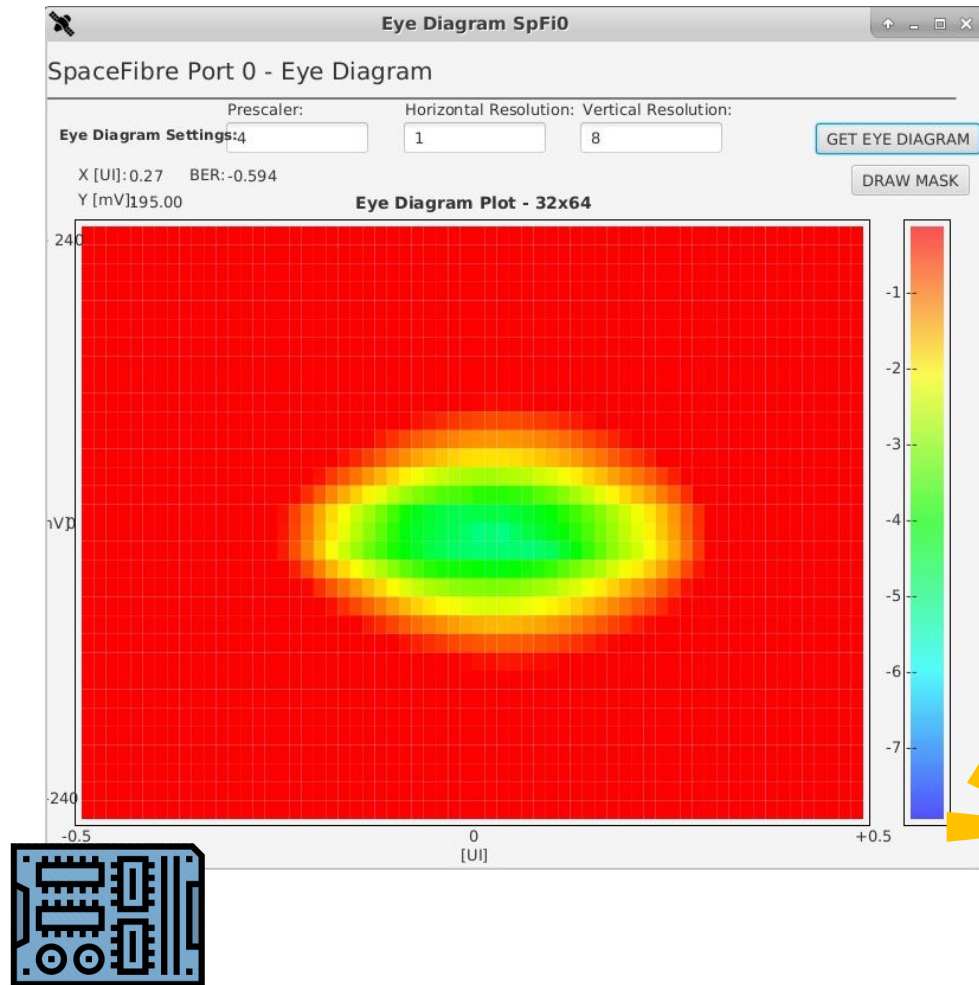
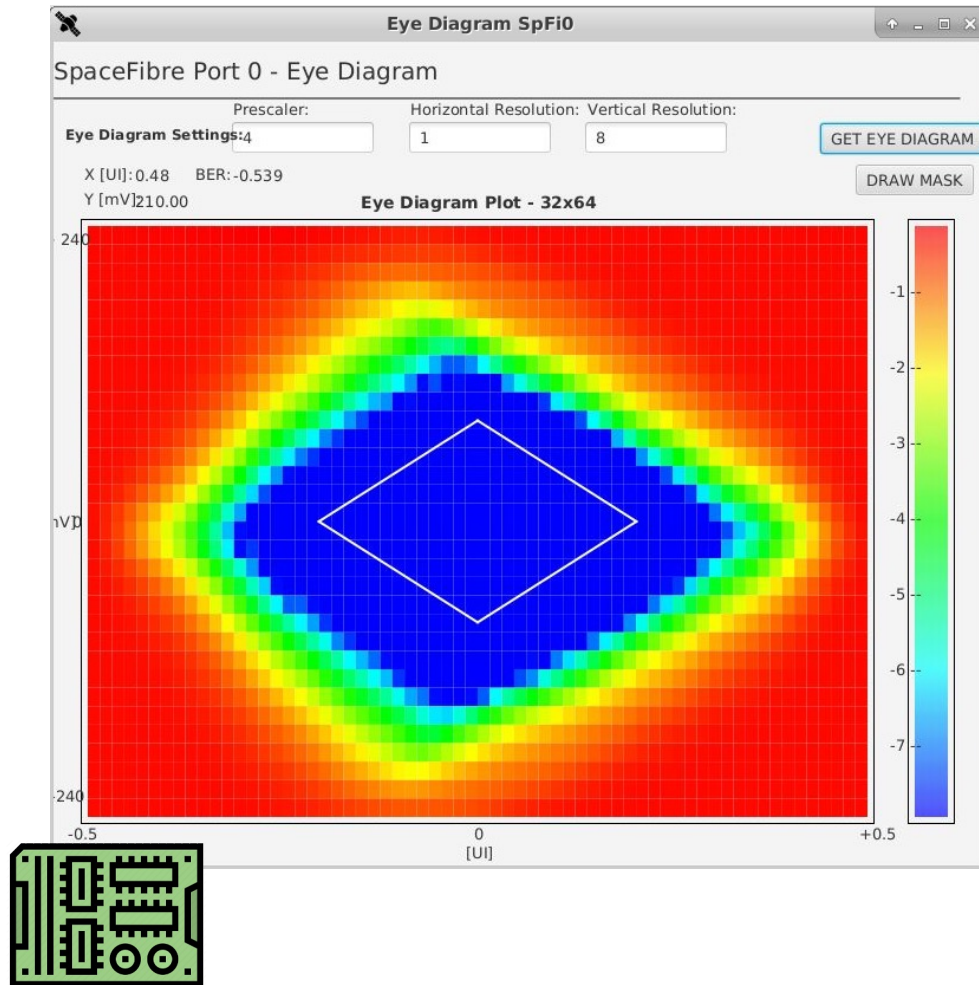
Probing



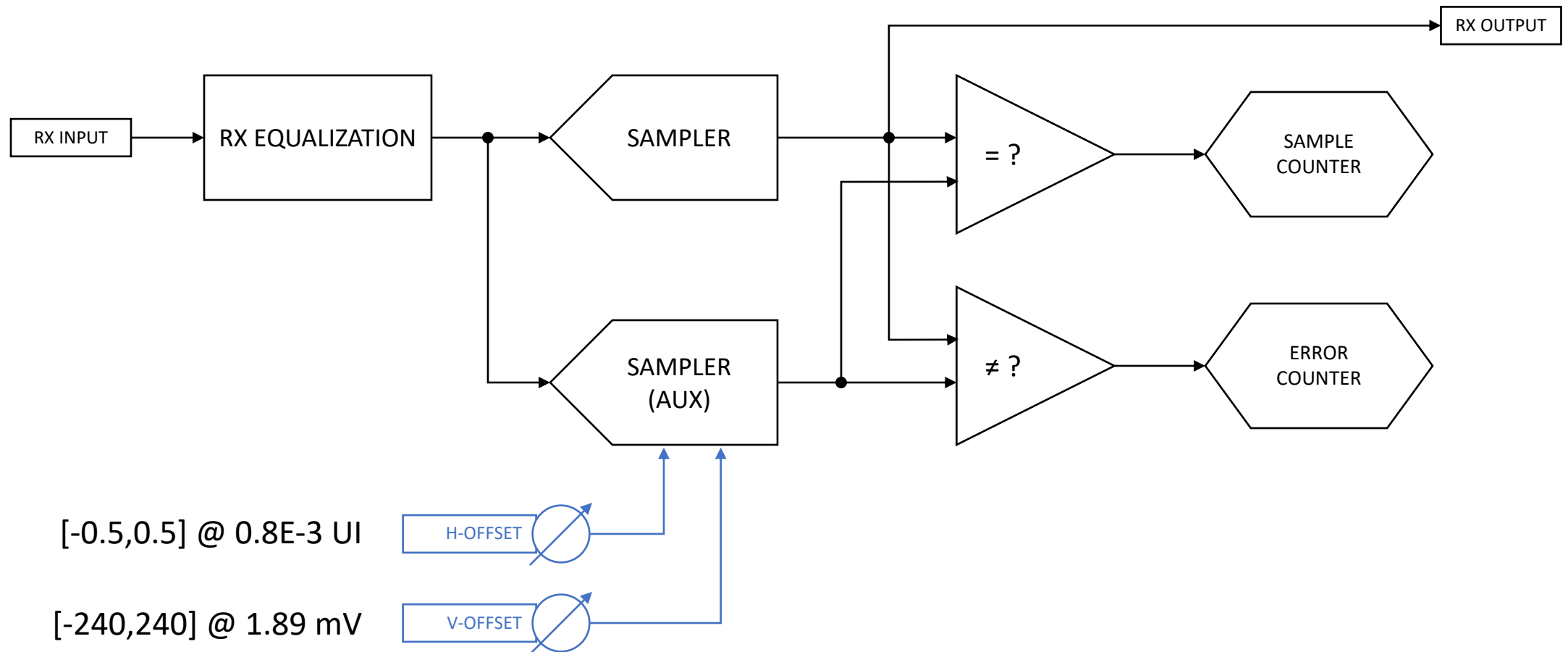
IC RX-Equalization



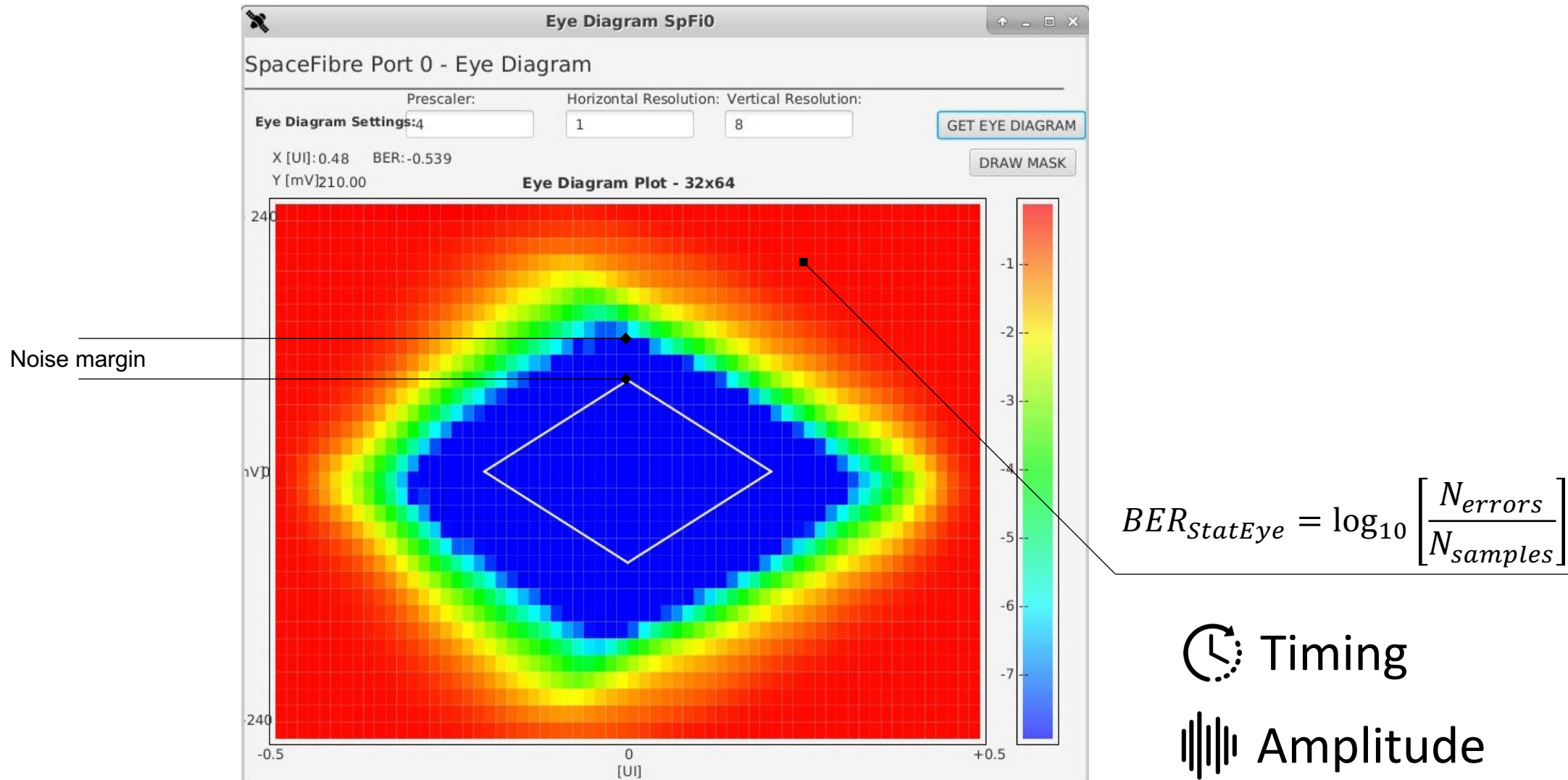
Statistical Eye Diagram = BER heatmap



Statistical Eye Diagram (RX-stage)



Statistical Eye Diagram = BER heatmap (2)



SpaceART StatEye Diagram for SpFi

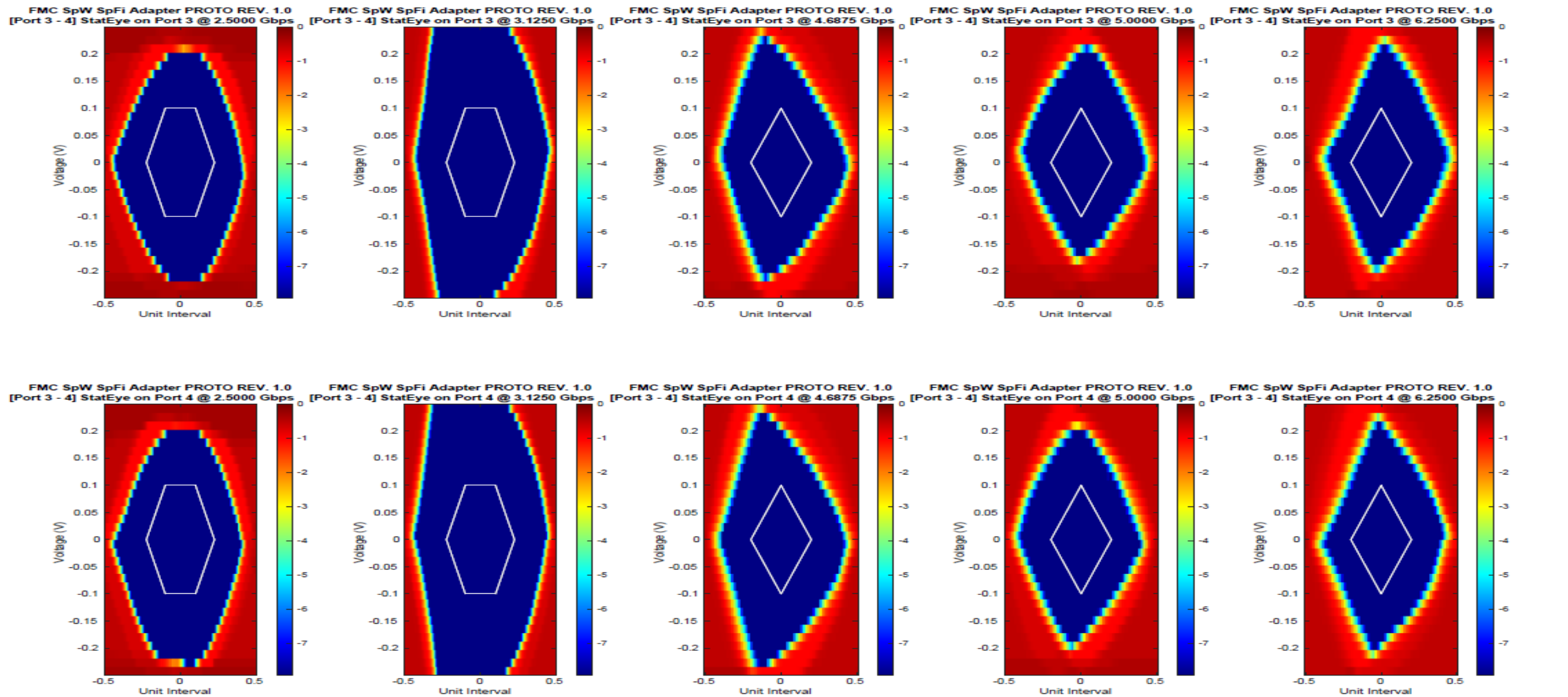
```
ING-Achille
Applications linux-test-freq.c (... [ingeniars@achill... ingeniars@achille... test_eye_diagram...
Open +
linux-test-freq.c
~/Desktop/API_EYE/examples/c/test_eye_diagram_freq
File Edit View Search Terminal Help
05 XXXXXXXXXXXXXXXX+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
06 XXXXXXXXXXXXXXXX+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
07 XXXXXXXXXXXXXXXX+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
08 XXXXXXXXXXXXXXXX+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
09 XXXXXXXXXXXXXXXX+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
10 XXXXXXXXXXXXXXXX+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
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28 XXXXXXXXXXXXXXXX+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
29 XXXXXXXXXXXXXXXX+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
30 XXXXXXXXXXXXXXXX+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
31 XXXXXXXXXXXXXXXX+XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

LEGENDA:
' ' if log10(BER) <= -12.0
'-' if log10(BER) <= -6.0
'+' if log10(BER) <= -1.0
'X' if log10(BER) <= inf

ingeniars@achille:~/Desktop/API_EYE/examples/c/test_eye_diagram_freq$
```

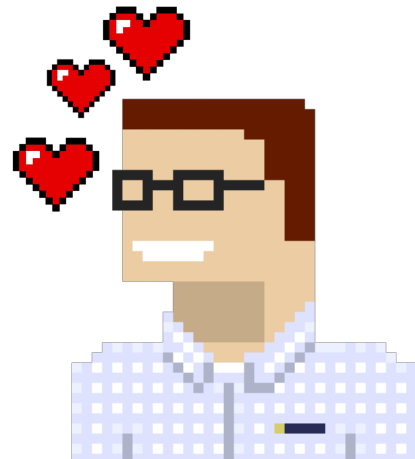
```
main.c
226 printf("Activating SpFi CODEC #d...\n",p);
227 cmd_spfi.codec = cmd_spfi_params.codec = p;
228 cmd_spfi.start_mode = true;
229 cmd_spfi.autostart = true;
230 cmd_spfi.serial_loopback = false;
231 sa_send_command(SA_CMD_SPFI_SET_CODEC_STATUS_NORMAL, (void*) &cmd_spfi, NULL);
232 sleep(1);
233 sa_send_command(SA_CMD_SPFI_SET_VC_PARAMS, (void*) &cmd_spfi_params, NULL);
234 }
235 printf("Press ENTER to continue\n");
236 getchar();
237
238 SA_GET_EYE_DIAGRAM cmd_eye = {
239 .port = ( eye_port ),
240 .prescaler = 4U,
241 .hres = 1U,
242 .vres = 8U
243 };
244 printf("Sending command to EyeDiagram IP, port %d...\n",cmd_eye.port);
245 sa_send_command(SA_CMD_GET_EYE_DIAGRAM, (void*) &cmd_eye, NULL);
246 printf("Press ENTER to get eye matrix...\n");
247 getchar();
248 printf("Requiring data...\n");
249 sa_rcv_command(&cmd_rx, &cmd_ret, NULL);
250 // Check returned eye diagram
251 if ( cmd_ret.cols == 0 || cmd_ret.rows == 0 ) {
252 printf("ERROR: remote instrument returned invalid data...\n\n");
253 return 1;
254 }
255
256
257 // Calculate BER
258 FILE* eye_fp; eye_fp = fopen("eyedata.txt", "wb");
259 for ( int r = 0; r < (cmd_ret.rows); r++ ) {
260 for ( int c = 0; c < (cmd_ret.cols); c++ ) {
```

SpaceART StatEye Diagram for SpFi



It matters for John

- Understand the problem
- Solve the problem
 - Find a better operating point at RX-end (timing and amplitude)
 - Explore signal pre-emphasis and de-emphasis options and visualize effects
- Integrated within a full SpFi EGSE solution



Conclusions

- SpaceFibre is a real need already for space missions
- High data-rates poses serious Signal Integrity challenges
- Eye Diagrams & RX Margin Analysis (StatEye) are valuable tools
- SpaceART is a flexible and comprehensive EGSE solution



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CONTACTS

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THANK YOU

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today at our booth
or at ingeniars.com

