Alexsander Loula
Gerente de Desenvolvimento de Negócios
RF & Mobile

Tecnologias para desenvolvimento de aplicações de monitoramento de espectro, SIGINT, radar e SDR

Agenda

- Introdução
- Tecnologias Envolvidas:
  - Barramento de Alta Velocidade
  - Alta Velocidade de Armazenamento
  - Técnicas Avançadas de Programação
- Plataforma para RF
- Soluções de Clientes
- Demo
- Resumo

Introdução

Visão geral de mercado

- **SIGINT = COMINT + ELEINT + MASINT**
  - COMINT (***COM****munications* ***INT****elligence*)
    - Focada nas comunicações humanas
  - ELINT (***EL****ectronics* ***INT****elligence*)
    - Focada no uso de sensores para obter dados principalmente sobre a rede de defesa inimiga, como alcance de radares
  - MASINT (***M****easurement* ***A****nd* ***S****ignatures* ***INT****elligence*)
    - Focada na obtenção de dados quantitativos e qualitativos de sinais (comprimento de onda, fase, modulação, largura de pulsos, etc.)

O que é Guerra Eletrônica

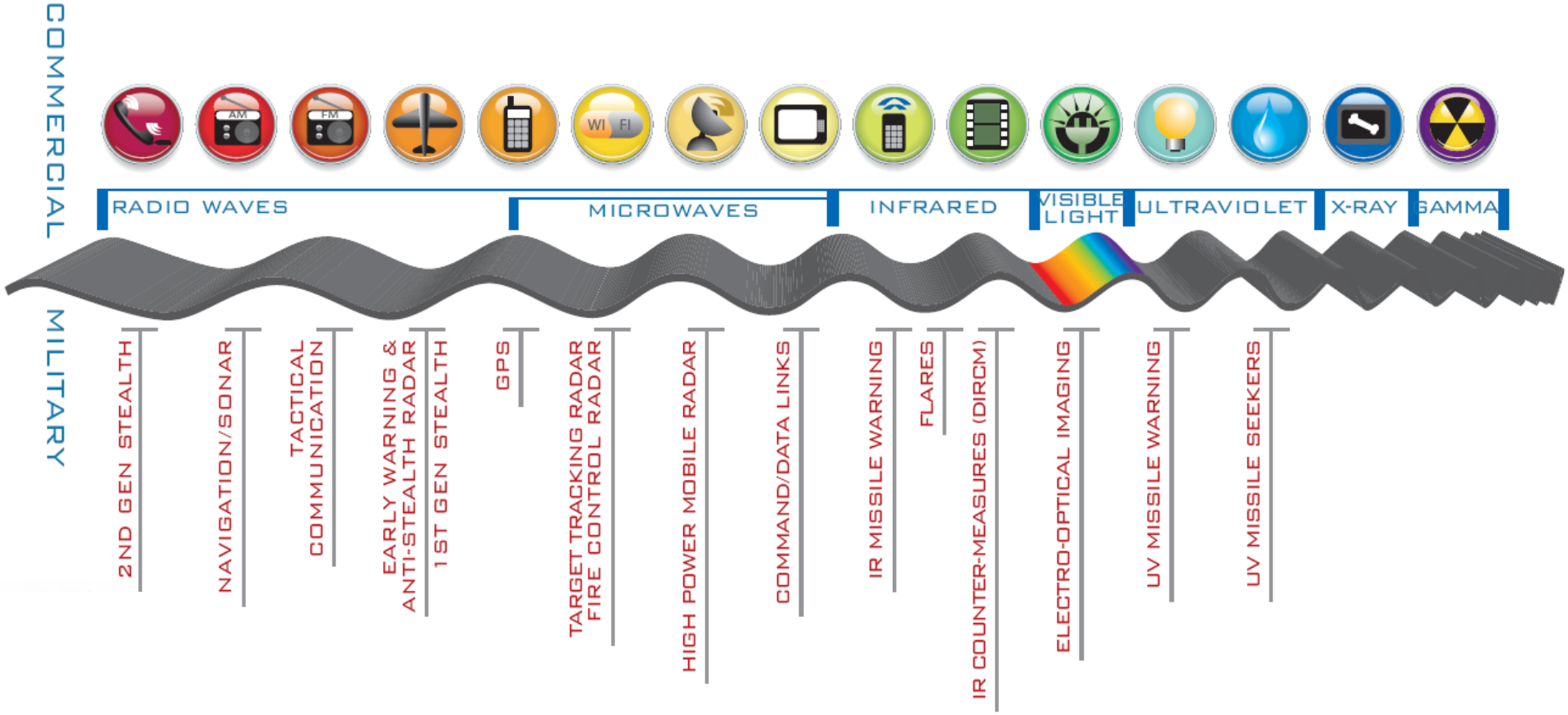
Electronic Warfare (EW)

- Vigilância
- Reconhecimento da ameaça
- Interferência
- Fraude
- Cancelamento ativo
- Pulse eletromagnético (EMP)...

“Guerra Eletrônica (EW) é a luta pelo controle do espectro eletromagnético”

AOC (The Electronic Warfare & Information Operations Association)

Espectro


COMMERCIAL
MILITARY
RADIO WAVES
MICROWAVES
INFRARED
VISIBLE LIGHT
ULTRAVIOLET
X-RAY
GAMMA
AM
FM
WI FI
2ND GEN STEALTH
NAVIGATION/SONAR
TACTICAL COMMUNICATION
EARLY WARNING & ANTI-STEALTH RADAR
1ST GEN STEALTH
GPS
TARGET TRACKING RADAR FIRE CONTROL RADAR
HIGH POWER MOBILE RADAR
COMMAND/DATA LINKS
IR MISSILE WARNING
FLARES
IR COUNTER-MEASURES (DIRCM)
ELECTRO-OPTICAL IMAGING
UV MISSILE WARNING
UV MISSILE SEEKERS

Visão geral de um sistema de monitoramento e espectro e SIGINT

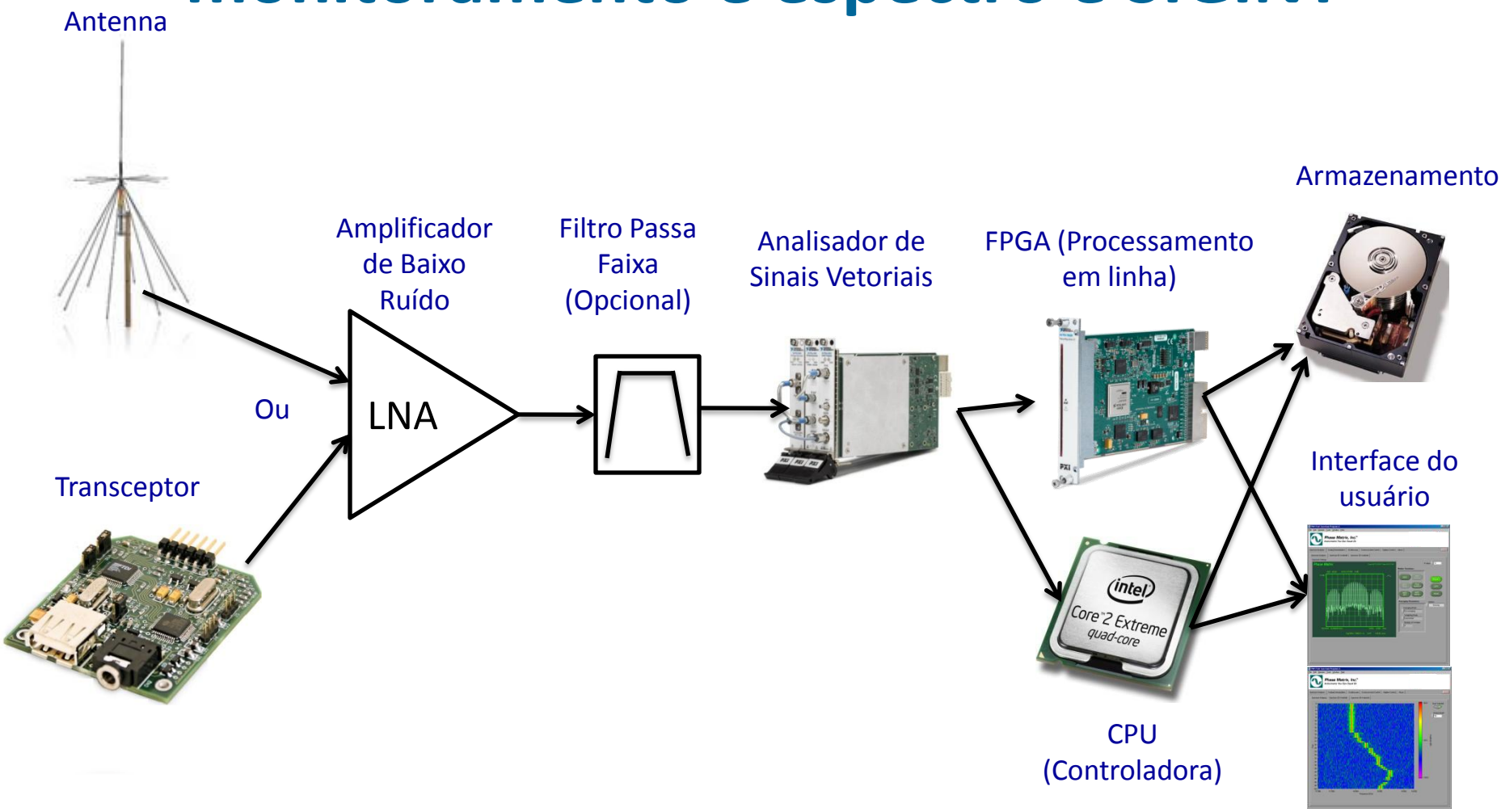
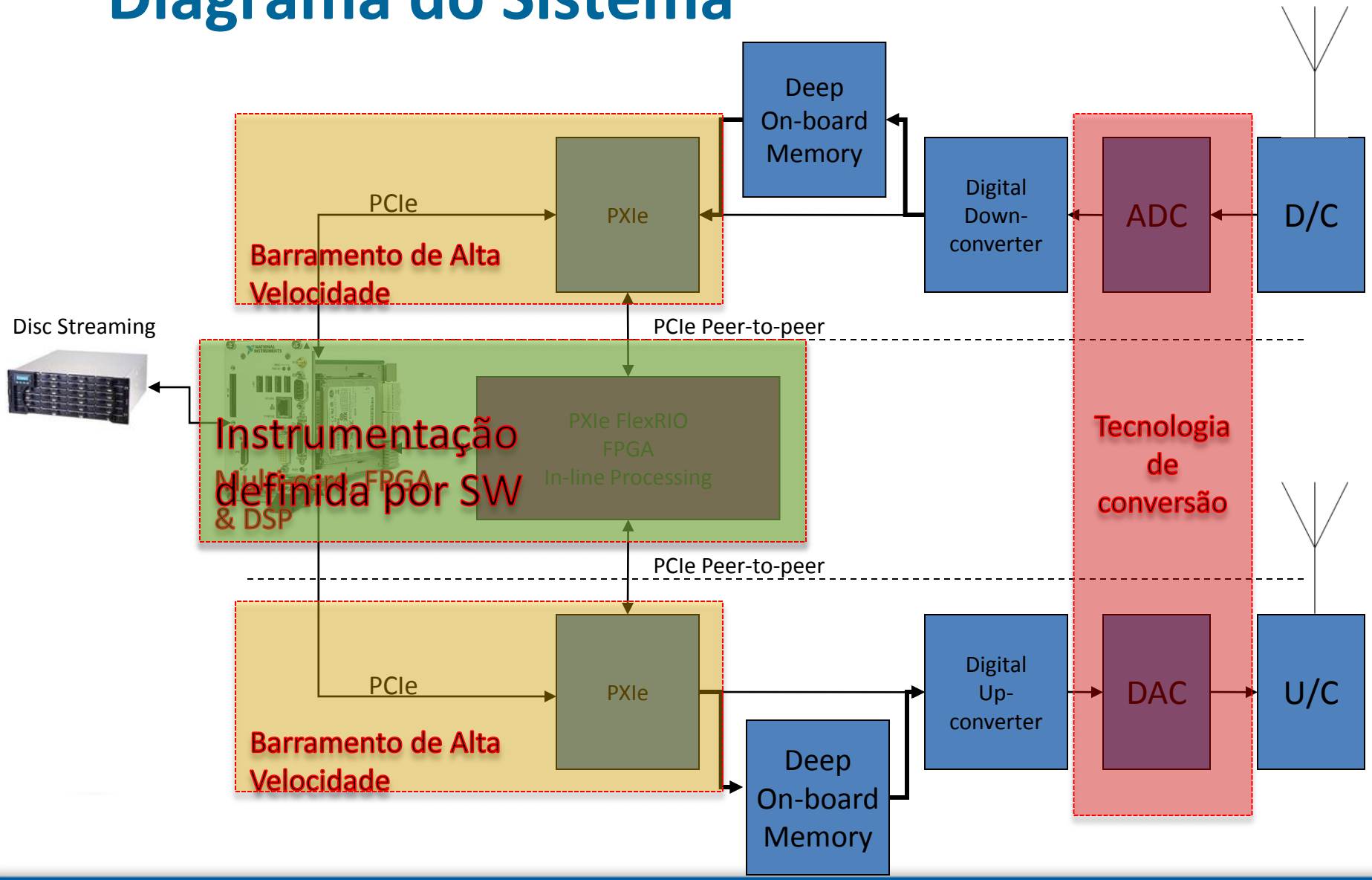


Diagrama do Sistema



Requisitos básicos do sistema

- **Desempenho**
  - Varredura rápida de espectro
  - Demodulação em Tempo-Real
  - Largura de banda
  - Alto alcance dinâmico (*Dynamic Range*)
  - Gravação (*Streaming*) por grandes períodos
- **Flexibilidade**
  - Interface do usuário programável
  - Demodulação definida pelo usuário
  - Alarmes, tendências e relatórios
- **Sistema**
  - Derivado de padrões da indústria
  - Pequeno e baixo consumo
  - Baixo custo

Tecnologias Envolvidas

Barramento de Alta Velocidade

PCI EXPRESS®

PXI

Disco de Alta Velocidade

Técnicas Avançadas de Programação

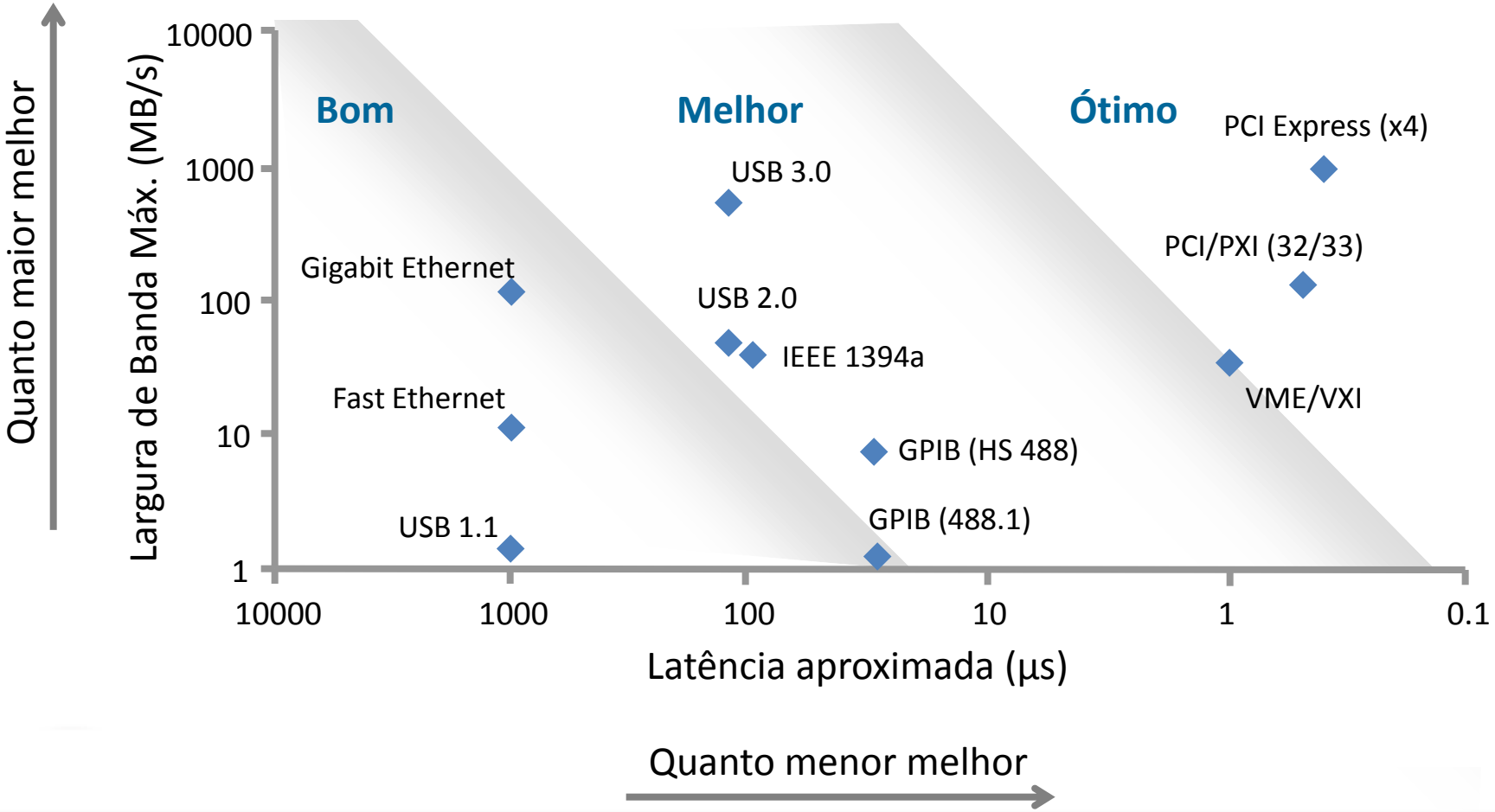
POWERED BY

NATIONAL INSTRUMENTS LabVIEW

Tecnologia #1:
Barramento de Alta Velocidade

Desempenho de barramentos

Largura de Banda vs. Latência

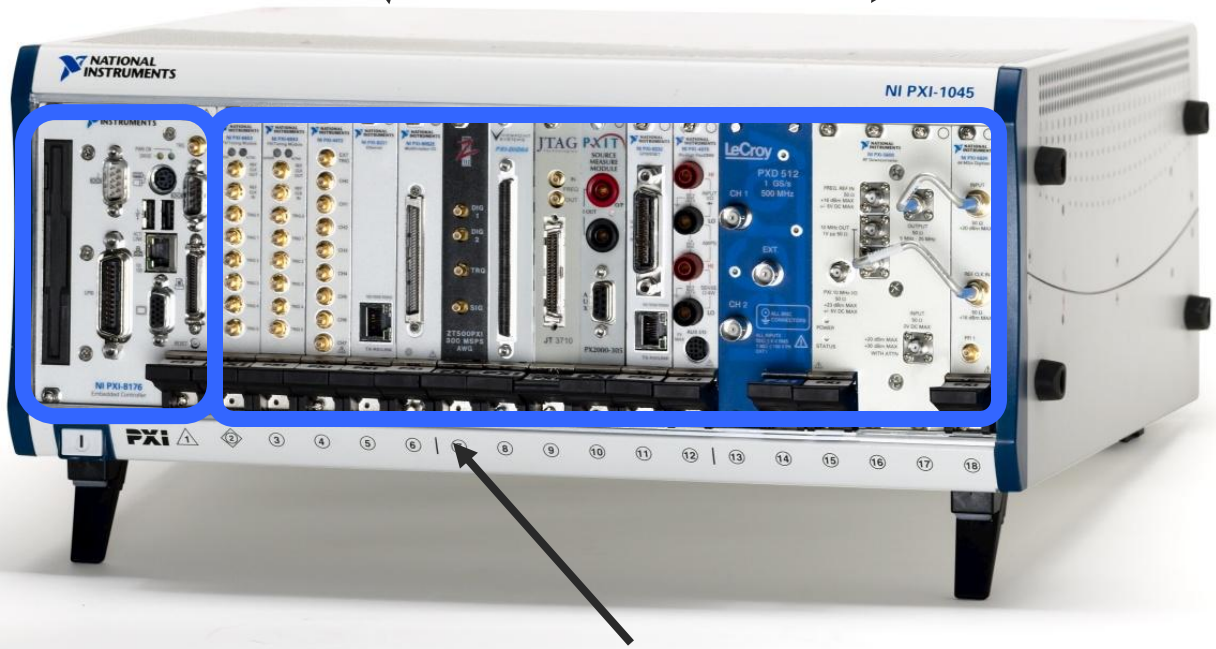


Visão global do sistema PXI

Bastidor
- Barramento PCI/PCI Express
- Sincronismo
- Temporização
- Clock de Sistema

Chassis
- Alimentação DC ou AC

Controladora PXI
- CPU embarcada ou remota
- Windows, Real-time ou Linux
- Multicore



Plataforma aberta, mais de 60 fabricantes globais
http://www.pxisa.org

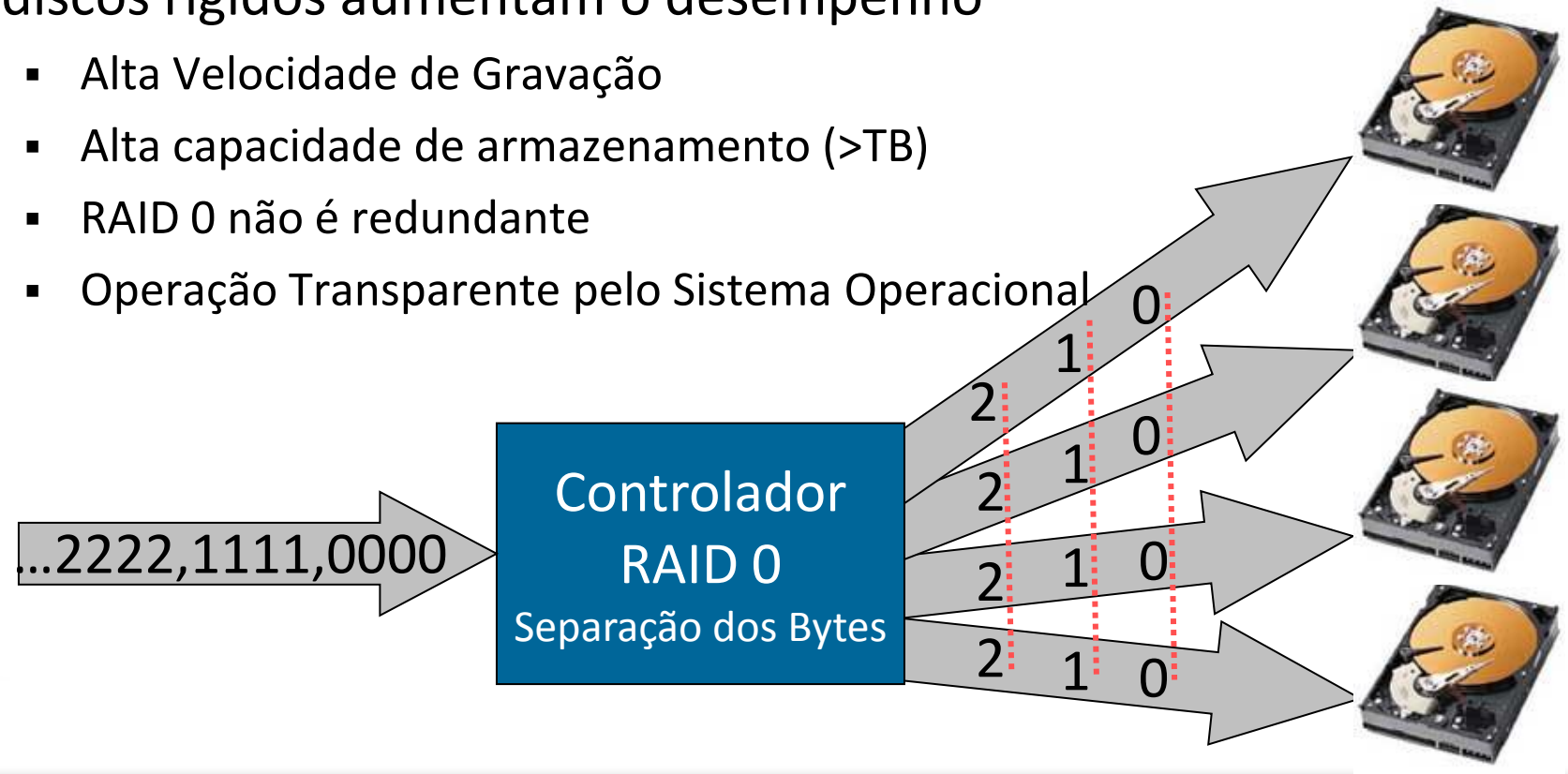
Slots para instrumentos

Padrão adotado globalmente

Tecnologias #2:
Armazenamento em Alta Velocidade

Conjunto de Discos (RAID)

- Redundant Array of Independent Disks
- Com RAID 0, operações paralelas em múltiplos discos rígidos aumentam o desempenho
  - Alta Velocidade de Gravação
  - Alta capacidade de armazenamento (>TB)
  - RAID 0 não é redundante
  - Operação Transparente pelo Sistema Operacional



Taxas Típicas de Disco

- GPS (2 MHz) = 10 MB/s
- Broadcast de TV (6 MHz) = 35 MB/s
- Monitoramento Espectral (20 MHz ou superior) = acima de 100 MB/s

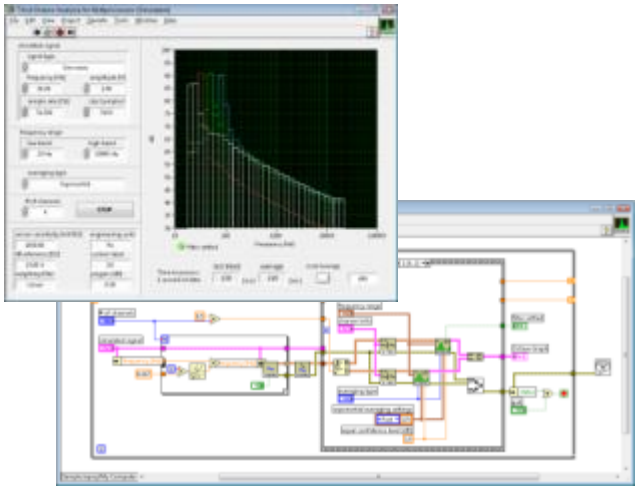
Drive	Transferência (MB/s)	Tamanho	Detalhes
USB hard disk	25	320 GB	Western Digital passport
PXI controller	30	60 GB	NI PXIe-8130
IDE	55	160 GB	Western Digital – 7.200 rpm
SATA	75	250 GB	Seagate Barracuda – 7.200 rpm
RAID 0 (4 disks)	100	1 TB	RAID via Express card
RAID 0 (4 disks)	200	1 TB	NI HDD-8263 RAID controller
RAID 0 (12 disks)	600	3 TB	NI HDD-8264 RAID controller

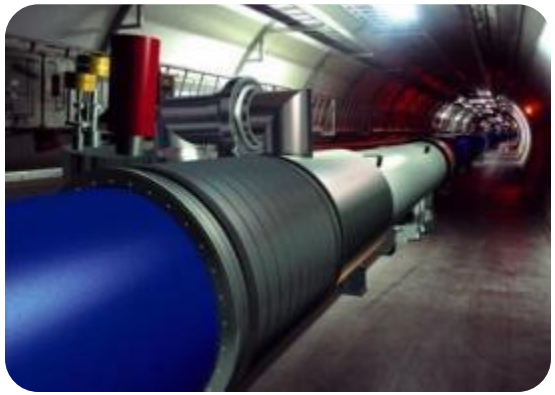
Tecnologias #3:
Técnicas Avançadas de Programação

Ferramenta Poderosa de Programação

LEGO® MINDSTORMS®
NXT
"O Brinquedo do Ano"

POWERED BY
NATIONAL INSTRUMENTS
LabVIEW™

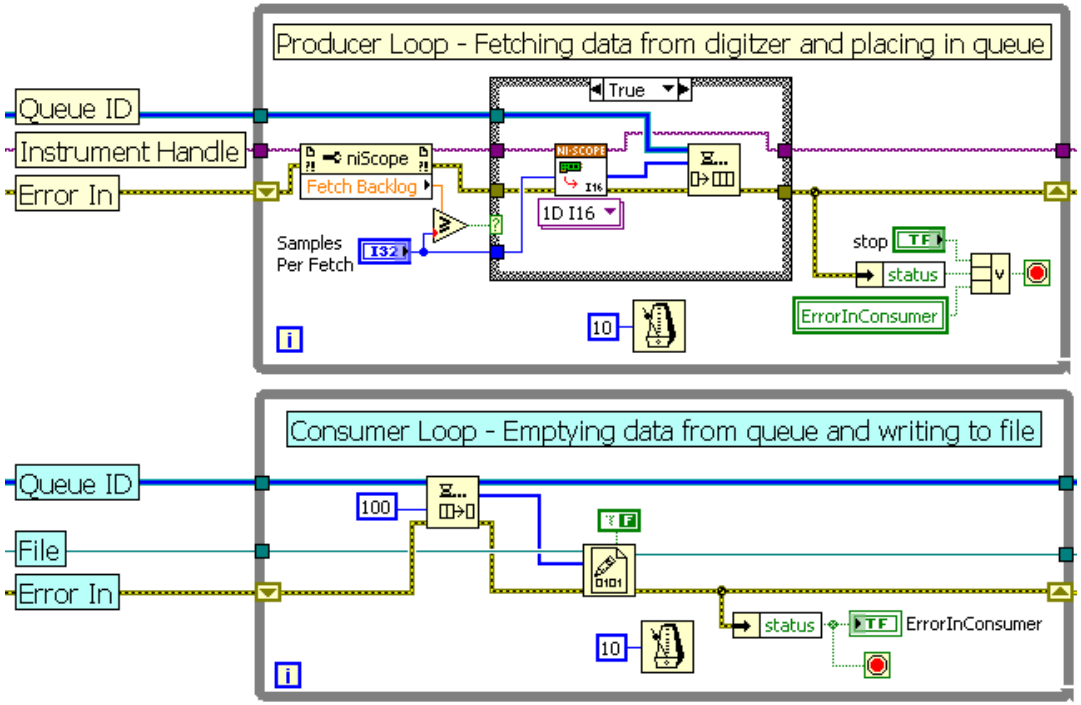




CERN Large Hadron Collider
"O Instrumento mais poderoso da Terra"

LabVIEW

- Programação gráfica simplifica o uso de arquiteturas avançadas
- Fluxo paralelo de dados aumenta o desempenho do sistema

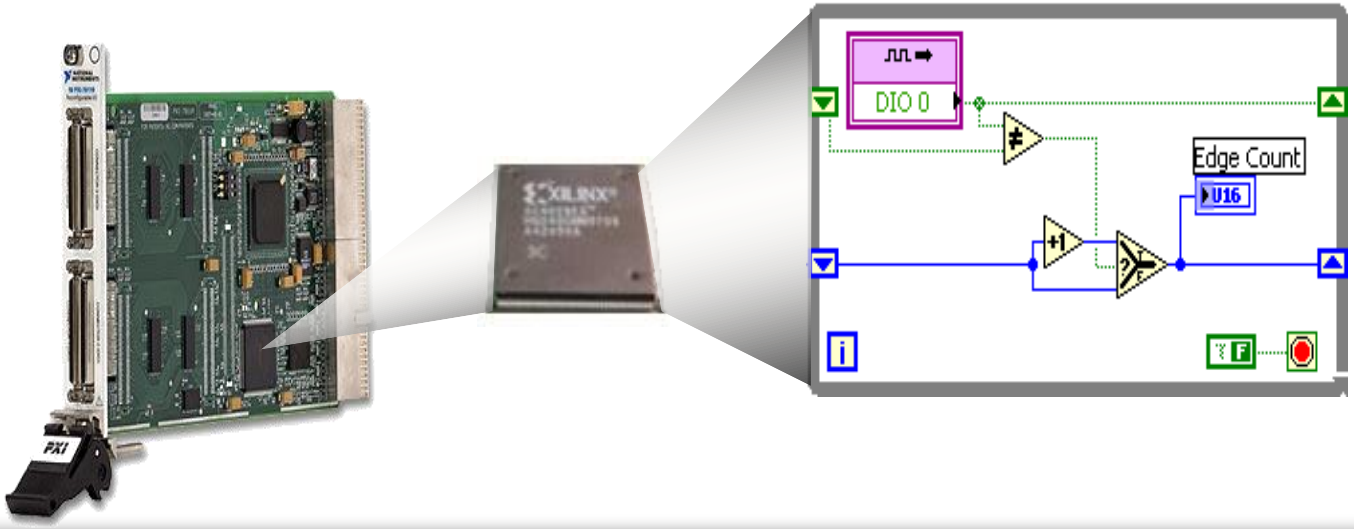


Produtor

Consumidor

LabVIEW FPGA

- Programação gráfica de FPGA
- Temporização e sincronização em alta-velocidade
- Customização de protocolos
- Processamento em linha

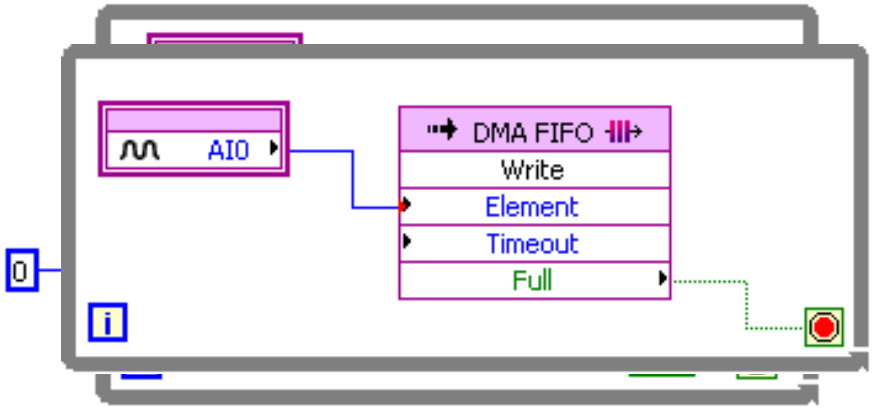


Abstração de código com LabVIEW FPGA

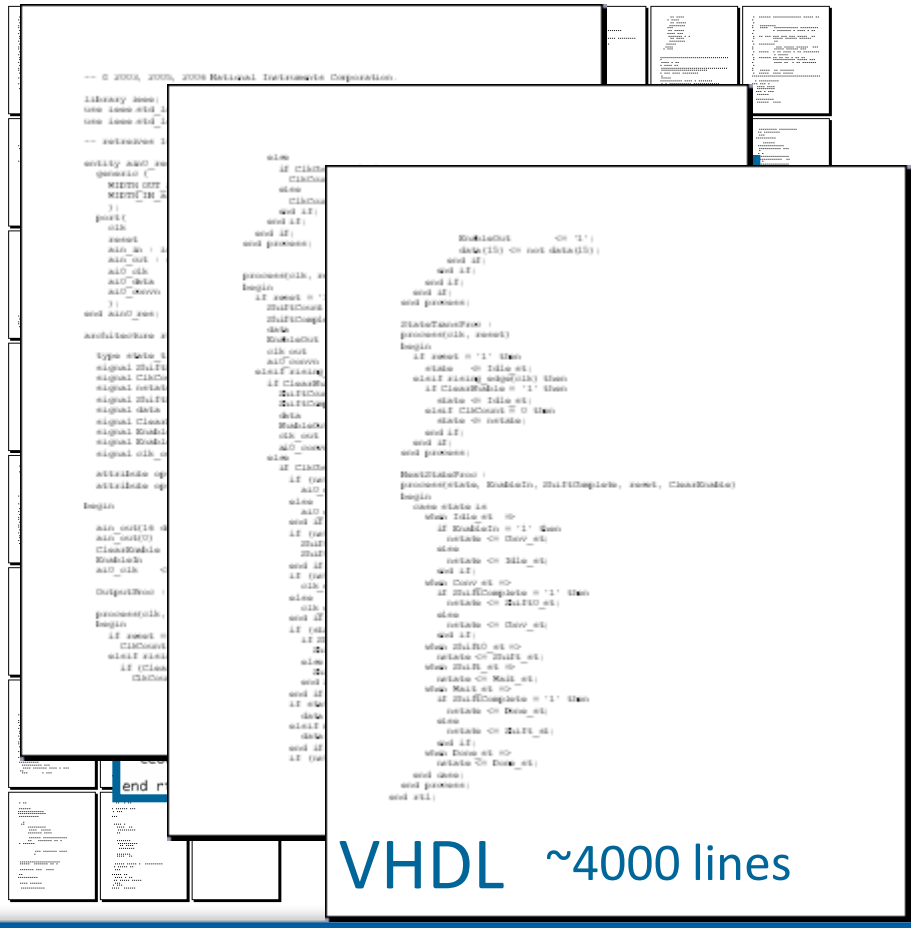
Counter

Analog I/O

I/O with DMA



LabVIEW FPGA



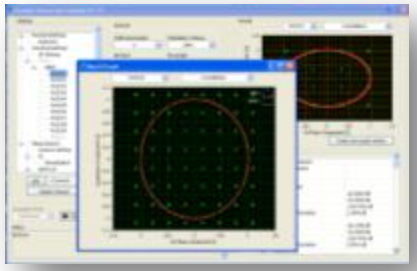
VHDL ~4000 lines

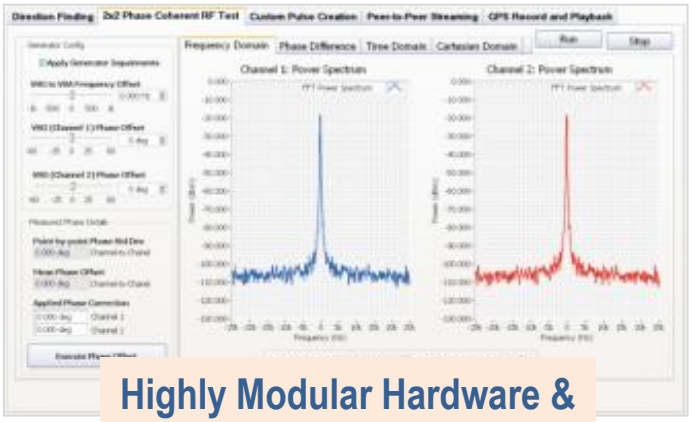
Plataforma para RF

A abordagem da NI para RF

Optimized APIs

Soft Front Panels

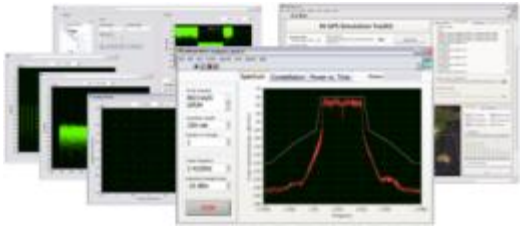




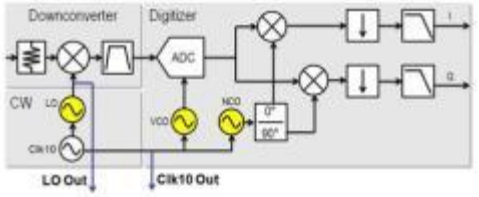
Highly Modular Hardware & Software

Cellular, Wireless, and GPS Test Toolkits

(802.11 a/b/g/n , GSM/EDGE, WCDMA, LTE, WiMAX, GPS, etc.)



Reference Architectures



Multicore Processing

RF Signal Generators & Analyzers

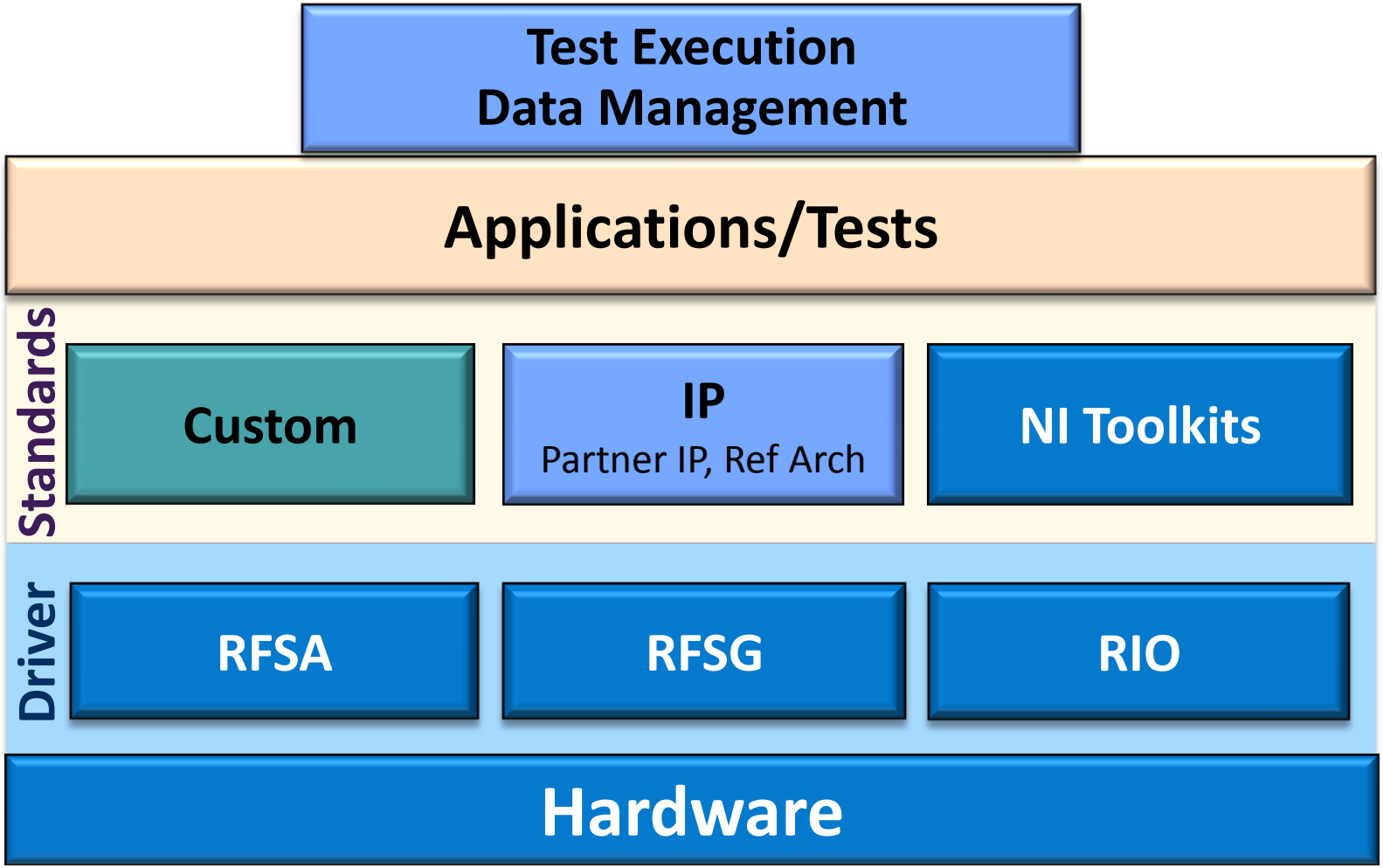
FPGA I/O and Coprocessing

RF Vector Network Analyzer

Switching, Amplifiers, Attenuators

Power Meters

Arquitetura de SW



Plataforma de teste definida por SW

All in one
PXI Platform!

GSM Tester

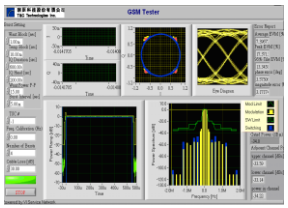
WLAN Tester

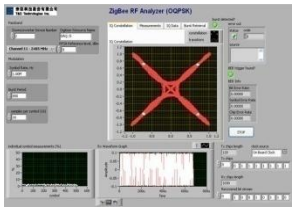
Spectrum

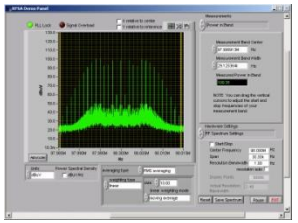
WiMAX Tester

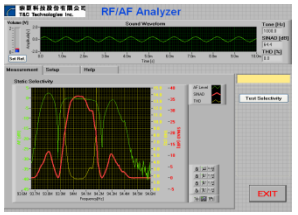
Power Meter

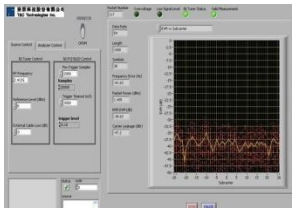
RFID Tester

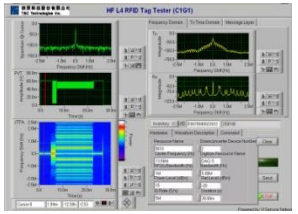




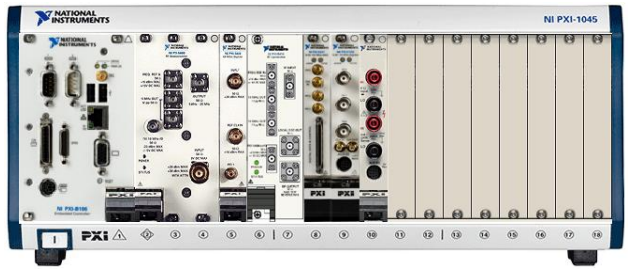






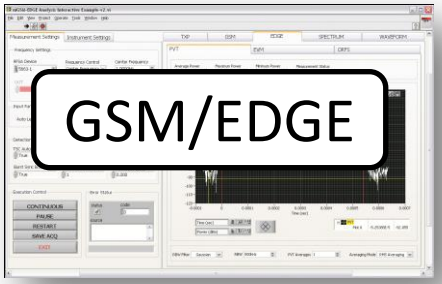


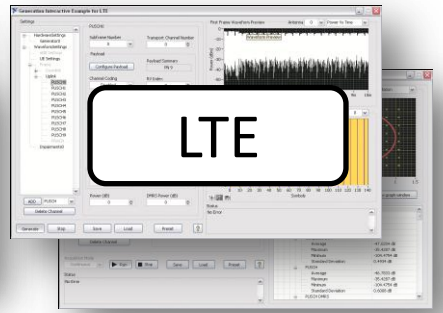
Multi-
Protocol
UUT

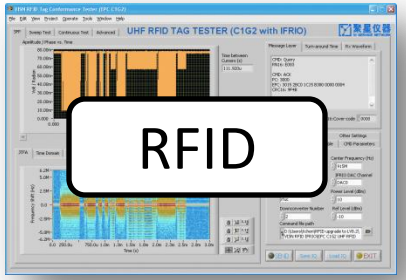


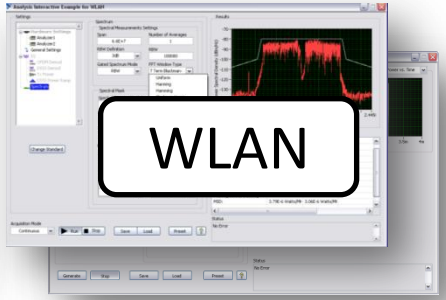
Images courtesy of Agilent, Tektronix, R&S, Anritsu

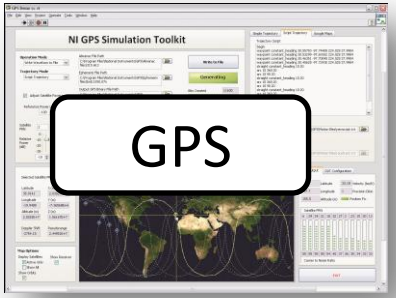
Toolkits de SW

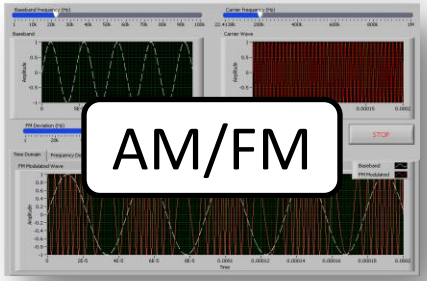


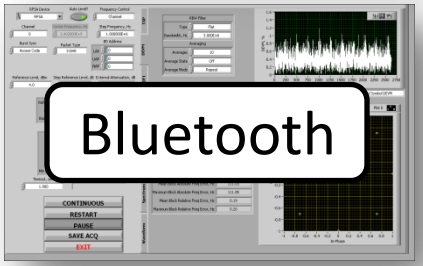












Analisadores de Sinais Vetoriais

2.7 GHz	6.6 GHz	3.6 GHz / 14 GHz
• Phase Noise = -90 dBc/Hz • Noise D. = -134 dBm/Hz • Bandwidth 20 MHz • Low Cost	• Phase Noise = -105 dBc/Hz • Noise D. = -158 dBm/Hz • Bandwidth 50 MHz • Fast tuning, <450 µsec	• Phase Noise = -129 dBc/Hz • Noise D. = -165 dBm/Hz • Bandwidth 25 or 50 MHz • Amp Acc = ± 0.2 dB

•Phase noise = Typical with 1 GHz input @ 10 kHz offset.
•Noise density in the 1 GHz or higher range.

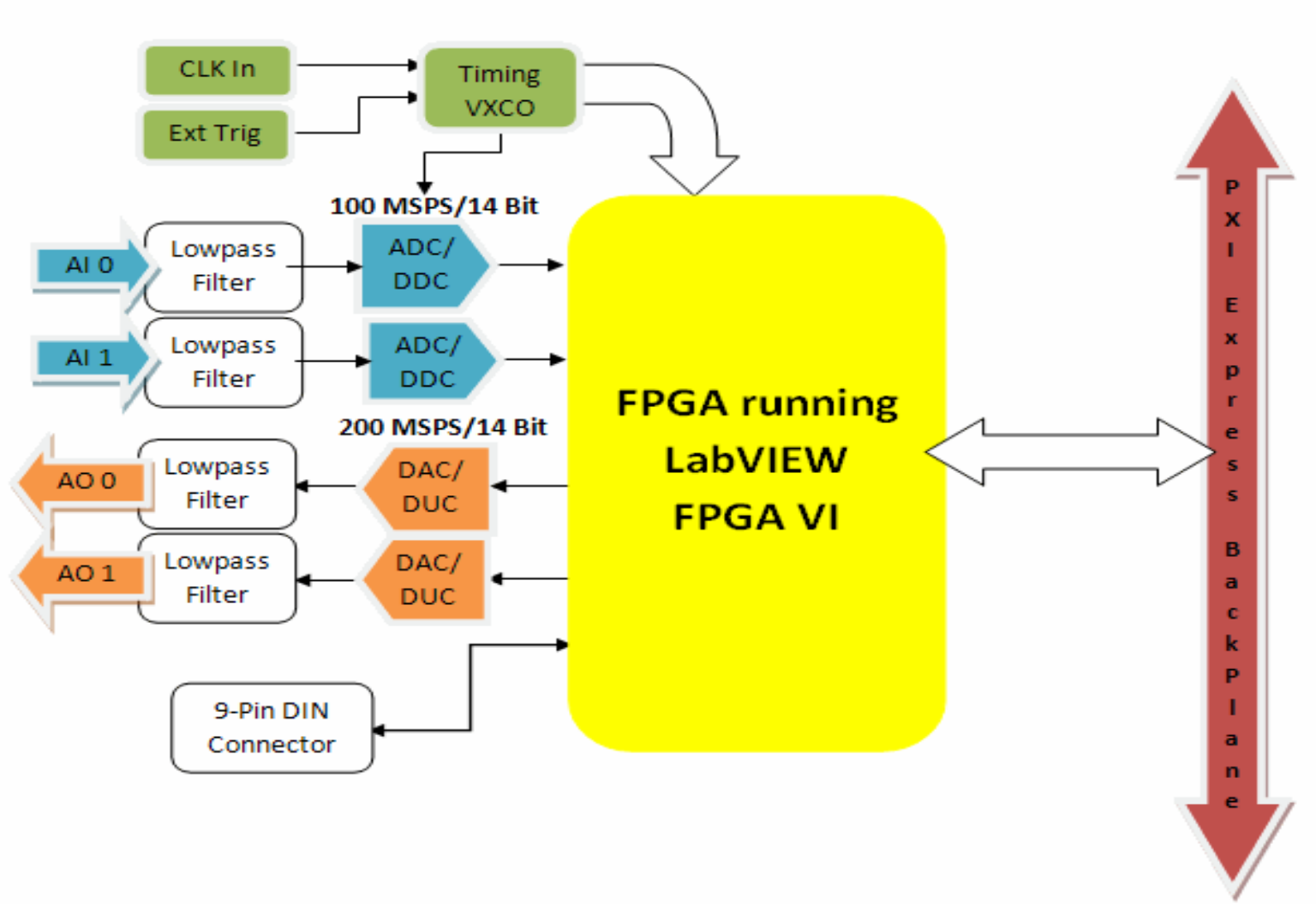
Analisador de Sinais Vetoriais de 26.5 GHz

- 100 kHz to 26.5 GHz frequency range
- Wideband (350 MHz) and narrowband (30 kHz and 8 MHz) IF outputs
- Fast-tuning local oscillator (<1 ms)
- -118 dBc/Hz phase noise at 10 kHz offset from 1 GHz (typical)

Transceptor FPGA

- 2 IF inputs and 2 IF outputs
- 20 MHz real-time IF bandwidth
- Xilinx Virtex-5 SX95T FPGA optimized for DSP
- 100 MS/s 14-bit ADC
- 200 MS/s 14-bit DAC

Diagrama em Blocos do Transceiver



FlexRIO

- **NI-PXIe 7965R Specifications**
  - DSP-focused Virtex-5 SX95T FPGA
  - 512 MB onboard DDR2 DRAM
  - 16 DMA channels for high-speed data streaming at more than 800 MB/s
  - Peer-to-peer data streaming to and from other FPGA instruments modules and select NI modular
- **NI 5762 Specifications**
  - 2 simultaneously sampled 16-bit channels
  - 100 MHz bandwidth and unfiltered versions
  - AC coupled, 50 Ω input
  - 12 bidirectional general-purpose digital I/O channels

NI-USRP (Radio Definido por Software)

- **Specifications**
  - NI-USRP 2920: Tunable center frequency from 50 MHz to 2.2 GHz covering FM radio, GPS, GSM, radar, and ISM bands
  - NI-USRP 2921: Tunable coverage of 2.4 GHz and 5 GHz bands for Wi-Fi, Bluetooth, and other ISM applications
  - Affordable teaching and research solution
  - Up to 20 MHz baseband I/Q bandwidth streaming at 25 MS/s for host-based processing with NI LabVIEW
  - Windows 7/Vista/XP compatibility

Geradores de Sinais

- 500 kHz to 1.3, 3.3 or 6.6 GHz
- Less than 2 ms sweep tuning speed
- Less than 1 ppb frequency resolution
- -110 dBc/Hz phase noise at 1 GHz, 10 kHz offset typical
- FM, 2-FSK, OOK modulation

Sintetizador

FSW-0020 Specifications

- Freq. Range: 0.2 to 20 GHz
- Resolution: 0.001 Hz
- Switching Speed: 100 µs
- Max. Power: 13 dBm
- 10 kHz Phase Noise: -116 dBc/Hz@20 GHz
- Spurious: -70 dBc

Pré e Amplificador

NI PXI-5690 Preamplifier

- 100 kHz to 3.0 GHz frequency range
- 2-channel fixed or programmable gain with bypass
- 30 dB fixed gain on channel 0; -10 to +20 dB programmable gain on channel 1

NI PXI-5691 Amplifier

- 500 MHz to 8GHz frequency range
- Up to +24 dBm maximum output power
- Up to 60 dB total gain
- 0.5 dB gain resolution

Chaveadores e Multiplexadores

NI PXI-2549 Dual Terminated

- 50 Ω characteristic impedance
- 2.7 GHz bandwidth
- Insertion loss at 2.7 GHz <1.5 dB (typical <1.35 dB)
- VSWR at 2.7 GHz <1.5 (typical <1.4)

NI PXI-2595 4x1 Multiplexer

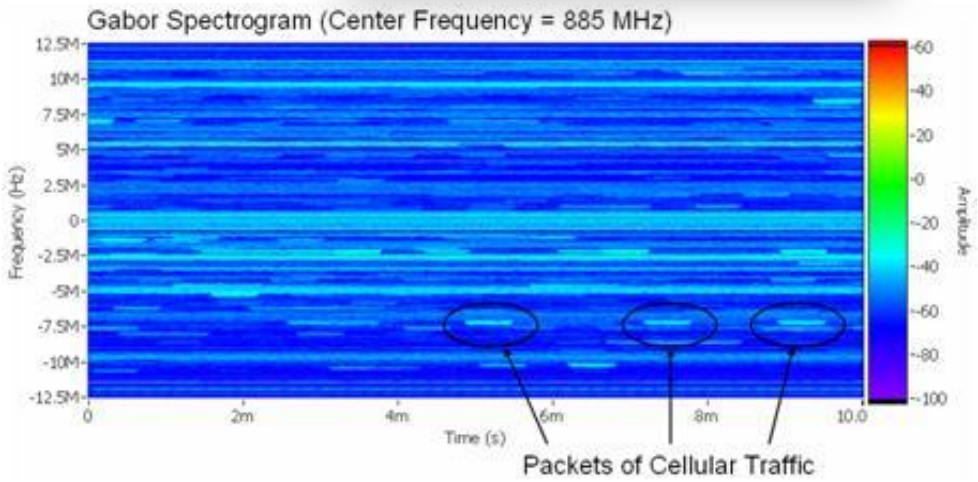
- 4x1 multiplexer configuration
- 5 GHz bandwidth
- 50 Ω characteristic impedance
- SMA direct connectivity

Soluções de Clientes

High-Speed Data Streaming

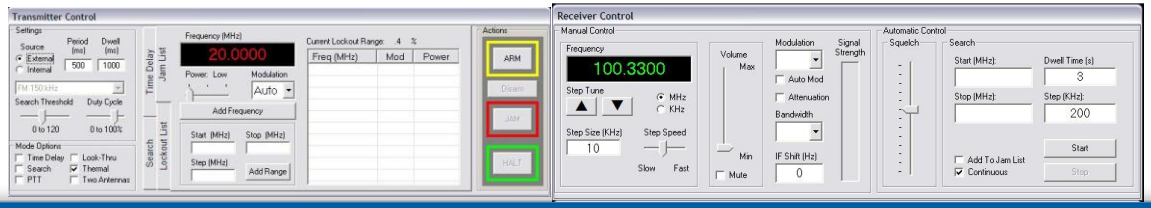
Spectrum Monitoring - Huari Telecom

- Identification of interference signals within a particular bandwidth of interest
- Continuously acquire waveforms for long periods of time
- 20 MHz of RF bandwidth for 5+ hours



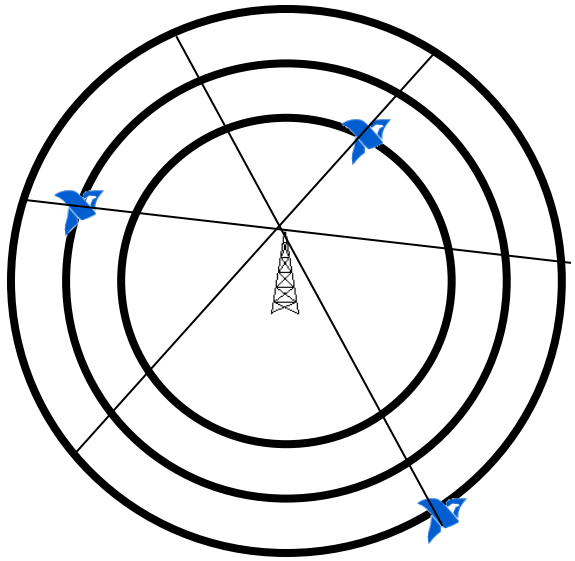
Tactical Jammer – ASIT

- COMINT/ RDF System flying on Predator UAV
- Tactical Communications Jammer using COTS components
- 20-3000 MHZ Collection and Geolocation
- Operate 30 minutes from mil pouch batteries
- Provide AM, FM modulation with external input
- Provide programmable internal modulation
- Fully Remoted via SatcomBased on COTS 3U cPCI components



Triangulation

- PXI-6682 Synchronization Module
  - GPS synchronization (accuracy of 15 ns to signal)
  - Future time events, clocks, and timestamping
- PXI-5661 Vector Signal Analyzer
  - 20 MHz Vector Signal Analyzer
- PXI chassis and controller
- System Monitor



Digital Radar Timing Generator for the Advanced Hawkeye Program – LMCO

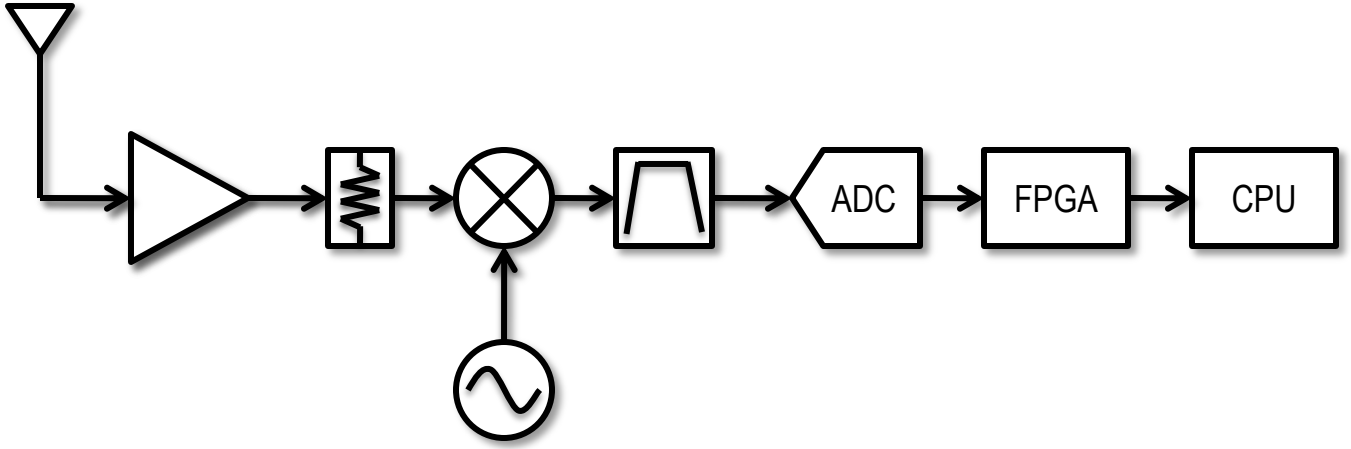
Challenge: Produce a digital radar timing generator having multiple synchronized pulse outputs of various pulse widths and delays, having 25 ns accuracy, and to be adjustable on the fly.

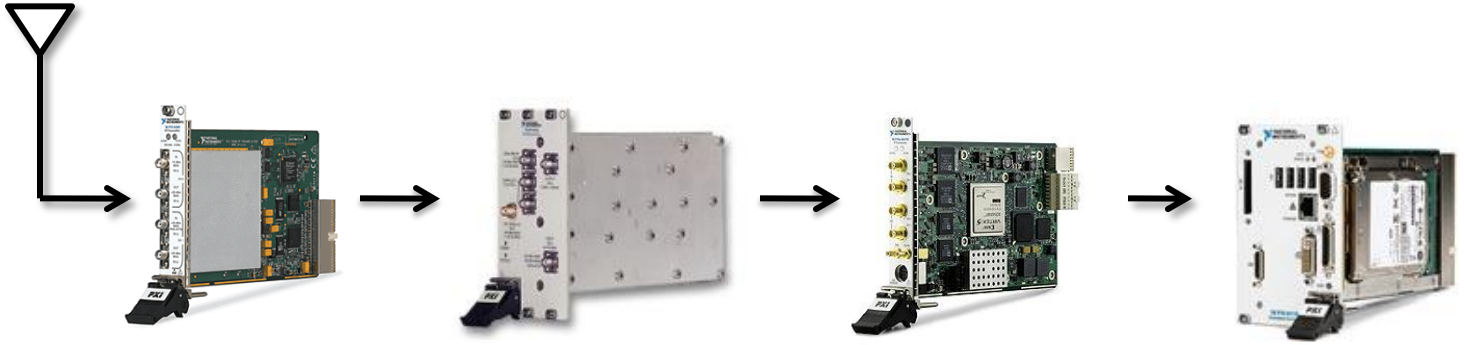
Products: LabVIEW, LabVIEW FPGA, RF hardware

Result: "We chose to use the Configurable FPGA module. Using LabVIEW code for the I/O and control combined with our own VHDL code we were able to achieve long repetition cycles of complex pulse groups. The timing generator is used in conjunction with a rack full of RF test equipment controlled by LabVIEW for testing radar systems. In addition we use the FPGA to make simulators and emulators for various serial protocols including standard UARTS, packet communications, I2C, and SPI.

Demo

Monitoramento de Espectro em Tempo Real





Resumo

- Tecnologia de Barramento
- Armazenamento em alta velocidade
- Programação com LabVIEW
- Processamento em linha com FPGA
- Instrumentação modular

Obrigado!

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