Optimizing Embedded Software Energy Consumption

Elmar Stahleder

- Find the program part causing the highest energy consumption
- Locate unexpected power peaks
- Check if power-saving modes are used efficiently

Optimizing Embedded Software Energy Consumption

- **Motivation**
- Requirements
- Solution
- Example

LAUTERBACH DEVELOPMENT TOOLS

Energy = Current x Voltage x Time

In microprocessor-controlled applications each of this parameters can be influenced by the software

- Dynamic use of power-saving modes
- Dynamic change of CPU frequency
- Dynamic change of target voltage

- Dynamic use of chip internal and external resources (RAM, Flash)
- Dynamic function run-times (cached, non-cached)

LAUTERBACH DEVELOPMENT TOOLS

Tasks of Energy Profiling

Software developers have to constantly search for optimal settings of these three parameters

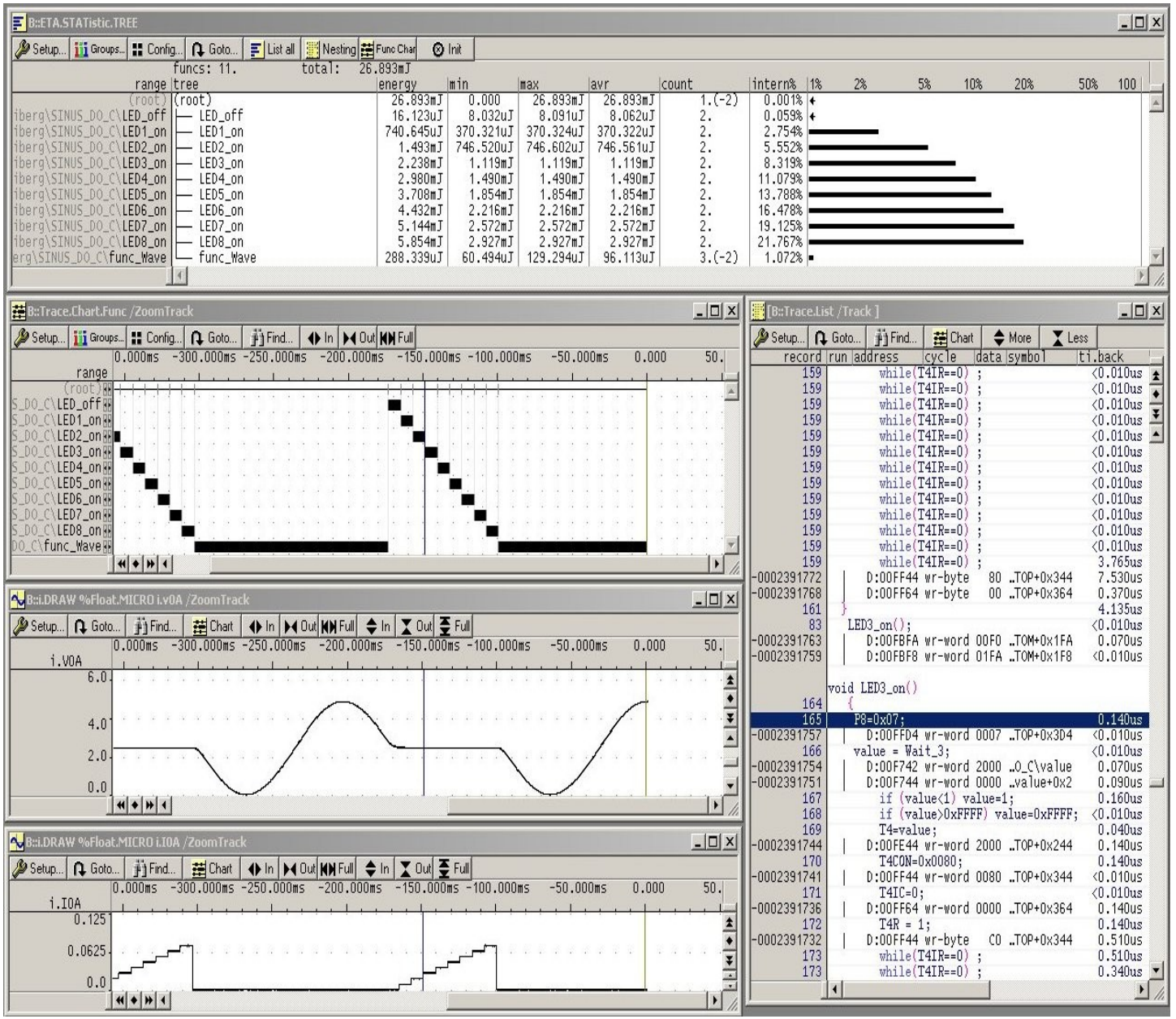
Energy = Current x Voltage x Time

- Detect power-hungry hardware parts
- Detect power-hungry software parts
- Detect wrong usage of power-saving modes
- Detect unexpected power peaks

- Calculation of energy consumption (overall, task, function ...)

- How program changes affect power consumption

LAUTERBACH DEVELOPMENT TOOLS



Energy statistics

Program chart

Program flow

Voltage waveform

Current waveform

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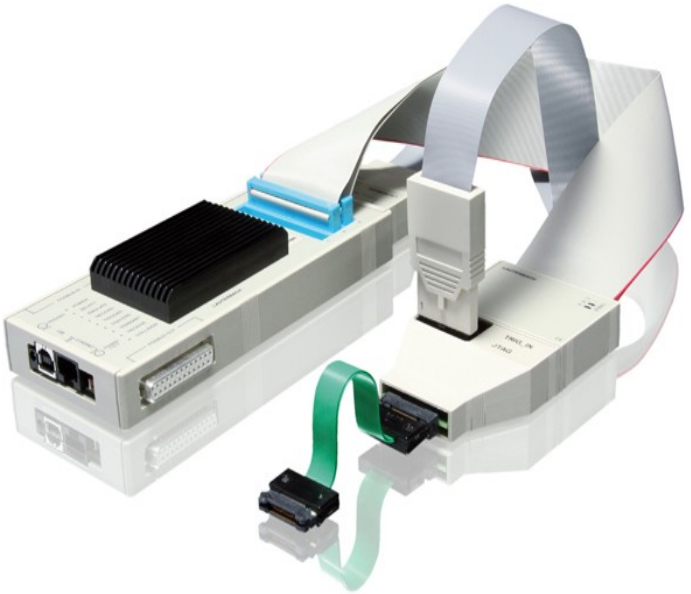
Debugger + Real-time Trace

Debug control and
run-time measurement



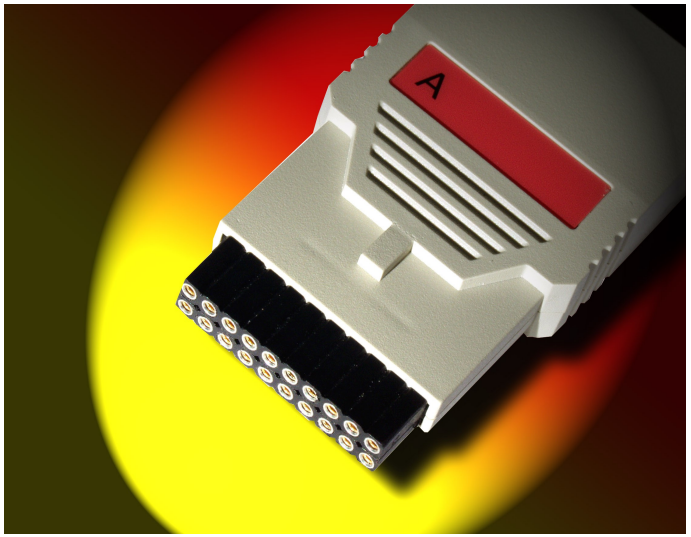
Logic Analyzer + Analog Probe

Current and voltage measurement

- Time-correlated measurement of program flow, current and voltage
- Cross-trigger capability
- Tool control integrated in debug user interface

Analog Probe

Signal	Pin	Pin	Signal
I2-	1	2	GND
I2+	3	4	GND
I1-	5	6	GND
I1+	7	8	GND
I0-	9	10	GND
I0+	11	12	GND
V3	13	14	GND
V2	15	16	GND
V1	17	18	GND
V0	19	20	GND



- V[3..0] voltage inputs (0..5 V, 1 MOhm)
- I[2..0] current inputs (requires shunt resistance)

- 12 bit resolution
- 625 KHz sampling rate (one channel)

Sampling rate = 625 KHz / number-of-enabled-channels

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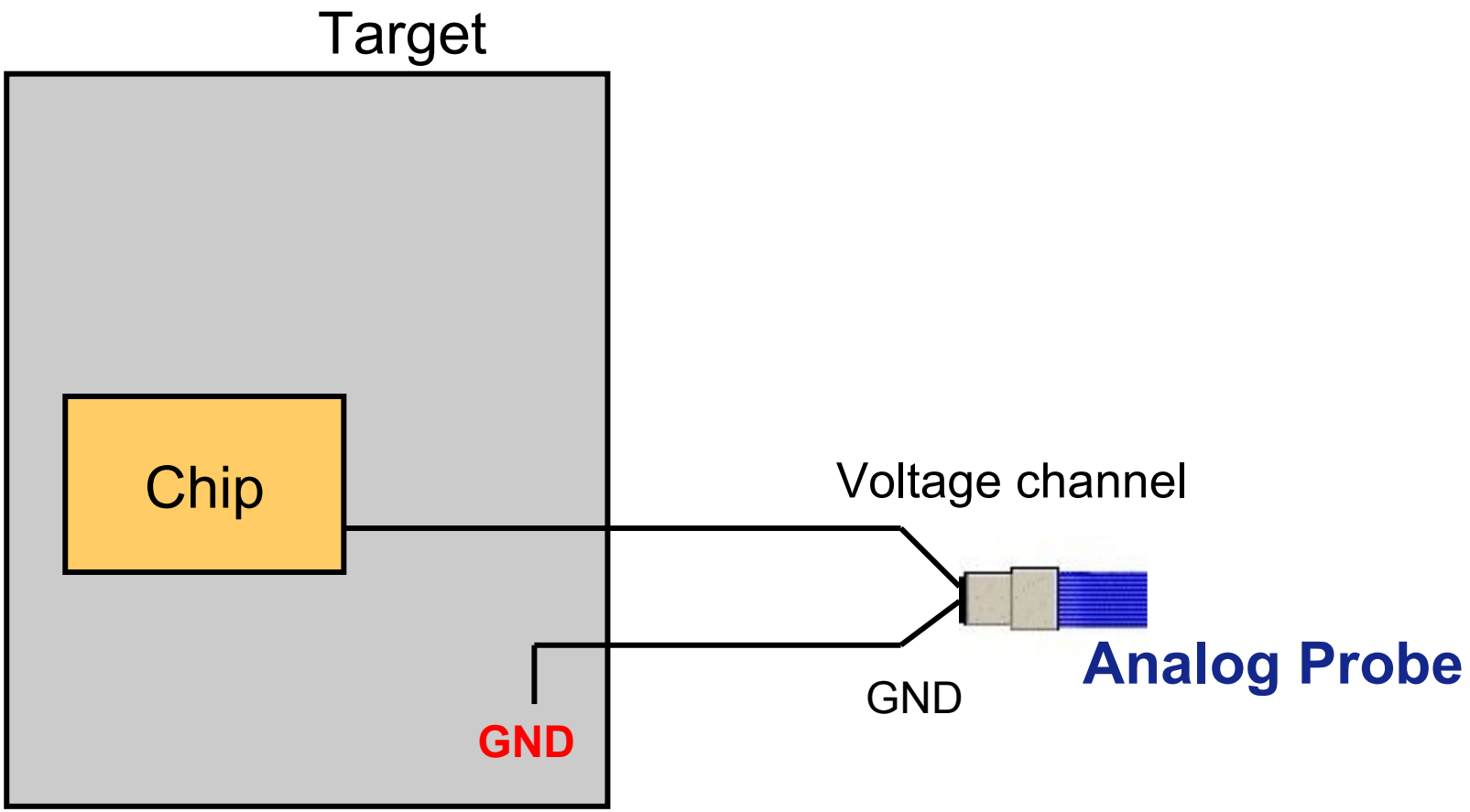
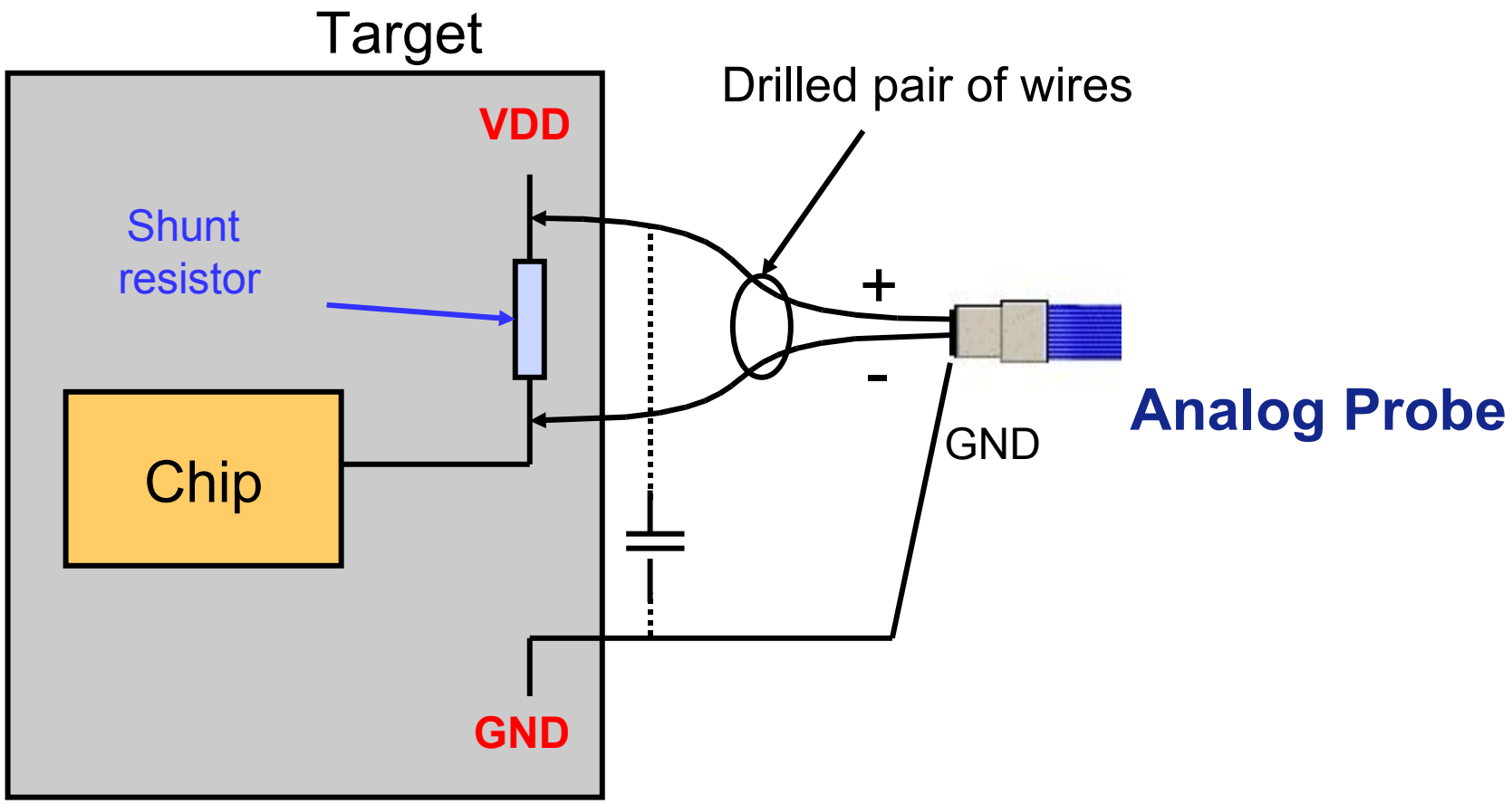
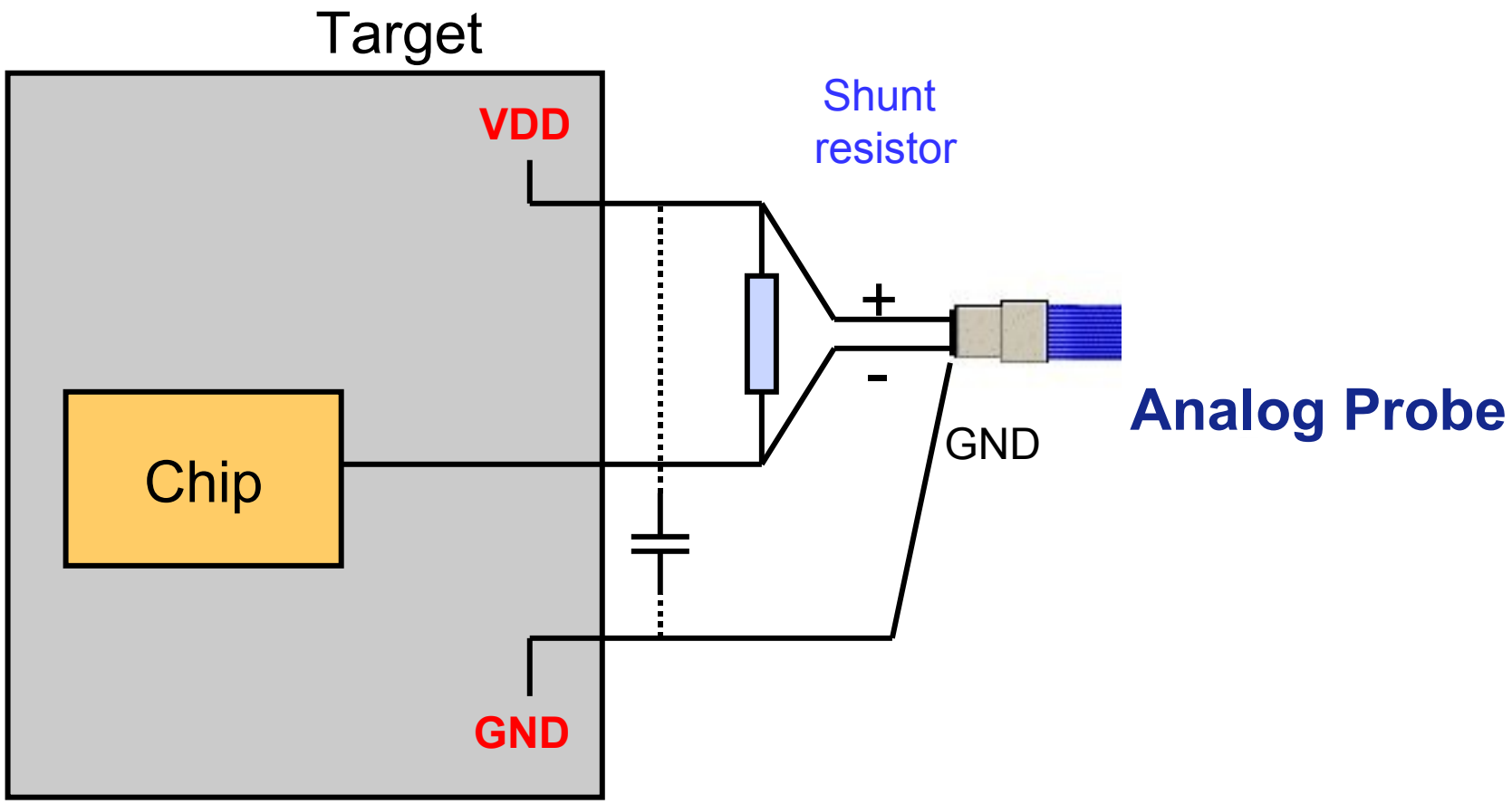
Voltage Measurement



Current Measurement



Current Measurement



Shunt Resistance

Calculation of shunt resistance

Max-current at 125mV voltage drop

R=U/I

e.g. 125mV/4A = 0.03125 → 0.025 Ohm
e.g. 125mV/2A = 0.0625 → 0.050 Ohm

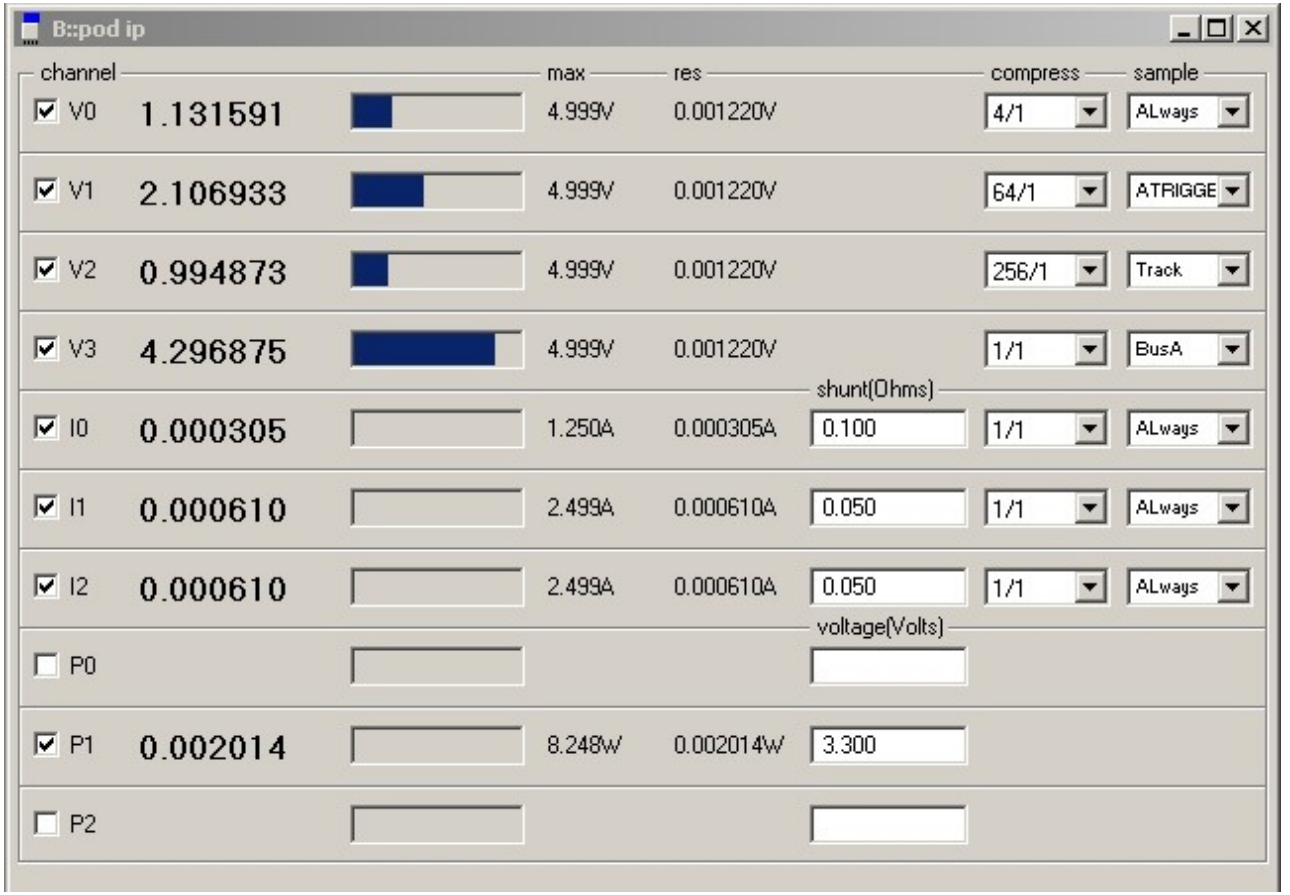
Many dev boards are equipped with shunt resistors and provide pins either side

Configuration

4 voltage channels

3 current channels

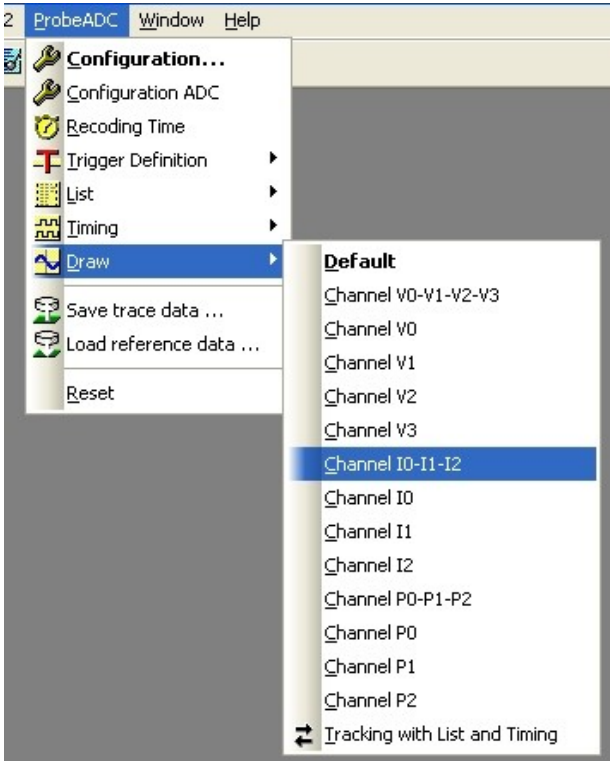
3 power channels
(virtual channels)

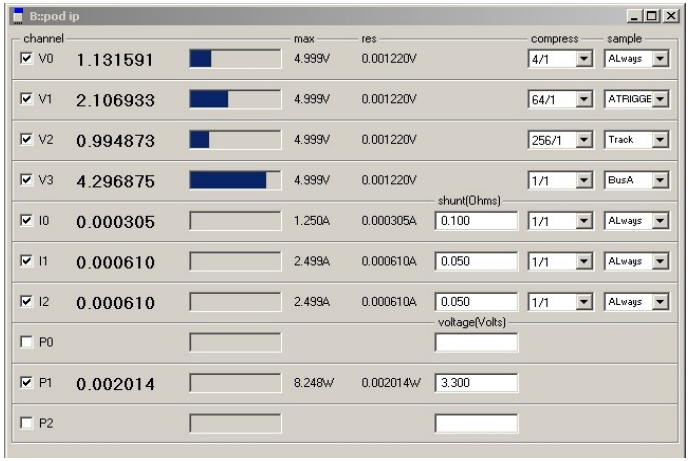


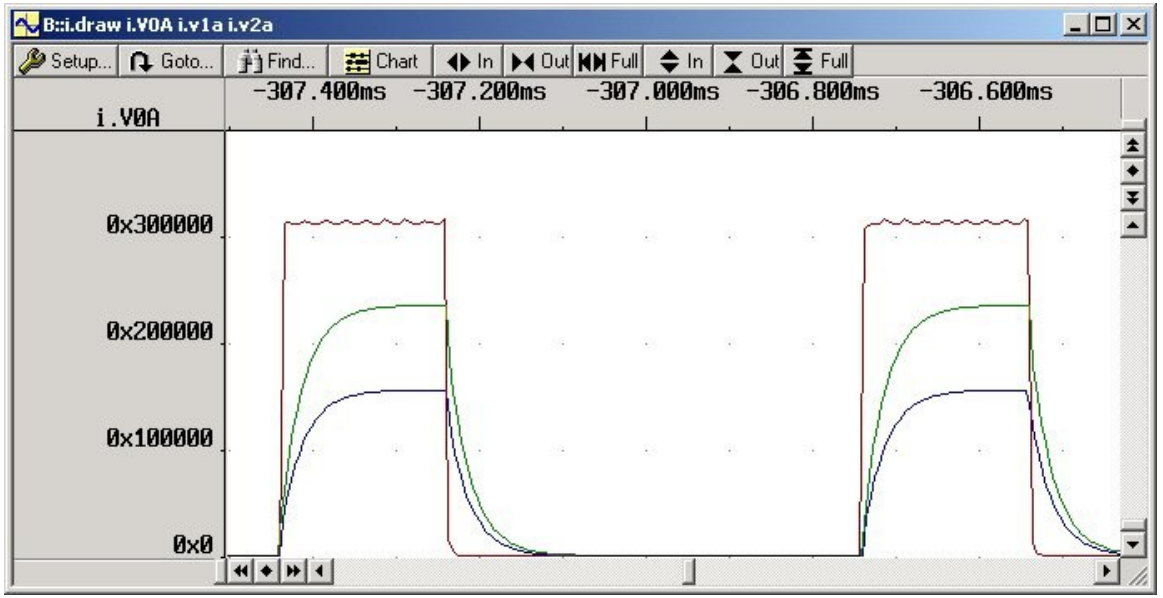
Channel enable

- Shunt resistance
- Voltage

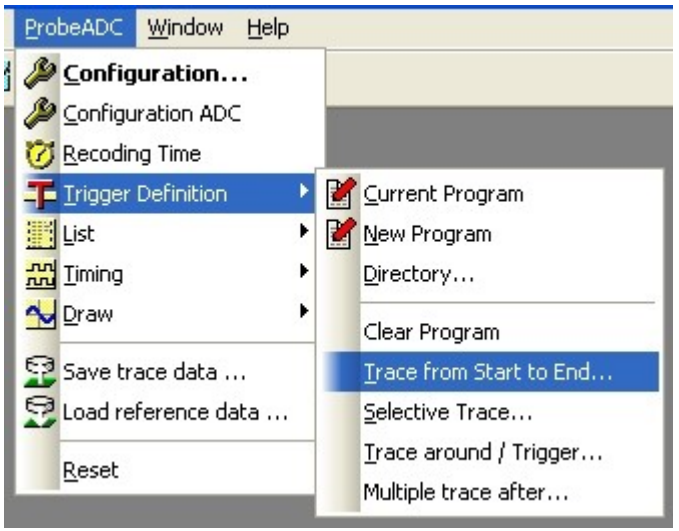
User Interface



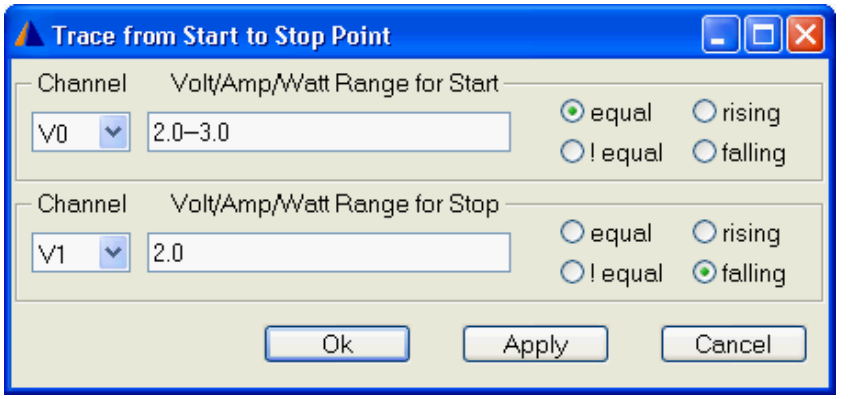


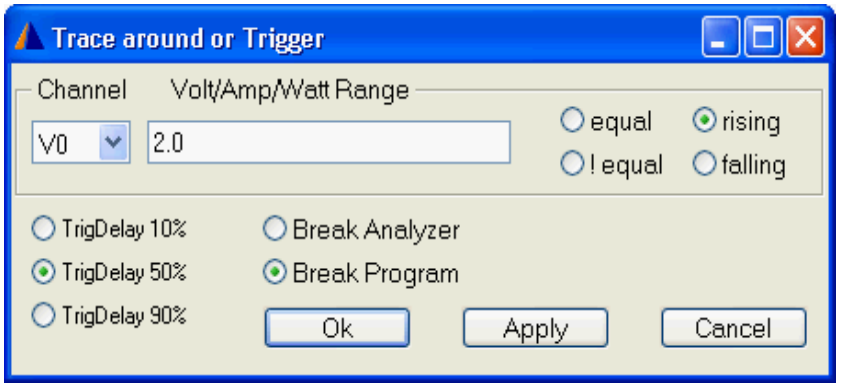


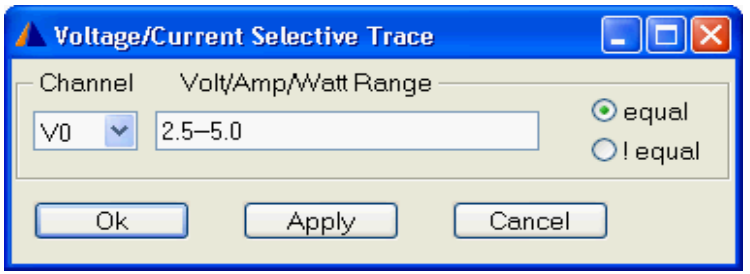
User Interface

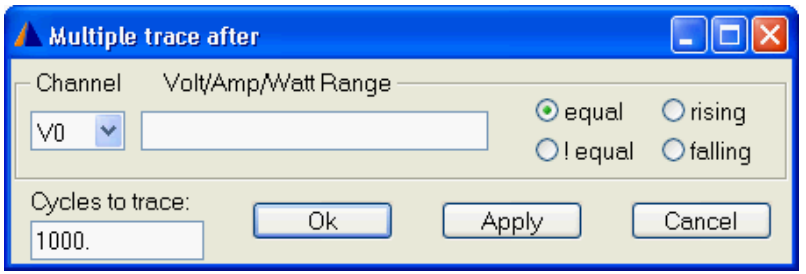


Trigger on voltage, current and power

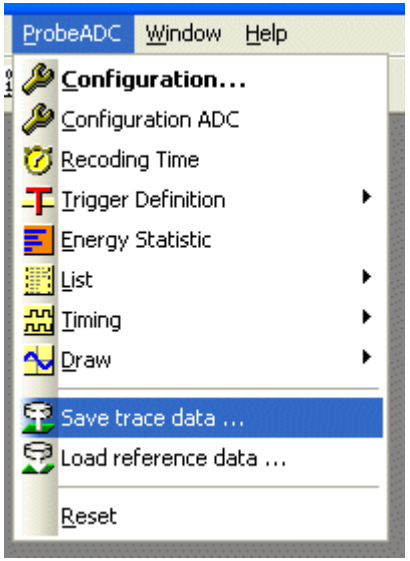








Data Save / Export / Offline Analysis



TRACE32 off-line analysis

- Save recording: i.SAVE <filename> <recordrange>
- Load to simulator: t.LOAD <filename> /Config

Data export (as text file)

- Select printer type: PRinTer.FILE <filename>
- Open i.List window with the analog channels of interest
- Scroll cursor to the first record of interest
- Left mouse click to i.List icon, click to Print all

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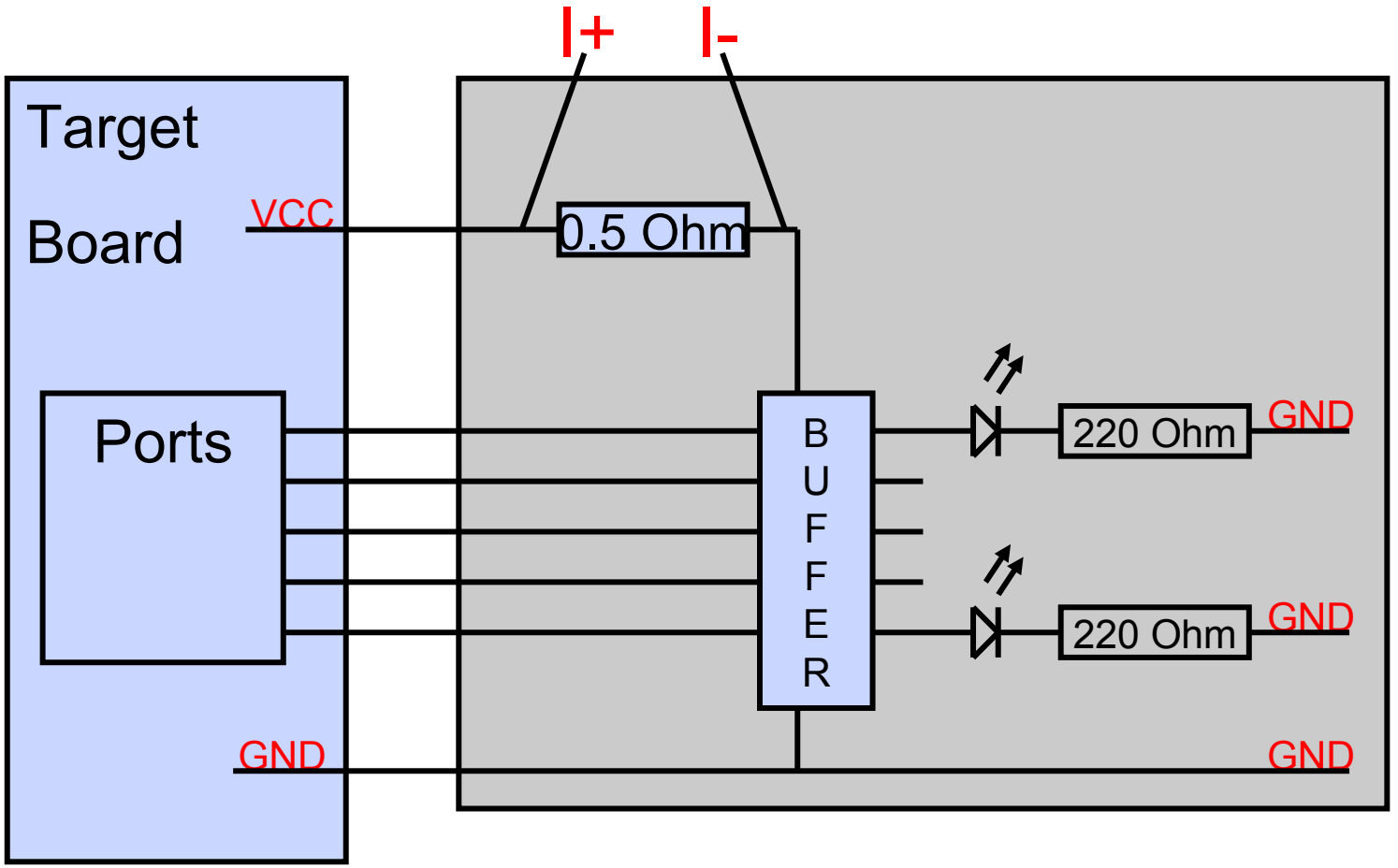
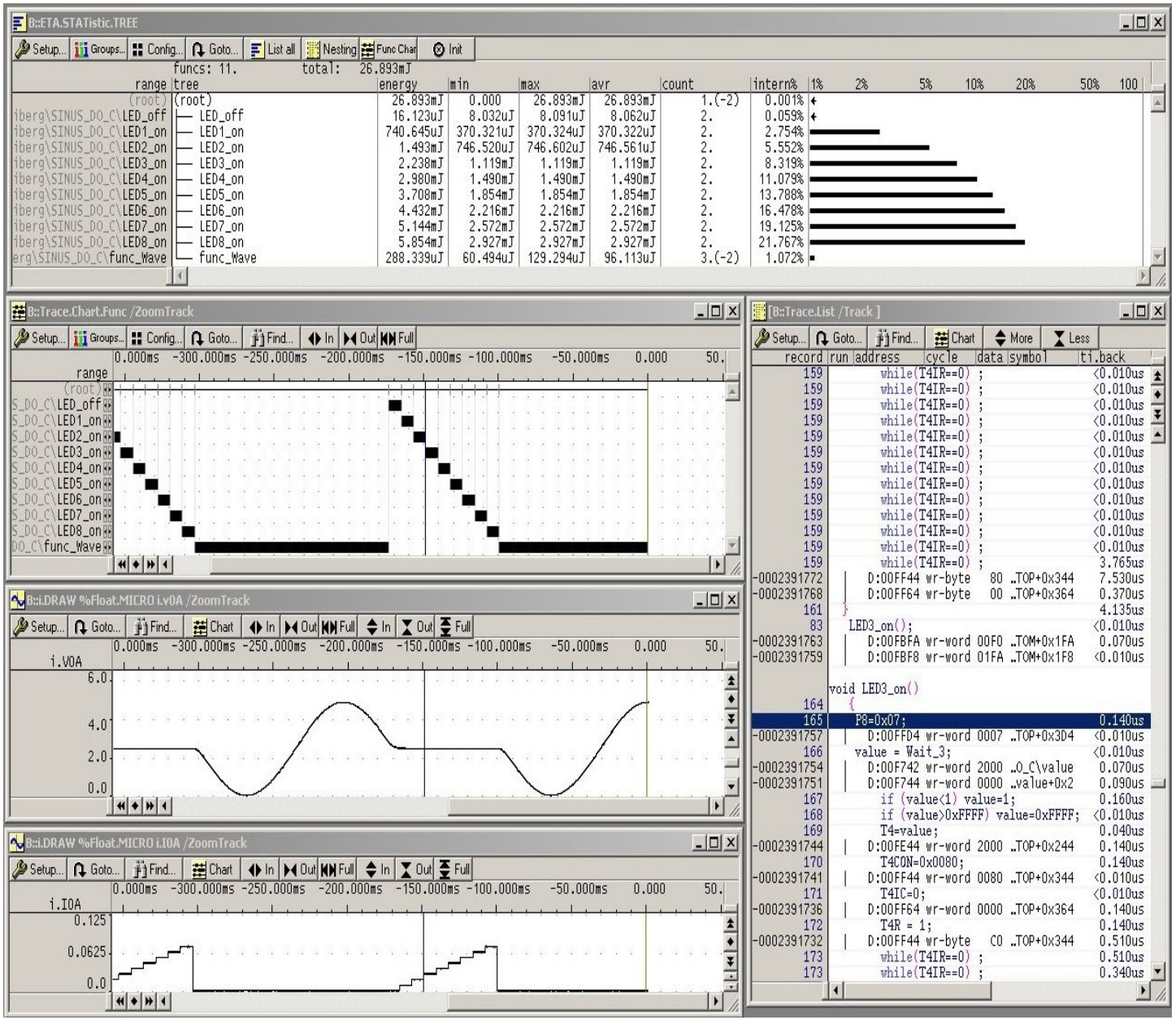
Demo Application





Energy statistics

Chart display

Program flow

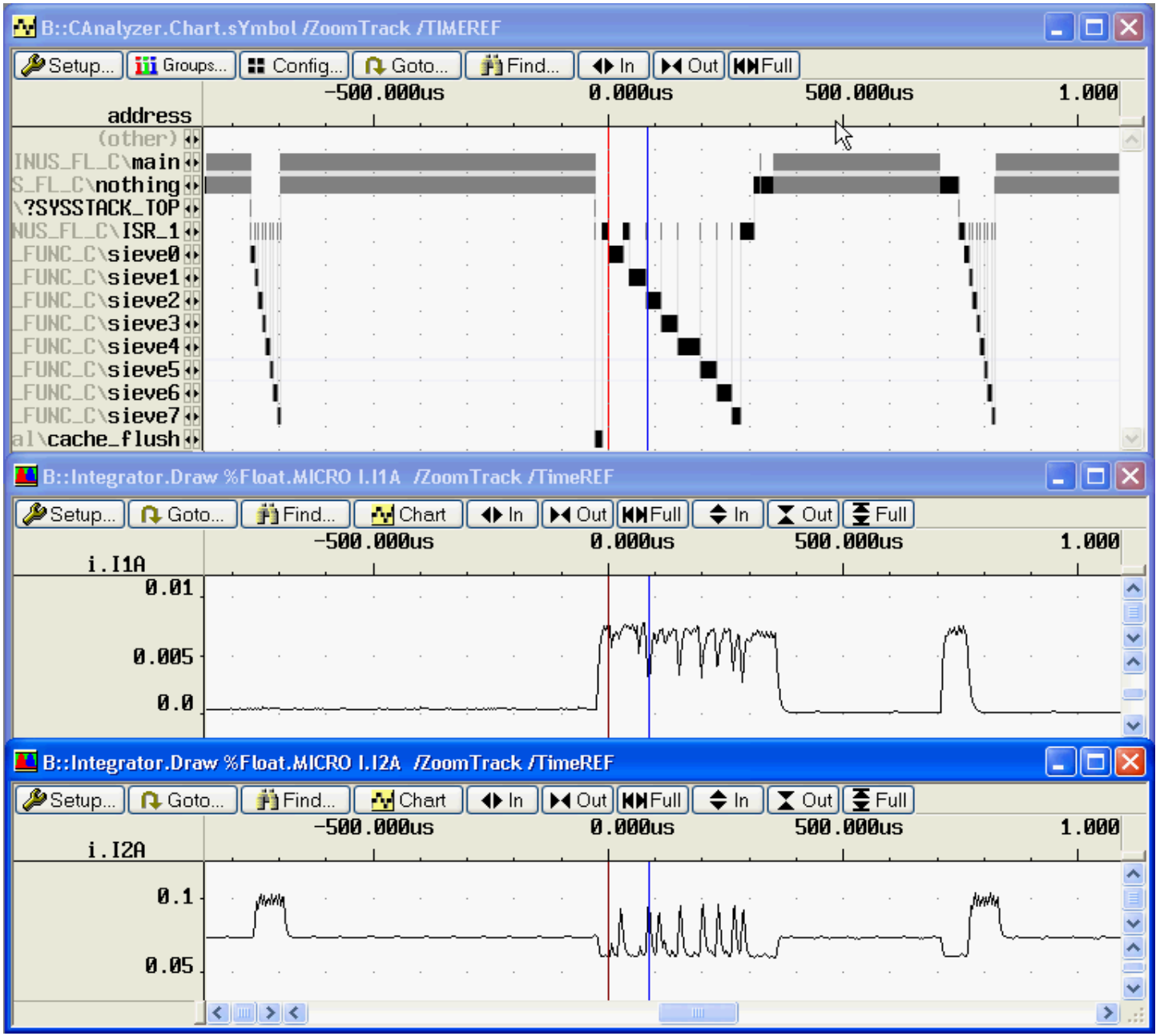
Voltage waveform

Current waveform

Cached/
non-cached
program flow

Memory
interface
current

Core current



Thank You!

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Questions?