OPBOX ver 2.0 - USB 2.0
Mini Ultrasonic Box
with Integrated Pulser and Receiver

http://www.optel.eu

Specification and User Manual

OPBOX 2.0 is a complete ultrasonic testing device, suitable for all ultrasonic measurements and due to many additional digital inputs/outputs and internal processor it can be used as a controller for more complicated devices.



The box can work together with following devices:
· multi channel multiplexer
· Phased array systems
· Scanner - it has input for incremental encoders;

The box has an implemented one channel pulser & receiver and can be used with one transducer or with two (one is sending, and the second one receiving).

Features

- Low noise preamplifier (0.74 nV/√(Hz))
- High gain up to +92 dB
- Switchable analog filters
- Support fast TGC (time gain compensation)
- 2 signal inputs PE and TT
- Input attenuator (-20dB)
- Input Impedance 50 Ohm, 10pF
- 100MHz sampling frequency, 10bit resolution
- Up to 256k x 8bit samples memory
- Delay settings up to 65535 sample periods
- Various triggering mode
- BNC or Lemo analog connectors
- Dimensions: L 100mm W 82mm H 32mm
- DB15 connector: I/O lines 6 Inputs and 6 Outputs
- USB 2.0 Hi Speed
- Power supply: delivered by the USB connector (5 VDC)

Rev.: 2.0.32

Date: 2011-02-28

Przedsiębiorstwo Badawczo-Produkcyjne **OPTEL** Sp. z o.o. ul. Morelowskiego 30 PL-52-429 Wrocław
phone: +48 71 329 68 53 fax.: +48 71 329 68 52 e-mail: optel@optel.pl http://www.optel.pl

Technical Data

Analog parameters:

Input Amplifier Gain:	-28dB to 68dB (step 0.5dB)
Input Post-Amplifier:	off or +24dB
Input Attenuator:	off or -20dB
Input Range:	±275mV (±2V with Attenuator active)
Full Bandwidth:	0.5 MHz - 25 MHz (-3dB)
Switchable Filters (-3dB):	0.5 - 6MHz, 0.5 - 10MHz, 0.5 - 15MHz, 0.5 - 25MHz, 1 – 6MHz, 1 - 10MHz, 1 - 15MHz, 1 - 25MHz, 2 - 6MHz, 2 – 10MHz, 2 – 15MHz, 2 - 25MHz, 4 - 6MHz, 4 - 10MHz, 4 - 15MHz, 4 – 25MHz

Pulser:

Pulse Voltage	off(0V) to 360V (positive pulse, Short circuit step pulser)
Charging Time	regulated from 0 to 3.1us in 0.1us steps
Fall Time	<= 20 ns
Pulse Duration	Short circuit, bandwidth up to about 50MHz
Output impedance	< 1 Ohm

A/D data acquisition:

Resolution	10 bit ADC (8-bit stored)
Sampling Frequency(MHz)	100; 50; 33,3; 25; 20; 16,7; 14,3; 12,5, 11,1; 10; 9,1, 8,3; 7,7; 7,14 and 6,67
Data Buffer	from 0 to 256k samples in step of 1
Delay Time	Post trigger from 0 to 65535 sample periods in step of 1

Hardware data processing:

Signal processing	RF (Raw Samples), Absolute, Averaging by 4
Measure gates	3 independent gate, Level and Peak detectors
PRF	Up to 10000 in selected designs

DAC (TGC) with arbitrary waveform generator:

Frequency:	100MHz
Resolution:	8 bit
Max. gain changing:	48dB pro step

Trigger settings:

On-board trigger timer;

Application trigger rate (Software controlled);

External trigger 2x inputs, TTL Signal;

Position triggers from Encoders modules.

Counters / Input for incremental encoder:

Two Encoder modules for support Incremental Encoders

Full channel inputs (CHA, CHB, IDX)

32-bit Position register, Capture and Compare feature

Inputs / Outputs

Analog:
2 x BNC or Lemo connectors

DB15 female connector:

DB15 pin	Signal name	Standard	Description
1	GPO 0	TTL 5V	SYNC_OUT output or general purpose output
2	GPO 2	TTL 5V	General purpose output
3	GND		ground
4	GPI 1	TTL/LVTTL	General purpose input or CHB input for ENC1
5	GPI 3	TTL/LVTTL	General purpose input or CHA input for ENC2
6	GPO 5	TTL 5V	General purpose output
7	Reserved		
8	GPI 5	TTL/LVTTL	General purpose input or IDX input for ENC2
9	GPO 1	TTL 5V	General purpose output
10	GPO 3	TTL 5V	General purpose output
11	GPI 0	TTL/LVTTL	General purpose input or CHA input for ENC1
12	GPI 2	TTL/LVTTL	General purpose input or IDX input for ENC1
13	GPO 4	TTL 5V	General purpose output
14	GND		ground
15	GPI 4	TTL/LVTTL	General purpose input or CHB input for ENC2

1. Device overview

1.1 Interface description

- Vendor ID: 0x0547
- Product ID: 0x1003
- Device Version: 2.0 (0x0200)
- Bus powered (<500mA)
- USB 2.0 High Speed (480Mbps)
- Class: Vendor
- Endpoints:
  1. Endpoint 0 (control): IN/OUT, 64-bytes max packet size
  2. Endpoint 2 (TGC curve): OUT, Bulk, 512-bytes max packet size
  3. Endpoint 6 (sample data): IN, Bulk, 512-bytes max packet size

2. Functional description

OPBOX-2.0 is controlled thru USB interface by Direct Orders and set of Control Registers.

List of Direct Orders:

No	Name	Ven. Req.
1.	OPBOX_SN	(0xd0)
2.	RESET	(0xD1)
3.	DIRECT_SW_TRIG	(0xD3)
4.	DIRECT_ACK	(0xD4)
5.	DIRECT_DATA_READY	(0xD5)
6.	PULSE_AMPLITUDE	(0xD6)

List of Control Registers:

No	Name	Address
1.	DEV_REV	0x00
2.	POWER_CTLR	0x02
3.	GP_INPUTS	0x0C
4.	GP_OUTPUTS	0x0E
5.	TRIGGER	0x10
6.	TRG_OVERRUN	0x12
7.	XY_DIVIDER	0x14
8.	TIMER	0x16
9.	ANALOG_CTRL	0x1A
10.	PULSER_TIME	0x1C
11.	MEASURE	0x20
12.	DELAY	0x22
13.	DEPTH	0x24
14.	CONST_GAIN	0x28
15.	PEAKDET_CTRL	0x30
16.	PDA_START	0x32
17.	PDA_STOP	0x38
18.	PDA_REF_VAL	0x3C
19.	PDA_REF_POS	0x3E
20.	PDA_MAX_VAL	0x42
21.	PDA_MAX_POS	0x44
22.	PDB_START	0x48
23.	PDB_STOP	0x4C
24.	PDB_REF_VAL	0x50
25.	PDB_REF_POS	0x52
26.	PDB_MAX_VAL	0x56
27.	PDB_MAX_POS	0x58

28. PDC_START 0x5C
29. PDC_STOP 0x60
30. PDC_REF_VAL 0x64
31. PDC_REF_POS 0x66
32. PDC_MAX_VAL 0x6A
33. PDC_MAX_POS 0x6C
34. ENC1_CTRL 0x70
35. ENC1_POS 0x72
36. ENC1_CAPT 0x76
37. ENC1_FILTER 0x7A
38. ENC2_CTRL 0x80
39. ENC2_POS 0x82
40. ENC2_CAPT 0x86
41. ENC2_FILTER 0x8A

Detailed information about Direct Orders and Control Registers can be find in document: "OPBOX-2.0 – Control Register Description"

2.1 Power-up sequence

OPBOX-2.0 is powered from USB bus and need to comply with USB2.0 specification. USB2.0 specification specify some restrictions about device power-up behavior (power-up current, inrush current) and power consumption. To meet with this restrictions OPBOX-2.0 has three power areas (Analog Power Area, DC12V Converter Area and Data Converters Area) with separate enable and status features.

After plug the USB connector, all of these 3 areas are turn-off and only digital part of device (FPGA and USB controller) are powered. User application need to do power-up sequence before starting measurements.

Power-up sequence:
1. Switch on "Analog PWR" - by setting bit [0] in POWER_CTRL register
2. Check "ANALOG PWR Status" flag (bit [8] in POWER_CTRL) until it return '1'
3. Switch on "DC12V Converter" - by setting bit [1] in POWER_CTRL register
4. Check "DC12V Status" flag (bit [9] in POWER_CTRL) until it return '1'
5. Switch on "Data Converters" - by setting bit [3] in POWER_CTRL register
6. If status flags (bits [9] [8]) are set to '1' device is correctly powered and ready for measurements

Additional flag in POWER_CTRL register "VREG Status" provide information about Pulser Amplitude control. If this flag is '0' means that Pulser Amplitude module may be overload by to fast pulse repetition and/or to large load at PE output.

2.2 Measurement sequence description

Preparing to measurement sequence
1. Set Pulser Time (by writing to PULSER_TIME register)
2. Set Pulser Amplitude (by using PULSE_AMPLITUDE Direct Order (0xD6))
3. Set Delay (post trigger time) by writing to DELAY register
4. Set Depth of measurement (sample data size) by writing to DEPTH
5. Set Analog parameters (filters, Attenuator, input..) by ANALOG_CTRL register
6. Set Measurement parameters (Sampling Frequency, gain mode, data processing mode) by MEASURE register
7. Set Trigger mode (set source, enable source if needed) by TRIGGER register

After reception trigger, device process measurement sequence as below:

1. Generating Pulse
2. Starting Delay counter if Delay non zero
3. Starting sampling Depth of data
4. Setting "New Data Ready" flag in TRIGGER register (available also by DIRECT_DATA_READY direct order)

Upload Sample Data

1. User application check "New Data Ready" flag by TRIGGER register or DIRECT_DATA_READY direct order
2. If Data Ready (flag = '1') data can be uploaded by USB IN packet from Endpoint 6
3. After finishes upload, user application need to send "Upload ACK" to device to release data memory and permit to receive next trigger. Upload acknowledge can be done by writing '1' to "Upload ACK" bit in TRIGGER register or using DIRECT_ACK direct order (faster).

2.3 Peak Detectors modules

OPBOX-2.0 has 3 Peak Detectors modules (PDA, PDB, PDC)

Peak Detector features:

- configurable Start and Stop for each module
- configurable Reference Level
- information about position where signal crossed Reference Level
- information about maximum signal value and it position in gate

Using Peak Detectors.
Each Peak Detector module starts simultaneously with measurement sequence. Peak Detector search Reference Level cross, Max Value and Max Position between Start and Stop parameters (gate time). After measurement results are available via PEAKDET_CTRL and associated to each Peak Detector registers: PDx_REF_POS, PDx_MAX_VAL, PDx_MAX_POS.

Caption! Results are automatically cleared when user application sets "Encoder x Reset" bit in ENCx_CTRL register **or** send "Uploak ACK" to device.
It's important to read Peak Detectors results after measurement finishes and "New Data Ready" is set in TRIGGER register and before sending an "Upload ACK"!

2.4 Encoders modules

OPBOX-2.0 has two encoders modules ENC1 and ENC2 which support two full channel incremental encoders.

Encoder modules features:

- two separate modules
- full channel encoder operation (CHA, CHB and IDX inputs)
- 32-bit position register
- Capture feature (measurement position stamp)
- Compare feature (position trigger generator)

Using Encoders modules ENC1 and ENC2

1. Enable module by setting bit [0] in ENCx_CTRL register

2. Set Input Mode, Decode mode and other bits if needed in ENCx_CTRL
3. Read ENCx_POS register to get current position.

Encoders modules uses General Purpose Inputs GPI[5:0] as encoder inputs.
Each input is standard 5V TTL inputs with 10kOhm pull-down resistors.
User must ensure proper signal levels on each input.

Connecting encoders to OPBOX-2.0 DB15 connector:

Signal name	Encoder 1 (ENC1)	Encoder 2 (ENC2)
CHA	GPI0 (pin 11)	GPI3 (pin 5)
CHB	GPI1 (pin 4)	GPI4 (pin 15)
IDX	GPI2 (pin 12)	GPI5 (pin 8)