# PD3200 PULSEDISCRIMINATOR KIT

User manual

## 1. Assembling the instrument and testing.

1.1 Connect power FET transistors type **IRF9540** - one or more, in parallel, to terminals for **Q4** (between **TP10** and **J2**- Power switch). Gate is near to **J2**, in the middle is drain.

1.2 Connect a battery to **J3** terminal, keep the right polarity, as marked on PCB.

1.3 Connect in series power switch and external fuse (1A) to **J2** terminal.

1.4 Connect temperature sensor LM335 to **J1** terminal, between **TP1** and **TP2**, from the left side of **AT90SMEGA8**.

1.5 Connect button **FUNC** and switch **DISC** to **J11** terminal, from the right side of display terminal, near to **TP11**. Pin assignments are described in section **7.2 Testing the button**.

1.6 Put connector for external buttons (which mounted on the coil handle) **CLEAR/GND** and **MODE** to **J12** terminal**.**

1.7 Connect internal piezo buzzer to **LS1** terminal, at the bottom right angle of the PCB (it is preferable to use piezo buzzer, it does not cause electromagnetic noises in the inner space). If the cable for external earphones not yet connected to **J7** terminal, a jumper should be mounted to **J7.1** and **J7.2**.

1.8 Connect cable for external earphones to **J7** terminal.

1.9 Connect power jack for external 12V voltage from auto battery to **J6** terminal, keep the proper polarity, as marked at PCB.

1.10 Connect search coil connector to **J4** terminal, which is at the top left angle of the board, near to **C5** capacitor.

1.11 Connect search coil to its connector.

1.12 Connect display to **J9** terminal. Note that pin1..16 of display must connect to pin 1..16 of **J9** (1X2 pins from the right are unconnected).

1.13 Power on the device.

## 2. Working in **ALL METALS** mode.

After startup a sound is produced and message **START** appears on 1-st display line. Starts initializing, which normally is in progress for 1-2 seconds, second sound is produced, then display shows **CLEAR**, and PD3200 goes in chosen work mode - **ALL METALS** or **DISC** (with respect to switch **DISC** position).

### 2.1. ALL METALS/fix(0,1,2,3,4) mode.

In this mode after power on display shows on **ALL METALS** 1-st line**.**

PD3200 continuously displays the signal level, selected profile, sound threshold, battery status, as follows:

- on 1-st line from the right – battery voltage as percent of nominal voltage– **0..100%** means low/charged battery;
- on 2-nd line right – chosen profile **PRF2** (**PRF1**) for normal/ decreased power;
- on 3-th line right – chosen threshold, after which sound appears;
- on 4-th line - signal level at the right side in numbers **0…300/400**. Bellow this value will be for convenience named ***digital value of the signal***;

  Note: If there is a signal in the range and user clears signal with button **CLEAR/GND**, the level goes to „0". After removing the signal source the signal level goes to negative.

- at the left side on 2-nd and 4-th line graphical bar-indicators are shown, for easy tracking the signal variations. These indicators can show positive and negative values, respectively increasing to right/ left side from the middle point.;

- indicator on 2-nd line is indicator of the moment signal. In mode **FIX(0,1,2,3)** it repeats the indicator of total signal, in mode **MOV(0,1,2,3,4)** shows the signal deviations only. Bellow for convenience this indicator will be named ***user signal indicator***;

- indicator on 4-th line is indicator of the total signal. It shows the total received signal in the coil range, without processing. Bellow this indicator will be named ***total signal indicator***;

Normally the both indicators show positive values when signal is present, if not – zero values (or varying -1..0..+1).

If in the coil range there is target with some characteristics, it produces signal, which is shown on the both indicators and on the digital value of the signal. If this signal overs chosen threshold (**th_A**), sound appears with frequency depended on the signal level – when signal increases the tone is with higher frequency.

If the total signal increases and overs 90, the graphical indicators shows hi-level status as "**>>>>>>**", but the digital value continues to change, the sound also changes. If signal level reaches up to overflow level, the 4-ti line shows **OVERFLOW** and frequency of the sound goes high.

### 2.2 ALL METALS/mov(0,1,2,3,4) mode.

Mode **MOV** can select when rotate left the **FUNC** button, modes **MOV0,1,2,3,4** are available. Difference between these submodes is in time for automatic tracking the current signal level, PD3200 continuously adapts to average signal level, and the transitory signal is shown as user signal at 2-nd line, which slow goes down, when the average signal reaches current level of the signal. This equalize is slowest in mode **MOV4**, and the coil moving can be slowest (in mode **MOV0** coil motion should be faster).

In mode **MOV** indicator of total signal on 4-th lines shows average signal, but indicator of user signal at 2-nd line shows the difference between average and current signal.

Note: If the current signal decreases below the average signal and difference is negative, the average signal equalizes faster to the current signal, this is fast negative adaptation, to minimize the long of the "deaf period" after every positive signal.

The sound arises after level of the user signal (not total signal) overs chosen threshold (**th_A).**

# 3. Setting work parameters in **ALL METALS** mode.

### 3.1. Fast/slow mode.

Submodes **fix0,1,2,3,4** are for faster/slower movements.

In fix0 movements are faster, but the signal will be more unstable to noises, fix4 ii slowest, but more stable.

Rotating the **FUNC** button switches between these submodes.

### 3.2. Setting the sound threshold level.

The level, after what sound arises, is sound threshold level. It depends on **th_A** parameter, and can be changed. To do this press **FUNC** button once - prompt shifts up from 4-th to 3-th line before parameter >**th_A**. Rotating left/right the value can adjust, to finish press again the button **FUNC** – prompt goes down before >**fix(0,1,2,3,4):**.

### 3.3. Switching the pulse power.

PD3200 can work with normal (**PRF2**) and decreased (**PRF1**) pulse power. To change press button **FUNC** twice, prompt arrow goes up before >**PRF**. Rotating left/right switches between **PRF1** and **PRF2**.

Note: Pulse power depends on pick of the coil current; which is 14/6A for **PRF2/1**. To ensure current = 14A, resistance of the coil must be <=0,5ohm, see section… for details.

After switching the profiles PD3200 restarts.

# 4. Working in DISC mode.

### 4.1. Button FUNC.

In this mode button **FUNC** switches **fix0,1,2,3** (**mov** is not available).

Work parameters for this mode are:

- sound threshold th_D;
- color threshold th_C;
- disc submode **NORM.DISC, DELTA DISC** and **FULL BALL (DISCR.0,1,2)**;
- get ground tolerance for **DELTA DISC (DISCR.1)** ;
- get ground tolerance for **FULL BALL (DISCR.2)**;

When there is no target signal operator can set these parameters in next manner:

Press once (or more times) button **FUNC**, prompt shifts up before selected parameter. Adjust the value by rotating left/right, then press **FUNC** and prompt returns to 4-st line before **fix**.

### 4.2. Data on the display.

When turn on switch **DISC** device switches from **ALL METALS** to **DISC** mode.

The next parameters continuously displayed:

- discrimination submode 0,1,2 (**NORM. DISC, DELTA DISC , FULL BALL.**) on 1-st line, from left.

- bar indicators for user and total signal on 2-nd and 4-th line;

- balance indicator at the end of 1-st line – this is special indicator, which shows if the signal is properly cleared when there is no target in range. To check it, operator has to lift the coil to ensure that no signal is in the range. Then balance indicator must show the same bars from the left/right side from the symbol "-" in the middle, with high=half of total high for a symbol (4-5 lines of total 8 lines). If these bars are not equal or their high is not proper, operator have to clear the signal by pressing the external **CLEAR/GND** button in **ALL METALS** mode (or press and hold first external button **MODE**, mode changes to **ALL METAL** temporary, at the same time press **CLEAR/GND** – the signal clears as in **ALL METALS** mode, then release the both external buttons).

- **th_C** parameter at 2-nd line. When there is a signal in the range and its amplitude is equal or higher than selected minimum amplitude for discrimination (par. **th_D** from service parameters), the signal is discriminated and if its coef. **C1** is positive and is higher than chosen color threshold **th_C**, the sound for color metal presence is hear.

- **th_D** parameter at 3-nd line. This is sound threshold for **DISC** mode. If amplitude of the signal overs this threshold (**fix>th_D**), signal is produced , and its tone is low or high, with respect to calculated **C1** coefficient and chosen color threshold (**th_C**).

- digital value of signal amplitude is shown on the 4-th line, from the right.

### 4.3. Normal discrimination.

**4.3.1** Setting the color threshold (value for **C1** coef, below/over what target is signalized with low/high tone).

To set this threshold signal must be cleared. Press twice **FUNC**, prompt shifts up before **>th_C**. Rotate left/right to select new level (normally 1..2), then press **FUNC** again.

When signal amplitude **fix**: reaches threshold **th_D**, it is discriminated and coef. **C1** and **C2** are calculated and displayed. For example, if **th_D = 10** when signal is **fix: 11** it is discriminated and if **C1** and **C2** are positive, the target is high conductivity, if negative – respectively low conductivity target.

Sometimes is possible the value of **C1** to be positive, but **C2** – negative. Possible reason of his may be presence of color and black metal simultaneously.

### 4.4 Delta discrimination.

To select delta discrimination, press the **FUNC** button 3 times, and rotate it, on 1-st line **DISC 0** switches to **DISC 1.** From the right side at 1-st line instead of balance indicator appears parameter **gnd:…** – it shows ground "color" after ground balance. Before ground balance its value is unknown, and is displayed as "…".

**Ground balancing:**

For adaptation (ground balance) press external button **CLEAR/GND** and hold it. **Get ground…** is displayed and long sound for starting balance is hear.

User has to change distance between ground and coil in normal work range, for example 5..15 sm, taking the coil up/down. PD3200 analyses received signal, and when retunes ground color, short sound is hear. However, if ground color overs allowed range of the current value, ground adaptation restarts – the long sound is hear again. Note, that parameter **ggt1** affects to allowed range of adaptation.

When button **CLEAR/GND** is hold pressed and user changes distance to ground but no sound is hear (short sound for re-tuning or long sound for restart), that means ground is balanced. Now release the button **CLEAR/GND**, short double sound signalizes successful procedure, error sound – high and long low tone, means unsuccessful adaptation.

After balancing parameter **gnd:** shows average ground color, it is considered as relative middle of color scale (because of that **C1:** at 2nd line is **0** after balance finish). From this moment when color of the signal is more positive than **gnd:**, it is signalized.

Note:

1. If color coef. of the ground signal changes in wide range, again and again restarting of ground balancing is possible. The allowed tolerance for ground coef. could be wider, if increase **ggt1** up to **4** or **5** (normally**3**). This will allow ground balance for bigger deviations of the color, but will decrease sensitivity for color metals. The other way is to put coil closer to ground surface, when the signal is bigger, color coef is more stable.

2. In time of adaptation the minimal signal level is memorized, this is normally the level when coil is away from ground. If after adaptation total signal is smaller than this minimal level, discrimination is not allowed and special sound is hear – short tones every second, which means "ground missing". That happens when the coil is away from ground, or total ground signal is deceased. In this case user should put coil closer to ground or make ground balance again.

When the **C1** coefficient of the signal is "more positive/negative than ground", it is signalized with high/low tone. The sound is constant tone, it does not inform about signal level of the target signal (which is different from the ground signal). PD3200 can separate as amplitude from total signal the ground and target signals, and can show target signal only as amplitude, as in **ALL METALS** mode. To do this, press and hold external button **MODE**, device switches to special **ALL + DELTA** mode. Ground signal is subtracted from total signal and only target signal (which is with more positive color coef. **C1**) is shown as amplitude. The tone is with variable frequency, with respect to target signal level, thus user may find out the place, where the signal has maximum amplitude. After ext. button **MODE** is released, PD3200 returns again to **DISC 1** mode.

*Example:*

- *Turn on the switch to go in* **DISC** *mode;*
- *Rotate button* **FUNC** *to choose* **DISC 1.;**
- *Press and hold pressed (until the end of procedure) the external button* **CLEAR/GND** *– appears long sound for starting the ground balance;*
- *Take up and down the coil, until short sounds "tuning" disappear (long sound for restarting the ground balance procedure must not appears, too);*
- *Release the button* **CLEAR/GND***;*
- *If double confirm sound appears, procedure is successful;*
- *Display for ground color is for example* **gnd:-3***; total color coef.* **C1** *shows values about 0…(-1).;*
- *If after button release appears error sound – procedure is unsuccessful, the display is* **gnd:…** *(unknown parameter);*
- *When the coil is away from the ground, short sounds appear every second – that means "Missed ground", the display is* **gnd:???***, the coil have to be closer to the ground;*
- *When target with more positive coef.* **C1** *is in the range,* **C1** *shows* **+2..+5,+6** *and higher, sound for color metal is produced;*
- *If press for a while button* **MODE,** *display switches to amplitude mode, the shown signal level is from the target only (amplitude of the background is subtracted), the tone follows amplitude (mode* **ALL+DELTA***);*

### 4.5 Discrimination mode FULL BALL.

Go to discriminaton submode parameter and select select **DISC 2.** Like **DISC 1** user have to make ground balance, for ability to separate the target signal from total signal (ground + target), and discriminate the target. The difference is, in this mode the both coef. **C1** and **C2** are used, which requires higher ground signal than **DISC 1.** When external button **MODE** is hold pressed, display goes to special mode **ALL + FULL**, and only target signal is shown (as level and sound, background signal is subtracted) and discriminated.

# 5. Service parameters.

To set service parameters go to **ALL METALS/fix** mode.

To get access to service parameters there is special trick – press **FUNC** and until is pressed, rotate it for 1..2 steps, then release. From this moment (until next turning off/on) service parameters are available.

## 5.1. Service parameters for ALL METALS/ DISC modes.

### 5.1.1. Setting the detection level (setting the 1-st sample).

The detection level depends on parameter **smp0**, which fixes the moment after pulse stop, to read signal level on amplifier output. This level is called detection level, because independently on metal type, the amplitude deviations are higher than next samples. Normally when **smp0** increases (delay of first sample increases), level decreases, because coil signal decays. Change of **smp0** may necessary if start level (on 2-th line after turn on) is too high: 750 and upper, or signal overflows. When the coil inductance is higher, **smp0** must have bigger value.

*Example:*
- *When turn on the device, start level on 3-th line is 820 (too high);*
- *Go to* **ALL METALS/fix** *mode;*
- *Signal is* **fix: 0,** *because of startup clearing;*
- *At the same time press and rotate the* **FUNC** *button for 1..2 steps to get access to service parameters;*
- *Press several times the same button to select* **smp0***;*
- *Increase the value rotating clockwise – signal amplitude changes immediately (goes lower);*
- *When signal is* **fix:-150***, press* **FUNC** *button again to finish;*
- *Turn off and on the device – now start level is 670, or decreased by 150;*
- *If needed, change* **smp0** *again;*

The maximum signal value, before overflow, or dynamic range of the device, depends on detection level. Typically this dynamic range is 250..350 steps, if detection level (startup level on 2-th line) is 400..450 (as mentioned before, this level depends on coil inductance and **smp0** parameter). If detection level is 500 and higher, dynamic range shrinks, it is = 900 – (detection level). Normally range = 150 is enough, if signals 2..4 units or higher are signalized, and 10..15 are discriminated. If the ground signal is high, the dynamic range is preferable to be wider, 300..400. If delay of the first sample is bigger (parameter **smp0**), detection level will be lower ( for example 200) and dynamic range will be 500..600, but the sensitivity will become smaller. Note, that sensitivity sometimes may be highest at exact detection level – for example 600, and decreases at higher or smaller values for this level (500 and 700). This means the bigger detection level does not guarantee higher sensitivity. Another reason to avoid high detection levels – 700 and upper, is that signal may become unstable.

### 5.1.2. Setting the 2-th sample.

This is parameter **smp1**, it fixes moment to read the second sample from signal and affects to value of color coefficient **C1** in **DISC** mode.

It is used in both ground balance modes **DISC 1** and **DISC 2**.

This parameter needs corrections, if **C1** coefficient is not stable for small/high signal levels for the same target.

### 5.1.3. Setting the 3-th sample.

This is parameter **smp2**, it fixes moment to read 3rd sample from signal and affects to color coef. **C2** (does not change coef. **C1**) in **DISC** mode (coef. **C2** is used in **FULL BALL**. mode).

This parameter affects to stability of coef. **C2**, for low/high signal levels for the same target.

### 5.1.4 Setting the end sample.

Parameter **sEnd** fixes the moment the last sample, when "echo" of pulse in coil decays to zero.

### 5.1.5 Setting the offset for color coefficient C1.

Parameter **o_c1** fixes offset of **C1** value (zero point of its color scale). Range for this parameter is 0..39. by default is 21.

When the parameter is changed, **C1** for separated metal is shifted to more positive or mode negative values.

For example, if in **NORM. DISC**. low- and high conductivity metals have respectively coef. **C1=–13** / **C1=–1**, if increase parameter **o_c1** by "6" the same metals will have respectively coef. **C1=–7** / **C1=+5**, and the first metal is again "low conductivity". But then second metal has yet positive coef. **C1=+5** and it is signalized as high conductivity metal.

### 5.1.6 Setting the offset for C2 coefficient.

Parameter **o_c2** like **o_c1** shifts values of coef. **C2** to more positive or negative values.

### 5.1.7 Setting the minimum level of the signal for ground balance in **FULL BALL mode**.

Parameter **minG** fixes minimum level of the signal to calculate coef. **C2**, which is used in **FULL BALL** mode. Allowed values are 10…100. by default 20. To calculate the coef. **C2** is used 3-th sample, but this is the sample with lowest amplitude (amplitude of 1-st and 2-nd sample are always higher than amplitude of 3-th sample). Therefore **FULL BALL** mode is suitable to work at ground with relatively high background signal. If this signal is lower, the more suitable mode is **DISC 1.**

### 5.1.10 Setting the battery status display.

When working on 1-st line (from the right side) battery status in percents **0..100%**. is shown. To calibrate it there are 2 service parameters - **ofsB** (offset for begin of the range, or voltage for 0% display), and **sclB** – scale coefficient (it fixes the voltage for 100% display).

*Example:*

*- power on the device from regulated power supply, set voltage to 13V;*

*- go to service parameter* **ofsB***, as described in 5.1;*

*- change the value to achieve display value* **bat: 0%** *. If the display is* **„---"***, decease* **ofsB***, if is >* **0 %** *- decrease it;*

*- set power voltage to nominal voltage for charged battery – for example 16,5V;*

*- go to service parameter* **sclB** *and change it to achieve display value* **bat:98..99%***;*

*- so when battery voltage is < 13V display will be* **"bat:---"***; in the range 13.. 16,5V -* **"bat:0..99%"***,, after 16,5V -* **„bat:+++"** *.*

### 5.1.11 Setting the Earth Field Effect correction.

See 9.6 for details.

## 5.2. Setting service parameters for CHARGE mode.

### 5.2.1. Setting the charge current.

Parameter **chgI** fixes charge current. Its value is number from 10 to 50, and the current is equal to Ichg*10mA (if Ichg=40, charge current will be 400mA).

### 5.2.2 Calibrating the Icharge display value to real value.

There are 2 parameters to calibrate the charge current – **ofsI** and **sclI**.
**ofsI** parameter shifts the discplay value, **sclI** parameter scales it.

### 5.2.3 Calibrating the battery voltage display value.

Parameter **sclU** scales the display value of Ubat.

### 5.2.4 Setting the display value for battery temperature in CHARGE mode.

To calibrate the battery temperature display there are 2 parameters, **ofsT** (offset for 0 degrees) and **sclT** – scaling the value in the range.

To set this parameter device should be turned in **CHARGE** mode, then in **ALL METALS** mode to adjust the both parameters, then again in **CHARGE** mode.

*Example:*
- *when power switch if off apply an external charge voltage to charge connector;*
- *check the current temperature display and remember the value as **T1**;*
- *clench in fingers temperature sensor for 1 min – the temperature will arise to about 35 degrees. Remember the current temperature display value as **T2**;*
- *Turn off external voltage, and turn power switch on, wait for startup procedure;*
- *Check for current values of **ofsT** and **sclT** and write them as **ofsT0**/**scltT0**;*
- *Calculate new values for **ofsT** and **sclT** using the next formula:*
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- *Enter the new parameter values;*
- *Turn off the device, then apply external charge voltage again;*
- *Check the display at indoor and body temperature (about 35 degrees) for LM335 sensor.*

### 5.2.4. Setting the maximum temperature for batteries in CHARGE mode.

Parameter **„maxT"** fixes maximum temperature, over which charge will stop. Range is 30..50, by default is 40 degrees.

# 6. How to achieve best performance

## 6.1 Requirements about the search coil.

### 6.1.1 Resistance

Resistance of coil must be 0.5..0.6 ohms. The pick value of the current through the coil is stabilized at 14A. To ensure this value, total resistance for coil+coil cord + power FET in active state have to be below 1ohm at 13V – minimal battery voltage. For coils with bigger resistance current through the coil will be not stabilized and lower than 14A, which means lower stability and sensitivity. If resistance could not be decreased and is 1,5ohms, for example, then increase the value of **R22** resistor, it fixes the voltage threshold for comparator, which controls the coil current. Voltage on positive lead of capacitor **C4** is normally **1,3..1,4V**, and limits the current to **13..14A**. If increase value of **R22** and as result voltage on **C4** goes to **0,8V**, the peak current will decrease to **8A.**

### 6.1.2 Inductance.

The inductance of coil must be 0,1..0,4mH. Bigger inductance means longer time to reach limit for pick current, that affects total power consumption – it arises. Parameter **smp0** must be adjusted, too, to adapt level of received signal from separate coil.

Note that more turns means higher received signal, but the inductance and resistance are bigger, too.

### 6.1.3. Wire.

Wire is preferable to be 1mm or higher. Other considerations are about the insulation – its capacitance must be as low as possible.

### 6.2. Coil amplifying and internal amplifying.

When coil has more turns, the received signal is higher. It is amplified by constant value, 1000 times, and is read after integrating and sampling. Allowed range for end signal is 0..2,56V. Than means, if the coil signal is higher, the steep part of the received signal (begin of its knee-like shape) may overs the ADC input range, then PD3200 will read samples from the slope part of the signal. In result, the sensitivity will decrease.

In this case may be better to decrease the amplifying of LM356 by changing value of **R42** from 470 to 1k, for example.

### 6.3 smp0 parameter.

**Smp0** highly affects to sensitivity. Possible way to choose the best value is to check how changes the signal level when putting a small target in center of the search coil plane, for example 10 eurocents.

*Example:*

- *enter service mode, choose* **smp0** *parameter;*
- *put coin in center of the search coil plane – signal arises from 12 to 54 – signal rises 54-12=**42**;*
- *decrease* **smp0**, **fix:** *goes to 110;*
- *put coin again – signal arises to 165, change is 165-110=**55**;*
- *decrease* **smp0**, **fix:** *goes to 250;*
- *put coin – signal arises to 323 , change is 323-250=**73**;*
- *decrease* **smp0**, **fix:** *is 400;*
- *put coin – signal goes to 460, change is 460-400=**63**;*
- *the best sensitivity is when **change = 73,** return to the corresponding* **smp0** *value;*
- *restart PD3200 to check the detection level ( at 3-th line after startup). If it is <700, keep the current value of* **smp0**, *if is higher is recommended to increase* **smp0** *and decrease as result the detection level.*

# 7. Testing the board.

## 7.1 Testing the display.

After power-on a welcome screen at the display appears, after what starts first-time clearing. If the display remains blank, check for decreased contrast and tune **R50** variable resistor, mounted at the left side of microcontroller, nearby to display connector **J9**.

## 7.2 Testing the button (encoder) **FUNC** and switch **DISC**.

To **J11** connector are connected both the button **FUNC** and the switch **DISC**. Pin arrangement is as follows:

**J11.1** - Common / zero. Middle pin of 3-pins section of the button FUNC, one of 2-pin section of the same button, and one of 2 pins of the **DISC** switch.

**J11.2,3** - left and right pin of 3-pins section of the button **FUNC**;

**J11.4** - second pin of the **DISC** switch;

**J11.5** - second pin of the 2-pins section of button **FUNC**.

To test in **ALL METALS/fix** mode, press the button **FUNC**, the prompt arrow "**>**" should go upper before parameter **>th_A.**

Rotating to left/right should change the value of the parameter, or switch between **fix** and **mov1,2,3.**

Turning on/off the switch **DISC** should change the work mode between **ALL METALS** and **NORM DISC**;

## 7.3 Testing the external buttons.

Buttons **CLEAR/GND** and **MODE** are connected to **J12**, arrangement is as follows:

**J12.1 -** button **CLEAR/GND;**

**J12.2** - button **MODE;**

**J12.3** - common.

To test in **ALL METALS** mode press and release the button **CLEAR/GND**, the signal is cleared, "**CLEAR..**" appears on 1-st display line and corresponding sound is produced.

When button **MODE** is pressed, display switches between **ALL METALS** and **DISC** mode and vice versa.

## 7.4 Testing the pulse control schematic.

First check for 100Hz signal on **TP3 (U10.4)**. Then check if monovibrator **U1** generates short negative impulse at **TP4 (U1.4)**. The same impulse, but converted to 12V level should be at coil terminal **J4.2**. Check for saw-voltage at the other coil terminal **(or TP5)**, with 100Hz frequency, and amplitude 1,4V for **POW2** and about 0,5V for **POW1**. This is drop voltage on 0, 1 ohm resistor and corresponds to coil pick current - 14A и 5A.

Normally, if PCB is powered by regulated power supply for testing, when changing the power voltage between 13..17V the pulse have to get shorted (power consumption decreases), because of current stabilizing, at higher voltages the current increases faster and pulse gets shorter.

If the current stabilizing schematic doesn't work, pulse will be constant with long duration, and this will cause big consumption from the power source.

At the positive comparator input U2C, is applied threshold voltage 1,4V or 0,5V, according to chosen power mode. When the voltage at the other negative input reaches to this threshold, comparator switches and resets the monovibrator, this stops the pulse.

## 7.5 Testing the signal amplifier and sample/hold schematic.

To test the signal amplifier is preferable to use 2-channel scope, apply to one channel signal END_PULSE (TP4) and synchronize to falling edge.

Check with other scope channel the signal at the amplifier out **(TP7)**. It goes from extremely positive to zero offset voltage, the transition is with typical knee-like figure.

Note: The DC zero offset voltage should be in range +0.2..0.5V. If necessary, adjust it by adding a resistor in parallel to **R45** or **R46**, the both resistor are **10к** value, the additional resistor should be 20..300к value.

If the signal is normal, check for sample pulses at **U5.8** – digital signal **HOLD**. There should be 4 consecutive pulses, according to 1-st, 2-nd, 3-th and end sample. When any of **smp0, 2, 3** or **sEnd** parameter changing, the change should be visible on the scope...

Note, that **smp0** affects all sampling pulses, **smp1** – 2-nd, 3-th and 4-th sample, **smp2** – 3-th and 4-th, **sEnd** – 4-th only..

The analog signal **U5.5 (TP8) SAMPLE_OUT**, which is applied to microcontroller ADC input, has typical stair-steps like shape.

## 7.6 Testing the battery charging schematic.

Note, that power switch should be in OFF state, before applying the charge voltage to **J6** terminal. When charge voltage is applied, PD3200 starts in charging mode.

The charging schematic consists of two stages:

- step-up voltage converter;

Step-up converter is based on MC34063 pulse regulator with additional external power FET. It boosts input voltage 10..15V to 24V (on **C8** leads).

- charge current regulator;

Current regulator is based on LM2576 switching regulator; it controls the current through the battery in charge time. Charge current + device supply current makes voltage drop on R37, which is amplified by U2D OAMP and controls LM2576. Microcontroller switches on/off the charge (signal **EN_CH**), and fixes desired current charge (signal **PWM_ICH**) in range 100..500mA, in accordance with **chgI** parameter.

# 8. PD3200 parameters list.

## 8.1 Work mode parameters.

### 8.1.1 Mode „ALL METALS"

**– th_A – sound threshold (ALL METALS threshold);**

This is minimal signal level, above what appears sound with variable in accordance to level tone. Below this threshold PD3200 do not produces sound. However, is signal level goes to negative values below fixed level (parameter **mNeg**) , arises sound "NEGATIVE LEVEL", which is alternate short low and high tone.

**- prf 1(2) Current settings profile;**

This parameter chooses one of two available independent settings for **smp0, smp1, smp2, sEnd, o_c1, o_c2, cEFE, scl3, scl4** (all the rest parameters are common).

This way user may use one coil for two peak pulse levels – normal and reduced.

If remove resistor **R20 (2k)**, the pulse level will not switch to reduced and will stay always normal. Thus **prf1** and **prf2** can switch settings for two separated coils, at normal pulse power.

### 8.1.2 Mode „DISC"

- **th_D – sound threshold (DISC threshold)**;

Fixes minimal signal level, after what discriminations starts, and low or high tone sound appears, in accordance with object type;

- **th_C – low / high tone threshold ( "Color" threshold);**

Fixes level of C1 coefficient, after what tone is high. Below this value tone is low;

*Note: After ground balance procedure this parameter must be 0..1..2, because then it determines how steps over/below remembered color range for ground (C1) device will sounds for object.*

- **DISC 0(1,2) – Discrimination mode;**

- **ggt1 –** allowed deflection range for **C1** for ground balance procedure in mode **DISC1;**

- **ggt2** – allowed deflection range for **C2** for ground balance procedure in mode **DISC 2;**

## 8.2 Service parameters for DETECTION mode:

– **smp0 – delay of first sampling after pulse stop;**

*This parameter generally affects to sensitivity. It must be set for separated coil, to achieve detection level in range 500..650;.*

– **smp1 – delay of second sampling after pulse stop;**

*This parameter affects to stability of* ***C1*** *value. It must be set to proper value, to achieve relatively constant display value for* ***C1*** *at low/high signal levels (****fix****:25..250). After that C1 values may shift to more positive/negative values with parameter* ***o_c1***;

– **smp2 – delay of third sampling after pulse stop;**

*This parameter affects to stability of* ***C2*** *value. It must be set to proper value, to achieve relatively constant display value for* ***C2*** *at low/high signal levels (****fix****:25..250). After that C1 values may shift to more positive/negative values with parameter* ***o_c2***;

- **sEnd – delay of last sampling;**
- **o_c1 – offset of C1 display value for "0";**
- **o_c2 – offset of C2 display value for "0";**
- **cEFE – Earth Field Effect correction;;**
- **scl3 – scale coefficient for signal at smp2 to calculate total signal amplitude in CHECK mode;**
- **scl4 – scale coefficient for signal at smp4 to calculate total signal amplitude in CHECK mode;**

*Note: Parametes* ***smp0, smp1, smp2, sEnd, o_c1, o_c2, cEFE, scl3, scl4*** *for* ***prf1*** *and* ***prf2*** *are independent, the next parameters (described below) are common.*

- **hist – hysteresis of signal amplitude ( and sound tone for ALL METALS);**
- **ofsB – offset of display value for battery status;**

*It determines for what voltage battery display value will be* ***bat: 0%;***

- **sclB – scale of display value for battery status;**

*Determines for what voltage display value will be* ***bat: 99%;***

- **mNeg - negative level, below what PD3200 signalize for negative signal;**
- **50Hz – correction of pulses frequency. To minimize affection of 50Hz AC environment for test in laboratory conditions;**

## 8.3 Service parameters for CHARGE mode:

- **ofsT – temperature display value offset factor;**
- **sclT – temperature display value scale factor;**
- **maxT – maximum temperature, after what charge stops;**
- **chgI – charge current in 100mA units;**
- **ofsI – charge current offset factor;**
- **sclI – charge current scale factor;**
- **sclU – battery voltage display value scale factor;**
- **maxU – maximum battery voltage, after what charge stops;**
- **RST – if is =10, clears all user settings ant sets to default values;**

# 9. Adjusting the settings of PD3200 for user coil.

## 9.1. Testing the pulse current stabilization for the both power modes.

PD3200 uses stabilization for coil current, which is not well known for PI-schematics, but it is very important to get a better performance.

*Current stabilizations makes stable measurements generally, they are relatively independent of coil + cable resistance, and resistance of the FET-channel in ON state. The last factor minimizes temperature drift after first turning on. Minimally affects the battery voltage drop at continuous work. Voltage drop on 0,1ohm resistor is compared to reference voltage 1,4V, and when it reaches this threshold, comparator flips and stops the pulse. Reference voltage in POW1 mode is 0,6 volts, and corresponds to current 6A.*

To test current stabilization device must be powered by regulated power source. When power voltage increases from 13 to 17volts, power consumption must decrease, for example from 600 to 300mA. This is because of current stabilization, for bigger voltage over the coil the current increases faster, the pulse goes shorter and average power consumption decreases.

When power voltage decreases the power consumption increases, but after minimal voltage starts decrease relatively to voltage – then stabilization stops, and the coil current depends of resistance of the coil - is good to adjust the battery display value for „0%" to be above this voltage.

## 9.2. Adjusting the optimal detection level.

Detection level depends of first sample delay after pulse stop.

The parameter **smp0** have to set, to achieve absolute level ( which is displayed after power on, and when setting this parameter, too) to bi in range 400..700. If this absolute value is bigger, normally sensitivity is better, but the fix: amplitude may go unstable.

## 9.3. Adjusting the second sample.

Purpose for **smp1** is to achieve relatively stable display value for **C1** in **DISC** mode. By default **smp1**= 50, but for user coil this default value may produce unstable coefficient, for example for high conductivity metal to vary +3..+9 (or for low conductivity -2..-8) for signal levels **fix(1,2,3)**:20…200. In this case value of **smp1** have to change, for example =48, to get variation for the same high/low conductivity metals **C1**=+13…+14 / -2..-3. After this adjustment by setting the **o_c1** for example from 21 to 17 display values may be shifted to -4 steps, and will be **C1**=+9..+10/ -6..-7.

Sometimes to get stable C1 user may first change the **smp0** parameter.

## 9.4. Adjusting the third sample.

After adjusting the second sample in the same manner user have to adjust the 3-th sample, to stabilize **C2** display value. To shift **C2** user have to change **o_c2** parameter.

## 9.5. Adust the display value of signal amplitude in "CHECK..." mode.

„**CHECK...**" mode is used to check if target signal is short or long.

The difference between signal levels in **ALL METALS**/ **CHECK...** modes is described below:

In **ALL METALS** mode **fix**: shows the signal at the detection level (smp0). In **HECK...**mode **fix**: shows the sum of the signal level at 3-th and 4-th sample, which are with significant longer delay. At this longer delay signal level is always smaller than signal at 1-st sample, therefore this sum level is scaled, to get equal level as in ALL METALS mode. This is right for long signals, short signal will not produce level at 3-th and 4-th sample, and thus the sum level in CHECK will be smaller or "0".

High conductivity (and too small low conductivity) metals give short signal, which means that when switch to **CHECK...** signal amplitude will decrease signtifically or will be zero ( for 3-th and 4-th sample their signal will decay to zero)

Situation for low (and big low conductivity) metals is different, they give long signal, and signal level at 3-th and 4-th sample is big. After switching to **CHECK...** level will be same (or little bit decreased) as level in ALL METALS mode.

Parameters scl3 and scl4 determines proportion for 3-th and 4-th sample level for summarized signal in **CHECK....** mode.

## 9.6. Earth filed effect elimination.

Parameter **cEFE** determines correction to compensate influence of the earth magnetic field over the signal amplitude. This effect may arise for big coils, and relatively fast moving of the coil (ticker type) may produce negative/positive signals, without target in the range. In laboratory conditions this effect may be tested with magnet, which fast takes near/away from the coil. This signal arises always for big frames, if they shake.

Parameter **cEFE**, have to be adjusted until this signal is fully compensated (normally at **cEFE** =10..11). Note, that for values <8 correction is negative.

When **cEFE** =0 correction is disabled.

## 9.7. Fine adjusting the pulses frequency.

That have to do to get more stable amplitude in laboratory conditions, where a strong AC 50Hz ambient magnetic field is present.

Select parameter **50Hz** and adjust until periodic signal deviations (because of deference between pulse and AC frequency_ are minimized.