Chinese Tesla Coil Driver

(known as “cloud leopard driver”, “KC15051.01” or f. knows how else :P)

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There is ABSOLUTELY NO WARRANTY; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

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Short comment:

This basic style is used for translated original text (may be slightly enhanced in some places)

This style is used for my own comments and thoughts

This style is used when in original has been written something wrong.

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Tesla Coil Driver

1. Features

- Complete DRSSTC driver on 1 board
- Can handle 2 GDTs
- GDTs support high current, up to 20A

2. Applications

- SSTC
- DRSSTC
- SKP(??!?)TC

3. General description

KC15051 is a universal driver for SSTCs and DRSSTCs.

Supports both: **DR** (Double Resonant Tesla Coil) and **SKP** (Pulse Jumping Tesla Coil) modes.

*Fuck knows where **SKP** term came from, anyway it means that Tesla coil is driven once in a while, once a second e.g.*
*whereas with "**DR**" mode Tesla Coil plays tones.*

Driver requires single power supply, supports both AC and DC.

As an PSU input filter there are 2 big capacitors onboard 2x4700uF, 25V which provide some stability of operation.

GDT provides up to 20A peak output current, which may be useful for very high power IGBTs with large input capacitances (Cin [nF]).

GDT driver uses 4 of FDD8424H N&P MOSFET pairs. This IC is capable of driving up to 20A, and therefore short rise time of IGBT input voltage can be achieved.
Power loss is reduced.

It means that value of series resistor can be low (somewhere around 2ohms usually)

Left side and right side of the full bridge SSTC inverter can be driven separately.

You can use 2 GD Transformers with 3 windings, instead of 1 GD Transformer with 5 windings. Using 2 GD Transformers may be a good idea when IGBT (or MOSFET) has large input capacitances (Cin [nF])

4. Version:

V1.0

Revision history

Version number	**Revision date**	**Remarks** *(?)*
V1.0	2018/12/9	1. Version
Here some blank fields in original	*Here some blank fields in original*	*Here some blank fields in original*
Here some blank fields in original	*Here some blank fields in original*	*Here some blank fields in original*

5. Functions description:

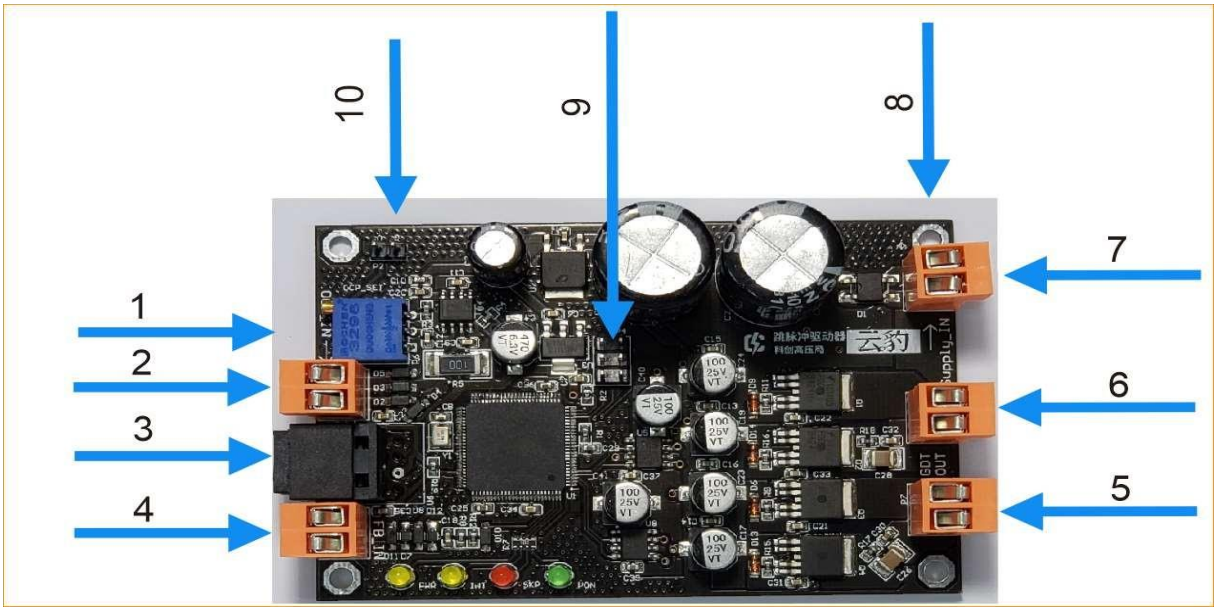

Figure 1. Pin definition

No.	Name	Input - I Output - O	
1	OCP_SET	N/A	Overcurrent feedback potentiometer
2	OCP_IN	I	Overcurrent feedback input
3	OPT	I	Fiber optic interface for interrupter
4	FB_IN	I	Voltage feedback terminal *(but actually it is a current feedback terminal) for current transformer*
5	GDT(A)	O	Output for connecting a GD Transformer (A)
6	GDT(B)	O	Output for connecting a GD Transformer (B)
7	Supply_IN	N/A	Power supply input
8	G	N/A	Ground (common)
9	P4	N/A	NC *(but I think it does something)*

Figure 2. Indicator light function

Name	Function
PWR	Power indicator
INT	Fiber input indicator
SKP	Overcurrent indicator
PON	FB_IN indicator

6. Specifications

1.1. Complete specification *(??)*

Label (Name)	Min	Max	Unit
Supply_IN AC (RMS)	9 *(14 recommended)*	15 *(16 recommended)*	[V]
SUPPLY_IN DC	12 *(22 recommended)*	25 *(but, do not exceed 22, unless you replaced input capacitors with 50V rated ones)*	[V]
OCP_IN (RMS)	-3	3	[V]
OCP_IN (peak)	-8	8	[V]
FB_IN (peak)	-3.3 *(actually you can go up to -3.5V)*	3.3 *(up to 3.5V)*	[V]
OCP_IN (RMS)	-900	900	[mA]
FB_IN (peak)	-900 *(actually do not exceed -100mA!!!)*	900 *(actually do not exceed 100mA!!!)*	[mA]
GDT A, B peak current	-20	20	[A]
Ambient temperature	N/A	50	[°C]

1.2. Recommended power supply rating: *(?)*

I know this voltage ratings suck, this info is duplicated what is already mentioned above, anyway, here is what original documentation says:

Label (Name)	Min	Max	Unit
Supply_IN AC (RMS)	12 *(I do recommend 14 as minimum)*	14 *(I do recommend 16 as maximum)*	[V]
SUPPLY_IN DC	12 (*(I do recommend 22 as minimum)*	24 (I do recommend 25, but do not exceed 22, unless you replaced input capacitors with 50V rated ones).	[V]

Of course, AC rating is approximately around DC√2 for it is peak value of sinewave.*

7. Terminals diagrams:

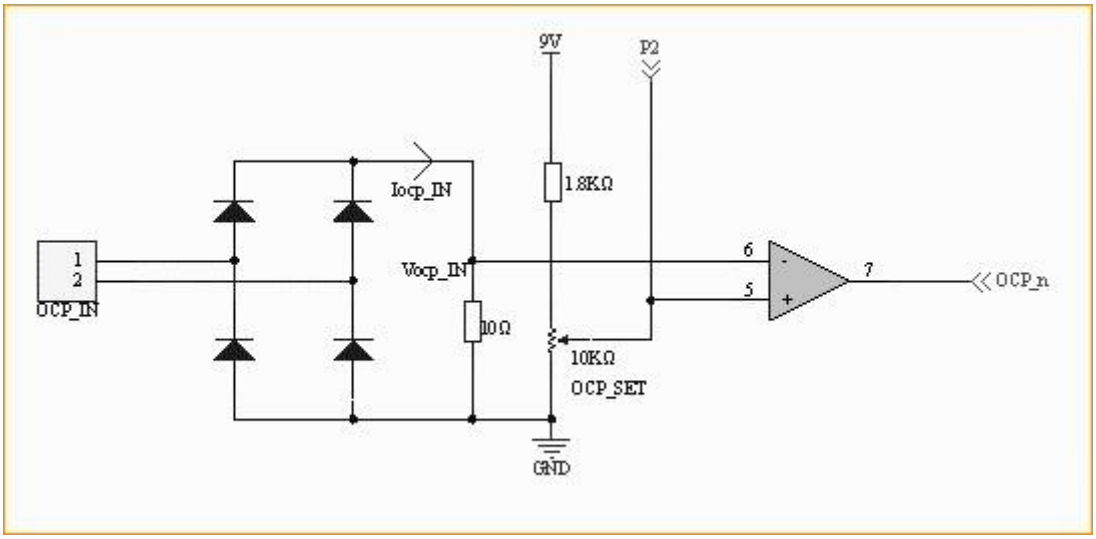

Figure 3. OCP_IN Overcurrent feedback

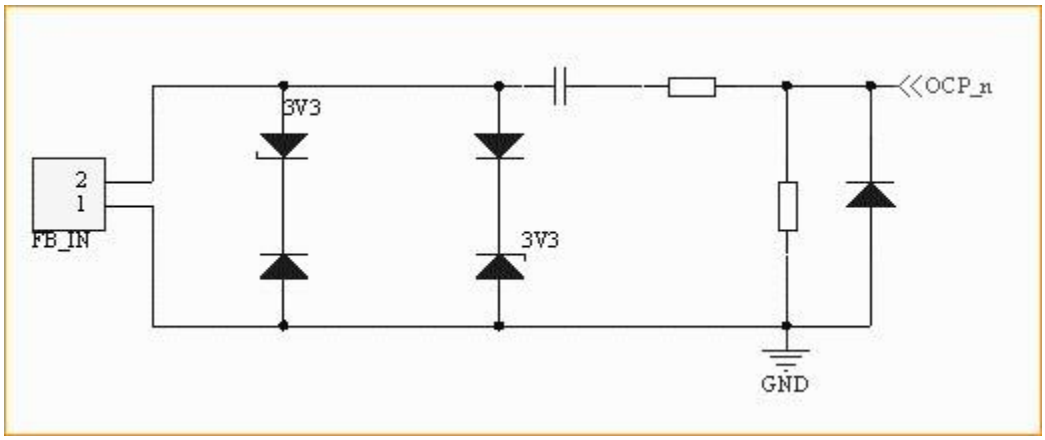

Figure 4. FB_IN Current feedback for TC excitation

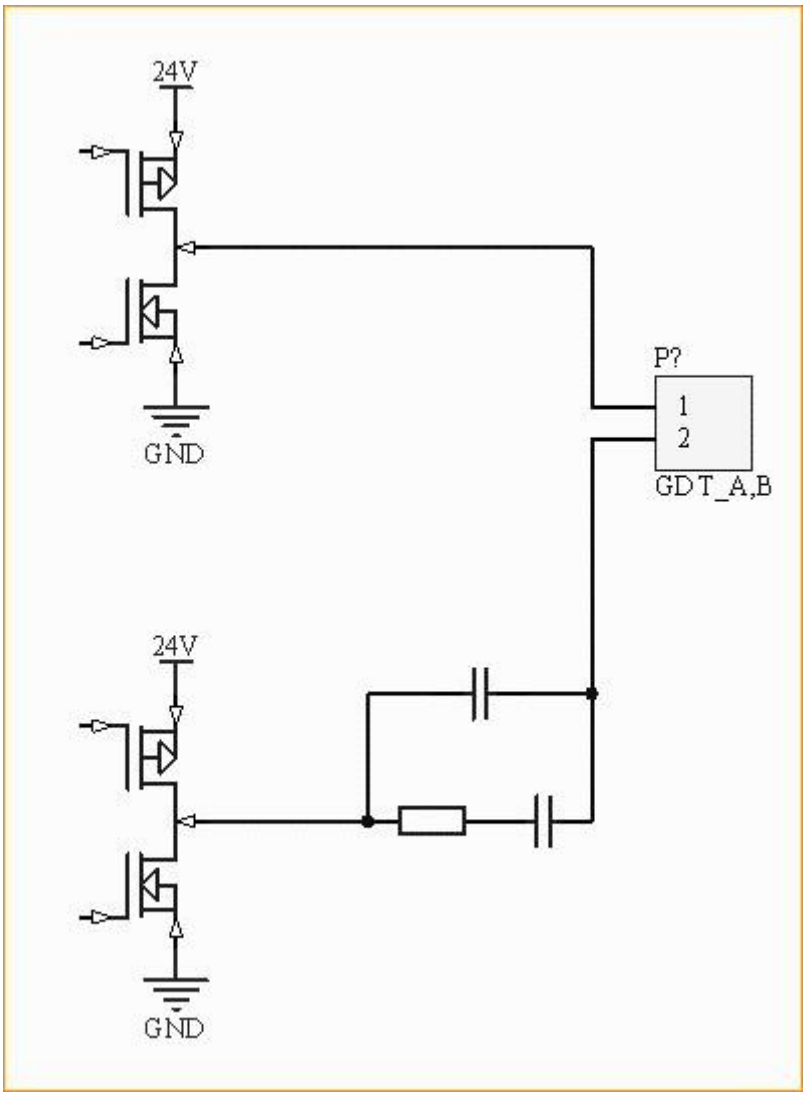

Figure 5. GDT drive final stage

8. Functional description:

1. **OCP_SET**

OCP_SET potentiometer adjusts reference voltage of the overcurrent comparator (see *Figure 3.* for details)

2. **OCP_IN**

Current feedback senses instantaneous value. If an absolute value of current (voltage) is higher than a reference point, driver will stop driving for a while. The current limiting circuit is shown on *Figure 3.*

Current limiting circuit consists of full-wave rectifier, resistor that creates measurable difference for input current, voltage divider (1.8k : 10k potentiometer - OCP_SET) and a comparator.

The relationship between the input current of the OCP_IN port and the voltage of the current signal is Iocp_IN × 10 = Vocp_IN because of the 10 ohms onboard resistor (see *Figure 3.* for details).

After the current feedback is rectified by a full bridge, it is converted into Vocp_IN with a 10 ohm resistor.
Vocp_IN is compared with the reference voltage by a comparator.
When Vocp_IN is greater than the reference voltage (determined by trimmed OCP_SET), overcurrent is detected by ALTERA EPM240T100C5N CPLD. Driver stops driving Tesla Coil for a while. The working waveform is shown in *Figure 6.*

3. **FB_IN**

The feedback circuit is shown in *Figure 4.*

FB_IN is an input terminal for feedback current transformer, that senses current in secondary (primary current can be sensed also, but high current transformers are more expensive… nevertheless achievable).

The feedback signal enters the CPLD after being rectified *after being clipped to around 3.5V by input Zener diodes,* limited and then DC-blocked by the decoupling capacitor.

Note! Direction of windings of the current transformer matters!
If your Tesla Coil does not excite, that may be the reason.

4. **GDT (A) and (B)**

The GDT driver uses FDD8424H MOSFET P channel + N channel pairs. 2x2 pairs (2 full bridges – 1. is A and 2. Is B).

FDD8424H allows a maximum pulse current of 20A in peak. GDT (A) is in phase with GDT (B).

It is not recommended to use GDT driver for very small Tesla Coils due to their high resonant frequency. Let's say that GDT is capable to work at maximum 200kHz…

5. **G - ground hole** *(circuit common)*

Only 1 of 4 holes is actually grounded (attached to common), the others are floating.

6. **Fiber port (interface)**

DLT1120 optical fiber needs to be used with an interrupter.

If your interrupter does not trigger Tesla Coil properly, you need to enlarge capacitor C35*, or shield a driver somehow.*

7. **PWR Indicator**

The PWR indicator lights up when power *(to the Supply_IN pin)* is connected to the driver.

8. **INT indicator**

The INT indicator lights up when the optical head receives a valid signal.

9. **SKP indicator**

When the overcurrent feedback (OCP_IN) signal is greater than the overcurrent comparator reference, the SKP indicator will light, and the GDT output will turn off until the current feedback signal is less than the overcurrent comparator reference.

10. **PON indicator**

If There is a valid signal at FB_IN, PON indicator lights up

11. **On time limit** *(built-in function I guess)*

When an error occurs and the time is of Tesla Coil excitation is greater than 10ms, Driver will stop driving GDT drivers to avoid damage

9. Working waveform:

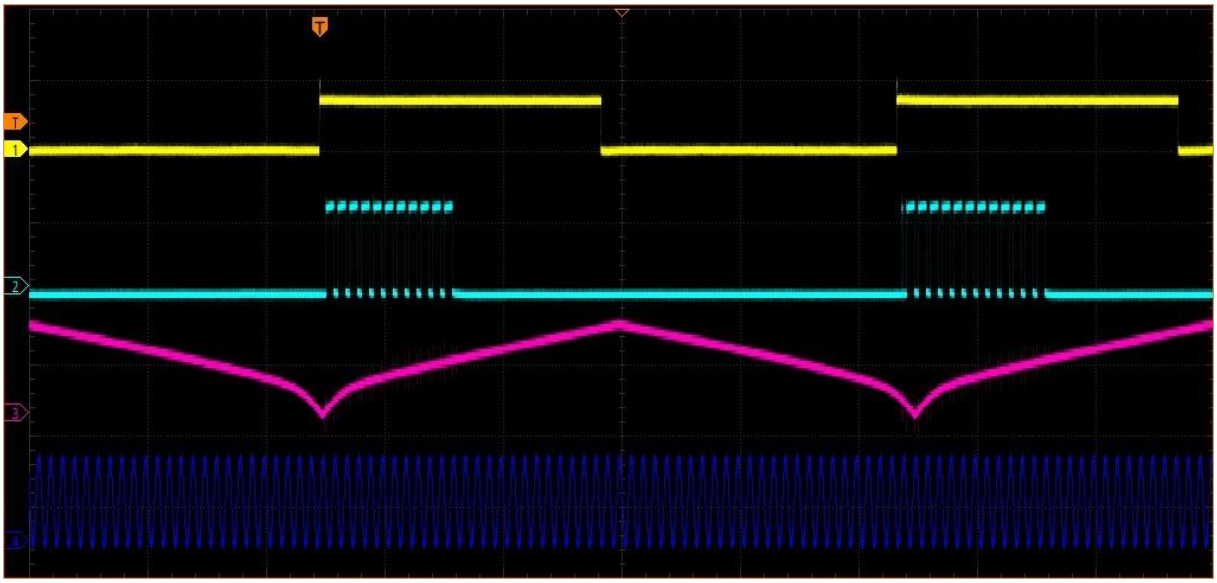

Figure 6. Working waveform

Test condition: FB_IN @ 100kHz fiber input @ OOK modulation 1MHz carrier modulation 2kHz

1 Optical fiber input signal envelope (yellow), 2 GDT (light blue), 3 OCP_IN (pink), 4 FB_IN (dark blue)

10. Test circuit:

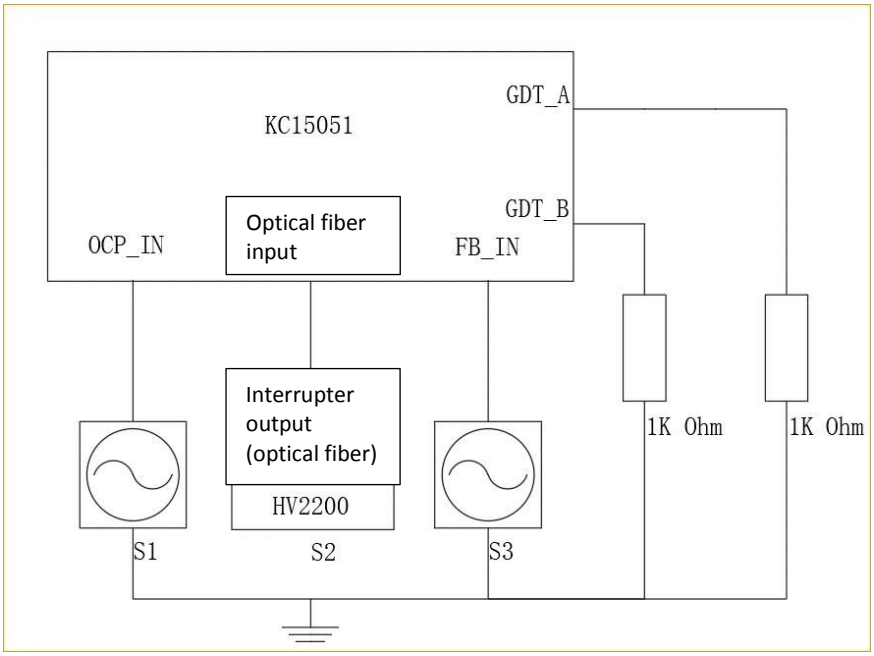

Figure 7. Test circuit

S3 @ 100Khz sine wave; S2 @ OOK modulation 1MHz carrier modulation 2kHz; S1 @ 2Khz triangle wave

The measurement results are shown in Figure 4.

The 2-port signal in Figure 6 is the GDT output voltage at either end to ground.

OCP_IN and FB_IN are the positive pins of this terminal near the OCP_SET potentiometer, and the other pins are negative.

The arc extinguishing controller (HV2200) is set to AUTO and SKP mode, and the output envelope is adjusted to about 2kHz by adjusting the frequency and pulse width knob

A rectangular wave with a 50% duty cycle.

11. Typical wiring method

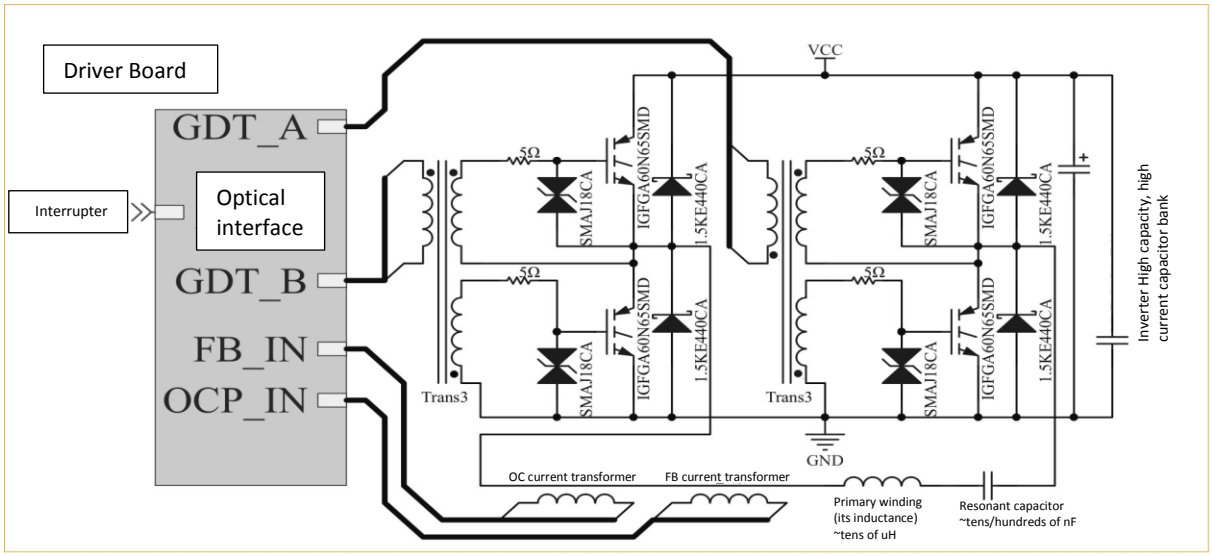

Figure 8. Typical wiring principle

12. Mechanical dimensions

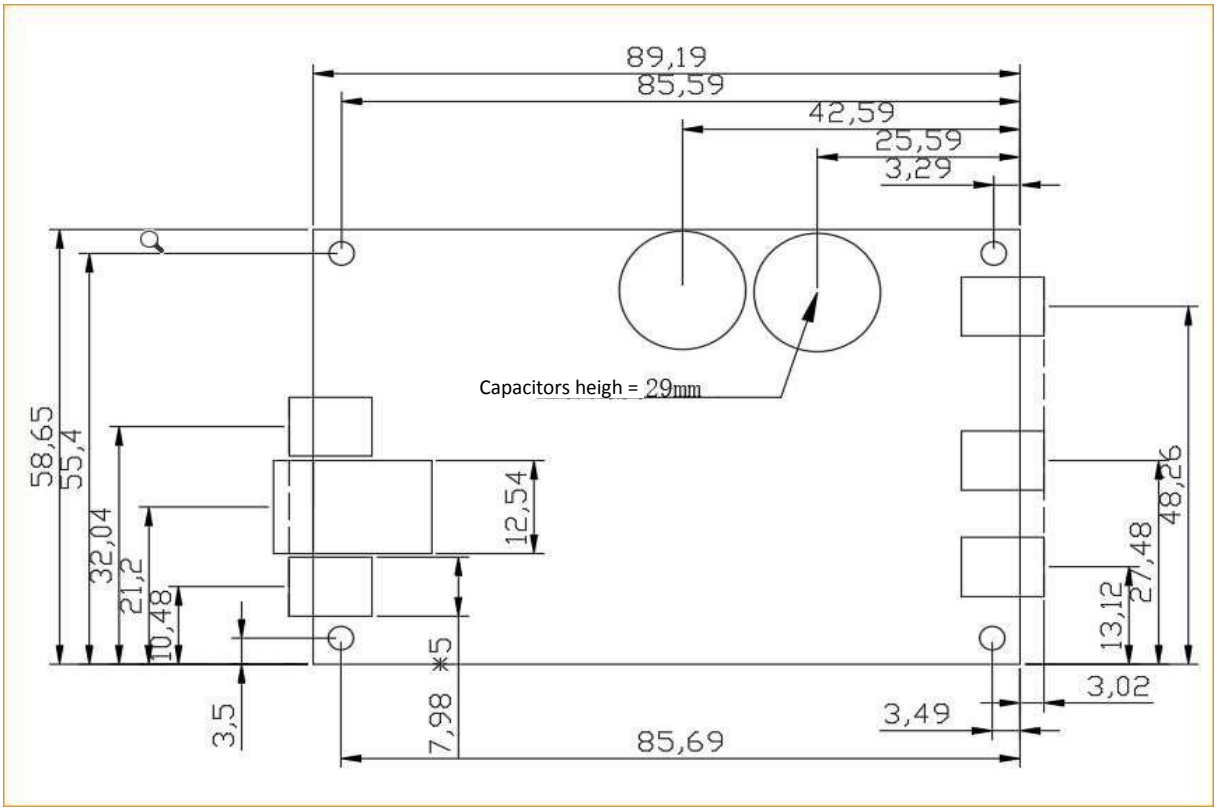

Figure 9. Mechanical dimensions

The values are in millimeters, of course. Tolerance is ± 0.5[mm]. Connector alignment tolerance is ± 1mm.
So, on the diagram values should be round to the first decimal place…

13. Toxic and harmful substances or elements

Part Name	Toxic and harmful substances or elements					
	Pb	Hg	Cd	Hexavalent chromium (Crd6+)	Polybrominated biphenyls (PBB)	PBDE
PCBA	X	0	0	0	0	0
optical fiber	0	0	0	0	0	0

0: It means that the content of the toxic and hazardous substance in all homogeneous materials of the part is below the limit required by the SJ / T 11363-2006 standard.

X: indicates that the content of the toxic and hazardous substance in at least one homogeneous material of the part exceeds the limit specified in the SJ / T 11363-2006 standard.

14. Packaging and Supply Information

Model	Fiber model	Starting batch *(???)*	Package dimensions *(??)*	weight	Order number
KC15051.01	BLT1120	1	180x100x117mm	350g *Actually 54g+-.1g*	KC1505101

Don't know where these "Package dimensions" came from, so here are some true dimensions that I have measured:
Board size: 89.5x59mm±0.5mm (1.6mm PCB)
Absolute dimensions: 97x59x30+-0.5mm

15. Notes

1. Firstly, test driver for proper operation (*Figure 7.*) You should check FB_IN current transformer polarization. Wrong wiring may destroy a driver.
2. For feedback current transformer, cascade 2 toroids. Single toroid may cause phase mismatch that damage the full bridge. *(don't know why single toroid may cause phase mismatch… there are some nice single toroid current transformers :P)*
3. A single GDT (A or B) is capable to handle full bridge inverter (If its C_{in}s are low).
4. Please ensure that the drive board is grounded only at 'G' hole *(No.8, Figure 1.)*.
5. Before powering on the full bridge high voltage, please check the GDT polarity to avoid bridge arm common state. *(??)*
6. Tesla coil generates a strong EM field during its operation, take care of your electronic equipment to avoid their damage.
7. People with built-in medical equipment should under no circumstances being around Tesla coil during its operation.
8. Tesla coil may cause medical devices to malfunction and threaten life.
9. Please make sure that the Tesla coil and the surrounding equipment are grounded and maintain a sufficient safety distance. (Not being hit by an arc does not mean you are safe. User must clearly know the other threats of the Tesla coil).
10. There are dangerous voltages in the control and power parts of the Tesla coil.
    The arc extinguishing control box should use non-conductor means such as optical fiber or radio waves to communicate with Tesla coil driver to avoid electrical breakdown. After the power is turned off, voltage is still high for couple of minutes (also depends on discharging resistor). When debugging, ensure that your system has been discharged.
11. When the Tesla coil is working, the circuit and arc will generate high temperature. During the work, ensure that the cooling fan works normally. It is strictly forbidden to place flammable and explosive materials nearby.

16. Disclaimer

The manufacture and operation of Tesla coils may lead to personal injury or property damage. This danger is inherent in Tesla coils, is unavoidably known by the application of Tesla coils, and has no direct relationship with the quality of related products. Any adverse consequences of the use of Tesla coils have nothing to do with the designer, manufacturer, seller of this device, etc. The user must bear all consequences. Otherwise, please do not make, buy, or use Tesla coils and related equipment.

The Tesla coil driver is not a consumer product, and it is mainly used for professional large and medium-sized Tesla coils. You must have relevant professional knowledge to use it. Relevant parties have no obligation to judge whether the user has professional knowledge and shall not bear any consequences of improper use by the user.