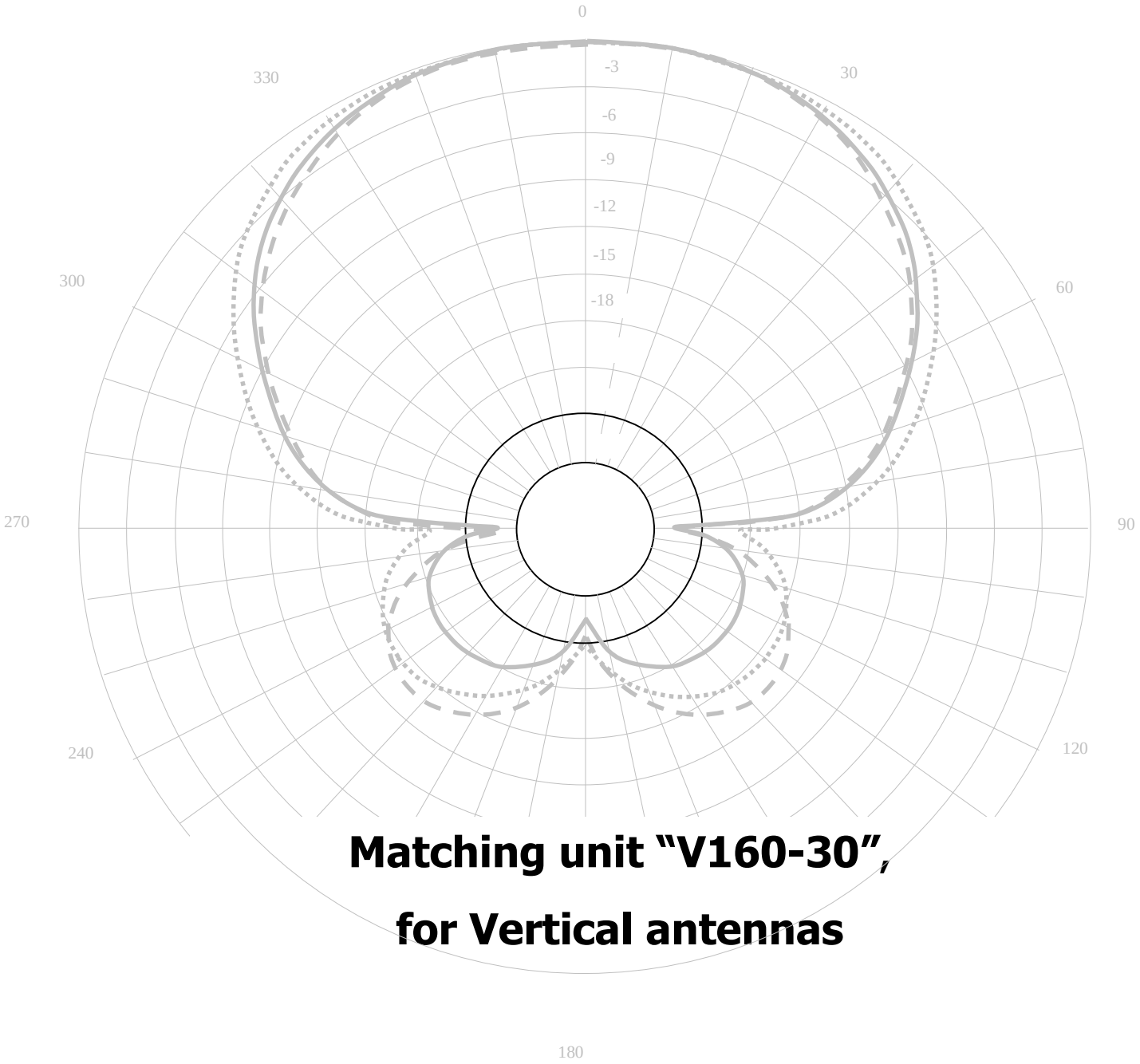
Antenna solutions for HAM RADIO




# Matching unit “V160-30”,

# for Vertical antennas

**User manual**

**Ver. 2**

## Table of Contents:





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## I. Safety first!

Don't forget to always follow common safety rules working with the matching unit and vertical antenna.

Do not locate vertical antenna near overhead power lines or other electric light or power circuits, or where it can come into contact with such circuits. When installing the antenna, take extreme care not to come into contact with such circuits, because they may cause serious injury or death.

Vertical antennas will absorb all the nearby strike, lightings! Be very careful when doing any work with the matching unit, vertical.

Except radials, you MUST DO GROUNDING at the base of vertical and connect all the radials to the ground rod as well as matching unit.

It is a good idea to make initial adjustments of the network components with swiping antenna analyzer. It will help you to make tuning quickly and most efficient way.
After initial adjustment you can check SWR, bandwidth applying 100W or less power.

If you are lucky to be near see or ocean, with great amount of salted air, moisture, it is better to protect all the connections to the matching unit with self-adhesive type at least.

## II. INSTALATION:

Do not mount this matching unit on your vertical antenna!

Vertical structures (even guyed towers) always vibrates and this may case a damage to components inside matching unit.

Use separate support for mounting matching unit as close as practical to antenna.

It could be a separate mounting pipe or just a few bricks used as a podium to matching unit.

Take precaution measures against bad weather conditions, snowing etc.

Weather proofing of connectors is a must.



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## III. Vertical Antennas and Matching unit "V160-30"

This matching unit designed to match 15 ÷ 20 meters (50 ÷ 70 feet) high Vertical antenna with 2 or 4 Top Loading wires, each 6 ÷ 8 meters (20 ÷ 25 feet) long, on 160, 80, 40 and 30 meters bands.

This is a classic configuration of good transmit antenna on TopBand.

Self-resonance frequency of such a Vertical radiator is in 2.5 ÷ 3.0Mhz range.

Matching Unit should be placed at the base of vertical antenna.

Components selection, schematic and parts will allow you to match wide range of input impedances on different bands.

Two sub-bands on 160 and on 80 will let you use both CW and SSB allocation on those bands.

You can reconfigure matching schemes to allow use of the 3rd sub band on 80 meters, to extend coverage of the most wide ham band.

While 15 ÷ 20 meters (50 ÷ 70 feet) antenna is a bit too high to provide good vertical pattern on 40 and 30 meters bands, it is still usable.

Vertical radiator can be made of wire wound along the plastic mast, self-standing aluminum tubing or guyed metal tower sections with good intersection joints.

The top hat loading wires may serve as a guy wires at the same time, and can be placed not only from the very top of mast, but 2 ÷ 3 meters (7 ÷ 10 feet) bellow to give extra mechanical strength.

It is mandatory to use few (2 ÷ 3) insulators at the ends of the top loading wires if running more the 100W.

For best antenna performance you must use a descent radial system. 30 ÷ 60 radials, each 20 ÷ 30 meters (65 ÷ 100 feet) long are recommended as a starting point. Fewer and shorter radials will work, but with diminished results.

The wire radials should be placed as symmetrically as possible straight from the feed point around the vertical antenna and spaced evenly, regardless of how many radials are used.

As a good compromise, you can use elevated radials, 2 or 4 per band, at 2 ÷ 5 (7 ÷ 15 feet) meters above the ground, trimmed as dipoles elements at the target frequencies.

Good quality base insulator is needed.

Most important concern is vertical`s mechanical strength and stability of the whole structure, it`s resistance to the wind, icing, corrosion and other bad weather condition.

For best performance on reception (especially on 160), it is strongly advised to use a dedicated, well-spaced off the vertical, receive only antenna system. Vertical antennas are known of high degree sensitivity to the manmade, local and atmospheric propagated noise.



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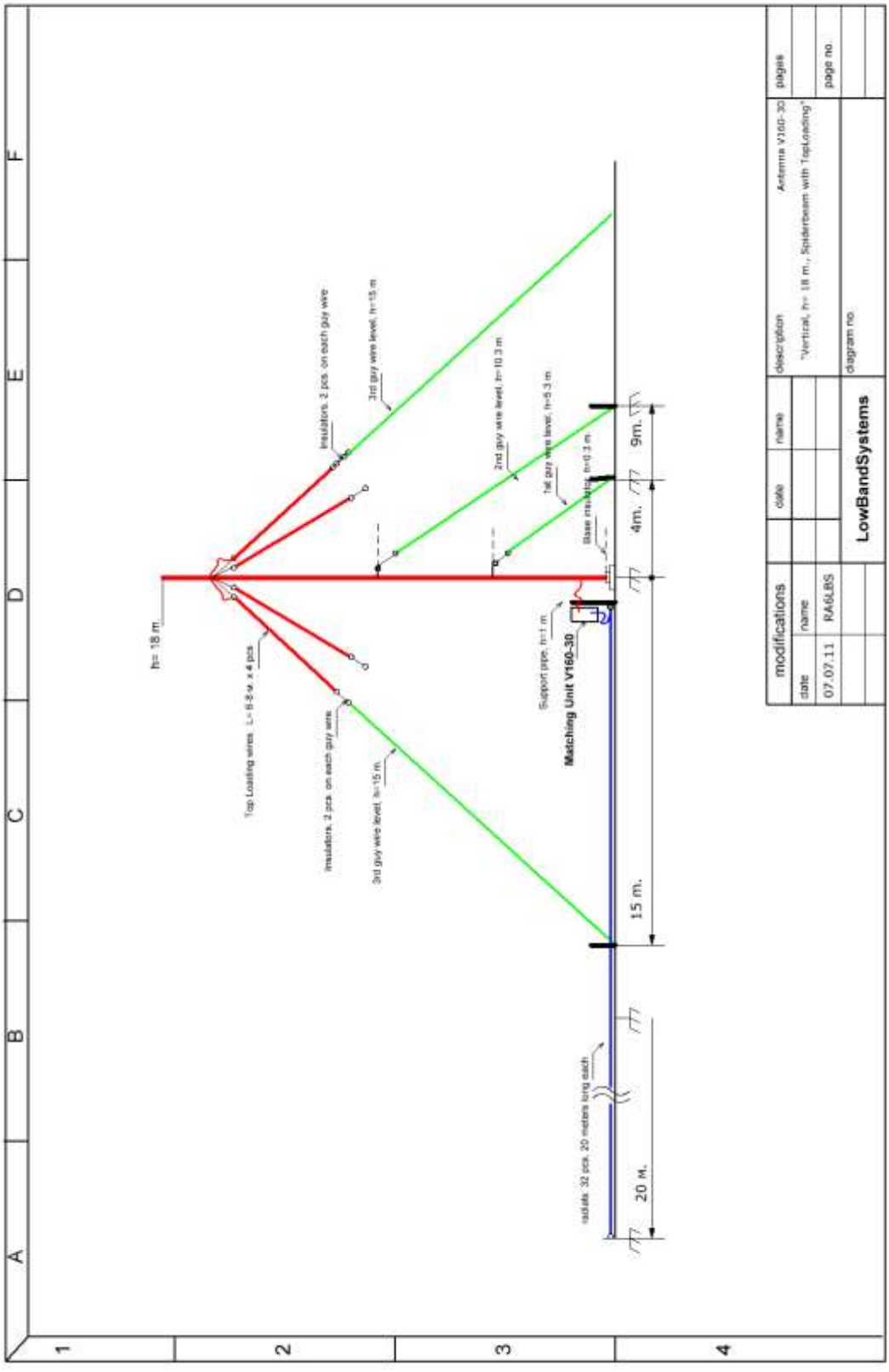
## IV. Suggested Vertical Antenna layouts:

**Using Plastic mast (Spider pole suggested) AND TopLoading at lower height serving as guy wires**



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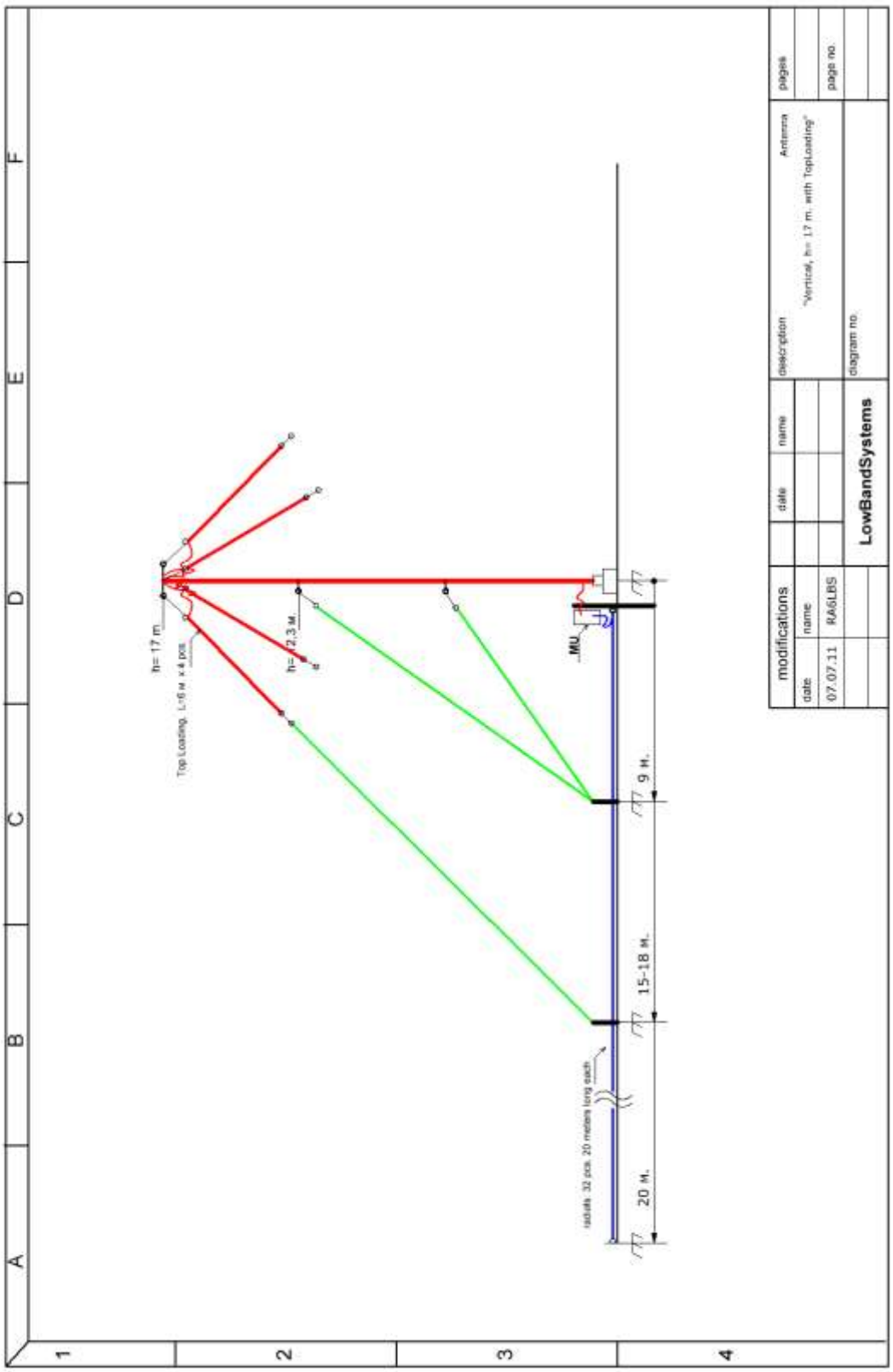
**Using Aluminium mast**



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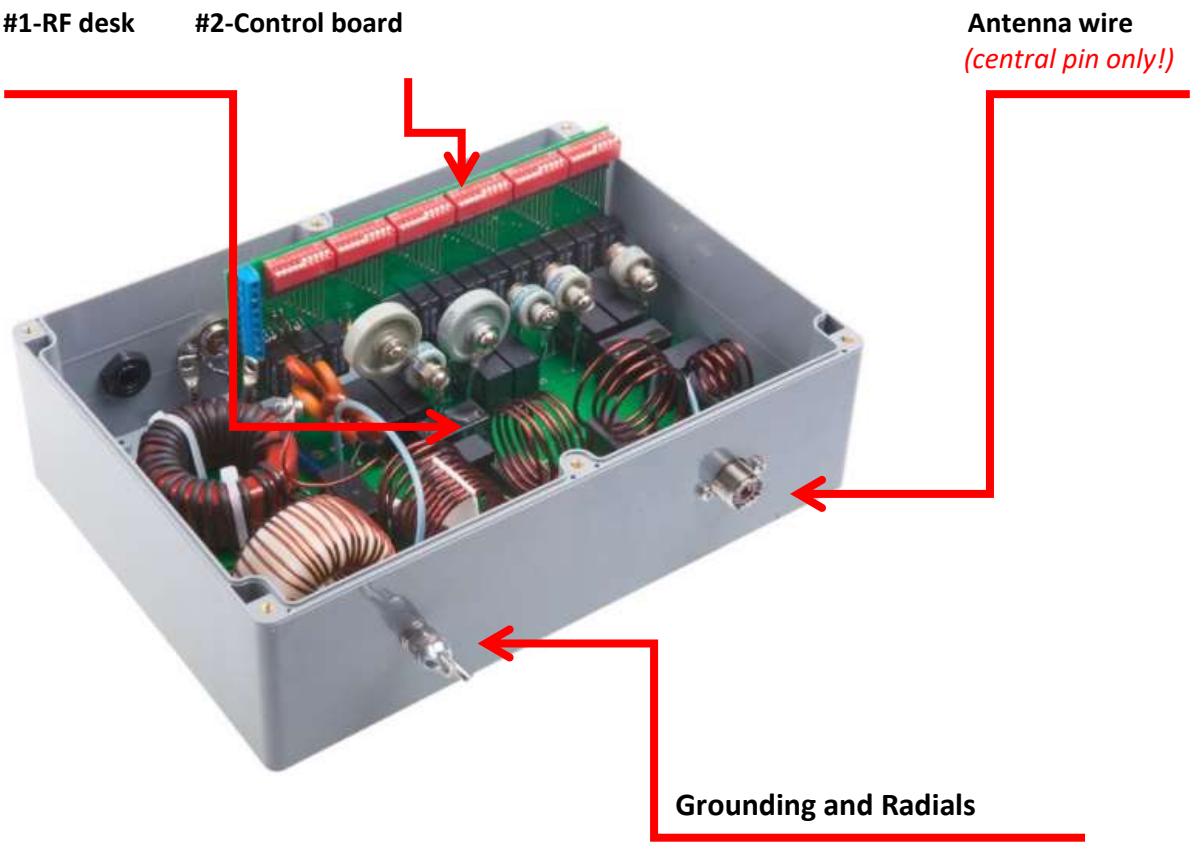
## V. Matching unit "V160-30"

### Specification:

| | |
|---|---|
| Sub Bands of operation: | 160CW - 160SSB - 80CW - 80SSB - *(80DX)* - 40 - *30*; |
| Maximum power, ICAS: | 1000 Watts; |
| Input impedance: | 50 ohms; |
| Enclosure: | IP65 (NEMA4) rated ABS or polycarbonate box; |
| Coaxial connector to transmitter: | UHF style, SO-239; |
| Control cable connector: | Terminals inside the enclosure; |
| Recommended control cable: | 8 conductor, min. cross area requirement 0,7 мм2; |
| Control voltage: | 24 ÷ 28VDC, 0.5A max; |
| Control voltage format: | Standard "1 of 6" and a separate power line |
| | |
| Control console: | LowBandSystem`s "MC-6R"; |
| Matching network type: | L network, series-shunt or shunt-series |

### Theory of operation:

Matching unit consists of 2 PCBs, RF desk and Control board:




Band selection is done with simple "1 of 6" control format.

Separate power line used to supply 24VDC (at the control board terminals!) to the relatively high consumption relays at RF desk.

Control board contains six "memory banks" that selects matching components values on each of 6 working sub-bands. "Digital tuning" of antenna is easy, quick and requires no soldering in the field.

You can use LowBandSystems controller MC-6R or some other means of selecting band. Sophisticated band decoder, one that recognizes frequency segments of your radio can do the job too.



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## RF desk:

RF desk consists of L network components (capacitors and coils) and a bunch of relays.

Control logic allows using series-shunt or shunt-series network on appropriate bands.

There are Five only fixed value capacitors, five only fixed value inductors and some relays, utilizing binary principle of components selection.

On 160 meters band, matching network for antennas with self-resonance on 2.5 ÷ 3.0Mhz requires much bigger value of capacitance and inductance then on any other band.

Sixth capacitor used only on 160. Consists of few capacitors in parallel, and depending on your local condition, you may use just few of them, reducing total value.

Sixth, large inductance wound on a ferrite core, with 3 taps is used on 160. You can choose which taps suits your local conditions best.

## Control board:

Most unique part of LowBandSystems matching unit "V160-30" is control board:

**Network management:**

Matching network topology selection (series-shunt or shunt-series) is fixed by control board`s logic.

On control board there are six "memory banks" which selects matching components values on each of the six sub-bands:

**Capacitance management:**

Using 5 position DIP switches and only 5 capacitors, you have selection of 31 values ranging from 100 to 1200 pf to match your antenna on 80, 40 and 30 meters bands.
Each next capacitor has a value that doubles previous as close as it is possible with high power caps.

On 160, with sixth cap involved (5 pcs. in parallel, total 3600pf), total capacitance is 3700 ÷ 4800pf.
Manually removing one of those 5 caps you can lower this range by 1000, 2000 or 3000 pf.

**Inductance management:**

Using 5 position DIP switches and only 5 coils, you have selection of 31 values ranging from 0.5 to 4.3 uH to match your antenna on 80, 40 and 30 meters bands.
Each next coil has a value that doubles previous.

On 160, with additional coil wound on ferrite, you have a total inductance of 16.5 – 20.5 uH.
3 taps on a coil, with easy to use bolted connection, allows you to lower this range by 3 or 6 uH (13.5 – 17.5 or 11.5-14.5).

"Digital" tuning, very wide selection of matching components values, no need for soldering in the field, makes whole process of tuning easy and fast.



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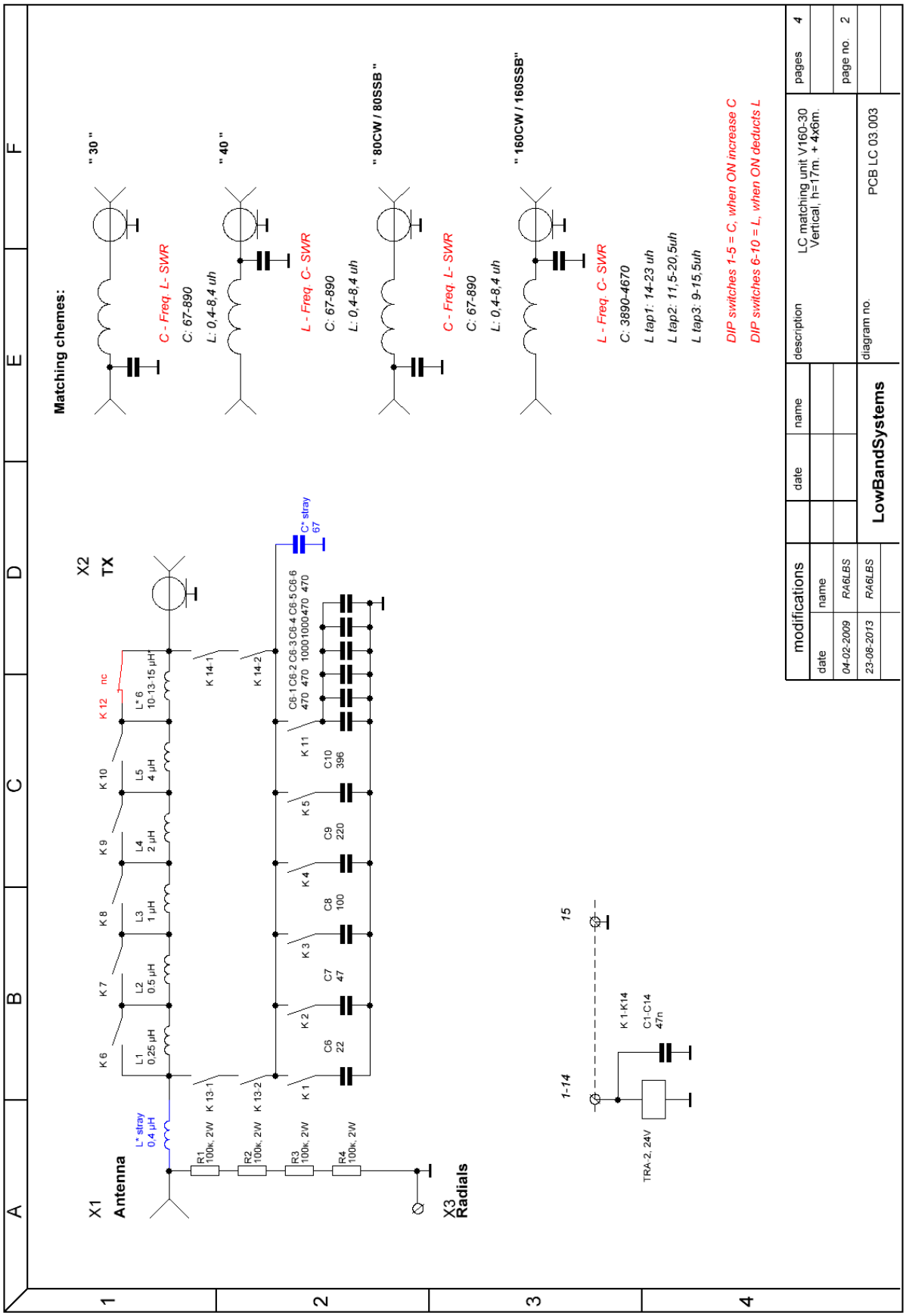
## RF DESK simplified Schematic



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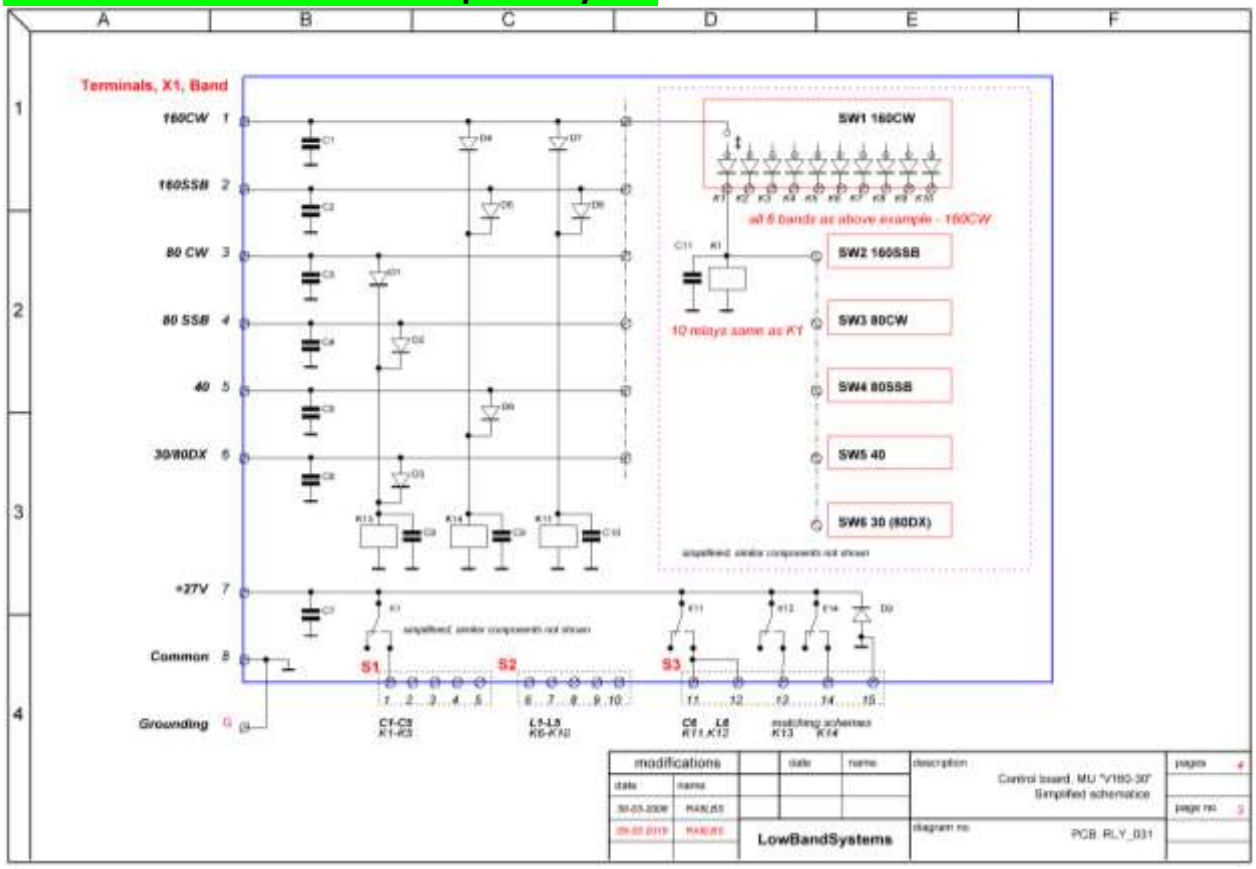
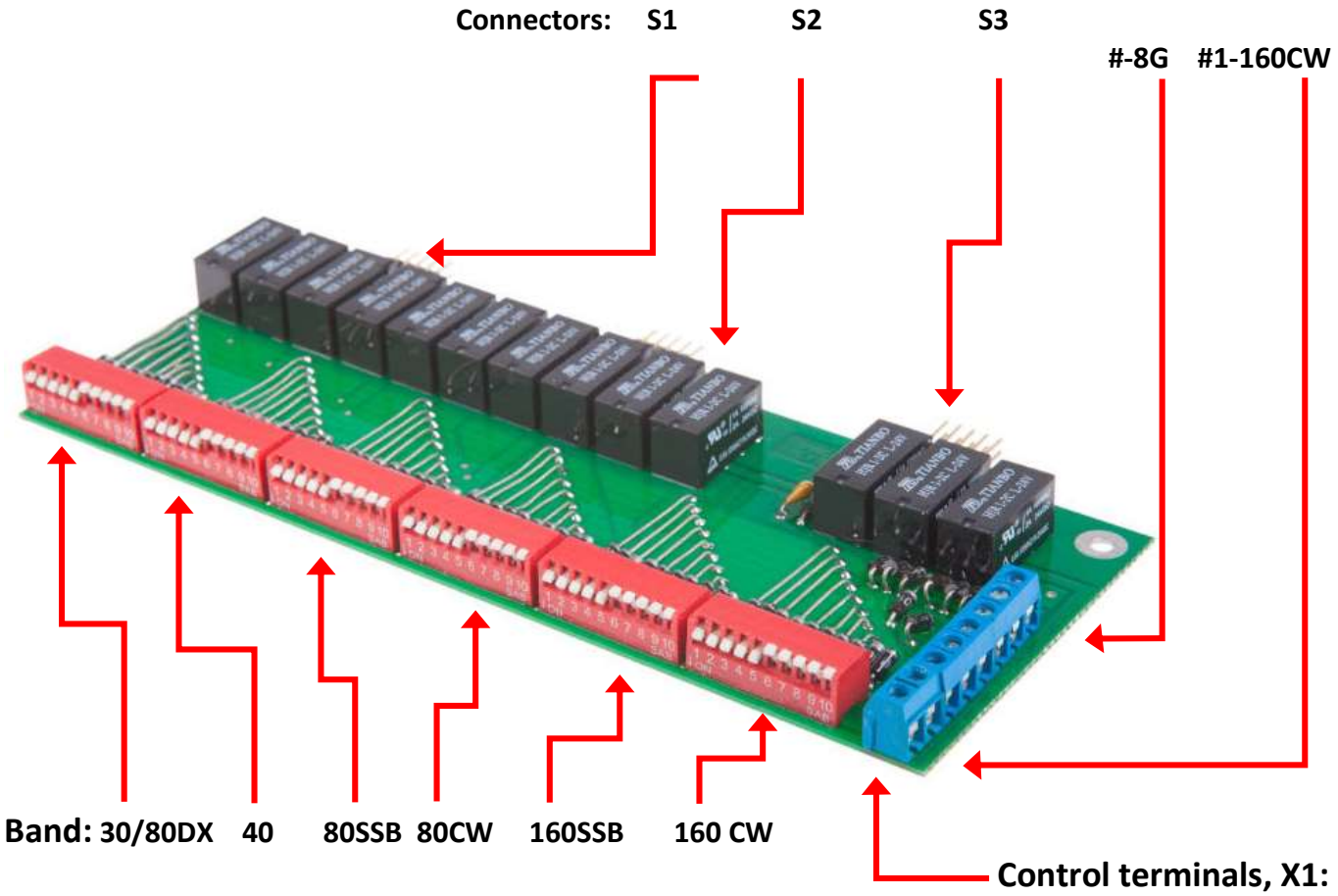
## Control board Schematic and parts layout:



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## VII. Matching your antenna, step by step:

### To Start:

- Connect Grounding wire and all the radials to "Radials" terminal;
- Connect your antenna wire to "Antenna" terminal;
- Connect control cable to control board;
- Place matching unit so, that you have a good access to the control board;
- Place control console near the antenna for your convenience;

**Advice for real experts:**
Measure impedance of your antenna first with analyzer, calculate needed components values and set them in advance.

### General:

- Most useful tool while adjusting network components is swiping analyzer like RigExpert AA-54;
- Never ever, try to adjust air wound coils. Only "Digital" selection of appropriate coils will let you do the job;



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## Bands 80 & 30

80 meters band usually is easiest band to start matching and to learn how "Digital" tuning works.

Switch controller to one of the sub bands on 80 or 30
Check "MC-6R" Toggle switch S2 "Detuning" position on the rear panel is OFF
Switch power ON

| | | |
|---|---|---|
| Set initial network components values on 80: | L= 6 uH | C= 550 pf. |
| Set initial network components values on 30: | L= 2.2 uH, | C= 450 pf. |

1) Using your antenna analyzer, swiping frequency range from 3 to 4.5 Mhz (9.5 ÷ 11 Mhz), find frequency of the best SWR. Most probably you will find it outside of the HAM band, not perfect match, but you should see obvious curve and relatively low SWR value;

2) Changing DIP pins #6-10 (inductance) you have to change SWR on this frequency. Your goal is to obtain best possible SWR. And it should be VERY close to 1:1,0 Playing with all the possible combination of DIPs #1 ÷ #5 you will see SWR change and a minor change of the best match frequency. When you get closer to 1:1,0 SWR, play with low value capacitors only. It is helpful to know the total value of capacitance in matching network to understand better what to do next.

3) Your next goal is to "move" this frequency by changing switches DIPS #1 ÷ #5 (capacitors) closer to the target frequency and then playing again with DIP pins #6 ÷ 10 (inductance) to get best possible match.

4) Don't try to make big steps while "changing" frequency. It is more productive to move in small steps, like 100 ÷ 200kHz on 80 and 50 ÷ 100kHz on 30.

## Bands 160 & 40

Switch controller to 160 (or 40)
Check "MC-6R" Toggle switch S2 "Detuning" position on the rear panel is OFF
Switch power ON

| | | |
|---|---|---|
| Set initial network components values on 160: | L= 20 uH | C= 4000 pf. |
| Set initial network components values on 40: | L= 6.5 uH | C= 375 pf. |

1) Using your antenna analyzer, swiping frequency range from 1.8 to 2.5Mhz (6 ÷ 8Mhz), find frequency of the best SWR. Most probably you will find it outside of the HAM band, not perfect match, but you should see obvious curve and relatively low SWR value;

2) Changing DIP pins #1-5 (capacitance) you have to change SWR **on this frequency**. Your goal is to obtain best possible SWR. And it should be VERY close to 1:1,0. Playing with all the combination of DIPs #1 ÷ #5 you will see SWR change and a minor change of the best match frequency. When you get closer to 1:1,0 SWR, play with low value capacitors only. It is helpful to know the total value of capacitance in matching network to understand better what to do next.

3) Your next goal is to "move" this frequency changing switches DIPS #6-#10 (inductance) closer to the target frequency and then playing again with capacitors.

4) Don't try to make big steps while "changing" frequency. It is more productive to move in small steps, like 150 ÷ 300kHz on 160 and 50 ÷ 100kHz on 40.



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## Table of total capacitance value, "Digitally" managed

**Please note:**

- To manage capacitance, you have to close or open pins #1-#5 on a DIP switch (of appropriate band) located on control board PCB;
- Values shown in the table is approximate, to represent trend, while very close to real ones;
- Closing DIPs switch (ON), you INCREASE capacitance in a matching network;
- On 160, by cutting out one (or two or three) of 1000pf capacitors in C6 stack, you can reduce capacitance range 1000 or 2000 or 3000 pf. respectively if needed;

| DIPs ON: | Bands 80-30, Capacitance, pf | Band 160, Capacitance, pf |
|---|---|---|
| none | **65** | **3600** |
| #1 | 80 | 3625 |
| #2 | 105 | 3650 |
| #1+#2 | 130 | 3675 |
| #3 | 155 | 3700 |
| #1+#3 | 180 | 3725 |
| #2+#3 | 205 | 3750 |
| #1+#2+#3 | 230 | 3775 |
| #4 | 255 | 3800 |
| #1+#4 | 280 | 3825 |
| #2+#4 | 305 | 3850 |
| #1+#2+#4 | 330 | 3875 |
| #3+#4 | 355 | 3900 |
| #1+#3+#4 | 380 | 3925 |
| #2+#3+#4 | 405 | 3950 |
| #1+#2+#3+#4 | 430 | 3975 |
| #5 | 455 | 4000 |
| #1+#5 | 480 | 4025 |
| #2+#5 | 505 | 4050 |
| #1+#2+#5 | 530 | 4075 |
| #3+#5 | 555 | 4100 |
| #1+#3+#5 | 580 | 4125 |
| #2+#3+#5 | 605 | 4150 |
| #1+#2+#3+#5 | 630 | 4175 |
| #4+#5 | 655 | 4200 |
| #1+#4+#5 | 680 | 4225 |
| #2+#4+#5 | 705 | 4250 |
| #1+#2+#4+#5 | 730 | 4275 |
| #3+#4+#5 | 755 | 4300 |
| #1+#3+#4+#5 | 780 | 4325 |
| #2+#3+#4+#5 | 805 | 4350 |
| #1-#5 | **830** | **4375** |



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## Table of total inductance value, "Digitally" managed

**Please note:**

- To manage inductance, you have to close or open pins #6-#10 on a DIP switch (of appropriate band) located on control board PCB;
- Values shown in the table is approximate, to represent trend, while very close to real ones;
- Closing DIP switches (ON), you DECREASE inductance value in a matching network;
- On 160, by changing TAP on L6 from #2 to #1 or to #3, you can change initial inductance to 11.8uH and 16.8uH respectively if needed;

| DIPs ON: | Band 160, Inductance, uH tap #2 of L6 | Bands 80-30, Inductance, uH |
|---|---|---|
| none | **22,55** | **8,55** |
| #6 | 22,30 | 8,30 |
| #7 | 22,05 | 8,05 |
| #6+#7 | 21,80 | 7,80 |
| #8 | 21,55 | 7,55 |
| #6+#8 | 21,30 | 7,30 |
| #7+#8 | 21,05 | 7,05 |
| #6+#7+#8 | 20,80 | 6,80 |
| #9 | 20,55 | 6,55 |
| #6+#9 | 20,30 | 6,30 |
| #7+#9 | 20,05 | 6,05 |
| #6+#7+#9 | 19,80 | 5,80 |
| #8+#9 | 19,55 | 5,55 |
| #6+#8+#9 | 19,30 | 5,30 |
| #7+#8+#9 | 19,05 | 5,05 |
| #6+#7+#8+#9 | 18,80 | 4,80 |
| #10 | 18,55 | 4,55 |
| #6+#10 | 18,30 | 4,30 |
| #7+10 | 18,05 | 4,05 |
| #6+#7+#10 | 17,80 | 3,80 |
| #8+#10 | 17,55 | 3,55 |
| #6+#8+#10 | 17,30 | 3,30 |
| #7+#8.#10 | 17,05 | 3,05 |
| #6+#7+#8+#10 | 16,80 | 2,80 |
| #9+#10 | 16,55 | 2,55 |
| #6+#9+#10 | 16,30 | 2,30 |
| #7+#9+#10 | 16,05 | 2,05 |
| #6+#7+#9+#10 | 15,80 | 1,80 |
| #8+#9+#10 | 15,55 | 1,55 |
| #6+#8+#9+#10 | 15,30 | 1,30 |
| #7+#8+#9+#10 | 15,05 | 1,05 |
| K6-K10 | **14,80** | **0,80** |



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