Modifying conventional drivers for use with the ScannerMAX Compact 506

The ScannerMAX Compact 506 is a small, low-inertia galvanometer-based optical scanner capable of driving 3mm aperture mirrors at lightshow scanning speeds in excess of 50K (nearly 5kHz small signal bandwidth and 150 microsecond small steps) with no distortion, and capable of driving mirrors up to 1 inch diameter. The small size, high performance, and yet low cost of the Compact 506 have made it an instant favorite among lightshow and industrial clients alike.

Pangolin has not yet released a driver for the Compact 506. Up until now, Pangolin has sold the Compact 506 to large equipment manufacturers who already manufacture their own drivers. Pangolin has worked directly with those manufacturers to detail the component changes needed to get their driver to perform optimally with the Compact 506.

We have found that the Compact 506 will work with some existing drivers with no changes at all, and there are a few clients who purchase Compact 506 and simply use it with existing drivers. However, by making a small number of modifications, optimal performance can be achieved.

What makes the Compact 506 different from conventional galvos

The Compact 506 is constructed in a way that is completely different from the typical moving magnet galvanometer. With a strong contradiction to the conventional moving magnet technique that was originally invented nearly 40 years ago, the Compact 506 utilizes a laminated stator with a recently-patented magnetic circuit, along with a different rotor construction technique, and our patented high-output position sensor design. The overall concept of achieving scanning by attaching a mirror to the end of a motor is the same, but the behavior of our galvos is different.

The Compact 506 behaves differently from typical lightshow galvos in the following ways:

1. The position signal is up to ten times as strong
2. Torsional and bending-mode resonances are infinitely higher
3. The coil resistance is 50% lower, but inductance is around four times as high
4. The torque-to-inertia ratio is around 20% higher
5. There is a return-to-center magnetic spring phenomenon
6. There is no rotor/mirror stop

Stronger Position Signal

In relation to point number 1 above, since the position signal is much stronger, unmodified amplifiers will operate the Compact 506 LED at only around 1 milliamp to accomplish the same amount of signal that was previously achieved at 8 to 20 milliamps with conventional scanners. Therefore, ideally, an amplifier is modified to provide much more feedback (less amplification) around the position signal, and also to boost the amount of current flowing through the LED.

Stronger Rotor

In relation to point number 2 above, due to the construction of the rotor, torsional-mode resonances are essentially insignificant or even immeasurable.

Due to the combination of points number 1 and 2, the stronger position signal (providing higher signal-to-noise ratio) and stronger rotor (raising torsional-mode resonances to out-of-band proportions), means that no notch filter is needed, even when driving large mirrors with high

servo gains. Moreover, for the filters used in the low-frequency-damping-to-high-frequency damping transition, the cutoff frequency of these filters can be raised significantly, thus improving dynamic performance as well as accuracy.

Lower coil resistance and a cooler-running motor

In relation to point number 3 above, the compensation around the power amplifier stage needs to be changed to correctly handle a coil whose resistance is 50% lower and inductance is higher. This is easily accomplished.

Intuition might lead someone to believe that the higher inductance would be a significant impediment to small-signal performance. However, due to the combination of point numbers 3 and 4 above, the low coil resistance and higher torque-to-inertia ratio all play a role in actually increasing scanning speed. Therefore, real-world tests with conventional drivers reveal similar small-signal performance similar to those of a Cambridge model 6210, and even better large-signal performance. Moreover, due to the combination of points number 3 and 4, the lower coil resistance and higher torque-to-inertia ratio means that not as much current is needed to accelerate the scanner, and moreover any current required is met by the lower coil resistance. Because of this, the heat generated within the scanner is significantly lower for any given projected image, and thus the scanner runs cooler.

In relation to point number 5 above, there is a return-to-center spring phenomenon, which means that some (at least small) amount of current is required to be driven into the scanner in order to hold a particular position. Amplifiers made for conventional scanners employ a current integrator to provide a high-frequency damping action. When used with the Compact 506, this current integrator can become saturated at the far excursions because of the small holding current needed to overcome the magnetic spring. Because of this, feedback around the integrator must be increased somewhat. Of course this is easily accomplished as well.

Greater convenience

In relation to point number 6, by removing the mirror stop, we have been able to add stiffness (strength) to the rotor, thus raising resonant frequencies. The lack of a mirror stop also adds convenience when it comes time to re-orient the mirrors for left-handed and right-handed X-Y mounts (with conventional scanners the mirrors must be un-mounted and flipped around on the shaft). Note that while the mirror stop has been removed, the mirror will always operate within a predictable range of angles, due to point number 5.

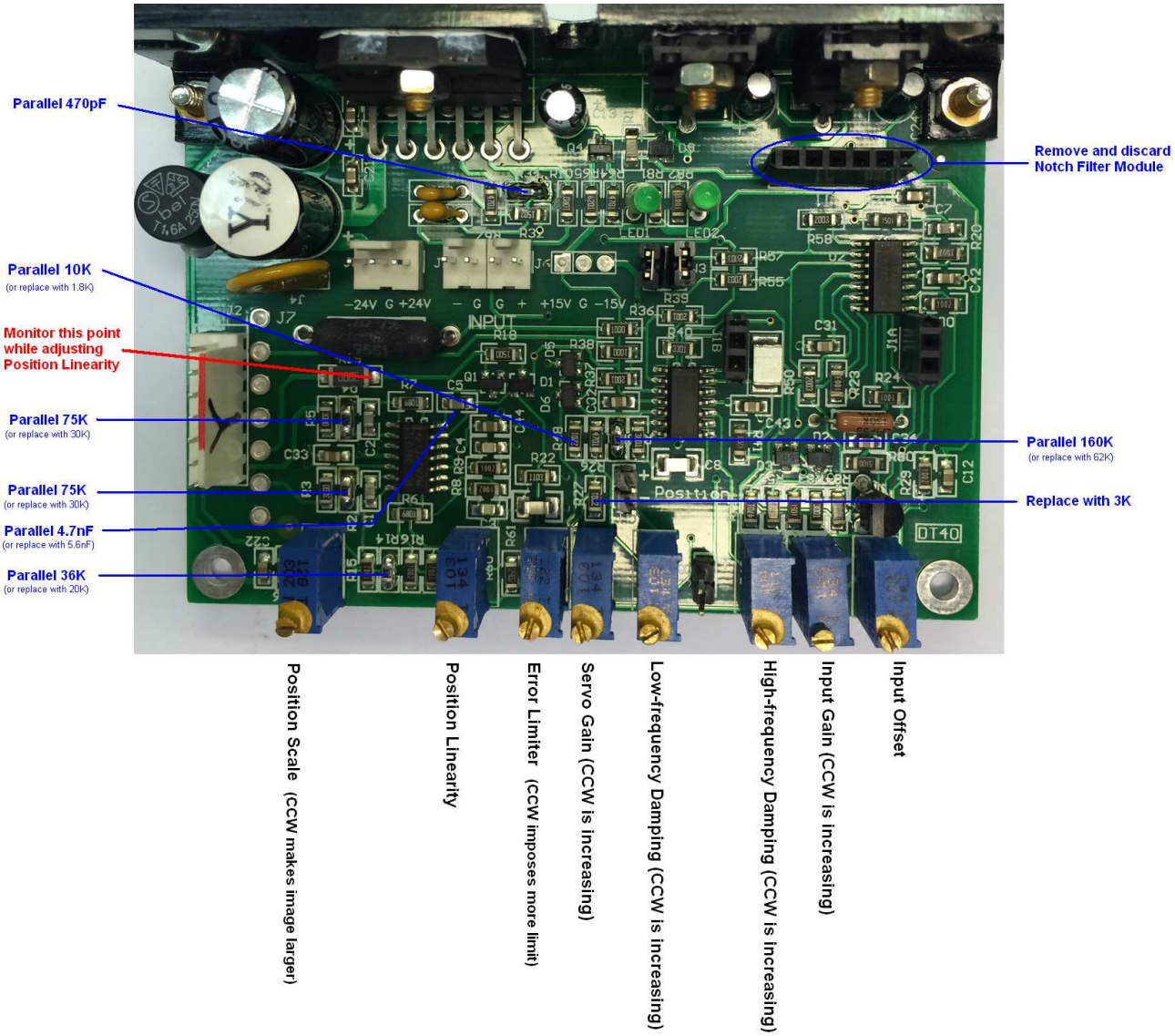
The combination of properties ultimately leads to faster scanning

The stronger position signal and stronger rotor construction combine to allow for the raising of internal servo filter frequencies and removal of the notch filter, even with large mirrors. These changes remove the phase loss associated with driving conventional galvos, thus ultimately allowing higher small-signal scanning speeds (easily achieving 50K+ from amplifiers that barely achieve 30K with conventional galvos). The lower coil resistance allows a given amount of drive voltage to ultimately result in higher peak currents, and thus higher peak torque to drive the mirror. This, along with the higher torque-to-inertia ratio means large-signal performance is better as well.

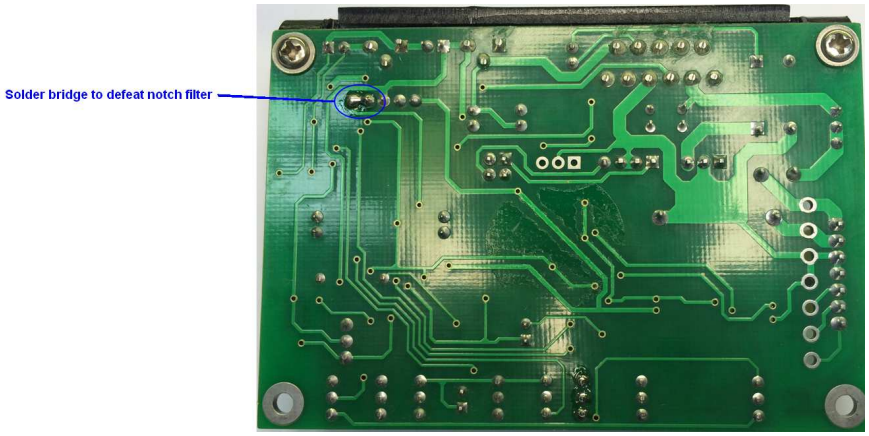
You can now understand how our slogan of “Stronger, Cooler, Faster” isn’t just a moniker, but actually what is accomplished with ScannerMAX scanners.

Modifying the Dragon Tiger model DT40 drivers

Below you can see a picture that details the changes needed for DT40 drivers. These drivers are also sold along with DT30 and DT25 scanners as well. Basically, if the amplifier looks like the one below, it's similar enough that the modifications described below should work.



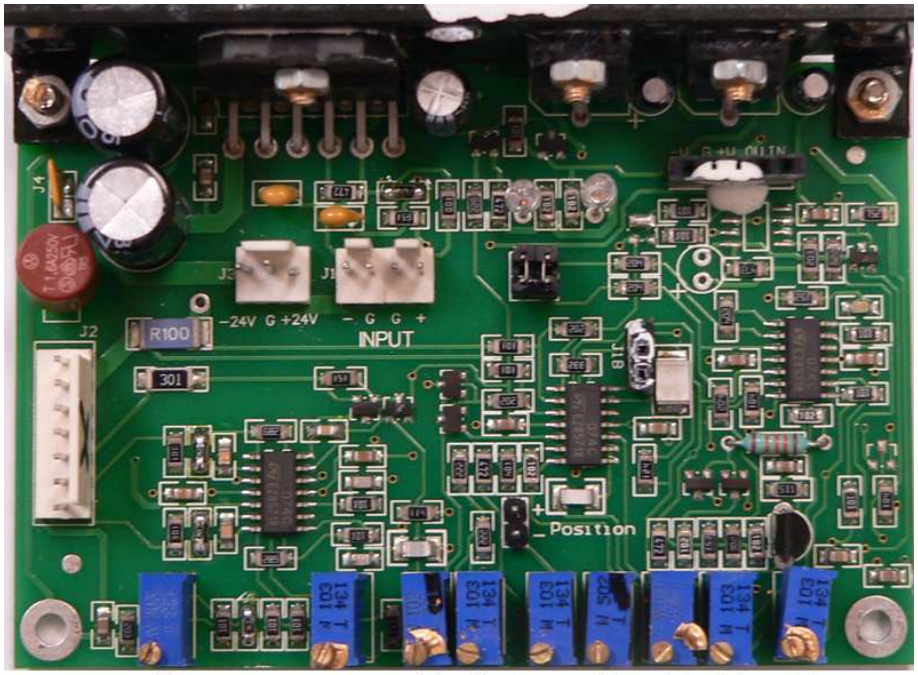
Since the notch filter is removed, it must be bypassed by soldering across the input/output pins.



Another version of the DT40 Driver

Below you will see a slightly different version of the DT40 driver. The layout of components in the upper-right area is somewhat different. These are components for the coil temperature calculator, which may or may not be populated, depending on the model and vintage. No component changes are needed in this area for the Compact 506, so they are not mentioned.

The most striking difference is the additional “Bandwidth” control, in between the Low Frequency Damping and High Frequency Damping potentiometers. Tuning this particular potentiometer is not easy without special equipment or techniques, and therefore we’d recommend you leave this particular potentiometer alone while re-tuning the amp.

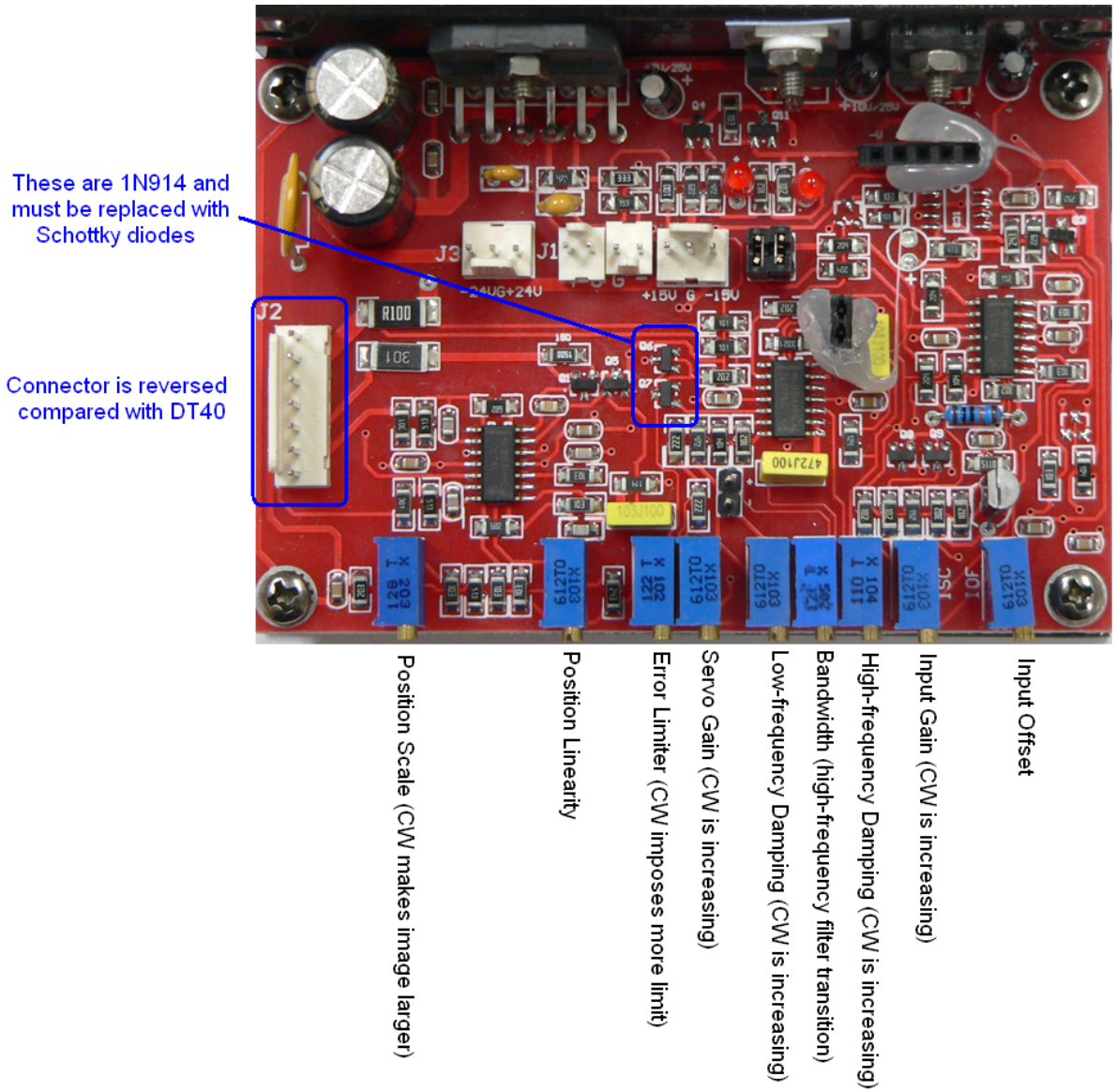


Some modifications are optional

In the case of all DT40 drivers, including the “red board version” described below, the most important component changes consist of position-sensor-related components located toward the left/bottom of the board. Specifically, the two 75K and 36K paralleled over existing resistors (or changing them to two 30K and one 20K respectively). Once this small modification is made, and the notch filter is bypassed, the DT40 driver can be used with the Compact 506 without further modifications. The other component changes described on the previous page provide only marginal benefit and are thus, deemed optional.

“Red Board version”

Below you will see a picture of a driver very similar to DT40, but made by another company. The components used, component values, and component placement are almost identical to the DT40 driver, and thus, the modifications needed are also very similar. The main difference is that the scanner connector (J2) is reversed (rotated) when compared with the normal DT40, which means that pins 1 through 7 are arranged as 7 through 1.



The company that makes this “red board version” populates D6 and D7 with normal small-signal diodes (such as 1N914) instead of the Schottky diodes that the normal DT40 driver uses. This limits its performance to around 30K with Chinese scanners.

In addition to all of the other DT-40 modifications described above, which are entirely necessary for use with the Compact 506, better performance can be had from the “red board version” by changing D6 and D7 to Schottky type, such as Rohm part number RB400D, available from Digikey and other similar electronics suppliers.

Once the DT40 driver is modified, you can start with the Position Scale control turned all the way clockwise (all the way counter-clockwise on the “red board version”), and Input Gain control turned all the way counter-clockwise (all the way clockwise on the “red board version”). This setting of the controls will allow the Compact 506 to run at around 48 degrees optical with +/- 10V differential input. Turning the Position Scale control counter-clockwise will increase the maximum projected angle. Pangolin’s mirror sets will typically handle up to 60 degree optical in all directions. (Note that turning this also affects scanner tuning, so adjustment of this should be done early in the tuning process.)

Servo Gain, Low-frequency Damping and High-frequency Damping behave as they do with conventional galvos, with the difference being that the DT40 potentiometers **appear** to be wired backwards. The reality is that the layout was actually made for front-facing potentiometers, not top-facing potentiometers and, interestingly enough, the sense (i.e. polarity) of top-facing potentiometers is reversed when compared to front-facing potentiometers. However, since the potentiometers on the “red board version” are front-facing, these behave in a more normal fashion, where clockwise is “increasing” various parameter.

To adjust Position Linearity, you can project a grid pattern and adjust the Position Linearity control so that the blocks in the upper portion of the grid are the same size as the blocks at the lower portion. Alternatively you can monitor the AC Millivolts at the point shown above in red.

The Error Limiter adjustment is to provide control over large squarewave performance. To adjust this, you should input a relatively large (75% or so) squarewave and turn this clockwise until overshoot is seen. Then turn it counter-clockwise (or clockwise on the “red board version”) until overshoots are largely or completely eliminated.

Scan speeds in excess of ILDA 50K can be achieved with the Compact 506 and DT40 drivers. Tuning can drive the scanner to more than 60K without running out of servo gain or damping. The thing preventing this system from going 60K or more is a dichotomy between small-signal and large-signal performance. More modifications to the amplifier are needed to accomplish 60K+ performance.

Cables used with normal DT40 and “red board version” servo drivers

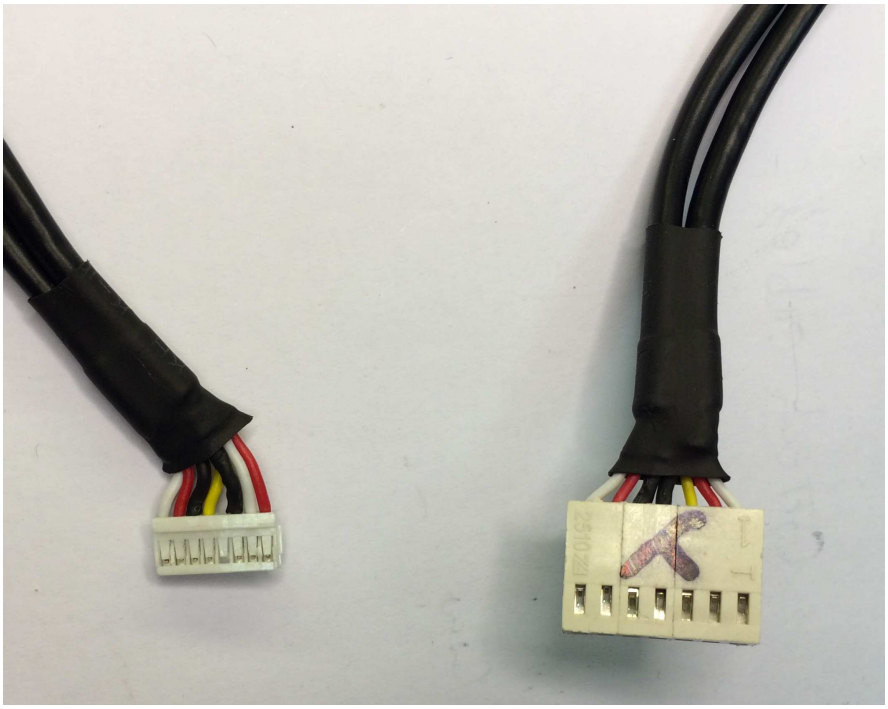
Since the connector on the Compact 506 is different from that on the DT40 and other Chinese scanners, the scanner-end connector of the cable must be replaced. Moreover, since the Compact 506 connector has 8 pins but normal DT40 and “red board version” (CLP) cables have only 7 pins, an additional connection is needed – either at the Compact 506 connector, or on the Compact 506 scanner itself. Below is a table showing the pin numbers, colors, and to which pin connections must be made on the Compact 506.

DT40 pin	“red board” pin	Color	Signal name	Compact 506 pin
1	7	White	Position “B”	2
2	6	Red	Position ”A”	1
3	5	Yellow	LED output	5
4	4	Black (braid)	Position “common”	3 and 4
5	3	Black (braid)	Ground/Shield	6
6	2	Red	Galvo Low	7
7	1	White	Galvo High	8

Note that there are two separate cables that have red and white wires. It is important to get the right wire connected to the right pin. The cables are separated by function, with the motor signals on one cable and position signals on the other. The groups of signals are separated in the table above. Also note that the J2 connector used on the “red board version” drivers is rotated 180 degrees compared with that of the normal DT40 servo driver. This leads to the pin numbers being different on each driver.

A picture of the modified DT40 cable is below.

Compact 506 Connector Shell is TE Connectivity part number: 353908-8
Compact 506 Connector Pins are TE Connectivity part number: 353907-1

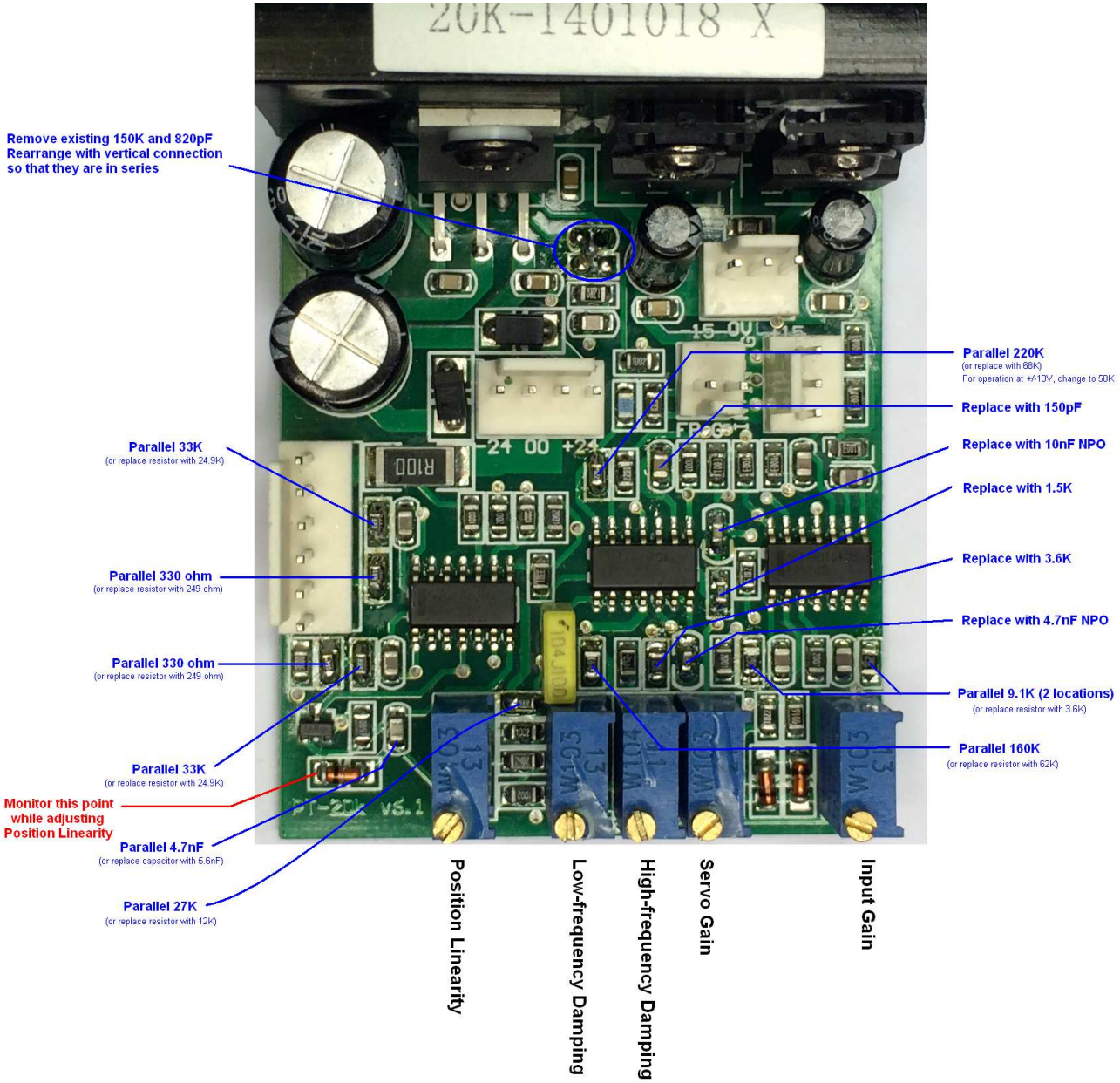


As discussed above, there are fewer than 8 wires on the normal DT40 and “red board version” cables, but the Compact 506 needs all 8 connections in order to operate properly. Therefore an additional wire may be added at the connector end, or alternatively you could simply solder a bridge over pins 3 and 4 on the Compact 506 scanner itself, as shown below.



Modifying the Phenix Technologies PT20 drivers

Below you can see a picture that details the changes needed for PT20 drivers. As with the DT40, there are a variety of scanners by a variety of names being sold with drivers that look like this. Basically, if the amplifier looks like the one below, then the suggested modifications should work.



Once the PT20 driver is modified, Servo Gain, Low-frequency Damping and High-frequency Damping can be adjusted as they are on conventional galvos.

To adjust Position Linearity, you can project a grid pattern and adjust the Position Linearity control so that the blocks in the upper portion of the grid are the same size as the blocks at the lower portion. Alternatively you can monitor the AC Millivolts at the point shown above in red.

Scan speeds in excess of 30K can be achieved with the Compact 506 and PT20 drivers, even when using +/-18V power supplies. Large signal performance is also quite good, even though these drivers only have a 20W power amplifier stage.

Cables for PT20s

Since the connector on the Compact 506 is different from that on the PT20, it means that the connector must be replaced. Moreover, since the Compact 506 connector has 8 pins but PT-20 has only 6, additional changes are needed – either at the Compact 506 connector, or on the scanner itself.

PT20 pin	Color	Signal name	Compact 506 pin
1	White	Galvo High	7
2	Red	Galvo Low	8
3	Black (braid)	Ground/Shield	3, 4, and 6
4	White	LED output	5
5	Red	Position “A”	1
6	Yellow	Position “B”	2

Note that there are two separate cables that have red and white wires. It is important to get the right wire connected to the right pin. The cables are separated by function, with the motor signals on one cable and position signals on the other. The groups of signals are separated in the table above.

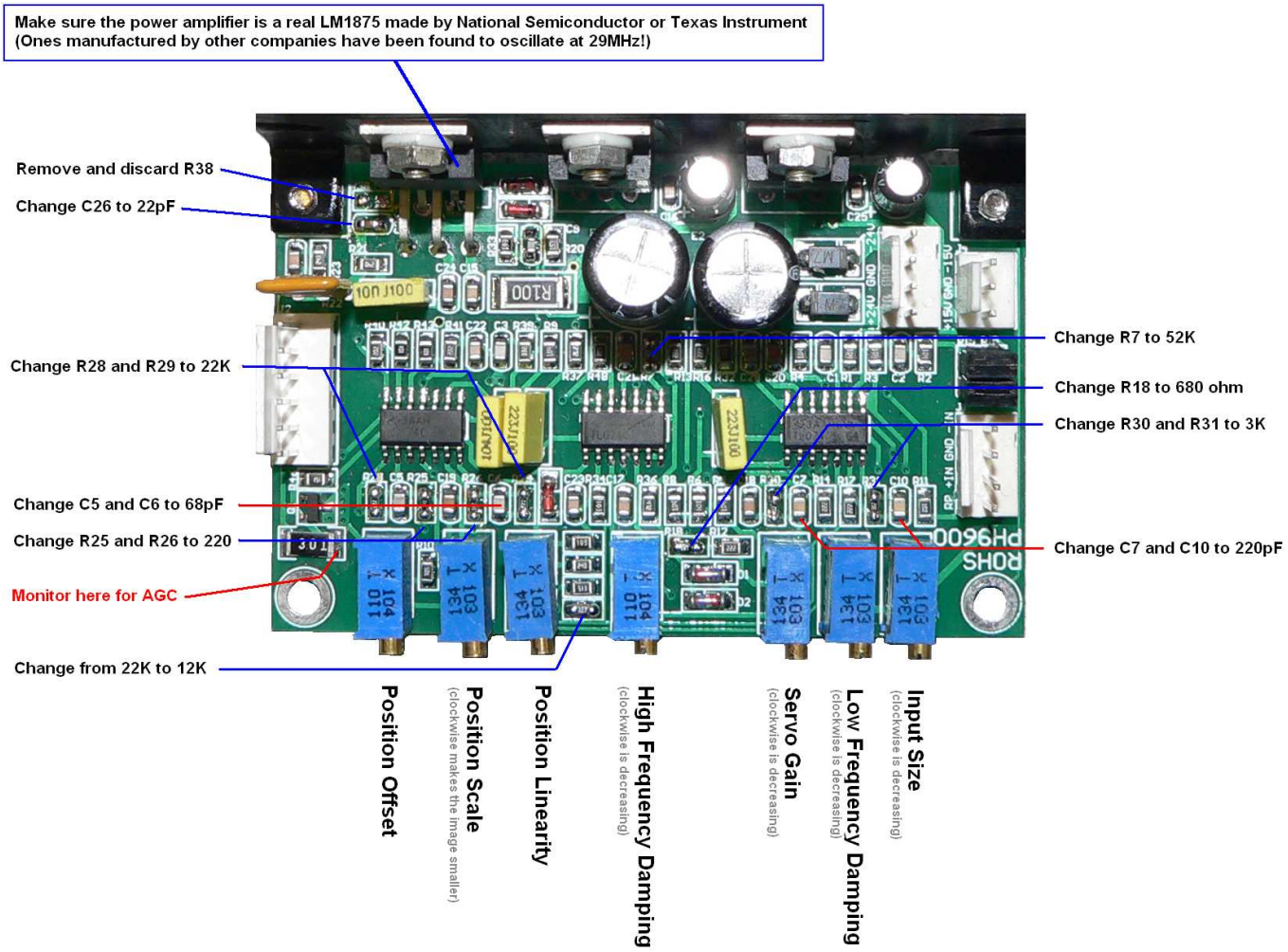
A picture of the modified cable is below.

Compact 506 Connector Shell is TE Connectivity part number: 353908-8
Compact 506 Connector Pins are TE Connectivity part number: 353907-1



Modifying the PH9600 driver

Below you can see a picture that details the changes needed for PH9600 driver. As with the DT40, there are a variety of scanners by a variety of names being sold with drivers that look like this. Basically, if the amplifier looks like the one below, then the suggested modifications should work.



Once the PH9600 driver is modified, Servo Gain, Low-frequency Damping and High-frequency Damping can be adjusted as they are on conventional galvos.

IMPORTANT NOTE: The Input Size, Servo Gain, Low Frequency Damping, and High Frequency Damping controls all behave as though they are wired backwards. On these controls, clockwise motion is decreasing and counter-clockwise motion is increasing.

To adjust Position Linearity, you can project a grid pattern and adjust the Position Linearity control so that the blocks in the upper (or leftward) portion of the grid are the same size as the blocks at the lower (or rightward) portion. Alternatively you can monitor the AC Millivolts at the point shown above in red (right side of the 300 ohm resistor).

Scan speeds in excess of 30K can be achieved with the Compact 506 and PH9600 drivers, even when using +/-18V power supplies. Large signal performance is also quite good, even though these drivers only have a 20W power amplifier stage.

Cables for PH9600

Since the connector on the Compact 506 is different from the one supplied with the PH9600 driver, it means that the connector must be replaced. Moreover, since the Compact 506 connector has 8 pins but PTH9600 driver has only 6 pins, additional changes are needed – either at the Compact 506 connector, or on the scanner itself.

PH9600 pin	Color	Signal name	Compact 506 pin
1	Red	Galvo High	7
2	White	Galvo Low	8
3	Black (braid)	Ground/Shield	3, 4, and 6
4	Black (briad)	LED output	5
5	White	Position “A”	1
6	Red	Position “B”	2

Note that there are two separate cables that have red and white wires. It is important to get the right wire connected to the right pin. The cables are separated by function, with the motor signals on one cable and position signals on the other. The groups of signals are separated in the table above.

A picture of the modified cable is below.

Compact 506 Connector Shell is TE Connectivity part number: 353908-8
Compact 506 Connector Pins are TE Connectivity part number: 353907-1



Possible scanner modification needed for drivers mentioned above

As discussed above, there are fewer than 8 wires on the PT20 and PH9600 cable, but the Compact 506 needs all 8 in order to operate properly. Therefore additional wires may be added at the connector end, or alternatively you could simply solder a bridge over **three pins** on the Compact 506 scanner itself, as shown below.

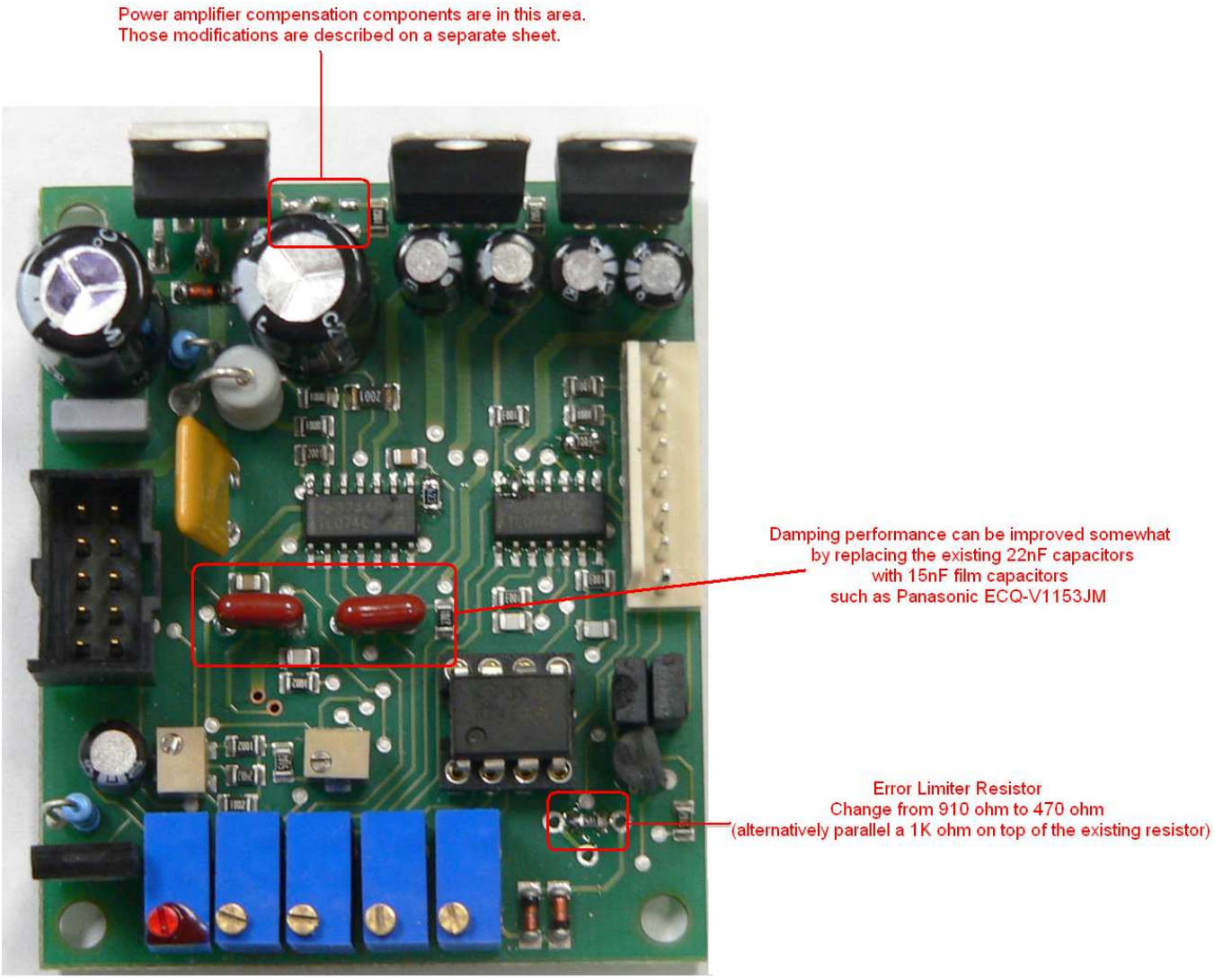


Modifying the MediaLas Micro Amp (CT6210 version)

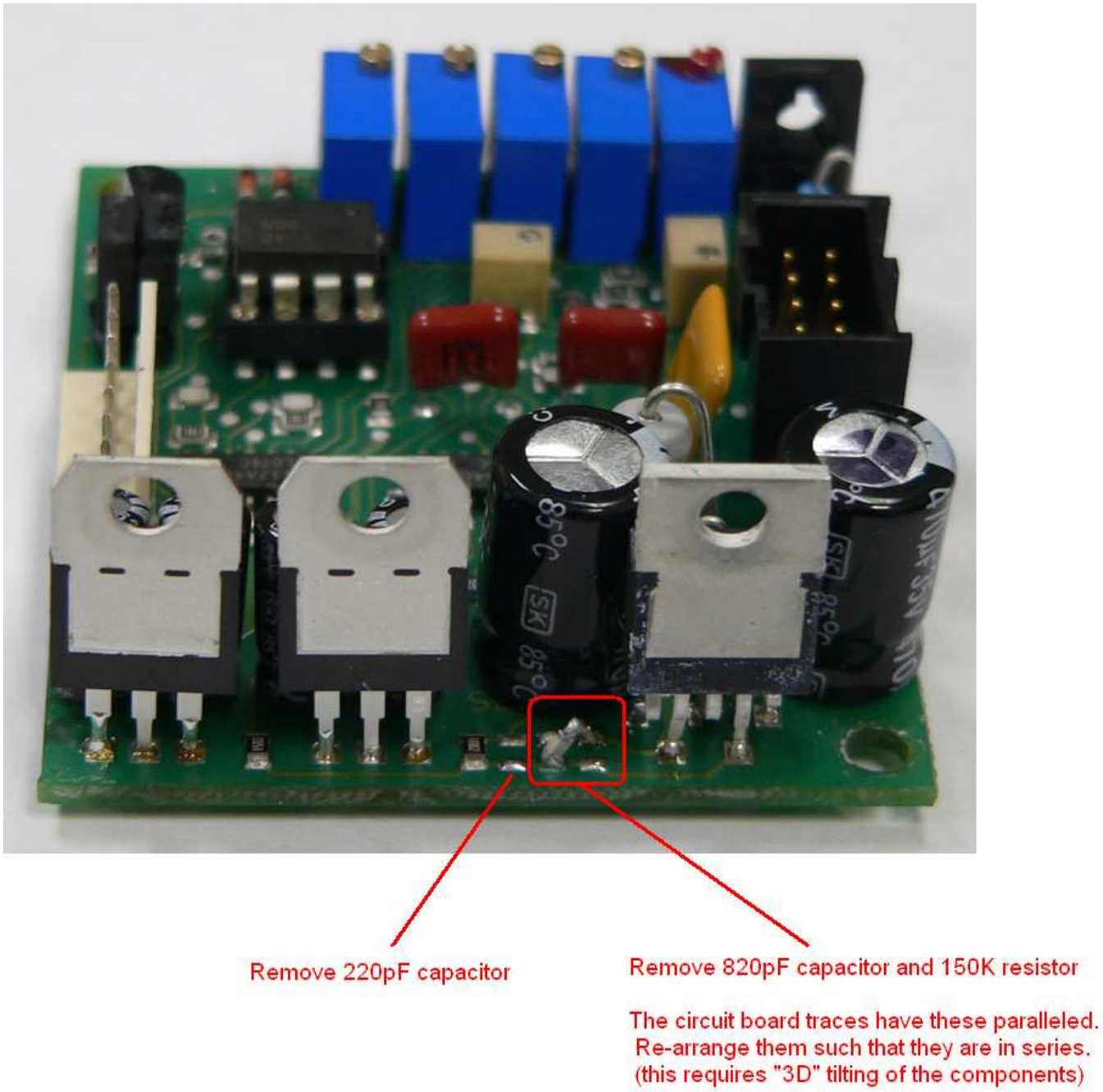
There are two different versions of the MediaLas Micro Amp: one for the original Cambridge model 6800, and another for the Cambridge model 6210. We have only tested the version for the CT6210 which we believe is more common these days anyway.

Below you can see a picture that details the changes needed for MediaLas Micro Amp.

This picture shows the top-view of the amplifier. Here the main change is the error limiter resistor, whose preferred value changes from 910 ohms to 470 ohms.



Below you see a picture from the rear of the board. This view better shows the component changes needed to the power amplifier compensation circuit.



Overall the changes are pretty minor. By merely removing a capacitor in the power amp section and re-arranging another capacitor and resistor, and by changing a resistor in the error limiter, the MediaLas Micro Amp can be used immediately with the Compact 506. Somewhat better damping performance can be obtained by changing two more capacitors, but the improvement is relatively minor and many users will not notice much of a difference.

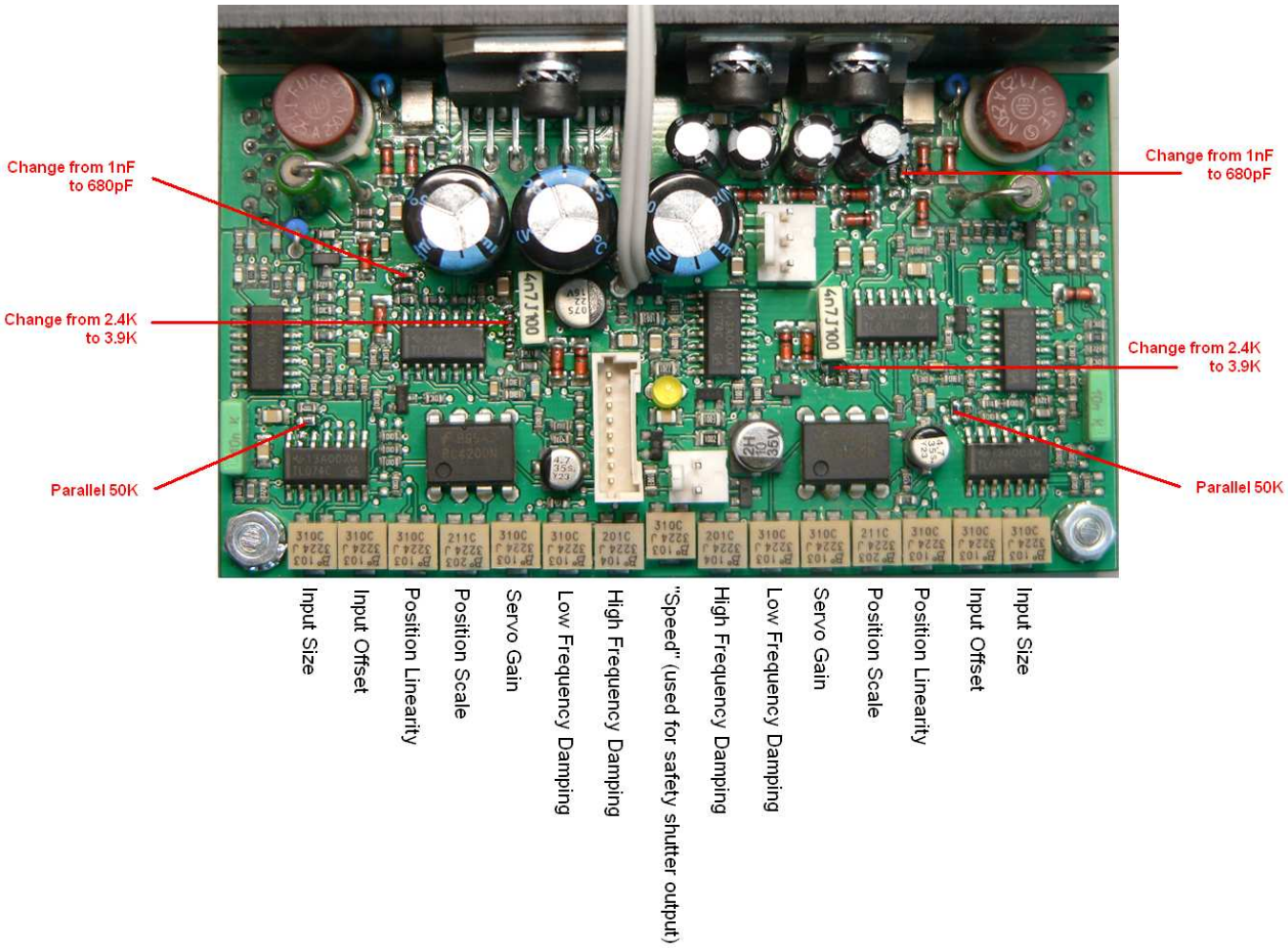
Once modified, the Compact 506 will deliver a solid 30K performance with the Micro Amp, and provide very good large-signal performance. The modified amplifier can be tuned faster – to around 40K, with some minimal degradation in small-signal to large-signal transitional performance.

Modifying the HB Super Apollo Micro Amp (CT6210 version)

There are two different versions of the Super Apollo Micro Amp: one for the original Cambridge model 6800, and another for the Cambridge model 6210. We have only tested the version for the CT6210 which we believe is more common these days anyway.

Below you can see a picture that details the changes needed for HB Super Apollo Micro Amp.

This picture shows the top-view of the amplifier as no component changes are needed to the bottom side. The changes are made to the power amplifier compensation, high frequency damping rolloff, and summing amplifier overall gain.



As with the MediaLas Micro Amp, overall the changes are pretty minor. Actually the HB Super Apollo Micro Amp can be used with the Compact 506 without changes, but overshoots will be seen at certain angles. By performing the modifications prescribed above, better performance can be obtained.

Once modified, the Compact 506 will deliver more than 30K performance with the HB Super Apollo Micro Amp, even with large mirrors, and provide very good large-signal performance.

Modifying other servo driver amplifiers

In addition to the servo drivers mentioned above, Pangolin has also performed modifications on many other drivers and amplifiers to work with the Compact 506. Please contact Pangolin if you would like information on other servo drivers, or to arrange for Pangolin to derive optimal component values for your servo driver.

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