Radio Installation Guide
For Turbine Powered Model Aircraft

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Section 1
Introduction

Gas turbine propulsion systems have provided many positive contributions to our hobby such as increased thrust capability, reliability and scaleness of sound. However, turbine installations also introduce complex issues that make an interference free radio link much more difficult to achieve. Turbine installation components include microprocessors, oscillators and electrical fuel pump motors each of which have the potential to emanate radio interference that can disrupt the radio link controlling the aircraft. Additionally, turbine powered airframes have numerous metal parts and are constructed with conductive materials, such as carbon fiber, all of which can further interfere with radio signals. This guide will present a number of precautions and common sense procedures that will help ensure a solid radio link between the pilot's transmitter and the aircraft's receiver thereby mitigating the potential for radio interference.

Section 2
Component Placement Within The Aircraft

Most all of the electronic components that are available today from the leading turbine manufacturers have been engineered to have a very low RF signature. Experience has taught that, while interference from on-board electronics has become a far less frequent issue than in the past, the on-board components can sometimes still cause disruptions in the model's radio link. Therefore, it is important to segregate the radio receiver system from the turbine's electronics to the greatest possible extent. The turbine's ECU, fuel pump and all other electronics should be physically located as far from the receiver and antenna as is possible. All servo wires should be routed as far from the turbine components as is possible and all turbine component wires as far from the receiver components as is possible. Try to avoid stacking the receiver and turbine batteries atop or immediately adjacent to each other. While most of the manufacturers have implemented noise suppression equipment on their electronics the modeler should ensure that all on-board fuel, smoke oil and hydraulic pumps have noise suppression caps installed and, if not, install them.

Section 3
Antenna Routing

The receiver antenna should be routed as far as possible from the turbine's electronics, all metal parts and all carbon fiber parts. Many times, it is necessary to extend the antenna on the outside of the aircraft or down the inside of the leading edge of a wing to ensure that the antenna is not installed adjacent to these other components. Ideally, the antenna should be extended 90 degrees from the axis of the airframe such that it is not shielded by any structure and is located at a maximum possible distance from the turbine's electronic components. For this reason, externally mounted whip antennas have become widely used by many turbine modelers. These external whip antennas are available in two configurations; full length and base loaded mini whip. The full length external whip antennas maintain the stock antenna's length with the last 20 to 30 inches being made of thin gauge piano wire that extends external to the model. Whereas, the base loaded mini whip antennas extend approximately 8 inches externally. Both the full length and the base loaded mini whip antennas have been used successfully for several years in turbine powered aircraft. While there will be some loss of intrinsic signal strength in the base loaded mini antennas, the increased radio reception afforded by extending the antenna externally from the aircraft dramatically overwhelms the decrease in intrinsic signal strength.

Section 4
Receiver and Servo Battery Requirements

There are three primary battery attributes to consider when selecting a battery for supplying power to the receiver and servo components: capacity, impedance and the maximum continuous discharge current. Individual battery product specifications may be obtained from the battery manufacturer's spec sheets. As an example; Sanyo battery information may be found at: http://www.sanyo.com/batteries/specs.cfm and Gold Peak battery information may be found at: http://www.gpbatteries.com/.

Capacity: The battery should have ample capacity to sustain several flights with a generous amount of reserve capacity. The amount of capacity that is needed will change according to the weight of the aircraft, its speed, the number of flight surfaces and the type of servo equipment (digital, etc.) that is used. As an example, AMA document 520-A specifies that for Experimental Turbine aircraft (with a takeoff weight in excess of 55 pounds): "*The battery supplying flight control servo power shall have a minimum size of 1000 mah + 250 mah per flight control servo.*"

Generally speaking, battery capacities between 1700 mah and 4000 mah are commonly employed in turbine powered model jet aircraft. Battery capacities in the lower end of this range are adequate for lighter, slower aircraft that do not utilize digital or other high current drawing servos. On the other hand, aircraft that are heavier and/or faster with many flight surfaces and that use high current drawing servos should have battery capacities closer to the higher end of this range.

Impedance: Battery impedance is a measure of the internal resistance of the battery cell. A battery will demonstrate a voltage drop as a function of current according to the equation, V=IR. It is obviously very important that low impedance batteries be used in applications with high discharge current loads such as heavier airplanes with many flight surfaces. Otherwise, significant voltage fluctuations will occur with variations in current. Ideally, the on-board battery pack voltage to the receiver and servos should not drop more than .2 volts at maximum current.

Example: Using the equation, V=IR, for a 5 cell pack:

Voltage drop = .2 volts = (Max Current) X (5 Cells) X (Impedance per cell) or;

Impedance per cell = (.2 Volts) / ((Max Current) X (5 Cells)) = .04 / (Max Current)

Therefore, for a maximum current of 2 amps the impedance per cell should be less than ((.04) / (2 amps)) = 20 mΩ in order for the voltage drop to be less than .2 volts. Likewise, a maximum current of 4 amps would require the impedance per cell to be less than 10 mΩ, etc.

Maximum Continuous Discharge Current: The maximum continuous discharge current is the highest current that can be drawn continuously from a battery pack. The modeler must be careful to ensure that the batteries used in turbine aircraft have the capability to deliver adequate amperage current for each specific installation.

Battery Types: There are four types of battery chemistry to choose from: Nickel Cadmium (NiCd), Nickel Metal Hydryde (NiMH), Lithium Ion (Li-Ion) and Lithium Pomer (Li-Po). The following chart depicts a general comparison of these battery types:

Battery Chemistry	***Primary Advantages***	***Primary Disadvantages***
NiCd	Most proven technology compared to all other types having been used for over 20 years.	The energy density is inferior to all other battery types.
NiMH	The energy density is superior to NiCd. Low internal resistance is superior to Li-Ion/Li-Po and comparable to NiCds. High continuous discharge current capability is superior to Li-Ion/Li-Po and comparable to NiCds.	The energy density is inferior to Li-Ion or Li-Po.
Li-Ion	The energy density is superior to NiCd and NiMH. Available off-the-shelf in redundant parallel configurations.	High internal resistance. Maximum continuous discharge current is inferior to NiCd and NiMH. Highly flammable if shorted or charged improperly.
Li-Po	The energy density is superior to NiCd and NiMH.	High internal resistance. Maximum continuous discharge current is inferior to NiCd and NiMH. Highly flammable if shorted or charged improperly. Soft Packaging.

Footnote: Energy density is the capacity/weight ratio of the battery. As an example, a 2000 mah battery that weighs 10 ounces will have a energy density of 200 mah/ounce. A high ratio is superior to a low ratio since a higher ratio means that more battery capacity is provided per ounce of installed weight.

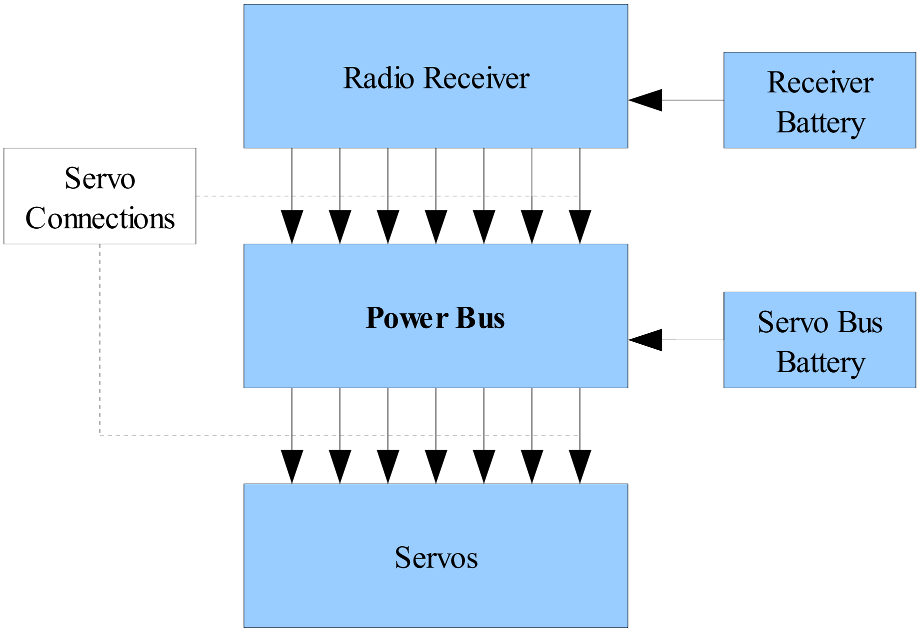
Parallel Battery Configurations: Batteries are installed in parallel for three reasons; increased capacity, redundancy and reduced current draw per battery cell. Reducing current obviously helps a battery avoid its maximum continuous discharge current limit specs and has the benefit of reducing the voltage drop due to internal resistance. As an example, Li-Ion and Li-Po batteries are very desirable due to their very high energy density and their two primary disadvantages, high internal resistance and maximum continuous discharge current specs, can be addressed by configuring the batteries in parallel. Thus, parallel Li-Ion and Li-Po configurations have become a very successful battery option for a number of applications in the RC hobby over the last few years.

Battery Voltage Regulators: Virtually all model airplane radio receivers and servos are designed for a 4.8V to 6.0V battery source and perform best when the battery source provides a constant voltage regardless of the battery's internal impedance or current. Battery voltage regulators provide this capability. Voltage regulators are typically used with 5 cell 6V NiCd, 5 cell 6V NiMH, 2 cell 7.4V Li-Ion or 2-cell 7.4V Li-Po to provide a constant 5.0V to 6.0V source to the model's receiver and servos. Battery regulators are generally not necessary for low impedance NiCd/NiMH batteries in low current installations. When selecting a regulator you should ensure that its maximum current load is significantly larger than the maximum current draw of your installation.

Power Buses:

Power buses provide the capability to supply your receiver and servos from separate battery sources as depicted below.

Typical Power Bus Configuration



The primary advantages of a power bus are as follows:

- Constant Receiver battery voltage since the receiver is the only device powered by the Receiver battery.
- The servos do not draw current through the receiver so concerns are eliminated regarding the maximum current that would otherwise flow through the receiver to the servos. In essence, the maximum current that the servos can draw is limited only by the gauge of wire used in the power bus and servos.

The receiver battery will typically be a small unregulated 4 cell 4.8V NiCd or NiMH battery with a 500 mah to 700 mah capacity. Whereas, the servos are typically powered by a 3000 to 4000 mah 5 cell 6.0V NiCd or NiMH battery pack which may or may not be regulated. Many modelers are also using redundant parallel 2 cell 7.4V Li-Ion packs (4 cells total) which are regulated to a voltage between 5V and 6V.

Another advantage of most power bus products is RF filtering on the servo connections. Some power buses optically isolate all of the servo connections from the receiver thereby eliminating interference that would otherwise travel down the servo wires to the receiver.

Section 5
Receiver and Servo Wiring Considerations

All battery and servo wiring should be heavy gauge (22 awg) and, in high current applications such as in heavier aircraft, the battery wire should be an even heavier gauge wire (16-18 awg). The stock Airtronics/JR/Futaba connectors work well, however, a keeper of some type is recommended to secure the connectors. Some pilots use the Deans 3-pin connectors instead of the stock connectors because of their high friction connection points which do not need any type of keeper.

All lengthy runs of wire should be twisted and/or looped through ferrite beads at the receiver end of the wire to suppress RF interference. Twisted wire and/or ferrite beads should also be considered for wire connecting the receiver to other electronic equipment such as ECUs, gear cyclers, etc. However, twisted wire and ferrite beads are not needed when using an optically isolated power bus since the bus's optical isolation feature eliminates the potential for RF interference to propagate to the receiver from the servo wiring.

Section 6
Range Testing

Range testing is the final validation of a good radio installation. Most radio manufacturers publish rule of thumb guideline distances for a good range check which is typically performed with the antenna collapsed or removed. For example, range checks are performed with JR 10X equipment with the antenna removed and the general rule of thumb is that the radio link should be solid at a minimum of 100'. However, it is not uncommon to sustain a solid radio link with the JR 10X antenna removed in excess of 300' with in ideal installation where all of the precautions are taken as described in this document. Nevertheless, it is sometimes not practical to achieve an ideal installation. Many times the airframe just will not accommodate the complete segregation of the receiver and turbine electronic systems and range testing may reveal a degraded radio link as a result of on-board interference. When this occurs the following steps are recommended to mitigate the source of the on-board interference:

- Endeavor to isolate the offending component and then relocate that component. If the offending component is connected directly to the receiver, such as with an electronic gear sequencer or a turbine ECU, then use a twisted servo lead and/or put a ferrite bead on the component lead where it plugs into the receiver.
- Try a different radio frequency (channel). It is possible that the interference is isolated to a certain frequency or frequency range and that the problem can be solved by moving away from those frequencies.
- If you are using a single conversion receiver then try a dual conversion receiver instead and vice versa.

Section 7

Failsafe Setup

The AMA turbine regulations now require that turbine ECUs be programmed to shut the turbine down on a radio failsafe condition that lasts 2 seconds or longer. The procedure for setting the failsafe up differs somewhat between turbine manufacturers, however, the basic concept is similar for all brands. Refer to your turbine ECU instructions for the correct method for programming the automatic shutdown of your turbine upon encountering a failsafe condition. Each installation should be tested to ensure that the turbine will be properly shutdown. Most ECU brands tabulate the total number of failsafe conditions that are encountered during each run of the ECU so the easiest way to test the failsafe setup is to simply turn the transmitter off and then back on after powering up the ECU and then check the ECUs fail safe count to confirm that the count was incremented by 1 for each time that the transmitter was turned off and then back on. For example, the JetCat ECUs failsafe count information may be viewed from the GSU's *RC Menu* which can be accessed with the *Select Menu* Button on the JetCat GSU. Once the failsafe count is confirmed then the delayed shutdown on failsafe should also be tested to confirm the 2 second (approximate) time frame. This is accomplished by simply starting up the turbine and then turning the transmitter off while measuring the time that elapses after the radio is powered off until the turbine shuts down.

The pilot should monitor whether any brief (less than 2 secs) failsafe conditions occur during flight by checking the failsafe count information following each flight. If failsafe conditions are found to have occurred in flight, brief as they may have been, then the cause of the failsafe conditions should be identified and eliminated prior to subsequent flights. Also, the radio may be programmed to create a change in the aircrafts configuration upon encountering a failsafe condition which serves to notify the pilot. For example, a plane's retractable landing gear may be programmed to extend out to their landing configuration upon encountering a radio failsafe condition. Therefore, the pilot would be notified that a fail safe condition had just been encountered if he ever observes the landing gear unexpectedly extending during flight. The pilot should always immediately land the aircraft whenever there is the slightest reason to believe that a failsafe condition may have occurred.

Section 8
Radio Equipment Maintenance

Radio receiver and transmitter module electronics are subject to frequency drift over time. Therefore, a good rule of thumb is to send your transmitter and receiver modules back to the manufacturer or an authorized service center every two years to have them re-tuned. Range checks should also be frequently conducted on all aircraft. While it is very important to range check an aircraft prior to its first flight, it is equally important to continue to conduct range checks for as long as the aircraft is flown. The receiver and/or transmitter module should be serviced by an authorized service center whenever an unexplained reduction in range is observed.

The current draw of all aircraft radio installations should be measured periodically to ensure that no servos are approaching a stall condition and to verify that no other excess current anomalies exist. Multimeter Adapters and stand alone devices are available from several RC specialty companies that may be used to measure the current draw of an aircraft's radio installation. Current draw measurements should be made for each servo component in an installation prior to the first flight and then the entire installation should be measured periodically thereafter. It is not uncommon for medium sized turbine radio installations to have a total current draw in excess of .5 amps @ 4.8 Volts with all of the servos at idle. Installations with a large number of servos can draw up to an 1 amp at idle and should therefore be evaluated to ensure that the maximum current draw in flight will never exceed the maximum allowed current specifications for the individual components (receiver, battery, regulator, etc.)

NiCd and NiMH batteries should be cycled once every 90 days to confirm their capacity. NiCd and NiMH batteries may generally be expected to last 2 to 3 years past their manufacturing date. However, their life expectancy can vary greatly for a variety of reasons so it is very important to cycle these batteries on a regular schedule. When a battery is found to have reduced capacity then its full capacity can sometimes be recovered by cycling the battery again. Batteries that demonstrate reduced capacity during two or more subsequent cycling procedures should be promptly replaced and properly disposed of.

Li-Ion and Li-Po batteries should never be cycled since these types of batteries may be irreversibly harmed when completely discharged. The internal resistance of Li-Ion and Li-Po batteries increases over time and, due to this increase, a good rule of thumb is to replace and properly dispose of these types of batteries after approximately 2 years of use. Li-Ion and Li-Po batteries can be extremely dangerous when shorted, overcharged or subjected to excessive discharge currents so it is of utmost importance that extreme care be taken when handling and using these types of batteries.

Section 9
Spectrum Analyzers, Scanners And Other Monitoring Equipment

Monitoring equipment can be used to measure RF interference sources in the 72 Mhz band both within an aircraft installation and around the general vicinity of a flying site. Various products are available ranging from very expensive spectrum analyzers down to low cost hand held scanners. All of these products offer varying degrees of sensitivity and accuracy.

Recently, the Yaesu VR-5000 communications receiver has been successfully used by a number of jet modelers and it has become generally accepted as an excellent tool for measuring RF interference though out the RC hobby. This device is ideal for examining the 72Mhz band and offers many features found in spectrum analyzers yet it is superior for our RC applications since it is much more sensitive than typical spectrum analyzers and will also do channel scans similar to communications receivers and scanners. This device is also superior to most other scanners since it will do a band scan that displays an entire frequency range (such as from 72Mhz to 73Mhz) on a x-y graphical display similar to a spectrum analyzer's display. It has excellent resolution so that RF signals that exist in between the RC bands, such as pager repeaters, may also be monitored in 5Khz and 10Khz increments.

Rudimentary Explanation of How RC Receivers Work

There are two popular types of receivers in use, single conversion and dual conversion. All receivers actually transmit a radio signal, called an “image signal” for the purpose of processing the incoming signal from the transmitter. Single conversion receivers transmit an image signal that is offset 455 kHz above the transmitter’s signal while dual conversion receivers transmit an image signal that is offset 10.700 MHz below the transmitter’s signal. In other words, the crystals for your receivers are not actually oscillating at the transmitter’s frequency printed on them but are oscillating at the receiver’s image frequency. The receiver essentially combines this image frequency with the transmitter’s signal to produce a resulting signal that is 455 kHz for single conversion receivers and 10.7 MHz for dual conversion signals. In dual conversion receivers, the 10.7 MHz signal is then converted electronically to 455 kHz, hence the “dual conversion” nomenclature. In other words, regardless of what transmitter frequency that you are operating on, all receivers eventually convert the signal to 455 kHz. The primary reason that the receivers are designed this way is so that the receivers can be tuned to various transmitter frequencies and yet all have a standard internal operating frequency.

As an example, RC transmitter channel 21 transmits on 72.210 MHz. The single conversion receiver image signal is 72.665 MHz and when mixed with the 72.210 transmitter signal yields an internal frequency of 455 kHz. The dual conversion image signal is 61.510 MHz and when mixed with the 71.210 transmitter signal yields an internal frequency of 10.7 MHz which is then converted electronically to an internal frequency of 455 kHz.

As an experiment, monitor your airplane installations for the image signal being transmitted by your RC receivers with a Yaesu VR-5000 or equivalent device. You can readily detect these signals 455 kHz above the transmitter's frequency on single conversion receivers and 10.7 MHz below the transmitter's frequency for dual conversion receivers.

Frequencies To Monitor for Interference

Obviously, the primary frequency to monitor is the transmitter's frequency. However, interference emanated on the image signal's frequency, can also cause radio communication failures, especially with single conversion receivers. Single conversion receiver installations should be monitored for interference both at 455 kHz above and 455 kHz below the transmitter's signal. The installation should be monitored both above and below the transmitter's frequency since interference on either side of the transmitter's frequency can potentially produce a bogus 455 kHz signal. In other words, in the above channel 21 example, if you were running a single conversion receiver, you should check your installation for interference on the transmitter's frequency of 72.210 MHz as well as ± 455 kHz or at 72.665 MHz and 71.755 MHz.

If you want to be ultraconservative, then you would also check the single conversion receiver's first harmonic 910 kHz above and below the transmitter's frequency as well. Also, if you are running a dual conversion receiver and endeavored to take an ultraconservative approach, then you should also monitor ± 10.7 MHz or at 82.910 MHz and 61.510 Mhz.

As a point of caution, pager repeaters and other radio devices are licensed by the FCC to operate within the 72 MHz band exactly halfway between our RC channels with a 10 kHz separation and which creates the potential for interference with all types of RC aircraft equipment. Therefore, when monitoring a flying site for interference with a Yaesu VR-5000 or equivalent device it is recommended that the resolution of the device be set to 10 kHz or less so that the entire 72 Mhz band is monitored in 10 MHz increments or smaller such that any licensed operators will be detected.

Section 10

Single Conversion Versus Dual Conversion Receivers

Theoretically, dual conversion receivers are more capable of filtering out a large portion of any potential image frequency interference with their front end tuning and first amplifier stage. Single conversion receivers are also more susceptible to interference in the 72 Mhz band than dual conversion receivers since the single conversion image frequency is also located within the 72 Mhz frequency band while the dual conversion image frequency is displaced 10.7 Mhz away from the 72 Mhz band.

On the other hand, proponents of single conversion technology will argue that dual conversion receivers can be more susceptible to interference due to complexity since the incoming signal is processed in two stages both of which have the potential to encounter interference. Whereas, single conversion receivers are only processed through one stage. However, dual conversion proponents will then argue that the second conversion stage in a dual conversion receiver which converts the 10.7 Mhz signal to 455 kHz is electronic and so it is theoretically immune from RF interference.

Another potential issue with single conversion receivers relates to transmitter channel separation. That is, since the RC channels are separated by 20 kHz then any two transmitters that are operated simultaneously 22 or 23 channels apart will create potential interference for all single conversion receivers present since the mixture of two transmitters 22 or 23 channels apart will create 440 kHz or 460 kHz interfering signals respectively. The resulting 440 kHz and 460 kHz interfering signals are only 15 kHz and 5 kHz away from any single conversion receiver's 455 kHz internal frequency respectively and so every single conversion receiver in the area has the potential to encounter interference. As an example, if one pilot is flying on channel 15 and another pilot is flying on channel 38 then the pilots are flying 23 channels apart which is 23 X 20 kHz or 460 kHz. The mixture of channels 15 and 38 will therefore create potential interference at 460 kHz which is only 5 kHz away from the 455 kHz internal frequency of every single conversion receiver at the flying field that day.

Yet another problem with single conversion receivers relates to the potential for interference from TV channel 4's audio (TV4). TV4 is broadcast on 71.75 MHz. RC Channel 20's single conversion mirror image frequency is 71.735 MHz and RC Channel 21's single conversion image is 71.755 MHz. So, for single conversion receivers, TV4 is only 15 MHz from RC channel 20's mirror image frequency and only 5 MHz from RC channel 21's image frequency. **So; We have a messy interfering signal at 15 kHz and 5 kHz away from the single conversion image frequency for RC channels 20 and 21 respectively.** Our RC channels are 20 kHz apart so the 15 kHz separation may squeak by undetected but the 5 kHz signal separation most probably will cause interference. Also, there have been documented instances of where the TV4 signal was so wide banded that it impacted the single conversion image frequencies of channels 19, 20, 21 and 22 as observed on a spectrum analyzer. Nevertheless, interference with TV4 does not always happen since it depends on the relative signal strength of TV4 in your area and other factors such as the band width of the TV4 signal and the tuning of your receiver. However, it is strongly advised that single conversion receivers on RC channels 20 and 21 be avoided in any area near a TV4 broadcasting station. On the other hand, dual conversion receivers are immune from this type of interference from TV4 for all RC channels including channel's 20 and 21.

For these and other reasons, dual conversion receivers are generally considered to be more immune to interference than single conversion receivers. However, single conversion receivers have been used successfully by a large number of modelers for many years. All pilots have their preferences and many pilots continue to successfully employ the single conversion technology.

Section 11: Manufacturer Websites

http://www.duralitebatteries.com - Power bus, regulators and batteries.

http://www.electrodynam.com - Power bus, regulators, batteries and switches.

http://www.fromeco.org - Regulators, batteries and switches.

http://www.gpina.com/industrial/index.htm - Gold Peak battery specifications.

http://www.i4cproducts.com/the_isolator.htm – Regulators.

http://www.sanyo.com/batteries/specs.cfm - Sanyo battery specifications.

http://www.smart-fly.com - Power bus, regulators and switches.

http://www.wsdeans.com - Antennas and connectors.

RC Frequency Chart

Channel	Ch Freq	Actual Single Conversion Image Fr+	Mirrored Single Conversion Image Fr-	Mirrored Dual Conversion Image Fr+	Actual Dual Conversion Image Fr-
15	72.090	72.545	71.635	82.790	61.390
16	72.110	72.565	71.655	82.810	61.410
17	72.130	72.585	71.675	82.830	61.430
18	72.150	72.605	71.695	82.850	61.450
19	72.170	72.625	71.715	82.870	61.470
20	72.190	72.645	71.735	82.890	61.490
21	72.210	72.665	71.755	82.910	61.510
22	72.230	72.685	71.775	82.930	61.530
23	72.250	72.705	71.795	82.950	61.550
24	72.270	72.725	71.815	82.970	61.570
25	72.290	72.745	71.835	82.990	61.590
26	72.310	72.765	71.855	83.010	61.610
27	72.330	72.785	71.875	83.030	61.630
28	72.350	72.805	71.895	83.050	61.650
29	72.370	72.825	71.915	83.070	61.670
30	72.390	72.845	71.935	83.090	61.690
31	72.410	72.865	71.955	83.110	61.710
32	72.430	72.885	71.975	83.130	61.730
33	72.450	72.905	71.995	83.150	61.750
34	72.470	72.925	72.015	83.170	61.770
35	72.490	72.945	72.035	83.190	61.790
36	72.510	72.965	72.055	83.210	61.810
37	72.530	72.985	72.075	83.230	61.830
38	72.550	73.005	72.095	83.250	61.850
39	72.570	73.025	72.115	83.270	61.870
40	72.590	73.045	72.135	83.290	61.890
41	72.610	73.065	72.155	83.310	61.910
42	72.630	73.085	72.175	83.330	61.930
43	72.650	73.105	72.195	83.350	61.950
44	72.670	73.125	72.215	83.370	61.970
45	72.690	73.145	72.235	83.390	61.990
46	72.710	73.165	72.255	83.410	62.010
47	72.730	73.185	72.275	83.430	62.030
48	72.750	73.205	72.295	83.450	62.050
49	72.770	73.225	72.315	83.470	62.070
50	72.790	73.245	72.335	83.490	62.090
51	72.810	73.265	72.355	83.510	62.110
52	72.830	73.285	72.375	83.530	62.130
53	72.850	73.305	72.395	83.550	62.150
54	72.870	73.325	72.415	83.570	62.170
55	72.890	73.345	72.435	83.590	62.190
56	72.910	73.365	72.455	83.610	62.210
57	72.930	73.385	72.475	83.630	62.230
58	72.950	73.405	72.495	83.650	62.250
59	72.970	73.425	72.515	83.670	62.270
60	72.990	73.445	72.535	83.690	62.290