nstitute Report

IB 111-2012/69

Pilot Gain and the Workload Buildup Flight Test Technique:

About the Influence of Natural Pilot Gain on the Achievable Pilot Gain Range

Ina Niewind

Institute of Flight Systems
Braunschweig/Manching

57 Pages
33 Figures
4 Tables
9 References

German Aerospace Center
Institute of Flight Systems
Flight Test Manching

Availability I: internally and externally unrestricted

Braunschweig/Manching, 23rd September 2012

		Signatures
Head of Institute:	Prof. Dr.-Ing. Stefan Levedag	
Head of Department:	Prof. Dr.-Ing. Klaus-Uwe Hahn	
Author:	Dipl.-Ing. Ina Niewind	

Background and Overview

The term "pilot gain" essentially describes the way the pilot acts on the inceptor during flight. It is a key aspect of handling qualities research and related flight tests. Pilots are asked to fly intentionally high or low gain and there are specific tasks associated with high gain flying - e.g. air-to-air refueling - and low gain flying - e.g. a course correction during a ferry flight. Most test organizations have their famous high and low gain pilots and the term "pilot gain" is understood very well on an intuitive level - especially when sitting in the backseat of an aircraft controlled by a high gain pilot. But in spite of all this, there is no generally accepted verbal or mathematical definition of "pilot gain".

A simulator study was performed in March to July 2012; participants were 12 experimental test pilots from the Bundeswehr Technical and Airworthiness Center for Aircraft (WTD 61) and Cassidian. A second study in July-August 2012 covered 12 operational pilots from the Eurofighter squadron in Laage. The aim of this study was - among others - to validate potential pilot gain measures. Based on valid pilot gain measures this report covers the question if the pilot gain range depends on the pilot's natural gain, e.g. if a high gain pilot can vary his pilot gain more than a low gain pilot.

This report gives a comprehensive overview of the test results related to the pilot gain range.

Chapter 1 gives an introduction to the topic of "pilot gain".

Chapter 2 gives an overview of the test strategy, the test setup and the participants.

Chapter 3 presents the different representations of the pilot gain range and gives an introduction to their interpretation and the statistical background.

Chapter 4 provides an overview of the pilot gain range for 10 different pilot gain measures which have been identified as valid in a previous report.

Chapter 5 summarizes the results and states limitations which apply for the results.

Content

Abbreviations and Nomenclature

HOTAS	Hands On Throttle and Stick
HTF	Highest Task Frequency
PIO	Pilot-Induced/Involved/In-the-loop Oscillation
PIW	Pilot Inceptor Workload
PSD	Power Spectral Density
PT1/2	Point Tracking pilot model 1/2
QIE	Normalized Integral of the Quadratic Error
RMS	Root Mean Square
WTD 61	Bundeswehr Technical and Airworthiness Center for Aircraft

Nomenclature

σ	sample standard deviation
μ	mean value
Φ	normal distribution function
i	index
K	pilot model gain
n	number of data points
T_D	lead compensation time constant
T_e	time delay
T_I	lag compensation time constant
u_i	residuals normalized to the standard normal distribution
x_i	residuals

Figures

Tables

1. Pilot Gain

1.1. Definition of Pilot Gain

The term "pilot gain" essentially describes the way the pilot acts on the inceptor during flight. Very often the term "pilot gain" is used synonymously with the expression "aggressiveness", a term quite familiar to most pilots. Pilot gain is a key aspect of handling qualities research and related flight tests. Pilots are asked to fly intentionally high or low gain and there are specific tasks associated with high gain flying, e.g. air-to-air refueling, and low gain flying, e.g. a course correction during a ferry flight.

The lower the pilot gain, the more the pilot-vehicle system resembles the stable aircraft dynamics; the higher the pilot gain, the less stable is the pilot-vehicle system. This is why high gain pilots tend to find unfavorable aircraft dynamics a low gain pilot may only experience in an emergency situation. Pilot gain is a matter of task, training, aircraft dynamics and the current stress level, but it is also a matter of individual disposition. In nearly all flight test organizations there is a famous low gain pilot and a famous high gain pilot. Both dispositions have their advantages and disadvantages and none is generally superior to the other.

Even though pilot gain is one of the most important aspects in handling qualities testing and even though it is very well understood on an intuitive level, there is no generally accepted verbal or mathematical definition.

1.1. Classes of Pilot Gain Measures

In order to determine potential pilot gain measures, literature was reviewed [8]. Also, pilots and air crew members were asked about their definition of pilot gain [8]. Three types of pilot gain measures were defined and extended in [6]:

- time domain-based pilot gain measures, e.g. stick speed
- tracking performance
- PSD / frequency domain-based pilot gain measures, e.g. signal power
- duty cycle and number of control inputs per minute
- model-based pilot gain measures, e.g. pilot model gain

The tracking performance was added since the term "high gain" had a significantly negative connotation with respect to the pilot's abilities.

1.2. Individual Variation in Pilot Gain

In spite of standardized training, there is a significant individual variation in the pilots' natural pilot gain. Consequently, especially test pilots are often categorized as low, medium and high gain pilots.

1.3. Analyzing Pilot Gain

In order to analyze the phenomenon of pilot gain, a suitable test setup was defined in [8] and refined in [7]. The idea was to use a tracking task which is performed first with the pilot's normal control behavior (natural pilot gain). In a second step the pilot is asked to apply intentionally low gain during the same task. The third step is the same task again, but intentionally performed in a high gain fashion.

1.4. Validation of Potential Pilot Gain Measures

Based on the test setup, a validation was performed for 30 potential pilot gain measures [6].

The validity of a potential pilot gain measure was based on its ability to reflect the pilot gain the pilot intended to apply during the test. The validity was quantified by means of a validity index with a range from -1 (monotonically decreasing value with pilot gain) and 1 (monotonically increasing value with pilot gain).

In addition, three significant outliers were identified during the tests. Their different tracking behavior was supported by PSD plots and time histories of their stick inputs. An efficient pilot gain measure had to be able to identify these three outliers with their specific effects.

Finally, a pilot gain ranking was derived based on the 20 pilot gain measures which achieved a good validity index. The deviation of individual pilot gain measures from the overall ranking was used as a third parameter for the validation process.

1.5. Pilot Gain Measures

Out of the 30 different potential pilot gain measures which were investigated in [6], the 10 pilot gain measures which passed the validation process are introduced in the following subchapters.

1.5.1. Time Domain-Based Pilot Gain Measures

One result of the pilot gain survey in [8] is that pilots prefer time-domain based measures like stick deflection, stick speed and stick acceleration. These parameters are experienced in real life and are therefore more tangible. The RMS stick speed is a part of Grays "Pilot Inceptor Workload (PIW) [3], [4]; the RMS control column deflection was e.g. used in [2].

In summary, the following time domain-based pilot gain measures are recommended in [6]:

- Mean Stick Speed
- RMS Stick Speed
- *(Percentage of High Stick Speeds)*
- Mean Stick Acceleration
- RMS Stick Acceleration
- *(Percentage of High Stick Accelerations)*

The percentage of high stick speeds and/ high stick accelerations depends on an engineering judgment for a limiting value for a "high" stick speed or acceleration. The limit depends - amongst others - on the task at hand, the inceptor and the aircraft dynamics. In the frame of this report the limits were set to the following values:

- Limit Large Stick Deflection: 0.25 u
- Limit High Stick Speed: 1 u/s^2
- Limit High Stick Acceleration: 30 u/s^2

with u being the unit of stick deflection ranging from ± 1 u for stop to stop inputs.

In spite of the similarly good results for both, stick speed and acceleration-based measures, measures based on stick speed should be preferred since they require only one differentiation of the stick deflection and are thus less susceptible to noise artifacts due to the differentiation process.

1.5.2. Frequency Domain-Based Pilot Gain Measures

The frequency domain is reflected in Power Spectral Density (PSD) plots. The PSD area (area below the spectral density curve) reflects the signal power of the pilot's stick inputs within a specified frequency range. Among others it was used in [2] as a potential measure for pilot control activity, even though the frequency ranges were defined in a different way than in this report. Figure 1-1 shows an example of a PSD plot.

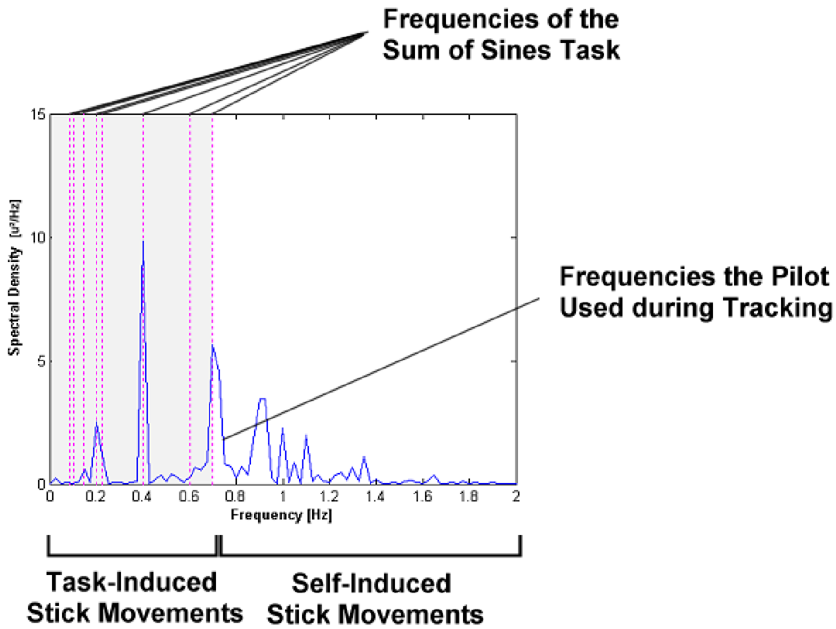


Figure 1-1: Example PSD Plot with PSD Areas

The PSD peaks in the area between 0 Hz and the Highest Task Frequency (HTF, 0.7 Hz) are sharp and defined. They reflect the frequencies of the sum of sines task which was used for the target movement (see Chapter 2.5).

The PSD peaks in the area beyond the HTF are more scattered and distributed over a frequency range. They are often a result either of high pilot gain or flaws in the aircraft dynamic (or both).

When the aircraft dynamic is kept constant, pilot gain is the main contributing factor for differences in this area.

In [8] it already appeared that low and high gain pilots tend to have different interpretations of intentionally applied low and high gain. These differences were mainly reflected in PSD plots.

Figure 1-2 and Figure 1-3 show PSD plots of a typical low and high gain pilot.

During the simulator study, the task frequency of 0.4 Hz created a significant reaction in the pilot's stick movement for all pilots (1). A typical low gain pilot shows a significant increase in the peak with increasing pilot gain whereas a some high gain pilots show only a small increase, keep this frequency peak constant or even reduce their frequency content at this frequency.

The signal power in the range of self-induced frequencies (2) is very small for the low gain pilot for all applied pilot gains whereas a high gain pilot usually creates a significant signal power in this area which increases significantly with an increase in pilot gain.

When using a normal tracking strategy, the highest task frequency at 0.7 Hz (3) only creates a small peak for a typical low gain pilot, but creates quite a pronounced peak for a typical high gain pilot.

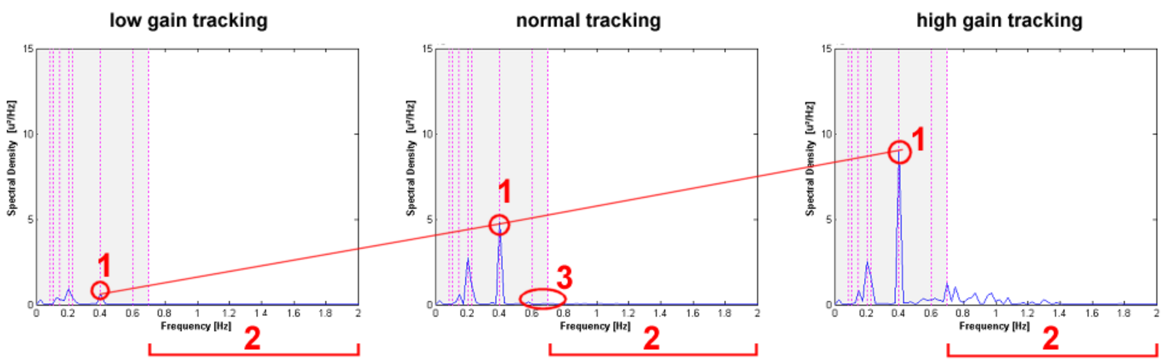


Figure 1-2: PSD Plots of a Typical Low Gain Pilot

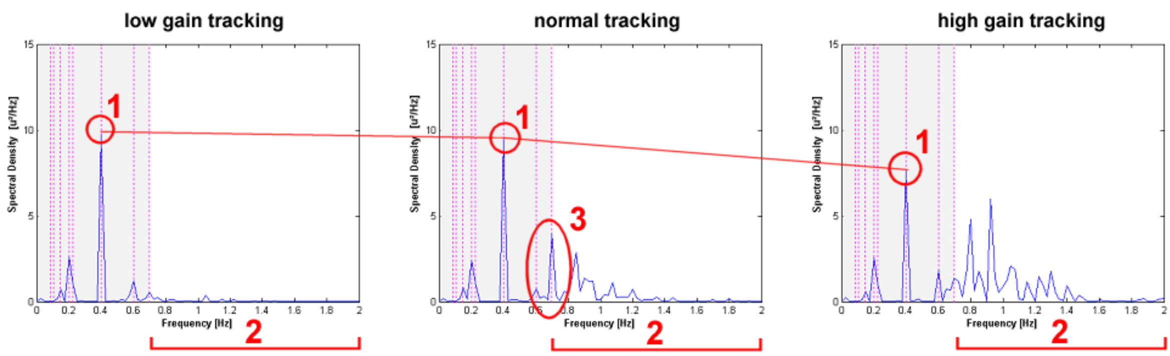


Figure 1-3: PSD Plots of a Typical High Gain Pilot

The PSD power in significant frequency regions - represented by the PSD area – and also ratios between different PSD areas were evaluated in [6].

The following parameters were recommended as pilot gain measures:

- PSD Area HTF – 2 Hz
- *(PSD Ratio Area (HTF - 2 Hz) vs. Area (0 - 2 Hz))*
- *(PSD Ratio Area (HTF - 2 Hz) vs. Area (0 Hz - HTF))*

Note that the use of PSD ratios may mask outliers with extreme values.

1.5.3. Pilot Model-Based Pilot Gain Measures

In literature the terms "pilot gain" and "pilot model gain" (as in a "K" factor in a control system-related model) are often mixed [8].

Also, especially during the study with operational pilots, many of which had just received their basic training in Sheppard, the pilots stated that pilot gain[1] was taught to them as the amount of control deviation they allow during tracking and the magnitude and quickness of reaction when a control deviation occurs. This description is well in line with the concept of "K" in pilot models.

Basically two pilot models were evaluated in [6] but only one created data which could be used as a pilot gain measure. It was the more complex model which was based on the model, but not the assumptions, of Neal and Smith [5]. In the frame of this report it is called PT1 model (PT = Point Tracking as opposed to Boundary Avoidance Tracking (BAT) which was another aspect of the simulator study).

$$F_1(s) = K_1 e^{-T_{e1}s} \frac{T_D s + 1}{T_I s + 1}$$

[1] Actually for operational pilots the term „aggressiveness" was used instead of „pilot gain" as none of them was familiar with the latter term.

The only valid pilot model-based pilot gain measure was QIE PT1 which basically reflects the difference between the pilot's inputs and the pilot model inputs. It is the integral of the quadratic error between the pilot model and the pilot's inputs, normalized to a duration of one minute.

Figure 1-4 gives an example which demonstrates the increase in QIEPT1 with increasing pilot gain. In general, the pilot model does not sufficiently cover extreme amplitudes of the high gain tracking run. As a consequence, the difference between the pilot's and the pilot model inputs is larger with increasing pilot gain.

In the upper plots, the pilot's inputs are shown in blue, the pilot model inputs in red. The lower plots represent the difference between both.

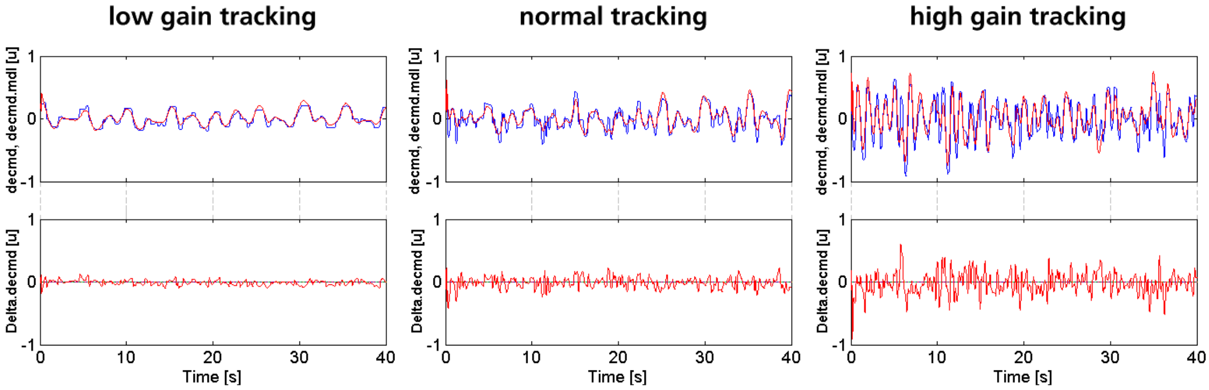


Figure 1-4: Change of Pilot Model Fit with Increasing Pilot Gain – Pilot's and Pilot Model PT1 Inputs (Upper Plots) and Difference between Both (Lower Plots)

2. Test Strategy and Participants

The simulator study "Pilot Gain and the Workload Buildup Flight Test Technique: Test Pilots" was conducted from March to July 2012. Participants were 8 experimental test pilots from the Bundeswehr Technical and Airworthiness Center for Aircraft (WTD 61) and 4 experimental test pilots from Cassidian.

The simulator study "Pilot Gain and the Workload Buildup Flight Test Technique: Operational Pilots" was conducted from 30th July to 3rd August 2012 at Fighter Wing 73 in Laage which is mainly a Eurofighter training squad. Participants were 7 Eurofighter student pilots, most of which had just finished their training at Sheppard AFB and 5 more experienced pilots who originated either from F-4F or Tornado.

The participating pilots were assigned IDs with four capital letters in order to make the results anonymous. These IDs are, however, not used in Table 2-1 and Table 2-2 below since the number of flight hours and age has the potential to compromise the intended anonymity. An arbitrary index from 1-24 is used instead.

Subchapters 2.3 to 2.6 provide only a brief overview of the test strategy. More comprehensive information can be found in the dedicated report about the test and evaluation strategy [7].

2.1. Participating Test Pilots

Table 2-1 gives an overview of the participating test pilots and their background.

Classification	Index	X1 / X2[2]	Agile Aircraft					Sluggish Aircraft					Flight Hours	Age
			EF2000/Typhoon	F4 Phantom	PA 200 Tornado	PC 9	Alpha Jet	C160 Transall	P3 Orion	Global 5000	Citation 551 / 525	Airbus Family		
Fighter Pilots (EF2000, F-4)	1	X1	**X**		X								5900	54
	2	X1		**X**								X	4000	39
	3	X1	X	**X**				X		X			4000	50
	4	X1	X	**X**		X		X					3400	47
Bomber Pilots (Tornado)	5	X1	X	X	**X**								5000	41
	6	X1			**X**						X		4970	48
	7	X1			**X**								1550	36
	8	X1			**X**	X							2000	37
Transport Pilots	9	X2						**X**					6700	54
	10	X1						**X**	X				4000	46
	11	X1						**X**				X	2950	47
	12	X1						**X**				X	3600	44

Table 2-1: Participating Test Pilots

[2] X = Test Pilot Rating. X1: full course at a test pilot school, X2: short course (4 months).

All participating test pilots were male and between 36 and 54 years old with an experience ranging from 1550 to 6700 flight hours. The main aircraft type, defined by the aircraft type the pilots flew prior to becoming a test pilot, is indicated by a bold "**X**".

2.2. Participating Operational Pilots

Table 2-2 gives an overview of the participating operational pilots and their background.

Classification	Index	Agile Aircraft			Flight Hours	Flight Hours EF2000	Age
		EF2000/Typhoon	F4 Phantom	PA 200 Tornado			
Fighter Pilots (F-4)	13	X	**X**		1700	120	32
	14		**X**		280	0	26
Bomber Pilots (Tornado)	15	X		**X**	1500	180	35
	16	X		**X**	1250	10	31
	17	X		**X**	1000	25	31
Young EF Pilots (< 1000 FH, EF only)	18	**X**			340	15	26
	19	**X**			300	5	28
	20	**X**			450	145	26
	21	**X**			440	140	28
	22	**X**			260	14	29
	23	**X**			300	15	26
	24	**X**			930	5	25

Table 2-2: Participating Operational Pilots

All participating operational pilots were male and between 25 and 35 years old with an experience ranging from 260 to 1700 flight hours. The main aircraft type is indicated by a bold "**X**". For the "Young Eurofighter Pilots" who had just come back from their basic training in Sheppard this is Eurofighter. For the more experienced pilots who had flown in another fighter wing before, the main aircraft type is the aircraft type they were originally trained on.

None of the operational pilots had experience on transport aircraft. "Young Eurofighter Pilots" was added as a new category in addition to the categories used in Table 2-1.

2.3. Simulator

The simulator consists of a simple seat equipped with a throttle on the left hand side and a joystick plus armrest on the right hand side. Both throttle and joystick are from Thrustmaster ("HOTAS Warthog"). The joystick is sold as a replica of the A-10C stick, which is, however, used as a center stick whereas the simulator used the joystick as a modern side stick. The stick's inputs are provided with a resolution of 16 bit. The throttle was not used in the frame of this study.

Figure 2-1: Thrustmaster HOTAS Warthog Hardware

Multiple ergonomic parameters of the simulator seat are adjustable within a wide range.

The display uses the in-house software 2indicate. It was provided on a monitor in front of the pilot with a black background.

A high definition video camera was used to record the pilot's comments and reactions.

The simulator is shown below in Figure 2-2. The final trials with the test pilots were performed in the pilot's building ("Direktionsgebäude") at WTD 61 in Manching. For the study with the operational pilots, a room was provided by the 73rd Fighter Squadron. Both, the rooms in Manching and in Laage, were chosen so that external distraction was kept at a minimum.

Figure 2-2: Simulator Setup with Test Pilot

2.4. Aircraft Dynamics

Appropriate aircraft dynamics were determined in the frame of a Master Thesis [9]. It was chosen based on simulator sessions with military test pilots from WTD 61. A linear model of the short period motion was used for the tests in order to have a simple setup and to avoid additional influences to the tests caused by speed or altitude maintenance or induced roll movements.

The resulting aircraft dynamics with respect to the short period motion are

$$\frac{q(s)}{\eta(s)} = -1.05 \frac{2.1633s + 1.9379}{s^2 + 3.3789s + 3.1801}.$$

Figure 2-3 shows the aircraft response to a boxcar input. More specifics about the aircraft dynamics and the background for this choice can be found in [9].

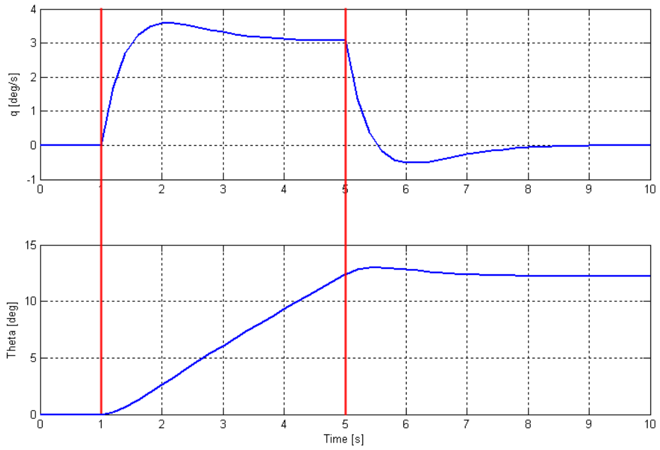


Figure 2-3: Aircraft Response to a Boxcar Input (Boxcar Input Indicated by Red Lines)

2.5. Target Movement

In the frame of [9], also suitable target movements were evaluated. A suitable movement was defined by a target movement which keeps the pilot constantly in the loop, is unpredictable, not too easy but also not excessively challenging.

Figure 2-4 shows an excerpt from the sum of sines task which was finally chosen by the pilots.

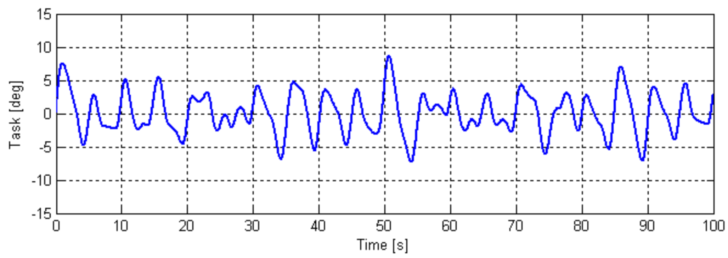


Figure 2-4: Time History Excerpt from Sum of Sines Task

Table 2-3 summarizes the frequencies and amplitudes which were used for the sum of sines task.

Sine	**Amplitude [deg]**	**Frequency [rad/s]**
1	0.64	$2/23 \cdot 2\pi$
2	1.44	$2/5 \cdot 2\pi$
3	1.60	$2/9 \cdot 2\pi$
4	2.08	$1/7 \cdot 2\pi$
5	1.12	$2/19 \cdot 2\pi$
6	2.88	$2/10 \cdot 2\pi$
7	0.16	$6/10 \cdot 2\pi$
8	0.14	$7/10 \cdot 2\pi$

Table 2-3: Sines Used for the Target Movement

The task was additionally overlaid with a slow sine of 0.027 Hz. The frequency is too low to have a direct effect on the pilot's tracking behavior and was added because some pilots commented that even though the task itself was unpredictable, they could predict quite well that the task never exceeded ±8 deg and always had a mean value of 0 deg.

The time history of the updated sum of sines task is shown in Figure 2-5 below. The sine had an amplitude of 5 deg. Higher values were not practicable because the presented motion of the updated task already pushed the limits of credibility for pitch angle changes.

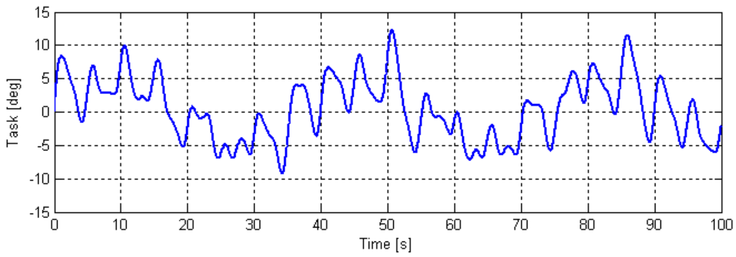


Figure 2-5: Updated Time History Excerpt from Updated Sum of Sines Task

2.6. Test Points

Table 2-4 shows the test points which were conducted by the participants.

Test Point	Description	Classification
1 2 3	Basic Data Psychological Test Tapping Test	Computer-Based Tests
4	Familiarization Phase	Simulator-Based Tests
5	Pilot Gain Calibration (Normal-Low-High Gain)	
6 7 8	Workload Buildup Flight Test Technique – Levels Workload Buildup Flight Test Technique – Original Workload Buildup Flight Test Technique – Original + Exceedable Boundary	

Table 2-4: Test Points

The relevant test point for this report is test point 5.

This test point is used to determine the pilot's natural pilot gain and his ability to vary his pilot gain on command. This test point is thus also called "pilot gain calibration".

It was used to validate different pilot gain measures in [6] and is used to determine the individual pilot gain range in the frame of this report.

The test point consists of 3 sub-test points, performed with the pilot's normal gain and intentionally performed in a low and high gain fashion. Each sub-test point creates 40 s of data for further evaluation. The tracking task is the one introduced in Chapter 2.5.

The intentional variation of pilot gain is a common procedure in handling qualities testing. In spite of this rather unusual approach in comparison with their daily missions, operations pilots were just as successful in varying their pilot gain as the test pilots. The main difference was the fact that they were not familiar with the term "pilot gain". The synonymous expression "aggressiveness" was used instead. Based on the test results, no difference could be identified between the operational pilots' application of different levels of aggressiveness and the test pilots' application of different levels of pilot gain.

2.7. Outliers

Three pilots created significantly different results than the rest of the pilots. The outliers were identified and analyzed in detail in [6].

2.7.1. Pilot IGOR

The fighter pilot with the ID IGOR performed his high gain test point in an unusually aggressive manner which seemed to have exceeded the limits of what can be considered reasonable tracking behavior. This test point is probably a simulator artifact since it is unlikely the pilot would have shown the same tracking behavior in flight. The stick inputs were quite violent and often went from stop to stop while the resulting tracking performance was quite poor.

2.7.2. Pilot BIER

During the pilot gain calibration runs the bomber pilot with the ID BIER evidently used higher pilot gain for his low gain run than for the normal gain run. A similar problem occurred during the pre-study when one participant unintentionally did the same thing. Back then the pilot commented that since he allowed a larger error during the low gain task, he reached a point when the tracking error was so big that he felt obliged to apply a large input which then ended up being more aggressive than what he had applied during the normal gain task [8]. It is quite likely the same thing happened to pilot BIER.

2.7.3. Pilot ABCD

The young EF pilot with the ID ABCD did not succeed in varying his pilot gain. As he commented after the complete test, he would recommend to let the pilots perform the pilot gain calibration again at the end of the test battery since he would then have performed it differently. All three test points of the pilot gain calibration created about the same value.

3. Pilot Gain Range

3.1. Background

Each pilot has his personal optimum of pilot gain ("natural pilot gain"). This optimum can be determined by adding no restrictions to the tracking task and by asking the pilot to perform this task in a "normal" manner as it was done in the frame of the pilot gain calibration runs.

Based on the pilot's natural tracking behavior, pilots can be classified as low, medium or high gain pilots. An example for the tracking behavior of a typical low and high gain pilot was shown in Figure 1-2 and Figure 1-3.

High gain pilots are also called high bandwidth pilots. Even though this expression is mainly related to the large bandwidth in the frequency region, it is interesting to investigate whether a high gain pilot also has a larger pilot gain range than a low gain pilot when both vary their pilot gain on command.

Four different plots are created in order to evaluate the pilot gain range vs. the pilot's natural gain. For the x-axis, always the normal gain data of the pilots is used. The plots are created for the valid pilot gain measures as they were identified in [6].

3.2. Absolute Pilot Gain Range

For the determination of the absolute pilot gain range, two plots are created. Example plots are shown in Figure 3-1.

The plot in Figure 3-1 left shows the difference between the high and low pilot gain values vs. the normal gain test point. As an example: if the pilot's high gain value is 4 and the low gain value is 1 u/s, the y-axis shows the data point 4 - 1 = 3. The grey line presents a linear regression through the data points, the light grey area is plus and minus one sample standard deviation.

The plot in Figure 3-1 right shows all data points from the calibration runs. The normal gain data point is represented by a square, the high gain test point by a triangle pointing upward, the low gain data point by a triangle pointing downward. The square data points are always located on a perfect line with increasing slope since they have the same value on the x- and y-axis. The grey lines through the upper and lower triangles again represent the linear regression, the grey areas represent plus and minus one sample standard deviation.

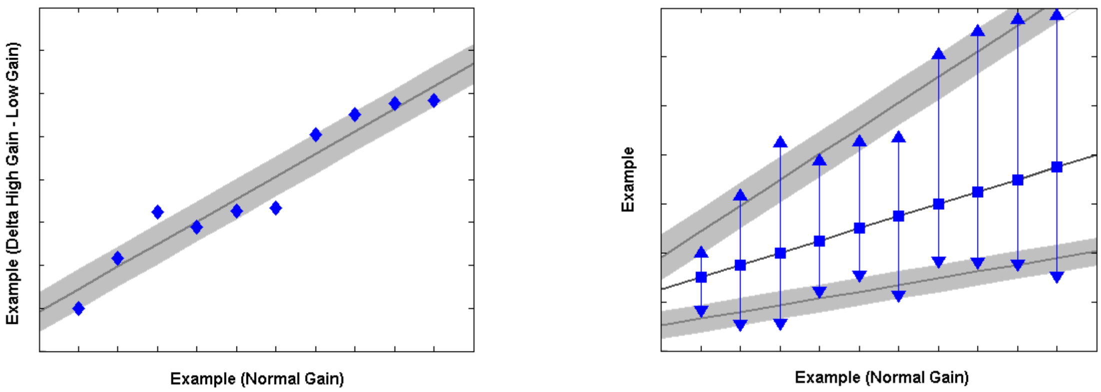


Figure 3-1: Absolute Pilot Gain Range Representation (Example for Increasing Pilot Gain Range)

Figure 3-1 presents example results with clear trends. The data points in the left figure show a clear trend towards a higher pilot gain range with increasing natural pilot gain. The right figure supports this result – the triangles form a cone around the normal gain values which opens to the right, indicating that the pilot gain range increases with increasing natural gain.

3.2.1. Relative Pilot Gain Range

Another way of presenting the data is the use of the relative pilot gain range. The basic representation is similar to the one in Figure 3-1 but instead of using the absolute values on the y-axis, the percentage is shown, using the normal gain test point's value of each pilot as the 100% value.

An example for the resulting plots is shown in Figure 3-2. A deceasing pilot gain range is shown for both plots. Note that in the right plot of the relative pilot gain range, the normal gain data points are always at the 100% line since they are the value which is used for normalization for each pilot. The grey areas again represent the regression line plus and minus one sample standard deviation.

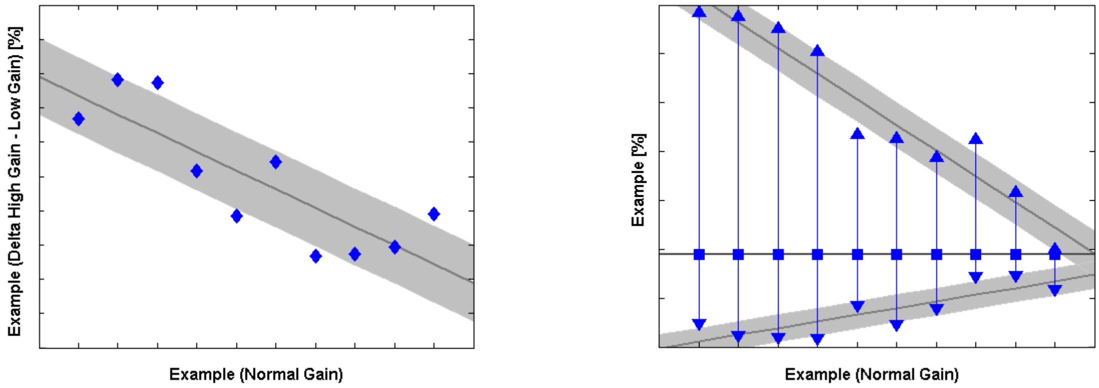


Figure 3-2: Relative Pilot Gain Range Representation (Example for Increasing Pilot Gain Range)

3.2.2. Outliers in Pilot Gain Range Plots

The pilot gain range plots also provide information about the correct application of low, normal and high pilot gain.

Figure 3-3 shows typical cases for the pilot gain range layout.

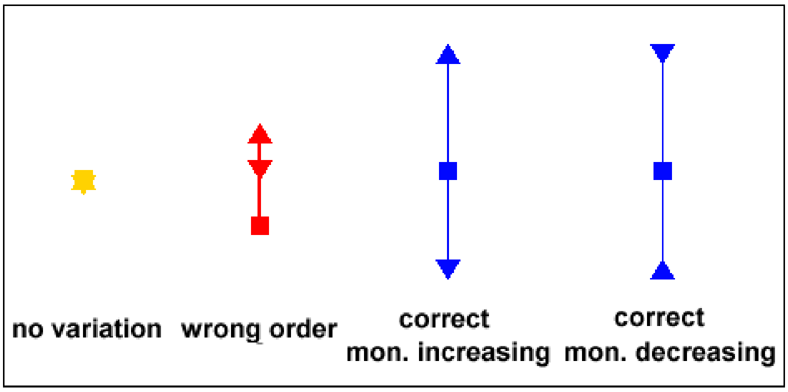


Figure 3-3: Validity of Pilot Gain Range Plots

Overlapping data points are an indication for a lack of pilot gain variation during the pilot gain calibration. This effect is mainly evident for pilot ABCD who was identified as an outlier due to his inability to vary pilot gain on command during the test (Subchapter 2.7.3).

A plot showing the square (normal gain) outside of the triangles is an indication for a wrong order of the pilot gain application, as it was identified for pilot BIER (Subchapter 2.7.2).

A plot showing the square in the middle between the two triangles with the triangles pointing away from the square is an indication for a monotonically increasing pilot gain measure.

A plot showing the square in the middle between the two triangles with the triangles pointing towards the square is an indication for a monotonically decreasing pilot gain measure. However, no monotonically decreasing pilot gain measure passed the validation in [6].

The third outlier, pilot IGOR can easily be identified by his excessive high gain value and resulting excessive pilot gain range.

In the frame of this report, the three outliers are marked in all plots.

3.3. Notes on Statistics

In the pilot gain range plots linear regression, regression coefficients and Sample Standard Deviations (SSDs) are calculated and displayed as additional information. They are meant to support the visualization of a general trend for the data points and to structure the complex graphs.

As a prerequisite for both, the mathematically correct application of linear regression and the calculation of a sample standard deviation for the residuals, the residuals have to be normally distributed around zero. The validation of normally distributed residuals was performed by means of a Kolmogorow-Smirnow-Test (also known as K-S test). More information about the test and the results can be found in the appendix.

All presented pilot gain measures and their associated linear regressions passed the test for normal distribution with $\alpha = 0.05$. The three outliers introduced in Chapter 2.7 were excluded for the statistical analysis.

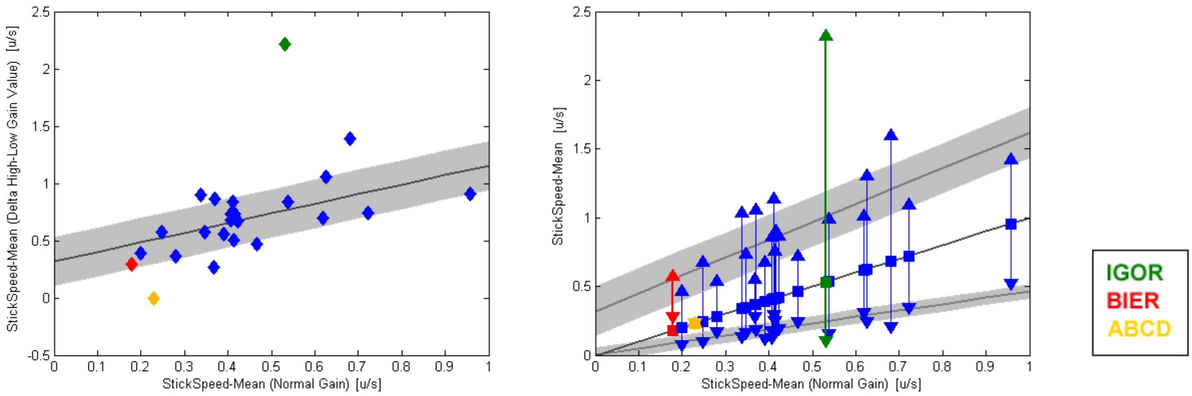
4. Pilot Gain Range of Selected Pilot Gain Measures

4.1. Mean Stick Speed

The mean stick speed achieved a validity index of 0.88, was able to identify all 3 outliers and produced only one ranking failure which was not extreme [6].

Figure 4-1 left shows the pilot gain range plots for the mean stick speed. The delta between the high and low gain value shows a scattered upward trend. The regression coefficient is poor (R^2 = 0.34 excluding outliers).

The same trend is reflected in Figure 4-1 right. In spite of the general trend of the linear regression, the highest and second highest data point both show a rather small pilot gain range. The scatter of the low gain values is significantly smaller than the scatter of the high gain values. The regression coefficients, however, only differ slightly (R^2 = 0.66 for the low gain data points, R^2 = 0.63 for the high gain data points, both excluding outliers).



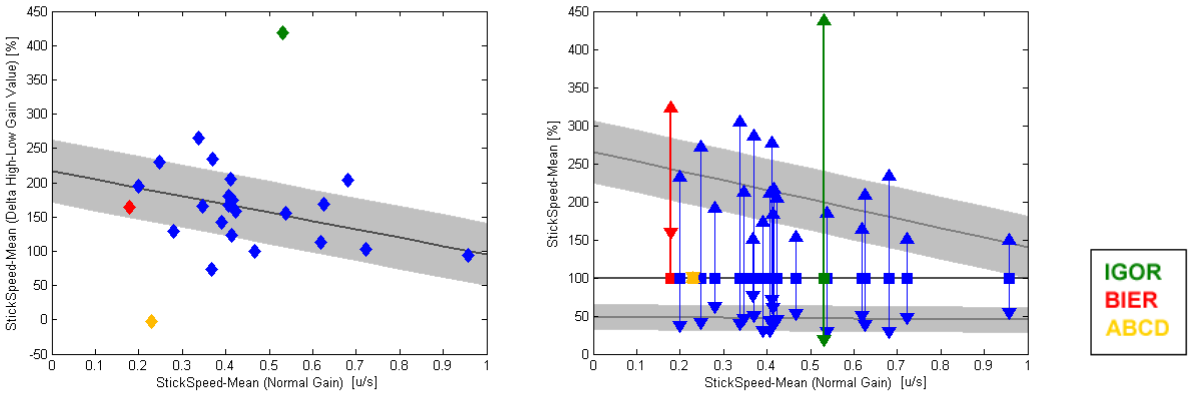
SSD [u/s]	R^2
0.21	0.34

	SSD [u/s]	R^2
Low Gain	0.05	0.66
High Gain	0.18	0.63

Figure 4-1: Pilot Gain Range Plots for the Mean Stick Speed

Figure 4-2 left shows the relative pilot gain range in percentage of the normal gain value of each pilot. The delta between the high and low gain value shows a scattered downward trend. The regression coefficient is poor ($R^2 = 0.18$ excluding outliers). The negative slope (instead of a positive slope like in Figure 4-1) is probably a result of different normal gain values used for normalization. It is easier to double a low normal gain value than to double a high normal gain value which is naturally already close to the limits of system stability.

The plot on the right shows the same trend. Again, the regression coefficients are poor ($R^2 < 0.01$ for the low gain values, $R^2 = 0.23$ for the high gain values, both excluding outliers). The low gain data points (excluding outliers) are located close around 47% of the normal gain value for all pilots with only small scatter. There appears to be no dependency on the natural gain; the regression line is approximately a constant which also explains the very poor regression coefficient for the low gain data points.



SSD [%]	R^2
46	0.18

	SSD [%]	R^2
Low Gain	17	< 0.01
High Gain	41	0.23

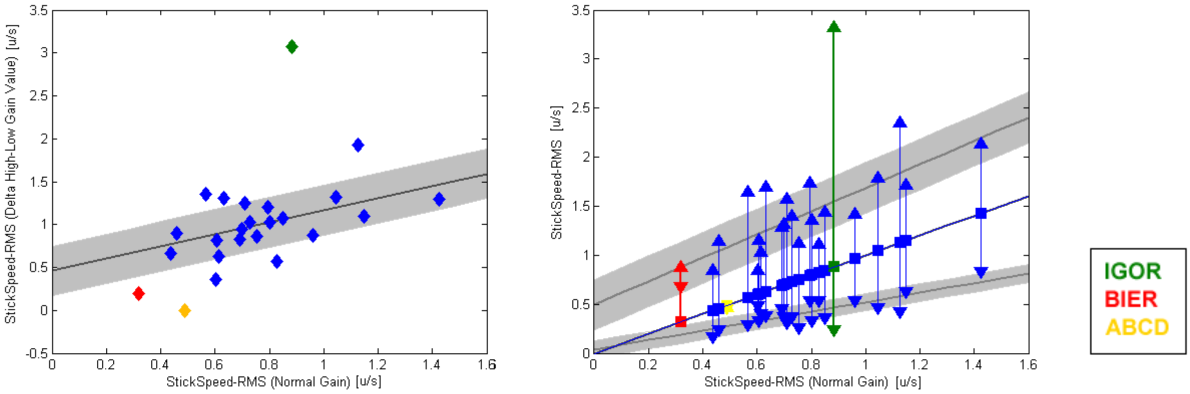
Figure 4-2: Relative Pilot Gain Range Plots for the Mean Stick Speed

4.2. RMS Stick Speed

The RMS stick speed achieved a validity index of 0.92, was able to identify all 3 outliers and produced no ranking failure [6].

Figure 4-3 left shows the pilot gain range plots for the RMS stick speed. Because of their mathematic similarity, mean and RMS values create similar plots. The delta between the high and low gain value shows a scattered upward trend. The regression coefficient is poor and even slightly worse than for the mean stick speed ($R^2 = 0.25$ excluding outliers).

The same trend is reflected in Figure 4-3 right. In spite of the general trend of the linear regression, the highest and second highest data point both show a rather small pilot gain range. The scatter of the low gain values is significantly smaller than the scatter of the high gain values. The regression coefficients only differ slightly, but the difference is more pronounced than for the mean stick speed ($R^2 = 0.64$ for the low gain data points, $R^2 = 0.55$ for the high gain data points, both excluding outliers).



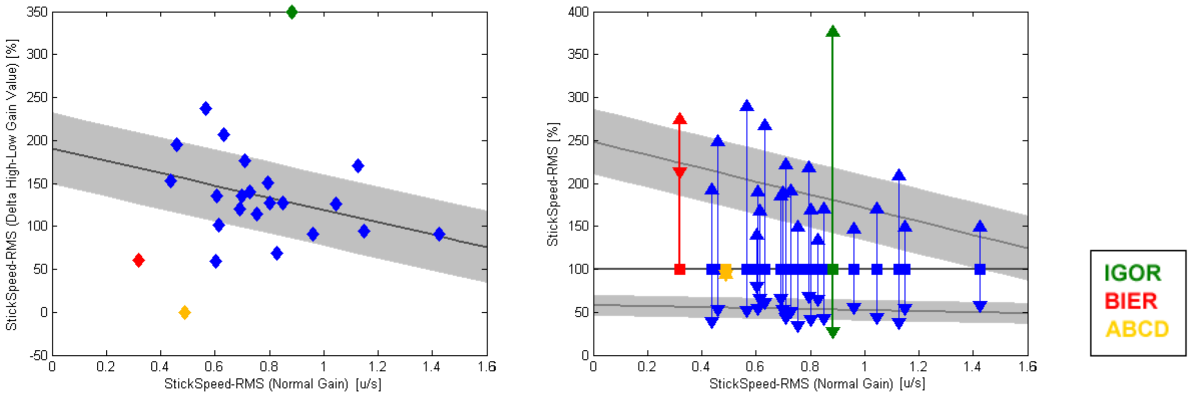
SSD [u/s]	R^2
0.29	0.25

	SSD [u/s]	R^2
Low Gain	0.09	0.64
High Gain	0.26	0.55

Figure 4-3: Pilot Gain Range Plots for the RMS Stick Speed

Figure 4-4 left shows the relative pilot gain range in percentage of the normal gain value of each pilot. The delta between the high and low gain value shows a scattered downward trend. The regression coefficient is poor ($R^2 = 0.15$ excluding outliers).

The plot on the right shows the same trend. As for the mean stick speed, the regression coefficients are poor ($R^2 = 0.01$ for the low gain values, $R^2 = 0.20$ for the high gain values, both excluding outliers). The low gain data points (excluding outliers) are located close around 53% of the normal gain value for all pilots with only small scatter. There appears to be no dependency on the natural gain; the regression line is approximately a constant which also explains the very poor regression coefficient for the low gain data points.



SSD [%]	R^2
12	0.15

	SSD [%]	R^2
Low Gain	12	0.01
High Gain	38	0.20

Figure 4-4: Relative Pilot Gain Range Plots for the RMS Stick Speed

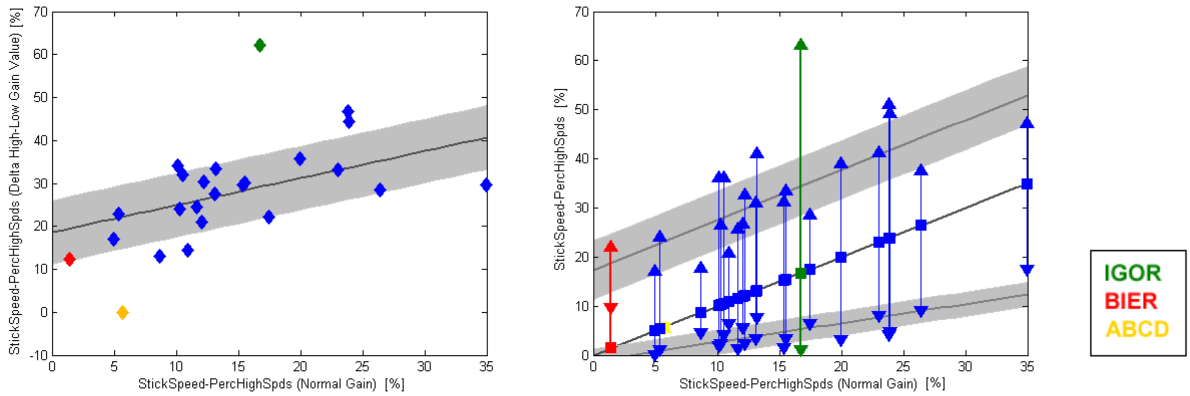
4.3. Percentage of High Stick Speeds

The percentage of high stick speeds achieved a validity index of 0.92, was able to identify all 3 outliers and produced no ranking failure [6].

Figure 4-5 left shows the pilot gain range plots for the percentage of high stick speeds. The delta between the high and low gain value shows a scattered upward trend. The regression coefficient is poor ($R^2 = 0.30$ excluding outliers).

The same trend is reflected in Figure 4-5 right. In spite of the general trend of the linear regression, the highest and second highest data point both show a rather small pilot gain range. The scatter of the low gain values is significantly smaller than the scatter of the high gain values. The regression coefficients only differ slightly ($R^2 = 0.58$ for the low gain data points, $R^2 = 0.62$ for the high gain data points, both excluding outliers).

Note that the linear regression can not reflect the fact that for a certain range of small natural gains the percentage of high stick speeds is close around 0%.



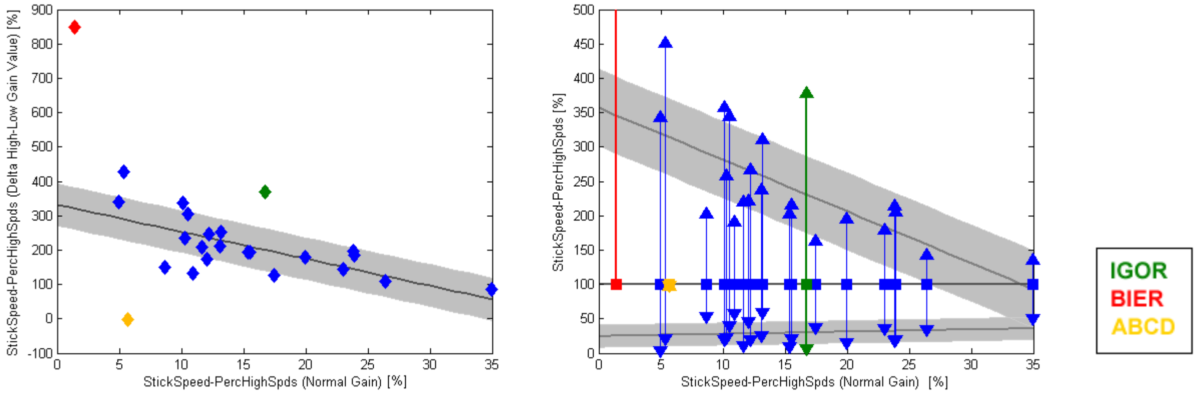
SSD [%]	R^2
7	0.30

	SSD [%]	R^2
Low Gain	2.5	0.58
High Gain	6.0	0.62

Figure 4-5: Pilot Gain Range Plots for the Percentage of High Stick Speeds

Figure 4-6 left shows the relative pilot gain range in percentage of the normal gain value of each pilot. The delta between the high and low gain value shows a scattered downward trend. The regression coefficient is poor, but significantly better than for the relative pilot gain range in terms of mean or RMS stick speed ($R^2 = 0.48$ excluding outliers).

The plot on the right shows the same trend. As for the RMS and mean stick speed, the regression coefficients are poor ($R^2 = 0.02$ for the low gain values, $R^2 = 0.51$ for the high gain values, both excluding outliers). The low gain data points (excluding outliers) are located close around 30% of the normal gain value for all pilots with only small scatter. There appears to be no dependency on the natural gain; the regression line is approximately a constant which also explains the very poor regression coefficient for the low gain data points.



SSD [%]	R²
61	0.48

	SSD [%]	R²
Low Gain	16	0.02
High Gain	56	0.51

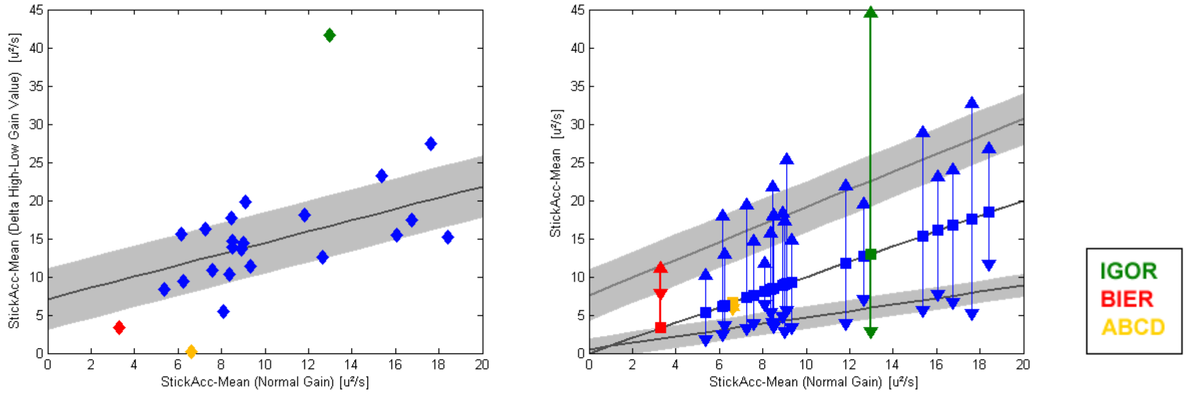
Figure 4-6: Relative Pilot Gain Range Plots for the Percentage of High Stick Speeds

4.4. Mean Stick Acceleration

The mean stick acceleration achieved a validity index of 0.92, was able to identify all 3 outliers and produced no ranking failure [6].

Figure 4-7 left shows the pilot gain range plots for the mean stick acceleration. The delta between the high and low gain value shows a scattered upward trend. The regression coefficient is poor ($R^2 = 0.36$ excluding outliers).

The same trend is reflected in Figure 4-7 right. The scatter of the low gain values is significantly smaller than the scatter of the high gain values. The regression coefficients only differ slightly ($R^2 = 0.58$ for the low gain data points, $R^2 = 0.66$ for the high gain data points, both excluding outliers).



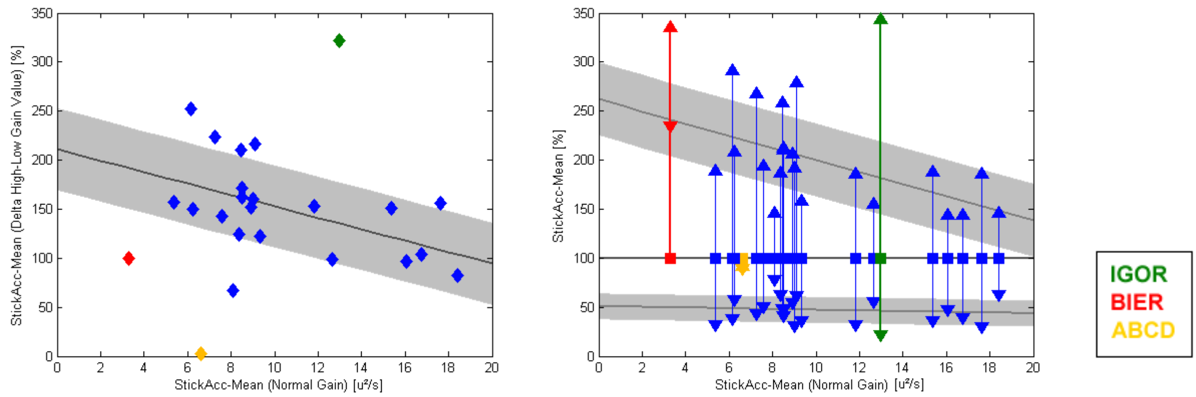
SSD [u/s²]	R^2
4.0	0.36

	SSD [u/s²]	R^2
Low Gain	1.4	0.58
High Gain	3.3	0.66

Figure 4-7: Pilot Gain Range Plots for the Mean Stick Acceleration

Figure 4-8 left shows the relative pilot gain range in percentage of the normal gain value of each pilot. The delta between the high and low gain value shows a scattered downward trend. The regression coefficient is poor ($R^2 = 0.24$ excluding outliers).

The plot on the right shows the same trend. The regression coefficients are poor ($R^2 = 0.01$ for the low gain values, $R^2 = 0.31$ for the high gain values, both excluding outliers). The low gain data points (excluding outliers) are located close around 47 % of the normal gain value for all pilots with only small scatter. There appears to be no dependency on the natural gain; the regression line is approximately a constant which also explains the very poor regression coefficient for the low gain data points.



SSD [%]	R²
13	0.24

	SSD [%]	R²
Low Gain	13	0.01
High Gain	37	0.31

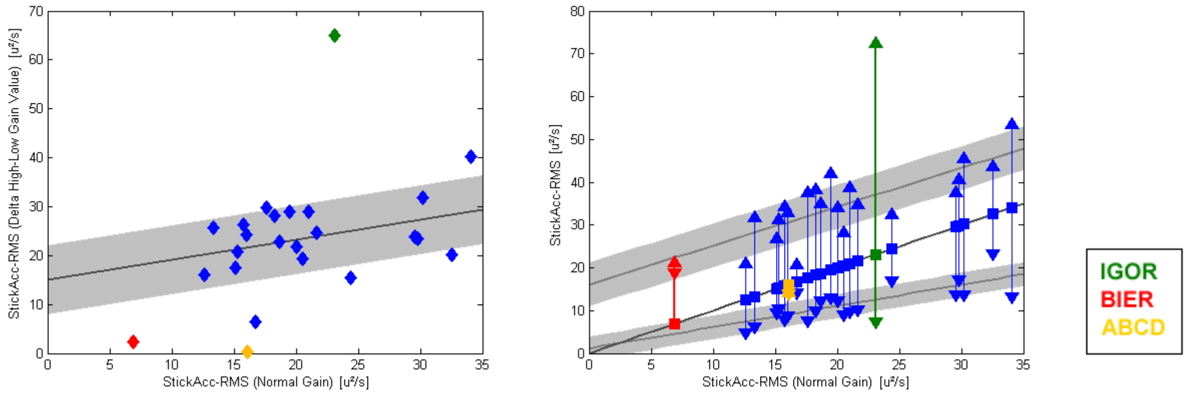
Figure 4-8: Relative Pilot Gain Range Plots for the Mean Stick Acceleration

4.5. RMS Stick Acceleration

The RMS stick acceleration achieved a validity index of 0.92, was able to identify all 3 outliers and produced no ranking failure [6].

Figure 4-9 left shows the pilot gain range plots for the RMS stick acceleration. The delta between the high and low gain value shows a scattered upward trend. The regression coefficient is poor ($R^2 = 0.15$ excluding outliers).

The same trend is reflected in Figure 4-9 right. The scatter of the low gain values is significantly smaller than the scatter of the high gain values. The regression coefficients are the same ($R^2 = 0.58$ for the low and high gain data points, both excluding outliers).



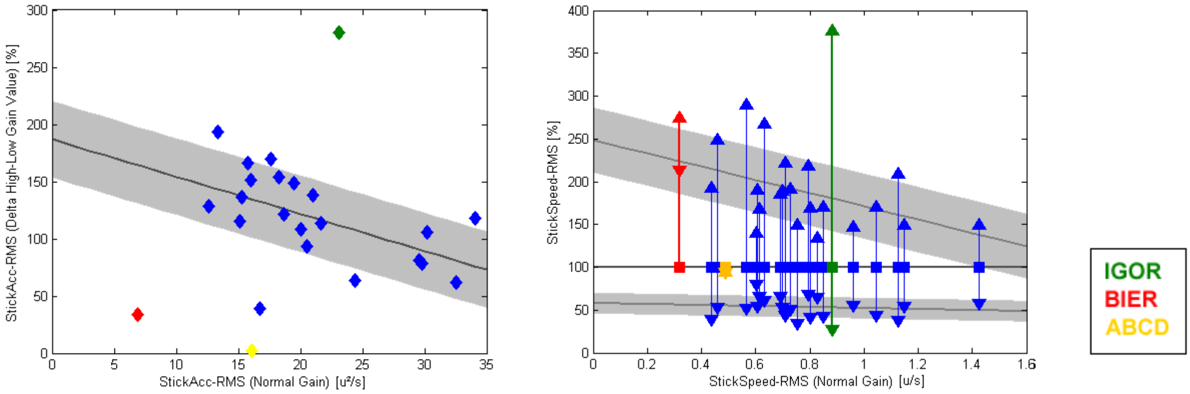
SSD [u/s²]	R²
6.9	0.15

	SSD [u/s²]	R²
Low Gain	2.7	0.58
High Gain	5.1	0.58

Figure 4-9: Pilot Gain Range Plots for the RMS Stick Acceleration

Figure 4-10 left shows the relative pilot gain range in percentage of the normal gain value of each pilot. The delta between the high and low gain value shows a scattered downward trend. The regression coefficient is poor ($R^2 = 0.29$ excluding outliers).

The plot on the right shows the same trend. The regression coefficients are poor ($R^2 < 0.01$ for the low gain values, $R^2 = 0.39$ for the high gain values, both excluding outliers). The low gain data points (excluding outliers) are located close around 55 % of the normal gain value for all pilots with only small scatter. There appears to be no dependency on the natural gain; the regression line is approximately a constant which also explains the very poor regression coefficient for the low gain data points.



SSD [%]	R^2
37	0.29

	SSD [%]	R^2
Low Gain	12	< 0.01
High Gain	27	0.39

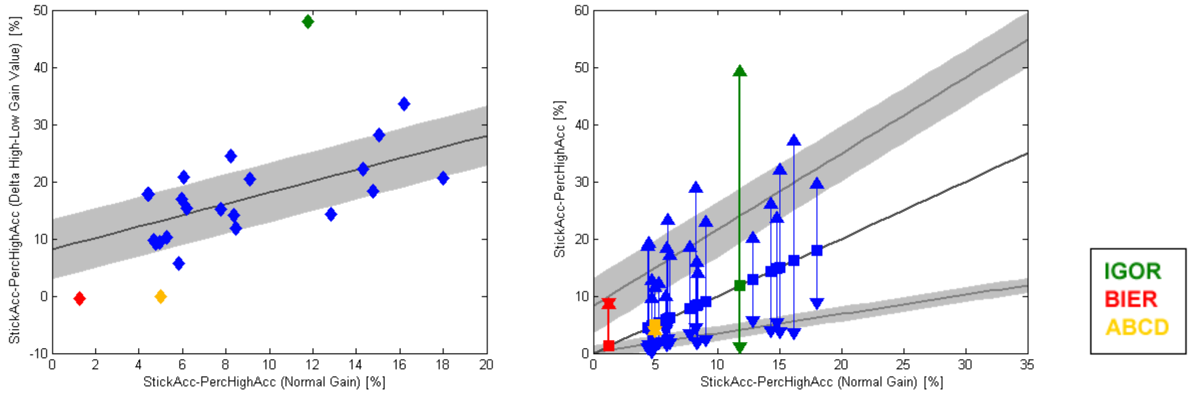
Figure 4-10: Relative Pilot Gain Range Plots for the RMS Stick Acceleration

4.6. Percentage of High Stick Accelerations

The percentage of high stick accelerations achieved a validity index of 0.92, was able to identify all 3 outliers and produced one ranking failure which was not extreme [6].

Figure 4-11 left shows the pilot gain range plots for the percentage of high stick accelerations. A high stick acceleration is defined as a stick acceleration exceeding 30 u/s² of the full stick movement in either direction with u being the unit of stick deflection ranging from ± 1 u for stop to stop inputs. The delta between the high and low gain value shows a scattered upward trend. The regression coefficient is poor, but better than the coefficient for the percentage of high stick speeds ($R^2 = 0.42$ excluding outliers).

The same trend is reflected in Figure 4-11 right. The scatter of the low gain values is significantly smaller than the scatter of the high gain values. The regression coefficients are about the same ($R^2 = 0.59$ for the low again data point, $R^2 = 0.60$ for the high gain data points, both excluding outliers).



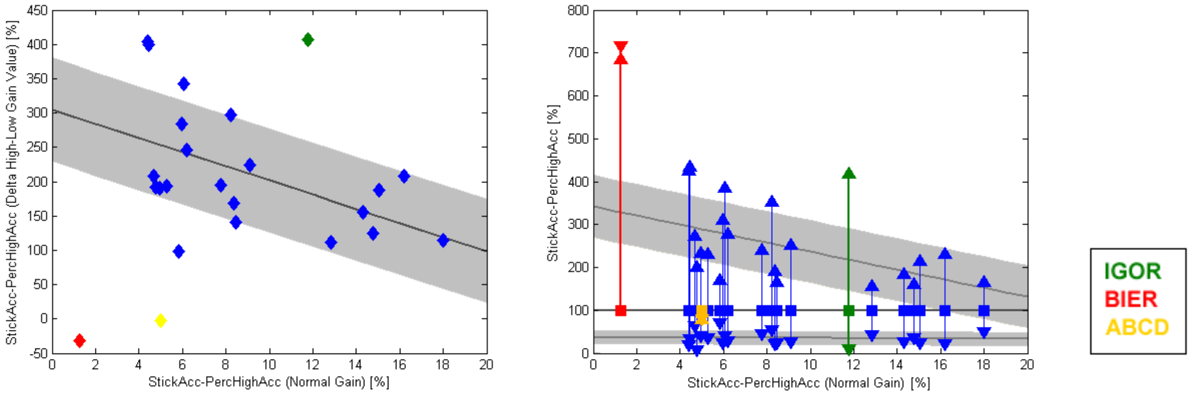
SSD [%	R²
5	0.42

	SSD [%]	R²
Low Gain	1	0.59
High Gain	5	0.60

Figure 4-11: Pilot Gain Range Plots for the Percentage of High Stick Accelerations

Figure 4-12 left shows the relative pilot gain range in percentage of the normal gain value of each pilot. The delta between the high and low gain value shows a scattered downward trend. The regression coefficient is poor ($R^2 = 0.29$ excluding outliers).

The plot on the right shows the same trend. The regression coefficients are poor ($R^2 < 0.01$ for the low gain values, $R^2 = 0.29$ for the high gain values, both excluding outliers). The low gain data points (excluding outliers) are located close around 36 % of the normal gain value for all pilots with only small scatter. There appears to be no dependency on the natural gain; the regression line is approximately a constant which also explains the very poor regression coefficient for the low gain data points.



SSD [%]	R^2
75	0.27

	SSD [%]	R^2
Low Gain	15	< 0.01
High Gain	73	0.29

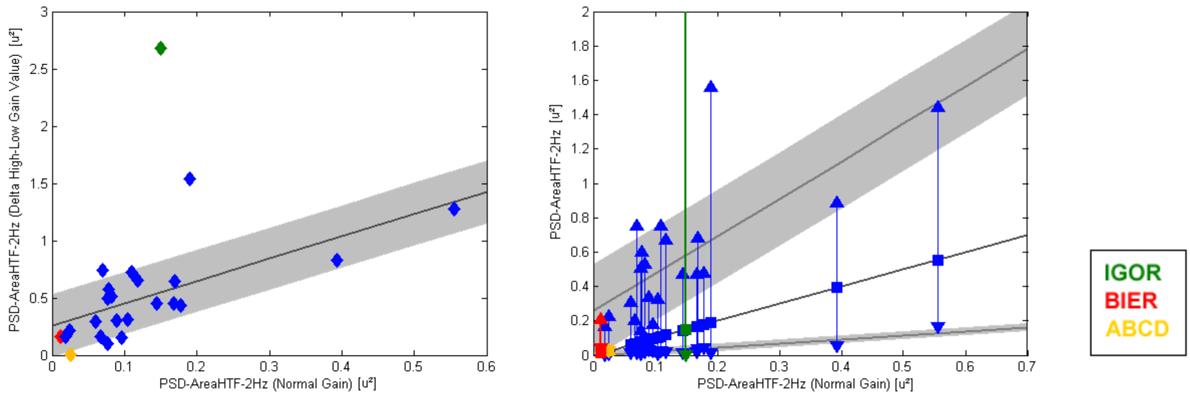
Figure 4-12: Relative Pilot Gain Range Plots for the Percentage of High Stick Accelerations

4.7. PSD Area (HTF – 2 Hz)

The PSD Area between the highest task frequency and 2 Hz achieved a validity index of 0.92, was able to identify all 3 outliers and produced no ranking failure [6].

Figure 4-13 left shows the pilot gain range plots for the PSD Area between the highest task frequency and 2 Hz. The delta between the high and low gain value shows a scattered upward trend with one significant outlier. The regression coefficient is poor ($R^2 = 0.27$ excluding outliers). All data points but two have normal gain values lower than 0.2 u². The two highest data points are around 0.39 u² and 0.56 u² and thus have a strong effect on the linear regression.

The same trend is reflected in Figure 4-13 right. The scatter of the low gain values is significantly smaller than the scatter of the high gain values. The regression coefficient is also better for the low gain values ($R^2 = 0.74$ for the low again data point, $R^2 = 0.60$ for the high gain data points, both excluding outliers). Most low gain values are close to 0 though, meaning that most pilots avoid inputs above the task frequency range when performing the tracking task in a low gain fashion. The linear regression can not fully cover this effect.



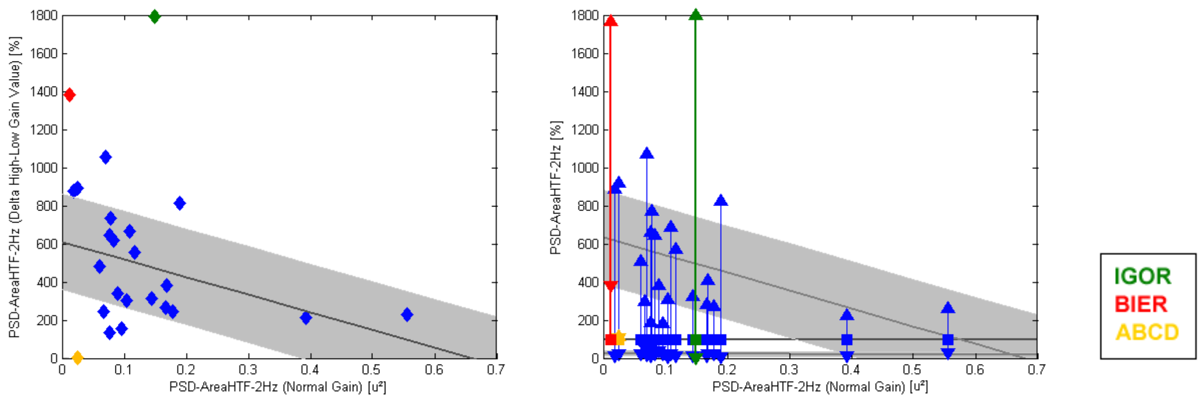
SSD [u²]	R²
0.27	0.44

	SSD [u²]	R²
Low Gain	0.02	0.74
High Gain	0.27	0.50

Figure 4-13: Pilot Gain Range Plots for the PSD Area HTF-2 Hz

Figure 4-14 left shows the relative pilot gain range in percentage of the normal gain value of each pilot. The delta between the high and low gain value shows a scattered downward trend. The regression coefficient is poor (R^2 = 0.17 excluding outliers). The trend is quite poor and mostly based on the two largest data points, while the other data points show no significant trend at all.

The plot on the right shows the same trend. The regression coefficients are poor (R^2 = 0.01 for the low gain values, R^2 = 0.18 for the high gain values, both excluding outliers). The low gain data points (excluding outliers) are located close around 24 % of the normal gain value for all pilots with only small scatter. There appears to be no dependency on the natural gain; the regression line is approximately a constant which also explains the very poor regression coefficient for the low gain data points.



SSD [%]	R²
251	0.17

	SSD [%]	R²
Low Gain	13	0.01
High Gain	246	0.18

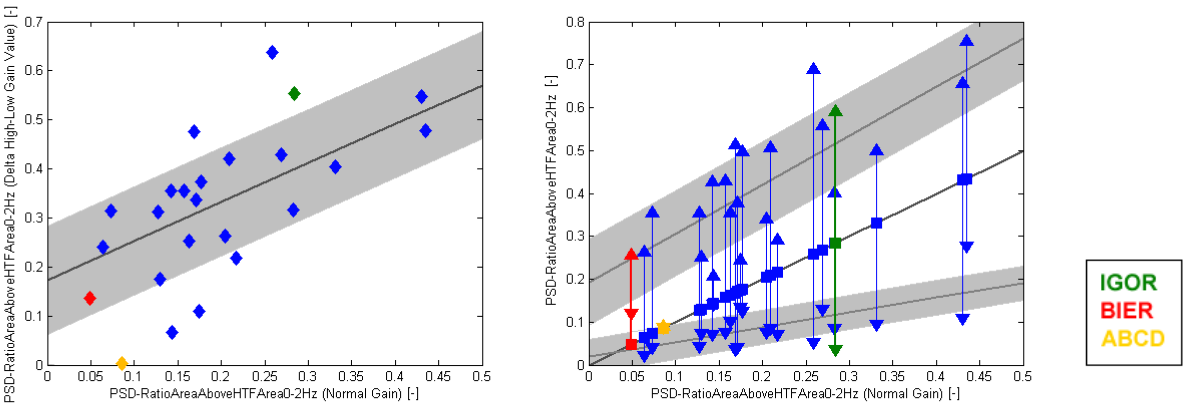
Figure 4-14: Relative Pilot Gain Range Plots for the PSD Area HTF-2 Hz

4.8. PSD Ratio Area (HTF - 2 Hz) vs. Area (0 - 2 Hz)

The ratio of the area between the highest task frequency and 2 Hz vs. the area between 0 and 2 Hz achieved a validity index of 0.92, was able to identify 2 out of 3 outliers and produced no ranking failure [6].

Figure 4-15 left shows the pilot gain range plots for the ratio of the area between the highest task frequency and 2 Hz vs. the area between 0 and 2 Hz. The delta between the high and low gain value shows a scattered upward trend with one significant outlier. The regression coefficient is poor ($R^2 = 0.33$ excluding outliers).

The same trend is reflected in Figure 4-15 right. The scatter of the low gain values is significantly smaller than the scatter of the high gain values. The regression coefficient is better for the high gain values ($R^2 = 0.56$ for the low again data point, $R^2 = 0.39$ for the high gain data points, both excluding outliers).



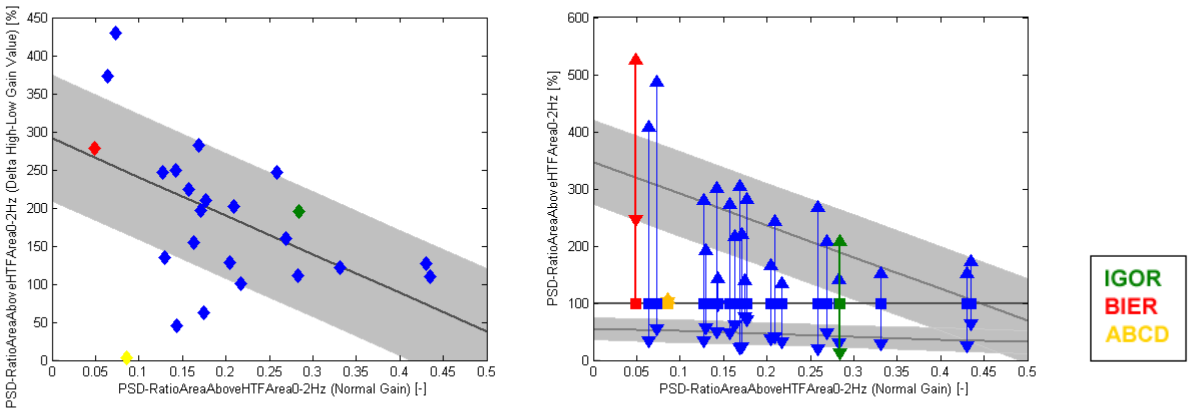
SSD [-]	R²
0.11	0.33

	SSD [-]	R²
Low Gain	0.04	0.39
High Gain	0.10	0.56

Figure 4-15: Pilot Gain Range Plots for the PSD Area Ratio (HTF-2Hz) vs. (0 – 2 Hz)

Figure 4-16 left shows the relative pilot gain range in percentage of the normal gain value of each pilot. The delta between the high and low gain value shows a scattered downward trend. The regression coefficient is poor ($R^2 = 0.27$ excluding outliers).

The plot on the right shows the same trend. The regression coefficients are poor ($R^2 = 0.05$ for the low gain values, $R^2 = 0.36$ for the high gain values, both excluding outliers). The low gain data points (excluding outliers) are located close around 46 % of the normal gain value for all pilots with only small scatter. There appears to be no dependency on the natural gain; the regression line is approximately a constant which also explains the very poor regression coefficient for the low gain data points.



SSD [%]	R²
82	0.27

	SSD [%]	R²
Low Gain	20	0.05
High Gain	74	0.36

Figure 4-16: Relative Pilot Gain Range Plots for the PSD Area HTF-2 Hz

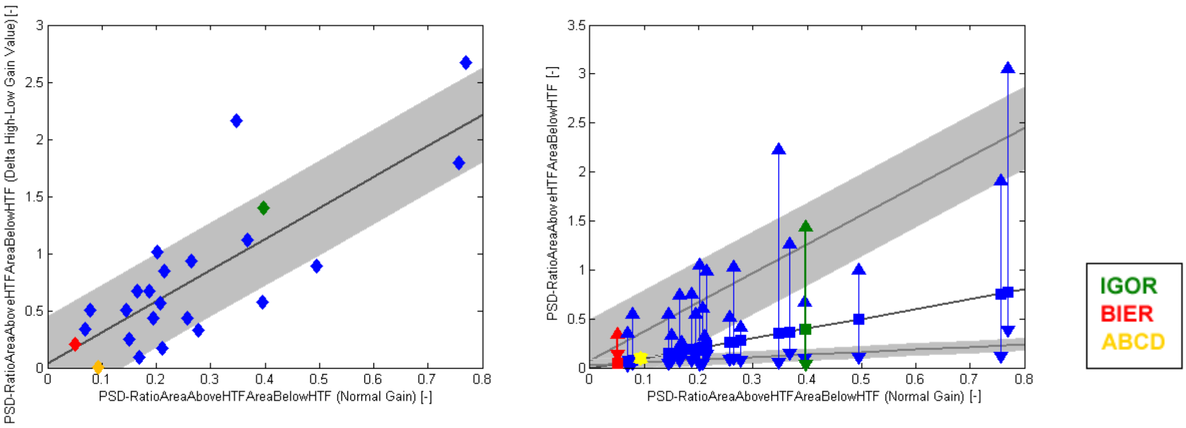
4.9. PSD Ratio Area (HTF - 2 Hz) vs. Area (0 Hz - HTF)

The ratio of the area above vs. the area below the highest task frequency achieved a validity index of 0.92, was able to identify 2 out of 3 outliers and produced no ranking failure [6].

Figure 4-17 left shows the pilot gain range plots for the ratio of the area between the highest task frequency and 2 Hz vs. the area between 0 and 2 Hz. The delta between the high and low gain value shows a scattered upward trend with one significant outlier. The regression coefficient is poor, but significantly higher than for other measures ($R^2 = 0.61$ excluding outliers). The two data points with the highest normal gain value have a strong influence on the regression coefficient which would be much worse without them ($R^2 = 0.23$).

The same trend is reflected in Figure 4-17 right. The scatter of the low gain values is significantly smaller than the scatter of the high gain values. The regression coefficient is better for the high gain values ($R^2 = 0.42$ for the low again data point, $R^2 = 0.64$ for the high gain data points, both excluding outliers).

As the low gain PSD area between the highest task frequency and 2 Hz was around 0 for many pilots, this PSD ratio is close to 0 for the low gain data points as well.



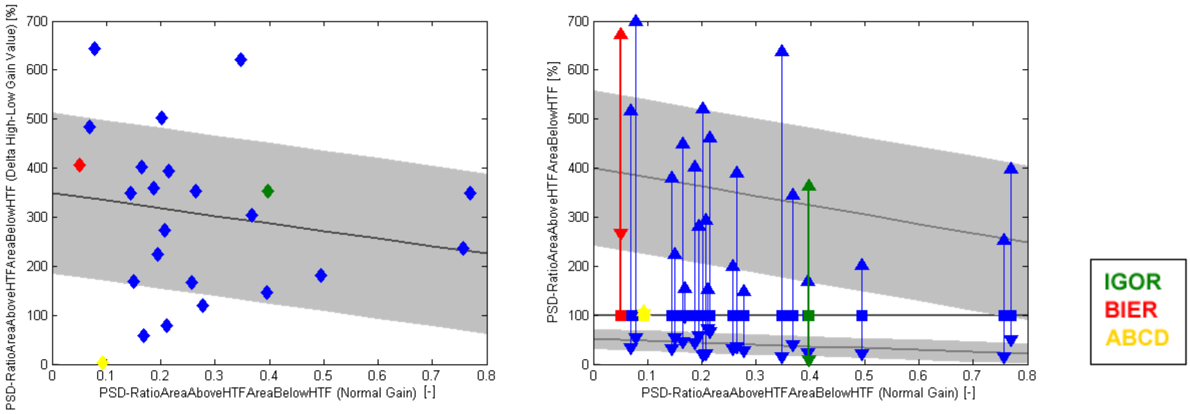
SSD [-]	R^2
0.41	0.61

	SSD [-]	R^2
Low Gain	0.06	0.42
High Gain	0.42	0.64

Figure 4-17: Pilot Gain Range Plots for the PSD Area Ratio (HTF-2Hz) vs. (0 Hz-HTF)

Figure 4-18 left shows the relative pilot gain range in percentage of the normal gain value of each pilot. The delta between the high and low gain value shows no significant trend even when the outliers are excluded. The regression line is strongly influenced by two data points with a high normal gain value.

The plot on the right shows the same trend. The regression coefficients are poor (R^2 = 0.10 for the low gain values, R^2 = 0.01 for the high gain values, both excluding outliers). The scatter of the high gain data points is excessive. The low gain data points (excluding outliers) are located close around 41 % of the normal gain value for all pilots with only small scatter. There appears to be no dependency on the natural gain; the regression line is approximately a constant which also explains the very poor regression coefficient for the low gain data points.



SSD [%]	R^2
163	0.03

	SSD [%]	R^2
Low Gain	20	0.10
High Gain	157	0.01

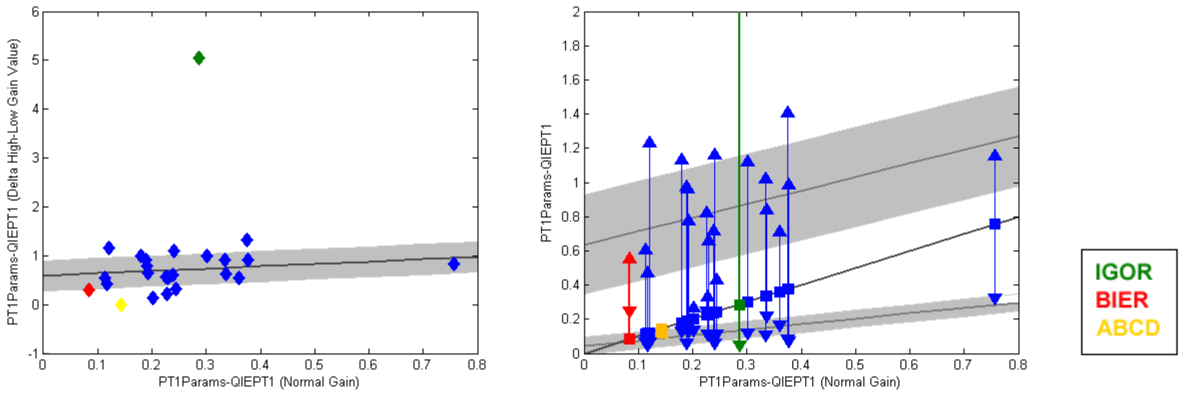
Figure 4-18: Relative Pilot Gain Range Plots for the PSD Area Ratio (HTF-2Hz) vs. (0 Hz-HTF)

4.10. Goodness of Fit of PT1 pilot model (QIE)

The model fit in terms of QIE achieved a validity index of 0.88, was able to identify all outliers and produced one ranking failure which was not extreme [6].

Figure 4-19 left shows the pilot gain range plots for the ratio model fit in terms of QIE. The delta between the high and low gain value shows a scattered upward trend with one significant outlier for pilot IGOR. Note that the location of this outlier significantly distorts the graph and creates the impression of low scatter which is actually not the case. The regression coefficient is very poor ($R^2 = 0.04$ excluding outliers). It is also strongly affected by one singular data point with a very high normal gain value.

The same trend is reflected in Figure 4-19 right. The scatter of the low gain values is significantly smaller than the scatter of the high gain values. The trend towards increasing pilot gain range with increasing normal gain values is hardly visible in this graph. The regression coefficient is better for the high gain values ($R^2 = 0.05$ for the low again data point, $R^2 = 0.29$ for the high gain data points, both excluding outliers).



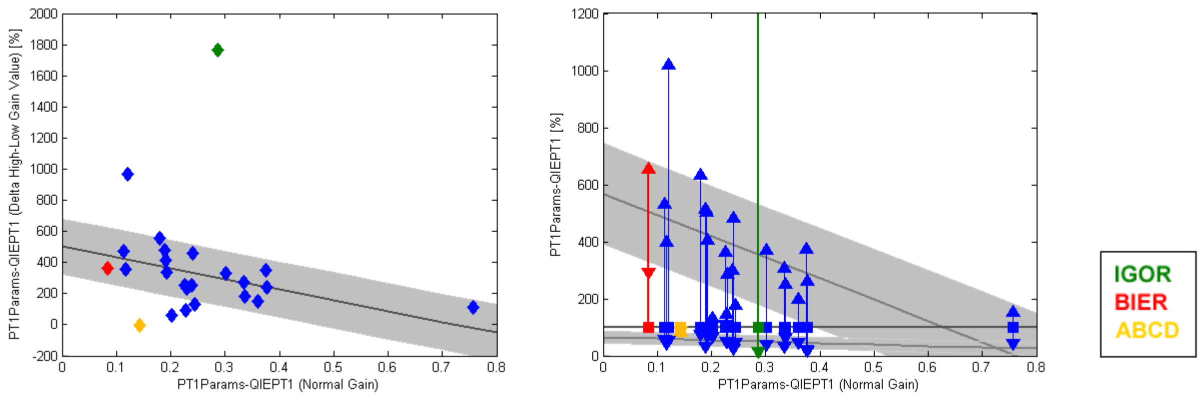
SSD [-]	R^2
0.31	0.04

	SSD [-]	R^2
Low Gain	0.06	0.05
High Gain	0.42	0.29

Figure 4-19: Pilot Gain Range Plots for the PT1 Model Fit in Terms of QIE

Figure 4-20 left shows the relative pilot gain range in percentage of the normal gain value of each pilot. The delta between the high and low gain value shows a scattered downward trend. The regression coefficient is poor ($R^2 = 0.22$ excluding outliers).

The plot on the right shows the same trend. The regression coefficients are poor ($R^2 = 0.10$ for the low gain values, $R^2 = 0.25$ for the high gain values, both excluding outliers). The low gain data points (excluding outliers) are located close around 52 % of the normal gain value for all pilots with only small scatter. There appears to be no dependency on the natural gain; the regression line is approximately a constant which also explains the very poor regression coefficient for the low gain data points.



SSD [-]	R^2
179	0.22

	SSD [-]	R^2
Low Gain	21	0.10
High Gain	176	0.25

Figure 4-20: Pilot Gain Range Plots for the PT1 Model Fit in Terms of QIE

5. Conclusions and Limitations

5.1. Absolute Pilot Gain Range

The absolute pilot gain range data shows a clear increase in absolute pilot gain range with increasing normal pilot gain. This means that a typical high gain pilot is able to vary his pilot gain more than a typical low gain pilot.

Both, the data points performed intentionally in a low and high gain manner, increase with increasing normal gain. A typical high gain pilot thus does not only have a higher normal gain value, but also higher low and high gain values than a low gain pilot. The increase is more pronounced for the high gain data points than for the low gain data points. This means that the difference between a typical low and high gain pilot is not as prominent for test points which are performed intentionally in a low gain manner, but for high gain test points the difference is quite striking. The latter effect is well in line with the experience from flight test that high gain pilots are able to uncover PIO tendencies which couldn't be found by low gain pilots.

5.2. Relative Pilot Gain Range

The relative pilot gain range data shows a clear decrease in relative pilot gain range with increasing normal gain. This means that a typical low gain pilot is able to increase his pilot gain by a higher percentage than a high gain pilot. This trend is probably a result of the already high normal gain value for high gain pilots. It is easier to double a low normal gain value than to double a normal gain value which is naturally already close to the limits of system stability.
While the high gain data points show a clear decreasing percentage with increasing normal gain, the low gain data points are at an approximately constant value for nearly all pilot gain measures.

Pilot Gain Measure	**Low Gain Value: Percentage of Normal Gain Value**
Mean Stick Speed [u/s]	47%
RMS Stick Speed [u/s]	53%
Percentage of High Stick Speeds [%]	30%
Mean Stick Acceleration [u/s²]	47%
RMS Stick Acceleration [u/s²]	55%
Percentage of High Stick Accelerations [u/s²]	36%
PSD Area HTF-2 Hz [u²]	24%
PSD Ratio Area (HTF - 2 Hz) vs. Area (0 - 2 Hz) [-]	46%
PSD Ratio Area (HTF - 2 Hz) vs. Area (0 Hz - HTF) [-]	41%
QIE of PT1 Pilot Model [-]	52%

Tabelle 5-1: Low Gain Values: Percentage of Normal Gain Value

5.3. Significance of the Results

The trends described above apply for nearly all presented measures. This is another confirmation for the right choice of valid pilot gain measures in [6].

Exceptions are the relative pilot gain plot of the PSD Area (HTF – 2 Hz), the PSD Ratio Area (HTF - 2 Hz) vs. Area (0 Hz - HTF) and the PSD Ratio Area (HTF - 2 Hz) vs. Area (0 Hz - HTF), mainly because the PSD Area (HTF – 2 Hz) which is always involved in these plots is very low for the normal gain test points of many pilots, thus creating a very low value used for normalization in the relative pilot gain plots. As a consequence, a small difference in the high gain data points can make quite a big difference in terms of percentage.

Another exception is presented by the QIE of the PT1 pilot model as a representation of the pilot model's goodness of fit. While the relative plot is well in line with the trends of other pilot gain measures, the absolute pilot gain plots hardly show any trend for the pilot gain range with increasing normal gain values. In general, pilot gain measures which depend on assumptions – like in this case the applicability of a certain pilot model – should be avoided.

5.4. Limitations

5.4.1. Predictive Ability for Individual Pilots

In all cases significant scatter is visible in the pilot gain range plots and the regression coefficients are rather poor. The plots therefore have no predictive ability for individual pilots and only show a trend for a larger population of pilots.

One of the reasons for this is that a pilot's control behavior is a complex matter and cannot be limited to a classification of pilots as high, medium and low gain pilots.

A good example is given by one of the participants. As an F-4 pilot he was expected to be more on the high gain side. His normal and low gain data points were, however, performed with rather low to medium pilot gain. His high gain data point was quite high though. During the debriefing this pilot commented that even though he is an F-4 pilot, he was originally trained as a glider pilot at a very young age. As his instructor always taught him to fly low gain - which is most reasonable for gliders - he still prefers this way of flying today. But being an F-4 pilot, of course he also has to have the ability to fly in a very aggressive manner when this is required. This background led to a relatively high pilot gain range even though his normal gain was rather low.

As each and every pilot is different and so is his or her background, no general predictions for the individual pilot gain range can be made based on simple classifications as low, medium or high gain pilot.

5.4.2. Limitations of the Database

The presented results are based on a single simulator study with one single type of aircraft dynamic and inceptor. In order to generalize the results, they should be repeated in different scenarios and preferably also in flight test.

5.4.3. Limitation to Sum of Sines Tasks

The applicability of the results should at first be limited to sum of sines tasks. Other types of tasks like steps and ramps may create different results and/or make it hard to quantify pilot gain in general since – for the example of a step and ramp task – the pilot switches from capture/acquisition to maintenance/fine tracking during the task.

Summary and Outlook

This report summarizes the investigation and results from an evaluation of the pilot gain range and how it is related to the pilot's natural gain. The evaluation is based on data from a simulator study which was performed with 12 experimental test pilots and 12 operational pilots who intentionally varied their pilot gain / aggressiveness during a closed-loop tracking task.

The results of this report can be summarized as follows:

- The absolute pilot gain range increases with increasing natural pilot gain.
- The relative pilot gain range decreases with increasing natural pilot gain.
- A typical high gain pilot has higher low and higher high gain values than a typical low gain pilot. The difference is more pronounced for the high gain test points.
- The low gain value is approximately a fixed percentage of the normal gain value.

Even though the trends are quite consistent over various pilot gain measures, all pilot gain range plots show significant scatter and the trends have poor regression coefficients. The results thus do not allow the prediction of an individual pilot's abilities. They rather show a trend for a larger population of pilots. A pilot's control behavior is too complex to be narrowed down to a simple classification as low, medium or high gain pilot. A good example for this was given by a fighter pilot who started off as a glider pilot at young age and therefore had a low natural gain, but a high pilot gain range.

The high consistency of the general trends with respect to the pilot gain range for various pilot gain measures raises the question how these measures correlate. A report covering the mathematic relations between different pilot gain measures in terms of regressions and scatter plots is planned.

Also, a report about pilot-dependent values (e.g. personality traits, but also mathematic measures) and their relation towards the pilots' natural pilot gain is planned.

References

ID	Author	Title
[1]	Clauß, G. Finze, F.-R. Partzsch, L.	Statistik Grundlagen, Verlag Harri Deutsch, 4. Auflage, 2002, ISBN 3-8171-1672-1 *(statistics book used as reference for K-S test, in German)*
[2]	Field, E.J., Giese, S.E.D.	Appraisal of Several Pilot Control Activity Measures. AIAA Atmospheric Flight Mechanics Conference and Exhibit, San Francisco, CA, AIAA 2005-6032 (2005)
[3]	Gray, W.R.	A Boundary Avoidance Tracking Flight Test Technique for Performance and Workload Assessment. 38th Symposium of the Society of Experimental Test Pilots, San Diego, CA (2007)
[4]	Gray, W.R.	A Generalized Handling Qualities Flight Test Technique Utilizing Boundary Avoidance Tracking, U.S. Air Force T&E Days, Los Angeles, CA, AIAA 2008-1648 (2008)
[5]	Neal, T.P. Smith, R.E.	A Flying Qualities Criterion for the Design of Fighter Flight Control Systems. Journal of Aircraft, Volume 8, Number 10, 1971
[6]	Niewind	Pilot Gain and the Workload Buildup Flight Test Technique: Validation of Potential Pilot Gain Measures. IB 111-2012/61 (2012)
[7]	Niewind, I.	Pilot Gain and the Workload Buildup Flight Test Technique: Test Conduction and Evaluation Strategy. IB 111-2012/51 (2012)
[8]	Niewind, I.	What the Hell is Pilot Gain? SFTE Symposium, Seattle (2011)
[9]	Opel, F.	Investigations on the Workload-Buildup Flight Test Technique: Dynamics, Displays and Task Variations. Master Thesis, German Aerospace Center, Institute of Flight Systems, IB 111-2012/40 and TH Wildau, Aeronautical Engineering, Reg. Nr. LLM09/17/SS2011 (2012)

Appendix: Kolmogorow-Smirnow Test

Normally distributed residuals are a prerequisite for the mathematically correct application of the linear regression and the calculation of the sample standard deviation around the regression.

The normal distribution was evaluated by means of a Kolmogorow-Smirnow test, also known as K-S test. This test is not specifically limited to the analysis of a normal distribution but can be used to compare any two kinds of data sets.

The K-S test is based on a comparison of a test statistic with a critical value. The test statistic must be smaller than the critical value, which is 0.28724 for the K-S test with $\alpha = 0.05$.

The largest test statistic is 0.227, the second largest is 0.209. The test would thus also pass for $\alpha = 0.10$ (critical value: 0.25858) and for $\alpha = 0.20$ overall only one test would fail (critical value: 0.22617).

The K-S test was performed in Excel.

Null hypothesis H_0: The residuals are normally distributed around zero.

Alternative H_1: The residuals are not normally distributed around zero.

The data is sorted in ascending order, given an index i starting with 1 for the lowest values and the residuals x_i are normalized to the form of a standard normal distribution:

$$u_i = \frac{x_i - \mu}{\sigma}$$

with u_i being the equivalent value of x_i in a normal distribution, μ is the mean value which is by definition zero for the residuals of a linear regression and σ is the sample standard deviation of the data, calculated as follows:

$$\sigma = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \mu)^2} \; .$$

with n being the number of data points under consideration.

Note that while strictly speaking σ is the population standard deviation and calculated with a factor of 1/n instead of 1/(n-1), many statistics books, including the one consulted for the K-S test in this report [1], use σ also in cases when the sample standard deviation (normally denoted with the letter s) is applied.

The equivalent distribution value of the normal distribution is calculated for all normalized values of the residuals u_i. These values are denoted with the greek letter Φ. They represent the statistical percentage of data points which should theoretically be smaller or equal to the associated normalized residual x_i. For a low x_i this value is close to 0, for a high x_i it is close to 1.

In a next step, the discrete computation points of the empirical distribution function are calculated by dividing the index of each normalized residual by the number of data points (i/n).

The delta between the normal distribution and the empirical distribution function is now calculated. As the empirical distribution function jumps right at the discrete values i/n, the delta is calculated for both, index i and index i-1 of the empirical distribution function. The test statistic is the supremum of all evaluated deltas.

$$\sup\left[\Phi(u_i) - \frac{i}{n}; \quad \Phi(u_i) - \frac{i-1}{n}\right]$$

An example with the test data of the RMS stick speed is given in Figure A-1 below. The empirical distribution grows by a fixed value (i/n) with each element of x_i. Depending on the distribution of the residuals x_i, the empirical distribution is more or less similar to the normal distribution. The limits for $\alpha = 0.05$ (95% limits) are shown as additional information.

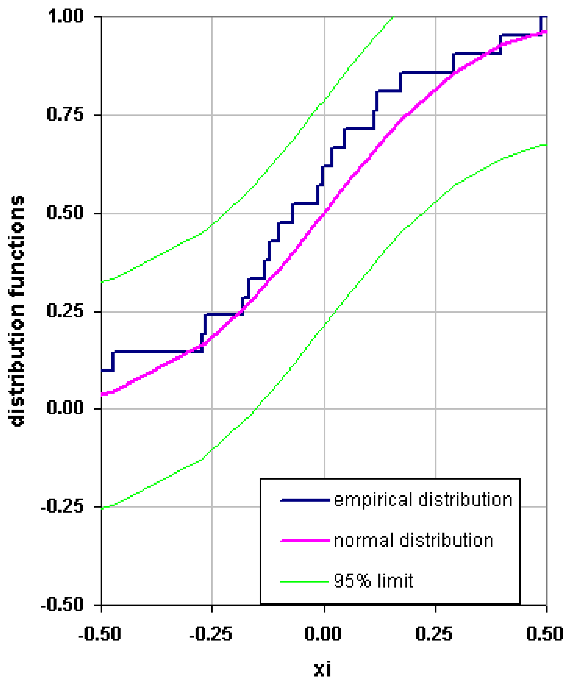


Figure A-1: Demonstration of the Principle of the K-S test

Note that the K-S test compares a discrete function (empirical distribution) with a continuous function (normal distribution).

The following pages show the calculations of the K-S test for all evaluated pilot gain measures.

Mean Stick Speed

Residuals (High - Low Gain)

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.355	-1.720	0.043	0.048	0.005	0.043
2	-0.240	-1.166	0.122	0.095	0.027	0.074
3	-0.216	-1.048	0.147	0.143	0.004	0.052
4	-0.190	-0.922	0.178	0.190	0.012	0.035
5	-0.180	-0.871	0.192	0.238	0.046	0.001
6	-0.158	-0.764	0.222	0.286	0.063	0.016
7	-0.136	-0.659	0.255	0.333	0.078	0.031
8	-0.097	-0.469	0.319	0.381	0.062	0.014
9	-0.092	-0.446	0.328	0.429	0.101	0.053
10	-0.033	-0.160	0.436	0.476	0.040	0.008
11	-0.002	-0.008	0.497	0.524	0.027	0.021
12	0.022	0.106	0.542	0.571	0.029	0.019
13	0.046	0.225	0.589	0.619	0.030	0.017
14	0.062	0.299	0.618	0.667	0.049	0.002
15	0.064	0.310	0.622	0.714	0.093	0.045
16	0.075	0.365	0.643	0.762	0.119	0.072
17	0.179	0.866	0.807	0.810	0.003	0.045
18	0.216	1.048	0.853	0.857	0.004	0.043
19	0.238	1.156	0.876	0.905	0.029	0.019
20	0.295	1.431	0.924	0.952	0.029	0.019
21	0.501	2.428	0.992	1.000	0.008	0.040
μ	0.000				sup(D1, D2)	0.119
σ	0.206				Critical Value	0.287

Nom Dist OK

Residuals (High - Low Gain), Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-98.318	-2.155	0.016	0.048	0.032	0.016
2	-59.689	-1.308	0.095	0.095	0.000	0.048
3	-53.279	-1.168	0.121	0.143	0.021	0.026
4	-44.014	-0.965	0.167	0.190	0.023	0.024
5	-28.528	-0.625	0.266	0.238	0.028	0.075
6	-27.686	-0.607	0.272	0.286	0.014	0.034
7	-26.208	-0.574	0.283	0.333	0.050	0.003
8	-8.625	-0.189	0.425	0.381	0.044	0.092
9	-6.785	-0.149	0.441	0.429	0.012	0.060
10	-6.231	-0.137	0.446	0.476	0.031	0.017
11	0.007	0.000	0.500	0.524	0.024	0.024
12	2.542	0.056	0.522	0.571	0.049	0.002
13	3.272	0.072	0.529	0.619	0.090	0.043
14	8.765	0.192	0.576	0.667	0.090	0.043
15	13.204	0.289	0.614	0.714	0.100	0.053
16	28.306	0.620	0.733	0.762	0.029	0.018
17	37.628	0.825	0.795	0.810	0.014	0.033
18	43.811	0.960	0.832	0.857	0.026	0.022
19	62.628	1.373	0.915	0.905	0.010	0.058
20	69.829	1.531	0.937	0.952	0.015	0.032
21	89.427	1.960	0.975	1.000	0.025	0.023
μ	0.000				sup(D1, D2)	0.100
σ	45.624				Critical Value	0.287

Nom Dist OK

Residuals Low Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.111	-1.893	0.029	0.048	0.018	0.029
2	-0.092	-1.562	0.059	0.095	0.036	0.011
3	-0.065	-1.107	0.134	0.143	0.009	0.039
4	-0.059	-1.013	0.156	0.190	0.035	0.013
5	-0.045	-0.773	0.220	0.238	0.018	0.029
6	-0.024	-0.406	0.342	0.286	0.056	0.104
7	-0.023	-0.386	0.350	0.333	0.016	0.064
8	-0.021	-0.355	0.361	0.381	0.020	0.028
9	-0.015	-0.263	0.396	0.429	0.032	0.015
10	-0.013	-0.224	0.411	0.476	0.065	0.017
11	-0.005	-0.079	0.469	0.524	0.055	0.008
12	-0.001	-0.025	0.490	0.571	0.081	0.034
13	0.011	0.184	0.573	0.619	0.046	0.002
14	0.016	0.265	0.605	0.667	0.062	0.015
15	0.024	0.414	0.661	0.714	0.054	0.006
16	0.029	0.500	0.692	0.762	0.070	0.023
17	0.042	0.716	0.763	0.810	0.046	0.001
18	0.059	1.001	0.842	0.857	0.016	0.032
19	0.077	1.311	0.905	0.905	0.000	0.048
20	0.105	1.788	0.963	0.952	0.011	0.058
21	0.111	1.898	0.971	1.000	0.029	0.019
μ	0.000				sup(D1, D2)	0.104
σ	0.059				Critical Value	0.287

Nom Dist OK

Residuals Low Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-17.067	-1.296	0.097	0.048	0.050	0.097
2	-16.383	-1.244	0.107	0.095	0.011	0.059
3	-15.928	-1.210	0.113	0.143	0.030	0.018
4	-15.634	-1.187	0.118	0.190	0.073	0.025
5	-10.874	-0.826	0.204	0.238	0.034	0.014
6	-7.534	-0.572	0.284	0.286	0.002	0.045
7	-7.037	-0.534	0.297	0.333	0.037	0.011
8	-6.699	-0.509	0.305	0.381	0.076	0.028
9	-5.790	-0.440	0.330	0.429	0.099	0.051
10	-3.607	-0.274	0.392	0.476	0.084	0.037
11	-1.425	-0.108	0.457	0.524	0.067	0.019
12	-0.887	-0.067	0.473	0.571	0.098	0.051
13	2.021	0.153	0.561	0.619	0.058	0.010
14	3.790	0.288	0.613	0.667	0.053	0.006
15	4.130	0.314	0.623	0.714	0.091	0.044
16	6.063	0.461	0.677	0.762	0.084	0.037
17	9.372	0.712	0.762	0.810	0.048	0.000
18	13.893	1.055	0.854	0.857	0.003	0.045
19	14.559	1.106	0.866	0.905	0.039	0.008
20	25.160	1.911	0.972	0.952	0.020	0.067
21	29.871	2.269	0.988	1.000	0.012	0.036
μ	0.000				sup(D1, D2)	0.099
σ	13.166				Critical Value	0.287

Nom Dist OK

Residuals High Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.243	-1.364	0.086	0.048	0.039	0.086
2	-0.211	-1.183	0.118	0.095	0.023	0.071
3	-0.169	-0.946	0.172	0.143	0.029	0.077
4	-0.151	-0.849	0.198	0.190	0.008	0.055
5	-0.148	-0.830	0.203	0.238	0.035	0.013
6	-0.139	-0.780	0.218	0.286	0.068	0.020
7	-0.118	-0.660	0.255	0.333	0.079	0.031
8	-0.112	-0.625	0.266	0.381	0.115	0.067
9	-0.099	-0.554	0.290	0.429	0.139	0.091
10	-0.034	-0.193	0.423	0.476	0.053	0.005
11	-0.028	-0.156	0.438	0.524	0.086	0.038
12	-0.006	-0.035	0.486	0.571	0.085	0.038
13	0.009	0.049	0.520	0.619	0.099	0.052
14	0.010	0.058	0.523	0.667	0.144	0.096
15	0.031	0.173	0.569	0.714	0.146	0.098
16	0.039	0.218	0.586	0.762	0.175	0.128
17	0.171	0.957	0.831	0.810	0.021	0.069
18	0.254	1.424	0.923	0.857	0.066	0.113
19	0.271	1.520	0.936	0.905	0.031	0.079
20	0.284	1.590	0.944	0.952	0.008	0.039
21	0.389	2.183	0.985	1.000	0.015	0.033
μ	0.000				sup(D1, D2)	0.175
σ	0.178				Critical Value	0.287

Nom Dist OK

Residuals High Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-68.453	-1.678	0.047	0.048	0.001	0.047
2	-53.631	-1.315	0.094	0.095	0.001	0.047
3	-43.326	-1.062	0.144	0.143	0.001	0.049
4	-38.726	-0.949	0.171	0.190	0.019	0.028
5	-30.127	-0.739	0.230	0.238	0.008	0.040
6	-24.405	-0.598	0.275	0.286	0.011	0.037
7	-24.194	-0.593	0.277	0.333	0.057	0.009
8	-13.801	-0.338	0.368	0.381	0.013	0.034
9	-9.518	-0.233	0.408	0.429	0.021	0.027
10	-8.338	-0.204	0.419	0.476	0.057	0.010
11	-8.216	-0.201	0.420	0.524	0.104	0.056
12	-3.606	-0.088	0.465	0.571	0.107	0.059
13	-3.185	-0.078	0.469	0.619	0.150	0.103
14	2.969	0.073	0.529	0.667	0.138	0.090
15	3.134	0.077	0.531	0.714	0.184	0.136
16	21.263	0.521	0.699	0.762	0.063	0.015
17	37.107	0.910	0.819	0.810	0.009	0.057
18	53.895	1.321	0.907	0.857	0.050	0.097
19	62.781	1.539	0.938	0.905	0.033	0.081
20	66.413	1.628	0.948	0.952	0.004	0.043
21	81.887	2.007	0.978	1.000	0.022	0.025
μ	0.000				sup(D1, D2)	0.184
σ	40.791				Critical Value	0.287

Nom Dist OK

RMS Stick Speed

Residuals (High - Low Gain)

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.529	-1.792	0.037	0.048	0.011	0.037
2	-0.472	-1.599	0.055	0.095	0.040	0.007
3	-0.270	-0.917	0.180	0.143	0.037	0.084
4	-0.264	-0.893	0.186	0.190	0.005	0.043
5	-0.180	-0.612	0.270	0.238	0.032	0.080
6	-0.168	-0.571	0.284	0.286	0.002	0.046
7	-0.131	-0.444	0.328	0.333	0.005	0.043
8	-0.121	-0.410	0.341	0.381	0.040	0.008
9	-0.101	-0.341	0.366	0.429	0.062	0.015
10	-0.070	-0.236	0.407	0.476	0.069	0.022
11	-0.011	-0.037	0.485	0.524	0.038	0.009
12	-0.003	-0.012	0.495	0.571	0.076	0.028
13	0.019	0.064	0.525	0.619	0.094	0.046
14	0.047	0.161	0.564	0.667	0.103	0.055
15	0.113	0.382	0.649	0.714	0.065	0.018
16	0.121	0.409	0.659	0.762	0.103	0.055
17	0.174	0.591	0.723	0.810	0.087	0.039
18	0.292	0.992	0.839	0.857	0.018	0.030
19	0.399	1.352	0.912	0.905	0.007	0.055
20	0.488	1.654	0.951	0.952	0.001	0.046
21	0.667	2.261	0.988	1.000	0.012	0.036
μ	0.000				**sup(D1, D2)**	0.103
σ	0.295				**Critical Value**	0.287

Nom Dist OK

Residuals (High - Low Gain), Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-88.158	-2.130	0.017	0.048	0.031	0.017
2	-62.039	-1.499	0.067	0.095	0.028	0.019
3	-45.101	-1.090	0.138	0.143	0.005	0.043
4	-30.619	-0.740	0.230	0.190	0.039	0.087
5	-22.324	-0.539	0.295	0.238	0.057	0.104
6	-21.399	-0.517	0.303	0.286	0.017	0.064
7	-13.381	-0.323	0.373	0.333	0.040	0.088
8	-12.138	-0.293	0.385	0.381	0.004	0.051
9	-6.476	-0.156	0.438	0.429	0.009	0.057
10	-5.628	-0.136	0.446	0.476	0.030	0.017
11	-5.586	-0.135	0.446	0.524	0.077	0.030
12	-2.751	-0.066	0.474	0.571	0.098	0.050
13	1.848	0.045	0.518	0.619	0.101	0.054
14	2.562	0.062	0.525	0.667	0.142	0.094
15	10.450	0.252	0.600	0.714	0.115	0.067
16	16.788	0.406	0.657	0.762	0.104	0.057
17	37.022	0.894	0.814	0.810	0.005	0.053
18	37.542	0.907	0.818	0.857	0.039	0.008
19	60.746	1.468	0.929	0.905	0.024	0.072
20	60.997	1.474	0.930	0.952	0.023	0.025
21	87.679	2.118	0.983	1.000	0.017	0.031
μ	0.000				**sup(D1, D2)**	0.142
σ	41.392				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.154	-1.766	0.039	0.048	0.009	0.039
2	-0.141	-1.614	0.053	0.095	0.042	0.006
3	-0.092	-1.051	0.147	0.143	0.004	0.051
4	-0.086	-0.982	0.163	0.190	0.027	0.020
5	-0.079	-0.901	0.184	0.238	0.054	0.007
6	-0.076	-0.872	0.191	0.286	0.094	0.047
7	-0.066	-0.752	0.226	0.333	0.107	0.060
8	-0.020	-0.227	0.410	0.381	0.029	0.077
9	-0.019	-0.218	0.414	0.429	0.015	0.033
10	-0.015	-0.175	0.430	0.476	0.046	0.002
11	-0.001	-0.011	0.496	0.524	0.028	0.019
12	0.000	0.005	0.502	0.571	0.070	0.022
13	0.033	0.375	0.646	0.619	0.027	0.075
14	0.036	0.412	0.660	0.667	0.007	0.041
15	0.045	0.521	0.699	0.714	0.015	0.032
16	0.073	0.834	0.798	0.762	0.036	0.084
17	0.084	0.961	0.832	0.810	0.022	0.070
18	0.096	1.105	0.865	0.857	0.008	0.056
19	0.104	1.186	0.882	0.905	0.023	0.025
20	0.119	1.366	0.914	0.952	0.038	0.009
21	0.157	1.801	0.964	1.000	0.036	0.012
μ	0.000				**sup(D1, D2)**	0.107
σ	0.087				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-19.083	-1.651	0.049	0.048	0.002	0.049
2	-16.128	-1.396	0.081	0.095	0.014	0.034
3	-13.524	-1.170	0.121	0.143	0.022	0.026
4	-11.876	-1.028	0.152	0.190	0.038	0.009
5	-10.494	-0.908	0.182	0.238	0.056	0.009
6	-9.623	-0.833	0.203	0.286	0.083	0.036
7	-7.604	-0.658	0.255	0.333	0.078	0.030
8	-3.238	-0.280	0.390	0.381	0.009	0.056
9	-3.101	-0.268	0.394	0.429	0.034	0.013
10	-2.312	-0.200	0.421	0.476	0.055	0.008
11	-0.476	-0.041	0.484	0.524	0.040	0.007
12	-0.005	0.000	0.500	0.571	0.072	0.024
13	3.065	0.265	0.605	0.619	0.014	0.033
14	3.485	0.302	0.619	0.667	0.048	0.001
15	7.003	0.606	0.728	0.714	0.013	0.061
16	8.469	0.733	0.768	0.762	0.006	0.054
17	11.239	0.972	0.835	0.810	0.025	0.073
18	11.755	1.017	0.845	0.857	0.012	0.036
19	11.845	1.025	0.847	0.905	0.057	0.010
20	14.587	1.262	0.897	0.952	0.056	0.008
21	26.020	2.251	0.988	1.000	0.012	0.035
μ	0.000				**sup(D1, D2)**	0.083
σ	11.557				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.375	-1.444	0.074	0.048	0.027	0.074
2	-0.371	-1.429	0.076	0.095	0.019	0.029
3	-0.272	-1.047	0.148	0.143	0.005	0.052
4	-0.228	-0.876	0.191	0.190	0.000	0.048
5	-0.198	-0.760	0.224	0.238	0.015	0.033
6	-0.177	-0.681	0.248	0.286	0.038	0.010
7	-0.148	-0.569	0.285	0.333	0.048	0.001
8	-0.095	-0.366	0.357	0.381	0.024	0.024
9	-0.069	-0.266	0.395	0.429	0.034	0.014
10	-0.067	-0.258	0.398	0.476	0.078	0.030
11	-0.065	-0.249	0.402	0.524	0.122	0.075
12	-0.037	-0.143	0.443	0.571	0.128	0.080
13	-0.012	-0.045	0.482	0.619	0.137	0.090
14	0.028	0.106	0.542	0.667	0.124	0.077
15	0.042	0.162	0.564	0.714	0.150	0.102
16	0.098	0.375	0.646	0.762	0.116	0.068
17	0.227	0.873	0.809	0.810	0.001	0.047
18	0.294	1.130	0.871	0.857	0.014	0.061
19	0.444	1.710	0.956	0.905	0.052	0.099
20	0.469	1.804	0.964	0.952	0.012	0.060
21	0.513	1.738	0.959	1.000	0.041	0.007
μ	0.000				**sup(D1, D2)**	0.150
σ	0.260				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-62.143	-1.647	0.050	0.048	0.002	0.050
2	-50.806	-1.347	0.089	0.095	0.006	0.041
3	-41.412	-1.098	0.136	0.143	0.007	0.041
4	-33.351	-0.884	0.188	0.190	0.002	0.046
5	-27.139	-0.719	0.236	0.238	0.002	0.046
6	-22.609	-0.599	0.275	0.286	0.011	0.036
7	-17.467	-0.463	0.322	0.333	0.012	0.036
8	-13.250	-0.351	0.363	0.381	0.018	0.029
9	-12.148	-0.322	0.374	0.429	0.055	0.007
10	-10.321	-0.274	0.392	0.476	0.084	0.036
11	-9.559	-0.253	0.400	0.524	0.124	0.076
12	-6.110	-0.162	0.436	0.571	0.136	0.088
13	-1.258	-0.033	0.487	0.619	0.132	0.085
14	2.841	0.075	0.530	0.667	0.137	0.089
15	11.025	0.292	0.615	0.714	0.099	0.052
16	27.394	0.726	0.766	0.762	0.004	0.052
17	31.370	0.831	0.797	0.810	0.012	0.035
18	35.224	0.934	0.825	0.857	0.032	0.015
19	47.217	1.251	0.895	0.905	0.010	0.037
20	67.995	1.802	0.964	0.952	0.012	0.059
21	84.436	2.238	0.987	1.000	0.013	0.035
μ	-0.003				**sup(D1, D2)**	0.137
σ	37.729				**Critical Value**	0.287

Nom Dist OK

Percentage of High Stick Speeds

Residuals (High - Low Gain)

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-11.045	-1.543	0.061	0.048	0.014	0.061
2	-11.034	-1.542	0.062	0.095	0.034	0.014
3	-11.020	-1.540	0.062	0.143	0.081	0.033
4	-7.527	-1.052	0.146	0.190	0.044	0.004
5	-6.714	-0.938	0.174	0.238	0.064	0.016
6	-5.147	-0.719	0.236	0.286	0.050	0.002
7	-4.807	-0.672	0.251	0.333	0.082	0.035
8	-1.497	-0.209	0.417	0.381	0.036	0.084
9	-0.915	-0.128	0.449	0.429	0.021	0.068
10	-0.026	-0.004	0.499	0.476	0.022	0.070
11	0.789	0.110	0.544	0.524	0.020	0.068
12	0.969	0.135	0.554	0.571	0.018	0.030
13	1.372	0.192	0.576	0.619	0.043	0.005
14	1.727	0.241	0.595	0.667	0.071	0.024
15	3.973	0.555	0.711	0.714	0.004	0.044
16	4.624	0.646	0.741	0.762	0.021	0.027
17	6.423	0.898	0.815	0.810	0.006	0.053
18	6.674	0.932	0.824	0.857	0.033	0.015
19	9.174	1.282	0.900	0.905	0.005	0.043
20	10.802	1.509	0.934	0.952	0.018	0.030
21	13.214	1.846	0.968	1.000	0.032	0.015
μ	0.000				**sup(D1, D2)**	0.084
σ	7.157				**Critical Value**	0.287

Nom Dist OK

Residuals (High - Low Gain), Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-114.039	-1.868	0.031	0.048	0.017	0.031
2	-113.873	-1.865	0.031	0.095	0.064	0.017
3	-68.526	-1.123	0.131	0.143	0.012	0.036
4	-62.894	-1.030	0.151	0.190	0.039	0.009
5	-30.851	-0.505	0.307	0.238	0.069	0.116
6	-18.525	-0.303	0.381	0.286	0.095	0.143
7	-18.274	-0.299	0.382	0.333	0.049	0.097
8	-16.634	-0.272	0.393	0.381	0.012	0.059
9	-16.314	-0.267	0.395	0.429	0.034	0.014
10	-16.100	-0.264	0.396	0.476	0.080	0.033
11	-7.656	-0.125	0.450	0.524	0.074	0.026
12	3.864	0.063	0.525	0.571	0.046	0.001
13	11.333	0.186	0.574	0.619	0.045	0.002
14	24.093	0.395	0.653	0.667	0.013	0.034
15	27.097	0.444	0.671	0.714	0.043	0.005
16	41.610	0.682	0.752	0.762	0.010	0.038
17	46.089	0.755	0.775	0.810	0.035	0.013
18	51.458	0.843	0.800	0.857	0.057	0.009
19	54.062	0.886	0.812	0.905	0.093	0.045
20	85.232	1.396	0.919	0.952	0.034	0.014
21	138.808	2.274	0.989	1.000	0.011	0.036
μ	-0.002				**sup(D1, D2)**	0.143
σ	61.045				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-3.765	-1.528	0.063	0.048	0.016	0.063
2	-3.304	-1.341	0.090	0.095	0.005	0.042
3	-3.222	-1.307	0.096	0.143	0.047	0.000
4	-3.204	-1.300	0.097	0.190	0.094	0.046
5	-2.039	-0.827	0.204	0.238	0.034	0.014
6	-1.431	-0.581	0.281	0.286	0.005	0.043
7	-1.122	-0.455	0.325	0.333	0.009	0.039
8	-0.689	-0.279	0.390	0.381	0.009	0.057
9	-0.513	-0.208	0.418	0.429	0.011	0.037
10	-0.451	-0.183	0.427	0.476	0.049	0.001
11	-0.447	-0.181	0.428	0.524	0.096	0.048
12	0.025	0.010	0.504	0.571	0.067	0.020
13	0.301	0.122	0.549	0.619	0.070	0.023
14	0.443	0.180	0.571	0.667	0.095	0.048
15	0.993	0.403	0.656	0.714	0.058	0.010
16	1.405	0.570	0.716	0.762	0.046	0.001
17	2.154	0.874	0.809	0.810	0.001	0.047
18	2.452	0.995	0.840	0.857	0.017	0.031
19	3.349	1.359	0.913	0.905	0.008	0.056
20	3.858	1.565	0.941	0.952	0.011	0.036
21	5.210	2.114	0.983	1.000	0.017	0.030
μ	0.000				**sup(D1, D2)**	0.096
σ	2.465				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-22.364	-1.382	0.084	0.048	0.036	0.084
2	-19.896	-1.229	0.110	0.095	0.014	0.062
3	-17.758	-1.097	0.136	0.143	0.007	0.041
4	-15.097	-0.933	0.176	0.190	0.015	0.033
5	-14.562	-0.900	0.184	0.238	0.054	0.006
6	-12.163	-0.751	0.226	0.286	0.060	0.012
7	-9.087	-0.561	0.287	0.333	0.046	0.002
8	-8.190	-0.506	0.306	0.381	0.075	0.027
9	-8.103	-0.501	0.308	0.429	0.120	0.073
10	-5.601	-0.346	0.365	0.476	0.112	0.064
11	-4.981	-0.308	0.379	0.524	0.145	0.097
12	-2.996	-0.185	0.427	0.571	0.145	0.097
13	1.004	0.062	0.525	0.619	0.094	0.047
14	3.231	0.200	0.579	0.667	0.088	0.040
15	7.074	0.437	0.669	0.714	0.045	0.002
16	12.356	0.763	0.777	0.762	0.015	0.063
17	14.201	0.877	0.810	0.810	0.000	0.048
18	17.858	1.103	0.865	0.857	0.008	0.056
19	25.328	1.565	0.941	0.905	0.036	0.084
20	29.730	1.837	0.967	0.952	0.014	0.062
21	30.009	1.854	0.968	1.000	0.032	0.016
μ	0.000				**sup(D1, D2)**	0.145
σ	16.187				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-8.582	-1.440	0.075	0.048	0.027	0.075
2	-7.670	-1.287	0.099	0.095	0.004	0.051
3	-6.688	-1.122	0.131	0.143	0.012	0.036
4	-6.534	-1.096	0.137	0.190	0.054	0.006
5	-5.836	-0.979	0.164	0.238	0.074	0.027
6	-5.320	-0.892	0.186	0.286	0.100	0.052
7	-3.535	-0.593	0.277	0.333	0.057	0.009
8	-2.992	-0.502	0.308	0.381	0.073	0.025
9	-1.850	-0.310	0.378	0.429	0.050	0.003
10	-1.362	-0.229	0.410	0.476	0.067	0.019
11	0.297	0.050	0.520	0.524	0.004	0.044
12	0.338	0.057	0.523	0.571	0.049	0.001
13	0.417	0.070	0.528	0.619	0.091	0.044
14	1.271	0.213	0.584	0.667	0.082	0.035
15	1.320	0.221	0.588	0.714	0.127	0.079
16	2.851	0.478	0.684	0.762	0.078	0.031
17	7.598	1.274	0.899	0.810	0.089	0.137
18	8.079	1.355	0.912	0.857	0.055	0.103
19	8.485	1.423	0.923	0.905	0.018	0.066
20	9.448	1.585	0.944	0.952	0.009	0.039
21	10.281	1.437	0.925	1.000	0.075	0.028
μ	0.001				**sup(D1, D2)**	0.137
σ	5.962				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-88.547	-1.589	0.056	0.048	0.008	0.056
2	-84.032	-1.508	0.066	0.095	0.029	0.018
3	-61.455	-1.103	0.135	0.143	0.008	0.040
4	-48.611	-0.872	0.192	0.190	0.001	0.049
5	-45.038	-0.808	0.209	0.238	0.029	0.019
6	-38.424	-0.689	0.245	0.286	0.040	0.007
7	-24.420	-0.438	0.331	0.333	0.003	0.045
8	-21.703	-0.389	0.348	0.381	0.032	0.015
9	-21.272	-0.382	0.351	0.429	0.077	0.030
10	-15.633	-0.281	0.390	0.476	0.087	0.039
11	-11.235	-0.202	0.420	0.524	0.104	0.056
12	-4.426	-0.079	0.468	0.571	0.103	0.055
13	2.245	0.040	0.516	0.619	0.103	0.055
14	23.723	0.426	0.665	0.667	0.002	0.046
15	29.445	0.528	0.701	0.714	0.013	0.035
16	36.894	0.662	0.746	0.762	0.016	0.032
17	41.297	0.741	0.771	0.810	0.039	0.009
18	53.822	0.966	0.833	0.857	0.024	0.023
19	66.416	1.192	0.883	0.905	0.021	0.026
20	77.040	1.382	0.917	0.952	0.036	0.012
21	133.825	2.401	0.992	1.000	0.008	0.039
μ	-0.004				**sup(D1, D2)**	0.104
σ	55.727				**Critical Value**	0.287

Nom Dist OK

Mean Stick Acceleration

Residuals (High - Low Gain)

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-7.361	-1.843	0.033	0.048	0.015	0.033
2	-5.948	-1.489	0.068	0.095	0.027	0.021
3	-4.795	-1.201	0.115	0.143	0.028	0.020
4	-4.388	-1.099	0.136	0.190	0.054	0.007
5	-3.925	-0.983	0.163	0.238	0.075	0.028
6	-3.800	-0.951	0.171	0.286	0.115	0.067
7	-2.235	-0.560	0.288	0.333	0.045	0.002
8	-1.247	-0.312	0.377	0.381	0.003	0.044
9	-0.713	-0.179	0.429	0.429	0.001	0.048
10	-0.451	-0.113	0.455	0.476	0.021	0.026
11	0.097	0.024	0.510	0.524	0.014	0.034
12	1.884	0.472	0.681	0.571	0.110	0.158
13	2.024	0.507	0.694	0.619	0.075	0.122
14	2.319	0.581	0.719	0.667	0.053	0.100
15	2.546	0.637	0.738	0.714	0.024	0.071
16	2.647	0.663	0.746	0.762	0.016	0.032
17	2.885	0.722	0.765	0.810	0.045	0.003
18	3.467	0.868	0.807	0.857	0.050	0.002
19	3.876	0.970	0.834	0.905	0.071	0.023
20	5.531	1.385	0.917	0.952	0.035	0.012
21	7.596	1.902	0.971	1.000	0.029	0.019
μ	0.000				**sup(D1, D2)**	0.158
σ	3.994				**Critical Value**	0.287

Nom Dist OK

Residuals (High - Low Gain), Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-77.375	-1.869	0.031	0.048	0.017	0.031
2	-58.832	-1.421	0.078	0.095	0.018	0.030
3	-55.125	-1.331	0.092	0.143	0.051	0.004
4	-47.845	-1.155	0.124	0.190	0.067	0.019
5	-47.257	-1.141	0.127	0.238	0.111	0.064
6	-29.467	-0.712	0.238	0.286	0.047	0.000
7	-10.377	-0.251	0.401	0.333	0.068	0.115
8	-10.180	-0.246	0.403	0.381	0.022	0.070
9	-1.808	-0.044	0.483	0.429	0.054	0.102
10	-0.779	-0.019	0.492	0.476	0.016	0.064
11	6.966	0.168	0.567	0.524	0.043	0.091
12	9.614	0.232	0.592	0.571	0.020	0.068
13	21.312	0.515	0.697	0.619	0.078	0.125
14	21.629	0.522	0.699	0.667	0.033	0.080
15	23.140	0.559	0.712	0.714	0.002	0.045
16	24.507	0.592	0.723	0.762	0.039	0.009
17	24.517	0.592	0.723	0.810	0.086	0.039
18	34.302	0.828	0.796	0.857	0.061	0.013
19	38.328	0.926	0.823	0.905	0.082	0.034
20	38.358	0.926	0.823	0.952	0.130	0.082
21	96.356	2.327	0.990	1.000	0.010	0.038
μ	0.000				**sup(D1, D2)**	0.130
σ	41.409				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-2.641	-1.852	0.032	0.048	0.016	0.032
2	-1.588	-1.113	0.133	0.095	0.038	0.085
3	-1.446	-1.014	0.155	0.143	0.013	0.060
4	-1.283	-0.899	0.184	0.190	0.006	0.041
5	-1.043	-0.731	0.232	0.238	0.006	0.042
6	-1.008	-0.707	0.240	0.286	0.046	0.002
7	-0.848	-0.594	0.276	0.333	0.057	0.010
8	-0.708	-0.496	0.310	0.381	0.071	0.023
9	-0.570	-0.400	0.345	0.429	0.084	0.036
10	-0.357	-0.250	0.401	0.476	0.075	0.027
11	0.005	0.004	0.501	0.524	0.022	0.025
12	0.042	0.029	0.512	0.571	0.060	0.012
13	0.192	0.134	0.553	0.619	0.066	0.018
14	0.430	0.301	0.618	0.667	0.048	0.001
15	0.474	0.332	0.630	0.714	0.084	0.036
16	0.603	0.422	0.664	0.762	0.098	0.051
17	1.252	0.878	0.810	0.810	0.000	0.048
18	1.292	0.906	0.817	0.857	0.040	0.008
19	1.305	0.915	0.820	0.905	0.085	0.037
20	2.436	1.708	0.956	0.952	0.004	0.051
21	3.465	2.429	0.992	1.000	0.008	0.040
μ	0.000				**sup(D1, D2)**	0.098
σ	1.427				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-16.559	-1.292	0.098	0.048	0.051	0.098
2	-16.355	-1.276	0.101	0.095	0.006	0.053
3	-14.918	-1.164	0.122	0.143	0.021	0.027
4	-14.057	-1.097	0.136	0.190	0.054	0.006
5	-11.532	-0.900	0.184	0.238	0.054	0.006
6	-10.173	-0.794	0.214	0.286	0.072	0.024
7	-8.667	-0.676	0.249	0.333	0.084	0.036
8	-6.827	-0.533	0.297	0.381	0.084	0.036
9	-5.162	-0.403	0.344	0.429	0.085	0.037
10	-4.461	-0.348	0.364	0.476	0.112	0.065
11	-0.071	-0.006	0.498	0.524	0.026	0.022
12	0.394	0.031	0.512	0.571	0.059	0.012
13	2.458	0.192	0.576	0.619	0.043	0.005
14	2.796	0.218	0.586	0.667	0.080	0.033
15	6.515	0.508	0.694	0.714	0.020	0.028
16	8.832	0.689	0.755	0.762	0.007	0.040
17	9.316	0.727	0.766	0.810	0.043	0.004
18	14.020	1.094	0.863	0.857	0.006	0.053
19	15.338	1.197	0.884	0.905	0.021	0.027
20	19.035	1.485	0.931	0.952	0.021	0.026
21	30.071	2.346	0.991	1.000	0.009	0.038
μ	0.000				**sup(D1, D2)**	0.112
σ	12.818				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-5.160	-1.552	0.060	0.048	0.013	0.060
2	-3.656	-1.099	0.136	0.095	0.041	0.088
3	-3.589	-1.079	0.140	0.143	0.003	0.045
4	-3.037	-0.913	0.181	0.190	0.010	0.038
5	-2.871	-0.863	0.194	0.238	0.044	0.003
6	-2.623	-0.789	0.215	0.286	0.071	0.023
7	-2.066	-0.621	0.267	0.333	0.066	0.019
8	-1.845	-0.555	0.290	0.381	0.091	0.044
9	-1.693	-0.509	0.305	0.429	0.123	0.076
10	-1.593	-0.479	0.316	0.476	0.160	0.113
11	-0.733	-0.220	0.413	0.524	0.111	0.063
12	0.456	0.137	0.555	0.571	0.017	0.031
13	0.505	0.152	0.560	0.619	0.059	0.011
14	0.647	0.195	0.577	0.667	0.089	0.042
15	0.677	0.203	0.581	0.714	0.134	0.086
16	3.218	0.967	0.833	0.762	0.071	0.119
17	3.444	1.035	0.850	0.810	0.040	0.088
18	3.513	1.056	0.855	0.857	0.003	0.045
19	4.430	1.332	0.909	0.905	0.004	0.051
20	4.720	1.419	0.922	0.952	0.030	0.017
21	7.252	1.816	0.965	1.000	0.035	0.013
μ	0.000				**sup(D1, D2)**	0.160
σ	3.326				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-66.283	-1.798	0.036	0.048	0.012	0.036
2	-45.833	-1.243	0.107	0.095	0.012	0.059
3	-39.697	-1.077	0.141	0.143	0.002	0.046
4	-29.011	-0.787	0.216	0.190	0.025	0.073
5	-23.019	-0.624	0.266	0.238	0.028	0.076
6	-21.719	-0.589	0.278	0.286	0.008	0.040
7	-18.851	-0.511	0.305	0.333	0.029	0.019
8	-15.673	-0.425	0.335	0.381	0.046	0.002
9	-14.774	-0.401	0.344	0.429	0.084	0.037
10	-14.544	-0.395	0.347	0.476	0.130	0.082
11	-3.678	-0.100	0.460	0.524	0.064	0.016
12	-2.593	-0.070	0.472	0.571	0.099	0.052
13	-0.448	-0.012	0.495	0.619	0.124	0.076
14	0.710	0.019	0.508	0.667	0.159	0.111
15	3.355	0.091	0.536	0.714	0.178	0.130
16	20.803	0.564	0.714	0.762	0.048	0.001
17	32.341	0.877	0.810	0.810	0.000	0.048
18	48.241	1.309	0.905	0.857	0.048	0.095
19	50.666	1.375	0.915	0.905	0.011	0.058
20	67.204	1.823	0.966	0.952	0.013	0.061
21	72.854	1.977	0.976	1.000	0.024	0.024
μ	0.000				**sup(D1, D2)**	0.178
σ	36.860				**Critical Value**	0.287

Nom Dist OK

RMS Stick Acceleration

Residuals (High - Low Gain)

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-15.370	-2.385	0.009	0.048	0.039	0.009
2	-9.576	-1.486	0.069	0.095	0.027	0.021
3	-8.091	-1.255	0.105	0.143	0.038	0.009
4	-4.144	-0.643	0.260	0.190	0.070	0.117
5	-4.000	-0.621	0.267	0.238	0.029	0.077
6	-3.838	-0.595	0.276	0.286	0.010	0.038
7	-3.782	-0.587	0.279	0.333	0.055	0.007
8	-3.244	-0.503	0.307	0.381	0.074	0.026
9	-1.497	-0.232	0.408	0.429	0.020	0.027
10	-0.451	-0.070	0.472	0.476	0.004	0.044
11	0.077	0.012	0.505	0.524	0.019	0.029
12	0.733	0.114	0.545	0.571	0.026	0.021
13	2.610	0.405	0.657	0.619	0.038	0.086
14	4.476	0.694	0.756	0.667	0.090	0.137
15	4.786	0.743	0.771	0.714	0.057	0.104
16	5.252	0.815	0.792	0.762	0.031	0.078
17	5.297	0.822	0.794	0.810	0.015	0.033
18	5.740	0.890	0.813	0.857	0.044	0.004
19	6.031	0.936	0.825	0.905	0.079	0.032
20	7.660	1.188	0.883	0.952	0.070	0.022
21	11.333	1.758	0.961	1.000	0.039	0.008
μ	0.000				**sup(D1, D2)**	0.137
σ	6.446				**Critical Value**	0.287

Nom Dist OK

Residuals (High - Low Gain), Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-93.667	-2.818	0.002	0.048	0.045	0.002
2	-44.292	-1.333	0.091	0.095	0.004	0.044
3	-26.257	-0.790	0.215	0.143	0.072	0.120
4	-22.529	-0.678	0.249	0.190	0.058	0.106
5	-18.794	-0.566	0.286	0.238	0.048	0.095
6	-17.696	-0.532	0.297	0.286	0.011	0.059
7	-13.369	-0.402	0.344	0.333	0.010	0.058
8	-11.571	-0.348	0.364	0.381	0.017	0.031
9	-10.068	-0.303	0.381	0.429	0.048	0.000
10	-4.463	-0.134	0.447	0.476	0.030	0.018
11	-2.844	-0.086	0.466	0.524	0.058	0.010
12	-1.025	-0.031	0.488	0.571	0.084	0.036
13	16.104	0.485	0.686	0.619	0.067	0.115
14	16.798	0.505	0.693	0.667	0.027	0.074
15	19.058	0.573	0.717	0.714	0.003	0.050
16	25.317	0.762	0.777	0.762	0.015	0.063
17	26.943	0.811	0.791	0.810	0.018	0.029
18	30.759	0.926	0.823	0.857	0.034	0.013
19	40.025	1.204	0.886	0.905	0.019	0.029
20	42.188	1.269	0.898	0.952	0.055	0.007
21	49.481	1.489	0.932	1.000	0.068	0.021
μ	0.005				**sup(D1, D2)**	0.120
σ	33.234				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-4.783	-1.756	0.040	0.048	0.008	0.040
2	-2.720	-0.999	0.159	0.095	0.064	0.111
3	-2.404	-0.883	0.189	0.143	0.046	0.094
4	-2.355	-0.865	0.194	0.190	0.003	0.051
5	-2.191	-0.805	0.211	0.238	0.028	0.020
6	-2.127	-0.781	0.217	0.286	0.068	0.021
7	-1.819	-0.668	0.252	0.333	0.081	0.034
8	-1.750	-0.643	0.260	0.381	0.121	0.073
9	-1.652	-0.606	0.272	0.429	0.156	0.109
10	-1.065	-0.391	0.348	0.476	0.128	0.081
11	-0.361	-0.133	0.447	0.524	0.077	0.029
12	-0.235	-0.086	0.466	0.571	0.106	0.058
13	0.753	0.276	0.609	0.619	0.010	0.037
14	1.286	0.472	0.682	0.667	0.015	0.063
15	1.355	0.497	0.691	0.714	0.024	0.024
16	1.659	0.609	0.729	0.762	0.033	0.015
17	1.783	0.655	0.744	0.810	0.066	0.018
18	2.197	0.807	0.790	0.857	0.067	0.019
19	3.626	1.332	0.908	0.905	0.004	0.051
20	4.706	1.728	0.958	0.952	0.006	0.053
21	6.074	2.230	0.987	1.000	0.013	0.035
μ	-0.001				**sup(D1, D2)**	0.156
σ	2.724				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-19.224	-1.542	0.062	0.048	0.014	0.062
2	-14.712	-1.180	0.119	0.095	0.024	0.071
3	-12.047	-0.966	0.167	0.143	0.024	0.072
4	-11.620	-0.932	0.176	0.190	0.015	0.033
5	-10.448	-0.838	0.201	0.238	0.037	0.011
6	-8.702	-0.698	0.243	0.286	0.043	0.004
7	-8.688	-0.697	0.243	0.333	0.090	0.043
8	-8.567	-0.687	0.246	0.381	0.135	0.087
9	-7.929	-0.636	0.262	0.429	0.166	0.119
10	-5.824	-0.467	0.320	0.476	0.156	0.108
11	-1.408	-0.113	0.455	0.524	0.069	0.021
12	-1.042	-0.084	0.467	0.571	0.105	0.057
13	3.823	0.307	0.620	0.619	0.001	0.049
14	6.157	0.494	0.689	0.667	0.023	0.070
15	6.351	0.509	0.695	0.714	0.020	0.028
16	9.709	0.779	0.782	0.762	0.020	0.068
17	11.261	0.903	0.817	0.810	0.007	0.055
18	11.961	0.960	0.831	0.857	0.026	0.022
19	14.294	1.147	0.874	0.905	0.031	0.017
20	17.954	1.440	0.925	0.952	0.027	0.020
21	28.717	2.304	0.989	1.000	0.011	0.037
μ	0.001				**sup(D1, D2)**	0.166
σ	12.466				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-10.662	-2.110	0.017	0.048	0.030	0.017
2	-6.718	-1.330	0.092	0.095	0.003	0.044
3	-6.497	-1.286	0.099	0.143	0.044	0.004
4	-5.947	-1.177	0.120	0.190	0.071	0.023
5	-5.368	-1.063	0.144	0.238	0.094	0.046
6	-3.027	-0.599	0.275	0.286	0.011	0.036
7	-2.480	-0.491	0.312	0.333	0.022	0.026
8	-2.013	-0.399	0.345	0.381	0.036	0.012
9	-1.084	-0.215	0.415	0.429	0.014	0.034
10	-0.209	-0.041	0.484	0.476	0.007	0.055
11	1.210	0.240	0.595	0.524	0.071	0.118
12	1.862	0.369	0.644	0.571	0.072	0.120
13	2.076	0.411	0.659	0.619	0.040	0.088
14	2.251	0.445	0.672	0.667	0.005	0.053
15	3.549	0.703	0.759	0.714	0.045	0.092
16	3.602	0.713	0.762	0.762	0.000	0.048
17	3.724	0.737	0.769	0.810	0.040	0.008
18	5.471	1.083	0.861	0.857	0.003	0.051
19	5.507	1.090	0.862	0.905	0.043	0.005
20	6.554	1.297	0.903	0.952	0.050	0.002
21	8.230	1.277	0.899	1.000	0.101	0.053
μ	0.001				**sup(D1, D2)**	0.120
σ	5.052				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-64.959	-2.373	0.009	0.048	0.039	0.009
2	-37.886	-1.384	0.083	0.095	0.012	0.036
3	-36.929	-1.349	0.089	0.143	0.054	0.007
4	-30.007	-1.096	0.136	0.190	0.054	0.006
5	-18.006	-0.658	0.255	0.238	0.017	0.065
6	-16.381	-0.599	0.275	0.286	0.011	0.037
7	-11.555	-0.422	0.336	0.333	0.003	0.051
8	-7.757	-0.283	0.388	0.381	0.007	0.055
9	-7.027	-0.257	0.399	0.429	0.030	0.018
10	-0.849	-0.031	0.488	0.476	0.011	0.059
11	5.237	0.191	0.576	0.524	0.052	0.100
12	8.101	0.296	0.616	0.571	0.045	0.093
13	10.482	0.383	0.649	0.619	0.030	0.078
14	10.927	0.399	0.655	0.667	0.012	0.036
15	14.687	0.537	0.704	0.714	0.010	0.038
16	24.926	0.911	0.819	0.762	0.057	0.104
17	25.893	0.946	0.828	0.810	0.018	0.066
18	27.466	1.004	0.842	0.857	0.015	0.033
19	27.969	1.022	0.847	0.905	0.058	0.011
20	36.569	1.336	0.909	0.952	0.043	0.004
21	39.024	1.426	0.923	1.000	0.077	0.029
μ	-0.004				**sup(D1, D2)**	0.104
σ	27.370				**Critical Value**	0.287

Nom Dist OK

Percentage of High Stick Accelerations

Residuals (High - Low Gain)

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-8.235	-1.597	0.055	0.048	0.007	0.055
2	-6.589	-1.278	0.101	0.095	0.005	0.053
3	-5.405	-1.049	0.147	0.143	0.004	0.052
4	-4.720	-0.915	0.180	0.190	0.011	0.037
5	-4.527	-0.878	0.190	0.238	0.048	0.001
6	-3.745	-0.726	0.234	0.286	0.052	0.004
7	-3.644	-0.707	0.240	0.333	0.093	0.046
8	-3.191	-0.619	0.268	0.381	0.113	0.065
9	-3.095	-0.600	0.274	0.429	0.154	0.107
10	-2.371	-0.460	0.323	0.476	0.153	0.106
11	-0.776	-0.151	0.440	0.524	0.084	0.036
12	-0.183	-0.035	0.486	0.571	0.086	0.038
13	0.963	0.187	0.574	0.619	0.045	0.003
14	2.810	0.545	0.707	0.667	0.040	0.088
15	3.231	0.627	0.735	0.714	0.020	0.068
16	5.120	0.993	0.840	0.762	0.078	0.125
17	5.149	0.999	0.841	0.810	0.032	0.079
18	5.198	1.008	0.843	0.857	0.014	0.034
19	6.559	1.272	0.898	0.905	0.006	0.041
20	8.123	1.576	0.942	0.952	0.010	0.038
21	9.325	1.809	0.965	1.000	0.035	0.012
μ	0.000				**sup(D1, D2)**	0.154
σ	5.155				**Critical Value**	0.287

Nom Dist OK

Residuals (High - Low Gain), Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-146.096	-1.940	0.026	0.048	0.021	0.026
2	-77.389	-1.028	0.152	0.095	0.057	0.104
3	-63.077	-0.838	0.201	0.143	0.058	0.106
4	-62.741	-0.833	0.202	0.190	0.012	0.059
5	-60.664	-0.806	0.210	0.238	0.028	0.020
6	-56.652	-0.752	0.226	0.286	0.060	0.012
7	-49.792	-0.661	0.254	0.333	0.079	0.032
8	-48.777	-0.648	0.259	0.381	0.122	0.075
9	-29.992	-0.398	0.345	0.429	0.083	0.036
10	-28.279	-0.376	0.354	0.476	0.123	0.075
11	-4.606	-0.061	0.476	0.524	0.048	0.001
12	-2.167	-0.029	0.489	0.571	0.083	0.035
13	5.990	0.080	0.532	0.619	0.087	0.040
14	13.790	0.183	0.573	0.667	0.094	0.046
15	38.015	0.505	0.693	0.714	0.021	0.027
16	40.676	0.540	0.705	0.762	0.056	0.009
17	69.552	0.924	0.822	0.810	0.013	0.060
18	77.286	1.026	0.848	0.857	0.009	0.038
19	100.647	1.337	0.909	0.905	0.005	0.052
20	140.080	1.861	0.969	0.952	0.016	0.064
21	144.098	1.914	0.972	1.000	0.028	0.020
μ	0.000				**sup(D1, D2)**	0.123
σ	75.291				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-2.026	-1.639	0.051	0.048	0.003	0.051
2	-1.383	-1.119	0.132	0.095	0.036	0.084
3	-1.340	-1.085	0.139	0.143	0.004	0.044
4	-1.141	-0.923	0.178	0.190	0.013	0.035
5	-0.989	-0.800	0.212	0.238	0.026	0.021
6	-0.925	-0.748	0.227	0.286	0.059	0.011
7	-0.743	-0.601	0.274	0.333	0.060	0.012
8	-0.715	-0.579	0.281	0.381	0.100	0.052
9	-0.636	-0.514	0.303	0.429	0.125	0.077
10	-0.370	-0.299	0.382	0.476	0.094	0.046
11	-0.083	-0.067	0.473	0.524	0.050	0.003
12	-0.018	-0.015	0.494	0.571	0.077	0.030
13	0.193	0.156	0.562	0.619	0.057	0.009
14	0.249	0.202	0.580	0.667	0.087	0.039
15	0.330	0.267	0.605	0.714	0.109	0.061
16	0.709	0.574	0.717	0.762	0.045	0.003
17	1.247	1.009	0.843	0.810	0.034	0.082
18	1.333	1.078	0.860	0.857	0.002	0.050
19	1.541	1.247	0.894	0.905	0.011	0.037
20	2.046	1.656	0.951	0.952	0.001	0.046
21	2.717	2.199	0.986	1.000	0.014	0.034
μ	0.000				**sup(D1, D2)**	0.125
σ	1.236				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-29.190	-1.893	0.029	0.048	0.018	0.029
2	-16.184	-1.049	0.147	0.095	0.052	0.099
3	-14.177	-0.919	0.179	0.143	0.036	0.084
4	-12.023	-0.780	0.218	0.190	0.027	0.075
5	-11.451	-0.742	0.229	0.238	0.009	0.038
6	-11.073	-0.718	0.236	0.286	0.049	0.002
7	-8.639	-0.560	0.288	0.333	0.046	0.002
8	-8.618	-0.559	0.288	0.381	0.093	0.045
9	-6.749	-0.438	0.331	0.429	0.098	0.050
10	-6.388	-0.414	0.339	0.476	0.137	0.089
11	-1.796	-0.116	0.454	0.524	0.070	0.023
12	-0.583	-0.038	0.485	0.571	0.087	0.039
13	1.554	0.101	0.540	0.619	0.079	0.031
14	4.902	0.318	0.625	0.667	0.042	0.006
15	5.062	0.328	0.629	0.714	0.086	0.038
16	8.645	0.560	0.712	0.762	0.049	0.002
17	9.654	0.626	0.734	0.810	0.075	0.028
18	15.920	1.032	0.849	0.857	0.008	0.039
19	18.183	1.179	0.881	0.905	0.024	0.024
20	28.324	1.836	0.967	0.952	0.014	0.062
21	34.634	2.245	0.988	1.000	0.012	0.035
μ	0.000				**sup(D1, D2)**	0.137
σ	15.424				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-6.189	-1.297	0.097	0.048	0.050	0.097
2	-5.644	-1.183	0.118	0.095	0.023	0.071
3	-5.342	-1.120	0.131	0.143	0.011	0.036
4	-5.127	-1.075	0.141	0.190	0.049	0.002
5	-4.334	-0.909	0.182	0.238	0.056	0.009
6	-3.513	-0.736	0.231	0.286	0.055	0.007
7	-3.394	-0.712	0.238	0.333	0.095	0.047
8	-3.209	-0.673	0.251	0.381	0.130	0.083
9	-2.688	-0.563	0.287	0.429	0.142	0.094
10	-1.763	-0.370	0.356	0.476	0.120	0.073
11	-1.171	-0.246	0.403	0.524	0.121	0.073
12	-0.067	-0.014	0.494	0.571	0.077	0.029
13	0.593	0.124	0.549	0.619	0.070	0.022
14	2.174	0.456	0.676	0.667	0.009	0.057
15	2.488	0.522	0.699	0.714	0.015	0.032
16	3.780	0.792	0.786	0.762	0.024	0.072
17	4.483	0.940	0.826	0.810	0.017	0.064
18	5.066	1.062	0.856	0.857	0.001	0.046
19	6.889	1.444	0.926	0.905	0.021	0.069
20	7.299	1.530	0.937	0.952	0.015	0.032
21	9.664	1.875	0.970	1.000	0.030	0.017
μ	0.000				**sup(D1, D2)**	0.142
σ	4.770				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-111.457	-1.540	0.062	0.048	0.014	0.062
2	-92.262	-1.275	0.101	0.095	0.006	0.054
3	-88.834	-1.227	0.110	0.143	0.033	0.015
4	-63.964	-0.884	0.188	0.190	0.002	0.046
5	-57.834	-0.799	0.212	0.238	0.026	0.022
6	-57.229	-0.791	0.215	0.286	0.071	0.024
7	-51.005	-0.705	0.241	0.333	0.093	0.045
8	-26.721	-0.369	0.356	0.381	0.025	0.023
9	-21.342	-0.295	0.384	0.429	0.045	0.003
10	-20.447	-0.282	0.389	0.476	0.087	0.040
11	-8.912	-0.123	0.451	0.524	0.073	0.025
12	-0.392	-0.005	0.498	0.571	0.074	0.026
13	5.156	0.071	0.528	0.619	0.091	0.043
14	11.318	0.156	0.562	0.667	0.105	0.057
15	29.401	0.406	0.658	0.714	0.057	0.009
16	29.608	0.409	0.659	0.762	0.103	0.056
17	57.533	0.795	0.787	0.810	0.023	0.025
18	95.473	1.319	0.906	0.857	0.049	0.097
19	105.714	1.460	0.928	0.905	0.023	0.071
20	127.919	1.767	0.961	0.952	0.009	0.057
21	138.290	1.910	0.972	1.000	0.028	0.020
μ	0.000				**sup(D1, D2)**	0.105
σ	72.384				**Critical Value**	0.287

Nom Dist OK

PSD Area (HTF - 2 Hz)

Residuals (High - Low Gain)

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.307	-1.126	0.130	0.048	0.083	0.130
2	-0.296	-1.086	0.139	0.095	0.043	0.091
3	-0.226	-0.829	0.203	0.143	0.061	0.108
4	-0.193	-0.707	0.240	0.190	0.049	0.097
5	-0.170	-0.625	0.266	0.238	0.028	0.076
6	-0.148	-0.542	0.294	0.286	0.008	0.056
7	-0.136	-0.500	0.309	0.333	0.025	0.023
8	-0.132	-0.485	0.314	0.381	0.067	0.019
9	-0.130	-0.478	0.316	0.429	0.112	0.065
10	-0.089	-0.327	0.372	0.476	0.104	0.057
11	-0.088	-0.323	0.373	0.524	0.150	0.103
12	-0.086	-0.317	0.376	0.571	0.196	0.148
13	-0.062	-0.228	0.410	0.619	0.209	0.162
14	0.057	0.211	0.583	0.667	0.083	0.036
15	0.087	0.319	0.625	0.714	0.089	0.042
16	0.091	0.333	0.630	0.762	0.132	0.084
17	0.160	0.585	0.721	0.810	0.089	0.041
18	0.162	0.595	0.724	0.857	0.133	0.085
19	0.252	0.925	0.823	0.905	0.082	0.035
20	0.342	1.253	0.895	0.952	0.058	0.010
21	0.914	3.350	1.000	1.000	0.000	0.047
μ	0.000				**sup(D1, D2)**	0.209
σ	0.273				**Critical Value**	0.287

Nom Dist OK

Residuals (High - Low Gain), Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-406.309	-1.618	0.053	0.048	0.005	0.053
2	-363.879	-1.449	0.074	0.095	0.022	0.026
3	-302.812	-1.206	0.114	0.143	0.029	0.019
4	-211.468	-0.842	0.200	0.190	0.009	0.057
5	-201.175	-0.801	0.212	0.238	0.027	0.021
6	-187.479	-0.746	0.228	0.286	0.058	0.010
7	-187.241	-0.745	0.228	0.333	0.105	0.058
8	-163.200	-0.650	0.258	0.381	0.123	0.075
9	-72.457	-0.288	0.386	0.429	0.042	0.006
10	-71.823	-0.286	0.387	0.476	0.089	0.041
11	-36.799	-0.147	0.442	0.524	0.082	0.034
12	52.050	0.207	0.582	0.571	0.011	0.058
13	85.632	0.341	0.633	0.619	0.014	0.062
14	107.808	0.429	0.666	0.667	0.001	0.047
15	131.344	0.523	0.699	0.714	0.015	0.033
16	154.360	0.615	0.731	0.762	0.031	0.016
17	194.730	0.775	0.781	0.810	0.029	0.019
18	283.537	1.129	0.871	0.857	0.013	0.061
19	306.516	1.220	0.889	0.905	0.016	0.032
20	378.144	1.506	0.934	0.952	0.018	0.029
21	510.577	2.033	0.979	1.000	0.021	0.027
μ	0.003				**sup(D1, D2)**	0.123
σ	251.165				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.037	-2.144	0.016	0.048	0.032	0.016
2	-0.026	-1.540	0.062	0.095	0.033	0.014
3	-0.016	-0.949	0.171	0.143	0.029	0.076
4	-0.016	-0.941	0.173	0.190	0.017	0.031
5	-0.016	-0.917	0.180	0.238	0.058	0.011
6	-0.008	-0.479	0.316	0.286	0.030	0.078
7	-0.006	-0.368	0.357	0.333	0.023	0.071
8	-0.003	-0.167	0.434	0.381	0.053	0.100
9	-0.001	-0.047	0.481	0.429	0.053	0.100
10	0.001	0.050	0.520	0.476	0.044	0.091
11	0.001	0.055	0.522	0.524	0.002	0.046
12	0.002	0.100	0.540	0.571	0.032	0.016
13	0.002	0.137	0.555	0.619	0.064	0.017
14	0.003	0.159	0.563	0.667	0.103	0.056
15	0.003	0.188	0.575	0.714	0.140	0.092
16	0.003	0.196	0.578	0.762	0.184	0.137
17	0.013	0.784	0.783	0.810	0.026	0.021
18	0.015	0.902	0.816	0.857	0.041	0.007
19	0.022	1.291	0.902	0.905	0.003	0.045
20	0.026	1.510	0.934	0.952	0.018	0.030
21	0.036	2.123	0.983	1.000	0.017	0.031
μ	0.000				**sup(D1, D2)**	0.184
σ	0.017				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-17.488	-1.296	0.097	0.048	0.050	0.097
2	-14.283	-1.058	0.145	0.095	0.050	0.097
3	-13.638	-1.011	0.156	0.143	0.013	0.061
4	-12.097	-0.897	0.185	0.190	0.005	0.042
5	-11.186	-0.829	0.204	0.238	0.035	0.013
6	-10.476	-0.776	0.219	0.286	0.067	0.019
7	-8.781	-0.651	0.258	0.333	0.076	0.028
8	-7.363	-0.546	0.293	0.381	0.088	0.041
9	-6.633	-0.492	0.312	0.429	0.117	0.069
10	-1.249	-0.093	0.463	0.476	0.013	0.035
11	-0.642	-0.048	0.481	0.524	0.043	0.005
12	-0.225	-0.017	0.493	0.571	0.078	0.030
13	0.042	0.003	0.501	0.619	0.118	0.070
14	0.778	0.058	0.523	0.667	0.144	0.096
15	1.103	0.082	0.533	0.714	0.182	0.134
16	1.193	0.088	0.535	0.762	0.227	0.179
17	11.493	0.852	0.803	0.810	0.007	0.041
18	14.206	1.053	0.854	0.857	0.003	0.044
19	14.692	1.089	0.862	0.905	0.043	0.005
20	29.747	2.205	0.986	0.952	0.034	0.081
21	30.810	2.283	0.989	1.000	0.011	0.036
μ	0.000				**sup(D1, D2)**	0.227
σ	13.494				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.293	-1.094	0.137	0.048	0.089	0.137
2	-0.281	-1.050	0.147	0.095	0.052	0.099
3	-0.229	-0.857	0.196	0.143	0.053	0.101
4	-0.204	-0.762	0.223	0.190	0.032	0.080
5	-0.167	-0.624	0.266	0.238	0.028	0.076
6	-0.164	-0.612	0.270	0.286	0.015	0.032
7	-0.152	-0.570	0.284	0.333	0.049	0.001
8	-0.133	-0.497	0.310	0.381	0.071	0.024
9	-0.115	-0.429	0.334	0.429	0.095	0.047
10	-0.104	-0.387	0.349	0.476	0.127	0.079
11	-0.087	-0.327	0.372	0.524	0.152	0.104
12	-0.084	-0.312	0.377	0.571	0.194	0.146
13	-0.026	-0.096	0.462	0.619	0.157	0.110
14	0.058	0.218	0.586	0.667	0.080	0.033
15	0.081	0.302	0.619	0.714	0.096	0.048
16	0.093	0.348	0.636	0.762	0.126	0.078
17	0.154	0.576	0.718	0.810	0.092	0.044
18	0.173	0.647	0.741	0.857	0.116	0.068
19	0.253	0.946	0.828	0.905	0.077	0.029
20	0.339	1.266	0.897	0.952	0.055	0.008
21	0.887	3.254	0.999	1.000	0.001	0.047
μ	0.000				**sup(D1, D2)**	0.194
σ	0.268				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-375.505	-1.527	0.063	0.048	0.016	0.063
2	-362.782	-1.475	0.070	0.095	0.025	0.022
3	-273.071	-1.110	0.133	0.143	0.009	0.038
4	-228.962	-0.931	0.176	0.190	0.015	0.033
5	-199.988	-0.813	0.208	0.238	0.030	0.018
6	-197.723	-0.804	0.211	0.286	0.075	0.027
7	-175.303	-0.713	0.238	0.333	0.095	0.048
8	-172.794	-0.703	0.241	0.381	0.140	0.092
9	-72.054	-0.293	0.385	0.429	0.044	0.004
10	-71.685	-0.291	0.385	0.476	0.091	0.043
11	-43.437	-0.177	0.430	0.524	0.094	0.046
12	43.262	0.176	0.570	0.571	0.002	0.046
13	85.667	0.348	0.636	0.619	0.017	0.065
14	96.616	0.393	0.653	0.667	0.014	0.034
15	142.831	0.581	0.719	0.714	0.005	0.053
16	153.105	0.623	0.733	0.762	0.029	0.019
17	208.930	0.850	0.802	0.810	0.007	0.040
18	269.893	1.097	0.864	0.857	0.007	0.054
19	305.868	1.244	0.893	0.905	0.012	0.036
20	363.856	1.480	0.931	0.952	0.022	0.026
21	503.208	2.046	0.980	1.000	0.020	0.027
μ	-0.003				**sup(D1, D2)**	0.140
σ	245.921				**Critical Value**	0.287

Nom Dist OK

PSD Ratio Area (HTF - 2 Hz) vs. Area (0 - 2 Hz)

Residuals (High - Low Gain)

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.222	-1.950	0.026	0.048	0.022	0.026
2	-0.202	-1.774	0.038	0.095	0.057	0.010
3	-0.127	-1.118	0.132	0.143	0.011	0.036
4	-0.101	-0.885	0.188	0.190	0.002	0.045
5	-0.082	-0.724	0.234	0.238	0.004	0.044
6	-0.073	-0.642	0.260	0.286	0.025	0.022
7	-0.050	-0.441	0.330	0.333	0.004	0.044
8	-0.042	-0.365	0.358	0.381	0.023	0.024
9	-0.032	-0.282	0.389	0.429	0.040	0.008
10	0.016	0.141	0.556	0.476	0.080	0.128
11	0.028	0.244	0.597	0.524	0.073	0.120
12	0.032	0.280	0.610	0.571	0.039	0.086
13	0.038	0.333	0.631	0.619	0.011	0.059
14	0.042	0.373	0.645	0.667	0.021	0.026
15	0.056	0.492	0.689	0.714	0.026	0.022
16	0.059	0.517	0.698	0.762	0.064	0.017
17	0.069	0.604	0.727	0.810	0.083	0.035
18	0.082	0.718	0.764	0.857	0.093	0.046
19	0.083	0.726	0.766	0.905	0.139	0.091
20	0.169	1.483	0.931	0.952	0.021	0.026
21	0.258	2.269	0.988	1.000	0.012	0.036
μ	0.000				**sup(D1, D2)**	0.139
σ	0.114				**Critical Value**	0.287
						Nom Dist OK

Residuals (High - Low Gain), Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-172.791	-2.100	0.018	0.048	0.030	0.018
2	-139.639	-1.697	0.045	0.095	0.050	0.003
3	-90.082	-1.095	0.137	0.143	0.006	0.042
4	-80.528	-0.979	0.164	0.190	0.027	0.021
5	-59.091	-0.718	0.236	0.238	0.002	0.046
6	-53.601	-0.651	0.257	0.286	0.028	0.019
7	-35.930	-0.437	0.331	0.333	0.002	0.045
8	-7.543	-0.092	0.463	0.381	0.083	0.130
9	-1.233	-0.015	0.494	0.429	0.065	0.113
10	4.824	0.059	0.523	0.476	0.047	0.095
11	9.078	0.110	0.544	0.524	0.020	0.068
12	13.513	0.164	0.565	0.571	0.006	0.041
13	16.236	0.197	0.578	0.619	0.041	0.007
14	19.042	0.231	0.591	0.667	0.075	0.028
15	30.486	0.370	0.644	0.714	0.070	0.022
16	39.143	0.476	0.683	0.762	0.079	0.031
17	54.471	0.662	0.746	0.810	0.064	0.016
18	76.829	0.934	0.825	0.857	0.032	0.015
19	86.306	1.049	0.853	0.905	0.052	0.004
20	114.727	1.394	0.918	0.952	0.034	0.014
21	175.866	2.137	0.984	1.000	0.016	0.031
μ	0.004				**sup(D1, D2)**	0.130
σ	82.297				**Critical Value**	0.287
						Nom Dist OK

Residuals Low Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.058	-1.374	0.085	0.048	0.037	0.085
2	-0.055	-1.299	0.097	0.095	0.002	0.049
3	-0.040	-0.936	0.175	0.143	0.032	0.079
4	-0.037	-0.876	0.190	0.190	0.000	0.048
5	-0.037	-0.866	0.193	0.238	0.045	0.003
6	-0.032	-0.744	0.229	0.286	0.057	0.010
7	-0.022	-0.511	0.305	0.333	0.029	0.019
8	-0.019	-0.454	0.325	0.381	0.056	0.009
9	-0.019	-0.450	0.326	0.429	0.102	0.055
10	-0.013	-0.298	0.383	0.476	0.093	0.046
11	-0.005	-0.120	0.452	0.524	0.071	0.024
12	-0.004	-0.083	0.467	0.571	0.105	0.057
13	0.002	0.040	0.516	0.619	0.103	0.056
14	0.004	0.097	0.539	0.667	0.128	0.080
15	0.011	0.248	0.598	0.714	0.116	0.069
16	0.018	0.419	0.662	0.762	0.100	0.052
17	0.026	0.614	0.731	0.810	0.079	0.031
18	0.045	1.054	0.854	0.857	0.003	0.045
19	0.055	1.295	0.902	0.905	0.002	0.045
20	0.072	1.705	0.956	0.952	0.004	0.051
21	0.107	2.526	0.994	1.000	0.006	0.042
μ	0.000				**sup(D1, D2)**	0.128
σ	0.042				**Critical Value**	0.287
						Nom Dist OK

Residuals Low Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-25.467	-1.284	0.100	0.048	0.052	0.100
2	-23.376	-1.179	0.119	0.095	0.024	0.072
3	-22.938	-1.157	0.124	0.143	0.019	0.028
4	-18.054	-0.910	0.181	0.190	0.009	0.038
5	-15.287	-0.771	0.220	0.238	0.018	0.030
6	-12.187	-0.615	0.269	0.286	0.016	0.031
7	-12.104	-0.610	0.271	0.333	0.063	0.015
8	-11.028	-0.556	0.289	0.381	0.092	0.044
9	-9.948	-0.502	0.308	0.429	0.121	0.073
10	-8.342	-0.421	0.337	0.476	0.139	0.092
11	-4.568	-0.230	0.409	0.524	0.115	0.067
12	-0.498	-0.025	0.490	0.571	0.081	0.034
13	1.925	0.097	0.539	0.619	0.080	0.033
14	3.740	0.189	0.575	0.667	0.092	0.044
15	5.264	0.265	0.605	0.714	0.110	0.062
16	7.806	0.394	0.653	0.762	0.109	0.061
17	14.332	0.723	0.765	0.810	0.044	0.003
18	23.297	1.175	0.880	0.857	0.023	0.070
19	28.440	1.434	0.924	0.905	0.019	0.067
20	29.605	1.493	0.932	0.952	0.020	0.028
21	49.382	2.490	0.994	1.000	0.006	0.041
μ	0.000				**sup(D1, D2)**	0.139
σ	19.831				**Critical Value**	0.287
						Nom Dist OK

Residuals High Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.149	-1.501	0.067	0.048	0.019	0.067
2	-0.149	-1.496	0.067	0.095	0.028	0.020
3	-0.147	-1.474	0.070	0.143	0.073	0.025
4	-0.114	-1.145	0.126	0.190	0.064	0.017
5	-0.090	-0.906	0.183	0.238	0.056	0.008
6	-0.086	-0.861	0.195	0.286	0.091	0.043
7	-0.069	-0.697	0.243	0.333	0.090	0.043
8	-0.027	-0.267	0.395	0.381	0.014	0.061
9	-0.024	-0.241	0.405	0.429	0.024	0.024
10	-0.009	-0.091	0.464	0.476	0.012	0.035
11	-0.003	-0.031	0.488	0.524	0.036	0.011
12	0.019	0.187	0.574	0.571	0.003	0.050
13	0.058	0.578	0.719	0.619	0.099	0.147
14	0.060	0.604	0.727	0.667	0.060	0.108
15	0.066	0.661	0.746	0.714	0.031	0.079
16	0.073	0.731	0.768	0.762	0.006	0.053
17	0.077	0.769	0.779	0.810	0.030	0.017
18	0.079	0.794	0.786	0.857	0.071	0.023
19	0.104	1.041	0.851	0.905	0.054	0.006
20	0.129	1.295	0.902	0.952	0.050	0.002
21	0.203	1.784	0.963	1.000	0.037	0.010
μ	0.000				**sup(D1, D2)**	0.147
σ	0.100				**Critical Value**	0.287
						Nom Dist OK

Residuals High Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-123.414	-1.668	0.048	0.048	0.000	0.048
2	-110.039	-1.487	0.069	0.095	0.027	0.021
3	-92.636	-1.252	0.105	0.143	0.038	0.010
4	-82.280	-1.112	0.133	0.190	0.057	0.010
5	-67.438	-0.911	0.181	0.238	0.057	0.009
6	-48.121	-0.650	0.258	0.286	0.028	0.020
7	-39.273	-0.531	0.298	0.333	0.036	0.012
8	-30.924	-0.418	0.338	0.381	0.043	0.005
9	-12.264	-0.166	0.434	0.429	0.006	0.053
10	3.750	0.051	0.520	0.476	0.044	0.092
11	10.085	0.136	0.554	0.524	0.030	0.078
12	11.663	0.158	0.563	0.571	0.009	0.039
13	13.011	0.176	0.570	0.619	0.049	0.002
14	32.370	0.437	0.669	0.667	0.002	0.050
15	32.407	0.438	0.669	0.714	0.045	0.003
16	44.520	0.602	0.726	0.762	0.036	0.012
17	51.357	0.694	0.756	0.810	0.053	0.006
18	63.364	0.856	0.804	0.857	0.053	0.005
19	67.579	0.913	0.819	0.905	0.085	0.038
20	96.668	1.306	0.904	0.952	0.048	0.000
21	179.602	2.427	0.992	1.000	0.008	0.040
μ	-0.001				**sup(D1, D2)**	0.092
σ	74.002				**Critical Value**	0.287
						Nom Dist OK

PSD Ratio Area (HTF - 2 Hz) vs. Area (0 Hz - HTF)

Residuals (High - Low Gain)

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.540	-1.304	0.096	0.048	0.049	0.096
2	-0.492	-1.188	0.117	0.095	0.022	0.070
3	-0.463	-1.119	0.132	0.143	0.011	0.036
4	-0.449	-1.083	0.139	0.190	0.051	0.004
5	-0.402	-0.972	0.166	0.238	0.073	0.025
6	-0.310	-0.748	0.227	0.286	0.058	0.011
7	-0.308	-0.744	0.228	0.333	0.105	0.057
8	-0.196	-0.473	0.318	0.381	0.063	0.015
9	-0.136	-0.329	0.371	0.429	0.057	0.010
10	-0.038	-0.093	0.463	0.476	0.013	0.035
11	0.069	0.166	0.566	0.524	0.042	0.090
12	0.077	0.185	0.573	0.571	0.002	0.050
13	0.104	0.250	0.599	0.619	0.020	0.027
14	0.121	0.292	0.615	0.667	0.052	0.004
15	0.174	0.421	0.663	0.714	0.051	0.004
16	0.175	0.422	0.664	0.762	0.098	0.051
17	0.221	0.534	0.703	0.810	0.106	0.059
18	0.250	0.604	0.727	0.857	0.130	0.082
19	0.423	1.021	0.846	0.905	0.058	0.011
20	0.544	1.314	0.906	0.952	0.047	0.001
21	1.177	2.843	0.998	1.000	0.002	0.045
μ	0.000				**sup(D1, D2)**	0.130
σ	0.414				**Critical Value**	0.287

Nom Dist OK

Residuals (High - Low Gain), Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-265.951	-1.630	0.052	0.048	0.004	0.052
2	-236.865	-1.452	0.073	0.095	0.022	0.026
3	-186.602	-1.144	0.126	0.143	0.016	0.031
4	-156.545	-0.959	0.169	0.190	0.022	0.026
5	-142.161	-0.871	0.192	0.238	0.046	0.001
6	-141.803	-0.869	0.192	0.286	0.093	0.046
7	-95.519	-0.585	0.279	0.333	0.054	0.007
8	-92.005	-0.564	0.286	0.381	0.095	0.047
9	-43.441	-0.266	0.395	0.429	0.034	0.014
10	4.277	0.026	0.510	0.476	0.034	0.082
11	11.711	0.072	0.529	0.524	0.005	0.052
12	21.731	0.133	0.553	0.571	0.018	0.029
13	38.745	0.237	0.594	0.619	0.025	0.022
14	45.455	0.279	0.610	0.667	0.057	0.009
15	78.304	0.480	0.684	0.714	0.030	0.018
16	79.428	0.487	0.687	0.762	0.075	0.028
17	117.519	0.720	0.764	0.810	0.045	0.002
18	146.029	0.895	0.815	0.857	0.043	0.005
19	183.834	1.127	0.870	0.905	0.035	0.013
20	307.111	1.882	0.970	0.952	0.018	0.065
21	326.658	2.002	0.977	1.000	0.023	0.025
μ	-0.004				**sup(D1, D2)**	0.095
σ	163.178				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.152	-2.647	0.004	0.048	0.044	0.004
2	-0.091	-1.576	0.058	0.095	0.038	0.010
3	-0.070	-1.220	0.111	0.143	0.032	0.016
4	-0.057	-0.988	0.162	0.190	0.029	0.019
5	-0.032	-0.559	0.288	0.238	0.050	0.098
6	-0.023	-0.406	0.342	0.286	0.057	0.104
7	-0.012	-0.200	0.421	0.333	0.087	0.135
8	-0.005	-0.081	0.468	0.381	0.087	0.134
9	-0.003	-0.044	0.483	0.429	0.054	0.102
10	0.005	0.079	0.532	0.476	0.055	0.103
11	0.008	0.142	0.556	0.524	0.033	0.080
12	0.014	0.235	0.593	0.571	0.022	0.069
13	0.022	0.389	0.652	0.619	0.032	0.080
14	0.024	0.422	0.663	0.667	0.003	0.044
15	0.025	0.442	0.671	0.714	0.044	0.004
16	0.040	0.689	0.755	0.762	0.007	0.040
17	0.041	0.708	0.760	0.810	0.049	0.001
18	0.044	0.763	0.777	0.857	0.080	0.032
19	0.052	0.910	0.819	0.905	0.086	0.038
20	0.065	1.124	0.869	0.952	0.083	0.035
21	0.104	1.806	0.965	1.000	0.035	0.012
μ	0.000				**sup(D1, D2)**	0.135
σ	0.057				**Critical Value**	0.287

Nom Dist OK

Residuals Low Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-24.732	-1.239	0.108	0.048	0.060	0.108
2	-22.881	-1.146	0.126	0.095	0.031	0.078
3	-22.611	-1.133	0.129	0.143	0.014	0.033
4	-15.703	-0.787	0.216	0.190	0.025	0.073
5	-14.626	-0.733	0.232	0.238	0.006	0.041
6	-13.410	-0.672	0.251	0.286	0.035	0.013
7	-13.142	-0.658	0.255	0.333	0.078	0.031
8	-11.939	-0.598	0.275	0.381	0.106	0.058
9	-9.520	-0.477	0.317	0.429	0.112	0.064
10	-7.726	-0.387	0.349	0.476	0.127	0.079
11	-6.043	-0.303	0.381	0.524	0.143	0.095
12	-1.044	-0.052	0.479	0.571	0.092	0.045
13	1.760	0.088	0.535	0.619	0.084	0.036
14	2.527	0.127	0.550	0.667	0.116	0.069
15	5.658	0.283	0.612	0.714	0.103	0.055
16	8.016	0.402	0.656	0.762	0.106	0.058
17	13.803	0.692	0.755	0.810	0.054	0.006
18	22.891	1.147	0.874	0.857	0.017	0.065
19	26.145	1.310	0.905	0.905	0.000	0.048
20	29.819	1.494	0.932	0.952	0.020	0.028
21	52.755	2.643	0.996	1.000	0.004	0.044
μ	0.000				**sup(D1, D2)**	0.143
σ	19.957				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.579	-1.379	0.084	0.048	0.036	0.084
2	-0.544	-1.295	0.098	0.095	0.002	0.050
3	-0.488	-1.160	0.123	0.143	0.020	0.028
4	-0.412	-0.980	0.163	0.190	0.027	0.021
5	-0.378	-0.901	0.184	0.238	0.054	0.007
6	-0.323	-0.769	0.221	0.286	0.065	0.017
7	-0.312	-0.742	0.229	0.333	0.104	0.057
8	-0.184	-0.438	0.331	0.381	0.050	0.003
9	-0.104	-0.248	0.402	0.429	0.026	0.021
10	-0.079	-0.188	0.425	0.476	0.051	0.003
11	0.046	0.110	0.544	0.524	0.020	0.068
12	0.078	0.186	0.574	0.571	0.003	0.050
13	0.100	0.238	0.594	0.619	0.025	0.023
14	0.123	0.293	0.615	0.667	0.051	0.004
15	0.170	0.404	0.657	0.714	0.057	0.010
16	0.180	0.427	0.665	0.762	0.096	0.049
17	0.242	0.576	0.718	0.810	0.092	0.044
18	0.278	0.662	0.746	0.857	0.111	0.064
19	0.379	0.902	0.816	0.905	0.088	0.041
20	0.696	1.657	0.951	0.952	0.001	0.046
21	1.112	2.687	0.996	1.000	0.004	0.044
μ	0.000				**sup(D1, D2)**	0.111
σ	0.420				**Critical Value**	0.287

Nom Dist OK

Residuals High Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-213.196	-1.359	0.087	0.048	0.040	0.087
2	-207.045	-1.319	0.094	0.095	0.002	0.046
3	-199.743	-1.273	0.102	0.143	0.041	0.006
4	-155.571	-0.991	0.161	0.190	0.030	0.018
5	-151.323	-0.964	0.167	0.238	0.071	0.023
6	-148.529	-0.946	0.172	0.286	0.114	0.066
7	-103.943	-0.662	0.254	0.333	0.079	0.032
8	-81.717	-0.521	0.301	0.381	0.080	0.032
9	-66.322	-0.423	0.336	0.429	0.092	0.045
10	-3.448	-0.022	0.491	0.476	0.015	0.063
11	7.105	0.045	0.518	0.524	0.006	0.042
12	14.239	0.091	0.536	0.571	0.035	0.012
13	37.701	0.240	0.595	0.619	0.024	0.023
14	39.412	0.251	0.599	0.667	0.068	0.020
15	81.188	0.517	0.698	0.714	0.017	0.031
16	101.195	0.645	0.740	0.762	0.021	0.026
17	130.326	0.830	0.797	0.810	0.013	0.035
18	143.666	0.915	0.820	0.857	0.037	0.011
19	159.102	1.014	0.845	0.905	0.060	0.012
20	304.047	1.937	0.974	0.952	0.021	0.069
21	312.768	1.993	0.977	1.000	0.023	0.024
μ	-0.004				**sup(D1, D2)**	0.114
σ	156.930				**Critical Value**	0.287

Nom Dist OK

QIE of PT1 Pilot Model

Residuals (High - Low Gain)

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.562	-1.819	0.034	0.048	0.013	0.034
2	-0.484	-1.564	0.059	0.095	0.036	0.011
3	-0.393	-1.270	0.102	0.143	0.041	0.007
4	-0.230	-0.744	0.228	0.190	0.038	0.086
5	-0.222	-0.719	0.236	0.238	0.002	0.046
6	-0.160	-0.519	0.302	0.286	0.016	0.064
7	-0.131	-0.424	0.336	0.333	0.003	0.050
8	-0.130	-0.421	0.337	0.381	0.044	0.004
9	-0.120	-0.389	0.349	0.429	0.080	0.032
10	-0.106	-0.342	0.366	0.476	0.110	0.062
11	-0.106	-0.342	0.366	0.524	0.158	0.110
12	-0.040	-0.128	0.449	0.571	0.122	0.075
13	0.108	0.348	0.636	0.619	0.017	0.065
14	0.140	0.452	0.674	0.667	0.008	0.055
15	0.160	0.517	0.698	0.714	0.017	0.031
16	0.229	0.740	0.770	0.762	0.008	0.056
17	0.267	0.862	0.806	0.810	0.004	0.044
18	0.322	1.042	0.851	0.857	0.006	0.042
19	0.392	1.269	0.898	0.905	0.007	0.041
20	0.512	1.656	0.951	0.952	0.001	0.046
21	0.554	1.792	0.963	1.000	0.037	0.011
μ	0.000				**sup(D1, D2)**	0.158
σ	0.309				**Critical Value**	0.287
						Nom Dist OK

Residuals (High - Low Gain), Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-300.835	-1.685	0.046	0.048	0.002	0.046
2	-249.836	-1.399	0.081	0.095	0.014	0.033
3	-204.141	-1.143	0.126	0.143	0.016	0.031
4	-107.916	-0.604	0.273	0.190	0.082	0.130
5	-103.239	-0.578	0.282	0.238	0.043	0.091
6	-94.530	-0.529	0.298	0.286	0.013	0.060
7	-85.840	-0.481	0.315	0.333	0.018	0.030
8	-85.207	-0.477	0.317	0.381	0.064	0.017
9	-65.298	-0.366	0.357	0.429	0.071	0.024
10	-34.101	-0.191	0.424	0.476	0.052	0.004
11	-0.315	-0.002	0.499	0.524	0.025	0.023
12	1.193	0.007	0.503	0.571	0.069	0.021
13	38.500	0.216	0.585	0.619	0.034	0.014
14	43.767	0.245	0.597	0.667	0.070	0.022
15	50.800	0.285	0.612	0.714	0.102	0.055
16	109.872	0.615	0.731	0.762	0.031	0.017
17	110.144	0.617	0.731	0.810	0.078	0.031
18	121.571	0.681	0.752	0.857	0.105	0.057
19	130.186	0.729	0.767	0.905	0.138	0.090
20	179.700	1.006	0.843	0.952	0.109	0.062
21	545.440	3.055	0.999	1.000	0.001	0.046
μ	-0.004				**sup(D1, D2)**	0.138
σ	178.549				**Critical Value**	0.287
						Nom Dist OK

Residuals Low Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.090	-1.716	0.043	0.048	0.005	0.043
2	-0.081	-1.539	0.062	0.095	0.033	0.014
3	-0.061	-1.152	0.125	0.143	0.018	0.029
4	-0.043	-0.821	0.206	0.190	0.015	0.063
5	-0.040	-0.755	0.225	0.238	0.013	0.035
6	-0.031	-0.583	0.280	0.286	0.006	0.042
7	-0.022	-0.416	0.339	0.333	0.006	0.053
8	-0.015	-0.288	0.387	0.381	0.006	0.053
9	-0.014	-0.272	0.393	0.429	0.036	0.012
10	-0.007	-0.134	0.447	0.476	0.029	0.018
11	-0.003	-0.057	0.477	0.524	0.047	0.001
12	-0.003	-0.048	0.481	0.571	0.091	0.043
13	-0.001	-0.012	0.495	0.619	0.124	0.076
14	0.009	0.174	0.569	0.667	0.097	0.050
15	0.028	0.541	0.706	0.714	0.009	0.039
16	0.032	0.606	0.728	0.762	0.034	0.014
17	0.032	0.607	0.728	0.810	0.081	0.034
18	0.040	0.760	0.776	0.857	0.081	0.033
19	0.066	1.254	0.895	0.905	0.010	0.038
20	0.070	1.324	0.907	0.952	0.045	0.003
21	0.134	2.542	0.994	1.000	0.006	0.042
μ	0.000				**sup(D1, D2)**	0.124
σ	0.053				**Critical Value**	0.287
						Nom Dist OK

Residuals Low Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-28.416	-1.340	0.090	0.048	0.043	0.090
2	-26.842	-1.266	0.103	0.095	0.008	0.055
3	-24.378	-1.150	0.125	0.143	0.018	0.030
4	-23.640	-1.115	0.132	0.190	0.058	0.010
5	-16.390	-0.773	0.220	0.238	0.018	0.029
6	-15.397	-0.726	0.234	0.286	0.052	0.004
7	-10.984	-0.518	0.302	0.333	0.031	0.017
8	-6.108	-0.288	0.387	0.381	0.006	0.053
9	-4.336	-0.204	0.419	0.429	0.010	0.038
10	-3.911	-0.184	0.427	0.476	0.049	0.002
11	-3.614	-0.170	0.432	0.524	0.091	0.044
12	-3.008	-0.142	0.444	0.571	0.128	0.080
13	-1.893	-0.089	0.464	0.619	0.155	0.107
14	-0.551	-0.026	0.490	0.667	0.177	0.129
15	13.845	0.653	0.743	0.714	0.029	0.076
16	14.355	0.677	0.751	0.762	0.011	0.036
17	16.023	0.756	0.775	0.810	0.034	0.013
18	17.329	0.817	0.793	0.857	0.064	0.016
19	17.832	0.841	0.800	0.905	0.105	0.057
20	33.661	1.587	0.944	0.952	0.009	0.039
21	56.426	2.661	0.996	1.000	0.004	0.044
μ	0.000				**sup(D1, D2)**	0.177
σ	21.207				**Critical Value**	0.287
						Nom Dist OK

Residuals High Gain

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-0.530	-1.819	0.034	0.048	0.013	0.034
2	-0.484	-1.661	0.048	0.095	0.047	0.001
3	-0.400	-1.372	0.085	0.143	0.058	0.010
4	-0.261	-0.894	0.186	0.190	0.005	0.043
5	-0.213	-0.731	0.232	0.238	0.006	0.042
6	-0.163	-0.559	0.288	0.286	0.002	0.050
7	-0.120	-0.412	0.340	0.333	0.007	0.054
8	-0.109	-0.373	0.355	0.381	0.026	0.021
9	-0.080	-0.275	0.392	0.429	0.037	0.011
10	-0.060	-0.207	0.418	0.476	0.058	0.011
11	-0.011	-0.038	0.485	0.524	0.039	0.009
12	0.003	0.010	0.504	0.571	0.068	0.020
13	0.049	0.170	0.567	0.619	0.052	0.004
14	0.120	0.412	0.660	0.667	0.007	0.041
15	0.174	0.596	0.724	0.714	0.010	0.058
16	0.186	0.637	0.738	0.762	0.024	0.024
17	0.245	0.840	0.799	0.810	0.010	0.038
18	0.332	1.138	0.872	0.857	0.015	0.063
19	0.354	1.215	0.888	0.905	0.017	0.031
20	0.473	1.623	0.948	0.952	0.005	0.043
21	0.497	1.607	0.946	1.000	0.054	0.006
μ	0.000				**sup(D1, D2)**	0.068
σ	0.292				**Critical Value**	0.287
						Nom Dist OK

Residuals High Gain, Percentage

i	xi	ui	Φ(ui)	i/n	D1 |Φ(ui)-i/n|	D2 |Φ(ui)-(i-1)/n|
1	-286.477	-1.624	0.052	0.048	0.005	0.052
2	-252.840	-1.433	0.076	0.095	0.019	0.028
3	-210.246	-1.192	0.117	0.143	0.026	0.021
4	-111.824	-0.634	0.263	0.190	0.073	0.120
5	-103.786	-0.588	0.278	0.238	0.040	0.088
6	-90.172	-0.511	0.305	0.286	0.019	0.067
7	-81.685	-0.463	0.322	0.333	0.012	0.036
8	-67.874	-0.385	0.350	0.381	0.031	0.017
9	-38.101	-0.216	0.414	0.429	0.014	0.034
10	-27.153	-0.154	0.439	0.476	0.037	0.010
11	-20.253	-0.115	0.454	0.524	0.070	0.022
12	-14.200	-0.081	0.468	0.571	0.104	0.056
13	27.519	0.156	0.562	0.619	0.057	0.009
14	48.910	0.277	0.609	0.667	0.057	0.010
15	77.431	0.439	0.670	0.714	0.045	0.003
16	85.498	0.485	0.686	0.762	0.076	0.028
17	86.507	0.490	0.688	0.810	0.121	0.074
18	93.158	0.528	0.701	0.857	0.156	0.108
19	146.214	0.829	0.796	0.905	0.108	0.061
20	197.535	1.120	0.869	0.952	0.084	0.036
21	541.829	3.072	0.999	1.000	0.001	0.047
μ	-0.001				**sup(D1, D2)**	0.156
σ	176.392				**Critical Value**	0.287
						Nom Dist OK