Purpose:

This project explores the performance of electronic inverters by analyzing the relationship between transistor dimensions, operational setpoints, and their transient performance. The objective is to identify key design parameters and their interactions that significantly influence transient response, enabling optimization of inverter performance.

Parameters Overview:

Regression Analysis was done on SAS to evaluate the impact of transistor dimensions (WidthNMOS, LengthNMOS, WidthPMOS, LengthPMOS) and operational setpoints (Setpoint) on transient response (TransientPt). 3 models, including 1 indicator and 2 interaction models were used to assess main effects and higher-order interactions, with diagnostic plots for model evaluation. The data dictionary used in the SAS code is given below:

- x1 = WidthNMOS;
- x2 = LengthNMOS;
- x3 = WidthPMOS;
- x4 = LengthPMOS;
- x5 = Setpoint;
- y = TransientPt;

Parameter Analysis:

The GLM Procedure

Dependent Variable: y

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	130.5492029	26.1098406	6.45	0.0012
Error	19	76.8544809	4.0449727		
Corrected Total	24	207.4036838			

Figure 1: ANOVA Table after Simple Linear Regression.

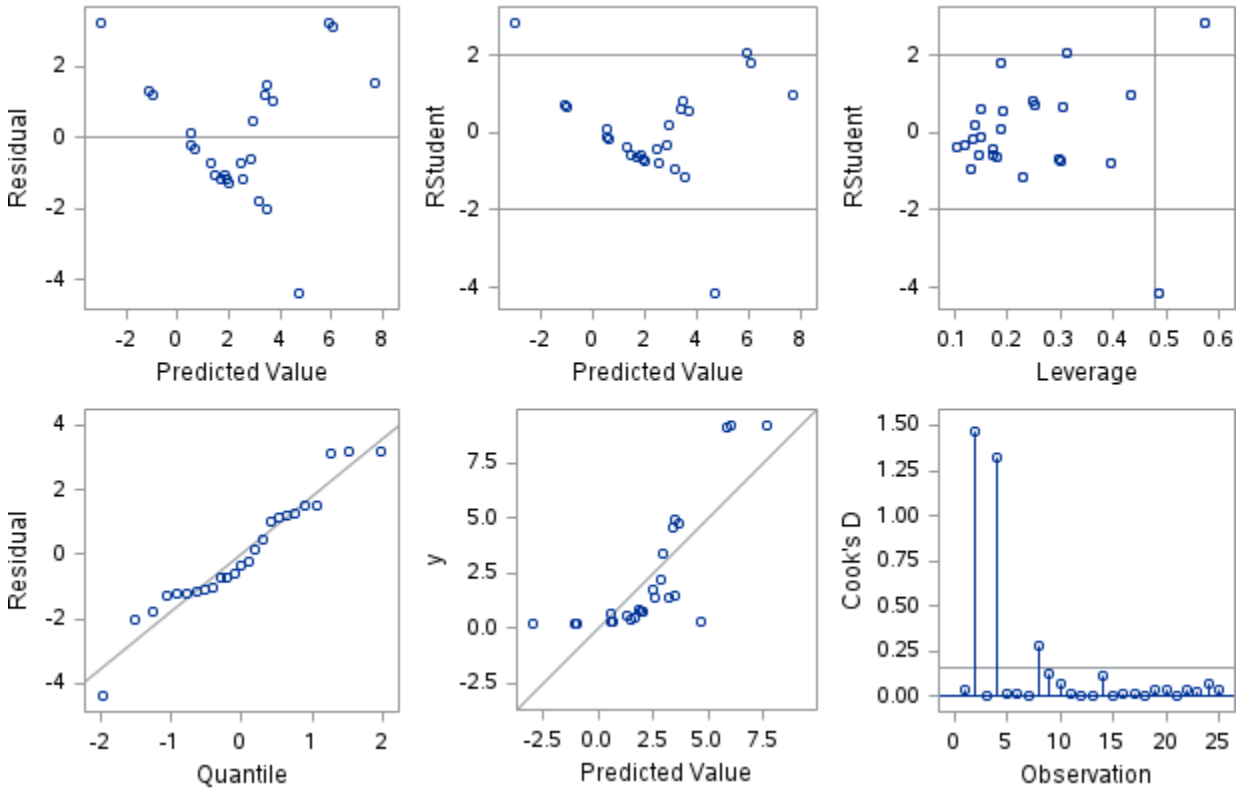

Figure 2: Diagnostic Plots for the Simple Linear Regression model.

While the ANOVA Table indicates the simple linear regression (SLR) model is significant, the diagnostic plots show that the normality assumption of the predictor variables does not hold. In particular, there are high-influence points, as well as some level of predictor interactions as shown by the leverage and residual plots respectively.

Model Analysis:

Model 1: Indicator Model using x5 (setpoint):

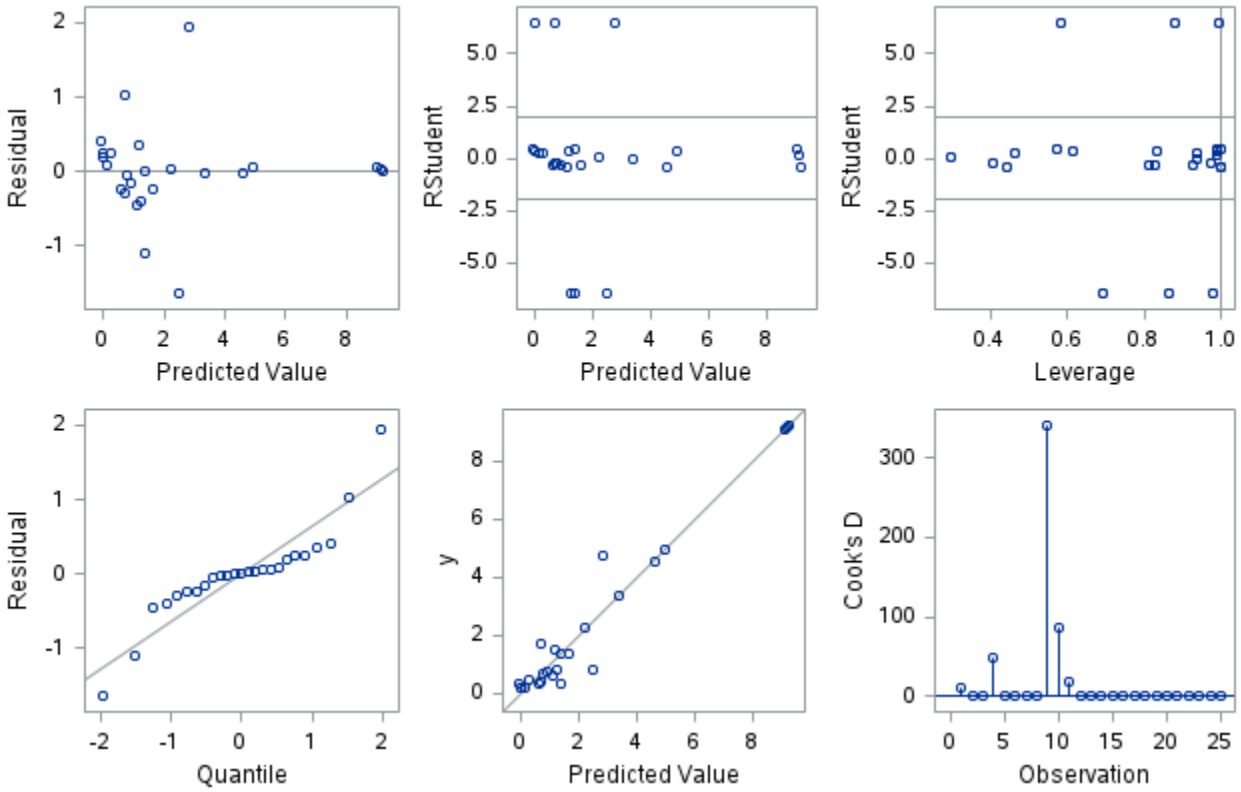

Figure 3: Diagnostic Plots for the Indicator Model.

The indicator model adds additional interaction terms to the SLR model using x5 (indicator) multiplied by each of the other predictor variables. The residual plots show a much more random distribution, indicating that the combination of setpoint variation and each of the other predictors account for a much higher proportion of the variation of transient response.

Model 2: Interaction Model using x2, x3 and x5:

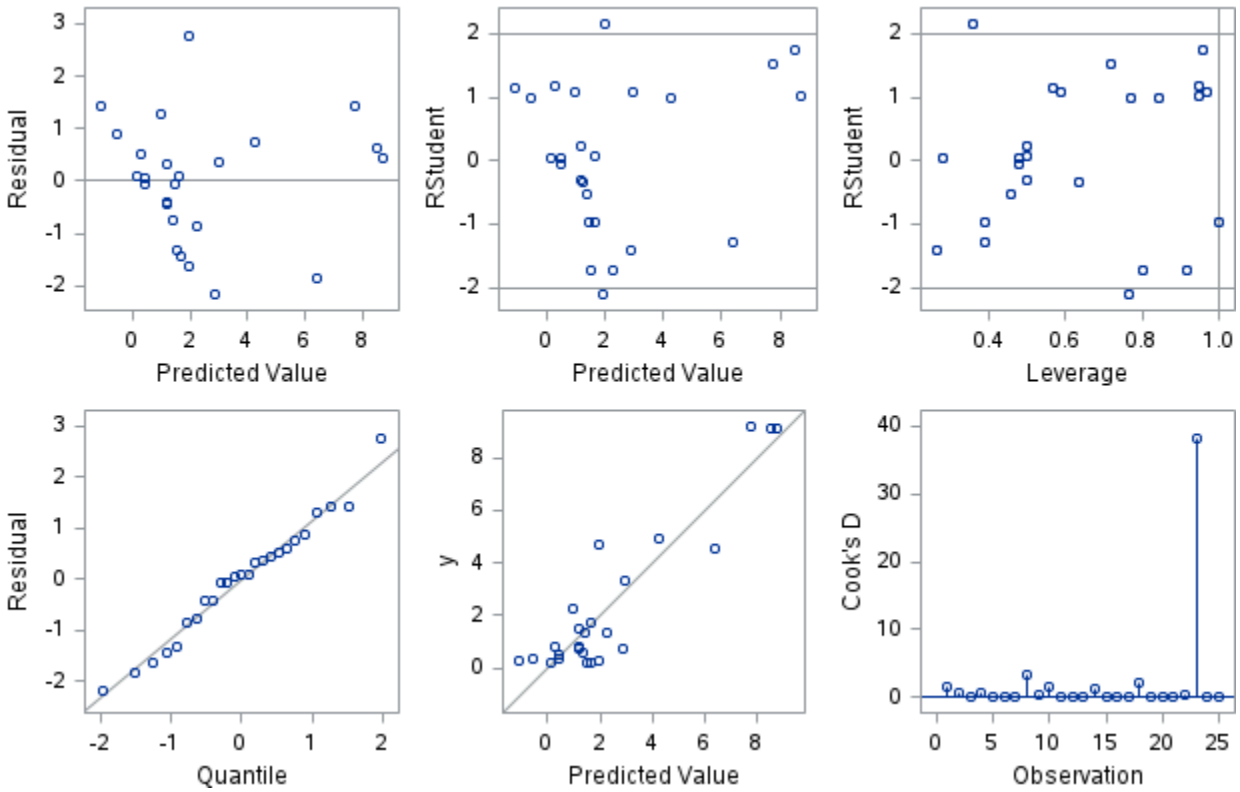

Figure 4: Diagnostic Plots for the Interaction Model using x2, x3, x5.

This interaction model only uses x2, x3 and x5 and adds the 2-way and 3-way combination terms to the SLR model. Like the previous indicator model, this interaction model also warrants the normality assumption more than the SLR model, and is affected less by high-leverage points. This model shows that LengthNMOS, WidthPMOS and setpoint by themselves can explain a large proportion of the variation of transient response.

Model 3: Interaction Model using all 2-way predictor interactions:

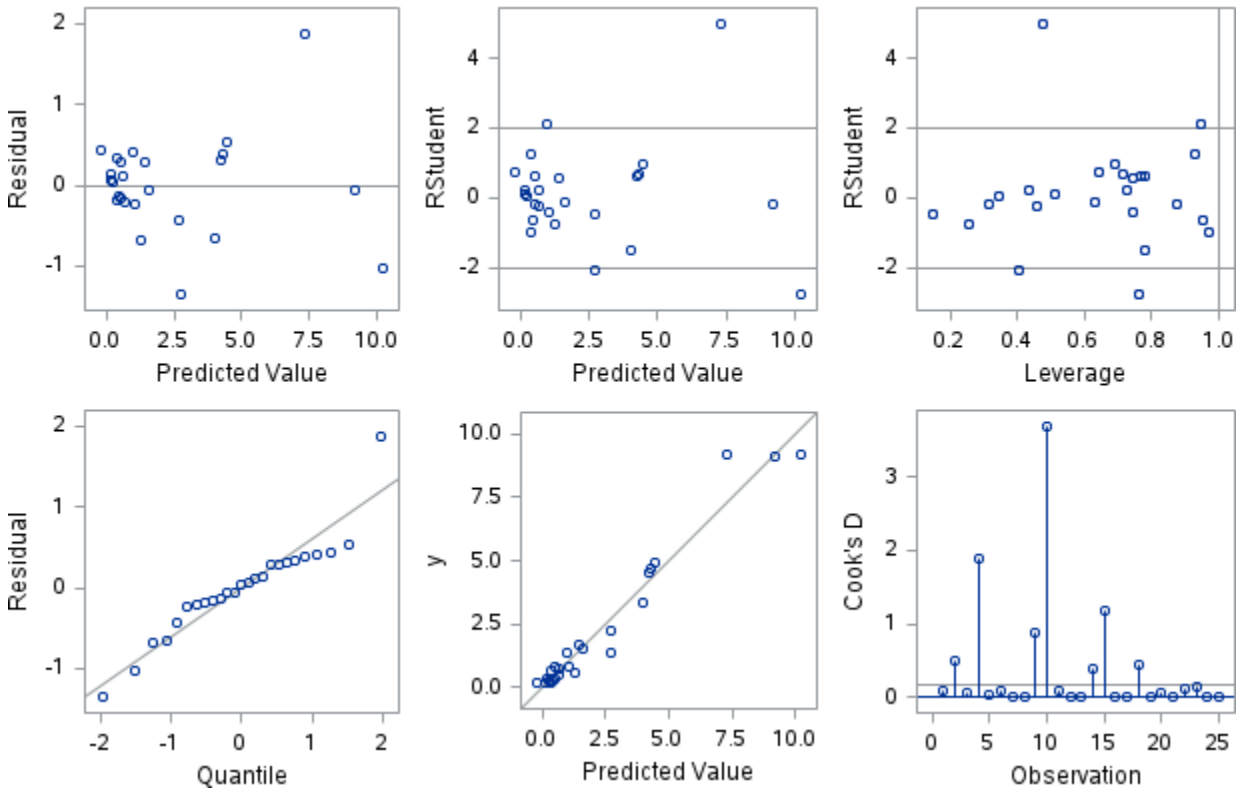

Figure 5: Diagnostic Plots for the Interaction Model using all 2-way predictor interactions.

This interaction model only uses all predictors and adds all the 2-way combination terms to the SLR model. Like the previous indicator model, this interaction model also warrants the normality assumption more than the SLR model, and is affected less by high-leverage points. This model shows that pairwise combinations of predictors explain a large proportion of the variation of transient response.

Results:

Result	SLR	Indicator	Interaction (x2, x3, x5)	Interaction (all 2-way)
R^2	0.6294	0.9529	0.8447	0.9578
Adjusted R^2	0.5319	0.7739	0.5858	0.8875
F-statistic	6.45	5.32	3.26	13.62
p-value (for F)	0.0012	0.0364	0.0392	0.0002

The interaction model with all 2-way predictor interactions works best for predicting transient response. This is shown by the high R^2 and Adjusted R^2 values (explaining high proportion of response variation), and the high F-statistic and p-value (model is highly significant).

The other indicator model suggests that LengthNMOS, WidthPMOS and setpoint themselves collectively account for a large proportion of the response variation; while the Indicator model suggests that the setpoint itself largely affects the other predictors' effect on the response.