SAS/ETS® 14.1 User's Guide
The TIMESERIES Procedure

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SAS Institute Inc., SAS Campus Drive, Cary, NC 27513-2414

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Chapter 39
The TIMESERIES Procedure

Contents

Overview: TIMESERIES Procedure

The TIMESERIES procedure analyzes time-stamped transactional data with respect to time and accumulates the data into a time series format. The procedure can perform trend and seasonal analysis on the transactions. After the transactional data are accumulated, time domain and frequency domain analysis can be performed on the accumulated time series.

For seasonal analysis of the transaction data, various statistics can be computed for each season. For trend analysis of the transaction data, various statistics can be computed for each time period. The analysis is similar to applying the MEANS procedure of Base SAS software to each season or time period of concern.

After the transactional data are accumulated to form a time series and any missing values are interpreted, the accumulated time series can be functionally transformed using log, square root, logistic, or Box-Cox transformations. The time series can be further transformed using simple and/or seasonal differencing. After functional and difference transformations have been applied, the accumulated and transformed time series can be stored in an output data set. This working time series can then be analyzed further using various time series analysis techniques provided by this procedure or other SAS/ETS procedures.

Time series analyses performed by the TIMESERIES procedure include:

- descriptive (global) statistics
- seasonal decomposition/adjustment analysis
- correlation analysis
- cross-correlation analysis
- spectral analysis

All results of the transactional or time series analysis can be stored in output data sets or printed using the Output Delivery System (ODS).

The TIMESERIES procedure can process large amounts of time-stamped transactional data. Therefore, the analysis results are useful for large-scale time series analysis or (temporal) data mining. All of the results can be stored in output data sets in either a time series format (default) or in a coordinate format (transposed). The time series format is useful for preparing the data for subsequent analysis with other SAS/ETS procedures. For example, the working time series can be further analyzed, modeled, and forecast with other SAS/ETS procedures. The coordinate format is useful when using this procedure with SAS/STAT procedures or SAS Enterprise Miner. For example, clustering time-stamped transactional data can be achieved by using the results of this procedure with the clustering procedures of SAS/STAT and the nodes of SAS Enterprise Miner.

The EXPAND procedure can be used for the frequency conversion and transformations of time series output from this procedure.

Getting Started: TIMESERIES Procedure

This section outlines the use of the TIMESERIES procedure and gives a cursory description of some of the analysis techniques that can be performed on time-stamped transactional data.

Given an input data set that contains numerous transaction variables recorded over time at no specific frequency, the TIMESERIES procedure can form time series as follows:

```
PROC TIMESERIES DATA=<input-data-set>
                OUT=<output-data-set>;
   ID <time-ID-variable> INTERVAL=<frequency>
                         ACCUMULATE=<statistic>;
   VAR <time-series-variables>;
RUN;
```

The TIMESERIES procedure forms time series from the input time-stamped transactional data. It can provide results in output data sets or in other output formats by using the Output Delivery System (ODS).

Time-stamped transactional data are often recorded at no fixed interval. Analysts often want to use time series analysis techniques that require fixed-time intervals. Therefore, the transactional data must be accumulated to form a fixed-interval time series.

Suppose that a bank wants to analyze the transactions associated with each of its customers over time. Further, suppose that the data set WORK.TRANSACTIONS contains four variables that are related to these transactions: CUSTOMER, DATE, WITHDRAWAL, and DEPOSITS. The following examples illustrate possible ways to analyze these transactions by using the TIMESERIES procedure.

To accumulate the time-stamped transactional data to form a daily time series based on the accumulated daily totals of each type of transaction (WITHDRAWALS and DEPOSITS), the following TIMESERIES procedure statements can be used:

```
proc timeseries data=transactions
                out=timeseries;
   by customer;
   id date interval=day accumulate=total;
   var withdrawals deposits;
run;
```

The OUT=TIMESERIES option specifies that the resulting time series data for each customer is to be stored in the data set WORK.TIMESERIES. The INTERVAL=DAY option specifies that the transactions are to be accumulated on a daily basis. The ACCUMULATE=TOTAL option specifies that the sum of the transactions is to be calculated. After the transactional data is accumulated into a time series format, many of the procedures provided with SAS/ETS software can be used to analyze the resulting time series data.

For example, the ARIMA procedure can be used to model and forecast each customer's withdrawal data by using an ARIMA(0,1,1)(0,1,1)$_s$ model (where the number of seasons is s=7 days in a week) using the following statements:

```
proc arima data=timeseries;
   identify var=withdrawals(1,7) noprint;
   estimate q=(1)(7) outest=estimates noprint;
   forecast id=date interval=day out=forecasts;
quit;
```

The OUTEST=ESTIMATES data set contains the parameter estimates of the model specified. The OUT=FORECASTS data set contains forecasts based on the model specified. See the SAS/ETS ARIMA procedure for more detail.

A single set of transactions can be very large and must be summarized in order to analyze them effectively. Analysts often want to examine transactional data for trends and seasonal variation. To analyze transactional data for trends and seasonality, statistics must be computed for each time period and season of concern. For each observation, the time period and season must be determined and the data must be analyzed based on this determination.

The following statements illustrate how to use the TIMESERIES procedure to perform trend and seasonal analysis of time-stamped transactional data.

```
proc timeseries data=transactions out=out
                outseason=season outtrend=trend;
   by customer;
   id date interval=day accumulate=total;
   var withdrawals deposits;
run;
```

Since the INTERVAL=DAY option is specified, the length of the seasonal cycle is seven (7) where the first season is Sunday and the last season is Saturday. The output data set specified by the OUTSEASON=SEASON option contains the seasonal statistics for each day of the week by each customer. The output data set specified by the OUTTREND=TREND option contains the trend statistics for each day of the calendar by each customer.

Often it is desired to seasonally decompose into seasonal, trend, cycle, and irregular components or to seasonally adjust a time series. The following techniques describe how the changing seasons influence the time series.

The following statements illustrate how to use the TIMESERIES procedure to perform seasonal adjustment/decomposition analysis of time-stamped transactional data.

```
proc timeseries data=transactions
                out=out
                outdecomp=decompose;
   by customer;
   id date interval=day accumulate=total;
   var withdrawals deposits;
run;
```

The output data set specified by the OUTDECOMP=DECOMPOSE data set contains the decomposed/adjusted time series for each customer.

A single time series can be very large. Often, a time series must be summarized with respect to time lags in order to be efficiently analyzed using time domain techniques. These techniques help describe how a current observation is related to the past observations with respect to the time (season) lag.

The following statements illustrate how to use the TIMESERIES procedure to perform time domain analysis of time-stamped transactional data.

```
proc timeseries data=transactions
                out=out
                outcorr=timedomain;
   by customer;
   id date interval=day accumulate=total;
   var withdrawals deposits;
run;
```

The output data set specified by the OUTCORR=TIMEDOMAIN data set contains the time domain statistics, such as sample autocorrelations and partial autocorrelations, by each customer.

Sometimes time series data contain underlying patterns that can be identified using spectral analysis techniques. Two kinds of spectral analyses on univariate data can be performed using the TIMESERIES procedure. They are singular spectrum analysis and Fourier spectral analysis.

Singular spectrum analysis (SSA) is a technique for decomposing a time series into additive components and categorizing these components based on the magnitudes of their contributions. SSA uses a single parameter, the window length, to quantify patterns in a time series without relying on prior information about the series' structure. The window length represents the maximum lag that is considered in the analysis, and it corresponds to the dimensionality of the principle components analysis (PCA) on which SSA is based. The components are combined into groups to categorize their roles in the SSA decomposition.

Fourier spectral analysis decomposes a time series into a sum of harmonics. In the discrete Fourier transform, the contribution of components at evenly spaced frequencies are quantified in a periodogram and summarized in spectral density estimates.

The following statements illustrate how to use the TIMESERIES procedure to analyze time-stamped transactional data without prior information about the series' structure.

```
proc timeseries data=transactions
                outssa=ssa
                outspectra=spectra;
   by customer;
   id date interval=day accumulate=total;
   var withdrawals deposits;
run;
```

The output data set specified by the OUTSSA=SSA data set contains a singular spectrum analysis of the withdrawals and deposits data. The data set specified by OUTSPECTRA=SPECTRA contains a Fourier spectral decomposition of the same data.

By default, the TIMESERIES procedure produces no printed output.

Syntax: TIMESERIES Procedure

The TIMESERIES Procedure uses the following statements:

PROC TIMESERIES *options* **;**
BY *variables* **;**
CORR *statistics-list / options* **;**
CROSSCORR *statistics-list / options* **;**
CROSSVAR *variable-list / options* **;**
COUNT */ options* **;**
DECOMP *component-list / options* **;**
ID *variable* **INTERVAL=** *interval-option* **;**
SEASON *statistics-list / options* **;**
SPECTRA *statistics-list / options* **;**
SSA */ options* **;**
TREND *statistics-list / options* **;**
VAR *variable-list / options* **;**

Functional Summary

Table 39.1 summarizes the statements and options that control the TIMESERIES procedure.

Table 39.1 TIMESERIES Functional Summary

Description	Statement	Option
Statements		
Specifies BY-group processing	BY	
Specifies variables to analyze	VAR	
Specifies cross variables to analyze	CROSSVAR	
Specifies the time ID variable	ID	
Specifies correlation options	CORR	
Specifies cross-correlation options	CROSSCORR	
Specifies discrete distribution analysis options	COUNT	
Specifies decomposition analysis options	DECOMP	
Specifies seasonal statistics options	SEASON	
Specifies spectral analysis options	SPECTRA	
Specifies SSA options	SSA	
Specifies trend statistics options	TREND	
Data Set Options		
Specifies the input data set	PROC TIMESERIES	DATA=
Specifies the output data set	PROC TIMESERIES	OUT=
Specifies the correlations output data set	PROC TIMESERIES	OUTCORR=
Specifies the cross-correlations output data set	PROC TIMESERIES	OUTCROSSCORR=
Specifies the decomposition output data set	PROC TIMESERIES	OUTDECOMP=
Specifies the frequency (count) output data set	PROC TIMESERIES	OUTFREQ=

Description	Statement	Option
Specifies the SAS log output data set	PROC TIMESERIES	OUTPROCINFO=
Specifies the seasonal statistics output data set	PROC TIMESERIES	OUTSEASON=
Specifies the spectral analysis output data set	PROC TIMESERIES	OUTSPECTRA=
Specifies the SSA output data set	PROC TIMESERIES	OUTSSA=
Specifies the summary statistics output data set	PROC TIMESERIES	OUTSUM=
Specifies the trend statistics output data set	PROC TIMESERIES	OUTTREND=
Accumulation and Seasonality Options		
Specifies the accumulation frequency	ID	INTERVAL=
Specifies the length of seasonal cycle	PROC TIMESERIES	SEASONALITY=
Specifies the interval alignment	ID	ALIGN=
Specifies the interval boundary alignment	ID	BOUNDARYALIGN=
Specifies that time ID variable values not be sorted	ID	NOTSORTED
Specifies the starting time ID value	ID	START=
Specifies the ending time ID value	ID	END=
Specifies the accumulation statistic	ID, VAR, CROSSVAR	ACCUMULATE=
Specifies missing value interpretation	ID, VAR, CROSSVAR	SETMISSING=
Time-Stamped Data Seasonal Statistics Options		
Specifies the form of the output data set	SEASON	TRANSPOSE=
Fourier Spectral Analysis Options		
Specifies whether to adjust to the series mean	SPECTRA	ADJUSTMEAN=
Specifies confidence limits	SPECTRA	ALPHA=
Specifies the kernel weighting function	SPECTRA	PARZEN | BARTLETT | TUKEY | TRUNC | QS
Specifies the domain where kernel functions apply	SPECTRA	DOMAIN=
Specifies the constant kernel scale parameter	SPECTRA	C=
Specifies the exponent kernel scale parameter	SPECTRA	EXPON=
Specifies the periodogram weights	SPECTRA	WEIGHTS
Singular Spectrum Analysis Options		
Specifies whether to adjust to the series mean	SSA	ADJUSTMEAN=
Specifies the grouping of principal components	SSA	GROUPS=
Specifies the window length	SSA	LENGTH=
Specifies the number of time periods in the transposed output	SSA	NPERIODS=
Specifies the division between principal component groupings	SSA	THRESHOLDPCT
Specifies that the output be transposed	SSA	TRANSPOSE=

Description	Statement	Option
Time-Stamped Data Trend Statistics Options		
Specifies the form of the output data set	TREND	TRANSPOSE=
Specifies the number of time periods to be stored	TREND	NPERIODS=
Time Series Transformation Options		
Specifies simple differencing	VAR, CROSSVAR	DIF=
Specifies seasonal differencing	VAR, CROSSVAR	SDIF=
Specifies transformation	VAR, CROSSVAR	TRANSFORM=
Time Series Correlation Options		
Specifies the list of lags	CORR	LAGS=
Specifies the number of lags	CORR	NLAG=
Specifies the number of parameters	CORR	NPARMS=
Specifies the form of the output data set	CORR	TRANSPOSE=
Time Series Cross-Correlation Options		
Specifies the list of lags	CROSSCORR	LAGS=
Specifies the number of lags	CROSSCORR	NLAG=
Specifies the form of the output data set	CROSSCORR	TRANSPOSE=
Time Series Decomposition Options		
Specifies the mode of decomposition	DECOMP	MODE=
Specifies the Hodrick-Prescott filter parameter	DECOMP	LAMBDA=
Specifies the number of time periods to be stored	DECOMP	NPERIODS=
Specifies the form of the output data set	DECOMP	TRANSPOSE=
Time Series Discrete Distribution Analysis Options		
Specifies the confidence limit size	COUNT	ALPHA=
Specifies the discrete distribution selection criterion	COUNT	CRITERION=
Specifies one or more discrete distributions	COUNT	DISTRIBUTION=
Printing Control Options		
Specifies the time ID format	ID	FORMAT=
Specifies which output to print	PROC TIMESERIES	PRINT=
Specifies that detailed output be printed	PROC TIMESERIES	PRINTDETAILS
Miscellaneous Options		
Specifies that analysis variables be processed in sorted order	PROC TIMESERIES	SORTNAMES
Limits error and warning messages	PROC TIMESERIES	MAXERROR=

Description	Statement	Option
ODS Graphics Options		
Specifies the count series graphical output	PROC TIMESERIES	COUNTPLOTS=
Specifies the cross-variable graphical output	PROC TIMESERIES	CROSSPLOTS=
Specifies the variable graphical output	PROC TIMESERIES	PLOTS=
Specifies the vector time series graphical output	PROC TIMESERIES	VECTORPLOTS=

PROC TIMESERIES Statement

PROC TIMESERIES *options* **;**

You can specify the following *options*:

DATA=*SAS-data-set*
names the SAS data set that contains the input data for the procedure to create the time series. If the DATA= option is not specified, the most recently created SAS data set is used.

COUNTPLOTS=*option* **| (** *options* **)** (Experimental)
specifies the count series graphical output to be produced. You can specify the following plotting *options*:

COUNTS plots the counts of the discrete values of the time series (OUTFREQ= data set).

CHISQPROB | CHISQ plots the chi-square probabilities.

DISTRIBUTION | DIST plots the discrete probability distribution.

VALUES plots the distinct values of the time series (OUTFREQ= data set).

ALL is equivalent to PLOTS=(COUNTS CHISQPROB DISTRIBUTION VALUES).

The COUNTPLOTS= option produces graphical results similar to the information contained in the data sets that are listed in parentheses next to the options.

By default, the TIMESERIES procedure produces no graphical output.

CROSSPLOTS=*option* **| (** *options* **)**
specifies the cross-variable graphical output to be produced. You can specify the following plotting *options*:

SERIES plots the two time series (OUT= data set).

CCF plots the cross-correlation functions (OUTCROSSCORR= data set).

ALL is equivalent to PLOTS=(SERIES CCF).

The CROSSPLOTS= option produces results similar to the information contained in the data sets that are listed in parentheses next to the options.

By default, the TIMESERIES procedure produces no graphical output.

MAXERROR=*number*

limits the number of warning and error messages that are produced during the execution of the procedure to the specified value. This option is particularly useful in BY-group processing, where it can be used to suppress the recurring messages. By default, MAXERRORS=50.

MAXVARLENGTH

specifies that processed variables be set to eight bytes in length. This option exists principally for use when data storage might be a concern.

OUT=*SAS-data-set*

names the output data set to contain the time series variables that are specified in the subsequent VAR and CROSSVAR statements. If BY variables are specified, they are also included in the OUT= data set. If an ID variable is specified, it is also included in the OUT= data set. The values are accumulated based on the INTERVAL= or the ACCUMULATE= option (or both) in the ID statement. The OUT= data set is particularly useful when you want to further analyze, model, or forecast the resulting time series with other SAS/ETS procedures.

OUTCORR=*SAS-data-set*

names the output data set to contain the univariate time domain statistics.

OUTCROSSCORR=*SAS-data-set*

names the output data set to contain the cross-correlation statistics.

OUTDECOMP=*SAS-data-set*

names the output data set to contain the decomposed or seasonally adjusted time series (or both).

OUTFREQ=*SAS-data-set*

names the output data set to contain the frequency (count) analysis.

OUTPROCINFO=*SAS-data-set*

names the output data set to contain information in the SAS log, specifically the number of notes, errors, and warnings and the number of series processed, number of analyses requested, and number of analyses failed.

OUTSEASON=*SAS-data-set*

names the output data set to contain the seasonal statistics. The statistics are computed for each season as specified by the INTERVAL= option in the ID statement or the SEASONALITY= option in the PROC TIMESERIES statement. The OUTSEASON= data set is particularly useful when analyzing transactional data for seasonal variations.

OUTSPECTRA=*SAS-data-set*

names the output data set to contain the univariate frequency domain analysis results.

OUTSSA=*SAS-data-set*

names the output data set to contain the singular spectrum analysis result series.

OUTSUM=*SAS-data-set*
names the output data set to contain the descriptive statistics. The descriptive statistics are based on the accumulated time series when the ACCUMULATE= or SETMISSING= options are specified in the ID or VAR statements. The OUTSUM= data set is particularly useful when you analyze large numbers of series and you need a summary of the results.

OUTTREND=*SAS-data-set*
names the output data set to contain the trend statistics. The statistics are computed for each time period as specified by the INTERVAL= option in the ID statement . The OUTTREND= data set is particularly useful when you analyze transactional data for trends.

PLOTS=*option* **| (** *options* **)**
specifies the univariate graphical output desired. By default, the TIMESERIES procedure produces no graphical output. You can specify the following plotting *options*:

SERIES plots the time series (OUT= data set).

RESIDUAL plots the residual time series (OUT= data set).

HISTOGRAM plots a histogram of the time series values

CYCLES plots the seasonal cycles (OUT= data set).

CORR plots the correlation panel (OUTCORR= data set).

ACF plots the autocorrelation function (OUTCORR= data set).

PACF plots the partial autocorrelation function (OUTCORR= data set).

IACF plots the inverse autocorrelation function (OUTCORR= data set).

WN plots the white noise probabilities (OUTCORR= data set).

DECOMP plots the seasonal adjustment panel (OUTDECOMP= data set).

TCS plots the trend-cycle-seasonal component (OUTDECOMP= data set).

TCC plots the trend-cycle component (OUTDECOMP= data set).

SIC plots the seasonal-irregular component (OUTDECOMP= data set).

SC plots the seasonal component (OUTDECOMP= data set).

SA plots the seasonal adjusted component (OUTDECOMP= data set).

PCSA plots the percent change in the seasonal adjusted component (OUTDECOMP= data set).

IC plots the irregular component (OUTDECOMP= data set).

TC plots the trend component (OUTDECOMP= data set).

CC plots the cycle component (OUTDECOMP= data set).

PERIODOGRAM< *(suboption)* > plots the periodogram (OUTSPECTRA= data set). You can specify the following *suboptions*:

MAXFREQ=*number* specifies the maximum frequency in radians to include in the plot.

MINPERIOD=*number* specifies the minimum period to include in the plot.

SPECTRUM< *(suboption)* > plots the spectral density estimate (OUTSPECTRA= data set). You can specify the following *suboptions*:

- **MAXFREQ**=*number* specifies the maximum frequency in radians to include in the plot.
- **MINPERIOD**=*number* specifies the minimum period to include in the plot.

SSA plots the singular spectrum analysis results (OUTSSA= data set).

ALL is equivalent to PLOTS=(SERIES HISTOGRAM ACF PACF IACF WN SSA PERIODOGRAM SPECTRUM).

BASIC is equivalent to PLOTS=(SERIES HISTOGRAM CYCLES CORR DECOMP)

The PLOTS= option produces graphical output for these results by using the Output Delivery System (ODS). The PLOTS= option produces results similar to the data sets listed in parentheses next to the preceding options.

PRINT=*option* **| (** *options* **)**

specifies the printed output desired. By default, the TIMESERIES procedure produces no printed output. You can specify the following printing *options*:

COUNTS prints the discrete distribution analysis (OUTFREQ= data set). This *PRINT=COUNTS* is experimental.

DECOMP prints the seasonal decomposition/adjustment table (OUTDECOMP= data set).

SEASONS prints the seasonal statistics table (OUTSEASON= data set).

DESCSTATS prints the descriptive statistics for the accumulated time series (OUTSUM= data set).

SUMMARY prints the descriptive statistics table for all time series (OUTSUM= data set).

TRENDS prints the trend statistics table (OUTTREND= data set).

SSA prints the singular spectrum analysis results (OUTSSA= data set).

ALL is equivalent to PRINT=(DESCSTATS SUMMARY).

The PRINT= option produces printed output for these results by using the Output Delivery System (ODS). The PRINT= option produces results similar to the data sets listed in parentheses next to the preceding options.

PRINTDETAILS

requests that output specified in the PRINT= option be printed in greater detail.

SEASONALITY=*number*

specifies the length of the seasonal cycle. For example, SEASONALITY=3 means that every group of three time periods forms a seasonal cycle. By default, the length of the seasonal cycle is one (no seasonality) or the length implied by the INTERVAL= option specified in the ID statement. For example, INTERVAL=MONTH implies that the length of the seasonal cycle is 12.

SORTNAMES

requests that the variables specified in the VAR and CROSSVAR statements be processed in sorted order by the variable names. This option enables the output data sets to be presorted by the variable names.

VECTORPLOTS=*option* **| (** *options* **)**

specifies the vector time series graphical output to be produced. You can specify the following plotting *options*:

SCALED	plots each time series scaled between 0 and 1.
SERIES	plots each time series on a common axis without scaling.
STACKED	plots each time series on stacked thumbnail plots.
ALL	is equivalent to PLOTS=(SCALED SERIES STACKED).

By default, the TIMESERIES procedure produces no graphical output.

BY Statement

You can use a BY statement to obtain separate dummy variable definitions for groups of observations that are defined by the BY variables.

When a BY statement appears, the procedure expects the input data set to be sorted in order of the BY variables.

If your input data set is not sorted in ascending order, use one of the following alternatives:

- Sort the data by using the SORT procedure with a similar BY statement.
- Specify the option NOTSORTED or DESCENDING in the BY statement for the TIMESERIES procedure. The NOTSORTED option does not mean that the data are unsorted but rather that the data are arranged in groups (according to values of the BY variables) and that these groups are not necessarily in alphabetical or increasing numeric order.
- Create an index on the BY variables by using the DATASETS procedure.

For more information about the BY statement, see *SAS Language Reference: Concepts*. For more information about the DATASETS procedure, see *Base SAS Procedures Guide.*

CORR Statement

CORR *statistics < / options >* **;**

You can use a CORR statement to specify options that are related to time domain analysis of the accumulated time series. Only one CORR statement is allowed.

You can specify the following time domain *statistics*:

LAG	time lag
N	number of variance products
ACOV	autocovariances
ACF	autocorrelations
ACFSTD	autocorrelation standard errors
ACF2STD	an indicator of whether autocorrelations are less than (–1), greater than (1), or within (0) two standard errors of zero
ACFNORM	normalized autocorrelations
ACFPROB	autocorrelation probabilities
ACFLPROB	autocorrelation log probabilities
PACF	partial autocorrelations
PACFSTD	partial autocorrelation standard errors
PACF2STD	an indicator of whether partial autocorrelation are less than (–1), greater than (1), or within (0) two standard errors of zero
PACFNORM	partial normalized autocorrelations
PACFPROB	partial autocorrelation probabilities
PACFLPROB	partial autocorrelation log probabilities
IACF	inverse autocorrelations
IACFSTD	inverse autocorrelation standard errors
IACF2STD	an indicator of whether the inverse autocorrelation is less than (–1), greater than (1) or within (0) two standard errors of zero
IACFNORM	normalized inverse autocorrelations
IACFPROB	inverse autocorrelation probabilities
IACFLPROB	inverse autocorrelation log probabilities
WN	white noise test statistics
WNPROB	white noise test probabilities
WNLPROB	white noise test log probabilities

If you do not specify any *statistics*, then the default is as follows:

```
corr lag n acov acf acfstd pacf pacfstd iacf iacfstd wn wnprob;
```

You can specify the following *options* after a slash (/):

LAGS=*(numlist)*
specifies the list of lags to be stored in OUTCORR= data set or to be plotted. The list of lags must be separated by spaces or commas. For example, LAGS=(1,3) specifies the first then third lag.

NLAG=*number*

specifies the number of lags to be stored in the OUTCORR= data set or to be plotted. The default is 24 or three times the length of the seasonal cycle, whichever is smaller. The LAGS= option takes precedence over the NLAG= option.

NPARMS=*number*

specifies the number of parameters that are used in the model that created the residual time series. The number of parameters determines the degrees of freedom associated with the Ljung-Box statistics. This option is useful when you analyze the residuals of a time series model whose number of parameters is specified by *number*. By default, NPARMS=0.

TRANSPOSE=NO | YES

specifies which values are recorded as column names in the OUTCORR= data set. You can specify the following values:

NO specifies that correlation statistics be recorded as the column names. This option is useful for graphing the correlation results with SAS/GRAPH procedures.

YES specifies that lags be recorded as the column names instead of correlation statistics as the column names. This option is useful for analyzing the correlation results with other SAS procedures such as the CLUSTER procedure in SAS/STAT or with SAS Enterprise Miner software.

By default, TRANSPOSE=NO.

COUNT Statement (Experimental)

COUNT < / *options* > **;**

You can use a COUNT statement to specify options that are related to the discrete distribution analysis of the accumulated time series. Only one COUNT statement is allowed.

You can specify the following *options* after a slash (/):

ALPHA=*number*

specifies the confidence limit size. The *number* must be between 0 and 1; the default is 0.05.

CRITERION=LOGLIK | AIC | BIC

specifies the discrete distribution selection criterion. The default is CRITERION=LOGLIK.

You can specify the following selection criteria:

AIC specifies the Akaike's information criterion.

BIC specifies the Bayesian information criterion.

LOGLIK specifies the log-likelihood as the criterion.

By default, CRITERION=LOGLIK.

DISTRIBUTION= *option* **|** **(** *options* **)**

specifies one or more discrete distributions for automatic selection. You can specify one or more of the following *options*:

BINOMIAL	specifies the binomial distribution.
ZMBINOMIAL	specifies the zero-modified binomial distribution.
GEOMETRIC	specifies the geometric distribution.
ZMGEOMETRIC	specifies the zero-modified geometric distribution.
POISSON	specifies the Poisson distribution.
ZMPOISSON	specifies the zero-modified Poisson distribution.
NEGBINOMIAL | NEGBIN	specifies the negative binomial distribution.

CROSSCORR Statement

CROSSCORR *statistics* < */ options* > **;**

You can use a CROSSCORR statement to produce statistics that are related to cross-correlation analysis of the accumulated time series. Only one CROSSCORR statement is allowed.

You can specify the following time domain *statistics*:

LAG	time lag
N	number of variance products
CCOV	cross covariances
CCF	cross-correlations
CCFSTD	cross-correlation standard errors
CCF2STD	an indicator of whether cross-correlations are less than (–1), greater than (1), or within (0) two standard errors of zero
CCFNORM	normalized cross-correlations
CCFPROB	cross-correlation probabilities
CCFLPROB	cross-correlation log probabilities

If do not specify any *statistics*, the default is as follows:

```
crosscorr lag n ccov ccf ccfstd;
```

You can also specify the following *options* after a slash (/):

NLAG=*number*

specifies the number of lags to be stored in the OUTCROSSCORR= data set or to be plotted. The default is 24 or three times the length of the seasonal cycle, whichever is smaller. The LAGS= option takes precedence over the NLAG= option.

LAGS=(*numlist*)
specifies a list of lags to be stored in OUTCROSSCORR= data set or to be plotted. The list of lags must be separated by spaces or commas. For example, LAGS=(1,3) specifies the first then third lag.

TRANSPOSE=NO | YES
specifies which values are recorded as column names in the OUTCROSSCORR= data set. You can specify the following values:

NO	specifies that cross-correlation statistics be recorded as the column names. This option is useful for graphing the cross-correlation results with SAS/GRAPH procedures.
YES	specifies that lags instead of cross-correlation statistics be recorded as the column names. This option is useful for analyzing the cross-correlation results with other procedures such as the CLUSTER procedure in SAS/STAT or with SAS Enterprise Miner software.

By default, TRANSPOSE=NO.

DECOMP Statement

DECOMP *components* < / *options* > **;**

You can use a DECOMP statement to specify *options* that are related to classical seasonal decomposition of the time series data. Only one DECOMP statement is allowed. The *options* affect all variables that are listed in the VAR statements. Decomposition can be performed only when the length of the seasonal cycle specified by the SEASONALITY= option in the PROC TIMESERIES statement or implied by the INTERVAL= option in the ID statement is greater than 1.

You can specify the following seasonal decomposition *components*:

ORIG | ORIGINAL	original series
TCC | TRENDCYCLE	trend-cycle component
SIC | SEASONIRREGULAR	seasonal-irregular component
SC | SEASONAL	seasonal component
SCSTD	seasonal component standard errors
TCS | TRENDCYCLESEASON	trend-cycle-seasonal component
IC | IRREGULAR	irregular component
SA | ADJUSTED	seasonally adjusted series
PCSA	percent change seasonally adjusted series
TC	trend component
CC | CYCLE	cycle component

If you do not specify any components, then the default is as follows:

```
decomp orig tcc sc ic sa;
```

You can also specify the following *options* after a slash (/):

MODE=*option*

specifies the type of decomposition to be used to decompose the time series. You can specify the following *options*:

ADD | ADDITIVE	uses additive decomposition.
MULT | MULTIPLICATIVE	uses multiplicative decomposition.
LOGADD | LOGADDITIVE	uses log-additive decomposition.
PSEUDOADD | PSEUDOADDITIVE	uses pseudo-additive decomposition.
MULTORADD	uses multiplicative decomposition when the accumulated time series contains only positive values, uses pseudo-additive decomposition when the accumulated time series contains only nonnegative values, and uses additive decomposition otherwise.

Multiplicative and log additive decomposition require strictly positive time series. If the accumulated time series contains nonpositive values and MODE=MULT or MODE=LOGADD, an error results. Pseudo-additive decomposition requires a nonnegative-valued time series. If the accumulated time series contains negative values and the MODE=PSEUDOADD option is specified, an error results.

By default, MODE=MULTORADD.

LAMBDA=*number*

specifies the Hodrick-Prescott filter parameter for trend-cycle decomposition. Filtering applies when the trend component or the cycle component is requested. If filtering is not specified, this option is ignored. By default, LAMBDA=1600.

NPERIODS=*number*

specifies the *number* of time periods to be stored in the OUTDECOMP= data set when the TRANSPOSE=YES option is specified. If TRANSPOSE=NO, the NPERIODS= option is ignored. If *number* is positive, the first or beginning time periods are recorded. If *number* is negative, the last or ending time periods are recorded. The NPERIODS= option specifies the number of OUTDECOMP= data set variables to contain the seasonal decomposition and is therefore limited to the maximum allowed number of SAS variables. If the number of time periods exceeds this limit, a warning is printed in the log and the number of periods stored is reduced to the limit.

If the NPERIODS= option is not specified, all of the periods specified between the ID statement START= and END= options are stored. If at least one of the START= or END= options is not specified, the default magnitude is the seasonality specified in the SEASONALITY= option in the PROC TIMESERIES statement or implied by the INTERVAL= option in the ID statement. If only the START= option or both the START= and END= options are specified and the seasonality is zero, the default is NPERIODS=5. If only the END= option or neither the START= nor END= option is specified and the seasonality is zero, the default is NPERIODS=–5.

TRANSPOSE= NO | YES

specifies which values are recorded as column names in the OUTDECOMP= data set.

NO specifies that decomposition components be recorded as the column names. This option is useful for analyzing or displaying the decomposition results with SAS/GRAPH procedures.

YES specifies that the time periods be recorded as the column names instead of decomposition components. The first and last time periods stored in the OUTDECOMP= data set correspond to the period specified in the START= option and END= option, respectively, in the ID statement. If only the END= option is specified, the last time ID value of each accumulated time series corresponds to the last time period column. If only the START= option is specified, the first time ID value of each accumulated time series corresponds to the first time period column. If neither the START= option nor the END= option is specified in the ID statement, the first time ID value of each accumulated time series corresponds to the first time period column. This option is useful for analyzing the decomposition results with other SAS procedures or with SAS Enterprise Miner software.

By default, TRANSPOSE=NO.

ID Statement

ID *variable* **INTERVAL=***interval* < *options* > **;**

The ID statement names a numeric variable that identifies observations in the input and output data sets. The ID variable's values are assumed to be SAS date or datetime values. In addition, the ID statement specifies the frequency to be associated with the time series. The ID statement *option* also specify how the observations are accumulated and how the time ID values are aligned to form the time series. The specified information affects all variables that are listed in subsequent VAR statements. If you do not specify an ID statement, the observation number, with respect to the BY group, is used as the time ID.

You must specify the following argument:

INTERVAL=*interval*

specifies the frequency of the accumulated time series. For example, if the input data set consists of quarterly observations, then specify INTERVAL=QTR. If the PROC TIMESERIES statement SEASONALITY= option is not specified, the length of the seasonal cycle is implied from the INTERVAL= option. For example, INTERVAL=QTR implies a seasonal cycle of length 4. If the ACCUMULATE= option is also specified, the INTERVAL= option determines the time periods for the accumulation of observations. The INTERVAL= option is required and must be the first option specified in the ID statement.

You can also specify the following *options*:

ACCUMULATE=*option*

specifies how the data set observations are to be accumulated within each time period. The frequency (width of each time interval) is specified by the INTERVAL= *interval*. The ID variable contains the time ID values. Each time ID variable value corresponds to a specific time period. The accumulated values form the time series, which is used in subsequent analysis.

This option is useful when there are zero or more than one input observations that coincide with a particular time period (for example, time-stamped transactional data). The EXPAND procedure offers additional frequency conversions and transformations that can also be useful in creating a time series.

You can specify the following *options*, which determine how the observations are accumulated within each time period based on the ID variable and on the frequency specified in INTERVAL= *interval*:

NONE does not accumulate observations; the ID variable values must be equally spaced with respect to the frequency.

TOTAL accumulates observations based on the total sum of their values.

AVERAGE | AVG accumulates observations based on the average of their values.

MINIMUM | MIN accumulates observations based on the minimum of their values.

MEDIAN | MED accumulates observations based on the median of their values.

MAXIMUM | MAX accumulates observations based on the maximum of their values.

N accumulates observations based on the number of nonmissing observations.

NMISS accumulates observations based on the number of missing observations.

NOBS accumulates observations based on the number of observations.

FIRST accumulates observations based on the first of their values.

LAST accumulates observations based on the last of their values.

STDDEV |STD accumulates observations based on the standard deviation of their values.

CSS accumulates observations based on the corrected sum of squares of their values.

USS accumulates observations based on the uncorrected sum of squares of their values.

If you specify the ACCUMULATE= option, the SETMISSING= option is useful for specifying how accumulated missing values are to be treated. If missing values are to be interpreted as 0, then specify SETMISSING=0. For more information about accumulation, see the section "Details: TIMESERIES Procedure" on page 2686.

By default, ACCUMULATE=NONE.

ALIGN=*option*

controls the alignment of SAS dates that are used to identify output observations. The ALIGN= option accepts the following values: BEGINNING | BEG | B, MIDDLE | MID | M, and ENDING | END | E. BEGINNING is the default.

BOUNDARYALIGN=*option*

controls how the ACCUMULATE= option is processed for the two boundary time intervals, which include the START= and END= time ID values. Some time ID values might fall inside the first and last accumulation intervals but fall outside the START= and END= boundaries. In these cases the BOUNDARYALIGN= option determines which values to include in the accumulation operation. You can specify the following *options*:

NONE	does not accumulate any values outside the START= and END= boundaries.
START	accumulates all observations in the first time interval.
END	accumulates all observations in the last time interval.
BOTH	accumulates all observations in the first and last.

For more information, see the section "Details: TIMESERIES Procedure" on page 2686. By default, BOUNDARYALIGN=NONE.

END=*value*
specifies a SAS date or datetime value that represents the end of the data. If the last time ID variable value is less than *value*, the series is extended with missing values. If the last time ID variable value is greater than *value*, the series is truncated. For example, END="&sysdate"D uses the automatic macro variable SYSDATE to extend or truncate the series to the current date. You can use the START= and END= options to ensure that data associated within each BY group contains the same number of observations.

FORMAT=*format*
specifies the SAS format for the time ID values. The default format is implied from the INTERVAL= option.

NOTSORTED
specifies that the time ID values might not be in sorted order. Prior to analysis, the TIMESERIES procedure sorts the data with respect to the time ID.

SETMISSING=*option* **|** *number*
specifies how missing values (either actual or accumulated) are to be interpreted in the accumulated time series. If you specify a *number*, missing values are set to the *number*. If a missing value indicates an unknown value, this option should not be used. If a missing value indicates no value, specify SETMISSING=0. You would typically use SETMISSING=0 for transactional data because no recorded data usually implies no activity. Instead of specifying a *number*, you can specify one of the following *options* to determine how missing values are assigned:

MISSING	sets missing values to missing.
AVERAGE | AVG	sets missing values to the accumulated average value.
MINIMUM | MIN	sets missing values to the accumulated minimum value.
MEDIAN | MED	sets missing values to the accumulated median value.
MAXIMUM | MAX	sets missing values to the accumulated maximum value.
FIRST	sets missing values to the accumulated first nonmissing value.
LAST	sets missing values to the accumulated last nonmissing value.
PREVIOUS | PREV	sets missing values to the previous period's accumulated nonmissing value. Missing values at the beginning of the accumulated series remain missing.
NEXT	sets missing values to the next period's accumulated nonmissing value. Missing values at the end of the accumulated series remain missing.

By default, SETMISSING=MISSING.

START=*value*

specifies a SAS date or datetime value that represents the beginning of the data. If the first time ID variable value is greater than *value*, missing values are added to the beginning of the series. If the first time ID variable value is less than *value*, the series is truncated. You can specify the START= and END= options to ensure that data associated with each BY group contains the same number of observations.

SEASON Statement

SEASON *statistics* < */ options* > **;**

You can use a SEASON statement to specify seasonal *statistics* and *options* that are related to seasonal analysis of the time-stamped transactional data. Only one SEASON statement is allowed. The *options* affect all variables specified in the VAR statements. Seasonal analysis can be performed only when the length of the seasonal cycle specified by the SEASONALITY= option in the PROC TIMESERIES statement or implied by the INTERVAL= option in the ID statement is greater than 1.

You can specify the following seasonal *statistics*:

NOBS	number of observations
N	number of nonmissing observations
NMISS	number of missing observations
MINIMUM	minimum value
MAXIMUM	maximum value
RANGE	range value
SUM	summation value
MEAN	mean value
STDDEV	standard deviation
CSS	corrected sum of squares
USS	uncorrected sum of squares
MEDIAN	median value

If you do not specify any of the seasonal *statistics*, then the default is as follows:

```
season n min max mean std;
```

You can also specify the following *options* after a slash (/):

TRANSPOSE= NO | YES

specifies which values are recorded as column names in the OUTSEASON= data set. You can specify the following values:

NO specifies that the seasonal statistics be recorded as the column names. This option is useful for graphing the seasonal analysis results with SAS/GRAPH procedures.

YES specifies that the seasonal indices instead of the seasonal statistics be recorded as the column names. This option is useful for analyzing the seasonal analysis results with SAS procedures or with SAS Enterprise Miner software.

By default, TRANSPOSE=NO.

SPECTRA Statement

SPECTRA *statistics* < */ options* > **;**

You can use a SPECTRA statement to specify which *statistics* appear in the OUTSPECTRA= data set. The SPECTRA statement *options* are used in performing a spectral analysis on the variables listed in the VAR statement. These *options* affect values that are produced in the PROC TIMESERIES statement's OUTSPECTRA= data set, and in the periodogram and spectral density estimate. Only one SPECTRA statement is allowed.

You can request the following univariate frequency domain *statistics*:

FREQ frequency in radians from 0 to π

PERIOD period or wavelength

COS cosine transform

SIN sine transform

P periodogram

S spectral density estimates

If you do not specify any frequency domain *statistics*, then the default is as follows:

```
spectra period p;
```

You can also specify the following *options* after a slash (/):

C=*coefficient*

specifies the scale coefficient for the kernel function. For more information, see the section "Kernel Option Details" on page 2681.

E=*exponent*

EXP=*exponent*

EXPON=*exponent*

specifies the exponent for the kernel function. For more information, see the section "Kernel Option Details" on page 2681.

ADJUSTMEAN=NO | YES

CENTER=NO | YES

specifies whether the series is to be adjusted by its mean prior to performing the Fourier decomposition. This adjustment sets the first periodogram ordinate to 0 rather than to $2n$ times the squared mean. This option is commonly used when the periodograms are to be plotted to prevent a large first periodogram ordinate from distorting the scale of the plot.

NO specifies that no adjustment of the series be performed.

YES specifies that the series be transformed by subtracting its mean.

By default, ADJUSTMEAN=NO.

ALPHA=*num*

specifies the width of a window that is drawn around the spectral density estimate in a spectral density versus frequency plot. Based on approximations proposed by Brockwell and Davis (1991), periodogram ordinates fall within this window with a confidence level of $1 -$ *num*. The value *num* must be between 0 and 1; the default is 0.05.

DOMAIN=*domain*

specifies how the smoothing function is interpreted. You can specify the following *domain* values:

FREQUENCY smooths the periodogram ordinates.

TIME applies the kernel as a filter to the time series autocovariance function.

By default DOMAIN=FREQUENCY, and smoothing is applied in the same manner as weights are applied when you specify the WEIGHTS= option.

kernel

specifies the smoothing function to use to calculate a spectral density estimate as the moving average of periodogram ordinates. The kernel function is an alternative smoothing method to using the WEIGHTS= option. You can specify the following *kernel* values:

PARZEN Parzen kernel

BARTLETT Bartlett kernel

TUKEY Tukey-Hanning kernel

TRUNC | TRUNCAT truncated kernel

QS | QUADR quadratic spectral kernel

If neither a WEIGHTS= option nor a *kernel* function is specified, the spectral density estimate is identical to the unmodified periodogram.

WEIGHTS=*numlist*

specifies the relative weights to use to compute a spectral density estimate as the moving average smoothing of periodogram ordinates. If neither a WEIGHTS= option nor a kernel function is specified, the spectral density estimate is identical to the unmodified periodogram. The following SPECTRA statement uses the WEIGHTS= option to specify equal weighting for each of the three adjacent periodogram ordinates that are centered on each spectral density estimate:

```
spectra / weights 1 1 1;
```

For information about how the weights are applied, see the section “Using Specification of Weight Constants” on page 2699.

Kernel Option Details

You can further parameterize each of the kernel functions with a kernel scale factor by using the C= and E= options. The default values of the kernel scale parameters, c and e, that are associated with each of the kernel functions together with their kernel scale factor values, M, for a series with 100 periodogram ordinates are listed in Table 39.2. The formula that is used to generate the table entries is $M = cK^e$, where K is the number of Fourier component frequencies.

Table 39.2 Default Kernel Scale Factor Parameters

Kernel	c	e	M
Bartlett	1/2	1/3	2.32
Parzen	1	1/5	2.51
Quadratic	1/2	1/5	1.26
Tukey-Hanning	2/3	1/5	1.67
Truncated	1/4	1/5	0.63

For example, to apply the truncated kernel by using default scale factor parameters in the frequency domain, you could use the following SPECTRA statement:

```
spectra / truncat;
```

For more information about the kernel function parameterization and the DOMAIN= option, see the section “Using Kernel Specifications” on page 2697.

SSA Statement

SSA < */ options* > **;**

The SSA statement requests singular spectrum analysis (SSA) of the accumulated time series. Only one SSA statement is allowed.

You can also specify the following *options* after a slash (/):

ADJUSTMEAN=NO | YES

CENTER=NO | YES

specifies whether the series should be adjusted by its mean prior to performing the singular spectrum analysis. You can specify the following values:

NO specifies that no adjustment of the series be performed.

YES specifies that the series be transformed by subtracting its mean.

By default, ADJUSTMEAN=NO.

GROUPS=*(numlist). . .(numlist)*

specifies the lists that categorize window lags into groups. The window lags must be separated by spaces or commas. For example, GROUPS=(1,3) (2,4) specifies that the first and third window lags form the first group and the second and fourth window lags form the second group. If you do not specify the GROUPS= option, the window lags are divided into two groups based on the THRESHOLDPCT= value.

For example, the following SSA statement specifies three groups:

```
ssa / groups=(1 3)(2 4 5)(6);
```

The first group contains the first and third principal components; the second group contains the second, fourth, and fifth principal components; and the third group contains the sixth principal component.

By default, the first group contains the principal components whose contributions to the series sum to greater than the THRESHOLDPCT= value of 90%, and the second group contains the remaining components.

LENGTH=*number*

specifies the window length to be used in the analysis. The window length represents the maximum lag to be used in the SSA autocovariance calculations, where *number* must be greater than 1. When the SEASONALITY= option is provided or implied by the INTERVAL= option in the ID statement, the default window length is the smaller of two times the length of the seasonal cycle and one-half the length of the time series. When no seasonality value is available, the default window length is the smaller of 12 and one half the length of the time series.

For example, the following SSA statement specifies a window length of 10:

```
ssa / length=10;
```

If the specified *number* is greater than one-half the length of the accumulated time series, the window length is reduced and a warning message is printed to the log. If you do not specify the window length option and the INTERVAL=MONTH or SEASONALITY=12 options are specified, a window length of 24 is used.

NPERIODS=*number*

specifies the *number* of time periods to be stored in the OUTSSA= data set when the TRANSPOSE=YES option is specified. If the TRANSPOSE option is not specified, the NPERIODS= option is ignored. The NPERIODS= option specifies the number of OUTSSA= data set variables to contain the groups.

If you do not specify this option, all the periods specified between the START= and END= options are stored of the ID statement. If at least one of the START= or END= options is not specified, the default magnitude is the seasonality specified by the SEASONALITY= option in the PROC TIMESERIES statement or implied by the INTERVAL= option in the ID statement. If only the START= option or both the START= and END= options are specified and the seasonality is zero, the default is NPERIODS=5. If only the END= option or neither the START= nor END= option is specified and the seasonality is zero, the default is NPERIODS=–5.

THRESHOLDPCT=*percentage*
specifies a *percentage* to be used to divide the SSA components into two groups based on the cumulative percentage of their singular values. The *percentage* must be between 0 and 100, inclusive. By default, THRESHOLDPCT=90.

For example, the following SSA statement specifies 80%:

```
ssa / THRESHOLDPCT=80;
```

The size of the second group must be at least 1, and it must be less than the window length. The *percentage* is adjusted to achieve this requirement.

For example, the following SSA statement specifies THRESHOLDPCT=0, which effectively sets the size of the second group to one less than the window length:

```
ssa / THRESHOLDPCT = 0;
```

The following SSA statement specifies 100%, which implies that the size of the last group is one:

```
ssa / THRESHOLDPCT= 100;
```

TRANSPOSE=NO | YES
specifies which values are recorded as column names in the OUTSSA= data set.

NO specifies that the specified groups be recorded as the column names. This option is useful for displaying the SSA results.

YES specifies that the time periods instead of the specified groups be recorded as the column names. The first and last time periods stored in the OUTSSA= data set correspond to the periods that are specified in the START= and END= options, respectively, in the ID statement. If only the END= option is specified in the ID statement, the last time ID value of each accumulated time series corresponds to the last time period column. If only the START= option is specified in the ID statement, the first time ID value of each accumulated time series corresponds to the first time period column. If neither the START= option nor the END= option is specified in the ID statement, the first time ID value of each accumulated time series corresponds to the first time period column. This option is useful for analyzing the SSA results using SAS Enterprise Miner software.

By default, TRANSPOSE=NO.

TREND Statement

TREND *statistics* < / *options* > **;**

You can use a TREND statement to specify *statistics* and related *options* for trend analysis of the time-stamped transactional data. Only one TREND statement is allowed. The specified *options* affect all variables that are listed in the VAR statements.

You can specify the following trend *statistics*:

NOBS	number of observations
N	number of nonmissing observations
NMISS	number of missing observations
MINIMUM	minimum value
MAXIMUM	maximum value
RANGE	range value
SUM	summation value
MEAN	mean value
STDDEV	standard deviation
CSS	corrected sum of squares
USS	uncorrected sum of squares
MEDIAN	median value

If you do not specify any trend *statistics*, the default is as follows:

```
trend n min max mean std;
```

You can also specify the following *options* after a slash (/):

NPERIODS=*number*

specifies the number of time periods to be stored in the OUTTREND= data set when the TRANSPOSE=YES option is specified. If the TRANSPOSE option is not specified, the NPERIODS= option is ignored. The NPERIODS= option specifies the number of OUTTREND= data set variables to contain the trend statistics and is therefore limited to the maximum allowed number of SAS variables.

If you do not specify this option, all the periods that are specified between the START= and END= options in the ID statement are stored. If at least one of the START= or END= options is not specified, the default magnitude is the seasonality that is specified in the SEASONALITY= option in the PROC TIMESERIES statement or implied by the INTERVAL= option in the ID statement. If only the START= option or both the START= and END= options are specified and the seasonality is zero, the default is NPERIODS=5. If only the END= option or neither the START= nor END= option is specified and the seasonality is zero, the default is NPERIODS=–5.

TRANSPOSE=NO | YES
specifies which values are recorded as column names in the OUTTREND= data set.

NO specifies that the specified groups be recorded as the column names. This option is useful for displaying the SSA results.

YES specifies that the time periods instead of the specified groups be recorded as the column names. The first and last time periods stored in the OUTSSA= data set correspond to the periods that are specified in the START= and END= options, respectively, in the ID statement. If only the END= option is specified in the ID statement, the last time ID value of each accumulated time series corresponds to the last time period column. If only the START= option is specified in the ID statement, the first time ID value of each accumulated time series corresponds to the first time period column. If neither the START= option nor the END= option is specified in the ID statement, the first time ID value of each accumulated time series corresponds to the first time period column. This option is useful for analyzing the SSA results using SAS Enterprise Miner software.

By default, TRANSPOSE=NO.

VAR and CROSSVAR Statements

VAR *variable-list* < */ options* > **;**

CROSSVAR *variable-list* < */ options* > **;**

The VAR and CROSSVAR statements list the numeric variables in the DATA= data set whose values are to be accumulated to form the time series.

An input data set variable can be specified in only one VAR or CROSSVAR statement. You can specify any number of VAR and CROSSVAR statements. You can specify the following *options* for either the VAR and CROSSVAR statement:

ACCUMULATE=*option*
specifies how the data set observations are to be accumulated within each time period for the variables in the *variable-list*. If you do not specify the ACCUMULATE= option in the VAR or CROSSVAR statement, accumulation is determined by the ACCUMULATE= option in the ID statement. For more information, see the ACCUMULATE= option in the ID statement.

DIF=*(numlist)*
specifies the differencing to be applied to the accumulated time series. The list of differencing orders must be separated by spaces or commas. For example, DIF=(1,3) specifies first then third order differencing. Differencing is applied after time series transformation. The TRANSFORM= option is applied before the DIF= option.

SDIF=*(numlist)*
specifies the seasonal differencing to be applied to the accumulated time series. The list of seasonal differencing orders must be separated by spaces or commas. For example, SDIF=(1,3) specifies first then third order seasonal differencing. Differencing is applied after time series transformation. The TRANSFORM= option is applied before the SDIF= option.

SETMISS=*option* | *number*

SETMISSING=*option* | *number*

specifies how missing values (either actual or accumulated) are to be interpreted in the accumulated time series for variables in the *variable-list*. If the SETMISSING= option is not specified in the VAR or CROSSVAR statement, missing values are set based on the SETMISSING= option of the ID statement. For more information, see the SETMISSING= option in the ID statement.

TRANSFORM=*transformation*

specifies the time series transformation to be applied to the accumulated time series. When you specify the TRANSFORM= option, the time series must be strictly positive. You can specify the following *transformations*:

NONE	does not apply any transformation.
LOG	logarithmic transformation
SQRT	square-root transformation
LOGISTIC	logistic transformation
BOXCOX(*n*)	Box-Cox transformation with parameter *n* where the *n* is between –5 and 5

By default, TRANSFORM=NONE.

Details: TIMESERIES Procedure

The TIMESERIES procedure can be used to perform trend and seasonal analysis on transactional data. For trend analysis, various sample statistics are computed for each time period defined by the time ID variable and INTERVAL= option. For seasonal analysis, various sample statistics are computed for each season defined by the INTERVAL= or the SEASONALITY= option. For example, if the transactional data ranges from June 1990 to January 2000 and the data are to be accumulated on a monthly basis, then the trend statistics are computed for every month: June 1990, July 1990, . . . , January 2000. The seasonal statistics are computed for each season: January, February, . . . , December.

The TIMESERIES procedure can be used to form time series data from transactional data. The accumulated time series can then be analyzed using time series techniques. The data is analyzed in the following order:

1. accumulation	ACCUMULATE= option in the ID, VAR, or CROSSVAR statement
2. missing value interpretation	SETMISSING= option in the ID, VAR, or CROSSVAR statement
3. time series transformation	TRANSFORM= option in the VAR or CROSSVAR statement
4. time series differencing	DIF= and SDIF= options in the VAR or CROSSVAR statement
5. descriptive statistics	OUTSUM= option and the PRINT=DESCSTATS option
6. seasonal decomposition	DECOMP statement or the OUTDECOMP= option in the PROC TIMESERIES statement

7.	correlation analysis	CORR statement or the OUTCORR= option in the PROC TIMESERIES statement
8.	singular spectrum analysis	SSA statement or the OUTSSA= option in the PROC TIMESERIES statement
9.	Fourier spectral analysis	SPECTRA statement or the OUTSPECTRA= option in the PROC TIMESERIES statement
10.	cross-correlation analysis	CROSSCORR statement or the OUTCROSSCORR= option in the PROC TIMESERIES statement

Accumulation

If the ACCUMULATE= option in the ID, VAR, or CROSSVAR statement is specified, data set observations are accumulated within each time period. The frequency (width of each time interval) is specified by the ID statement INTERVAL= option. The ID variable contains the time ID values. Each time ID value corresponds to a specific time period. Accumulation is useful when the input data set contains transactional data, whose observations are not spaced with respect to any particular time interval. The accumulated values form the time series, which is used in subsequent analyses.

For example, suppose a data set contains the following observations:

```
19MAR1999    10
19MAR1999    30
11MAY1999    50
12MAY1999    20
23MAY1999    20
```

If the INTERVAL=MONTH is specified, all of the above observations fall within a three-month period of time between March 1999 and May 1999. The observations are accumulated within each time period as follows:

If the ACCUMULATE=NONE option is specified, an error is generated because the ID variable values are not equally spaced with respect to the specified frequency (MONTH).

If the ACCUMULATE=TOTAL option is specified, the resulting time series is:

```
01MAR1999    40
01APR1999    .
01MAY1999    90
```

If the ACCUMULATE=AVERAGE option is specified, the resulting time series is:

```
01MAR1999    20
01APR1999    .
01MAY1999    30
```

If the ACCUMULATE=MINIMUM option is specified, the resulting time series is:

```
O1MAR1999    10
O1APR1999    .
O1MAY1999    20
```

If the ACCUMULATE=MEDIAN option is specified, the resulting time series is:

```
O1MAR1999    20
01APR1999    .
O1MAY1999    20
```

If the ACCUMULATE=MAXIMUM option is specified, the resulting time series is:

```
O1MAR1999    30
O1APR1999    .
O1MAY1999    50
```

If the ACCUMULATE=FIRST option is specified, the resulting time series is:

```
O1MAR1999    10
O1APR1999    .
O1MAY1999    50
```

If the ACCUMULATE=LAST option is specified, the resulting time series is:

```
O1MAR1999    30
O1APR1999    .
O1MAY1999    20
```

If the ACCUMULATE=STDDEV option is specified, the resulting time series is:

```
O1MAR1999    14.14
O1APR1999    .
O1MAY1999    17.32
```

As can be seen from the above examples, even though the data set observations contain no missing values, the accumulated time series can have missing values.

Boundary Alignment

When the BOUNDARYALIGN= option is used to qualify the START= or END= options, additional time series values can be incorporated into the accumulation operation. For instance, if a data set contains the following observations

```
01JAN1999   10
01FEB1999   10
01MAR1999   10
01APR1999   10
01MAY1999   10
01JUN1999   10
```

and the options START=′01FEB1999′d, END=′01APR1999′d, INTERVAL=QUARTER, and ACCUMULATE=TOTAL are specified, using the BOUNDARYALIGN= option results in the following accumulated time series:

If BOUNDARYALIGN=START is specified, the accumulated time series is

```
01JAN1999   30
01APR1999   10
```

If BOUNDARYALIGN=END is specified, the accumulated time series is

```
01JAN1999   20
01APR1999   30
```

If BOUNDARYALIGN=BOTH is specified, the accumulated time series is

```
01JAN1999   30
01APR1999   30
```

If BOUNDARYALIGN=NONE is specified, the accumulated time series is

```
01JAN1999   20
01APR1999   10
```

Missing Value Interpretation

Sometimes missing values should be interpreted as unknown values. But sometimes missing values are known, such as when missing values are created from accumulation and no observations should be interpreted as no value—that is, zero. In the former case, the SETMISSING= option can be used to interpret how missing values are treated. The SETMISSING=0 option should be used when missing observations are to be treated as no (zero) values. In other cases, missing values should be interpreted as global values, such as minimum or maximum values of the accumulated series. The accumulated and interpreted time series is used in subsequent analyses.

Time Series Transformation

There are four transformations available for strictly positive series only. Let $y_t > 0$ be the original time series, and let w_t be the transformed series. The transformations are defined as follows:

Log is the logarithmic transformation.

$$w_t = \ln(y_t)$$

Logistic is the logistic transformation.

$$w_t = \ln(c y_t / (1 - c y_t))$$

where the scaling factor c is

$$c = (1 - 10^{-6}) 10^{-\mathrm{ceil}(\log_{10}(max(y_t)))}$$

and $\mathrm{ceil}(x)$ is the smallest integer greater than or equal to x.

Square root is the square root transformation.

$$w_t = \sqrt{y_t}$$

Box Cox is the Box-Cox transformation.

$$w_t = \begin{cases} \frac{y_t^{\lambda} - 1}{\lambda}, & \lambda \neq 0 \\ \ln(y_t), & \lambda = 0 \end{cases}$$

More complex time series transformations can be performed by using the EXPAND procedure of SAS/ETS.

Time Series Differencing

After optionally transforming the series, the accumulated series can be simply or seasonally differenced by using the VAR and CROSSVAR statement DIF= and SDIF= options. For example, suppose y_t is a monthly time series. The following examples of the DIF= and SDIF= options demonstrate how to simply and seasonally difference the time series.

```
dif=(1) sdif=(1)
dif=(1,12)
```

Additionally, when y_t is strictly positive and the TRANSFORM=, DIF=, and SDIF= options are combined in the VAR and CROSSVAR statements, the transformation operation is performed before the differencing operations.

Descriptive Statistics

Descriptive statistics can be computed from the working series by specifying the OUTSUM= option or PRINT=DESCSTATS.

Seasonal Decomposition

Seasonal decomposition/analysis can be performed on the working series by specifying the OUTDECOMP= option, the PRINT=DECOMP option, or one of the PLOTS= options associated with decomposition in the PROC TIMESERIES statement. The DECOMP statement enables you to specify options related to decomposition. The TIMESERIES procedure uses classical decomposition. More complex seasonal decomposition/adjustment analysis can be performed by using the X11 or the X12 procedure of SAS/ETS.

The DECOMP statement MODE= option determines the mode of the seasonal adjustment decomposition to be performed. There are four modes: multiplicative (MODE=MULT), additive (MODE=ADD), pseudo-additive (MODE=PSEUDOADD), and log-additive (MODE=LOGADD) decomposition. The default is MODE=MULTORADD which specifies MODE=MULT for series that are strictly positive, MODE=PSEUDOADD for series that are nonnegative, and MODE=ADD for series that are not nonnegative.

When MODE=LOGADD is specified, the components are exponentiated to the original metric.

The DECOMP statement LAMBDA= option specifies the Hodrick-Prescott filter parameter (Hodrick and Prescott 1980). The default is LAMBDA=1600. The Hodrick-Prescott filter is used to decompose the trend-cycle component into the trend component and cycle component in an additive fashion. A smaller parameter assigns less significance to the cycle; that is, LAMBDA=0 implies no cycle component.

The notation and keywords associated with seasonal decomposition/adjustment analysis are defined in Table 39.3.

Table 39.3 Seasonal Adjustment Formulas

Component	Keyword	MODE= Option	Formula
original series	ORIGINAL	MULT	$O_t = TC_t S_t I_t$
		ADD	$O_t = TC_t + S_t + I_t$
		LOGADD	$log(O_t) = TC_t + S_t + I_t$
		PSEUDOADD	$O_t = TC_t(S_t + I_t - 1)$
trend-cycle component	TCC	MULT	centered moving average of O_t
		ADD	centered moving average of O_t
		LOGADD	centered moving average of $log(O_t)$
		PSEUDOADD	centered moving average of O_t
seasonal-irregular component	SIC	MULT	$SI_t = S_t I_t = O_t / TC_t$
		ADD	$SI_t = S_t + I_t = O_t - TC_t$
		LOGADD	$SI_t = S_t + I_t = log(O_t) - TC_t$
		PSEUDOADD	$SI_t = S_t + I_t - 1 = O_t / TC_t$
seasonal component	SC	MULT	seasonal Averages of SI_t
		ADD	seasonal Averages of SI_t
		LOGADD	seasonal Averages of SI_t
		PSEUDOADD	seasonal Averages of SI_t
irregular component	IC	MULT	$I_t = SI_t / S_t$
		ADD	$I_t = SI_t - S_t$
		LOGADD	$I_t = SI_t - S_t$
		PSEUDOADD	$I_t = SI_t - S_t + 1$
trend-cycle-seasonal component	TCS	MULT	$TCS_t = TC_t S_t = O_t / I_t$
		ADD	$TCS_t = TC_t + S_t = O_t - I_t$
		LOGADD	$TCS_t = TC_t + S_t = O_t - I_t$
		PSEUDOADD	$TCS_t = TC_t S_t$
trend component	TC	MULT	$T_t = TC_t - C_t$
		ADD	$T_t = TC_t - C_t$
		LOGADD	$T_t = TC_t - C_t$
		PSEUDOADD	$T_t = TC_t - C_t$
cycle component	CC	MULT	$C_t = TC_t - T_t$
		ADD	$C_t = TC_t - T_t$
		LOGADD	$C_t = TC_t - T_t$
		PSEUDOADD	$C_t = TC_t - T_t$
seasonally adjusted series	SA	MULT	$SA_t = O_t / S_t = TC_t I_t$
		ADD	$SA_t = O_t - S_t = TC_t + I_t$
		LOGADD	$SA_t = O_t / exp(S_t) = exp(TC_t + I_t)$
		PSEUDOADD	$SA_t = TC_t I_t$

When s is odd the trend-cycle component is computed from the s-period centered moving average as follows:

$$TC_t = \sum_{k=-\lfloor s/2 \rfloor}^{\lfloor s/2 \rfloor} y_{t+k}/s$$

When s is even the trend-cycle component is computed from the s-period centered moving average as follows:

$$TC_t = \sum_{k=-s/2}^{s/2-1} (y_{t+k} + y_{t+1+k})/2s$$

The seasonal component is obtained by averaging the seasonal-irregular component for each season.

$$S_{k+js} = \sum_{t=k \bmod s} \frac{SI_t}{T/s}$$

where $0 \le j \le T/s$ and $1 \le k \le s$. The seasonal components are normalized to sum to one (multiplicative) or zero (additive).

Correlation Analysis

Correlation analysis can be performed on the working series by specifying the OUTCORR= option or one of the PLOTS= options that are associated with correlation. The CORR statement enables you to specify options that are related to correlation analysis.

Autocovariance Statistics

LAGS	$h \in \{0, \ldots, H\}$
N	N_h is the number of observed products at lag h, ignoring missing values
ACOV	$\hat{\gamma}(h) = \frac{1}{T} \sum_{t=h+1}^{T} (y_t - \overline{y})(y_{t-h} - \overline{y})$
ACOV	$\hat{\gamma}(h) = \frac{1}{N_h} \sum_{t=h+1}^{T} (y_t - \overline{y})(y_{t-h} - \overline{y})$ when embedded missing values are present

Autocorrelation Statistics

ACF	$\hat{\rho}(h) = \hat{\gamma}(h)/\hat{\gamma}(0)$
ACFSTD	$Std(\hat{\rho}(h)) = \sqrt{\frac{1}{T}\left(1 + 2\sum_{j=1}^{h-1} \hat{\rho}(j)^2\right)}$
ACFNORM	$Norm(\hat{\rho}(h)) = \hat{\rho}(h)/Std(\hat{\rho}(h))$
ACFPROB	$Prob(\hat{\rho}(h)) = 2\left(1 - \Phi\left(\lvert Norm(\hat{\rho}(h))\rvert\right)\right)$
ACFLPROB	$LogProb(\hat{\rho}(h)) = -\log_{10}(Prob(\hat{\rho}(h))$
ACF2STD	$Flag(\hat{\rho}(h)) = \begin{cases} 1 & \hat{\rho}(h) > 2Std(\hat{\rho}(h)) \\ 0 & -2Std(\hat{\rho}(h)) < \hat{\rho}(h) < 2Std(\hat{\rho}(h)) \\ -1 & \hat{\rho}(h) < -2Std(\hat{\rho}(h)) \end{cases}$

Partial Autocorrelation Statistics

PACF	$\hat{\varphi}(h) = \Gamma_{(0,h-1)}\{\gamma_j\}_{j=1}^{h}$
PACFSTD	$Std(\hat{\varphi}(h)) = 1/\sqrt{N_0}$
PCFNORM	$Norm(\hat{\varphi}(h)) = \hat{\varphi}(h)/Std(\hat{\varphi}(h))$
PACFPROB	$Prob(\hat{\varphi}(h)) = 2\left(1 - \Phi\left(\lvert Norm(\hat{\varphi}(h))\rvert\right)\right)$
PACFLPROB	$LogProb(\hat{\varphi}(h)) = -\log_{10}(Prob(\hat{\varphi}(h))$
PACF2STD	$Flag(\hat{\varphi}(h)) = \begin{cases} 1 & \hat{\varphi}(h) > 2Std(\hat{\varphi}(h)) \\ 0 & -2Std(\hat{\varphi}(h)) < \hat{\varphi}(h) < 2Std(\hat{\varphi}(h)) \\ -1 & \hat{\varphi}(h) < -2Std(\hat{\varphi}(h)) \end{cases}$

Inverse Autocorrelation Statistics

IACF	$\hat{\theta}(h)$
IACFSTD	$Std(\hat{\theta}(h)) = 1/\sqrt{N_0}$
IACFNORM	$Norm(\hat{\theta}(h)) = \hat{\theta}(h)/Std(\hat{\theta}(h))$
IACFPROB	$Prob(\hat{\theta}(h)) = 2\left(1 - \Phi\left(\lvert Norm(\hat{\theta}(h))\rvert\right)\right)$
IACFLPROB	$LogProb(\hat{\theta}(h)) = -\log_{10}(Prob(\hat{\theta}(h))$
IACF2STD	$Flag(\hat{\theta}(h)) = \begin{cases} 1 & \hat{\theta}(h) > 2Std(\hat{\theta}(h)) \\ 0 & -2Std(\hat{\theta}(h)) < \hat{\theta}(h) < 2Std(\hat{\theta}(h)) \\ -1 & \hat{\theta}(h) < -2Std(\hat{\theta}(h)) \end{cases}$

White Noise Statistics

WN	$Q(h) = T(T+2)\sum_{j=1}^{h} \rho(j)^2/(T-j)$
WN	$Q(h) = \sum_{j=1}^{h} N_j \rho(j)^2$ when embedded missing values are present
WNPROB	$Prob(Q(h)) = \chi_{\max(1,h-p)}(Q(h))$
WNLPROB	$LogProb(Q(h)) = -\log_{10}(Prob(Q(h))$

Cross-Correlation Analysis

Cross-correlation analysis can be performed on the working series by specifying the OUTCROSSCORR= option or one of the CROSSPLOTS= options that are associated with cross-correlation. The CROSSCORR statement enables you to specify options that are related to cross-correlation analysis.

Cross-Correlation Statistics

The cross-correlation statistics for the variable x supplied in a VAR statement and variable y supplied in a CROSSVAR statement are:

LAGS	$h \in \{0, \ldots, H\}$
N	N_h is the number of observed products at lag h, ignoring missing values
CCOV	$\hat{\gamma}_{x,y}(h) = \frac{1}{T}\sum_{t=h+1}^{T}(x_t - \overline{x})(y_{t-h} - \overline{y})$
CCOV	$\hat{\gamma}_{x,y}(h) = \frac{1}{N_h}\sum_{t=h+1}^{T}(x_t - \overline{x})(y_{t-h} - \overline{y})$ when embedded missing values are present
CCF	$\hat{\rho}_{x,y}(h) = \hat{\gamma}_{x,y}(h)/\sqrt{\hat{\gamma}_x(0)\hat{\gamma}_y(0)}$
CCFSTD	$Std(\hat{\rho}_{x,y}(h)) = 1/\sqrt{N_0}$
CCFNORM	$Norm(\hat{\rho}_{x,y}(h)) = \hat{\rho}_{x,y}(h)/Std(\hat{\rho}_{x,y}(h))$
CCFPROB	$Prob(\hat{\rho}_{x,y}(h)) = 2\left(1 - \Phi\left(\lvert Norm(\hat{\rho}_{x,y}(h))\rvert\right)\right)$
CCFLPROB	$LogProb(\hat{\rho}_{x,y}(h)) = -\log_{10}(Prob(\hat{\rho}_{x,y}(h))$
CCF2STD	$Flag(\hat{\rho}_{x,y}(h)) = \begin{cases} 1 & \hat{\rho}_{x,y}(h) > 2Std(\hat{\rho}_{x,y}(h)) \\ 0 & -2Std(\hat{\rho}_{x,y}(h)) < \hat{\rho}_{x,y}(h) < 2Std(\hat{\rho}_{x,y}(h)) \\ -1 & \hat{\rho}_{x,y}(h) < -2Std(\hat{\rho}_{x,y}(h)) \end{cases}$

Spectral Density Analysis

Spectral analysis can be performed on the working series by specifying the OUTSPECTRA= option or by specifying the PLOTS=PERIODOGRAM or PLOTS=SPECTRUM option in the PROC TIMESERIES statement. PROC TIMESERIES uses the finite Fourier transform to decompose data series into a sum of sine and cosine terms of different amplitudes and wavelengths. The finite Fourier transform decomposition of the series x_t is

$$x_t = \frac{a_0}{2} + \sum_{k=1}^{K-1} f_k(a_k \cos\omega_k t + b_k \sin\omega_k t)$$

$$f_k = \begin{cases} 1/2 & \text{if } T \text{ is even and } k = K-1 \\ 1 & \text{otherwise} \end{cases}$$

where

t	is the time subscript, $t = 0, 1, 2, \ldots, T-1$
x_t	are the equally spaced time series data
T	is the number of observations in the time series
K	is the number of frequencies in the Fourier decomposition: $K = \frac{T+2}{2}$ if T is even, $K = \frac{T+1}{2}$ if T is odd
k	is the frequency subscript, $k = 0, 1, 2, \ldots, K-1$
a_0	is the mean term: $a_0 = 2\overline{x}$
a_k	are the cosine coefficients
b_k	are the sine coefficients
ω_k	are the Fourier frequencies: $\omega_k = \frac{2\pi k}{T}$

The Fourier decomposition is performed after the ACCUMULATE=, DIF=, SDIF= and TRANSFORM= options in the ID and VAR statements have been applied.

Functions of the Fourier coefficients a_k and b_k can be plotted against frequency or against wavelength to form *periodograms*. The amplitude periodogram I_k is defined as follows:

$$I_k = \frac{T}{2}(a_k^2 + b_k^2)$$

Since the Fourier transform is an even, periodic function of frequency which repeats every T ordinates the periodogram is also. Values of I_k for all k therefore can be mapped to the unique values $I_k : k = 0 \ldots K-1$ using the equations

$$\begin{aligned} I_k &= I_{-k} && \text{for all } k \\ I_k &= I_{k+nT} && \text{for } n = \pm 1, \pm 2, \pm 3, \ldots \\ I_k &= I_{T-k} && \text{for } 0 \le k \le K-1 \end{aligned}$$

The periodogram, I_k, is an estimate at the discrete frequencies ω_k of the spectral density function which characterizes the series x_t. By smoothing the periodogram an improved spectral density estimate with reduced variance and bias can be achieved at these points. Smoothing can be accomplished either through use of a spectral window smoothing function or by applying a lag window filter to the series autocovariance function.

When the SPECTRA statement's DOMAIN=FREQUENCY option is in effect spectral density estimates are computed by smoothing the periodogram ordinates using the equation

$$S_k(M) = \sum_{\tau=K-T}^{K-1} \mathrm{w}\left(\frac{\tau}{M}\right) I_{k+\tau}$$

where $\mathrm{w}(\theta)$ is the spectral window function whose form is specified by either the KERNEL= option or the WEIGHTS option. M is the kernel scale parameter which acts as a frequency scaling factor in the spectral window smoothing function. Values of $I_{k+\tau}$ that fall outside of $0 \le k + \tau \le K - 1$ are mapped to values inside this range by the equations presented previously.

When the DOMAIN=TIME option is specified spectral density values are estimated by applying a lag window filter, $\lambda(h, M)$, to the series autocovariance function. The spectral density estimate then can be computed from the filtered autocovariance function using the equation

$$S_k(M) = \sum_{h=-(T-1)}^{T-1} \lambda(h, M)\hat{\gamma}(h) \cos h\omega_k.$$

In this case the kernel scale parameter, M, serves as a scale factor for the lag length, h, in the time domain. In the lag window formulation the spectral density estimate is a consistent estimator as $T, M \to \infty$ under the conditions $\lambda(h, M) = 0$ for $|h| > M$, and $\lim_{T\to\infty} M/T = 0$. These conditions lead to the following parameterization of M provided by the SPECTRA statement:

$$M = cK^e$$

where the values $c > 0$ and $0 < e < 1$ satisfy the consistency conditions. To specify the kernel scale parameter explicitly, set $c =$ to the desired scale factor and $e = 0$.

For uniformity and computational efficiency all spectral density estimates are calculated using a spectral window weighting function, $\mathrm{w}(\theta)$, applied to the periodogram ordinates. In the case where the DOMAIN=TIME option is specified the effective spectral window weighting function is computed by the equation

$$\mathrm{w}_{\mathrm{TIME}}(\theta) = \sum_{h=-(T-1)}^{T-1} \lambda(h, M) \cos h\theta.$$

Because the kernel scale parameter, *M*, serves as a lag scale factor in the time domain and bandwidth scale factor in the frequency domain the impact of *M* on spectral density estimates depends on the value of the DOMAIN= option. When DOMAIN=FREQUENCY increasing values of *M* decrease variance and increase bias in the spectral density estimates whereas when DOMAIN=TIME increasing values of *M* increase variance and decrease bias.

Using Kernel Specifications

You can specify one of ten different kernel smoothing functions in the SPECTRA statement. Five smoothing functions are available as KERNEL= options and five complementary smoothing functions which correspond to lag window filters are available when the KERNEL= option is used in conjunction with the DOMAIN=TIME option.

For example, a Parzen kernel with a support of 11 periodogram ordinates in the frequency domain can be specified using the kernel option:

```
spectra / parzen c=5 expon=0;
```

The TIMESERIES procedure supports the following spectral window kernel functions in the frequency domain where $x = \tau/M$:

BARTLETT: Bartlett kernel

$$\mathrm{w}(x) = \begin{cases} 1-|x| & |x| \le 1 \\ 0 & \text{otherwise} \end{cases}$$

PARZEN: Parzen kernel

$$\mathrm{w}(x) = \begin{cases} 1-6|x|^2+6|x|^3 & 0 \le |x| \le \frac{1}{2} \\ 2(1-|x|)^3 & \frac{1}{2} \le |x| \le 1 \\ 0 & \text{otherwise} \end{cases}$$

QS: quadratic spectral kernel

$$\mathrm{w}(x) = \frac{3}{(2\pi x)^2}\left(\frac{\sin 2\pi x}{2\pi x} - \cos 2\pi x\right)$$

TUKEY: Tukey-Hanning kernel

$$w(x) = \begin{cases} (1+\cos(\pi x))/2 & |x| \le 1 \\ 0 & \text{otherwise} \end{cases}$$

TRUNCAT: truncated kernel

$$w(x) = \begin{cases} 1 & |x| \le 1 \\ 0 & \text{otherwise} \end{cases}$$

When the DOMAIN=TIME option is specified the five kernel functions above are interpreted as lag window filters on the autocovariance function. The lag window kernel functions correspond to the following spectral window smoothing functions where $\theta = 2\pi\tau/T$:

BARTLETT: Bartlett equivalent lag window filter

$$w(\theta) = \frac{1}{2\pi M}\left(\frac{\sin(M\theta/2)}{\sin(\theta/2)}\right)^2$$

PARZEN: Parzen equivalent lag window filter

$$w(\theta) = \frac{6}{\pi M^3}\left(\frac{\sin(M\theta/4)}{\sin(\theta/2)}\right)^4\left(1-\frac{2}{3}\sin^2(\theta/2)\right)$$

QS: quadratic spectral equivalent lag window filter

$$w(\theta) = \begin{cases} \frac{3M}{4\pi}(1-(M\theta/\pi)^2) & |\theta| \le \pi/M \\ 0 & |\theta| > \pi/M \end{cases}$$

TUKEY: Tukey-Hanning equivalent lag window filter

$$\begin{aligned} w(\theta) &= \frac{1}{4}D_M(\theta-\pi/M)+\frac{1}{2}D_M(\theta)+\frac{1}{4}D_M(\theta+\pi/M) \\ D_M(\theta) &= \frac{1}{2\pi}\frac{\sin[(M+1/2)\theta]}{\sin(\theta/2)} \end{aligned}$$

TRUNC: truncated equivalent lag window filter

$$w(\theta) = D_M(\theta)$$

Using Specification of Weight Constants

Any number of weighting constants can be specified. The constants are interpreted symmetrically about the middle weight. The middle constant (or the constant to the right of the middle if an even number of weight constants is specified) is the relative weight of the current periodogram ordinate. The constant immediately following the middle one is the relative weight of the next periodogram ordinate, and so on. The actual weights used in the smoothing process are the weights specified in the WEIGHTS option scaled so that they sum to 1.

The moving average calculation reflects at each end of the periodogram to accommodate the periodicity of the periodogram function.

For example, a simple triangular weighting can be specified using the following WEIGHTS option:

```
spectra / weights 1 2 3 2 1;
```

Computational Method

If the number of observations, T, factors into prime integers that are less than or equal to 23, and the product of the square-free factors of T is less than 210, then the procedure uses the fast Fourier transform developed by Cooley and Tukey (1965) and implemented by Singleton (1969). If T cannot be factored in this way, then the procedure uses a Chirp-Z algorithm similar to that proposed by Monro and Branch (1977).

Missing Values

Missing values are replaced with an estimate of the mean to perform spectral analyses. This treatment of a series with missing values is consistent with the approach used by Priestley (1981).

Singular Spectrum Analysis

Given a time series, y_t, for $t = 1, \ldots, T$, and a window length, $2 \leq L < T/2$, singular spectrum analysis Golyandina, Nekrutkin, and Zhigljavsky (2001) decompose the time series into spectral groupings using the following steps:

Embedding Step

Using the time series, form a $K \times L$ trajectory matrix, $\mathbf{X}$, with elements

$$\mathbf{X} = \{x_{k,l}\}_{k=1,l=1}^{K,L}$$

such that $x_{k,l} = y_{k-l+1}$ for $k = 1, \ldots, K$and $l = 1, \ldots, L$ and where $K = T - L + 1$. By definition $L \leq K < T$, because $2 \leq L < T/2$.

Decomposition Step

Using the trajectory matrix, $\mathbf{X}$, apply singular value decomposition to the trajectory matrix

$$\mathbf{X} = \mathbf{UQV}$$

where $\mathbf{U}$ represents the $K \times L$ matrix that contains the left-hand-side (LHS) eigenvectors, where $\mathbf{Q}$ represents the diagonal $L \times L$ matrix that contains the singular values, and where $\mathbf{V}$ represents the $L \times L$ matrix that contains the right-hand-side (RHS) eigenvectors.

Therefore,

$$\mathbf{X} = \sum_{l=1}^{L} \mathbf{X}^{(l)} = \sum_{l=1}^{L} \mathbf{u}_l q_l \mathbf{v}_l^T$$

where $\mathbf{X}^{(l)}$ represents the $K \times L$ principal component matrix, $\mathbf{u}_l$ represents the $K \times 1$ left-hand-side (LHS) eigenvector, q_l represents the singular value, and $\mathbf{v}_l$ represents the $L \times 1$ right-hand-side (RHS) eigenvector associated with the lth window index.

Grouping Step

For each group index, $m = 1, \ldots, M$, define a group of window indices $I_m \subset \{1, \ldots, L\}$. Let

$$\mathbf{X}_{I_m} = \sum_{l \in I_m} \mathbf{X}^{(l)} = \sum_{l \in I_m} \mathbf{u}_l q_l \mathbf{v}_l^T$$

represent the grouped trajectory matrix for group I_m. If groupings represent a spectral partition,

$$\bigcup_{m=1}^{M} I_m = \{1, \ldots, L\} \qquad \text{and} \qquad I_m \cap I_n = \emptyset \quad \text{for} \quad m \neq n$$

then according to the singular value decomposition theory,

$$\mathbf{X} = \sum_{m=1}^{M} \mathbf{X}_{I_m}$$

Averaging Step

For each group index, $m = 1, \ldots, M$, compute the diagonal average of $\mathbf{X}_{I_m}$,

$$\tilde{x}_t^{(m)} = \frac{1}{n_t} \sum_{l=s_t}^{e_t} x_{t-l+1,l}^{(m)}$$

where

$$\begin{array}{llllrcl}
s_t = 1, & e_t = t, & n_t = t & \text{for} & 1 \leq & t & < L \\
s_t = 1, & e_t = L, & n_t = L & \text{for} & L \leq & t & \leq T - L + 1 \\
s_t = T - t - 1, & e_t = L, & n_t = T - t + 1 & \text{for} & T - L + 1 < & t & \leq T
\end{array}$$

If the groupings represent a spectral partition, then by definition

$$y_t = \sum_{m=1}^{M} \tilde{x}_t^{(m)}$$

Hence, singular spectrum analysis additively decomposes the original time series, y_t, into m component series $\tilde{x}_t^{(m)}$ for $m = 1, \ldots, M$.

Specifying the Window Length

You can explicitly specify the maximum window length, $2 \leq L \leq 1000$, using the LENGTH= option or implicitly specify the window length using the INTERVAL= option in the ID statement or the SEASONALITY= option in the PROC TIMESERIES statement.

Either way the window length is reduced based on the accumulated time series length, T, to enforce the requirement that $2 \leq L \leq T/2$.

Specifying the Groups

You can use the GROUPS= option to explicitly specify the composition and number of groups, $I_m \subset \{1, \ldots, L\}$ or use the THRESHOLDPCT= option in the SSA statement to implicitly specify the grouping. The THRESHOLDPCT= option is useful for removing noise or less dominant patterns from the accumulated time series.

Let $0 < \alpha < 1$ be the cumulative percent singular value THRESHOLDPCT=. Then the last group, $I_M = \{l_\alpha, \ldots, L\}$, is determined by the smallest value such that

$$\left(\sum_{l=1}^{l_\alpha - 1} q_l \Bigg/ \sum_{l=1}^{L} q_l \right) \geq \alpha \qquad \text{where } 1 < l_\alpha \leq L$$

Using this rule, the last group, I_M, describes the least dominant patterns in the time series and the size of the last group is at least one and is less than the window length, $L \geq 2$.

The magnitudes of the principal components which are plotted using the PLOT=SSA option and selected by the THRESHOLDPCT= option are based on the singular values which appear on the diagonal of $\mathbf{Q}$. Alternatively, each principal component's contribution to variation in the series can be quantified by using the squares of the singular values. The relative contributions of the principal components to variation in the series are included in the printed tabular output produced by the PRINT=SSA option.

Data Set Output

The TIMESERIES procedure can create the OUT=, OUTCORR=, OUTCROSSCORR=, OUTDECOMP=, OUTFREQ=, OUTSEASON=, OUTSPECTRA=, OUTSSA=, OUTSUM=, and OUTTREND= data sets. In general, these data sets contain the variables listed in the BY statement. If an analysis step that is related to an output data step fails, the values of this step are not recorded or are set to missing in the related output data set and appropriate error and/or warning messages are recorded in the log.

OUT= Data Set

The OUT= data set contains the variables specified in the BY, ID, VAR, and CROSSVAR statements. If the ID statement is specified, the ID variable values are aligned and extended based on the ALIGN= and INTERVAL= options. The values of the variables specified in the VAR and CROSSVAR statements are accumulated based on the ACCUMULATE= option, and missing values are interpreted based on the SETMISSING= option.

OUTCORR= Data Set

The OUTCORR= data set contains the variables specified in the BY statement as well as the variables listed below. The OUTCORR= data set records the correlations for each variable specified in a VAR statement (not the CROSSVAR statement).

When the CORR statement TRANSPOSE=NO option is omitted or specified explicitly, the variable *names* are related to correlation statistics specified in the CORR statement options and the variable *values* are related to the NLAG= or LAGS= option.

NAME	variable name
LAG	time lag
N	number of variance products
ACOV	autocovariances
ACF	autocorrelations
ACFSTD	autocorrelation standard errors
ACF2STD	an indicator of whether autocorrelations are less than (–1), greater than (1), or within (0) two standard errors of zero
ACFNORM	normalized autocorrelations
ACFPROB	autocorrelation probabilities
ACFLPROB	autocorrelation log probabilities
PACF	partial autocorrelations
PACFSTD	partial autocorrelation standard errors
PACF2STD	an indicator of whether partial autocorrelations are less than (–1), greater than (1), or within (0) two standard errors of zero
PACFNORM	partial normalized autocorrelations
PACFPROB	partial autocorrelation probabilities
PACFLPROB	partial autocorrelation log probabilities
IACF	inverse autocorrelations
IACFSTD	an indicator of whether inverse autocorrelations are less than (–1), greater than (1), or within (0) two standard errors of zero
IACF2STD	two standard errors beyond inverse autocorrelation
IACFNORM	normalized inverse autocorrelations
IACFPROB	inverse autocorrelation probabilities
IACFLPROB	inverse autocorrelation log probabilities
WN	white noise test Statistics
WNPROB	white noise test probabilities
WNLPROB	white noise test log probabilities

The preceding correlation statistics are computed for each specified time lag.

When the CORR statement TRANSPOSE=YES option is specified, the variable *values* are related to correlation statistics specified in the CORR statement and the variable *names* are related to the NLAG= or LAGS= options.

NAME	variable name
STAT	correlation statistic name
LABEL	correlation statistic label
LAG*h*	correlation statistics for lag *h*

OUTCROSSCORR= Data Set

The OUTCROSSCORR= data set contains the variables specified in the BY statement as well as the variables listed below. The OUTCROSSCORR= data set records the cross-correlations for each variable specified in a VAR and the CROSSVAR statements.

When the CROSSCORR statement TRANSPOSE=NO option is omitted or specified explicitly, the variable *names* are related to cross-correlation statistics specified in the CROSSCORR statement options and the variable *values* are related to the NLAG= or LAGS= option.

NAME	variable name
CROSS	cross variable name
LAG	time lag
N	number of variance products
CCOV	cross-covariances
CCF	cross-correlations
CCFSTD	cross-correlation standard errors
CCF2STD	an indicator of whether cross-correlations are less than (–1), greater than (1), or within (0) two standard errors of zero
CCFNORM	normalized cross-correlations
CCFPROB	cross-correlation probabilities
CCFLPROB	cross-correlation log probabilities

The preceding cross-correlation statistics are computed for each specified time lag.

When the CROSSCORR statement TRANSPOSE=YES option is specified, the variable *values* are related to cross-correlation statistics specified in the CROSSCORR statement and the variable *names* are related to the NLAG= or LAGS= options.

NAME	variable name
CROSS	cross variable name
STAT	cross-correlation statistic name
LABEL	cross-correlation statistic label
LAG*h*	cross-correlation statistics for lag *h*

OUTDECOMP= Data Set

The OUTDECOMP= data set contains the variables specified in the BY statement as well as the variables listed below. The OUTDECOMP= data set records the seasonal decomposition/adjustments for each variable specified in a VAR statement (not the CROSSVAR statement).

When the DECOMP statement TRANSPOSE=NO option is omitted or specified explicitly, the variable *names* are related to decomposition/adjustments specified in the DECOMP statement and the variable *values* are related to the ID statement INTERVAL= option and the PROC TIMESERIES statement SEASONALITY= option.

NAME	variable name
MODE	mode of decomposition
TIMEID	time ID values
SEASON	seasonal index
ORIGINAL	original series values
TCC	trend-cycle component
SIC	seasonal-irregular component
SC	seasonal component
SCSTD	seasonal component standard errors
TCS	trend-cycle-seasonal component
IC	irregular component
SA	seasonally adjusted series
PCSA	percent change seasonally adjusted series
TC	trend component
CC	cycle component

The preceding decomposition components are computed for each time period.

When the DECOMP statement TRANSPOSE=YES option is specified, the variable *values* are related to decomposition/adjustments specified in the DECOMP statement and the variable *names* are related to the ID statement INTERVAL= option, the PROC TIMESERIES statement SEASONALITY= option, and the DECOMP statement NPERIODS= option.

NAME	variable name
MODE	mode of decomposition name
COMP	decomposition component name
LABEL	decomposition component label
PERIOD*t*	decomposition component value for time period *t*

OUTFREQ= Data Set

The OUTFREQ= data set contains the variables specified in the BY statement as well as the variables listed below. The OUTFREQ= data set records the counts of the discrete values of the time series for each variable specified in a VAR statement (not the CROSSVAR statement).

NAME	variable name
VALUES	distinct series values
COUNTS	counts of the discrete values
PERCENT	percentage of the total counts

OUTPROCINFO= Data Set

The OUTPROCINFO= data set contains information about the run of the TIMESERIES procedure. The following variables are present:

SOURCE	set to the name of the procedure, in this case TIMESERIES
NAME	name of the item being reported
LABEL	descriptive label for the item in _NAME_
STAGE	set to the current stage of the procedure; for TIMESERIES this is set to ALL
VALUE	value of the item specified in _NAME_

OUTSEASON= Data Set

The OUTSEASON= data set contains the variables specified in the BY statement as well as the variables listed below. The OUTSEASON= data set records the seasonal statistics for each variable specified in a VAR statement (not the CROSSVAR statement).

When the SEASON statement TRANSPOSE=NO option is omitted or specified explicitly, the variable *names* are related to seasonal statistics specified in the SEASON statement and the variable *values* are related to the ID statement INTERVAL= option or the PROC TIMESERIES statement SEASONALITY= option.

NAME	variable name
TIMEID	time ID values
SEASON	seasonal index
NOBS	number of observations
N	number of nonmissing observations
NMISS	number of missing observations
MINIMUM	minimum value

MAXIMUM	maximum value
RANGE	range value
SUM	summation value
MEAN	mean value
STDDEV	standard deviation
CSS	corrected sum of squares
USS	uncorrected sum of squares
MEDIAN	median value

The preceding statistics are computed for each season.

When the SEASON statement TRANSPOSE=YES option is specified, the variable *values* are related to seasonal statistics specified in the SEASON statement and the variable *names* are related to the ID statement INTERVAL= option or the PROC TIMESERIES statement SEASONALITY= option.

NAME	variable name
STAT	season statistic name
LABEL	season statistic name
SEASON*s*	season statistic value for season *s*

OUTSPECTRA= Data Set

The OUTSPECTRA= data set contains the variables that are specified in the BY statement in addition to the variables listed below. The OUTSPECTRA= data set records the frequency domain analysis for each variable specified in a VAR statement (not the CROSSVAR statement).

The following variable names are related to correlation statistics specified in the SPECTRA statement options.

NAME	variable name
FREQ	frequency in radians from 0 to π
PERIOD	period or wavelength
COS	cosine transform
SIN	sine transform
P	periodogram
S	spectral density estimates

OUTSSA= Data Set

The OUTSSA= data set contains the variables that are specified in the BY statement in addition to the variables listed below. The OUTSSA= data set records the singular spectrum analysis (SSA) for each variable specified in a VAR statement (not the CROSSVAR statement).

When the SSA statement TRANSPOSE=NO option is omitted or specified explicitly, the variable *names* are related to singular spectrum analysis specified in the SSA statement, and the variable *values* are related to the INTERVAL= option in the ID statement and the SEASONALITY= option in the PROC TIMESERIES statement.

NAME	variable name
TIMEID	time ID values
CYCLE	cycle index
SEASON	seasonal index
ORIGINAL	original series values
GROUP*i*	SSA result groups

The _GROUP*i*_ decomposition components are computed for each time period.

When the SSA statement TRANSPOSE=YES option is specified, the variable *values* are related to singular spectrum analysis specified in the SSA statement, and the variable *names* are related to the INTERVAL= option in the ID statement, the SEASONALITY= option in the PROC TIMESERIES statement, or the NPERIODS= option in the SSA statement. The following variables are written to a transposed OUTSSA= data set:

NAME	variable name
GROUP	group number
PERIOD*t*	SSA group value for time period *t*

OUTSUM= Data Set

The OUTSUM= data set contains the variables specified in the BY statement as well as the variables listed below. The OUTSUM= data set records the descriptive statistics for each variable specified in a VAR statement (not the CROSSVAR statement).

Variables related to descriptive statistics are based on the ACCUMULATE= and SETMISSING= options in the ID and VAR statements:

NAME	variable name
STATUS	status flag that indicates whether the requested analyses were successful
NOBS	number of observations
N	number of nonmissing observations

NMISS	number of missing observations
START	the starting date of the time series
END	the ending date of the time series
STARTOBS	the beginning observation of the time series
ENDOBS	the ending observation of the time series
MINIMUM	minimum value
MAXIMUM	maximum value
AVG	average value
STDDEV	standard deviation

The OUTSUM= data set contains the descriptive statistics of the (accumulated) time series.

OUTTREND= Data Set

The OUTTREND= data set contains the variables specified in the BY statement as well as the variables listed below. The OUTTREND= data set records the trend statistics for each variable specified in a VAR statement (not the CROSSVAR statement).

When the TREND statement TRANSPOSE=NO option is omitted or explicitly specified, the variable *names* are related to trend statistics specified in the TREND statement and the variable *values* are related to the INTERVAL= option in the ID statement or the SEASONALITY= option in the PROC TIMESERIES statement.

NAME	variable name
TIMEID	time ID values
SEASON	seasonal index
NOBS	number of observations
N	number of nonmissing observations
NMISS	number of missing observations
MINIMUM	minimum value
MAXIMUM	maximum value
RANGE	range value
SUM	summation value
MEAN	mean value
STDDEV	standard deviation
CSS	corrected sum of squares
USS	uncorrected sum of squares
MEDIAN	median value

The preceding statistics are computed for each time period.

When the TREND statement TRANSPOSE=YES option is specified, the variable *values* related to trend statistics specified in the TREND statement and the variable *names* are related to the INTERVAL= option in the ID statement, the SEASONALITY= option in the PROC TIMESERIES statement, or the NPERIODS= option in the TREND statement. The following variables are written to the OUTTREND= data set:

NAME	variable name
STAT	trend statistic name
LABEL	trend statistic name
PERIOD*t*	trend statistic value for time period *t*

STATUS Variable Values

The _STATUS_ variable that appears in the OUTSUM= data set contains a code that specifies whether the analysis has been successful or not. The _STATUS_ variable can take the following values:

0	success
1000	transactional trend statistics failure
2000	transactional seasonal statistics failure
3000	accumulation failure
4000	missing value interpretation failure
6000	series is all missing
7000	transformation failure
8000	differencing failure
9000	unable to compute descriptive statistics
10000	seasonal decomposition failure
11000	correlation analysis failure
15000	singular spectrum analysis failure
16000	spectral analysis failure

Printed Output

The TIMESERIES procedure optionally produces printed output by using the Output Delivery System (ODS). By default, the procedure produces no printed output. All output is controlled by the PRINT= and PRINTDETAILS options associated with the PROC TIMESERIES statement. In general, if an analysis step related to printed output fails, the values of this step are not printed and appropriate error or warning messages or both are recorded in the log. The printed output is similar to the output data set, and these similarities are described below.

PRINT=COUNTS	prints the discrete distribution analysis.
PRINT=DECOMP	prints the seasonal decomposition similar to the OUTDECOMP= data set.
PRINT=DESCSTATS	prints a table of descriptive statistics for each variable.
PRINT=SEASONS	prints the seasonal statistics similar to the OUTSEASON= data set.
PRINT=SSA	prints the singular spectrum analysis similar to the OUTSSA= data set.
PRINT=SUMMARY	prints the summary statistics similar to the OUTSUM= data set.
PRINT=TRENDS	prints the trend statistics similar to the OUTTREND= data set.
PRINTDETAILS	prints each table with greater detail.

If PRINT=SEASONS and the PRINTDETAILS options are both specified, all seasonal statistics are printed.

ODS Table Names

Table 39.4 relates the PRINT= options to ODS tables:

Table 39.4 ODS Tables Produced in PROC TIMESERIES

ODS Table Name	Description	Statement	Option
CountStatistics	Discrete distribution	PRINT	COUNTS
DistributionSelection	Discrete distribution Selection	PRINT	COUNTS
DistributionParameterEstimates	Discrete distribution Parameter Estimates	PRINT	COUNTS
DistributionEstimates	Discrete distribution Estimates	PRINT	COUNTS
SeasonalDecomposition	Seasonal decomposition	PRINT	DECOMP
DescStats	Descriptive statistics	PRINT	DESCSTATS
GlobalStatistics	Global statistics	PRINT	SEASONS
SeasonStatistics	Season statistics	PRINT	SEASONS
StatisticsSummary	Statistics summary	PRINT	SUMMARY
TrendStatistics	Trend statistics	PRINT	TRENDS
GlobalStatistics	Global statistics	PRINT	TRENDS
SSASingularValues	SSA singular values	PRINT	SSA
SSAResults	SSA results	PRINT	SSA

The tables are related to a single series within a BY group.

ODS Graphics Names

Statistical procedures use ODS Graphics to create graphs as part of their output. ODS Graphics is described in detail in Chapter 21, “Statistical Graphics Using ODS” (*SAS/STAT User’s Guide*).

Before you create graphs, ODS Graphics must be enabled (for example, with the ODS GRAPHICS ON statement). For more information about enabling and disabling ODS Graphics, see the section “Enabling and Disabling ODS Graphics” in that chapter.

The overall appearance of graphs is controlled by ODS styles. Styles and other aspects of using ODS Graphics are discussed in the section "A Primer on ODS Statistical Graphics" in that chapter.

This section describes the graphical output produced by the TIMESERIES procedure. PROC TIMESERIES assigns a name to each graph it creates. These names are listed in Table 39.5.

Table 39.5 ODS Graphics Produced by PROC TIMESERIES

ODS Graph Name	Plot Description	Statement	Option
ACFPlot	Autocorrelation function	PLOTS	ACF
ACFNORMPlot	Normalized autocorrelation function	PLOTS	ACF
CCFNORMPlot	Normalized cross-correlation function	CROSSPLOTS	CCF
CCFPlot	Cross-correlation function	CROSSPLOTS	CCF
ChiSquareProbabilitiesPlot	Discrete distribution evaluation	COUNTPLOTS	CHISQPROB
ChiSquareLogProbabilitiesPlot	Discrete distribution evaluation	COUNTPLOTS	CHISQPROB
CorrelationPlots	Correlation graphics panel	PLOTS	CORR
CrossSeriesPlot	Cross series plot	CROSSPLOTS	SERIES
CycleComponentPlot	Cycle component	PLOTS	CC
CyclePlot	Seasonal cycles plot	PLOTS	CYCLES
DecompositionPlots	Decomposition graphics panel	PLOTS	DECOMP
DiscreteDistributionPlot	Discrete distribution analysis	COUNTPLOTS	DISTRIBUTION
FrequencyAnalysisPlot	Frequency analysis	COUNTPLOTS	COUNTS
FrequencyCountsPlot	Frequency analysis	COUNTPLOTS	COUNTS
FrequencyValuesPlot	Frequency analysis	COUNTPLOTS	VALUES
IACFPlot	Inverse autocorrelation function	PLOTS	IACF
IACFNORMPlot	Normalized inverse autocorrelation function	PLOTS	IACF
IrregularComponentPlot	Irregular component	PLOTS	IC
PACFPlot	Partial autocorrelation function	PLOTS	PACF
PACFNORMPlot	Standardized partial autocorrelation function	PLOTS	PACF
PercentChangeAdjustedPlot	Percent-change seasonally adjusted	PLOTS	PCSA
Periodogram	Periodogram versus period	PLOTS	PERIODOGRAM
ResidualPlot	Residual time series plot	PLOTS	RESIDUAL

Table 39.5 (continued)

ODS Graph Name	Plot Description	Statement	Option
SeasonallyAdjustedPlot	Seasonally adjusted	PLOTS	SA
SeasonalComponentPlot	Seasonal component	PLOTS	SC
SeasonalIrregularComponentPlot	Seasonal-irregular component	PLOTS	SIC
SeriesHistogram	Histogram of series values	PLOTS	HISTOGRAM
SeriesPlot	Time series plot	PLOTS	SERIES
SpectralDensityPlot	Spectral density versus period	PLOTS	SPECTRUM
SSASingularValuesPlot	SSA singular values	PLOTS	SSA
SSAResultsPlot	SSA results	PLOTS	SSA
TrendComponentPlot	Trend component	PLOTS	TC
TrendCycleComponentPlot	Trend-cycle component	PLOTS	TCC
TrendCycleSeasonalPlot	Trend-cycle-seasonal component	PLOTS	TCS
WhiteNoiseLogProbabilityPlot	White noise log probability	PLOTS	WN
WhiteNoiseProbabilityPlot	White noise probability	PLOTS	WN

Examples: TIMESERIES Procedure

Example 39.1: Accumulating Transactional Data into Time Series Data

This example illustrates using the TIMESERIES procedure to accumulate time-stamped transactional data that has been recorded at no particular frequency into time series data at a specific frequency. After the time series is created, the various SAS/ETS procedures related to time series analysis, seasonal adjustment/decomposition, modeling, and forecasting can be used to further analyze the time series data.

Suppose that the input data set WORK.RETAIL contains variables STORE and TIMESTAMP and numerous other numeric transaction variables. The BY variable STORE contains values that break up the transactions into groups (BY groups). The time ID variable TIMESTAMP contains SAS date values recorded at no particular frequency. The other data set variables contain the numeric transaction values to be analyzed. It is further assumed that the input data set is sorted by the variables STORE and TIMESTAMP. The following statements form monthly time series from the transactional data based on the median value (ACCUMULATE=MEDIAN) of the transactions recorded with each time period. Also, the accumulated time series values for time periods with no transactions are set to zero instead of to missing (SETMISS=0) and only transactions recorded between the first day of 1998 (START='01JAN1998'D) and last day of 2000 (END='31JAN2000'D) are considered and, if needed, extended to include this range.

```
proc timeseries data=retail out=mseries;
   by store;
   id timestamp interval=month
                accumulate=median
                setmiss=0
                start='01jan1998'd
                end  ='31dec2000'd;
   var item1-item8;
run;
```

The monthly time series data are stored in the data WORK.MSERIES. Each BY group associated with the BY variable STORE contains an observation for each of the 36 months associated with the years 1998, 1999, and 2000. Each observation contains the variable STORE, TIMESTAMP, and each of the analysis variables in the input data set.

After each set of transactions has been accumulated to form corresponding time series, accumulated time series can be analyzed using various time series analysis techniques. For example, exponentially weighted moving averages can be used to smooth each series. The following statements use the EXPAND procedure to smooth the analysis variable named STOREITEM.

```
proc expand data=mseries out=smoothed from=month;
   by store;
   id date;
   convert storeitem=smooth / transform=(ewma 0.1);
run;
```

The smoothed series are stored in the data set WORK.SMOOTHED. The variable SMOOTH contains the smoothed series.

If the time ID variable TIMESTAMP contains SAS datetime values instead of SAS date values, the INTERVAL=, START=, and END= options must be changed accordingly and the following statements could be used:

```
proc timeseries data=retail out=tseries;
   by store;
   id timestamp interval=dtmonth
                accumulate=median
                setmiss=0
                start='01jan1998:00:00:00'dt
                end  ='31dec2000:00:00:00'dt;
   var _numeric_;
run;
```

The monthly time series data are stored in the data WORK.TSERIES, and the time ID values use a SAS datetime representation.

Example 39.2: Trend and Seasonal Analysis

This example illustrates using the TIMESERIES procedure for trend and seasonal analysis of time-stamped transactional data.

Suppose that the data set SASHELP.AIR contains two variables: DATE and AIR. The variable DATE contains sorted SAS date values recorded at no particular frequency. The variable AIR contains the transaction values to be analyzed.

The following statements accumulate the transactional data on an average basis to form a quarterly time series and perform trend and seasonal analysis on the transactions.

```
proc timeseries data=sashelp.air
                out=series
                outtrend=trend
                outseason=season print=seasons;
   id date interval=qtr accumulate=avg;
   var air;
run;
```

The time series is stored in the data set WORK.SERIES, the trend statistics are stored in the data set WORK.TREND, and the seasonal statistics are stored in the data set WORK.SEASON. Additionally, the seasonal statistics are printed (PRINT=SEASONS) and the results of the seasonal analysis are shown in Output 39.2.1.

Output 39.2.1 Seasonal Statistics Table

The TIMESERIES Procedure

Season Statistics for Variable AIR

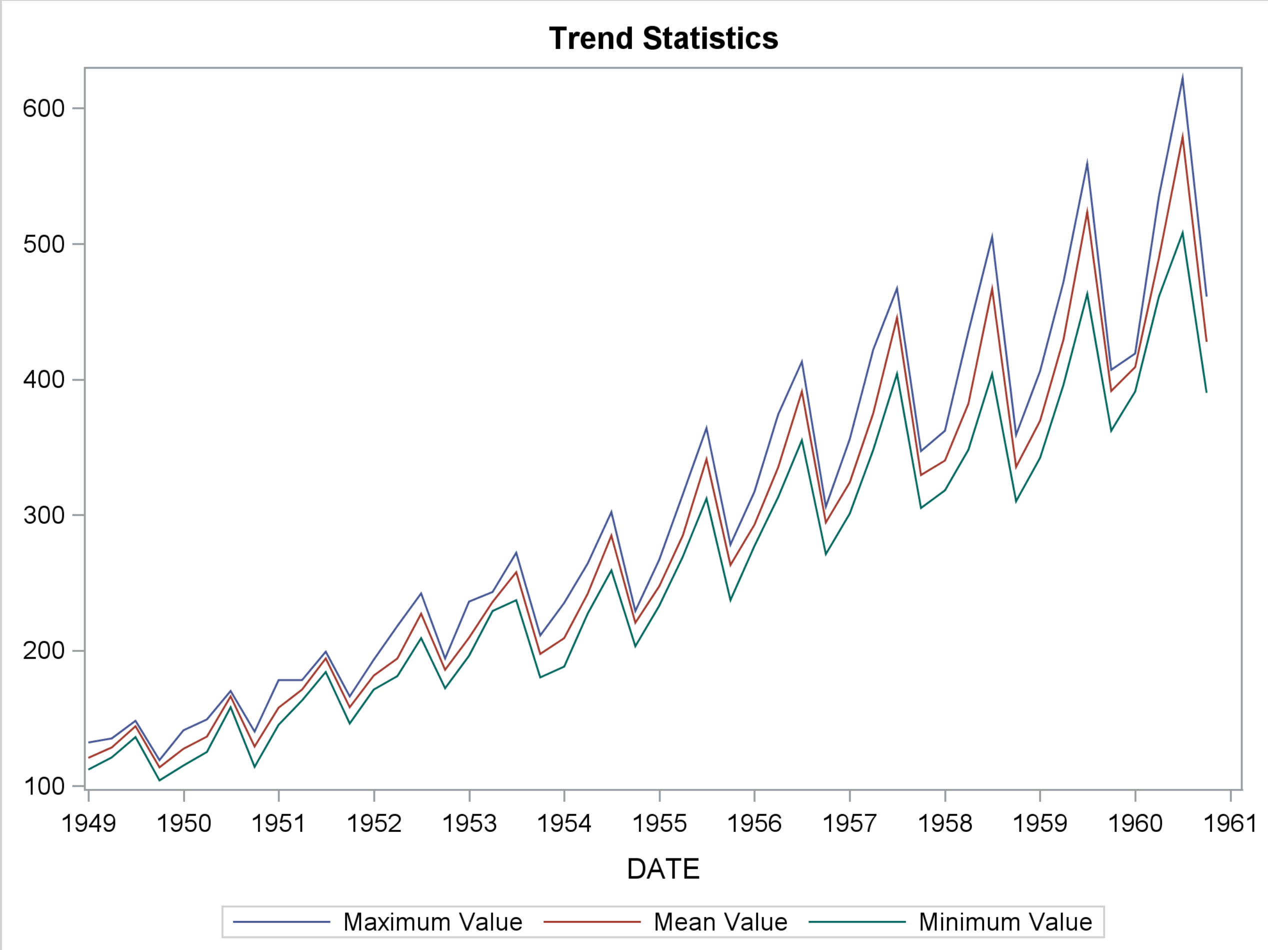
Season Index	N	Minimum	Maximum	Sum	Mean	Standard Deviation
1	36	112.0000	419.0000	8963.00	248.9722	95.65189
2	36	121.0000	535.0000	10207.00	283.5278	117.61839
3	36	136.0000	622.0000	12058.00	334.9444	143.97935
4	36	104.0000	461.0000	9135.00	253.7500	101.34732

Using the trend statistics stored in the WORK.TREND data set, the following statements plot various trend statistics associated with each time period over time.

```
title1 "Trend Statistics";
proc sgplot data=trend;
   series x=date y=max  / lineattrs=(pattern=solid);
   series x=date y=mean / lineattrs=(pattern=solid);
   series x=date y=min  / lineattrs=(pattern=solid);
   yaxis display=(nolabel);
   format date year4.;
run;
```

The results of this trend analysis are shown in Output 39.2.2.

Output 39.2.2 Trend Statistics Plot

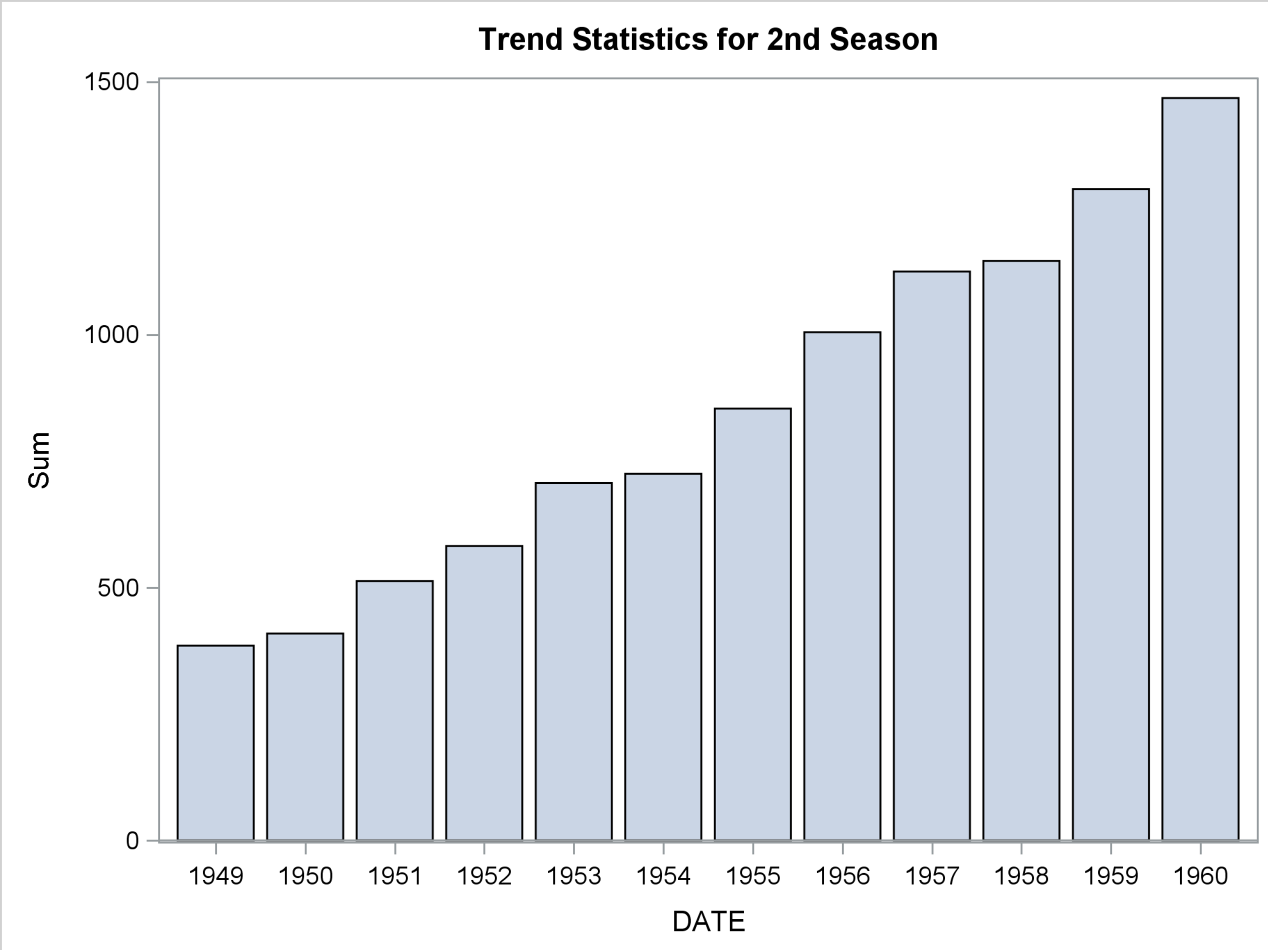


Using the trend statistics stored in the WORK.TREND data set, the following statements chart the sum of the transactions associated with each time period for the second season over time.

```
title1 "Trend Statistics for 2nd Season";
proc sgplot data=trend;
   where _season_ = 2;
   vbar date / freq=sum;
   format date year4.;
   yaxis label='Sum';
run;
```

The results of this trend analysis are shown in Output 39.2.3.

Output 39.2.3 Trend Statistics Bar Chart



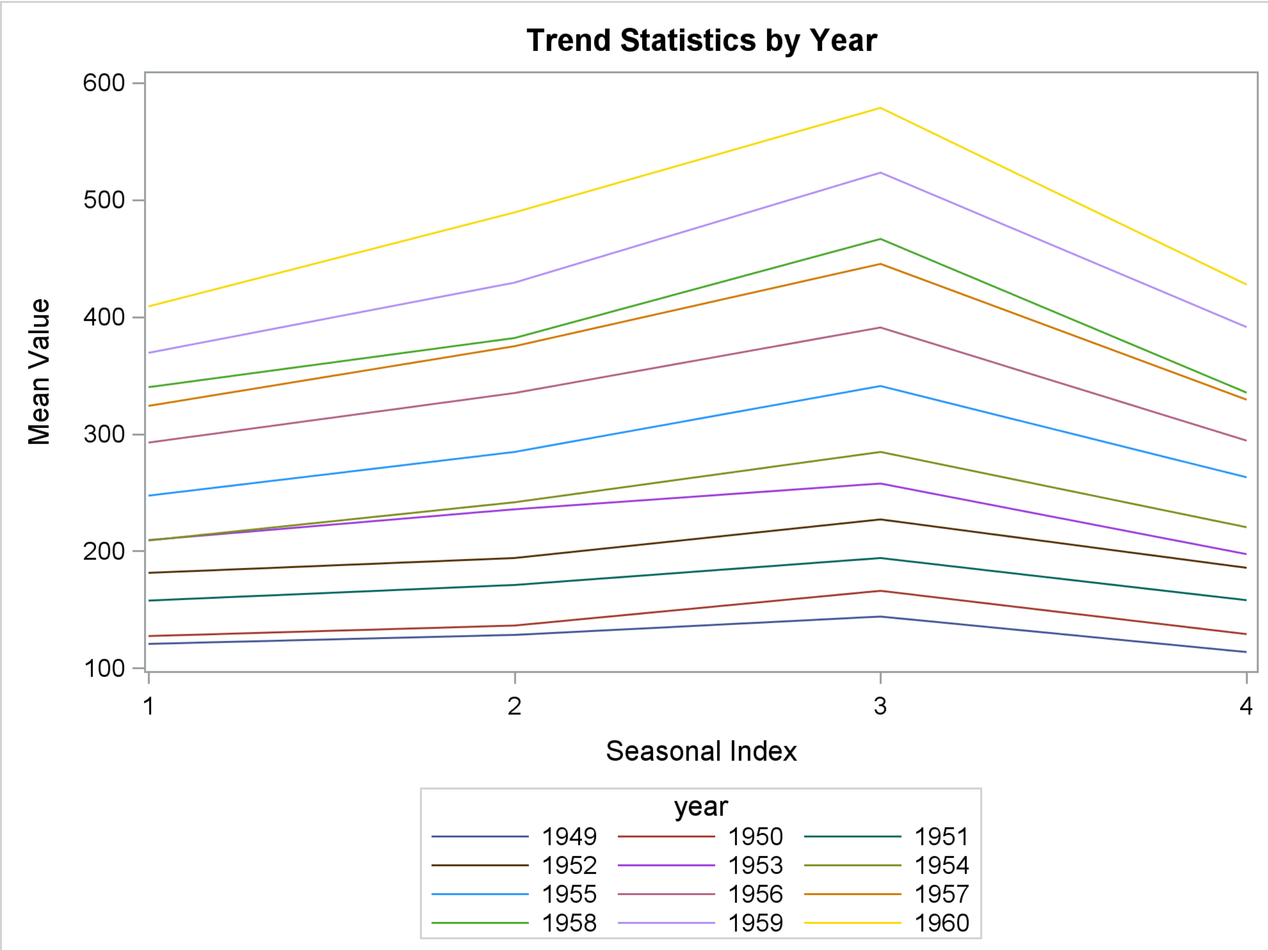
Using the trend statistics stored in the WORK.TREND data set, the following statements plot the mean of the transactions associated with each time period by each year over time.

```
data trend;
   set trend;
   year = year(date);
run;

title1 "Trend Statistics by Year";
proc sgplot data=trend;
   series x=_season_ y=mean / group=year lineattrs=(pattern=solid);
   xaxis values=(1 to 4 by 1);
run;
```

The results of this trend analysis are shown in Output 39.2.4.

Output 39.2.4 Trend Statistics

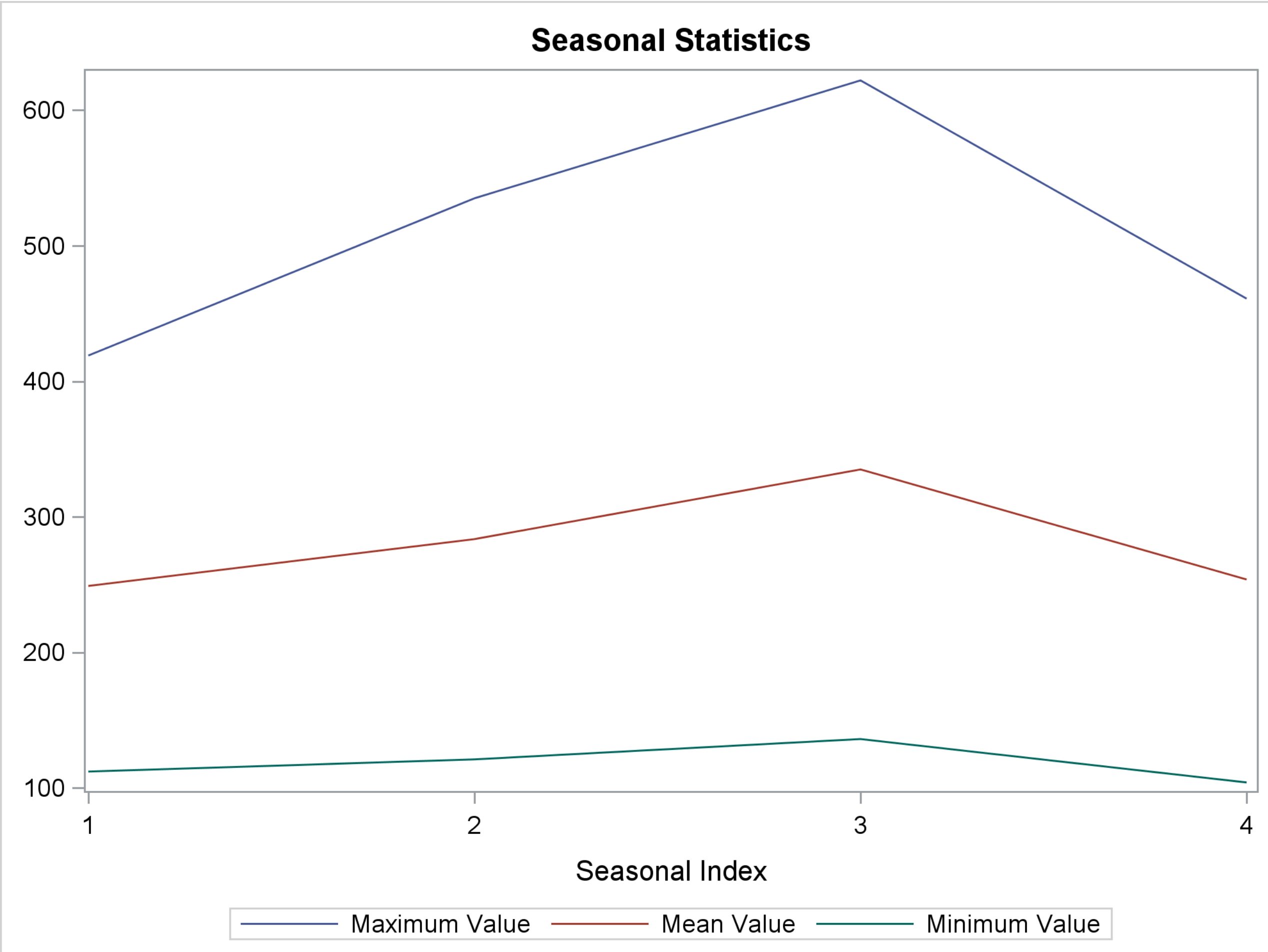


Using the season statistics stored in the WORK.SEASON data set, the following statements plot various season statistics for each season.

```
title1 "Seasonal Statistics";
proc sgplot data=season;
   series x=_season_ y=max  / lineattrs=(pattern=solid);
   series x=_season_ y=mean / lineattrs=(pattern=solid);
   series x=_season_ y=min  / lineattrs=(pattern=solid);
   yaxis display=(nolabel);
   xaxis values=(1 to 4 by 1);
run;
```

The results of this seasonal analysis are shown in Output 39.2.5.

Output 39.2.5 Seasonal Statistics Plot



Example 39.3: Illustration of ODS Graphics

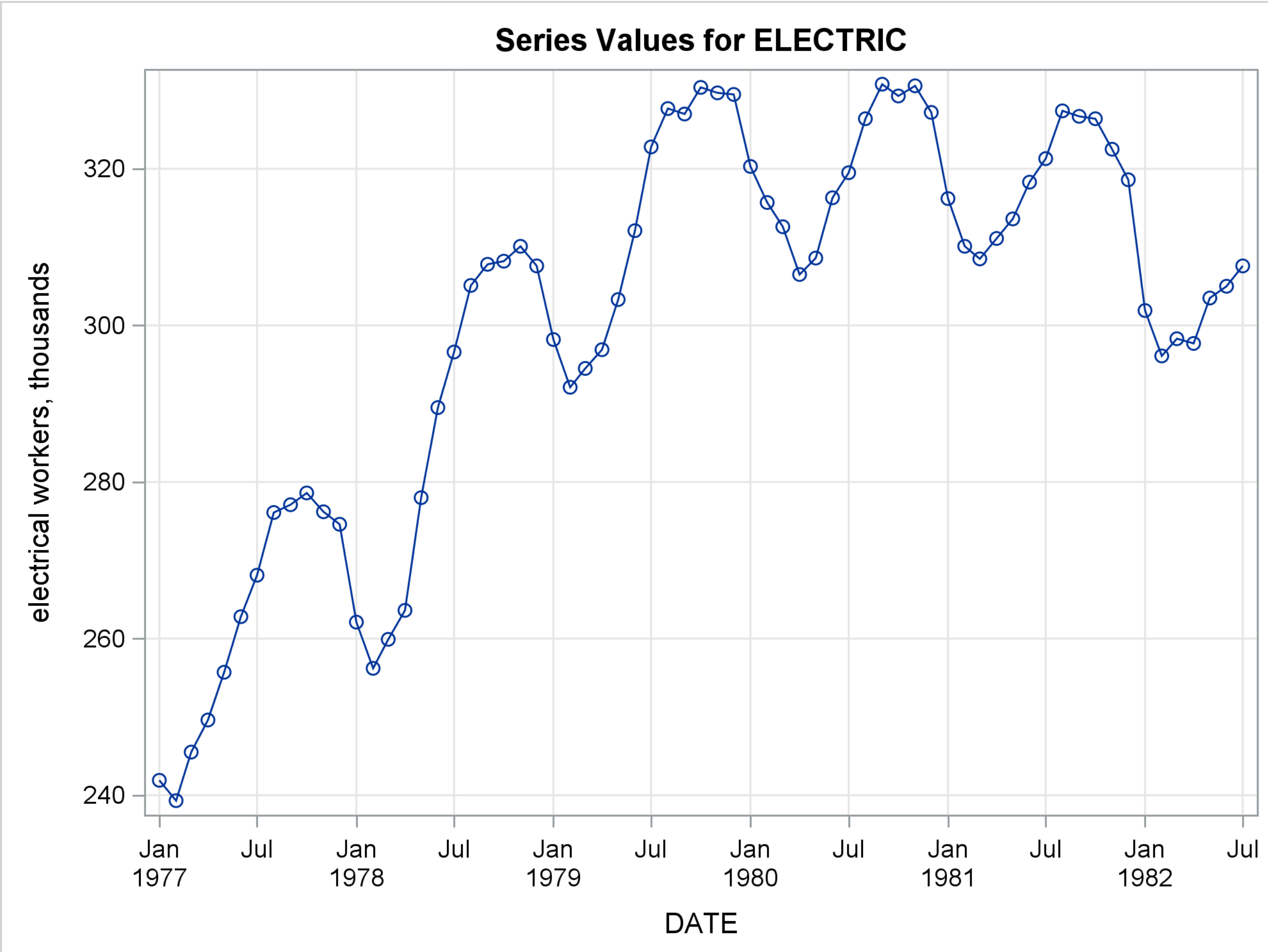
This example illustrates the use of ODS graphics.

The following statements use the SASHELP.WORKERS data set to study the time series of electrical workers and its interaction with the simply differenced series of masonry workers. The series plot, the correlation panel, the seasonal adjustment panel, and all cross-series plots are requested. Output 39.3.1 through Output 39.3.4 show a selection of the plots created.

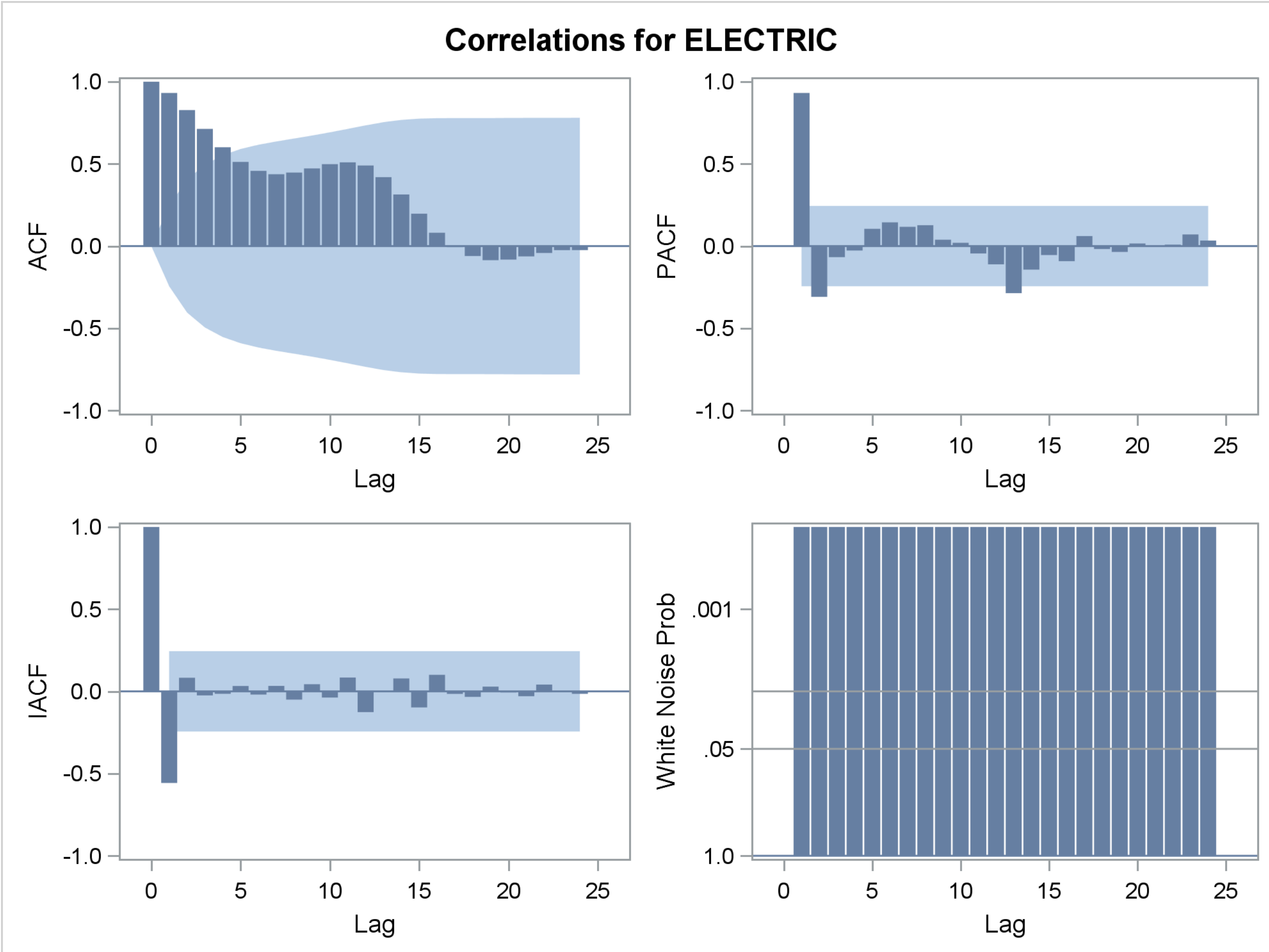
The graphical displays are requested by specifying the PLOTS= or CROSSPLOTS= options in the PROC TIMESERIES statement. For information about the graphics available in the TIMESERIES procedure, see the section "ODS Graphics Names" on page 2710.

```
title "Illustration of ODS Graphics";
proc timeseries data=sashelp.workers out=_null_
                plots=(series corr decomp)
                crossplots=all;
   id date interval=month;
   var electric;
   crossvar masonry / dif=(1);
run;
```

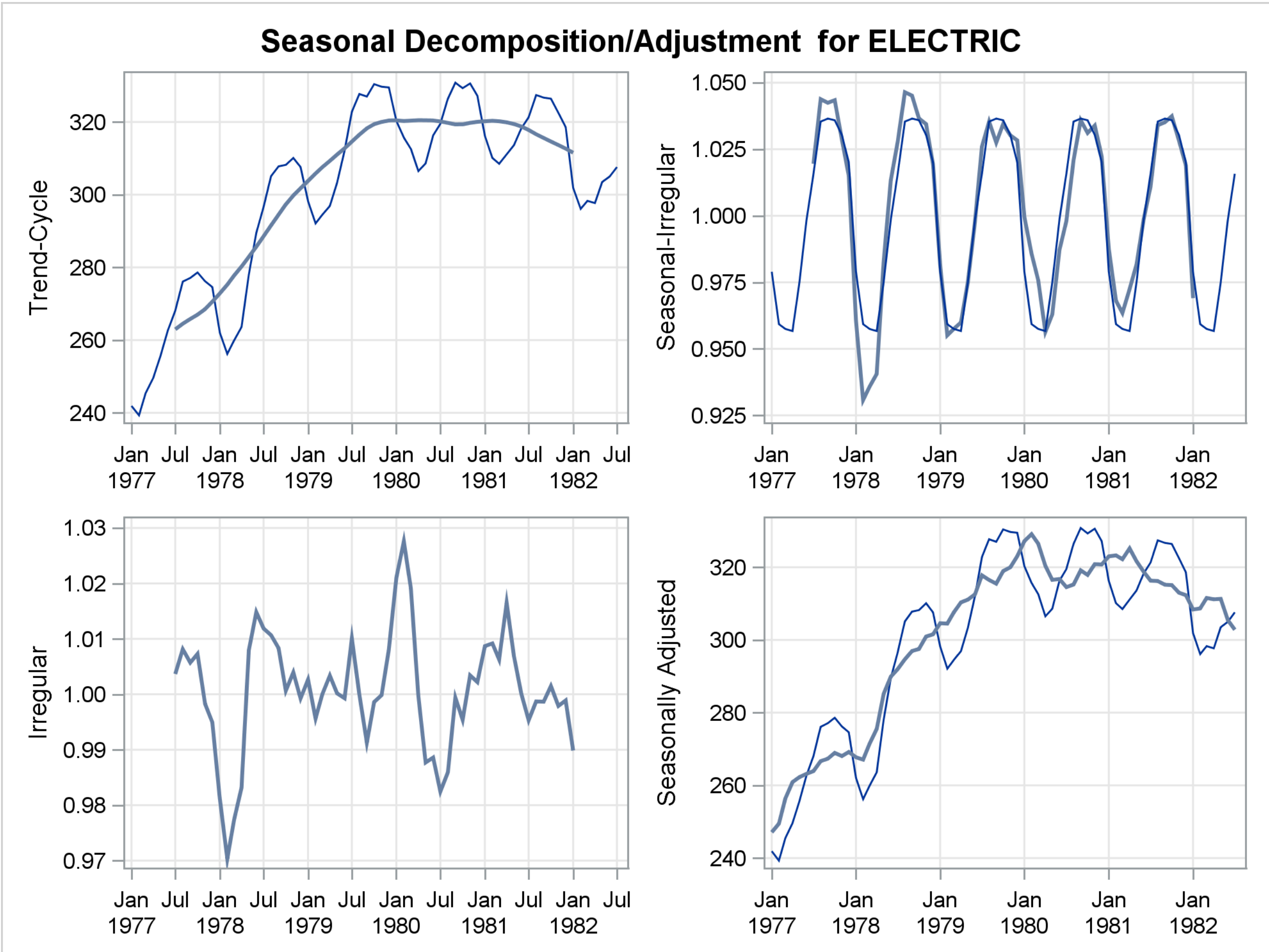
Output 39.3.1 Series Plot



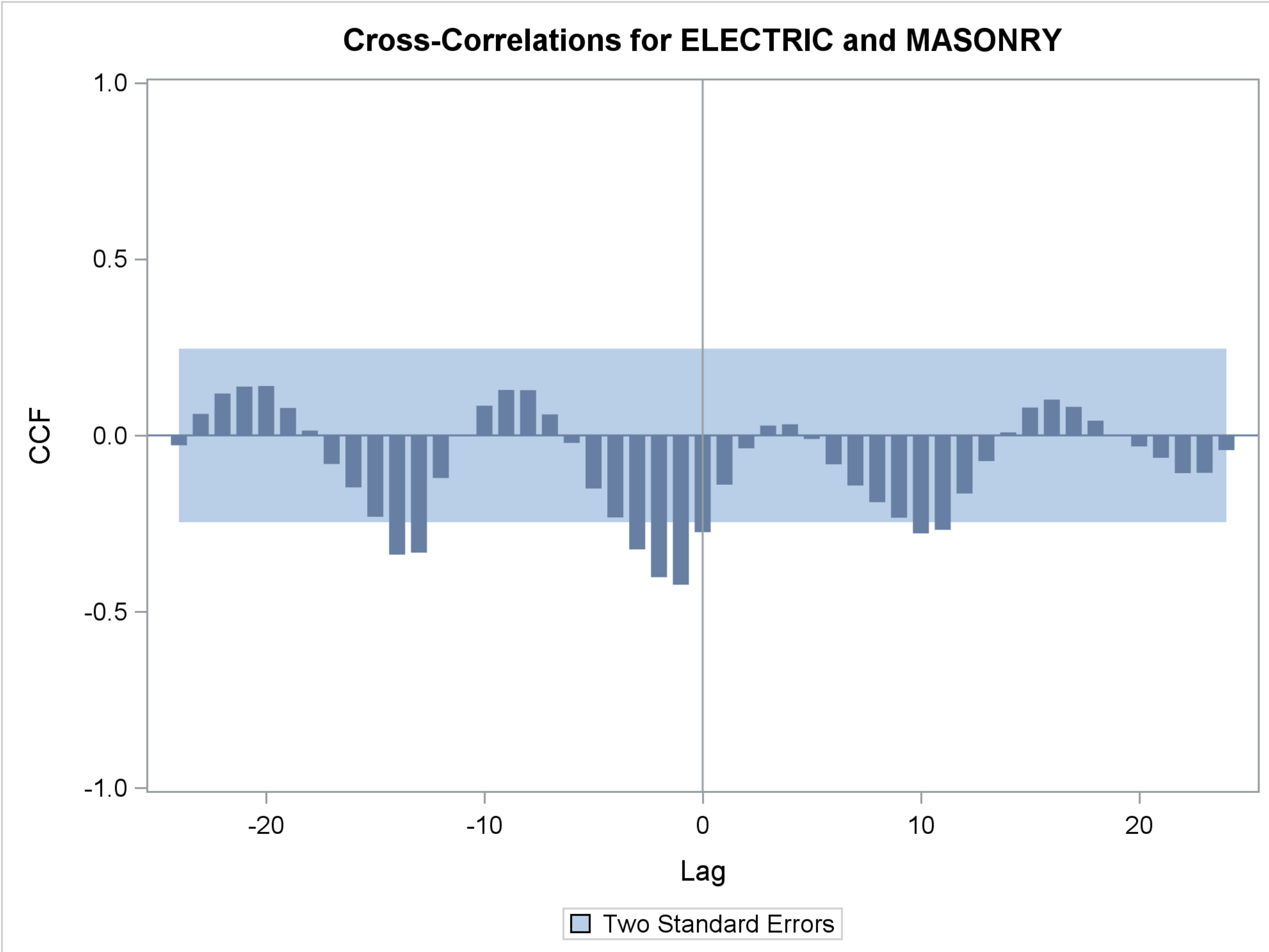
Output 39.3.2 Correlation Panel



Output 39.3.3 Seasonal Decomposition Panel



Output 39.3.4 Cross-Correlation Plot



Example 39.4: Illustration of Spectral Analysis

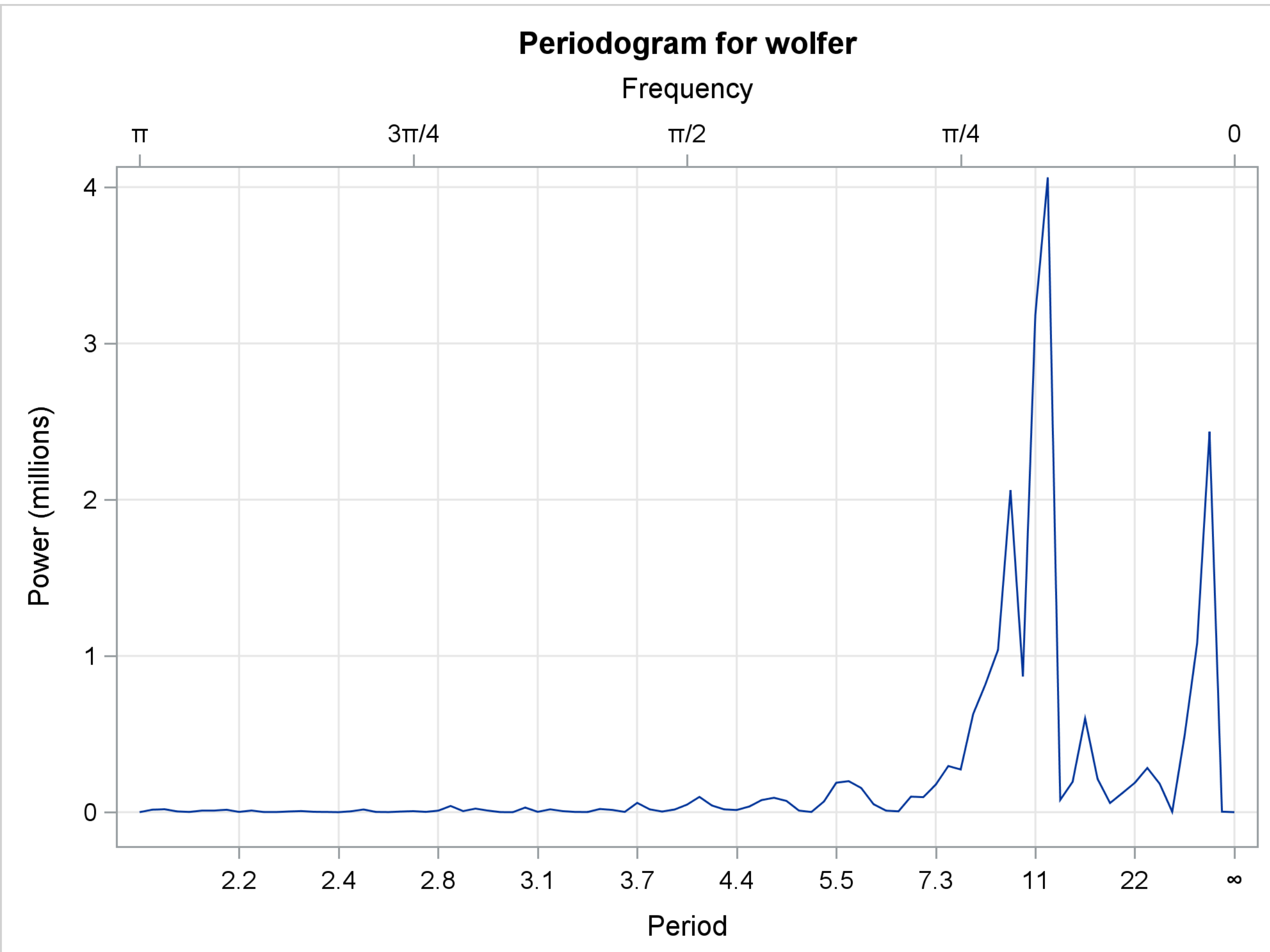
This example illustrates the use of spectral analysis.

The following statements perform a spectral analysis on the SUNSPOT dataset. The periodogram is displayed as a function of the period and frequency in Output 39.4.1. The estimated spectral density together with its 50% confidence limits are displayed in Output 39.4.2.

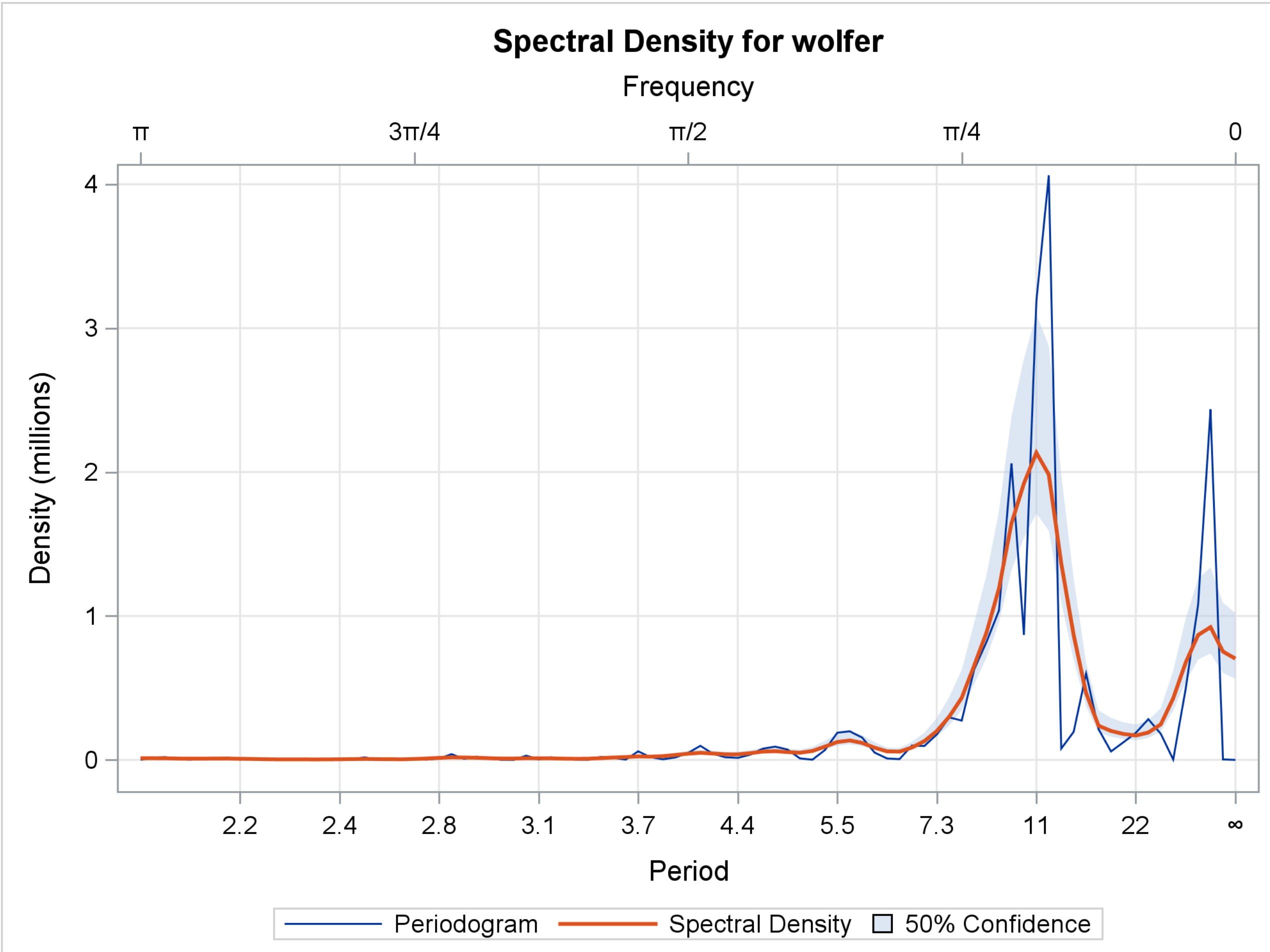
```
title "Wolfer's Sunspot Data";

proc timeseries data=sunspot plot=(series periodogram spectrum);
   var wolfer;
   id year interval=year;
   spectra freq period p s / adjmean bart c=1.5 expon=0.2;
run;
```

Output 39.4.1 Periodogram



Output 39.4.2 Spectral Density Plot



Example 39.5: Illustration of Singular Spectrum Analysis

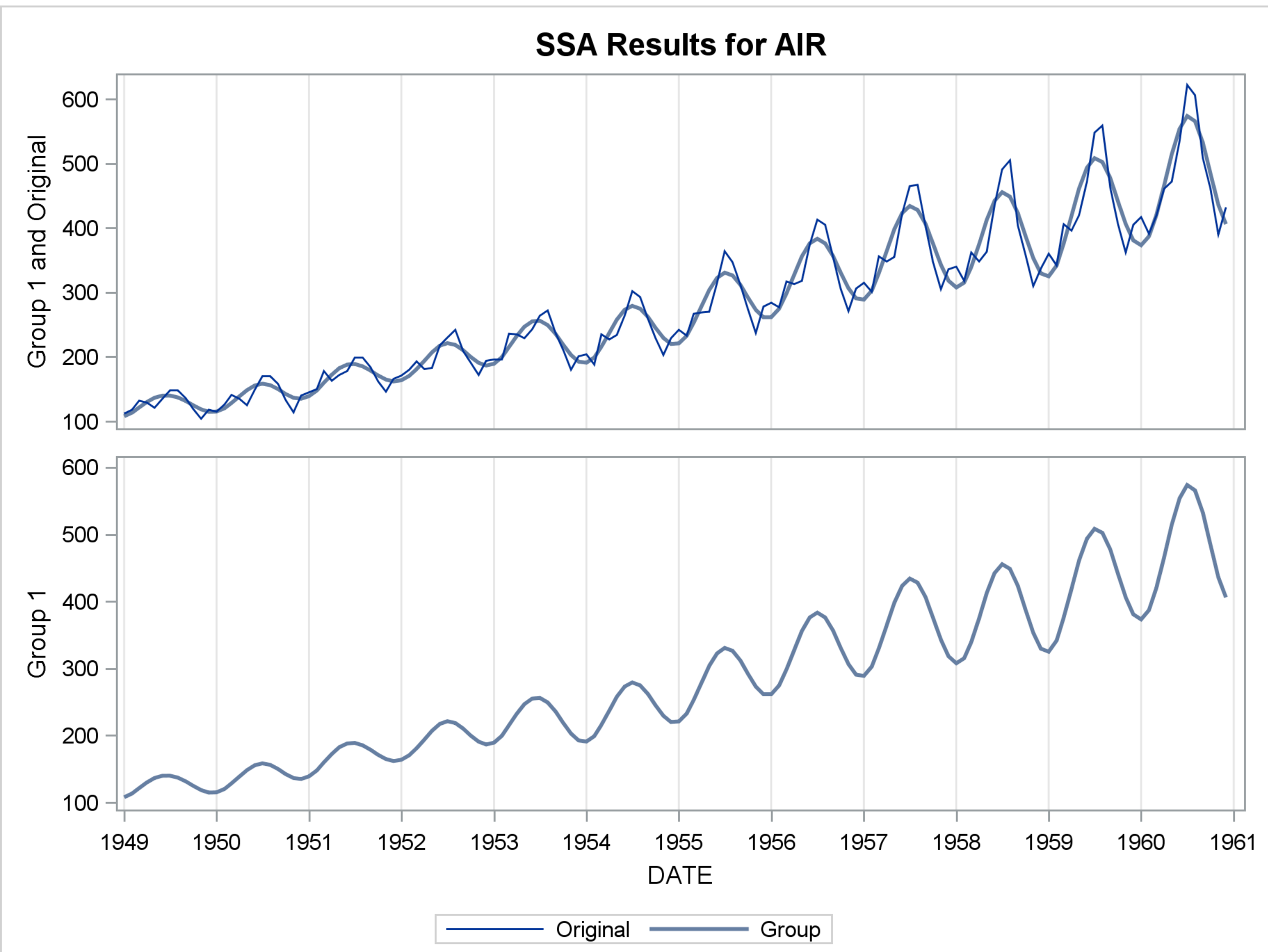
This example illustrates the use of singular spectrum analysis.

The following statements extract two additive components from the SASHELP.AIR time series by using the THRESHOLDPCT= option to specify that the first component represent 80% of the variability in the series. The resulting groupings, consisting of the first three and remaining nine singular value components, are presented in Output 39.5.1 through Output 39.5.3.

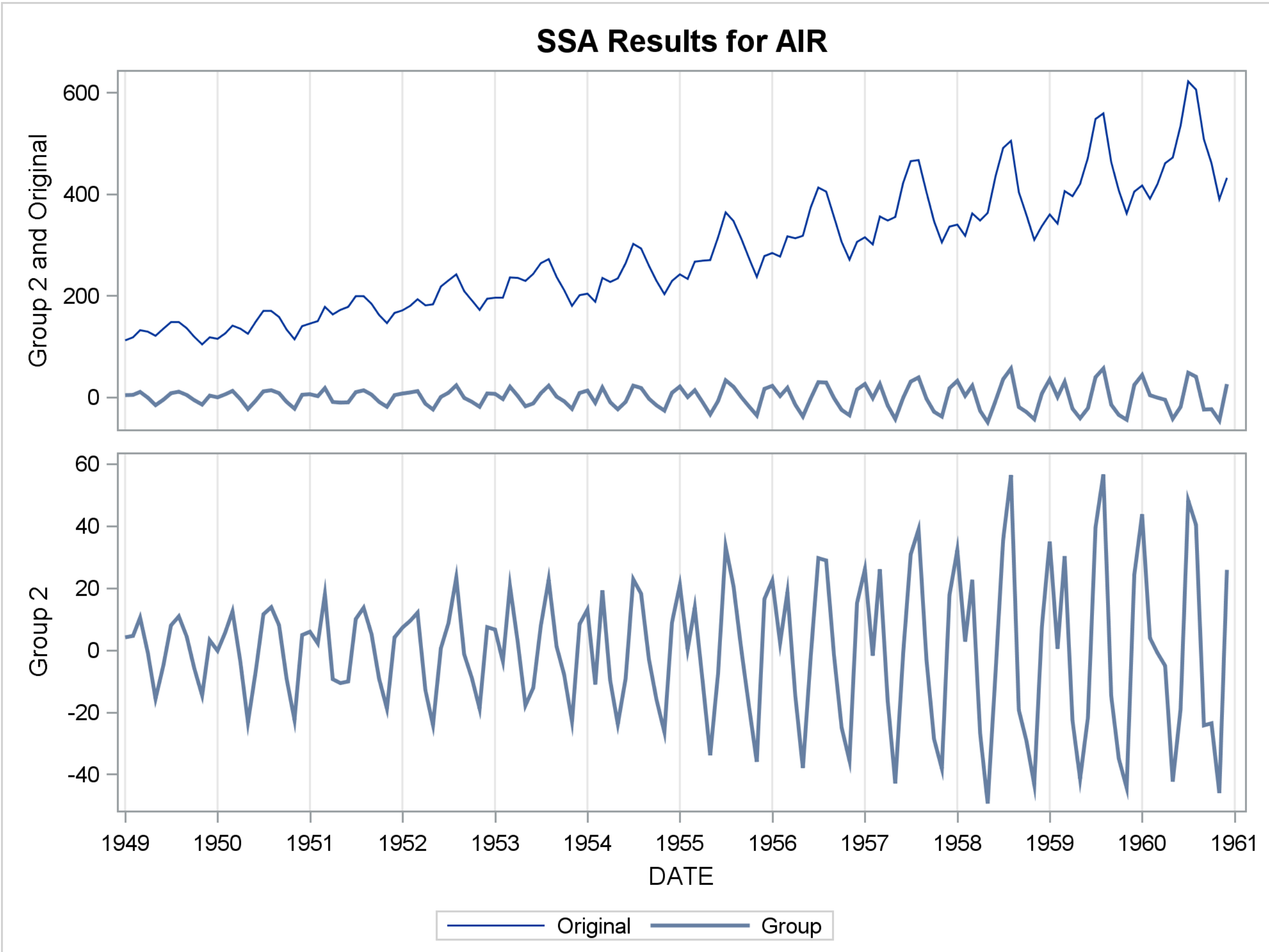
```
title "SSA of AIR data";

proc timeseries data=sashelp.air plot=ssa;
   id date interval=month;
   var air;
   ssa / length=12 THRESHOLDPCT=80;
run;
```

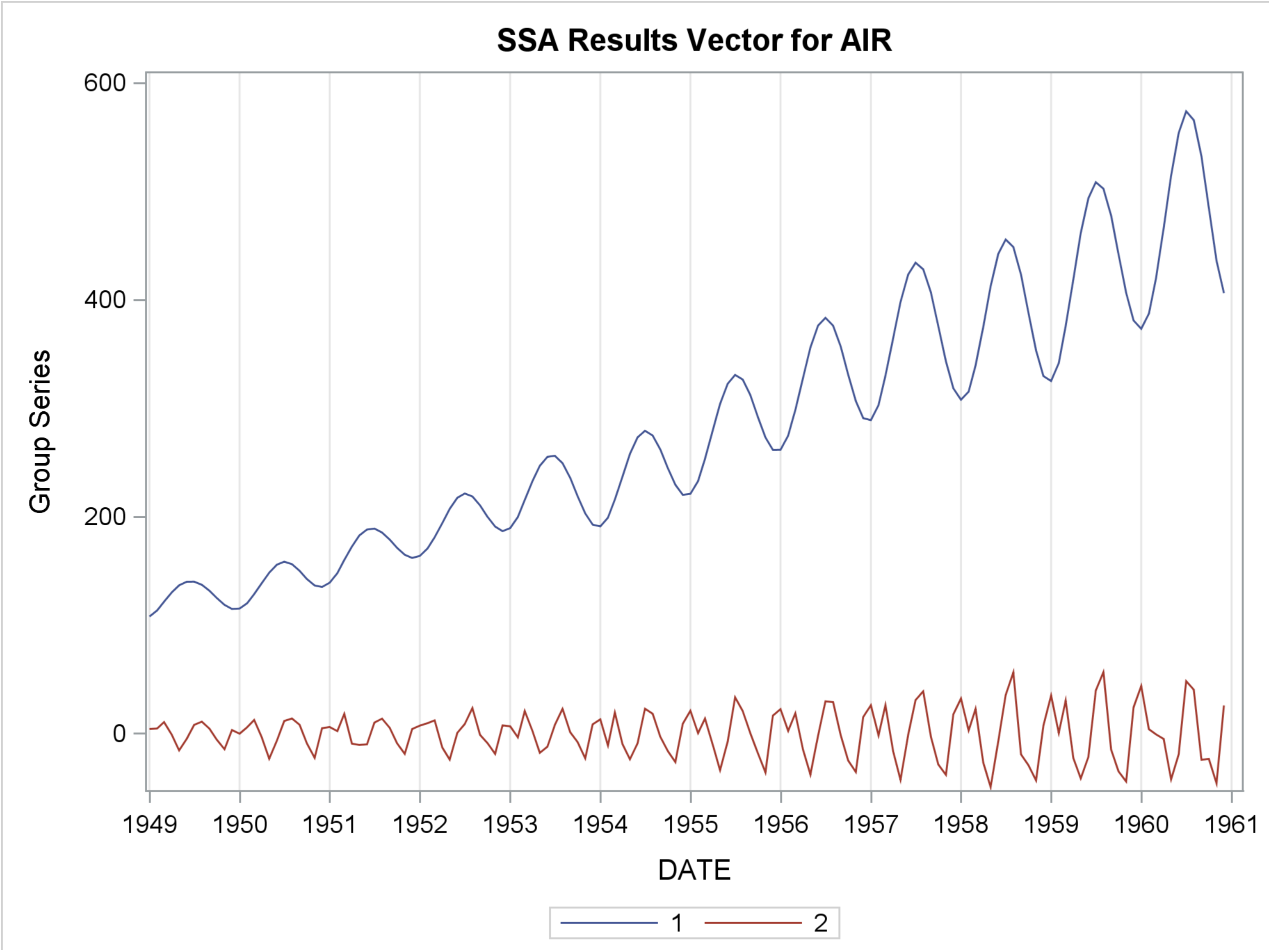
Output 39.5.1 Singular Value Grouping #1 Plot



Output 39.5.2 Singular Value Grouping #2 Plot



Output 39.5.3 Singular Value Components Plot



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