Applications of Known Pattern with Marker tool

- Analyze a data pattern and decompose or separate the various jitter components so the designer can better understand and improve system performance
- Measure the deterministic components: Duty-Cycle Distortion and Data Dependent Jitter (DCD+DDJ), Periodic Jitter (PJ), Bounded Uncorrelated Jitter (BUJ), Deterministic Jitter (DJ)
- Measure the Gaussian—or Random Jitter (RJ) component
- View DCD+DDJ relative to pattern transition density
- Compliance testing Fibre Channel and Gigabit Ethernet devices
- Advanced (not covered in this guide): view jitter data and model the signal as seen by the receiver, filtering RJ and PJ or altering acquisition configuration

Introduction

The use of a known, repeating pattern with a separate pattern marker provides the most accurate and fast analysis of a data signal. This tool separates jitter into components of DCD+DDJ, PJ, RJ and calculates a TJ for specification compliance testing.

The focus of this paper is to describe the DataCOM—Known Pattern with Marker (KPWM) tool and a basic setup for most common tests. This guide will highlight the menus and setup required to perform measurements under the most common circumstances. It will also provide a summary of the theory of operation. Refer to the VISI 6 Software Manual and the Help files for a more in- depth presentation.

DataCom Panel

Dialog Bar
Contains tool settings menus.

Plot area
Zoom in—hold down left mouse button, expand zoom box over area of interest.
Zoom out—double click left mouse.

VISI Status
Cursor coordinates - Displayed in the box at lower right portion of the VISI Panel. Units are same as those in plot.

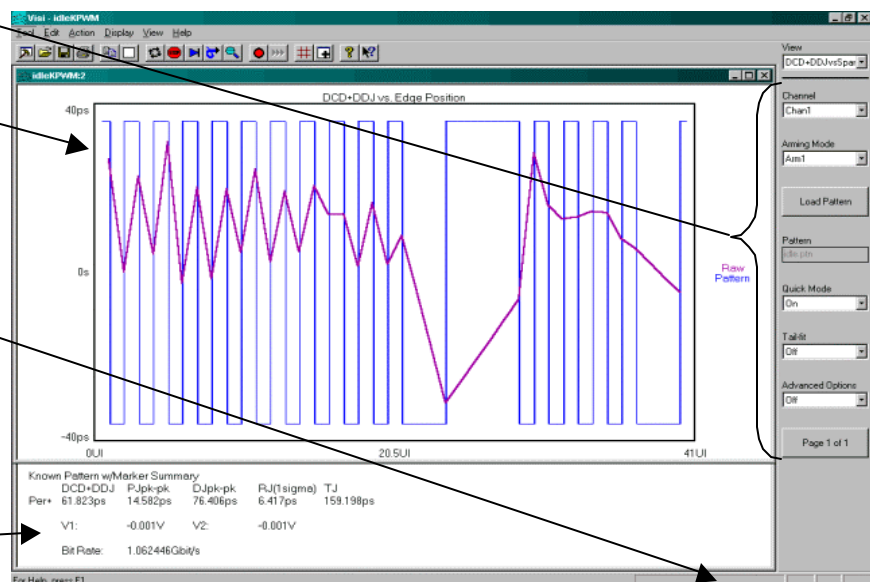**Statistics View**
Shows data from the most recent run.

Figure 1. Example DataCom Plot

Theory of Operation

This section will give a basic overview of the methodology behind the KPWM measurement. In addition to the data signal to be analyzed, this tool requires a pattern marker to be connected to the Arm Channel. The Marker signal has an edge relative to the same bit of the pattern each time the marker occurs. Since no bit-clock is used, analysis of jitter is independent of clock-jitter effects, and because the Arm is not a trigger, any jitter on the marker will not transfer to the measurement of the Data.

The following steps are performed automatically when a measurement is acquired using this tool. The first step is to accurately measure the unit interval (UI). This is done by making a series of pattern length measurements, calculating the mean and dividing that time by the length of the pattern in UI. This results in the Average or ideal UI and an accurate bit rate. Subsequent measurements and analysis will compare to this ideal UI and the jitter is displayed as the deviation from this ideal bit time.
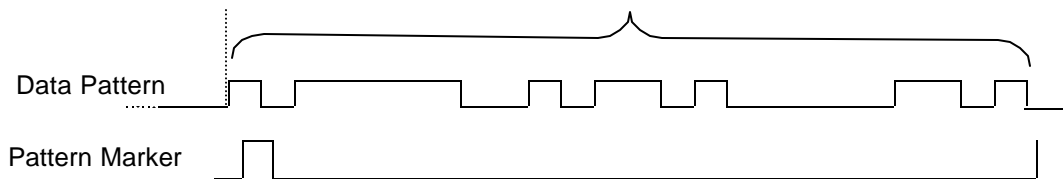
Figure 2. Calculating UI and Bit rate

After the UI measurement, a pattern match of the data must be done to identify the measured data stream relative to the expected bit sequence as well as the phase relationship to the pattern marker. This eliminates the need to have the pattern marker at the beginning of the expected pattern. The expected pattern is rotated against the measured pattern until it matches. See figure 3.
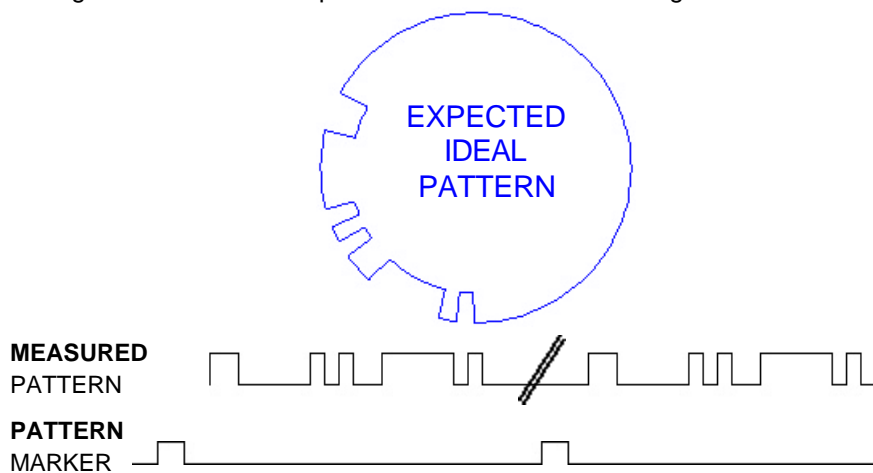
Figure 3. Performing pattern match (K285)

Next, the total DCD+DDJ is calculated. Histograms are made of every edge in the pattern. The mean values of these histograms are compared to the ideal edge locations. The measured mean location is subtracted from the calculated ideal edge location. The worst-case positive edge location is added to the worst-case negative edge location giving the total DCD+DDJ. This can also be thought of as comparing the earliest edge to the latest edge.
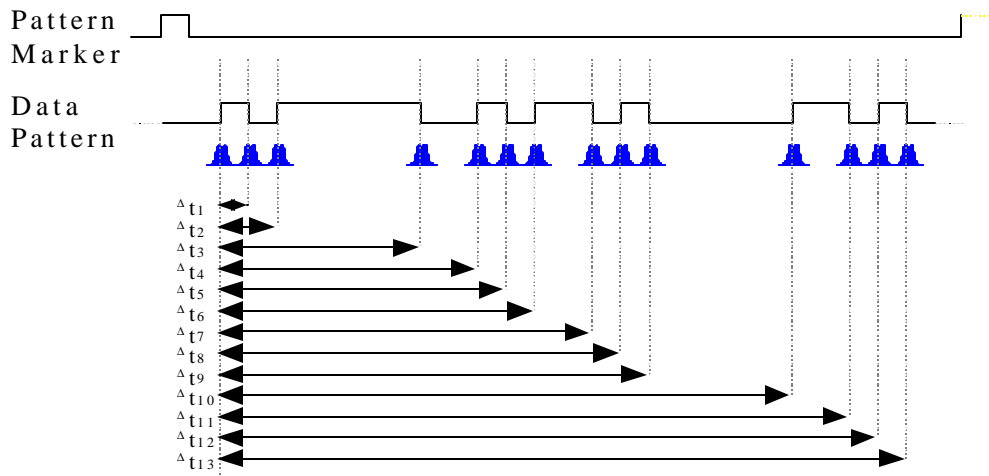

Figure 4.   DCD/DDJ Measurement

Lastly, data is gathered to show PJ and RJ frequency components.   PJ and RJ components are determined by taking the variance of timing measurements from the histogram at each UI. The variance is the square of the standard deviation of the histogram at each UI. If any "holes" in the variance record exists, they will be interpolated by either a cubic or linear fit. The plot of the variance versus UI (1-Sigma view) is the autocorrelation of the periodic and random jitter. Refer to the "High Frequency Modulation" Getting Started Guide for further information about this concept.

An FFT of the autocorrelation function is used to determine the periodic components. The Fast Fourier transform of the autocorrelation function is commonly referred to as the power spectral density or power spectrum. The largest magnitude periodic component represents the PJ contribution to TJ. The RJ component is determined by subtracting the spectral components, summing the background then taking the square root to provide a 1-sigma value.
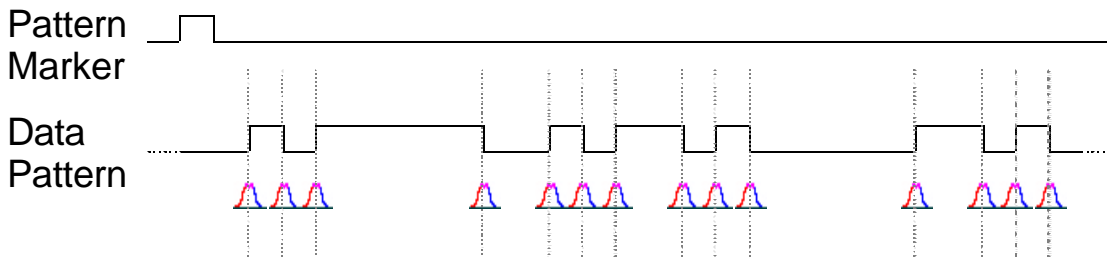

**Figure 5 Using TailFit™ to determine Random Jitter (RJ)**

Optionally, Tail-Fit allows the accurate determination of random jitter when there is a significant amount of periodic jitter. Refer to Histogram Getting Started Guide for more about Tail-Fit and RJ.

Views / Plots

Including the summary view, there are seven plots or views of the same data set. Each of the plots gives insight into the measurements of different components of jitter. In this section, the available views are briefly described. To change views, use the pull-down menu at the top of the VISI dialog bar or use the "PageUp" or "PageDn" keys on the keyboard.

DCD+DDJ Histogram

Displays the "normalized accumulation" of all the DCD+DDJ measurements taken during each run. The width of this plot is normalized to one Unit Interval of the data period. Ideally, all measurements would fall at zero on the x-axis with no jitter present. In actuality, the measurements show a distribution of measured times. There are two histograms plotted, one for rising and one for falling edges of the data pattern. There is often a difference in the absolute time of rising edges vs. falling edges. An indication of DCD or Duty Cycle Distortion—a difference in the width of a '1' vs. a '0'— can be seen when the two histograms are not over one another but have some distance between them.
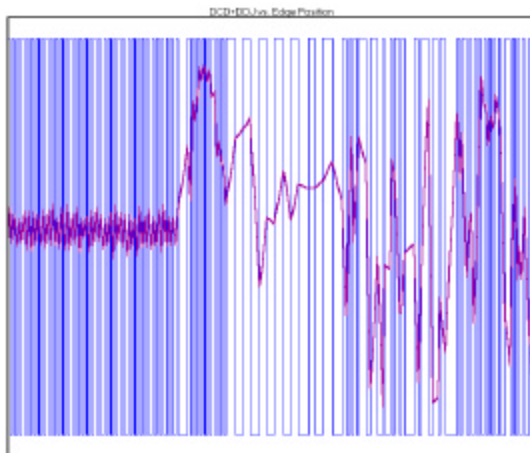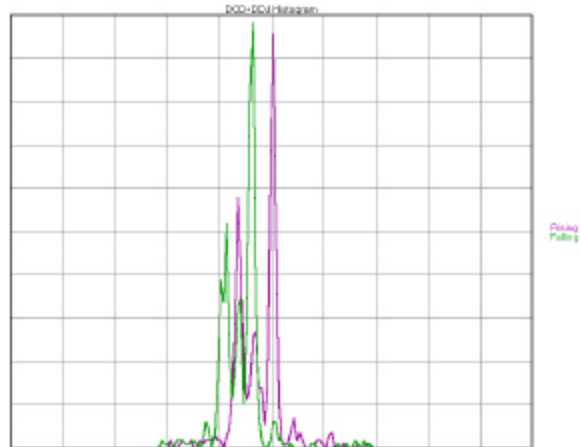

DCD+DDJ vs. Unit Interval

Plots the DCD+DDJ relative to the pattern. The "Pattern" line shows a representation of the entire pattern—zooming on any edge will show three line that represent the min, mean, and max time measurements from the histogram of each edge. The "Raw" line shows how the measured mean varied from the Ideal UI. The y-axis pk-pk is the value reported for DCD+DDJ in the statistics area. This plot also shows how the transition density affects jitter. Bandwidth limiting effects on the signal as well as reflections can be identified using this plot.

1-Sigma vs. Unit Interval

This view shows the 1-sigma values for the histograms of each binned UI measurement. Allows the user to see jitter accumulation. Modulation present shows up as a periodic variation of 1-sigma values. This information is used by the FFT view to show the actual frequency components and amplitude of the modulation. When there is a PLL imbedded in the device transmitting the data, a characteristic curve is often present. Refer to the "High Frequency Modulation" Getting Started Guide.

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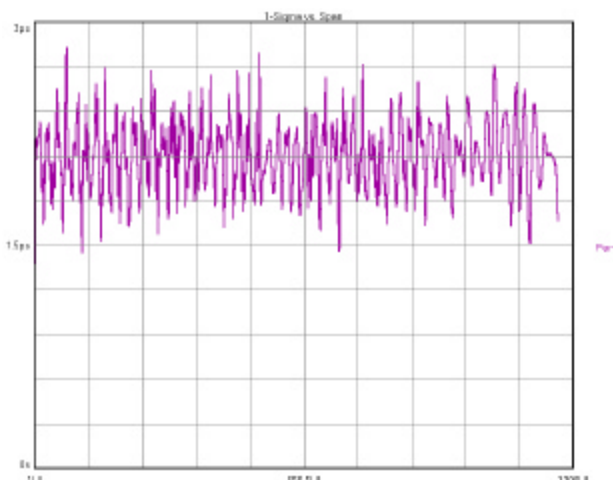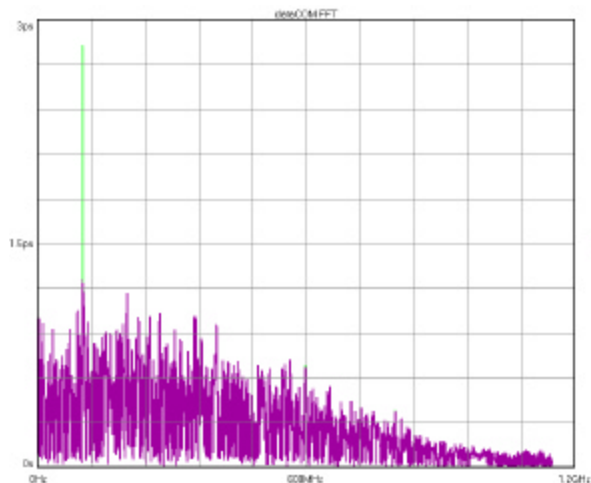
FFT

This is the FFT of the Autocorrelation of the variance from the 1-sigma vs. UI view. The plot shows the spectral power density of the uncorrelated jitter frequencies from the corner frequency specified to the Nyquist of the bit rate. The largest peak is displayed as the Periodic Jitter (PJ) number in the statistics area.

Bathtub Curve

Shows the "error probability density plot" of a data signal. The plot is normalized to one UI and the Total Jitter (TJ) number in the statistics area is derived from this view. The thick part of the line represents actual measurements. The thin part indicates extrapolated information based on RJ and DJ values. The point at which the color stops is the BER that TJ is determined.
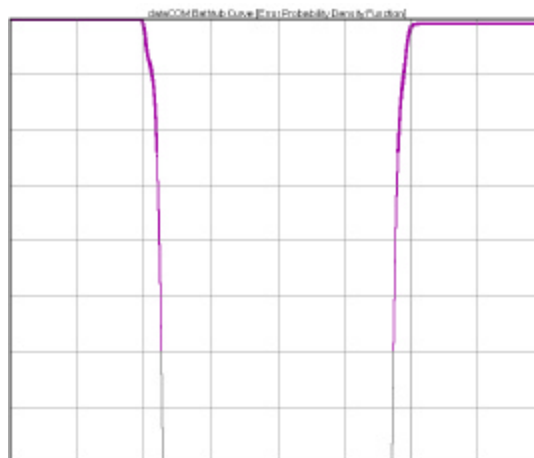
UI Distribution

The plot shows all measurement data taken of the serial data signal. The Unit Interval number is directly measured by the system. This plot does not directly relate to any numbers in the statistics area but does give an idea of the times measured for each UI. The information shown is similar to the "pattern" displayed in the DCD+DDJ vs UI view.

Making a Measurement

The tool defaults to a Fibre Channel setup.   The description covers most basic measurements and configuration.

- Connect a data signal to CH1 and a Pattern Marker to ARM1.
- If the "Pattern" window on the Dialog bar does not show the pattern to be measured, use one of the 3 options below for choosing the pattern to be analyzed:
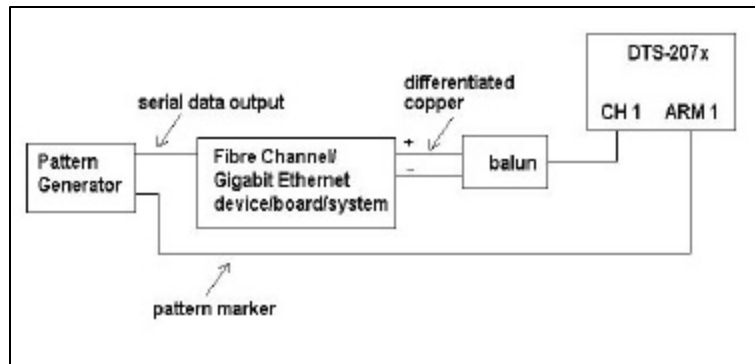

Figure 6. A typical setup.

Load Pattern   A dialog box will appear allowing you to choose a previously stored file.

OR

Edit Pattern   A dialog box opens allowing you to edit the current pattern or create a new one in binary or hexadecimal. You will be prompted to save this file.

OR

Learn Pattern   This function assumes that you have a repeating pattern on the measurement channel and a pattern marker on the arm channel. A dialog box opens prompting you for the number of bits in the pattern and the bit rate. Enter these values and press learn. You will be prompted to save this file. In some cases, there may be difficulties learning the pattern at high data rates. If using a generator as the source, you can lower the bit rate and learn the pattern at that lower rate. Then after saving the pattern, make the measurement at the previous rate. Learning the pattern does not need to be performed before every acquire, only if a pattern is changed or is not available in the Load dialog box.

- Choose the −3dB corner frequency—default is 637kHz for 1x Fibre Channel.

- Press Pulsefind   Press Single Acquire

In the case where there is over 20 ps of PJ, you should enable tail-fit to determine an accurate RJ. Note that this will significantly increase test time.   In the case where there is no high frequency jitter component, turning on "Quick Mode" may decrease the test time. This Mode will more sparsely sample and thus may not show high frequency information.

Possible Errors and solutions

"Failed bit rate calc – bad pattern or signal"   This error generally indicates that the pattern that the DTS is measuring at the input channel is not the same as the pattern chosen. Check that the signal is present and the input pattern matches the chosen pattern.

"Failed DDJ Measure – bad pattern or signal"   This error generally indicates that the pattern that the DTS is measuring at the input channel is not the same as the pattern chosen. Check that the signal is present and the input pattern matches the chosen pattern.

Dialog Bar, Page 1 of 7

View menu –
Select the View (plot) type.
Choose between DCD+DDJ
Histogram, DCD + DDJ vs
Span, 1sigma, FFT, Bathtub,
UI, Summary

Input Channel –
Select which input channel
is being used. Choose
between Channel 1 & 2.

Load Pattern –
Opens dialog box to select
previously saved patterns.

Pattern –
Displays the current pattern

Arming Channel –
Select which Arm channel is
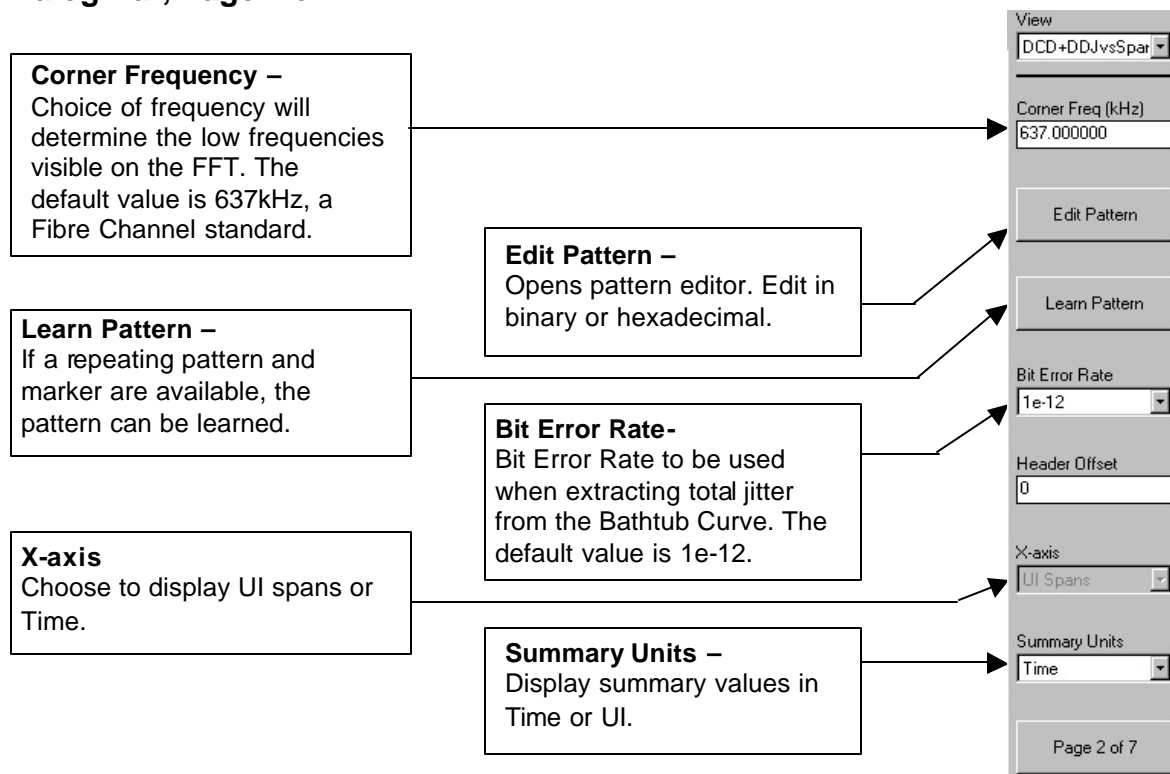being used. Choose between
ARM1 & ARM2.

Quick Mode—
Speeds acquisition time, but
may decrease acquisition of
high frequency jitter
information.

TailFit™ -
Enable, activates the Tail-fit
algorithm which separates and
quantifies the DJ and RJ to give
an accurate TJ value.

Advanced Options—
Choosing "on" enables access
to menu pages 2 through 7.

View
DCD+DDJvsSpan

Channel
Chan1

Arming Mode
Arm1

Load Pattern

Pattern
idle.ptn

Quick Mode
On

Tail-fit
Off

Advanced Options
On

Page 1 of 7

Dialog Bar, Page 2 of 7

Corner Frequency –
Choice of frequency will
determine the low frequencies
visible on the FFT. The
default value is 637kHz, a
Fibre Channel standard.

Edit Pattern –
Opens pattern editor. Edit in
binary or hexadecimal.

Learn Pattern –
If a repeating pattern and
marker are available, the
pattern can be learned.

Bit Error Rate-
Bit Error Rate to be used
when extracting total jitter
from the Bathtub Curve. The
default value is 1e-12.

X-axis
Choose to display UI spans or
Time.

Summary Units –
Display summary values in
Time or UI.

View
DCD+DDJvsSpan

Corner Freq (kHz)
637.000000

Edit Pattern

Learn Pattern

Bit Error Rate
1e-12

Header Offset
0

X-axis
UI Spans

Summary Units
Time

Page 2 of 7

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