

DS-0342 Servo Analysis Software
Simple Operation Manual
-Loop Gain Measurement of Control System-

DS-0342 Servo Analysis Software

Simple Operation Manual

-Loop Gain Measurement of Control System

This manual explains how to measure the loop gain of the servo control system.

An example of measuring the loop gain of a typical feedback control circuit as shown in figure 1 using the FRA method is described below.

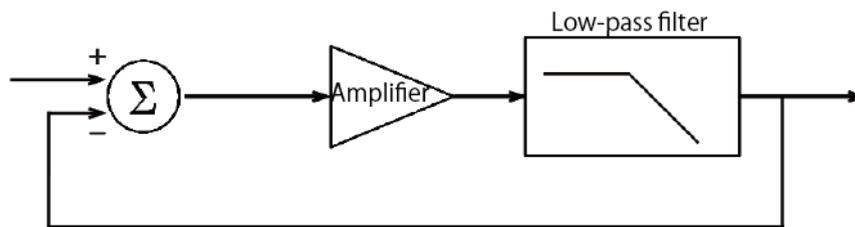
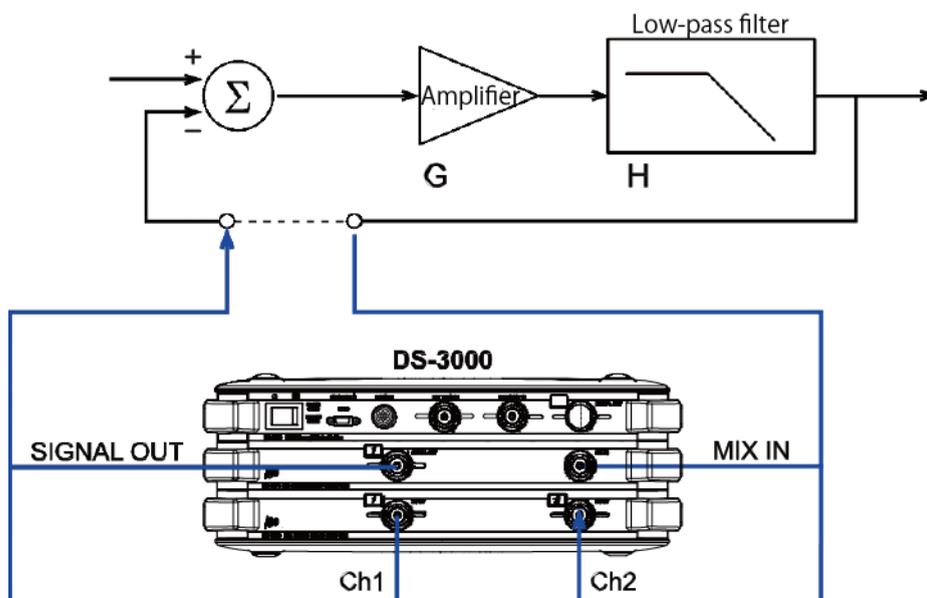


Figure 1: Example of feedback control circuit

1. How to obtain the loop gain directly (direct method)

A disturbance signal (in this case, sine wave) for measurement is injected to an arbitrary point transmitted by the voltage signal of the control loop circuit as shown in figure 1 to measure one loop transfer function (loop gain, GH in figure 2) of the direct control system.

The connection using the DS-0374 (Addition function) which is option of the DS-3000 series is shown as figure 2. The transfer function for CH1 and CH2 becomes loop gain (GH).



*The MIX IN and GND (0V) of SIGNAL OUT is internally connected.

Figure 2: Loop gain measurement method (direct method)

1. Select the type of signal as “Log Sin” and measure with a Log sine sweep mode.
2. Select the frequency range to be swept. Set [Min: 1 Hz, Max: 50 kHz] in here.
3. Select the frequency resolution. Set [Decade/ Line: 20] in here.
4. Select the direction to be swept. Set [L → H] in here.
 Select the amplitude of the signal output. Set 3 V (peak value of sine wave) in here.
 Set in the following order; [Input/ Output Setting] (menu) > [Sig Output Setting].

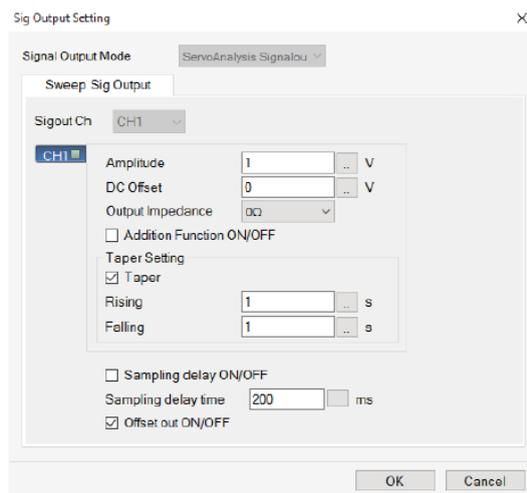


Figure 3: Signal output setting

5. Invert the polarity of the CH1 input time signal. Select "Polarity inversion" in the following order [Input/ Output Setting] (menu) > [Time-axis Pre-processing Setting] > [CH1].
6. Turn on the [MIX IN] on the command tool bar. By turning this on, a loop is formed.
 (Note): [MIX IN] tool bar is not stored in the panel condition.
7. Turn on the [CHECK] on the command tool bar to check if the control loop is correctly connected.
 1 Hz of sweep start frequency is outputted in here.
 CH1 is a small amplitude compressed by the amount of loop gain.

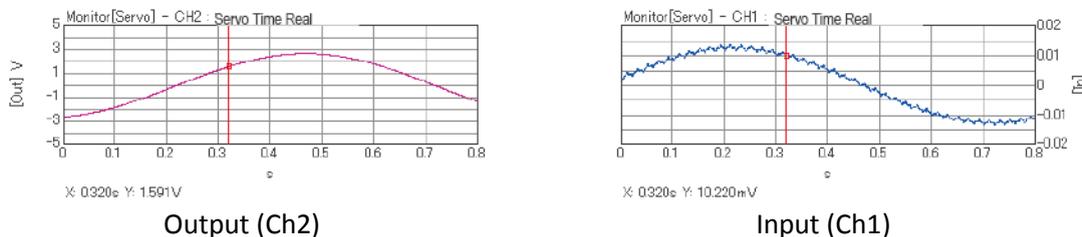


Figure 4: Signal output setting

- Start the measurement by pressing the [START] button on the command tool bar. It sweeps up to the maximum frequency and finishes the measurement automatically.

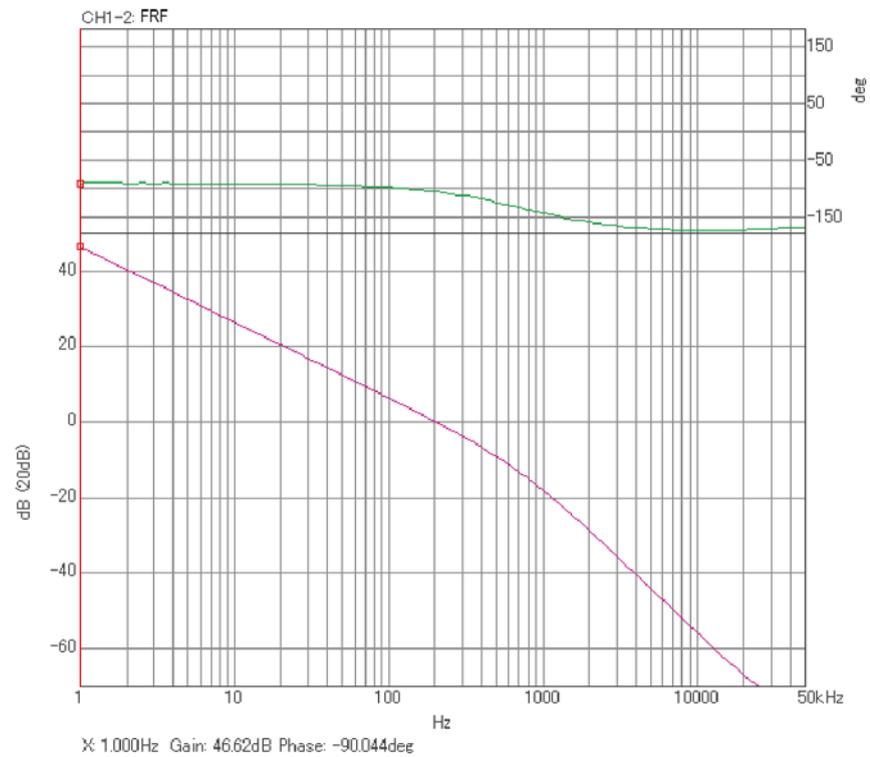


Figure 5: Bode graph of loop transfer function (direct method)

2. How to obtain the loop gain by calculation (calculation method)

Loop gain (GH) is calculated from the calculation by measuring the closed loop transfer function H_C of the control system by the connection as shown in figure 6.

$$H_C = \frac{GH}{1+GH} \quad \dots\dots\dots (1)$$

From this, GH can be obtained as follows:

$$GH = \frac{H_C}{1-H_C} \quad \dots\dots\dots (2)$$

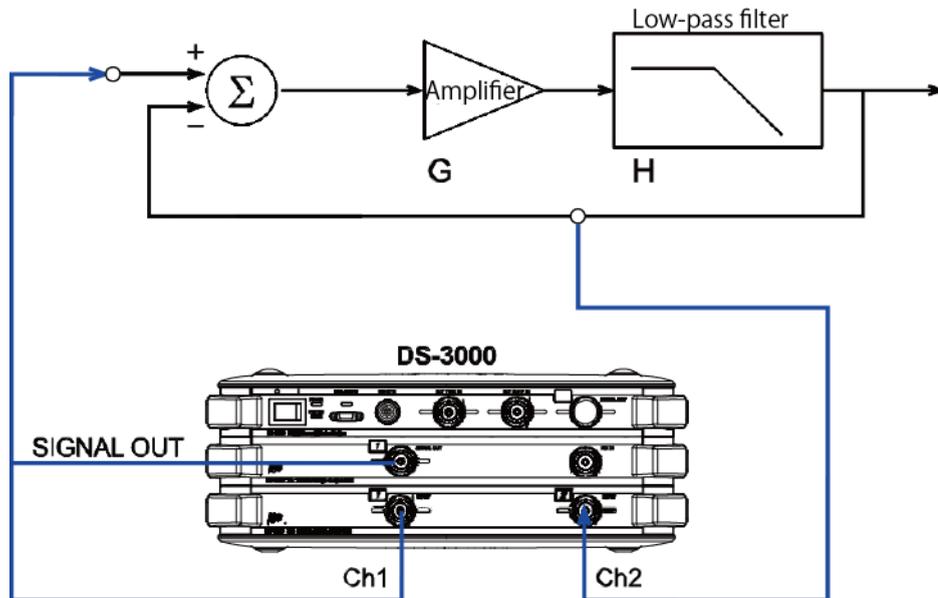


Figure 6: Loop gain measurement method (calculation method)

1. Select the type of signal as “Log Sin” and measure with a Log sine sweep mode.
2. Select the frequency range to be swept. Set [Min: 1 Hz, Max: 50 kHz] in here.
3. Select the frequency resolution. Set [Decade/ Line: 20] in here.
4. Select the direction to be swept. Set [L → H] in here.
5. Select the amplitude of the signal output. Set 3 V (peak value of sine wave) in here. Set in the following order; [Input/ Output Setting] (menu) > [Sig Output Setting].

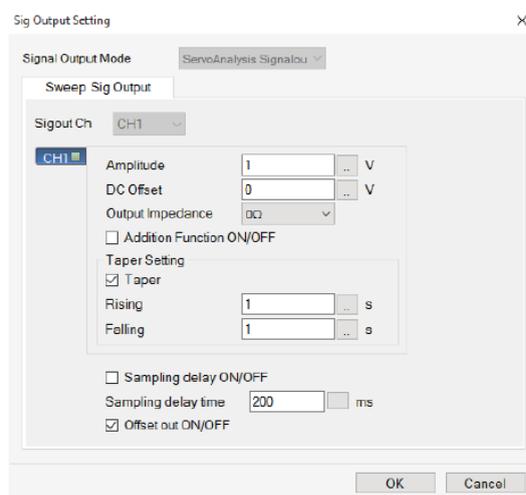


Figure 7: Signal Output Setting

- Turn on the [CHECK] on the command tool bar to check if the control loop system is correctly connected. 1 Hz of sweep start frequency is outputted in here. Both time waveforms are nearly the same in this frequency band.

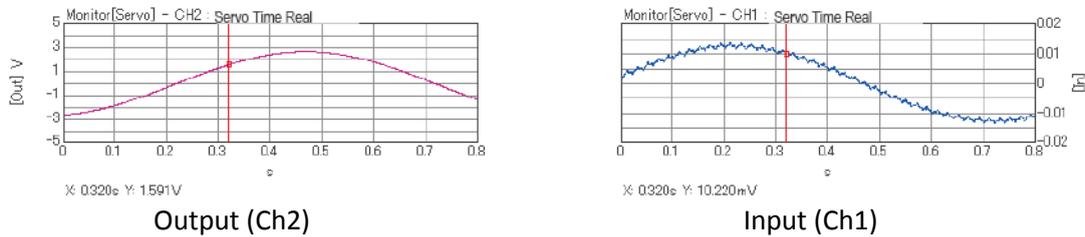


Figure 8: Monitoring of time waveform

- Start the measurement by pressing the [START] button on the command tool bar. It sweeps up to the maximum frequency and finishes the measurement automatically.

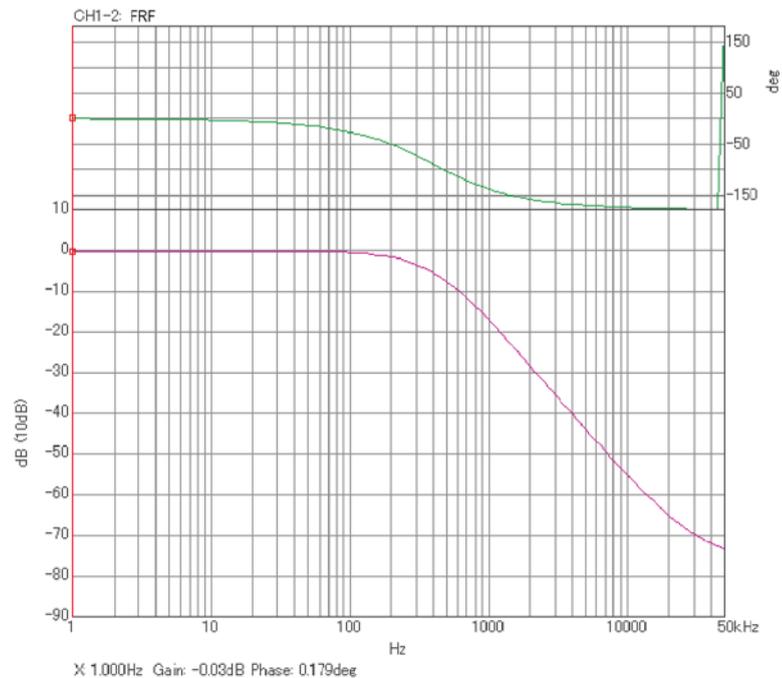


Figure 9: Close loop transfer function

- From the measured close loop transfer function, obtain the open loop transfer function (loop gain) by calculating the equation (2). Turn on the loop function by selecting in following order; [Analysis Setting] (menu) > [Freq Resp Function Operation] > [Loop Type] and select "Close loop → Open loop".

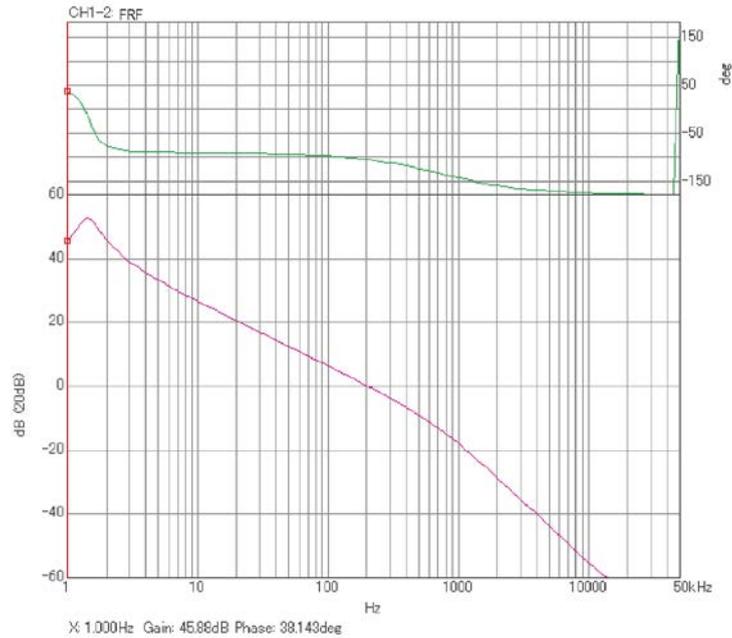


Figure 10: Loop gain obtained by calculation

As you can see from equation (1), the close loop transfer function H_C has a gain of 1 (0 dB) in a system with a low loop gain range, and the gain difference between channels of the measurement device itself may not be negligible. From this reason, in the low range of figure 10, there is a difference from the loop gain (figure 5) obtained by the direct method.

In order to correct this, it is necessary to obtain the transfer function for correction by inputting the exactly the same signals to CH1 to CH2, then obtain the open loop transfer function (loop gain) by a calculation after correcting (dividing, equalizing) the measured close loop transfer function.

In the [Calculation] tab;

Base	Measured close loop transfer function (Current)
Target	Transfer function for correction (Memory01)
Type	/ (Dividing)
Loop	Close loop → Open loop

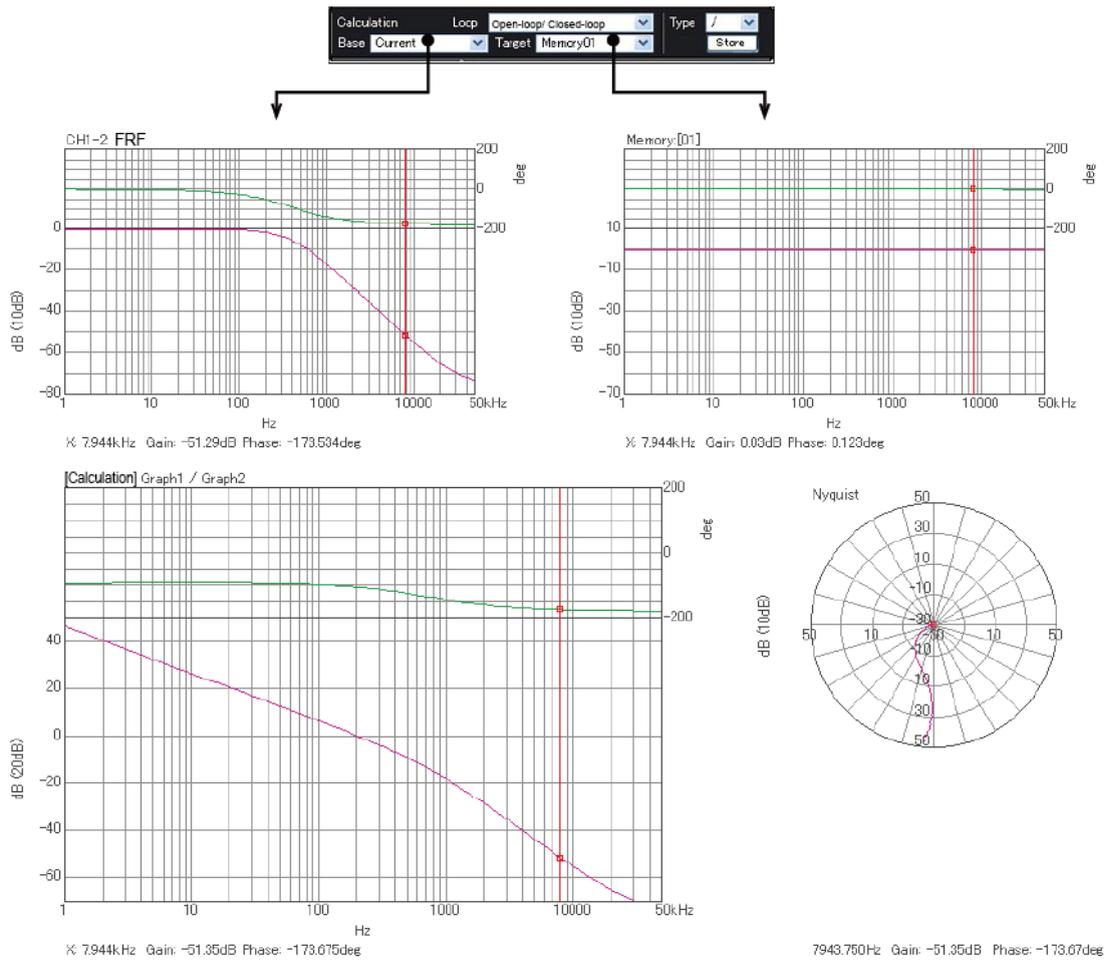


Figure 11: Close loop calculation of corrected transfer function

From the calculation result in figure 11, you can see that the loop gain obtained by the calculation method is almost the same as the direct method (figure 5).

-END-