Smart Analog

R02AN0017EJ0100
Rev. 1.00
May 31, 2013

Evaluating Sensors By Using Smart Analog Easy Starter (Ver. 2.0)

Introduction

This application note describes how to evaluate a sensor by using Smart Analog Easy Starter and Smart Analog IC 500 or 300.

Target Device

Smart Analog IC 500 (RAA730500) and Smart Analog IC 300 (RAA730300)

Contents

1. Overview

1.1 General

Smart Analog Easy Starter is dedicated, intuitive Smart Analog GUI software that speeds up evaluation of sensors and sensor modules that use Smart Analog ICs. Smart Analog Easy Starter ("Easy Starter") lets you specify all the Smart Analog circuit parameters on the computer screen, making it easy to reconfigure circuits and adjust characteristics.

This application note describes the procedure used to evaluate a sensor by using Smart Analog Easy Starter, using Smart Analog IC 500/300 as an example.

The procedure described in this application note is summarized below.

First, the analog circuit configuration best suited to the sensor to be used is selected from the Smart Analog IC 500/300 configurable amplifier configurations. (For how to select the amplifier configuration, see *1.3 Related Application Notes*.) The Smart Analog IC analog circuit parameters are then specified by using Easy Starter. The parameters are specified referring to the sensor's datasheet and application examples. The signals output from the sensor are amplified by the Smart Analog IC, A/D converted by the A/D converter incorporated in the MCU, and displayed on a graph on the Easy Starter GUI. The waveforms on Easy Starter are checked, parameters such as the gain and offset voltage are adjusted, and then the parameters best suit the sensor (or sensor module) to be evaluated are set. Any noise elements in the signals input from the sensor can be rejected by using the switched capacitor low-pass and high-pass filters in Smart Analog IC 500/300.

1.2 Conditions Under Which Operation Has Been Verified

The operation of the sample code shown in this application note has been verified under the conditions shown below.

Table 1-1 Conditions Under Which Operation Has Been Verified

Parameter	Description
Devices used	RAA730500 + RL78/G1A and RAA730300 + RL78/G1A
Evaluation boards used	TSA-IC500 and TSA-IC300
External devices used	S6036 made by Hamamatsu Photonics K.K.
Software	Smart Analog Easy Starter Ver. 2.0

1.3 Related Application Notes

Also refer to these documents when using this application note.

- *Smart Analog IC 500 Selecting Amplifiers Based on Sensor Type (R02AN0008E) Application Note*
- *Smart Analog IC 300 Selecting Amplifiers Based on Sensor Type (R02AN0016E) Application Note*

2. Hardware

2.1 Hardware Configuration Example

Figure 2-1 shows an example of the hardware configuration described in this application note. When evaluating a sensor by using Easy Starter, a sensor board, evaluation board, computer, and USB cable are required. Power can be supplied to the evaluation board either via the USB bus or from an external power supply. Sensor output signals are very small, so if noise from the USB power supply might affect the measurement results, we recommend using a stabilized external power supply.

When using the USB power supply, the sensor board simply has to be connected to the evaluation board, which is in turn connected to the computer via a USB cable. This completes the hardware setup.

Figure 2-1 Hardware Configuration Example

2.2 Function Block

Figure 2-2 shows the function block used for SPI communication and Figure 2-3 shows the function block used for UART communication between the control MCU and the computer. The signal output from the sensor is converted and amplified by a configurable amplifier in Smart Analog IC 500/300 and A/D converted by the A/D converter incorporated in the RL78/G1A.

The A/D converted data is sent to the computer via the USB controller or the USB adapter IC on the board. Easy Starter receives and displays the data in the form of graphs or tables.

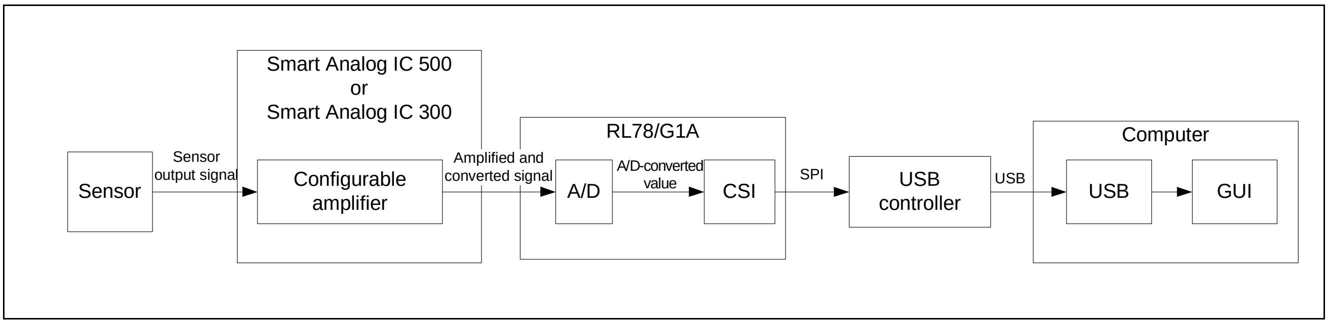


Figure 2-2 Function Block When Using SPI Communication

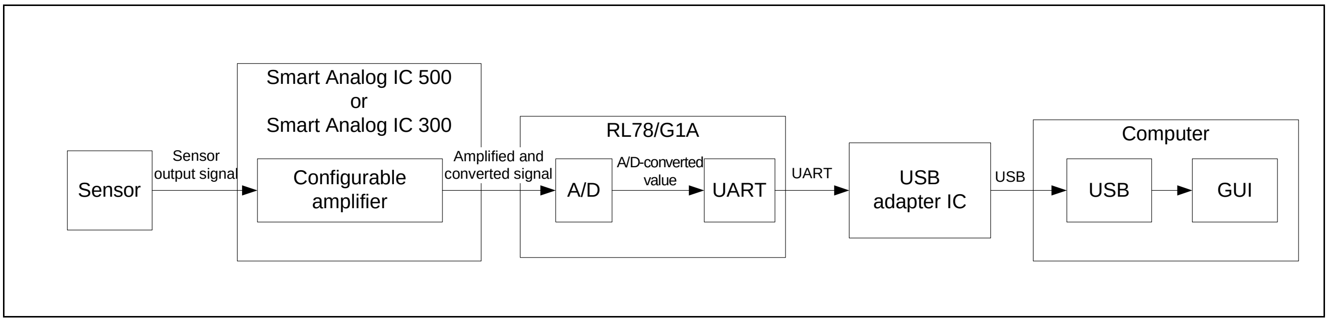


Figure 2-3 Function Block When Using UART Communication

3. Software

How to evaluate the sensor by using Easy Starter is described below. For how to install the driver and how to use Easy Starter in detail, see the help file.

3.1 Launching Smart Analog Easy Starter

After you finish hardware setup, double-click `start.exe` in the folder in which Easy Starter was extracted to launch Easy Starter.

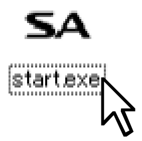


Figure 3-1 Smart Analog Easy Starter Icon

When Easy Starter is launched, the **Start** window opens.

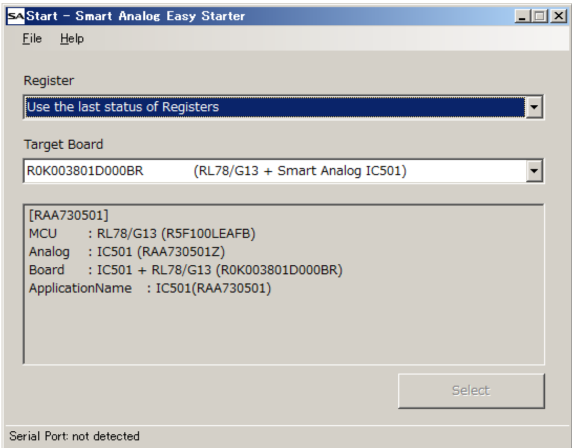


Figure 3-2 Start Window

3.2 Opening Main Window and Chip Config Window

The parameters of the analog circuits can be configured and changed in the **Chip Config** window. The first step to using Easy Starter is to open this **Chip Config** window, the procedure for which is described below.

When the **Start** window is opened with the hardware connected, detection of the virtual serial port on the evaluation board starts. Check that that "SerialPorts: COM*xx*Selected"[Note] appears at the bottom of the window. Select "Default" for **Register** and select the target board. Click the **Select** button to open **Main Window**.

Note: *xx* in COM*xx* depends on your environment. The **Select** button is not available if a serial port has not been detected correctly.

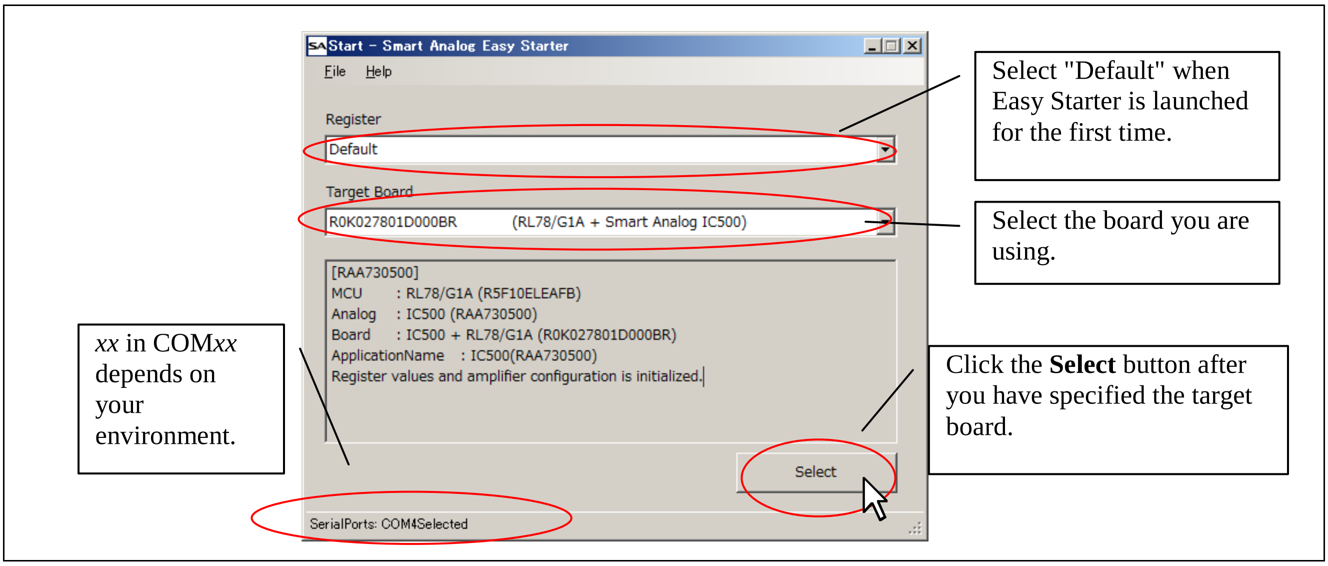


Figure 3-3 Start Window

Note: When the **Select** button is clicked, the dialog box below is displayed. Click **OK** to initialize the register configuration file.

Figure 3-4 Initialization Confirmation Message

To open the **Chip Config** window, click the **Chip Config** button in the **Smart Analog** area.

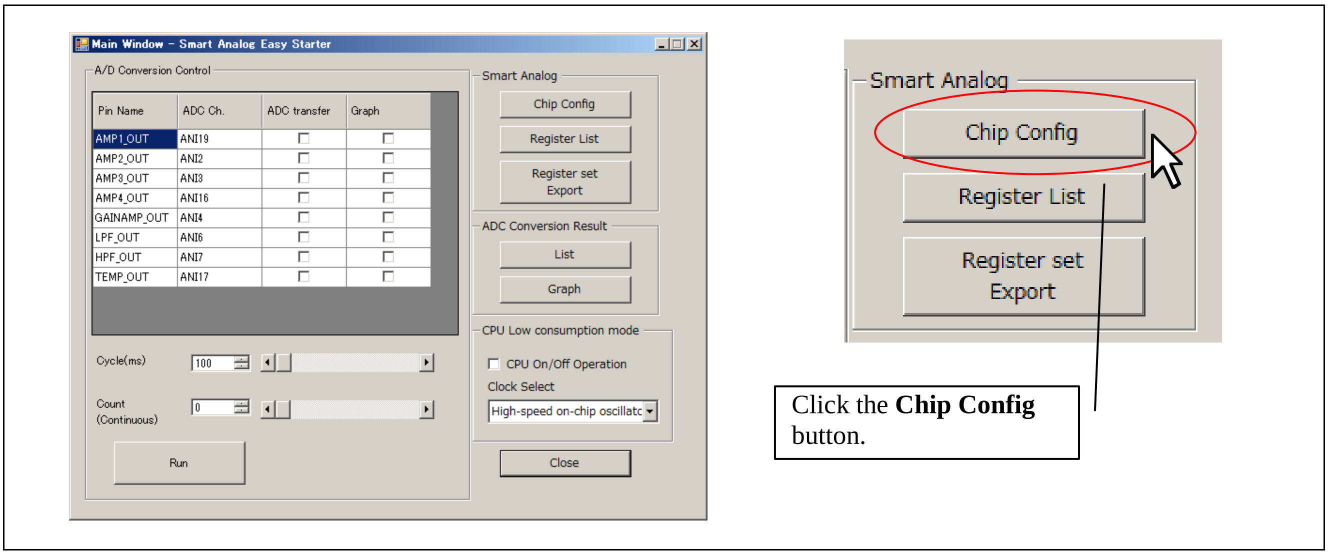


Figure 3-5 Main Window

The **Chip Config** window for the selected target board opens. In the **Chip Config** window, configure the parameters for the analog circuit.

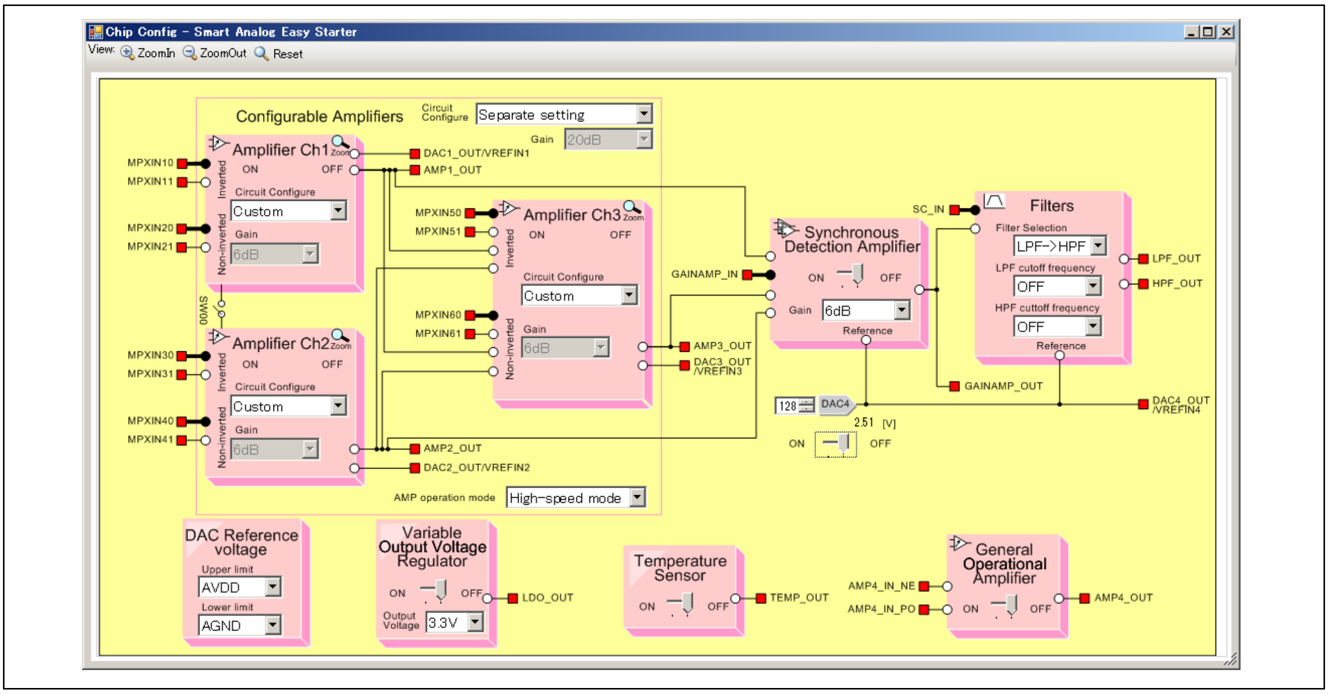


Figure 3-6 Chip Config Window When Using Smart Analog IC 500

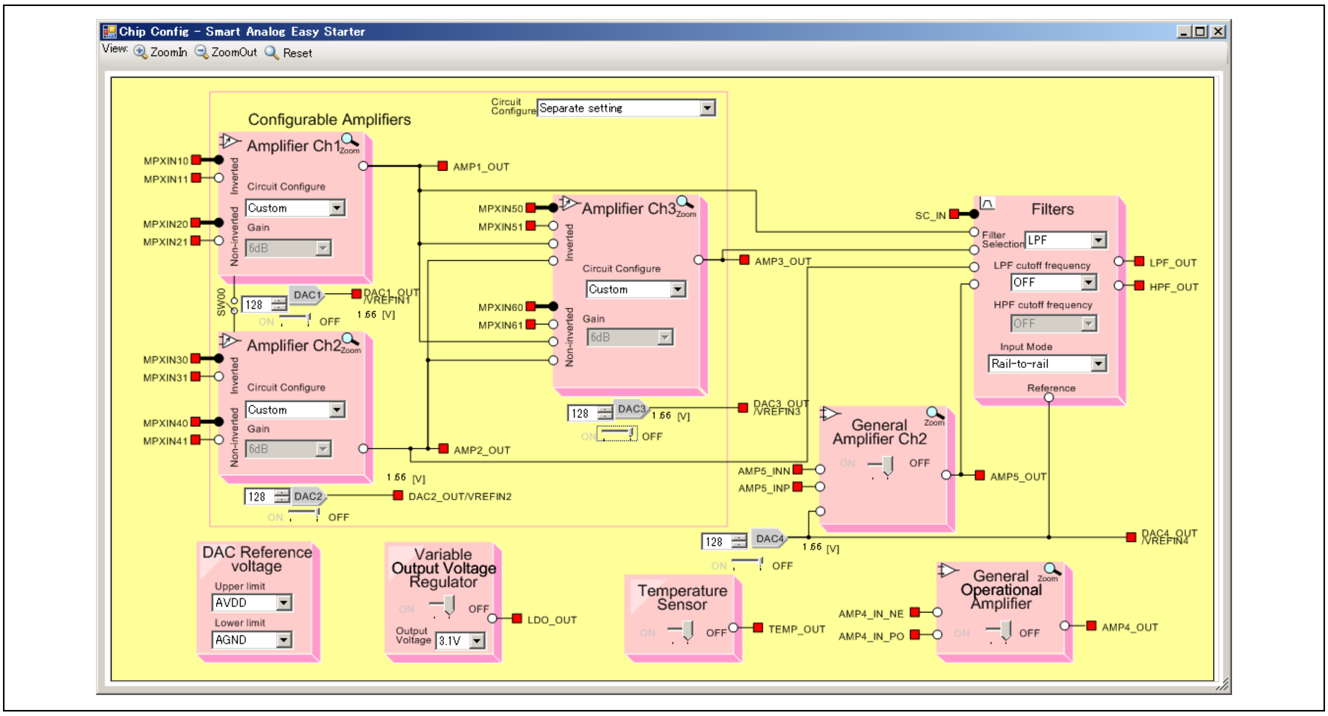


Figure 3-7 Chip Config Window When Using Smart Analog IC 300

3.3 Configuring Parameters for the Analog Circuit

This section describes how to configure the parameters for the analog circuit in the **Chip Config** window. In the example below, a photodiode is used as the sensor to be evaluated. When connecting the photodiode, select the transimpedance amplifier configuration. A transimpedance amplifier consists of a single configurable amplifier channel and a single D/A converter channel. If you are evaluating another type of sensor, see *1.3 Related Application Notes* for how to select the amplifier configuration.

The following sections respectively describe cases in which Smart Analog IC 500 and Smart Analog IC 300 are used.

3.3.1 Example setting when using Smart Analog IC 500

This section describes an example setting when using Smart Analog IC 500. The example shown in this section uses configurable amplifier Ch1 and D/A converter Ch1. Connect the sensor output pin to the MPXIN10 pin.

(1) Select "transimpedance amplifier" as the amplifier configuration.

Click the **Circuit Configure** combo box under **Amplifier Ch1** and select "Transimpedance".

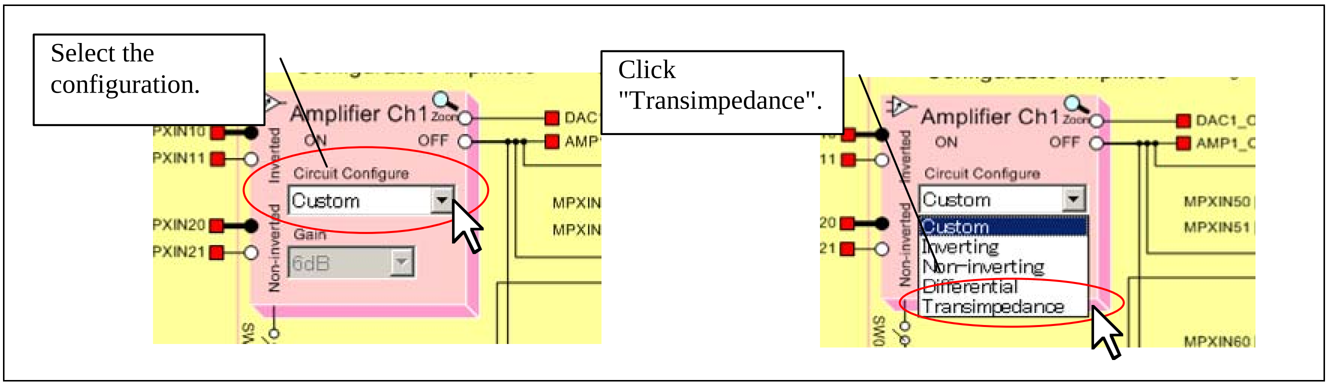


Figure 3-8 Specifying the Amplifier Configuration

When "Transimpedance" is selected as the amplifier configuration, the display of the **Amplifier Ch1** block changes as shown in Figure 3-9. Only the pins that must be set when using a transimpedance amplifier (MPXIN10 and MPXIN11) are displayed; the pins that are not required (MPXIN20 and MPXIN21) disappear. The ON/OFF trackbar control and **Gain** combo box for Amplifier Ch1 and the output voltage setting control for D/A converter Ch1 are also displayed. When these settings are changed, they not only change on the Easy Starter screen; they also change the configuration of the Smart Analog IC 500 circuits.

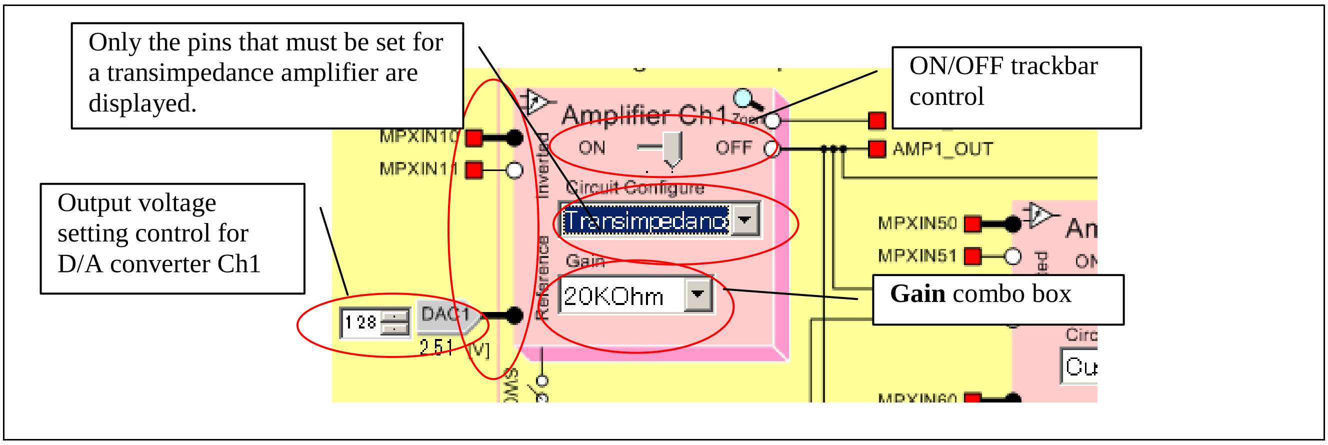


Figure 3-9 Screen After Transimpedance Amplifier Is Selected

(2) Specify the amplifier reference voltage.

Specify the amplifier reference voltage based on the sensor's datasheet and application examples. This setting determines the reverse bias voltage of the photodiode. In this example, the D/A converter output voltage is set to 0.

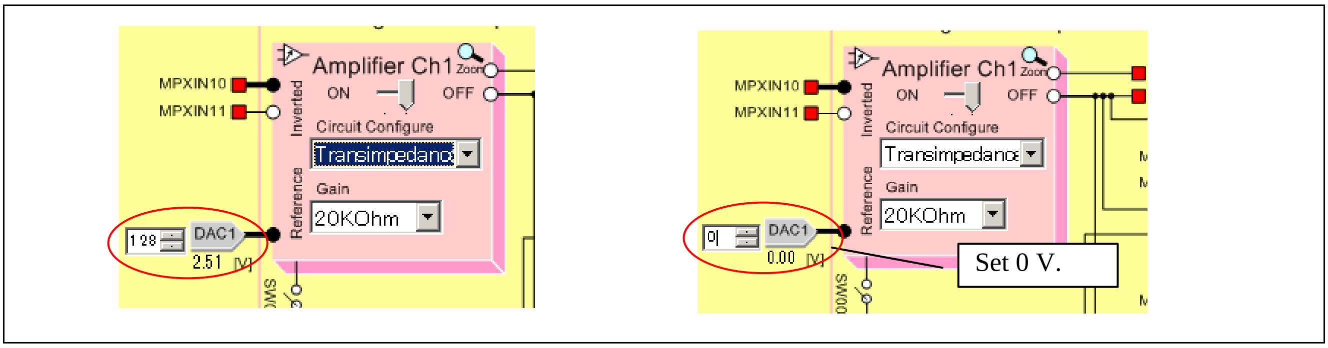


Figure 3-10 Specifying the Configurable Amplifier Reference Voltage

(3) Specify the amplifier gain[Note].

Because the sensor's output current is not yet known, the initial setting is the minimum specifiable gain value, which is 20 kΩ.

Note: When using a transimpedance amplifier, the gain indicates the feedback resistance.

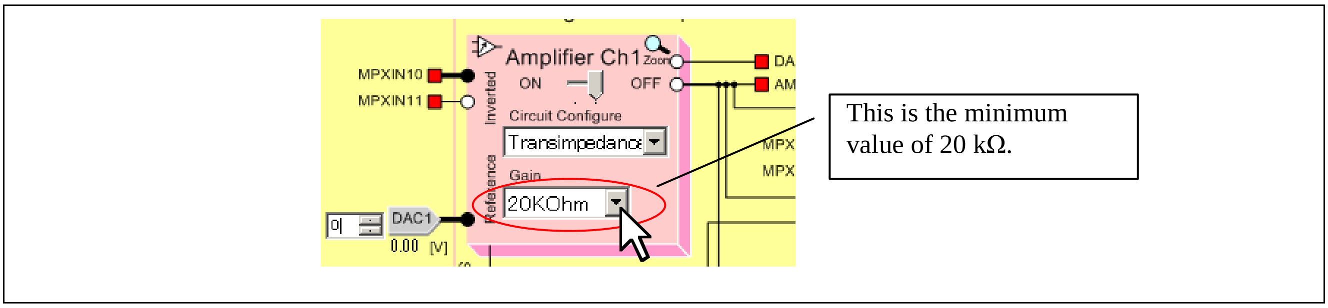


Figure 3-11 Specifying the Configurable Amplifier Gain

(4) Set Amplifier Ch1 to "ON".

After specifying the configurable amplifier configuration, reference voltage, and gain, set Amplifier Ch1 to "ON".

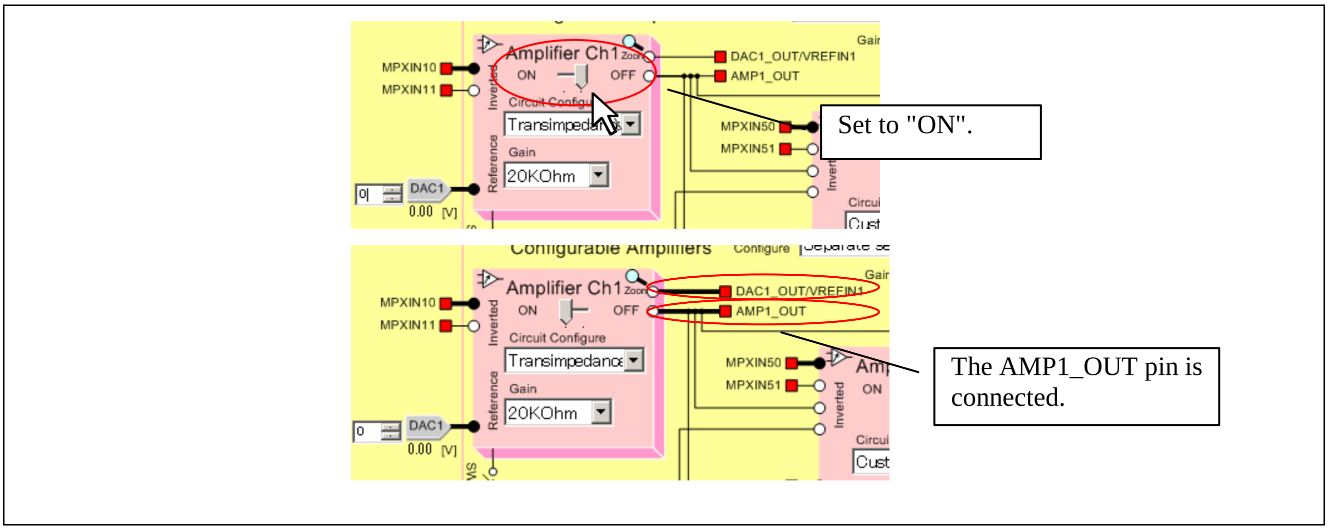


Figure 3-12 Enabling Operation of the Configurable Amplifier

After setting Amplifier Ch1 to "ON", configurable amplifier Ch1 and D/A converter Ch1 start operating. If SW01 is set to "Short", the Amplifier Ch1 signal can be output from the AMP1_OUT pin.

After completing these settings, check whether the settings of configurable amplifier Ch1 are correct. Click the **Zoom** icon on the right of the block title (**Amplifier Ch1**) to open the **AMP1 Config** window.

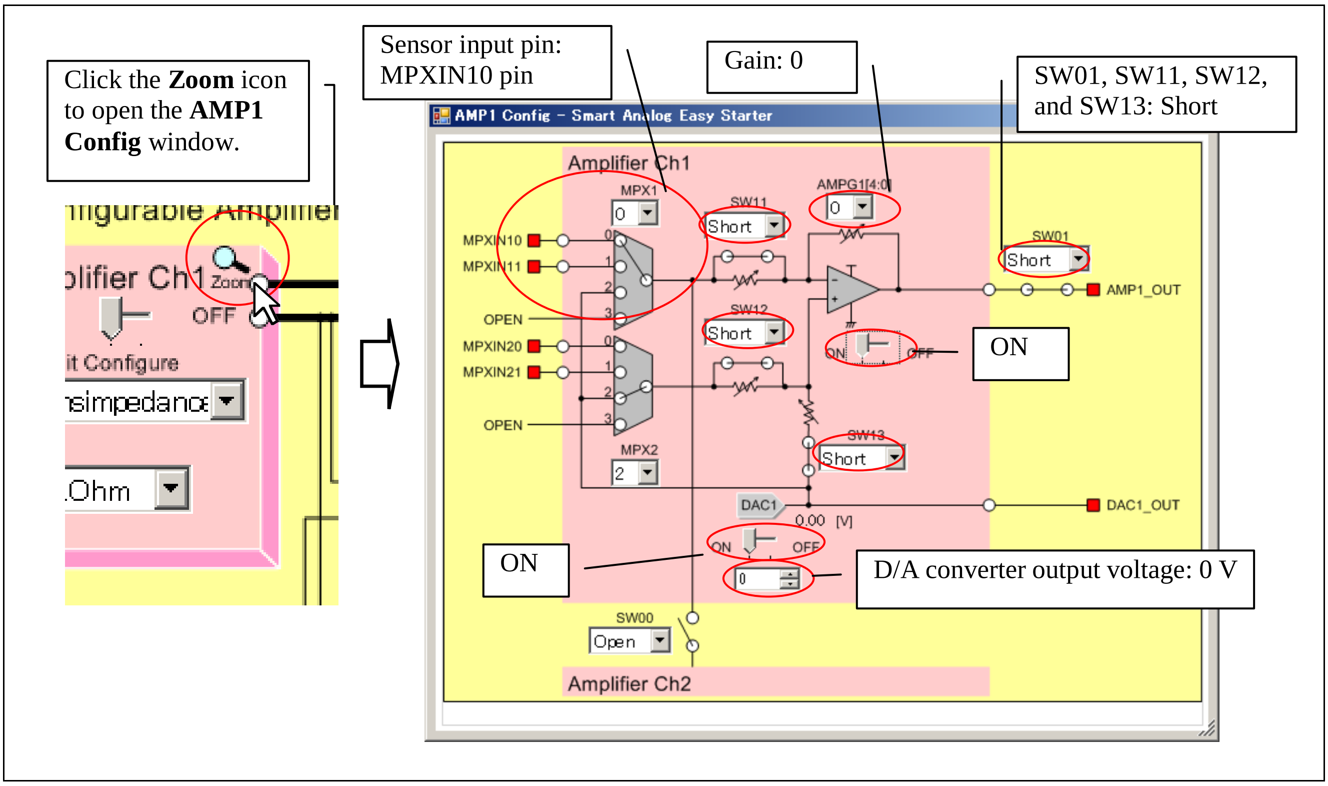


Figure 3-13 AMP1 Config Window

This completes configuring the configurable amplifier settings.

(5) The variable output voltage regulator setting is specified as follows:

On this evaluation board, a variable output voltage regulator is used to generate the A/D converter reference voltage. To enable the operation of this regulator, move the trackbar to "ON".

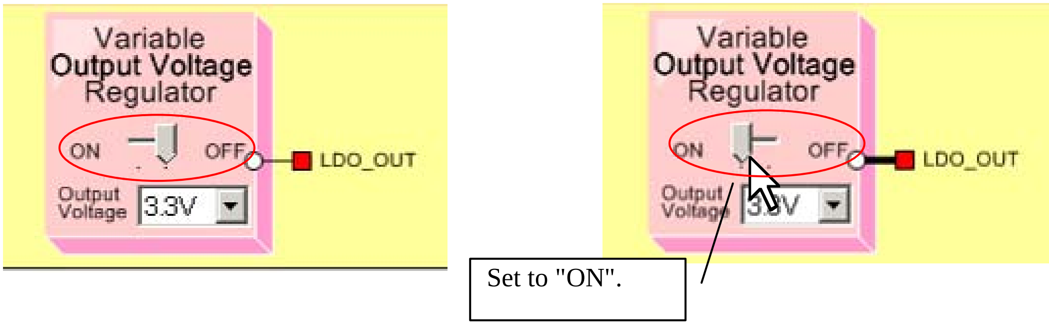


Figure 3-14 Setting the Variable Output Voltage Regulator

3.3.2 Example setting when using Smart Analog IC 300

This section describes an example setting when using Smart Analog IC 300. In this example, configurable amplifier Ch1 and D/A converter Ch5 are used and the sensor output pin is connected to the MPXIN10 pin.

(1) Select "transimpedance amplifier" as the amplifier configuration.

Click the **Circuit Configure** combo box under **Amplifier Ch1** and select "Transimpedance".

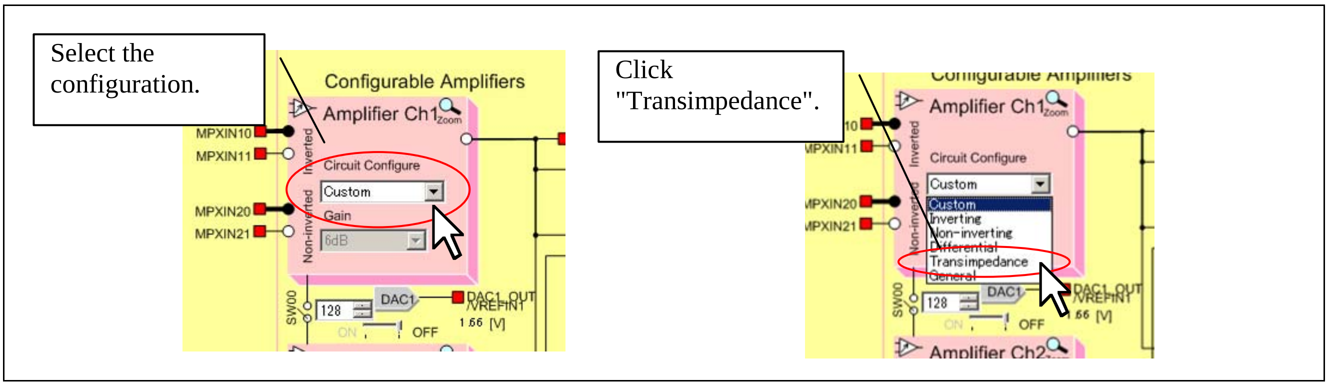


Figure 3-15 Specifying the Amplifier Configuration

When "Transimpedance" is selected as the amplifier configuration, the display of the **Amplifier Ch1** block changes as shown in Figure 3-16. Only the pins that must be set when using a transimpedance amplifier (MPXIN10 and MPXIN11) are displayed; the pins that are not required (MPXIN20 and MPXIN21) disappear. The ON/OFF trackbar control and **Gain** combo box for Amplifier Ch1 and the output voltage setting control for D/A converter Ch5 are also displayed. When these settings are changed, they not only change on the Easy Starter screen; they also change the configuration of the Smart Analog IC 300 circuits.

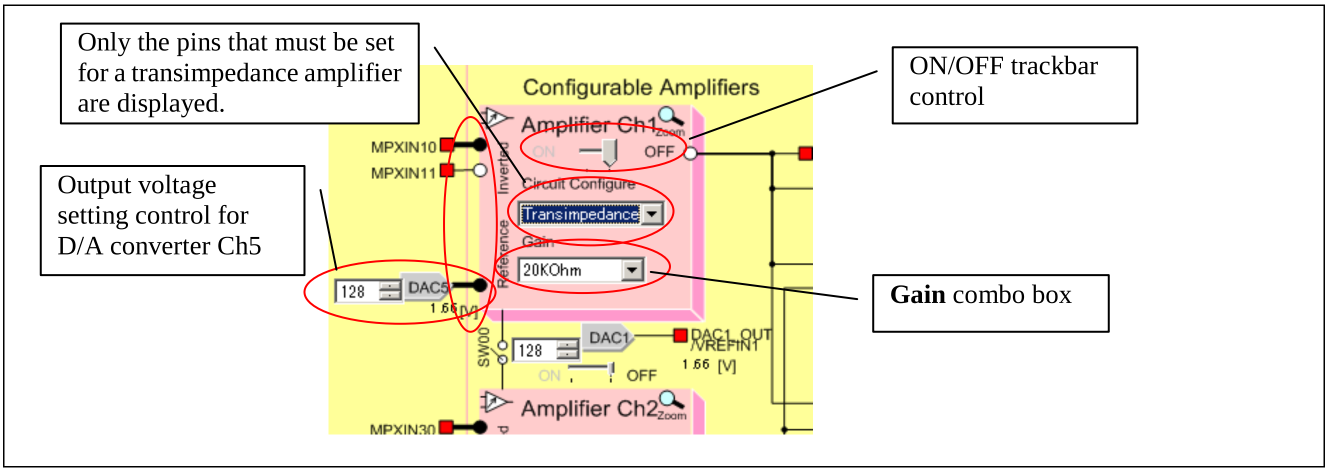


Figure 3-16 Screen After Transimpedance Amplifier Is Selected

(2) Specify the amplifier reference voltage.

Specify the amplifier reference voltage based on the sensor's datasheet and application examples. This setting determines the reverse bias voltage of the photodiode. In this example, the D/A converter output voltage is set to 0.

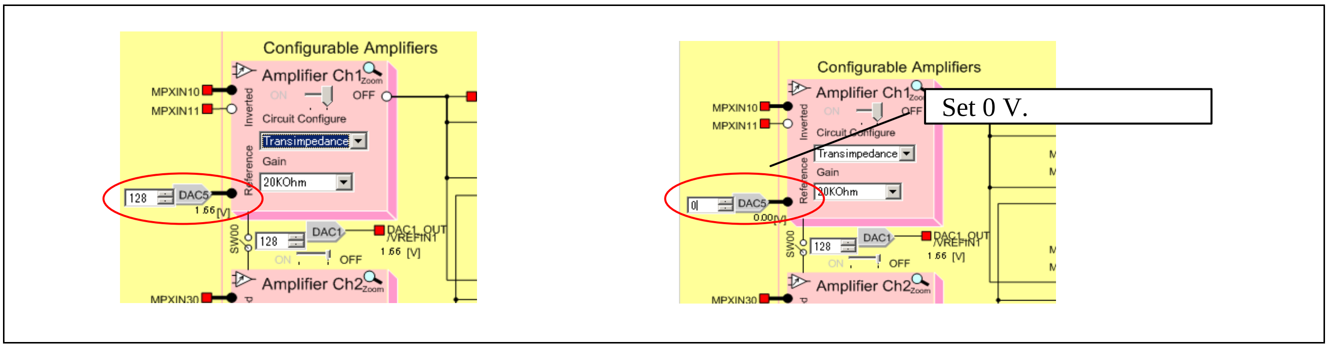


Figure 3-17 Specifying the Configurable Amplifier Reference Voltage

Note: D/A converter Ch1 is not used in this example.

(3) Specify the amplifier gain[Note].

Because the sensor's output current is not yet known, the initial setting is the minimum specifiable gain value, which is 20 kΩ.

Note: When using a transimpedance amplifier, the gain indicates the feedback resistance.

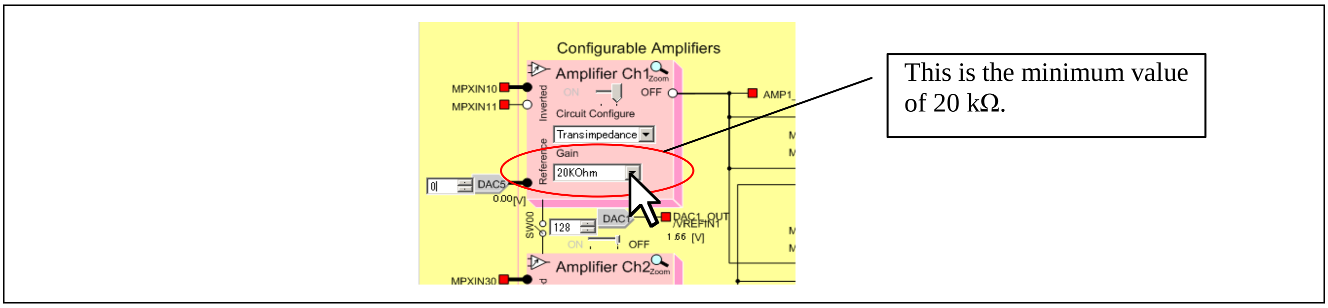


Figure 3-18 Specifying the Configurable Amplifier Gain

(4) Set Amplifier Ch1 to "ON".

After specifying the configurable amplifier configuration, reference voltage, and gain, set Amplifier Ch1 to "ON".

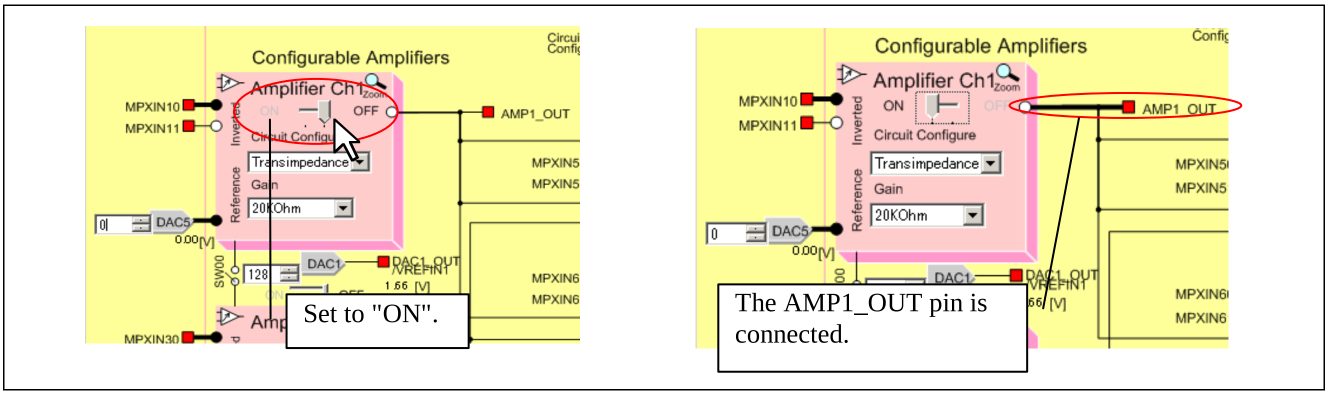


Figure 3-19 Enabling Operation of the Configurable Amplifier

After setting Amplifier Ch1 to "ON", configurable amplifier Ch1 and D/A converter Ch5 start operating. If SW01 is set to "Short", the Amplifier Ch1 signal can be output from the AMP1_OUT pin.

After completing these settings, check whether the settings of configurable amplifier Ch1 are correct. Click the **Zoom** icon on the right of the block title (**Amplifier Ch1**) to open the **AMP1 Config** window.

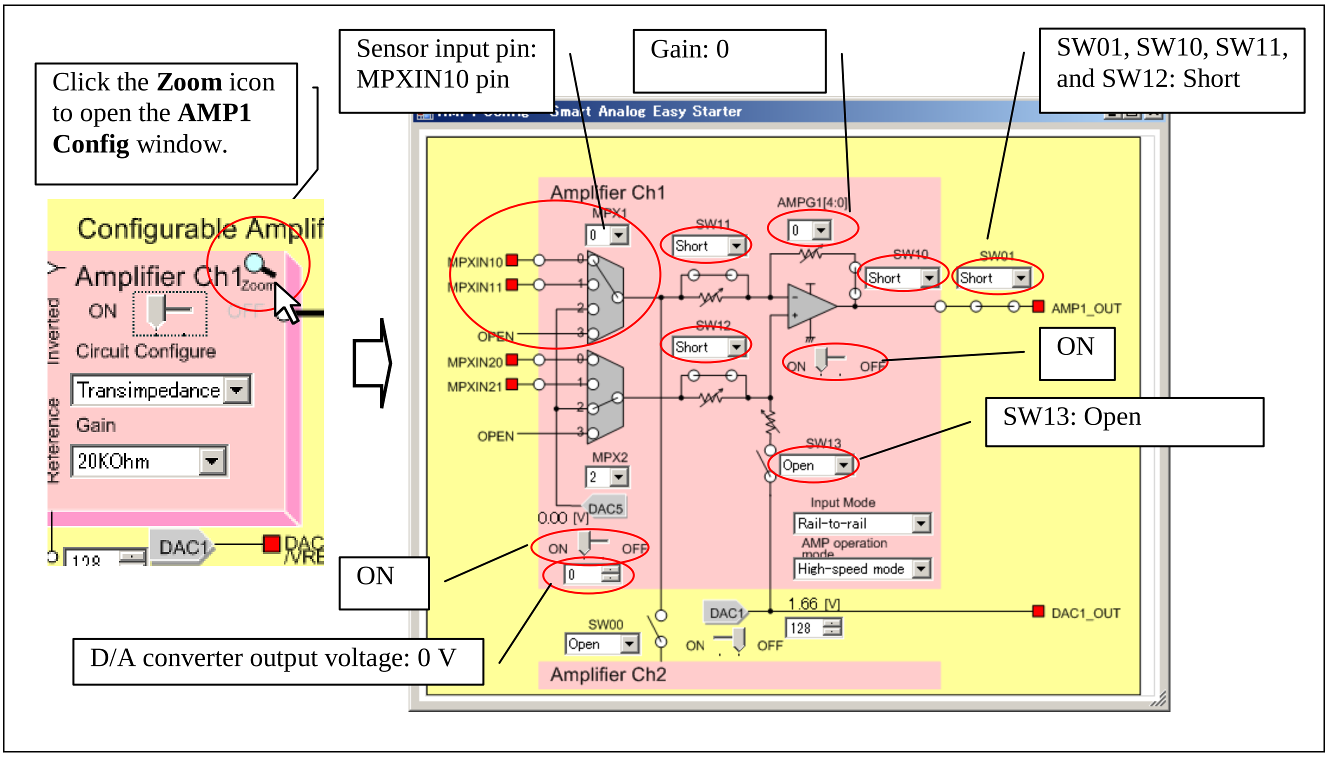


Figure 3-20 AMP1 Config Window

This completes configuring the configurable amplifier settings.

(5) The variable output voltage regulator setting is specified as follows:

On this evaluation board, a variable output voltage regulator is used to generate the A/D converter reference voltage. To enable the operation of this regulator, move the trackbar to "ON".

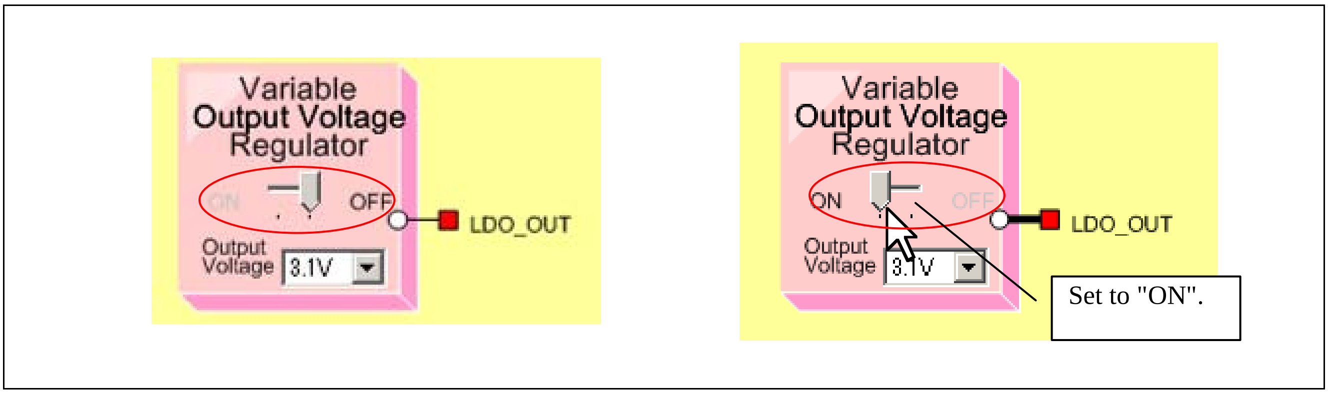


Figure 3-21 Setting the Variable Output Voltage Regulator

3.4 Displaying the Output Signal Waveforms

Next, optimize the analog circuit parameters by observing the output waveforms. How to specify the output signals and display them on a graph is explained below.

(1) Specify the settings in **Main Window**.

In **Main Window**, in the **A/D Conversion Control** area, select the **ADC transfer** and **Graph** check boxes for AMP1_OUT. In the **ADC Conversion Result** area, click the **Graph** button. The **ADC Graph** window opens. On the top right of the window, the signals that are selected by using the corresponding **Graph** check boxes are indicated in red.

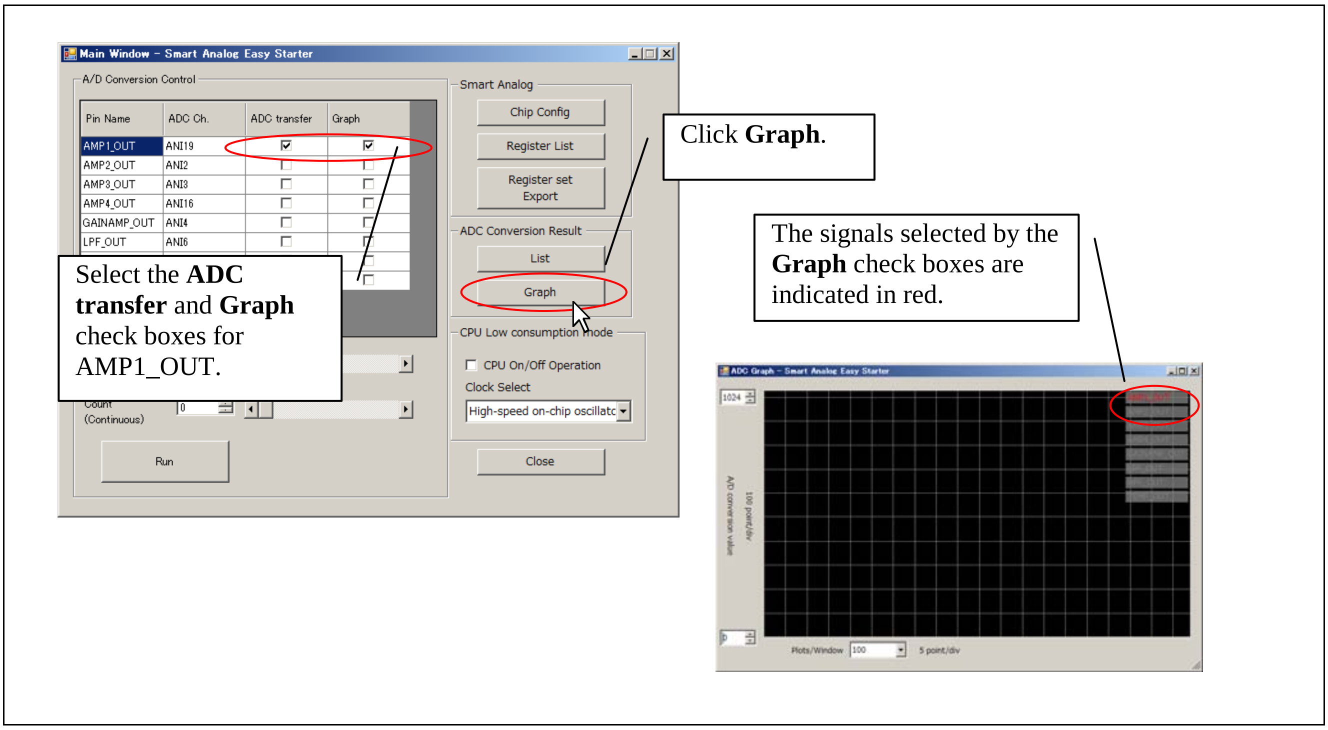


Figure 3-22 Specifying the Output Signal

Note: Adjust the maximum display value in accordance with the resolution of the A/D converter incorporated in the MCU on your evaluation board.

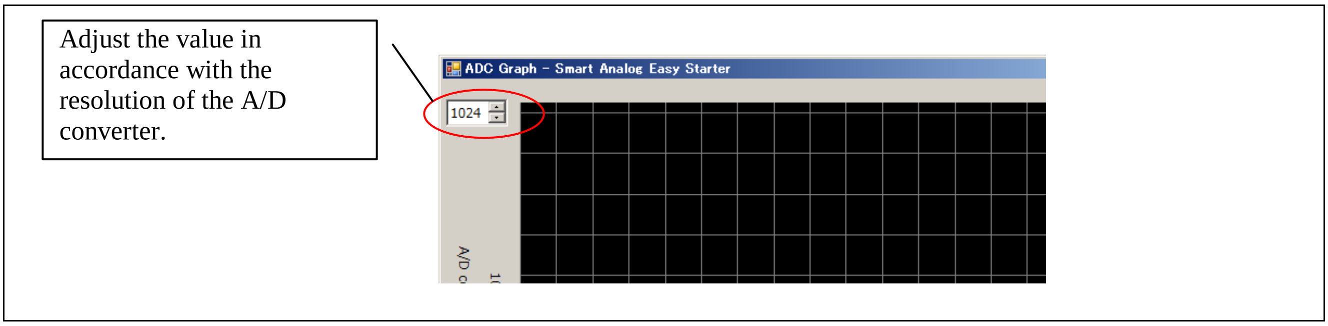


Figure 3-23 Changing the Maximum Display Value

(2) Display the output signal waveforms.

When the **Run** button in **Main Window** is clicked, A/D conversion starts and the output waveform can then be measured. The **Run** button changes to the **Stop** button while measurement is in progress. Some features become unavailable. When changing settings, first click the **Stop** button.

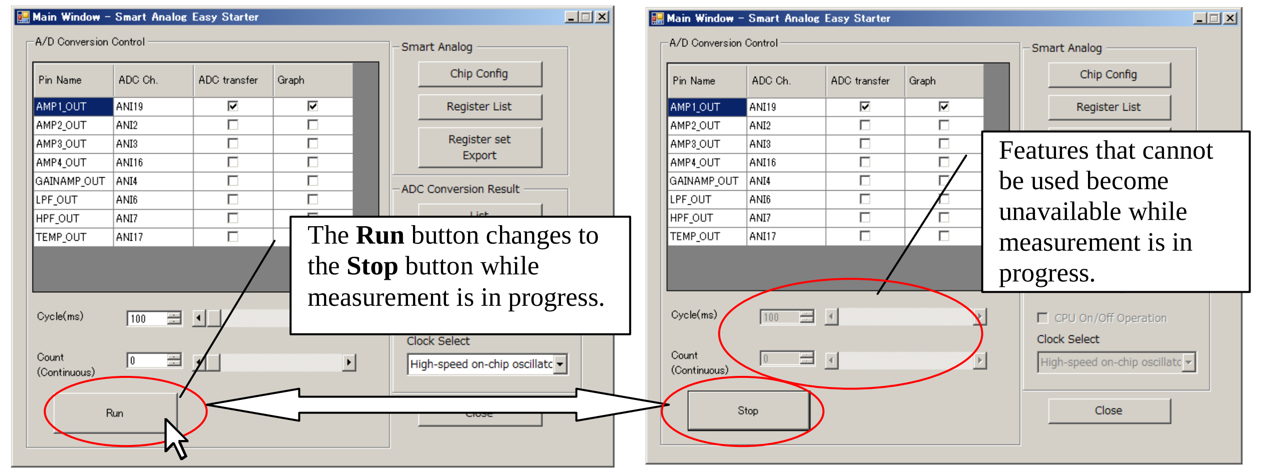


Figure 3-24 Measuring the Output Signal

The waveform of the output signal is plotted in the **ADC Graph** window.

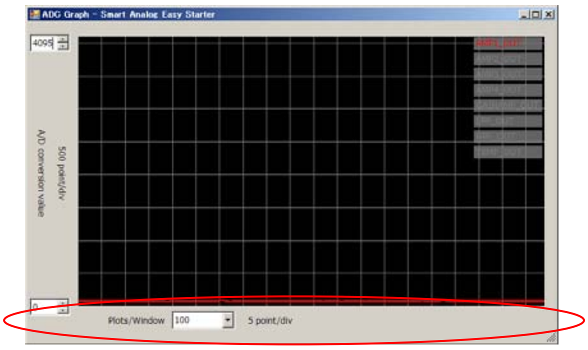


Figure 3-25 Displaying the Output Signal Waveforms

3.5 Gain Adjustment

Adjust the gain based on the waveform measured in the **ADC Graph** window.

Figure 3-26 shows an example for measuring illuminance in a general room. When measurement starts, the sensor's photodetection surface is at a 90-degree angle to the light source (room light). The photodetection surface is then tilted so that it directly faces the light source. The waveform indicating the change in illuminance detected by the sensor at this time is shown in Figure 3-26. The illuminance when the sensor is at a 90-degree angle to the light source is called the vertical illuminance, and the illuminance when the sensor is directly facing the light source is called the horizontal illuminance. In this measurement, the difference between vertical illuminance and horizontal illuminance is not output as a large signal change. This is because the gain with respect to the measurement target is low, making it hard to see minute changes in the sensor output.

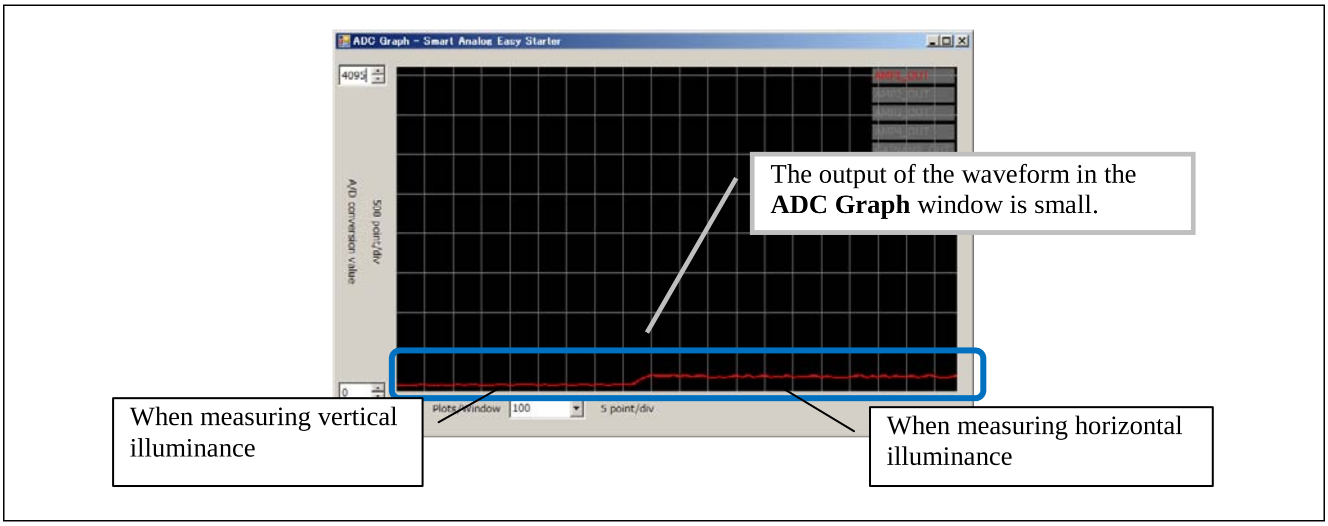


Figure 3-26 Displaying the Output Signal Waveforms

To improve this, select "640kOhm" from the **Gain** combo box to make the gain the maximum value.

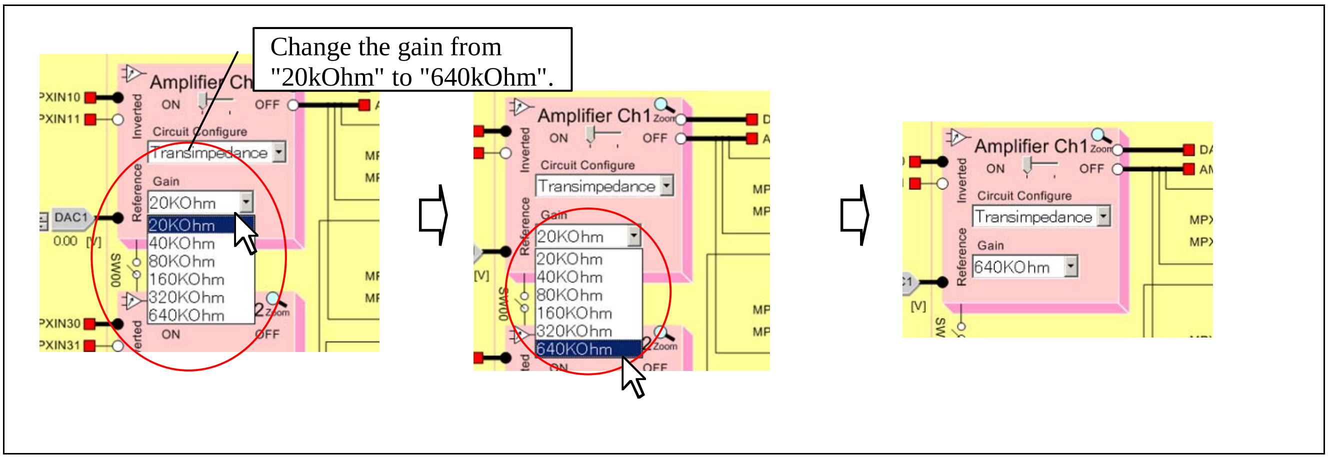


Figure 3-27 Setting the Gain

Check the measurement result in the **ADC Graph** window. The output waveform exceeds the maximum display value, 4095, and is therefore not displayed.

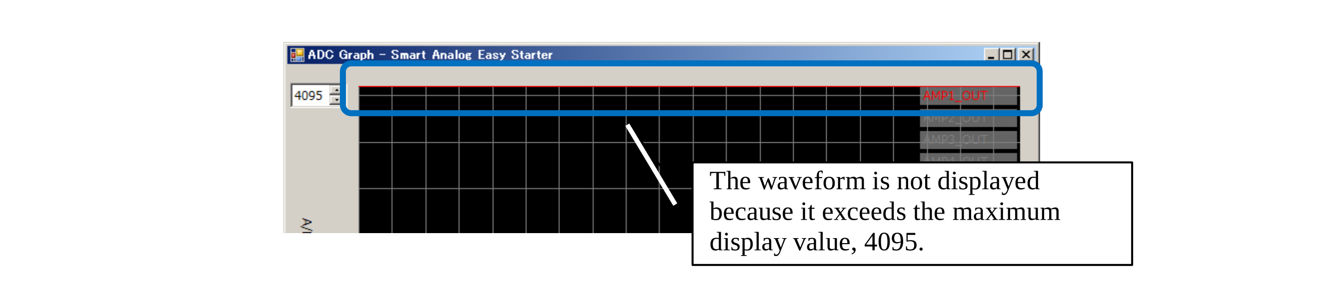


Figure 3-28 Displaying the Output Signal Waveforms

A larger gain is not necessarily preferable. It is necessary to obtain the optimum value that suits the conditions such as sensor's sensitivity and environment in which the sensor is used.

Because Smart Analog allows the user to reconfigure the characteristics even the power is on, the user can observe the waveform and adjust the gain in real time to determine the optimum value.

Decrease the gain step by step until the waveform is displayed.

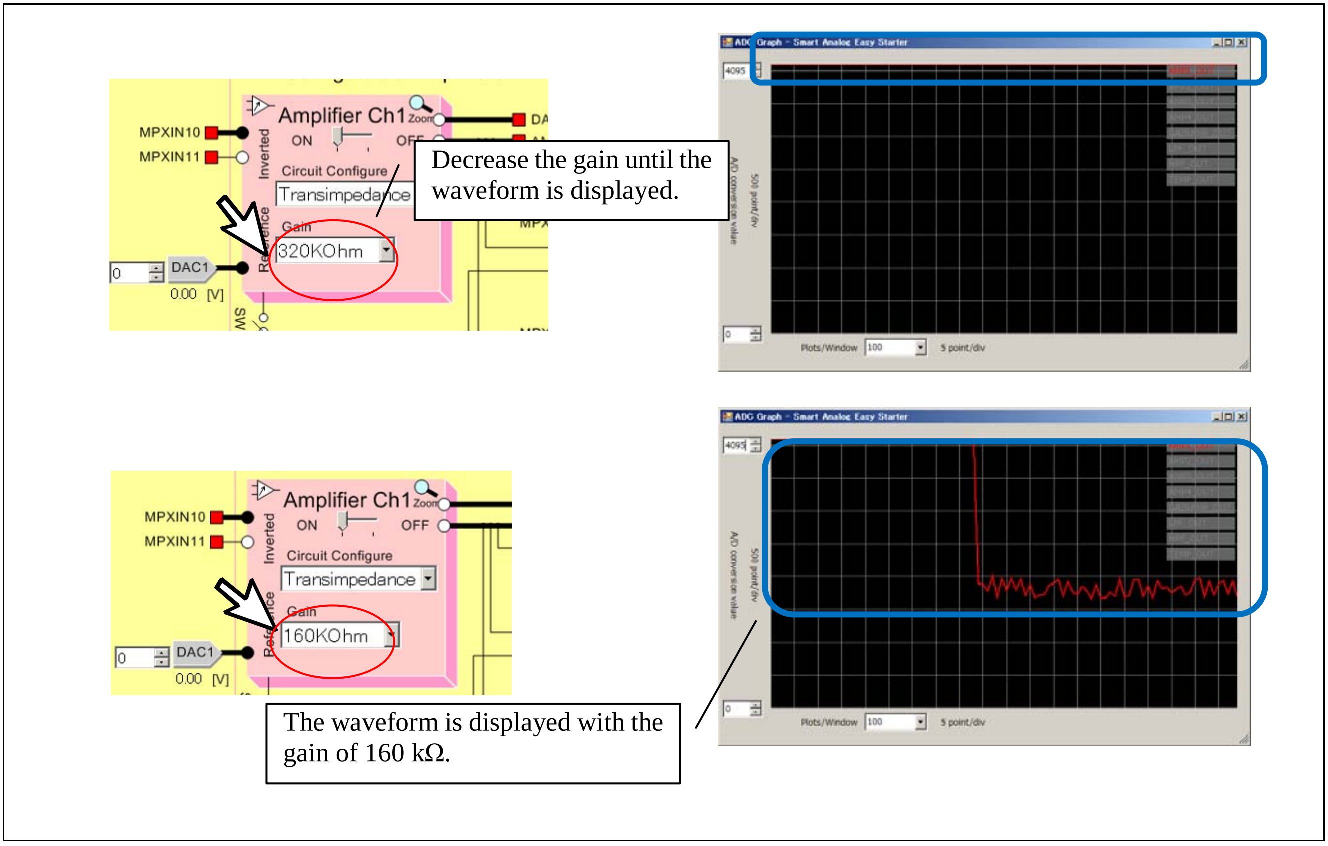


Figure 3-29 Setting the Gain

3.6 Noise Rejection Using the Filter

How to reject noise included in output signals is described below. Before setting the filter, check the level of noise in the output signal in the **ADC Graph** window.

To check the level of noise included in the signal, change the display range of the A/D conversion value (vertical axis) in the **ADC Graph** window. In this example, the display range is changed to be "between 2700 and 3700". You can then see that the noise level is approximately 400 LSB peak-to-peak. With regular sensors, noise enters the analog signal, and the allowable limit for noise differs depending on the system requirements. In this example, a low-pass filter is used to convert the signal element that must be acquired into a direct current signal to reduce high-frequency noise.

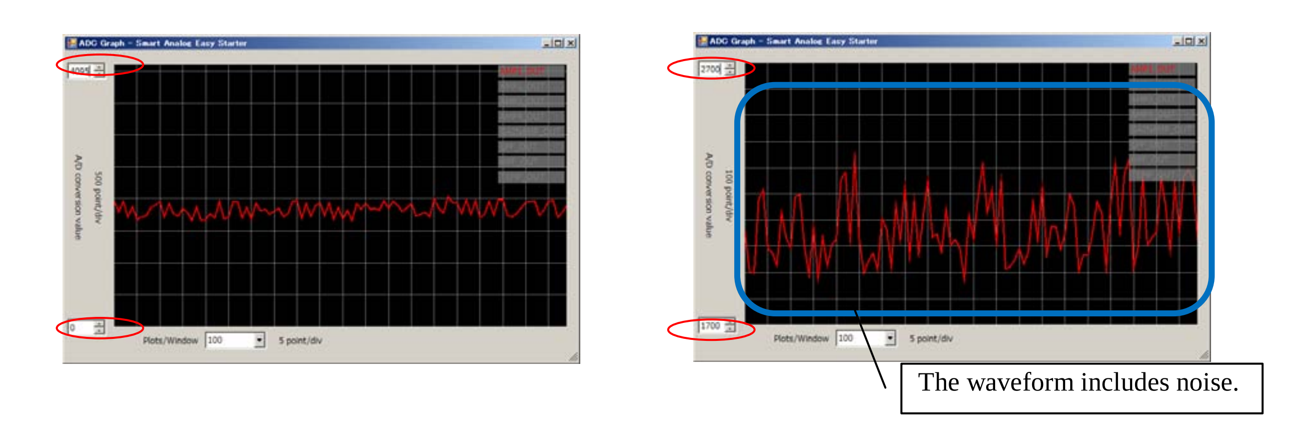


Figure 3-30 Displaying the Waveform

As the gain is increased, noise, as well as the input signal, is also amplified. If noise needs to be rejected, it can be rejected by using filters. For the switched capacitor low-pass and high-pass filters in Smart Analog IC 500/300, the cutoff frequency can be adjusted based on the frequency of the externally input clock.

The following sections respectively describe cases in which Smart Analog IC 500 and Smart Analog IC 300 are used.

3.6.1 Example setting when using Smart Analog IC 500

This section describes an example setting when using Smart Analog IC 500.

(1) Connect the configurable amplifier and filter.

Specify "through" for the **Gain** combo box in the **Synchronous Detection Amplifier** block in the **Chip Config** window. Then, connect the input pin to the synchronous detection amplifier to the AMP1_OUT pin.

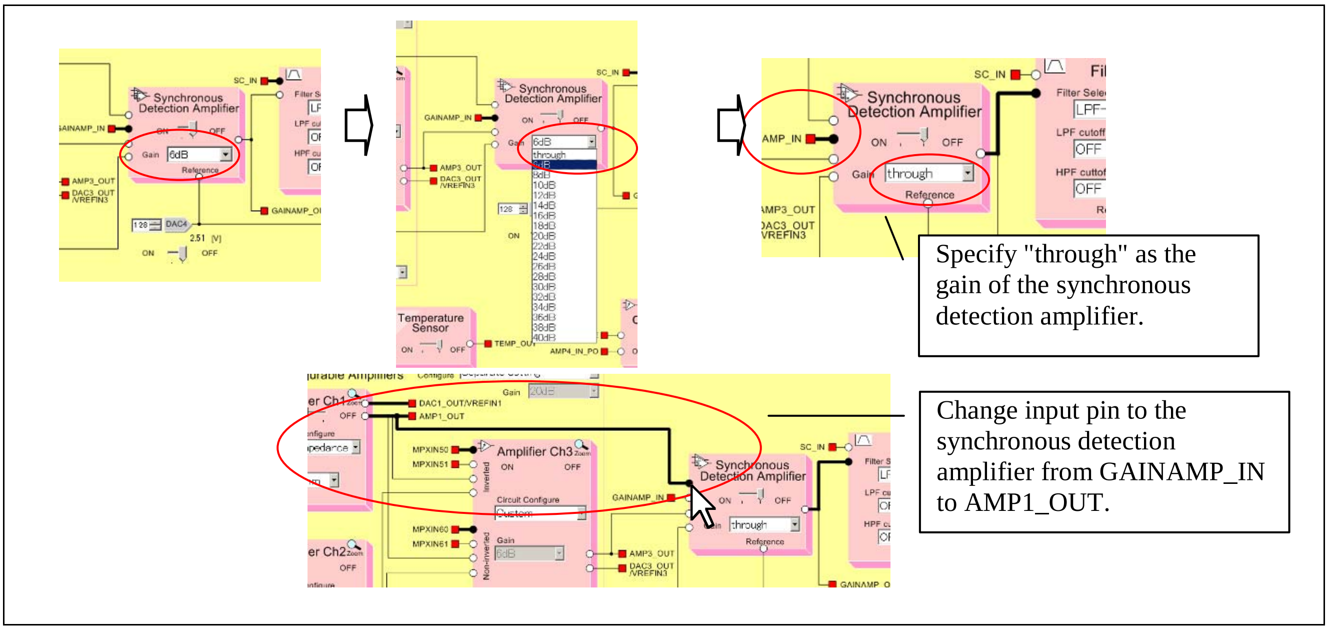


Figure 3-31 Connecting the Pin to the Filter

(2) Specify the settings for the filter.

In the **Filters** block, specify "LPF" in the **Filter Selection** combo box. Specify "10Hz" in the **LPF cutoff frequency** combo box. Because the sensor output signal to be obtained in this example is a direct current, set the lowest cutoff frequency.

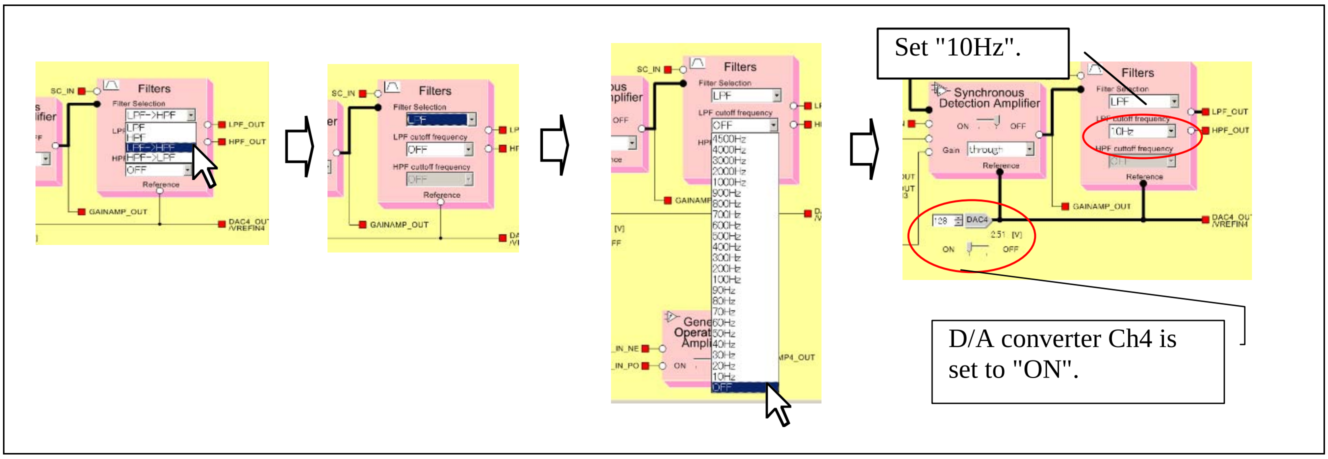


Figure 3-32 Selecting the Filter and Specifying the Cutoff Frequency

(3) Display the output signal waveforms and check the result of noise rejection.

In **Main Window**, click the **Stop** button. In the **A/D Conversion Control** area, select the **ADC transfer** and **Graph** check boxes for LPF_OUT, and then click the **Run** button.

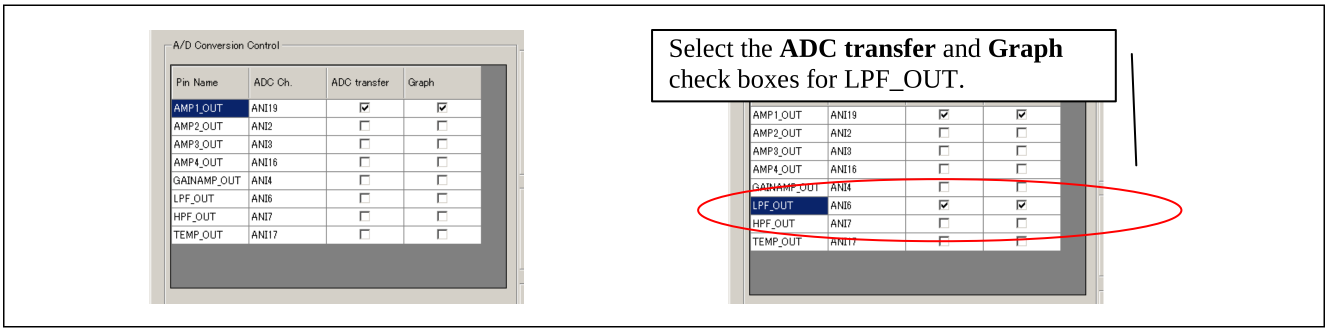


Figure 3-33 Specifying the LPF Graph Display Settings

In the **ADC Graph** window, the waveform of AMP1_OUT is displayed, but the waveform of LPF_OUT is not displayed. Restore the display range (minimum value: 0, maximum value: 4095) to display all the A/D conversion values.

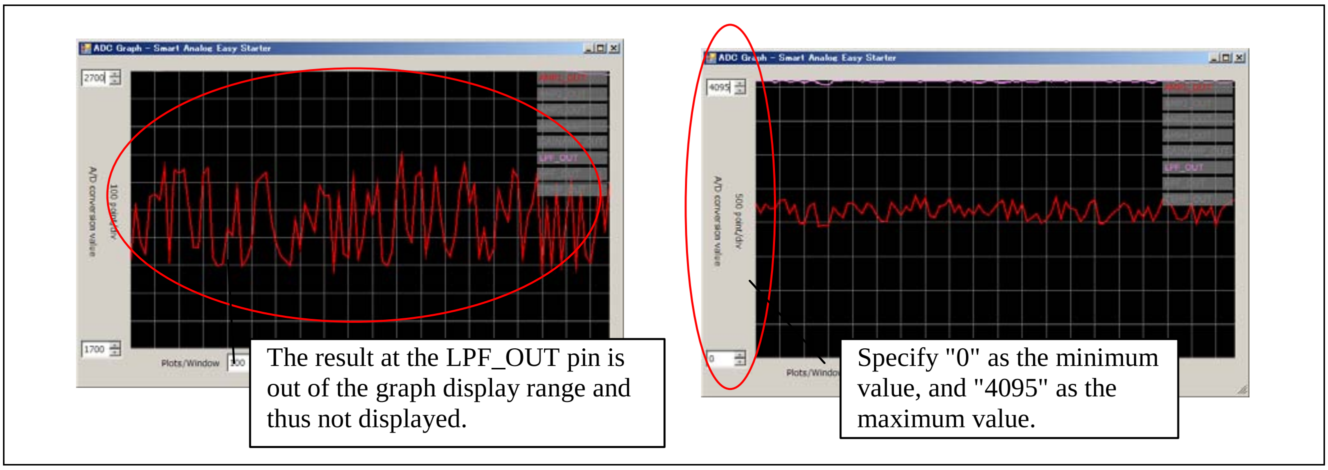


Figure 3-34 Checking the LPF Output Waveform

(4) Adjust the reference voltage of the filter.

Check the voltage level at LPF_OUT and adjust the voltage level at D/A converter Ch4 so as to be the same as that at AMP1_OUT. If the voltage level at LPF_OUT is high, lower the voltage level at D/A converter Ch4 and vice versa.

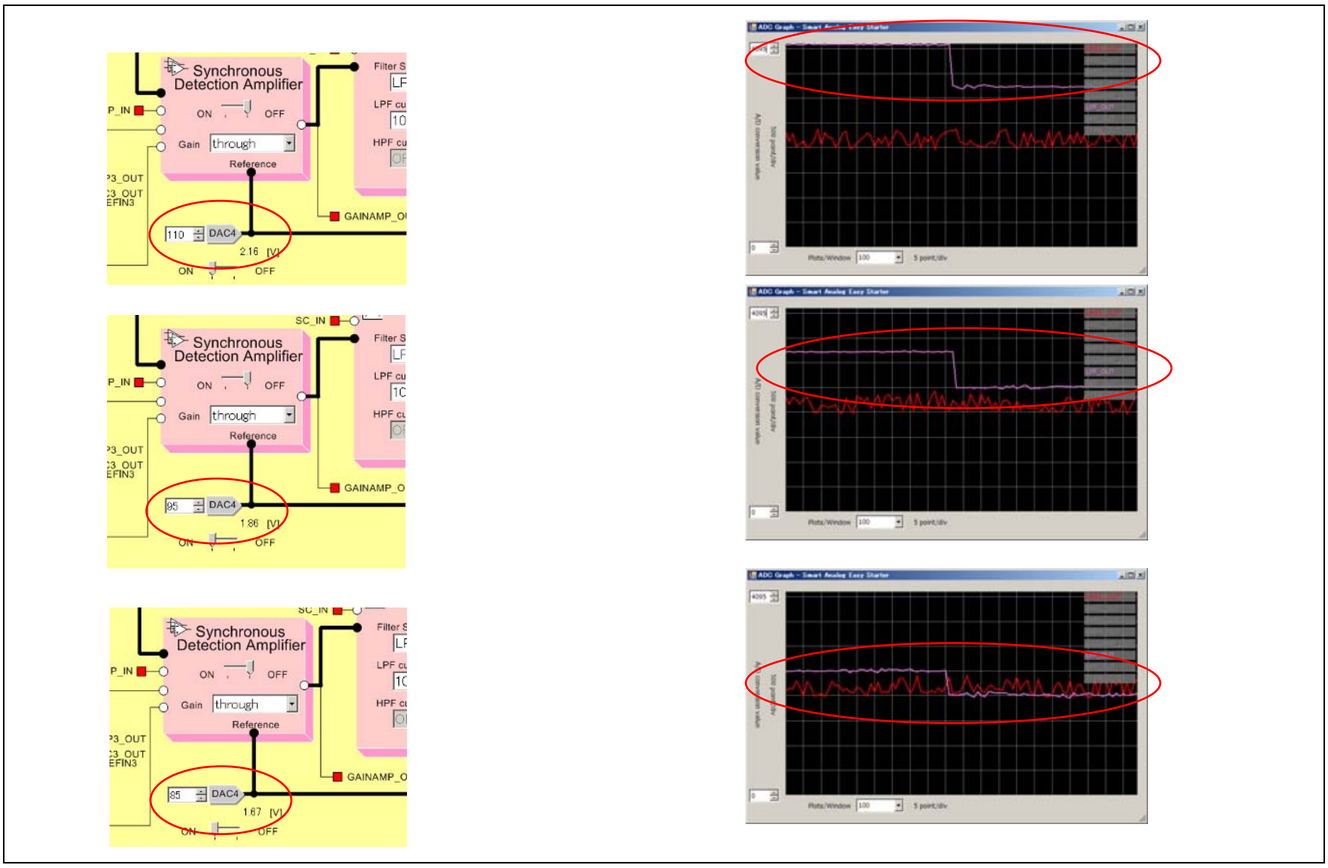


Figure 3-35 Adjusting the Voltage Level at D/A Converter

After adjusting the voltage level at AMP1_OUT and LPF_OUT, narrow the display range, and then observe the waveform. You can confirm that high-frequency noise in the waveform of LPF_OUT has been rejected, compared to the waveform of AMP1_OUT.

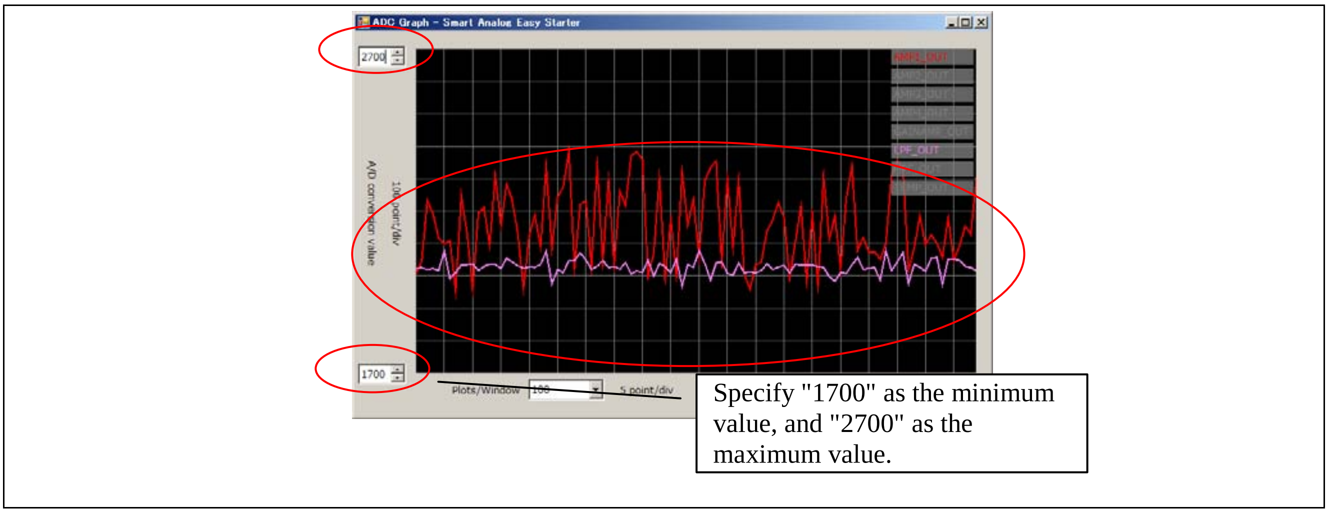


Figure 3-36 Checking LPF_OUT

3.6.2 Example setting when using Smart Analog IC 300

This section describes an example setting when using Smart Analog IC 300.

(1) Connect the configurable amplifier and filter.

In the **Chip Config** window, connect an input pin in the **Filters** block to the AMP1_OUT pin.

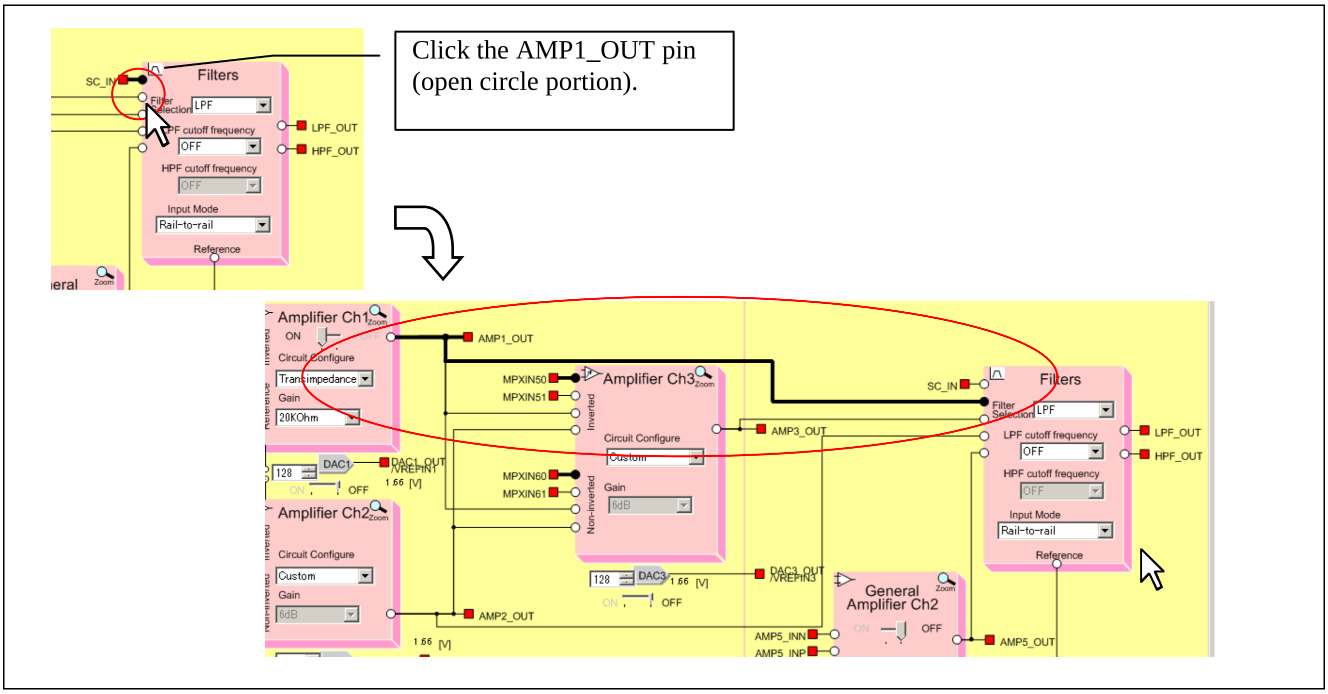


Figure 3-37 Connecting the Pin to the Filter

(2) Specify the settings for the filter.

Specify "LPF" in the **Filter Selection** combo box in the **Filters** block. Specify "10Hz" in the **LPF cutoff frequency** combo box. Because the sensor output signal to be obtained in this example is a direct current, set the lowest cutoff frequency.

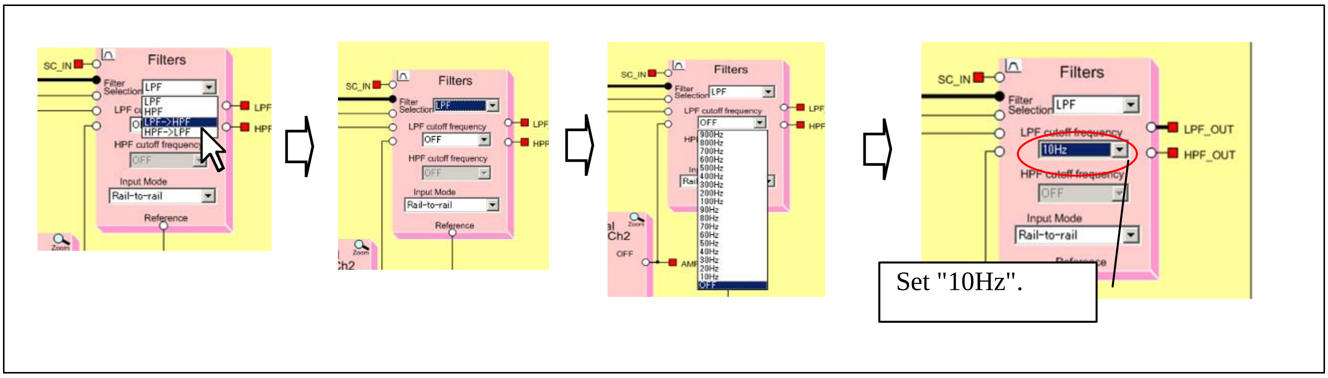


Figure 3-38 Selecting the Filter and Specifying the Cutoff Frequency

(3) Supply the reference voltage to the filter.

Specify the setting so that the reference voltage is supplied Ch4 to the filter from D/A converter. Set the power supply to D/A converter Ch4 to "ON".

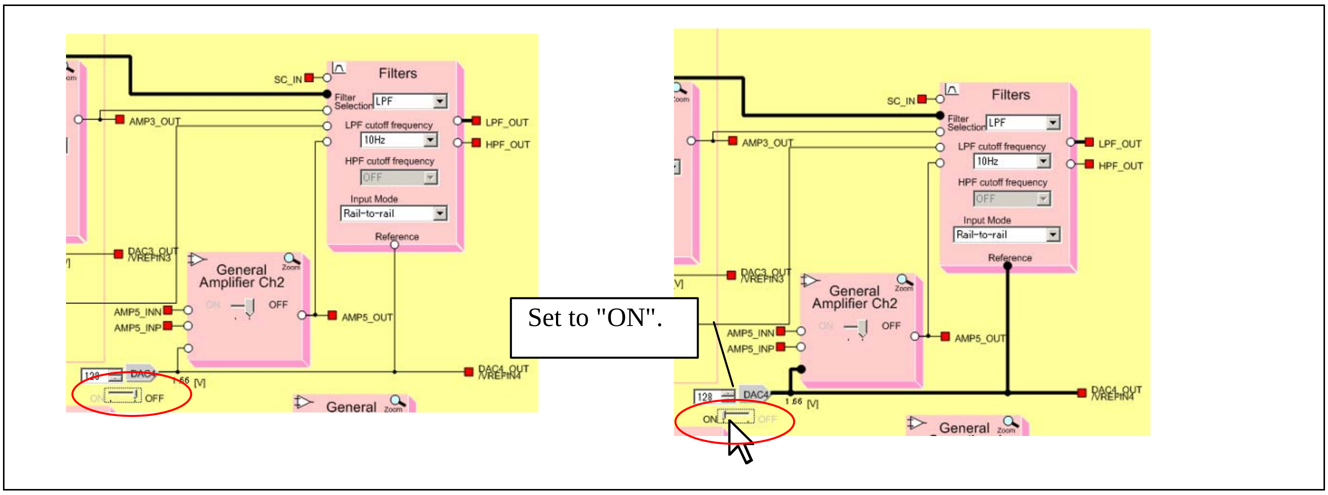


Figure 3-39 Supplying the Reference Voltage to the Filter

(4) Display the output signal waveforms and check the result of noise rejection.

In **Main Window**, click the **Stop** button. In the **A/D Conversion Control** area, select the **ADC transfer** and **Graph** check boxes for LPF_OUT, and then click the **Run** button.

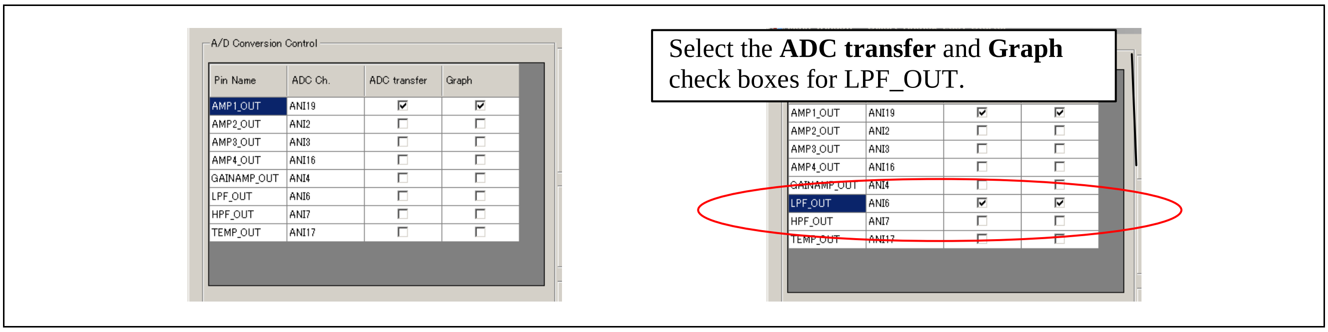


Figure 3-40 Specifying the LPF Graph Display Settings

In the **ADC Graph** window, the waveform of AMP1_OUT is displayed but the waveform of LPF_OUT is not displayed. Restore the display range (minimum value: 0, maximum value: 4095) to display all the A/D conversion values.

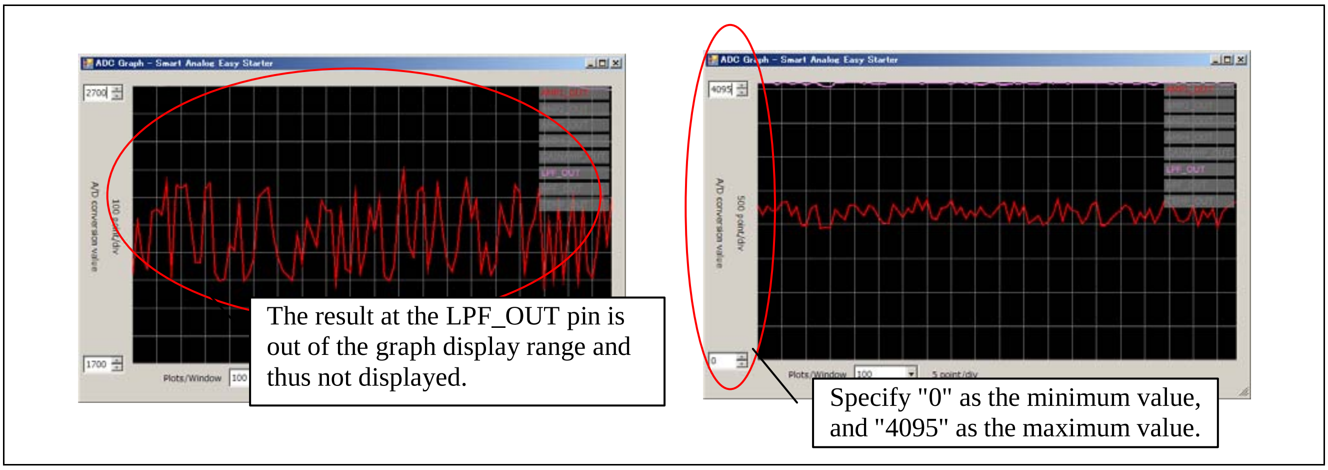


Figure 3-41 Checking the LPF Output Waveform

(5) Adjust the reference voltage of the filter.

Check the voltage level at LPF_OUT and adjust the voltage level at D/A converter Ch4 so as to be the same as that at AMP1_OUT. If the voltage level at LPF_OUT is high, lower the voltage level at D/A converter Ch4 and vice versa.

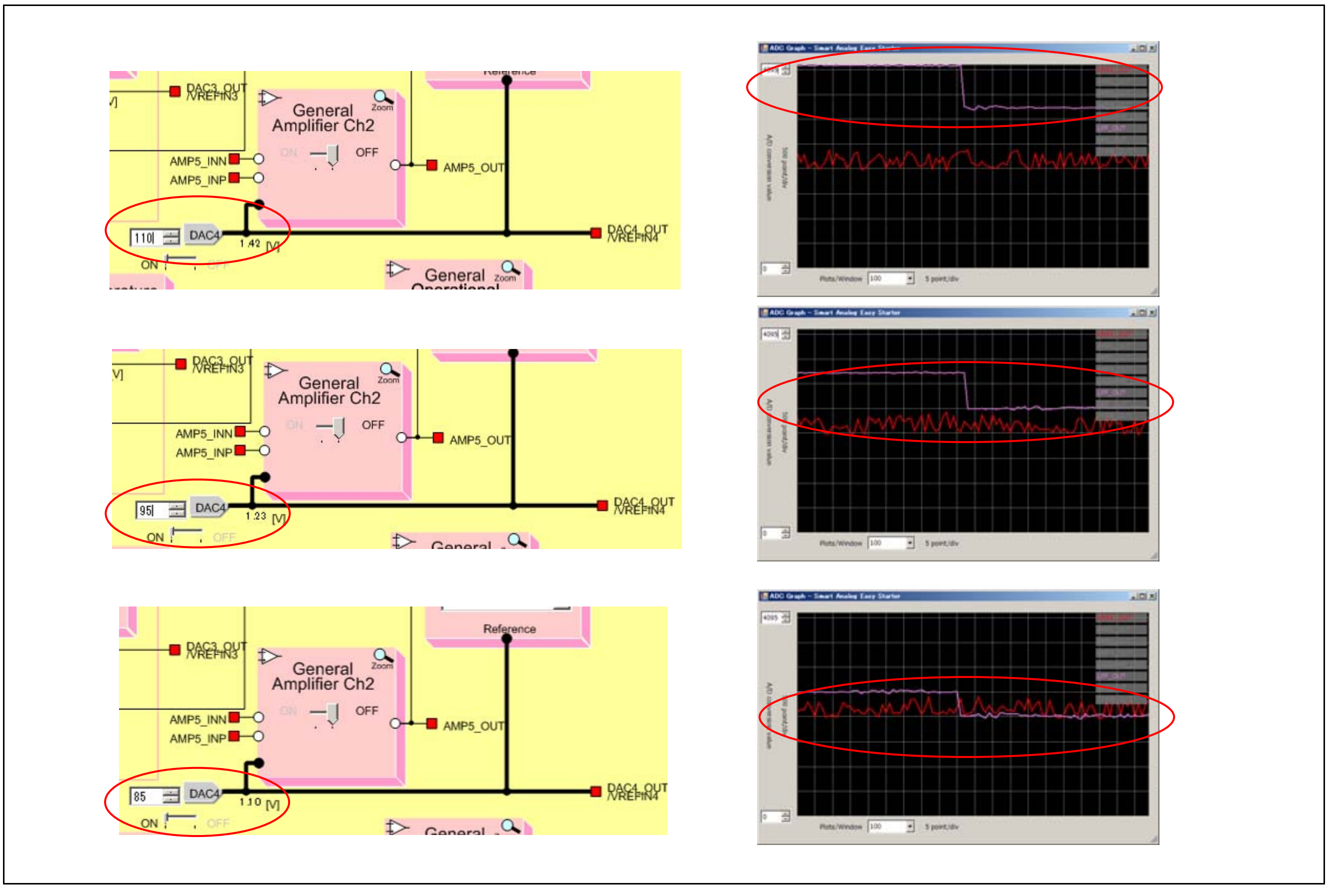


Figure 3-42 Adjusting the Voltage Level at D/A Converter

After adjusting the voltage level at AMP1_OUT and LPF_OUT, narrow the display range, and then observe the waveform. You can confirm that high-frequency noise in the waveform of LPF_OUT has been rejected, compared to the waveform of AMP1_OUT.

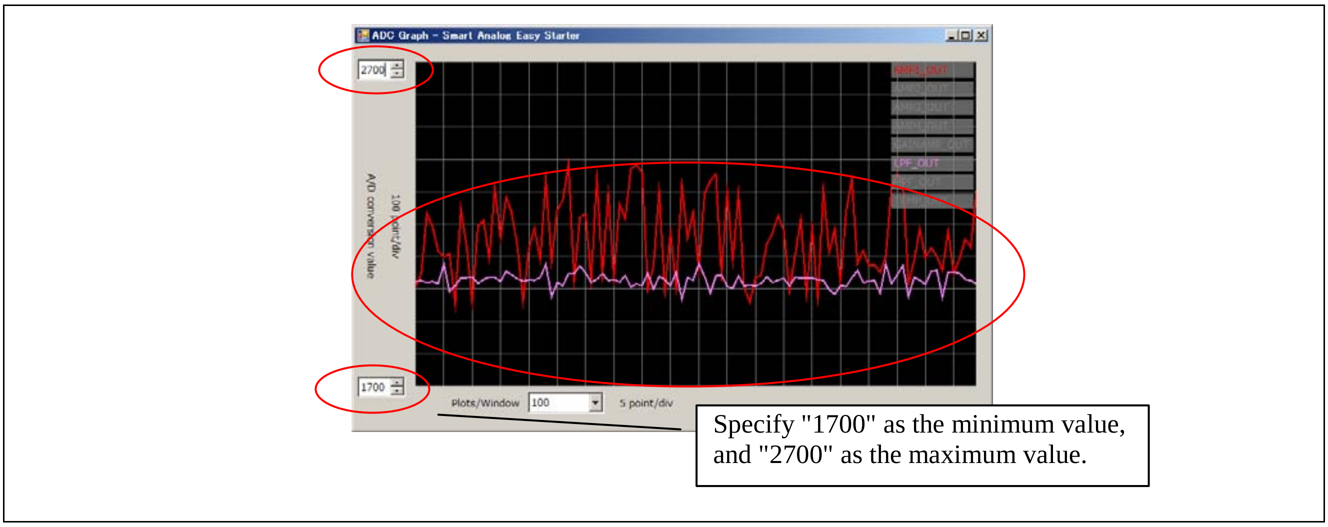


Figure 3-43 Checking LPF_OUT

3.7 Saving and Restoring the Settings

This section describes how to save the parameters configured for the analog circuits and conditions for gain adjustment and noise rejection and restore them when performing evaluation next time. The following describes how the configured circuit conditions are automatically saved.

When you have finished evaluation, click the **Close** button to close Easy Starter. A confirmation dialog box appears. Click **OK** to close Easy Starter. When Easy Starter is closed, the configured circuit conditions are automatically saved.

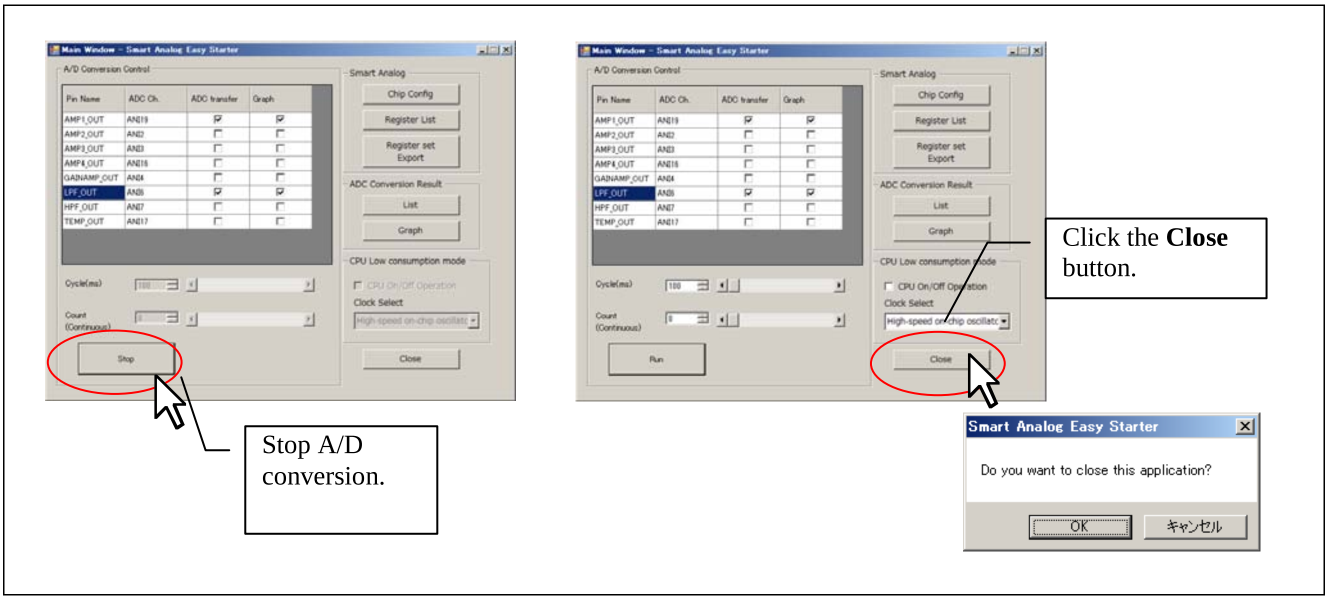


Figure 3-44 Terminating Easy Starter and Saving the Settings

To use the conditions specified for the last evaluation when launching Easy Starter next time, select "Use the last status of Registers" in the **Register** combo box. The conditions saved automatically at the end of the last evaluation can then be loaded and used for the next evaluation. To specify a new setting for evaluation, select "Default" in the **Register** combo box. If "Default" is selected, the settings specified in **Main Window** and the **Chip Config** window are cleared to the initial state.

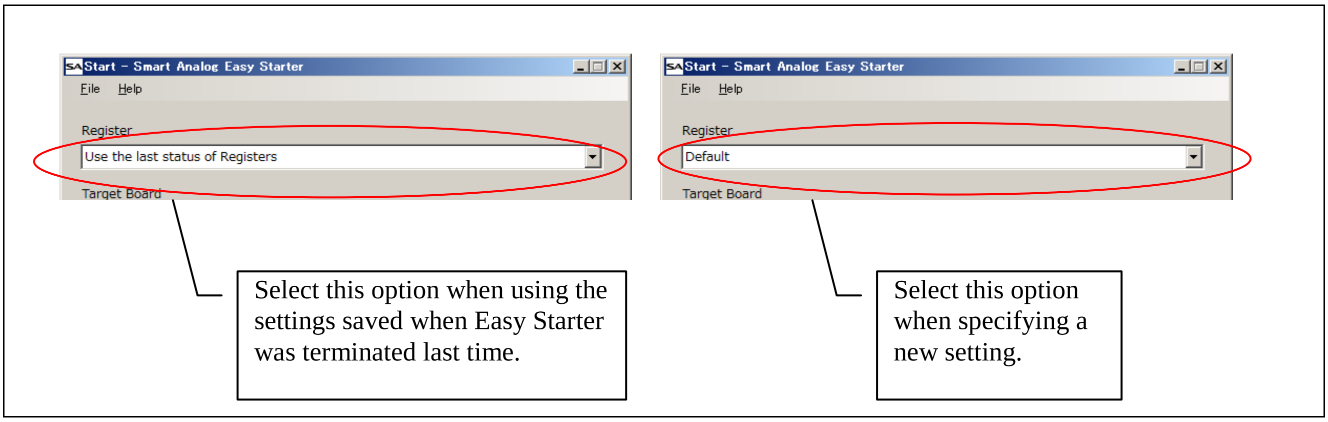


Figure 3-45 Restoring the Setting or Specifying a New Setting

3.8 Saving the Settings to a File and Restoring the Settings from a File

Only the settings when Easy Starter is closed are saved automatically, but it is possible to save intermediate settings configured during evaluation by creating individual files to save the settings.

After you finished evaluation, do not terminate Easy Starter but click the **Register set Export** button in **Main Window**. The **Export** dialog box opens. To identify the configuration, type simple information such as the sensor name or keyword in the **Description** box in the **Export** dialog box, and then click **Export**.

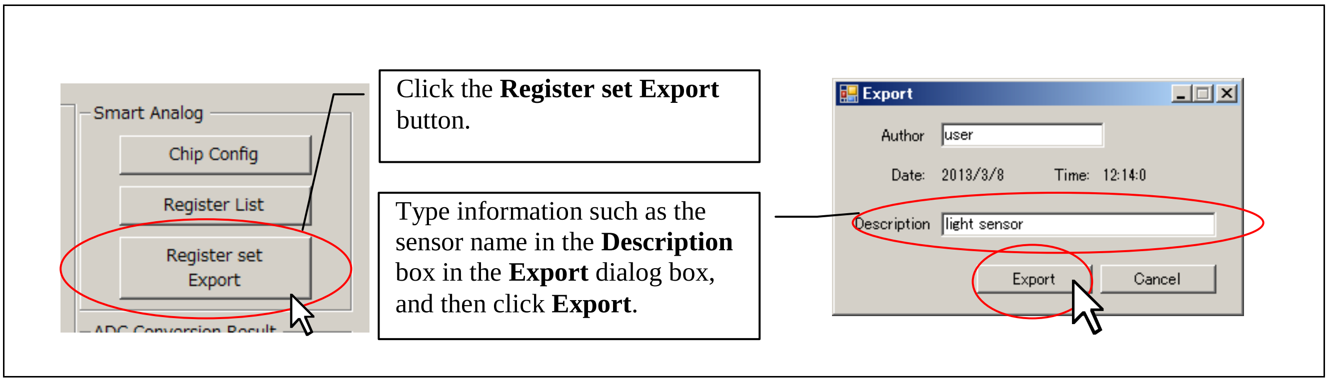


Figure 3-46 Saving the Configuration File (1)

In the **Save As** dialog box, specify a file name and save the file in any folder, without changing the default file type "Register set file(*.ini)".

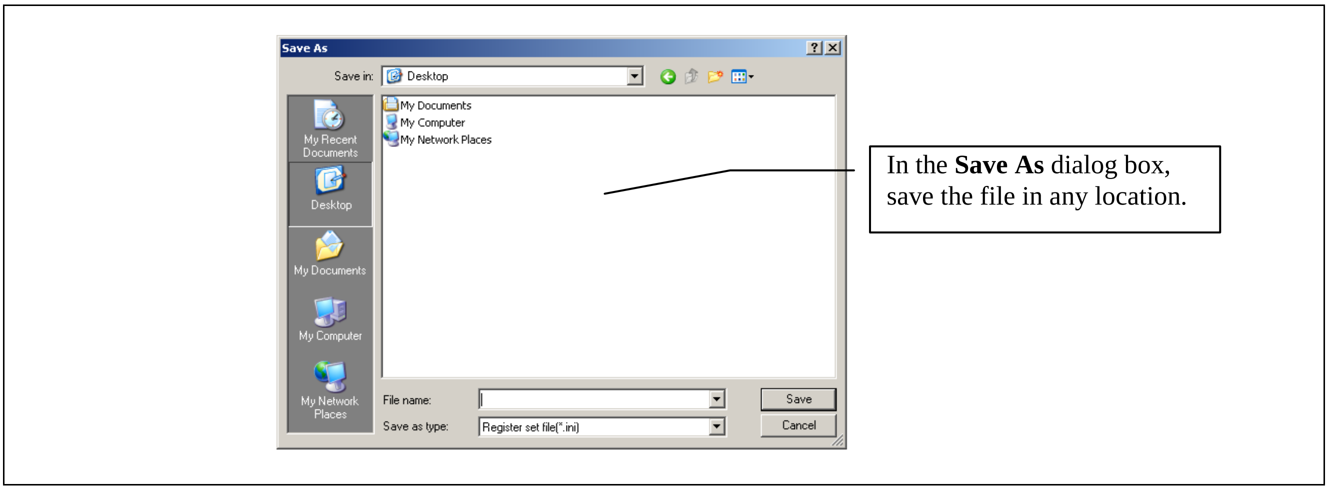


Figure 3-47 Saving the Configuration File (2)

How to restore the saved settings is described below. Perform the following to read the saved settings from the **Register** combo box in the **Start** window.

In the **Start** window, click the **File** menu, and then select **Option**.

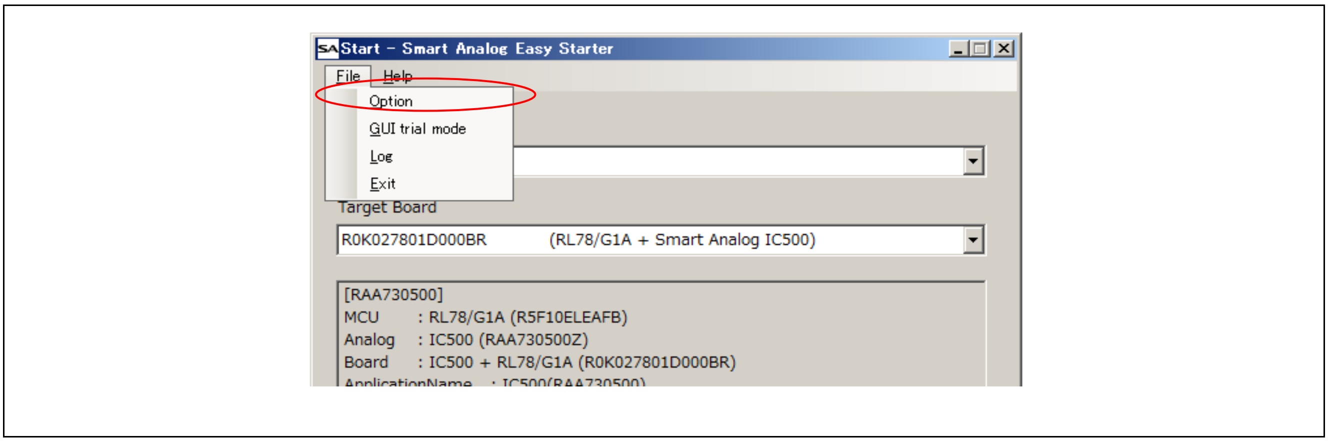


Figure 3-48 Restoring the Saved Settings (1)

In the **Option** dialog box, click the **Register Set Folder** tab, and then click the **Folder Select** button. In the **Browse For Folder** dialog box, select the folder in which the configuration file was saved, and then click **OK**.

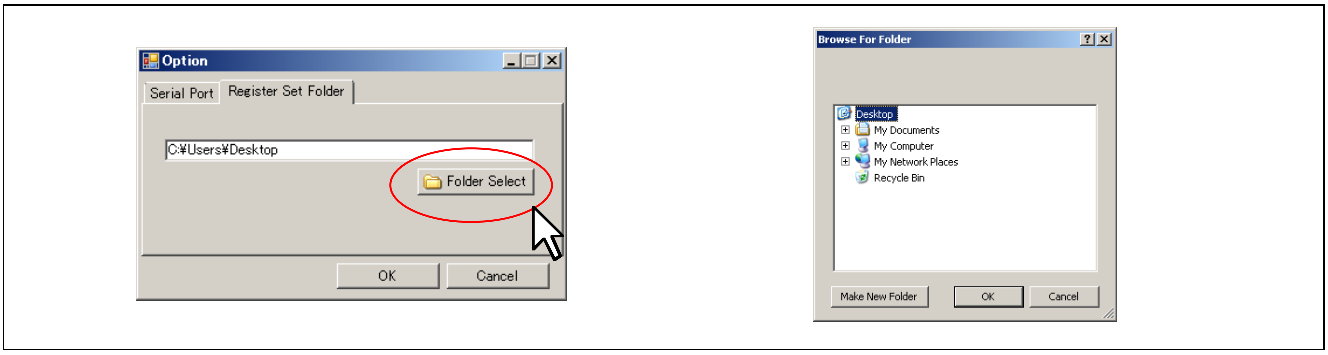


Figure 3-49 Restoring the Saved Settings (2)

In the **Start** window, click the **Register** combo box. The keyword input in the **Description** box in the **Export** dialog box for each configuration is displayed. If any of them is selected, the overview of the configuration file is displayed on the bottom of the window. Check the description and if it is the one you want to restore, click the **Select** button. The settings saved in the configuration file are then restored.

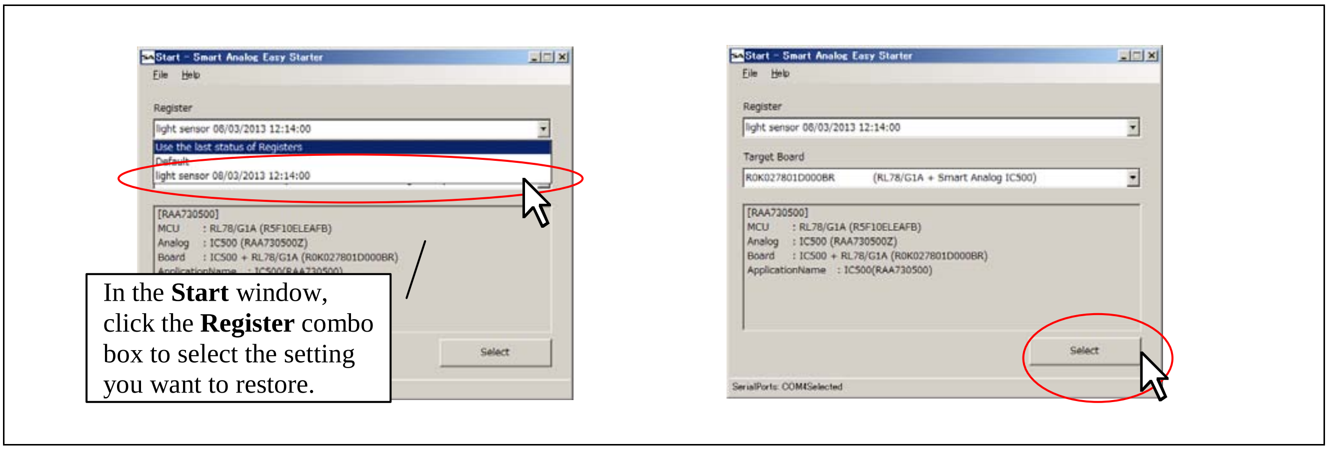


Figure 3-50 Restoring the Saved Settings (3)

3.9 Checking the Register Values and Outputting them to the C Source File

The circuit conditions configured in the **Chip Config** window can be checked as register values. The register values can be output as a C source file (structure arrays in C).

To check the specified register values, in **Main Window**, click the **Register List** button.

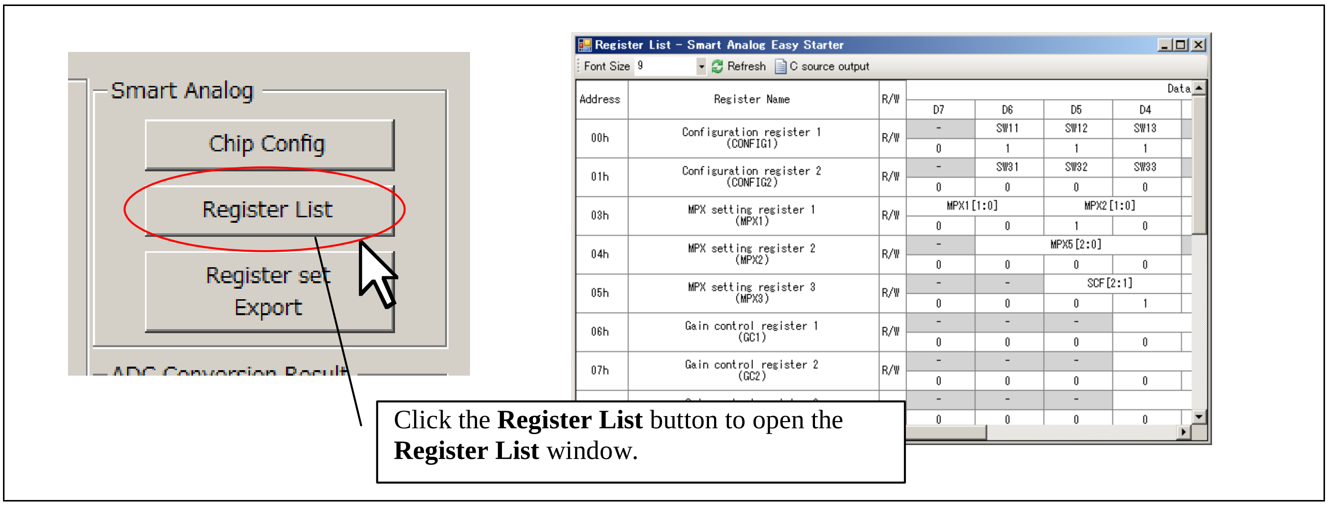
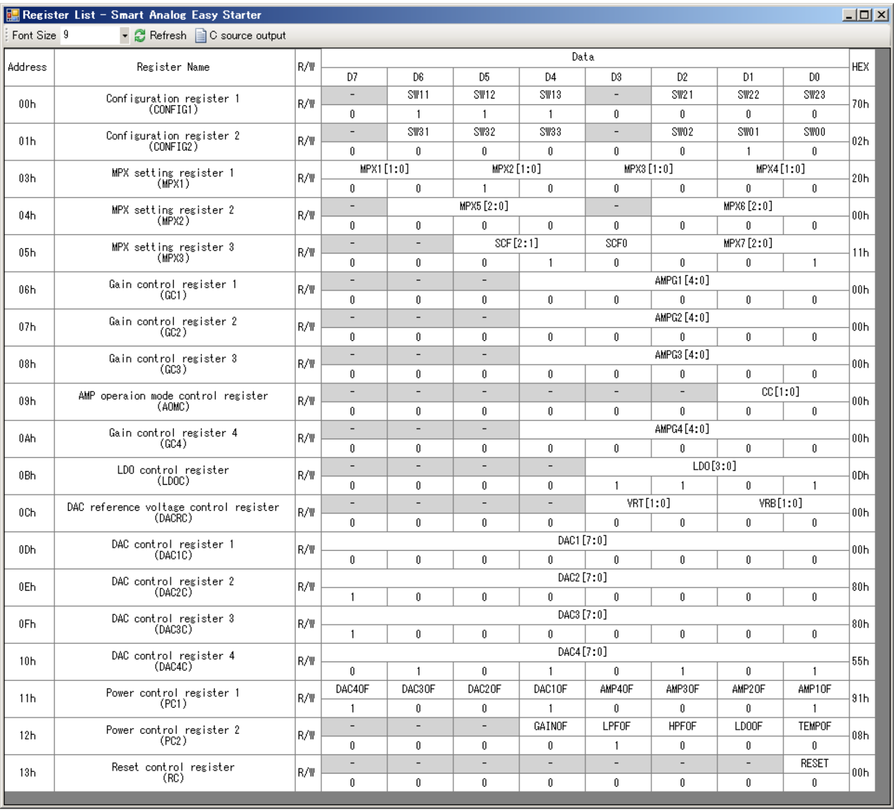


Figure 3-51 Checking the Register List

The register values are displayed in the **Register List** window.



Register List - Smart Analog Easy Starter

Font Size 9 Refresh C source output

Address	Register Name	R/W	D7	D6	D5	D4	D3	D2	D1	D0	HEX
00h	Configuration register 1 (CONFIG1)	R/W	-	SW11	SW12	SW13	-	SW21	SW22	SW23	70h
			0	1	1	1	0	0	0	0	
01h	Configuration register 2 (CONFIG2)	R/W	-	SW31	SW32	SW33	-	SW02	SW01	SW00	02h
			0	0	0	0	0	0	1	0	
03h	MPX setting register 1 (MPX1)	R/W	MPX1[1:0]		MPX2[1:0]		MPX3[1:0]		MPX4[1:0]		20h
			0	0	1	0	0	0	0	0	
04h	MPX setting register 2 (MPX2)	R/W	-	MPX5[2:0]			-	MPX6[2:0]			00h
			0	0	0	0	0	0	0	0	
05h	MPX setting register 3 (MPX3)	R/W	-	-	SCF[2:1]		SCF0	MPX7[2:0]			11h
			0	0	0	1	0	0	0	1	
06h	Gain control register 1 (GC1)	R/W	-	-	-	AMPG1[4:0]					00h
			0	0	0	0	0	0	0	0	
07h	Gain control register 2 (GC2)	R/W	-	-	-	AMPG2[4:0]					00h
			0	0	0	0	0	0	0	0	
08h	Gain control register 3 (GC3)	R/W	-	-	-	AMPG3[4:0]					00h
			0	0	0	0	0	0	0	0	
09h	AMP operaion mode control register (AOMC)	R/W	-	-	-	-	-	-	CC[1:0]		00h
			0	0	0	0	0	0	0	0	
0Ah	Gain control register 4 (GC4)	R/W	-	-	-	AMPG4[4:0]					00h
			0	0	0	0	0	0	0	0	
0Bh	LDO control register (LDOC)	R/W	-	-	-	-	LDO[3:0]				0Dh
			0	0	0	0	1	1	0	1	
0Ch	DAC reference voltage control register (DACRC)	R/W	-	-	-	-	VRT[1:0]		VRB[1:0]		00h
			0	0	0	0	0	0	0	0	
0Dh	DAC control register 1 (DAC1C)	R/W	DAC1[7:0]								00h
			0	0	0	0	0	0	0	0	
0Eh	DAC control register 2 (DAC2C)	R/W	DAC2[7:0]								80h
			1	0	0	0	0	0	0	0	
0Fh	DAC control register 3 (DAC3C)	R/W	DAC3[7:0]								80h
			1	0	0	0	0	0	0	0	
10h	DAC control register 4 (DAC4C)	R/W	DAC4[7:0]								55h
			0	1	0	1	0	1	0	1	
11h	Power control register 1 (PC1)	R/W	DAC4OF	DAC3OF	DAC2OF	DAC1OF	AMP4OF	AMP3OF	AMP2OF	AMP1OF	91h
			1	0	0	1	0	0	0	1	
12h	Power control register 2 (PC2)	R/W	-	-	-	GAINOF	LPFOF	HPFOF	LDOOF	TEMPOF	08h
			0	0	0	0	1	0	0	0	
13h	Reset control register (RC)	R/W	-	-	-	-	-	-	-	RESET	00h
			0	0	0	0	0	0	0	0	

Figure 3-52 Register Values Listed in the Register List Window

By programming MCU software based on C source files, the user can configure the analog circuit parameters, adjust the gain, and reject noise by using the Smart Analog IC in the MCU. In addition to outputting the configured circuit conditions as register values, Easy Starter can also output the register values as C structure arrays that consist of register values, addresses, and specified values, to a C source file.

In the **Register List** window, click the **C source output** icon on the toolbar.

The **Save As** dialog box is displayed. Specify a folder where to save the C source.

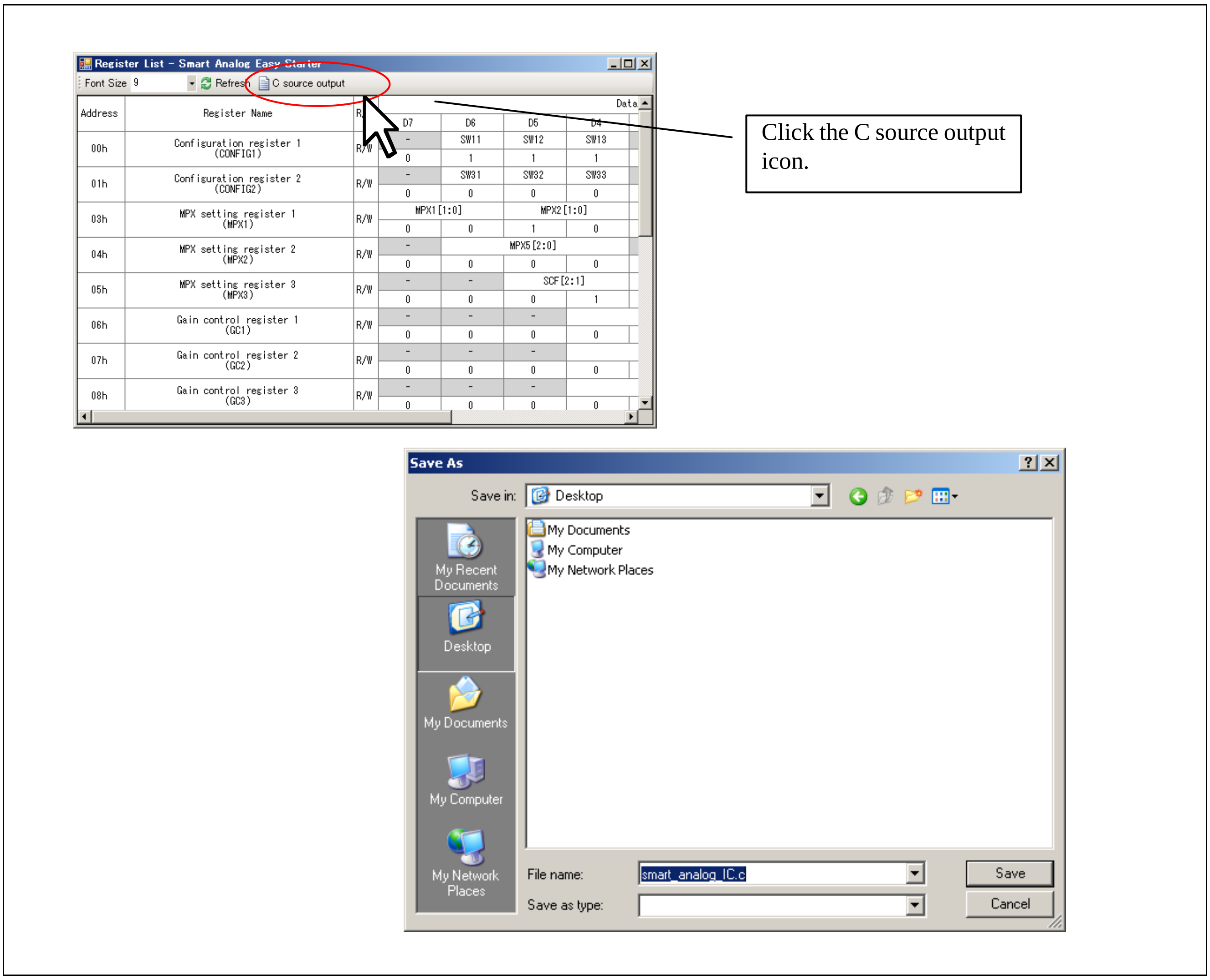


Figure 3-53 Outputting the C Source

Compile and link the saved C source in accordance with the microcontroller development environment you are using.

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Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	May 31, 2013	—	First edition issued.

General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU products from Renesas. For detailed usage notes on the products covered by this manual, refer to the relevant sections of the manual. If the descriptions under General Precautions in the Handling of MPU/MCU Products and in the body of the manual differ from each other, the description in the body of the manual takes precedence.

1. Handling of Unused Pins
   Handle unused pins in accord with the directions given under Handling of Unused Pins in the manual.
   — The input pins of CMOS products are generally in the high-impedance state. In operation with unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible. Unused pins should be handled as described under Handling of Unused Pins in the manual.
2. Processing at Power-on
   The state of the product is undefined at the moment when power is supplied.
   — The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the moment when power is supplied.
   In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the moment when power is supplied until the reset process is completed.
   In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the moment when power is supplied until the power reaches the level at which resetting has been specified.
3. Prohibition of Access to Reserved Addresses
   Access to reserved addresses is prohibited.
   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.
4. Clock Signals
   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has stabilized.
   — When the clock signal is generated with an external resonator (or from an external oscillator) during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Moreover, when switching to a clock signal produced with an external resonator (or by an external oscillator) while program execution is in progress, wait until the target clock signal is stable.
5. Differences between Products
   Before changing from one product to another, i.e. to one with a different part number, confirm that the change will not lead to problems.
   — The characteristics of MPU/MCU in the same group but having different part numbers may differ because of the differences in internal memory capacity and layout pattern. When changing to products of different part numbers, implement a system-evaluation test for each of the products.

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