



Gowin AGC IP

User Guide

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Revision History

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1 About This Guide

1.1 Purpose

The purpose of Gowin AGC IP User Guide is to help you learn the features and usage of Gowin AGC IP by providing the descriptions of the product overview, functional description, GUI and reference design.

1.2 Related Documents

The latest user guides are available on the GOWINSEMI Website. You can find related documents at www.gowinsemi.com

- [DS100](#), GW1N series of FPGA Products Data Sheet
- [DS117](#), GW1NR series of FPGA Products Data Sheet
- [DS891](#), GW1NRF Bluetooth series of FPGA Products Data Sheet
- [DS821](#), GW1NS series of FPGA Products Data Sheet
- [DS881](#), GW1NSER series of FPGA Products Data Sheet
- [DS861](#), GW1NSR series FPGA Products Data Sheet
- [DS102](#), GW2A series of FPGA Products Data Sheet
- [DS226](#), GW2AR series of FPGA Products Data Sheet
- [DS961](#), GW2ANR series of FPGA Products Data Sheet
- [SUG100](#), Gowin Software User Guide

1.3 Terminology and Abbreviations

The terminology and abbreviations used in this manual are as shown in Table 1-1.

Table 1-1 Terminology and Abbreviations

Terminology and Abbreviations	Meaning
IP	Intellectual Property
LUT	Look-up Tables
BSRAM	Block Static Random Access Memory
DSP	Digital Signal Processing
AGC	Automatic Gain Control
NLMS	Normalized Least Mean Square

1.4 Support and Feedback

Gowin Semiconductor provides customers with comprehensive technical support. If you have any questions, comments, or suggestions, please feel free to contact us directly by the following ways.

Website: www.gowinsemi.com

E-mail: support@gowinsemi.com

2 Overview

2.1 Introduction to Gowin AGC IP

Gowin AGC IP is used to control the slow changes of the gain factor. The short-term power of the speech signal is estimated and compared to the expected value during the period when the speech is active. The gain factor $g(n)$ decreases when the speech signal exceeds a threshold value, and vice versa. To avoid rapid changes of gain during short speech pauses, $g(n)$ is incremented or decremented in very small step.

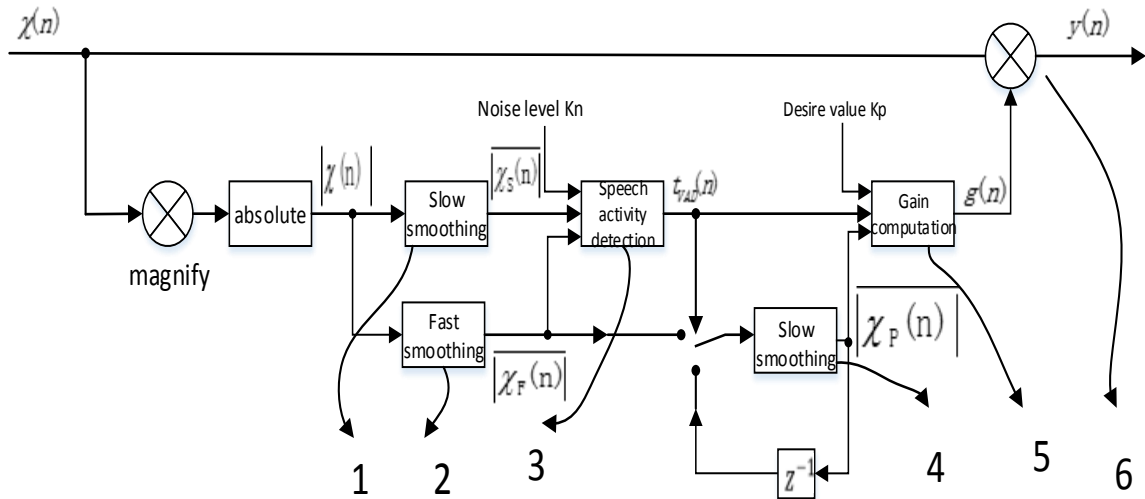
Table 2-1 Gowin AGC IP Overview

Gowin AGC IP	
Logic Resource	Please refer to Table 3-1.
Delivered Doc.	
Design Files	Verilog (encrypted)
Test and Design Flow	
Synthesis Software	Synplify_Pro/ GowinSynthesis
Application Software	Gowin Software

2.2 Algorithm

AGC means automatic gain control, which automatically adjusts the size of the gain according to the input speech signal, decreasing it when the speech signal is larger and increasing it when it is smaller, so that the speech signal is maintained in a stable range. The implementation of Gowin AGC IP algorithm is as shown in Figure 2-1.

Figure 2-1 Gowin AGC Algorithm Diagram



The operation corresponding to the serial number is:

1. Calculate $\overline{|x_s(n)|}$
2. Calculate $\overline{|x_f(n)|}$
3. Calculate $t_{vad}(n)$ to detect the speech and considering it as noise if it is below the threshold value Kn .
4. Calculate $\overline{|x_p(n)|}$ to determine whether the current gain needs to be increased or decreased.
5. Calculate $g(n)$ to get gain.
6. Calculate $y(n)$ to get output.

Each parameter in the diagram corresponding to the formula is as follows:

- $\overline{|x_s(n)|} = (1 - \gamma_s(n))|x(n)| + \gamma_s(n)\overline{|x_s(n-1)|}$
- $\gamma_s(n) = \begin{cases} \gamma_{s,r}, & \text{if } |x(n)| > \overline{|x_s(n-1)|} \\ \gamma_{s,f}, & \text{else} \end{cases}$

- $\overline{|\chi_F(n)|} = (1 - \gamma_F(n))|\chi(n)| + \gamma_F(n)\overline{|\chi_F(n-1)|}$
- $\gamma_F(n) = \begin{cases} \gamma_{F.r}, & \text{if } |\chi(n)| > \overline{|\chi_F(n-1)|} \\ \gamma_{F.f}, & \text{else} \end{cases}$
- $t_{VAD}(n) = \begin{cases} 1, & \text{if } \overline{|\chi_F(n)|} > \max\{\overline{|\chi_S(n)|}, K_n\} \\ 0, & \text{else} \end{cases}$
- $\chi_P(n) = \begin{cases} (1 - \gamma_P(n))\overline{|\chi_F(n)|} + \gamma_P(n)\overline{|\chi_P(n-1)|}, & \text{if } t_{VAD}(n) = 1 \\ \overline{|\chi_P(n-1)|}, & \text{else} \end{cases}$
- $\gamma_P(n) = \begin{cases} \gamma_{P.r}, & \text{if } \overline{|\chi_F(n)|} > \overline{|\chi_P(n-1)|} \\ \gamma_{P.f}, & \text{else} \end{cases}$
- $g(n) = \begin{cases} g_{\text{mod}}(n)g(n-1), & \text{if } \overline{|\chi_F(n)|} > \overline{|\chi_P(n-1)|} \\ g(n-1), & \text{else} \end{cases}$
- $g_{\text{mod}}(n) = \begin{cases} g_{\text{inc}}, & \text{if } \overline{|\chi_P(n)|}g(n-1) < Kp \\ g_{\text{dec}}, & \text{else} \end{cases}$
- $y(n) = \chi(n)g(n)$

$\gamma_{S.r} \ \gamma_{S.f} \ \gamma_{F.r} \ \gamma_{F.f} \ \gamma_{P.r} \ \gamma_{P.f}$ are Filter Constants configuration

parameters; for example, $\gamma_{S.r}$ corresponds to RSR.

Note!

The operation corresponding to the serial number in the diagram is abbreviated as "x

operation" for the convenience of description; for example, the NO.1 $\overline{|\chi_S(n)|}$ calculation is abbreviated as "1 operation".

3 Features and Performance

3.1 Features

- Supports gain configuration
- Supports speech detection threshold configuration
- Supports filter constant configuration

3.2 Max. Frequency

The maximum frequency of Gowin AGC IP is primarily determined by the device used and the speed grade of the devices. Take GW2A-55 series of FPGA for an instance. It can be up to 170M.

3.3 Latency

The maximum latency of Gowin AGC IP is mainly determined by the actual use. When the channels are synchronized, the data from the first channel, which takes about 73 cycles, is used to calculate the gain value and give the data pdata_out; for non-first channels, pdata_out is given for about 11 cycles per channel.

3.4 Resource Utilization

Gowin AGC IP can be implemented by Verilog language. Its performance and resource utilization may vary when the design is employed in different devices, or at different density, speed, grade or the different modes of IP configuration.

Gowin AGC IP takes GW2N-55 series of FPGA with default configuration for an instance to introduce resource utilization. The resource

utilization is shown in Table 3-1. For application verification on other Gowin FPGA, please pay attention to the post-released information.

Table 3-1 Gowin AGC IP Resource Utilization

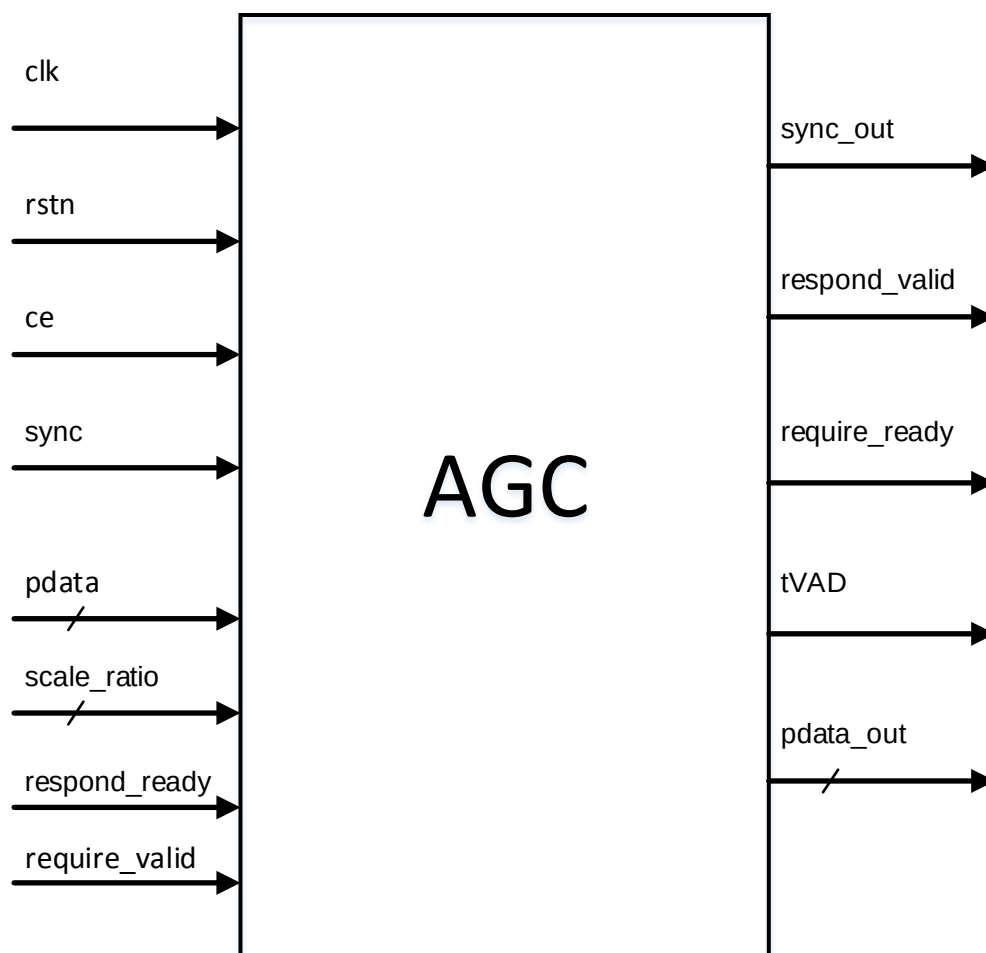
Device Series	Speed Grade	Resource Utilization			Remarks
GW2A-55	C8/I7	LUT		819	-
		DSP	MULT36X36	1	
			ALU54D	1	
		REG		922	

4 Functional Description

4.1 Port Description

The IO ports of the Gowin AGC IP are shown in Figure 4-1.

Figure 4-1 Gowin AGC IP Port Diagram



For the detailed IO ports description of Gowin AGC IP, please refer to

Table 4-1.

Table 4-1 Gowin AGC IP IO Description

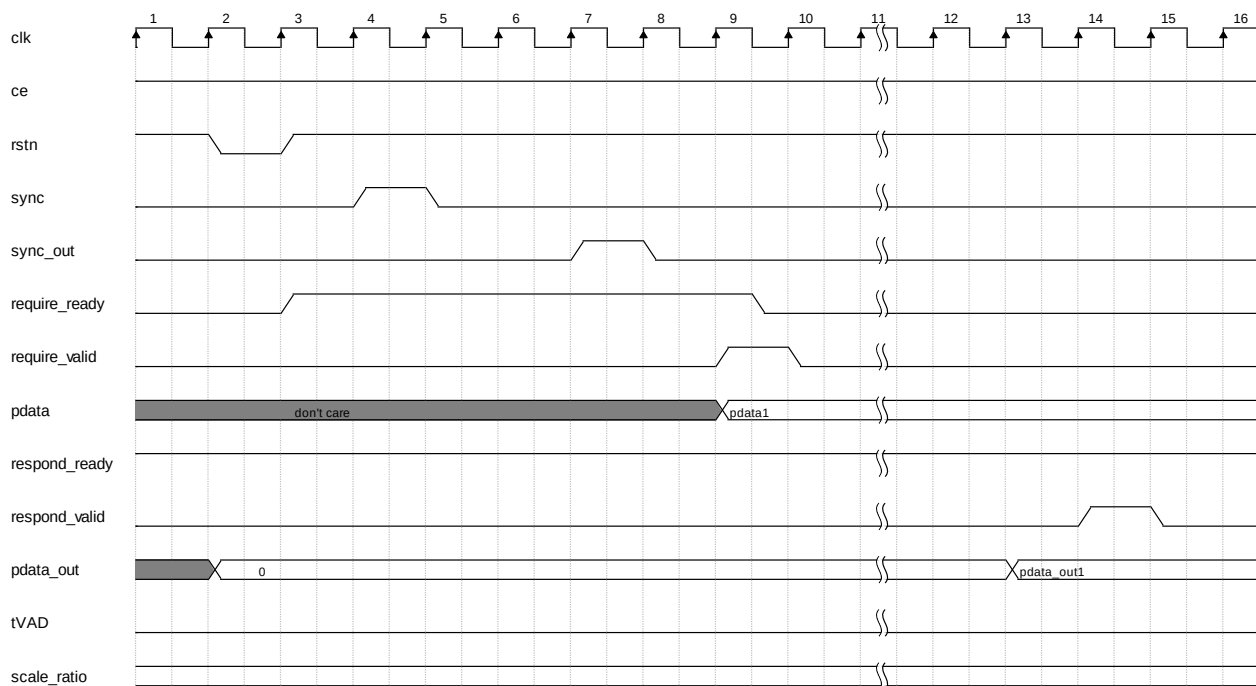
Signal	I/O	Description
clk	input	Clock
rstn	input	Reset(active-low)
ce	input	It can be set to constant 1 under the condition that the module work enables and the AGC is always working.
sync	input	The input sync signal is pulled up when the current data is the first channel data.
pdata	input	Input parallel data, 24 bit width.
scale_ratio	input	Front-end amplification factor, 8 bit width. The last four bits are the decimal. 8'h18 means 1.5 times amplification.
respond_ready	input	Handshake signal ready to output
require_valid	input	Input valid handshake signal
sync_out	output	Output sync signal
respond_valid	output	Output valid handshake signal
require_ready	output	Handshake signal ready to input
tVAD	output	Speech identification signal
pdata_out	output	Output parallel data, 24 bit width.

Note!

- scale_ratio can be used to fine tune the sound. If the input is too much, it will cause data overflow. When no sound adjustment is performed, the recommended input value is 8'h10.
- tVAD can be used for sound identification. When tVAD=1, it indicates that there is a sound input at this moment; when KN (sound detection threshold) is reduced, smaller sounds can be identified.

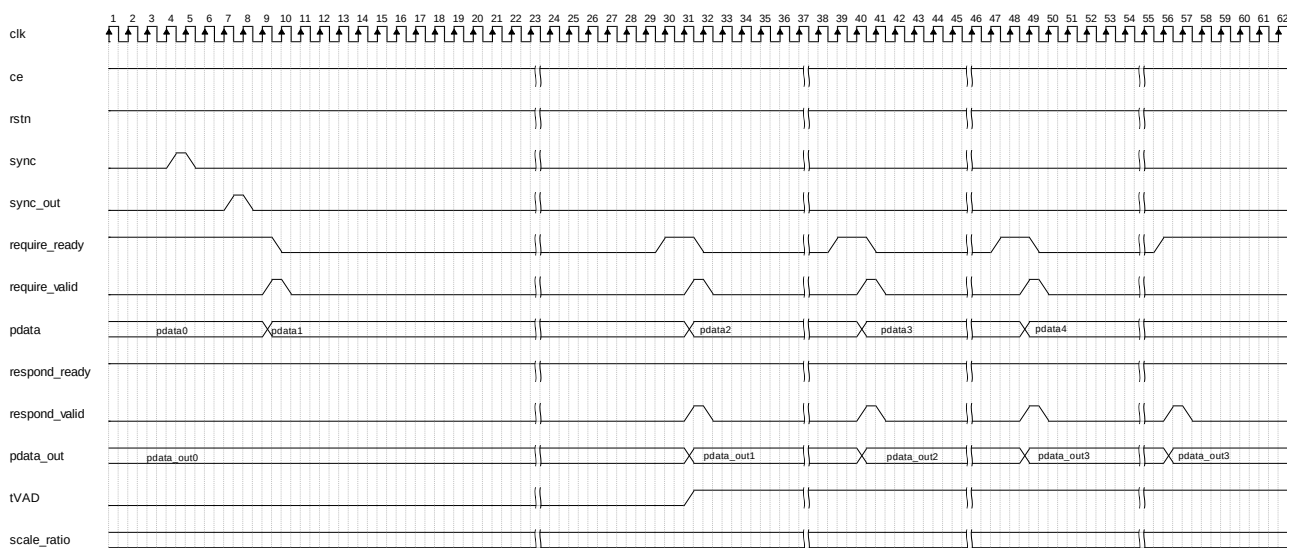
4.2 Timing Description

The timing diagram of Gowin AGC IP is shown in Figure 4-1 and Figure 4-3.

Figure 4-2 Gowin AGC IP Reset Timing Diagram

The reset timing diagram of Gowin AGC IP is as shown in Figure 4-2. ce can always be 1 when the IP is working. After reset, require_ready changes to 1, indicating that data can be accepted; respond_valid, tvAD, sync_out, and pdata_out are all set to 0.

IP starts working after sync and require_valid are input.

Figure 4-3 Gowin AGC IP Data Input Timing Diagram

The data input timing diagram of Gowin AGC IP is shown Figure 4-3.

1. The sync input indicates that a new frame transmission has started. After a delay of two clock cycles, the IP outputs a sync_out with high level. At this point, require_ready should be high, indicating that the data from the upper module of IP can be accepted. When the upper module gives a request_valid with high level, the IP pulls down the request_ready and will use the pdata for calculation. After the calculation, if respond_ready is high, the IP will update the value of pdata_out and pull respond_valid up for one clock cycle, indicating that the output is valid at this time.
2. The IP will keep up with the input scale_ratio and adjust to use the latest value for the calculation.
3. The data processing of IP lower module is fast enough, and respond_ready can always be 1.
4. After each sync synchronization, the gain value needs to be calculated using the data from the first channel, so it is a little slower and takes about 73 clock cycles to output pdata_out; the rest of each channel takes 11 clock cycles to get the output pdata_out using the gain value calculated by the first channel.

4.3 Instructions for Use

Typical Use of the IP

Gowin AGC IP can process single or multiple-channel audio data. IP use sync and require_valid to synchronize the number of channels. sync is pulled up for one cycle, indicating that the valid data arrival of the next channel is the data of the first channel; require_valid is pulled up for one cycle, indicating that the current data is the valid data of a certain channel.

For single channel calculation, it needs to use sync and require_valid to synchronize, indicating it is single channel data. The following is an example of the cooperation between the sync and require_valid:

```
(sync) require_valid >
(sync) require_valid >
.....
```

Note!

(sync) require_valid means the first require_valid signal after sync synchronization.

For the multiple-channel data transfer, it is also necessary to use sync and require_valid, indicating it is the data of the first channel, and then use require_valid signal to synchronize and process the data of other channels sequentially. The following is an example of the cooperation between the sync and require_valid of four-channel data

(sync) require_valid > require_valid > require_valid > require_valid >
 (sync) require_valid > require_valid > require_valid > require_valid >

For the processing data format, take 4-channel data as an instance, process the first number of each channel, and then process the second number of each channel

It is as follows:

C1_1,C2_1,C3_1,C4_1;
 C1_2,C2_2,C3_2,C4_2;
 C1_3,C2_3,C3_3,C4_3;
 C1_4, C2_4, C3_4, C4_4;
 C1_5, C2_5, C3_5, C4_5;

.....

C x1_x2 means the x2nd data of the x1 channel; for example, C3_4 means the 4th data of the 3rd channel.

The audio sampling rate needs to match the operating frequency of the IP; ensure that the IP can complete the data processing of each channel between two sampling points. That is, $1/f_s > ((T_f + n \cdot T_c)/f)$.

The multi-channel expressed in the text means that the multiple acquisition devices collect the audio data in a certain ambient, at the same moment, and at different positions. For example, in a room, the microphones at 4 different positions collect the speech in the room; then the collected data is 4-channel data.

Note!

- f_s is the audio sampling frequency.
- f is the operating frequency of the IP.
- $T_f=73$ is the cycles of the first channel operation completed.
- $T_c=11$ is the cycles of a non-first channel operation completed for multiple channels.
- n = the number of channels minus one, and the minimum value is 0; for example, if there are 3 channels, $n = 2$.

Parameters Configuration Description

- GINC: Gain increase range; when the value of GINC is larger, the gain can be increased faster.
- GDEC: Gain decrease range; when the value of GDEC is larger, the gain can be decreased faster.
- KN: Speech detection threshold; when increased, the threshold value is larger, and it affects tVAD signal.
- KP: Speech stabilization threshold; when KP is increased, the volume is larger.

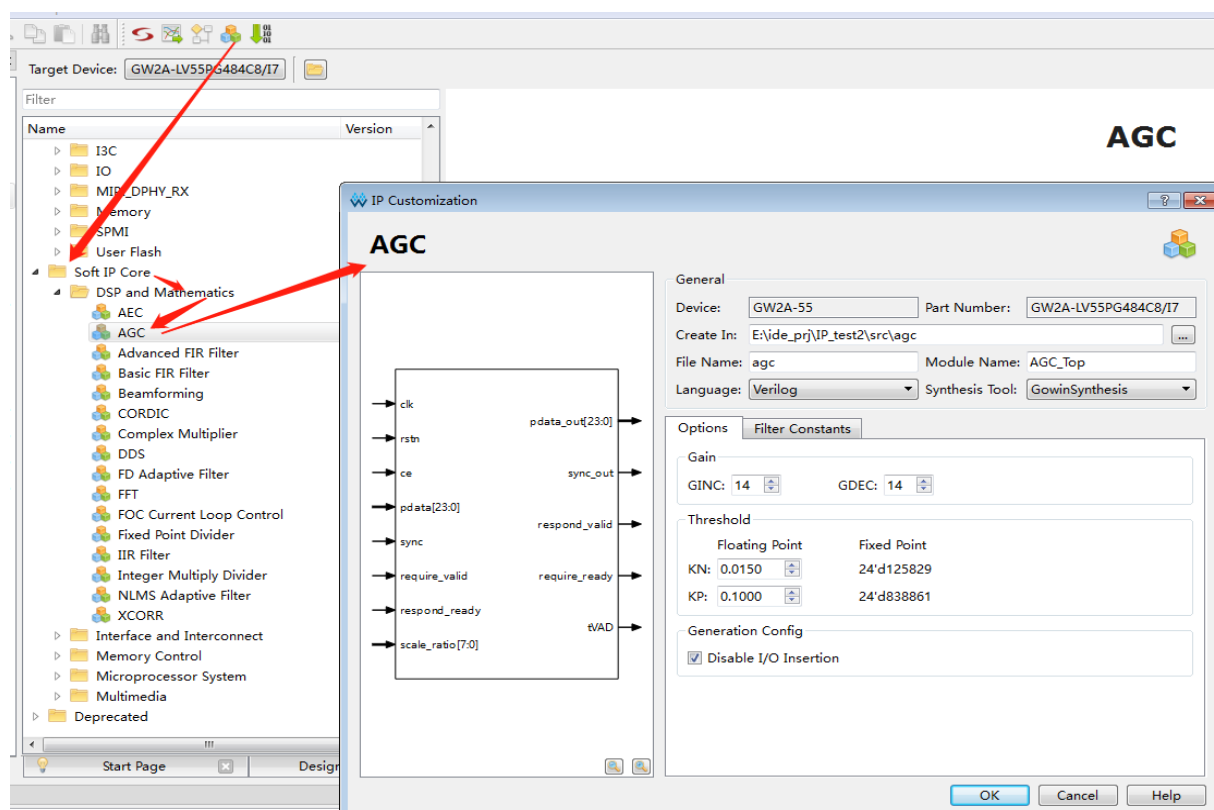
- RSR: 1 operation, filter increase parameter; if RSR increases, the value increases more slowly when the $\overline{\chi_s(n)}$ value increases; if RSR decreases, the value increases more quickly when the $\overline{\chi_s(n)}$ value increases.
- RSF: 1 operation, filter decrease parameter; if RSF increases, the value decreases more slowly when the $\overline{\chi_s(n)}$ value decreases; if RSF decreases, the value decreases more quickly when the $\overline{\chi_s(n)}$ value decreases.
- RSR: 2 operation, filter increase parameter; if RFR increases, the value increases more slowly when the $\overline{\chi_F(n)}$ value increases; if RSR decreases, the value increases more quickly when the $\overline{\chi_F(n)}$ value increases.
- RFF: 2 operation, filter decrease parameter; if RFF increases, the value decreases more slowly when the $\overline{\chi_F(n)}$ value decreases; if RFF decreases, the value decreases more quickly when the $\overline{\chi_F(n)}$ value decreases.
- RPR: 4 operation, filter increase parameter; if RPR increases, the value increases more slowly when the $\chi_p(n)$ value increases; if RPR decreases, the value increases more quickly when the $\chi_p(n)$ value increases.
- RPF: 4 operation, filter decrease parameter; if RPF increases, the value decreases more slowly when the $\chi_p(n)$ value decreases; if RPF decreases, the value decreases more quickly when the $\chi_p(n)$ value decreases.

5 Call and Configuration

5.1 IP Call

Start "IP Core Generator" from the "Tools" menu in the Gowin Software and to call and configure Gowin AGC IP. Or you can start via the icons as shown in Figure 5-1.

Figure 5-1 Gowin AGC IP Call Via Tool Bar

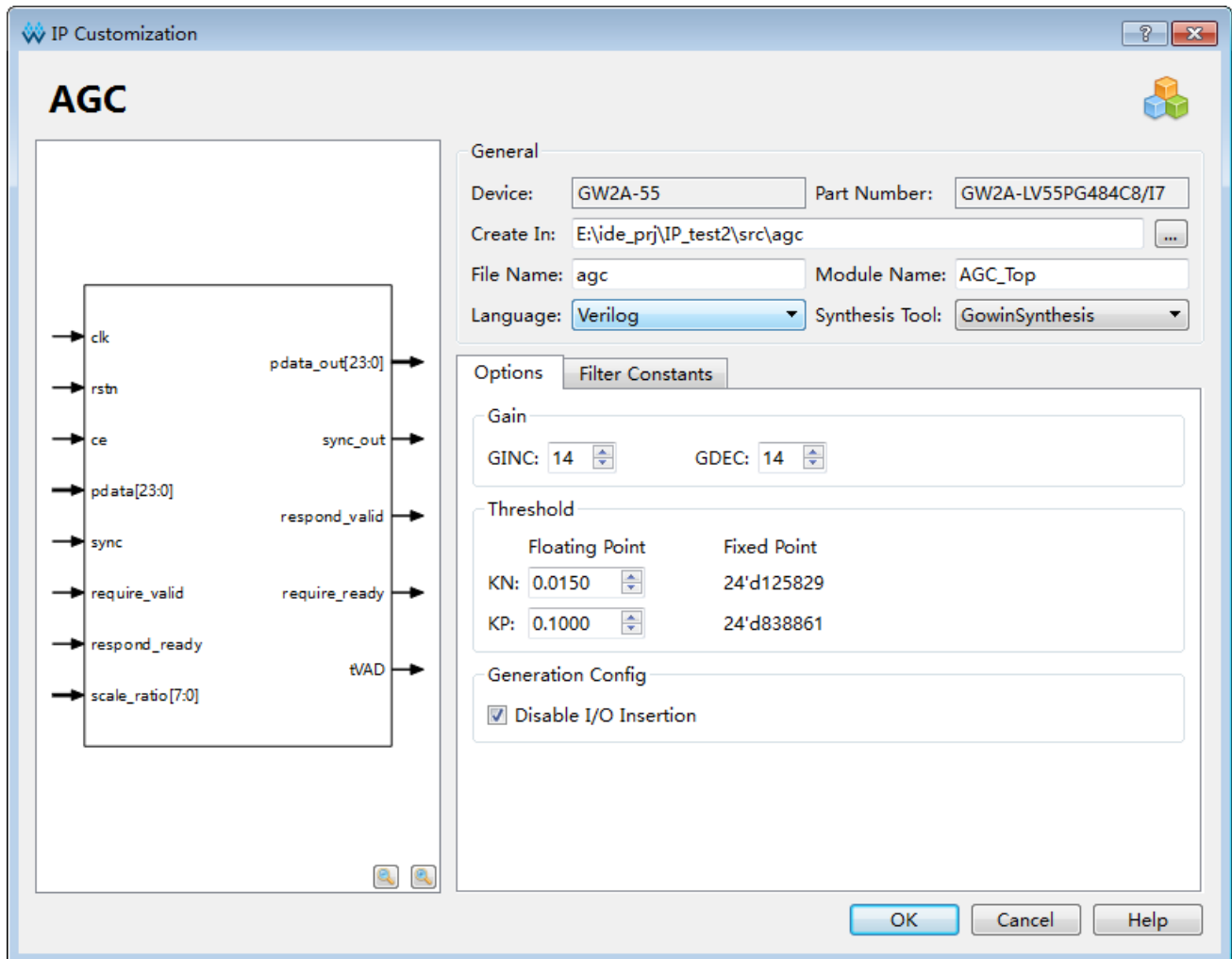


5.2 Configuration Interface

The Gowin AGC IP configuration interface is shown in Figure 5-2 and Figure 5-3.

Configuration Interface

Figure 5-2 Options Configuration Interface



The Gowin AGC IP options configuration description is shown in Table 5-1.

Table 5-1 Configuration Options Description

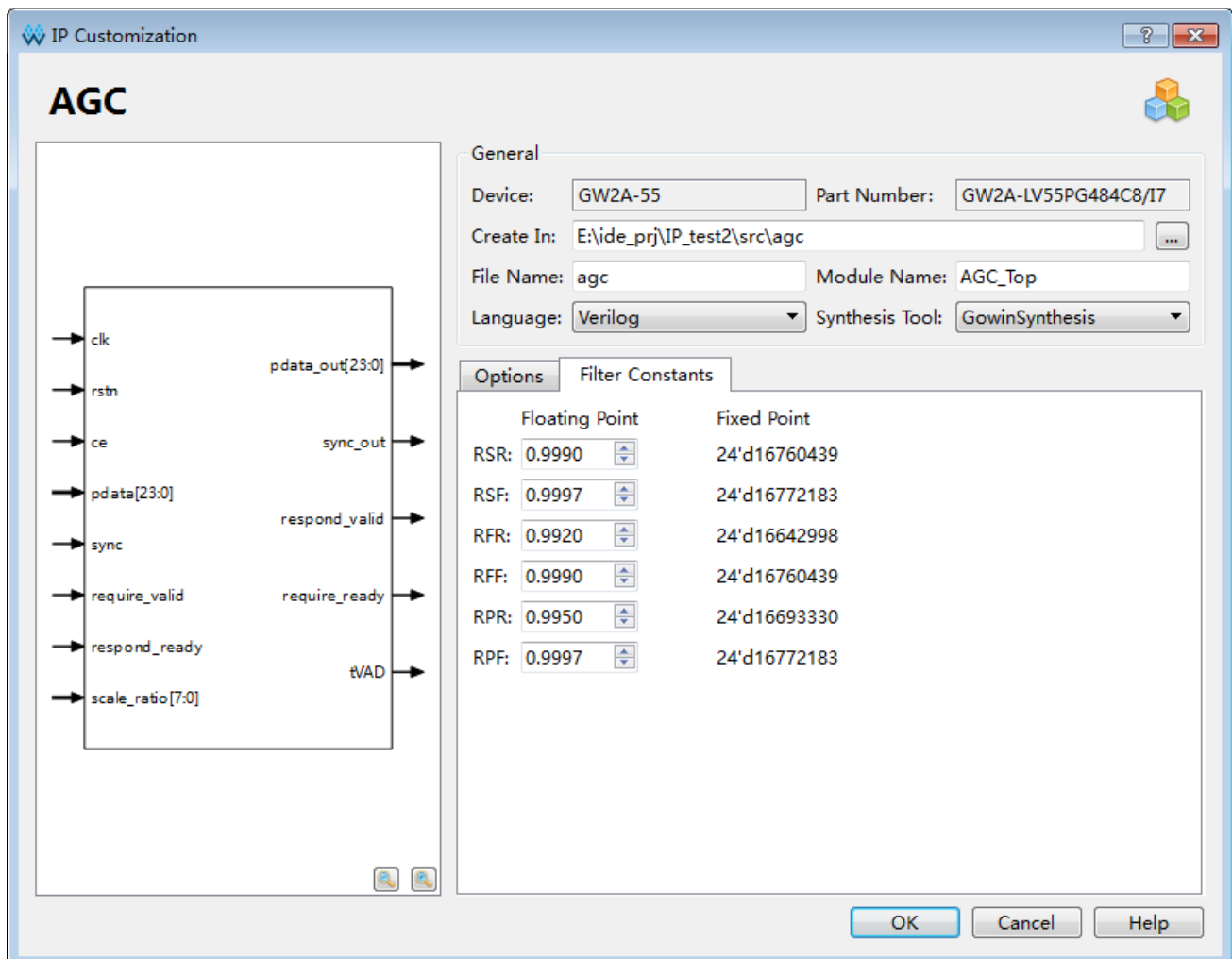
Options		Description
Gain	GINC	Gain increase range, 0-20.
	GDEC	Gain decrease range, 0-20.
Threshold	KN	Speech detection threshold, 0.0000~1.0000.
	KP	Speech stabilization threshold, 0.0000~1.0000.

Filter Constants Configuration Interface

The Filter Constants configuration options description is shown in

Figure 5-3.

Figure 5-3 Filter Constants Configuration Interface



The Filter Constants options description is shown in Table 5-2.

Table 5-2 Configuration Options Description

Options		Description
Filter Constants	RSR	1 operation, fliter increase parameter, 0.9000~0.9999.
	RSF	1 operation, fliter decease parameter, 0.9000~0.9999.
	RFR	2 operation, fliter increase parameter, 0.9000~0.9999.
	RFF	2 operation, fliter decease parameter, 0.9000~0.9999.
	RPR	4 operation, fliter increase parameter, 0.9000~0.9999.

Options		Description
	RPF	4 operation, fliter decease parameter, 0.9000~0.9999.

6 Reference Design

Please refer to the related test cases in [RefDesign](#).

