Gas Fraction Control System

for a

Gas Evolving Electrochemical Reactor

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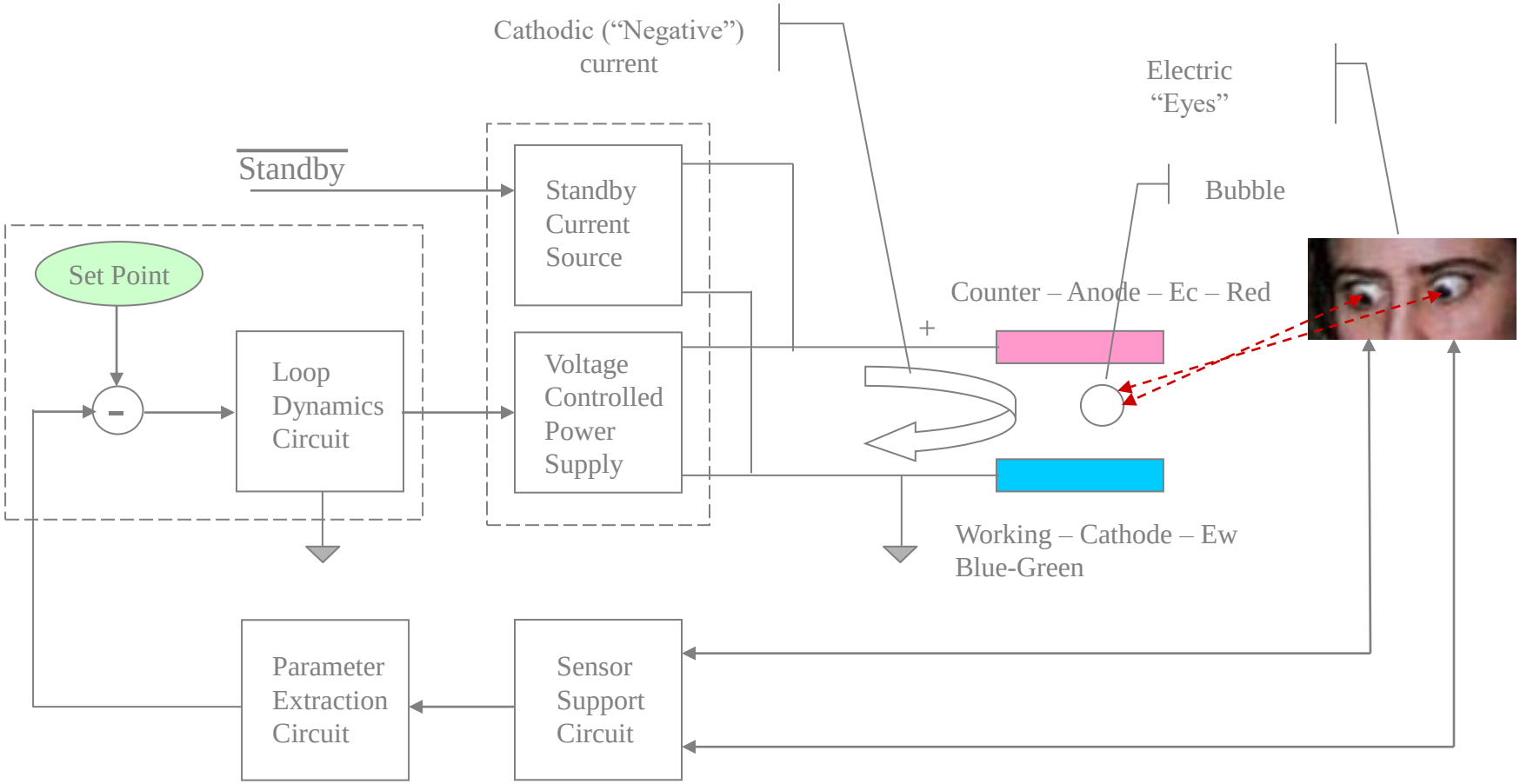
Reactor Controller Functional Diagram



Block Diagram for "Bubbleostatic" Operating Mode

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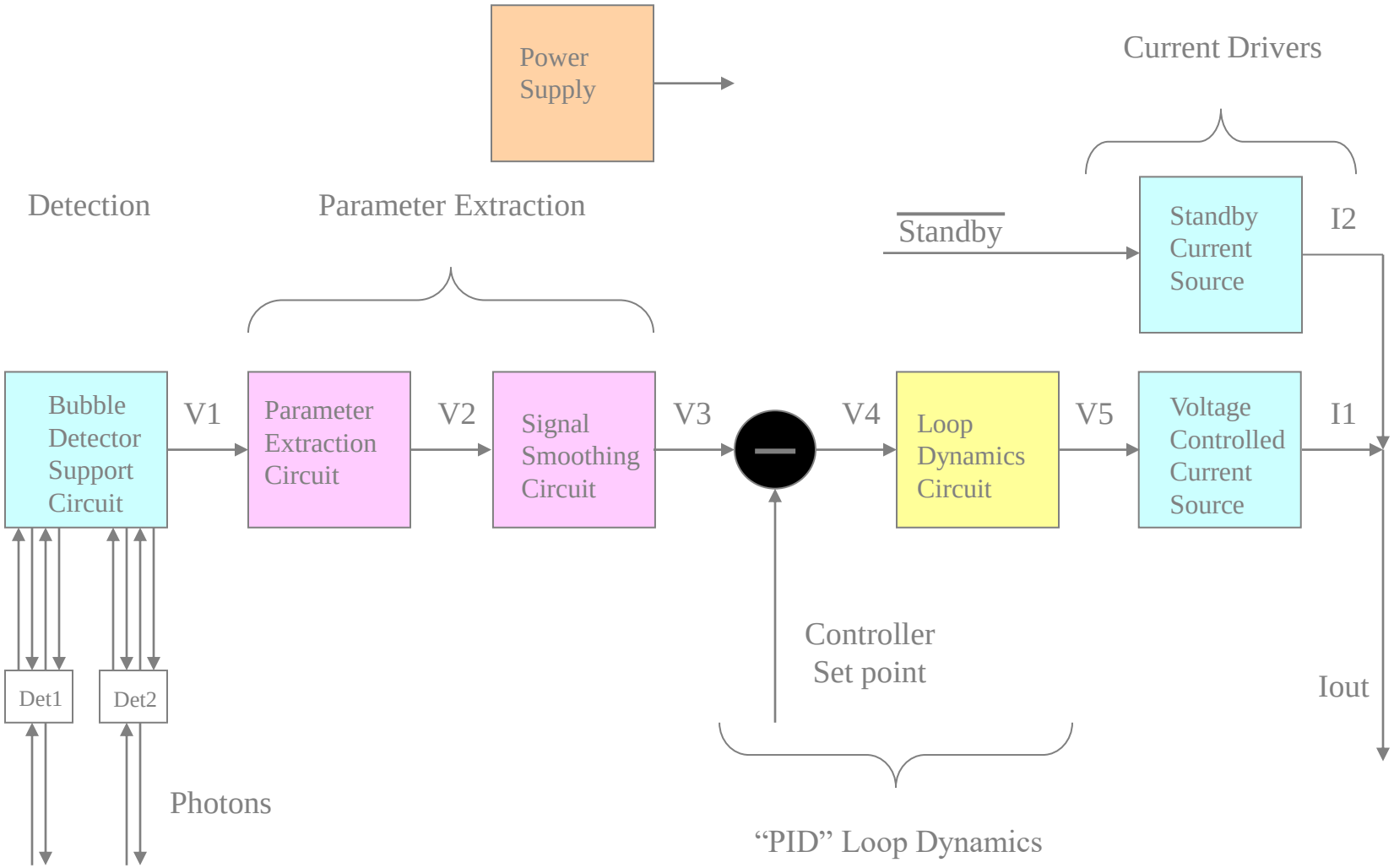
Reactor Control System Block Diagram



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Requirements - Loop Dynamics

1. Controller should provide at least a second order transfer function
2. Controller should provide easy adjustability of the transfer function dynamics

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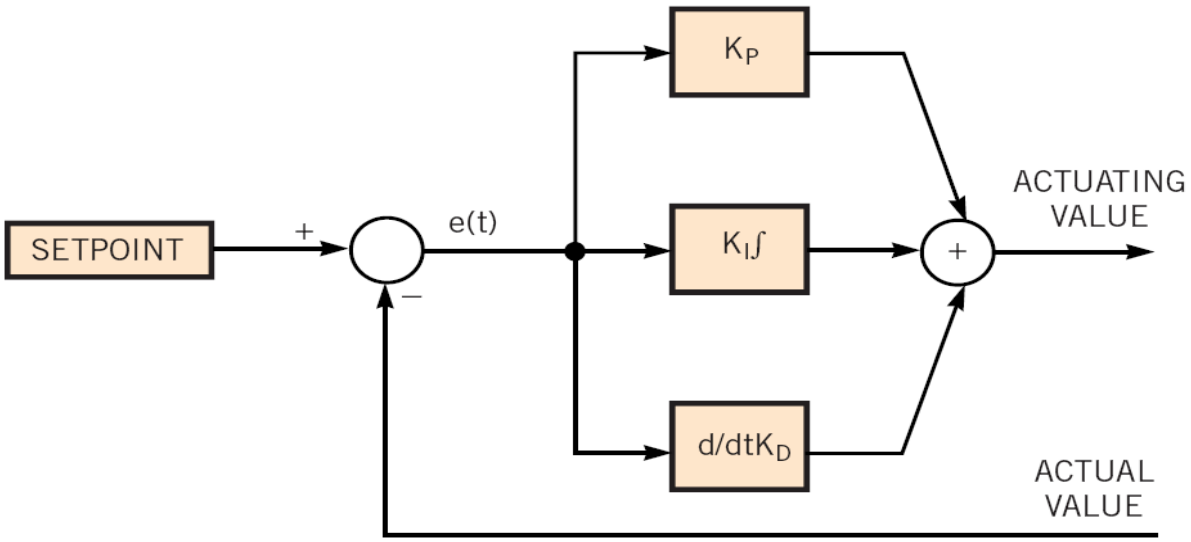
Loop Dynamics - The PID Controller



A PID controller calculates an actuating value from proportional, integral, and derivative components.

$$y(t) = K_P e(t) + K_I \int e(t)dt + K_D \frac{de(t)}{dt}.$$

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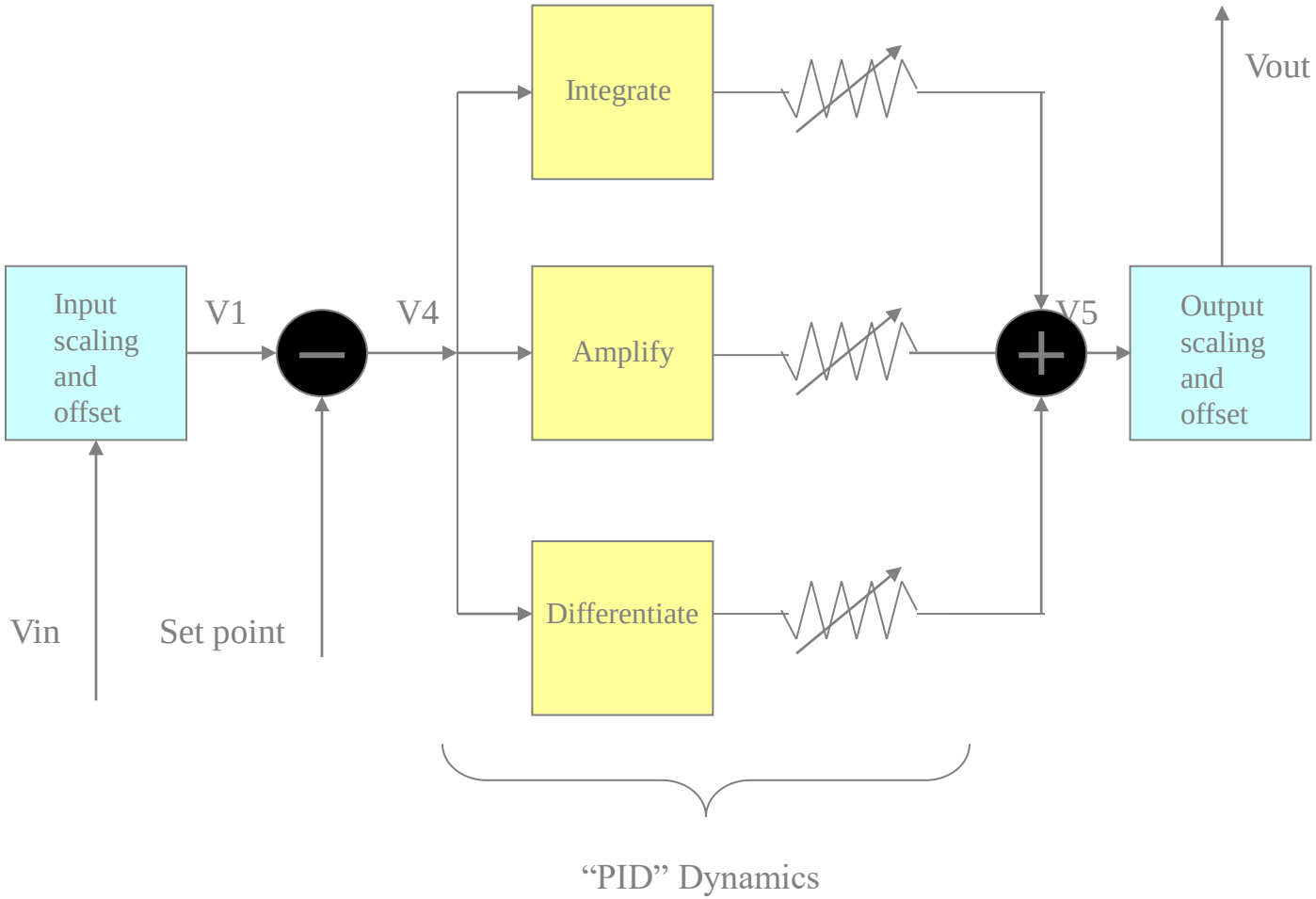
Concept 1 – Absolute Amplitude Feedback



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Parameter Extraction

1. Accept signals from one or more concentration sensing sources
2. Pre-process the sensor signal as required
3. Extract various parameters from the concentration sensor as required
4. Scale and offset the parameter signals as required

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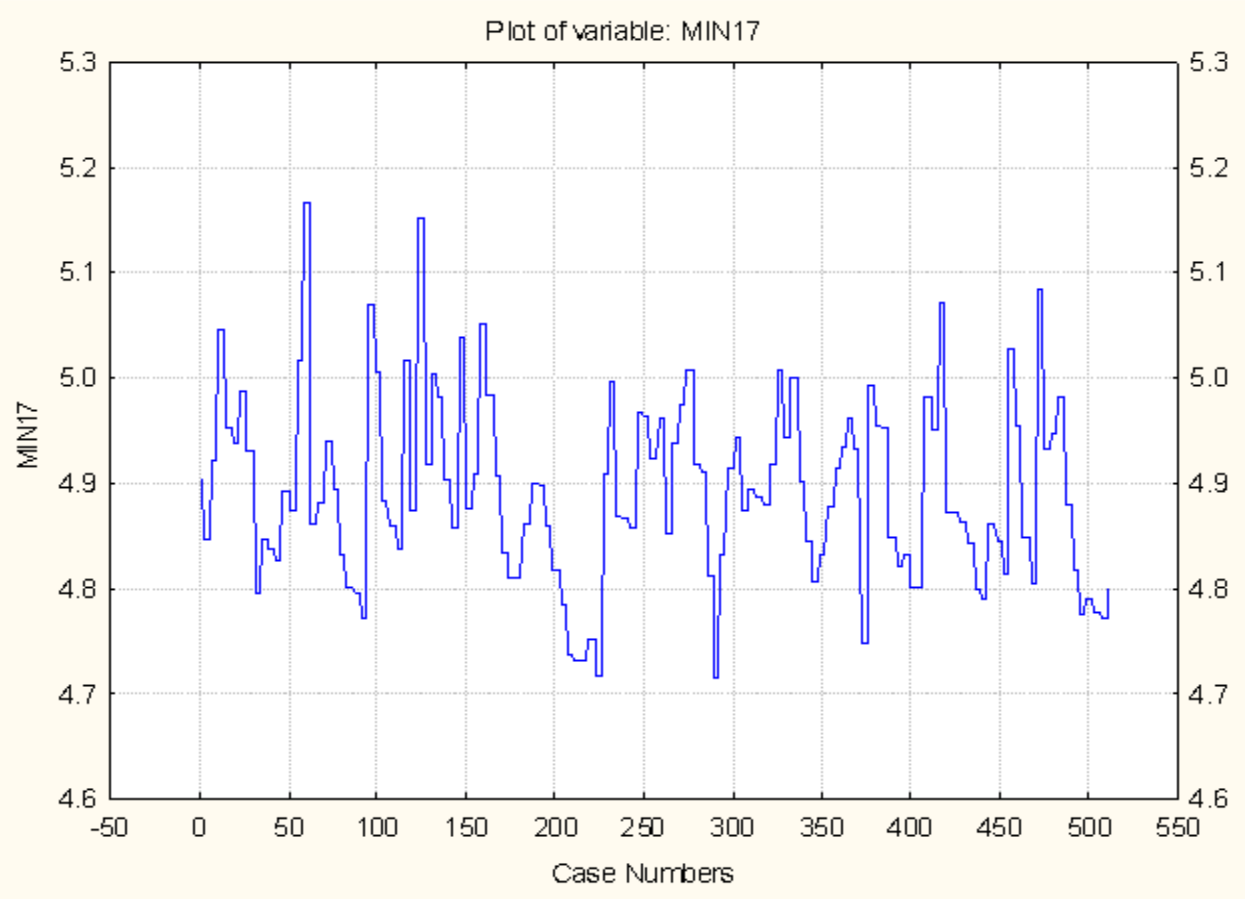
Typical Bubbleogram 512 Samples



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Typical Bubbleogram Descriptive Statistics

Variable	Descriptive Statistics (12 ml per min Spctral Anal - 060922A)							
	Valid N	Mean	Sum	Minimum	Maximum	Variance	Std.Dev.	Standard Error
Min 3	512	4.839546	2477.847	4.676569	5.020641	0.004905	0.070039	0.003095
Min 7	512	4.831184	2473.566	4.697005	5.023386	0.002857	0.053450	0.002362
Min 12	512	4.938938	2528.736	4.728728	5.133806	0.008715	0.093354	0.004126
Min 17	512	4.892734	2505.080	4.714392	5.167359	0.007639	0.087404	0.003863
Min 23	512	4.918353	2518.196	4.670163	5.107879	0.007004	0.083692	0.003699

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Power Spectral Density

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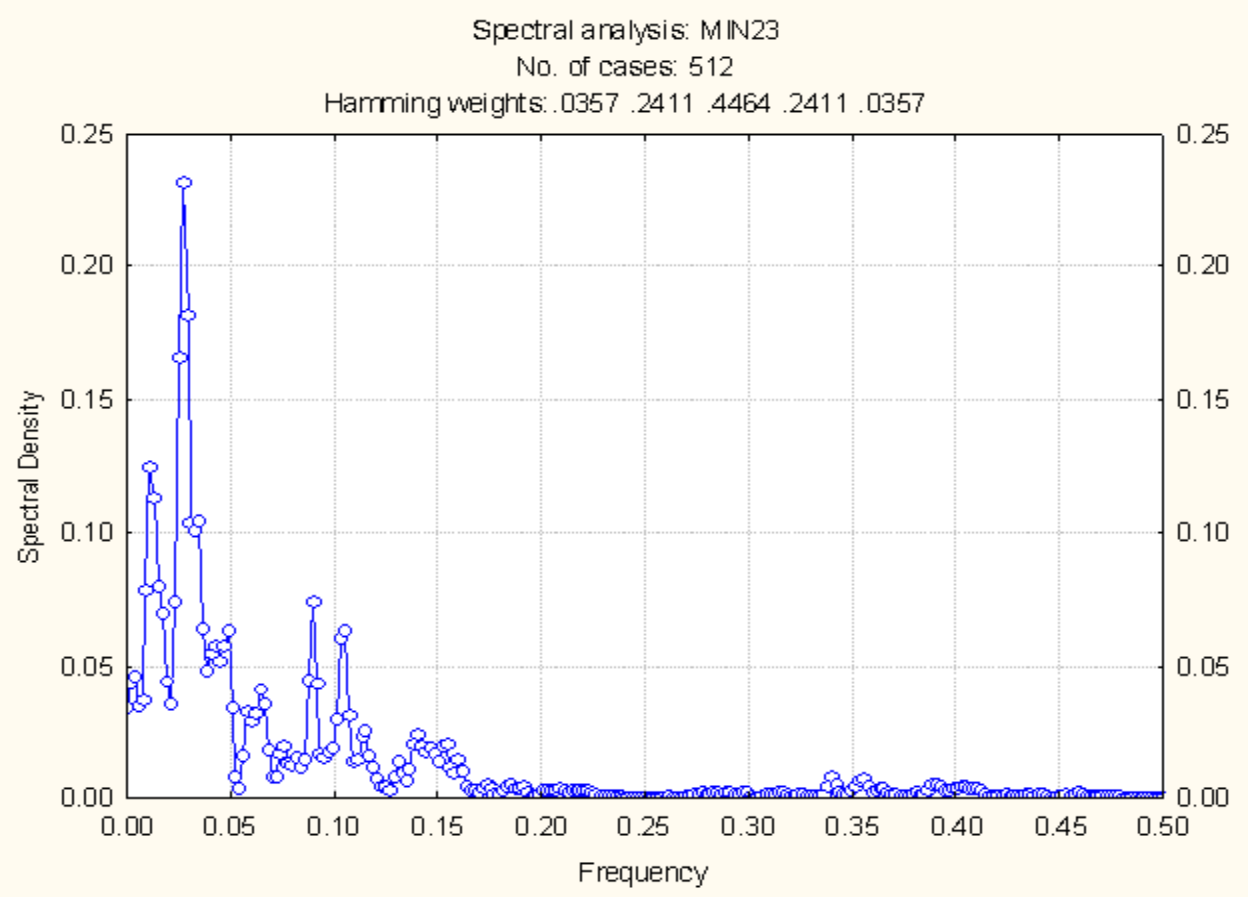

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Autocorrelation

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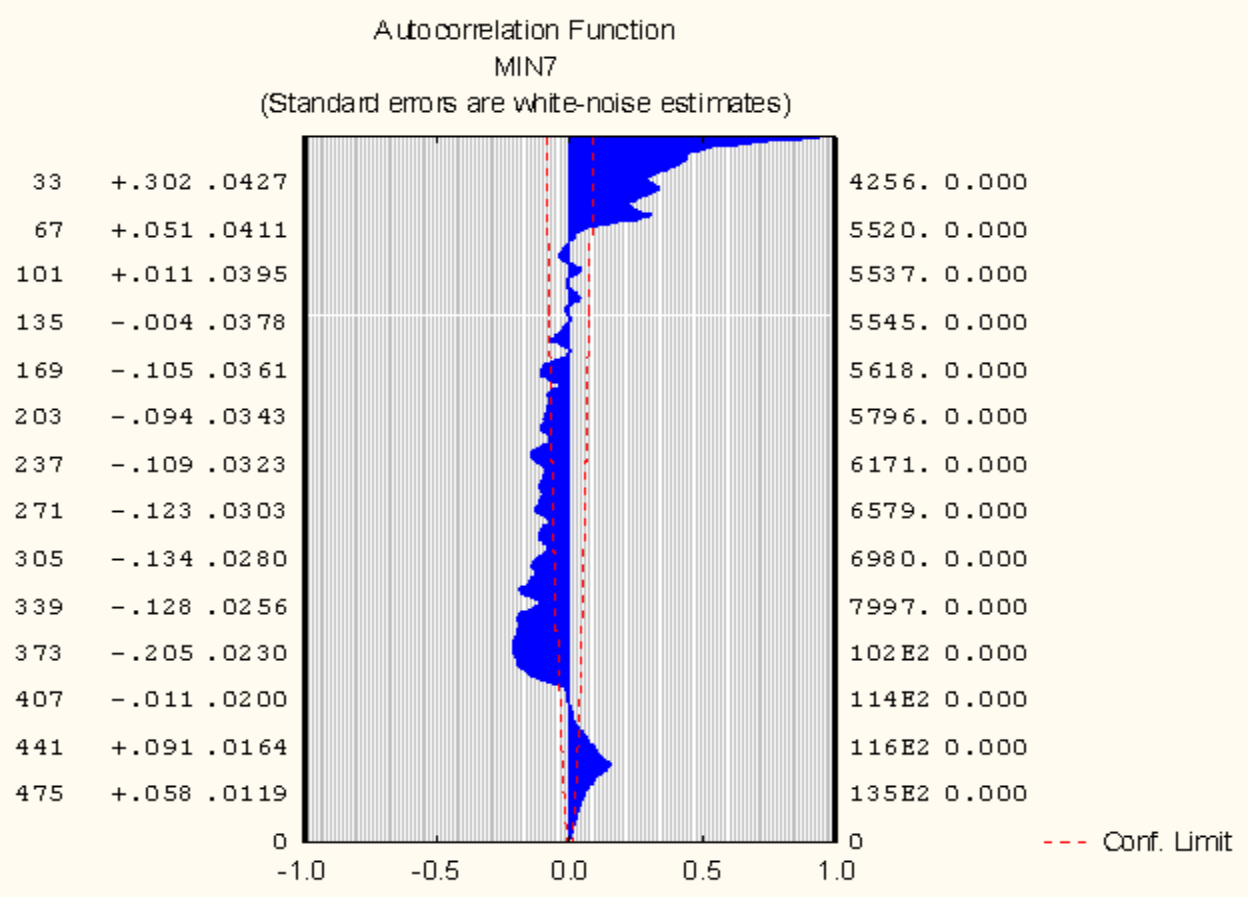

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Current Noise Signal Analysis

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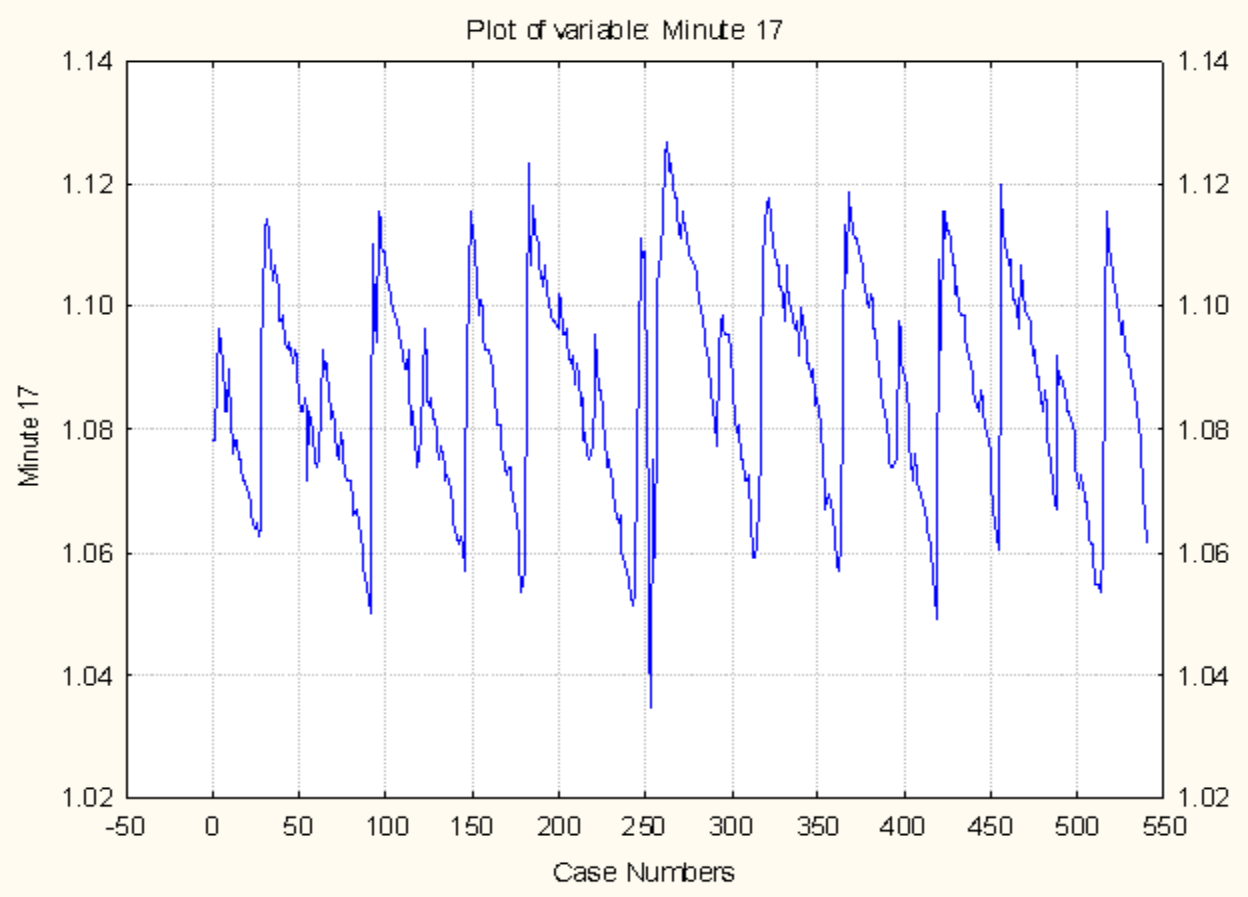
Current “Noise” Signal



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Current “Noise” Power Spectral Density

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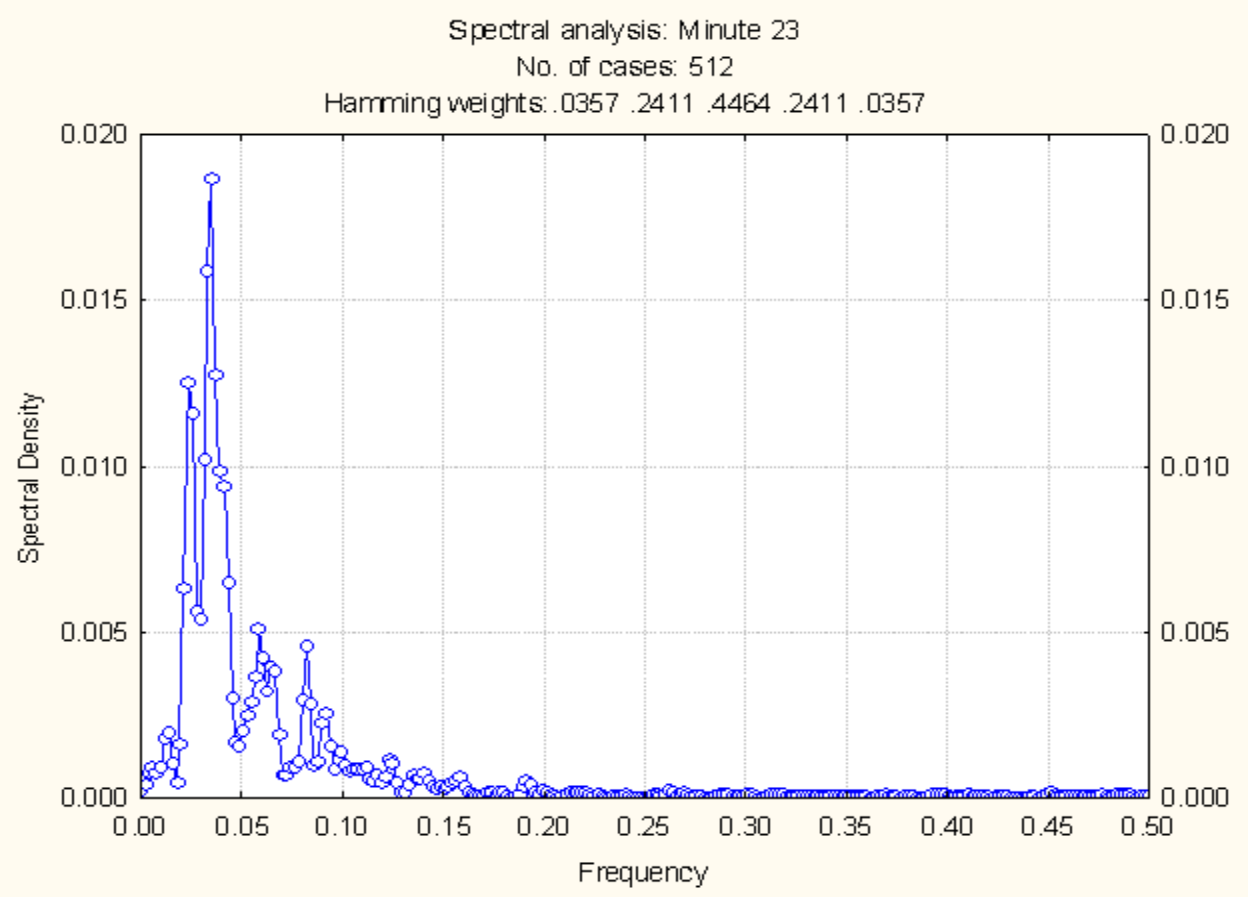
Current “Noise” PSD



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Current “Noise” Autocorrelation Functions

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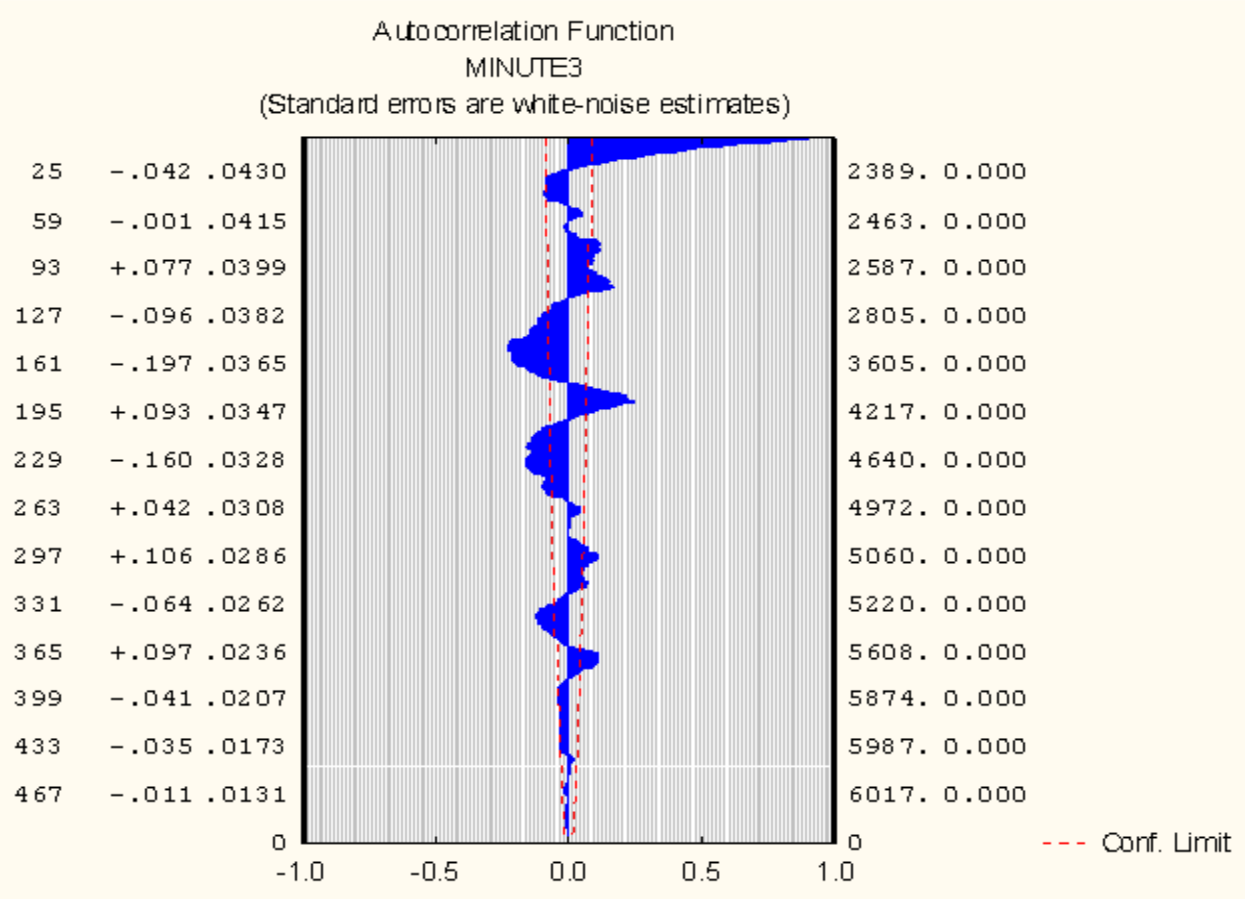
Current “Noise” Autocorrelation



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Cross Comparison – Bubbleogram vs. Current Noise - Waveforms

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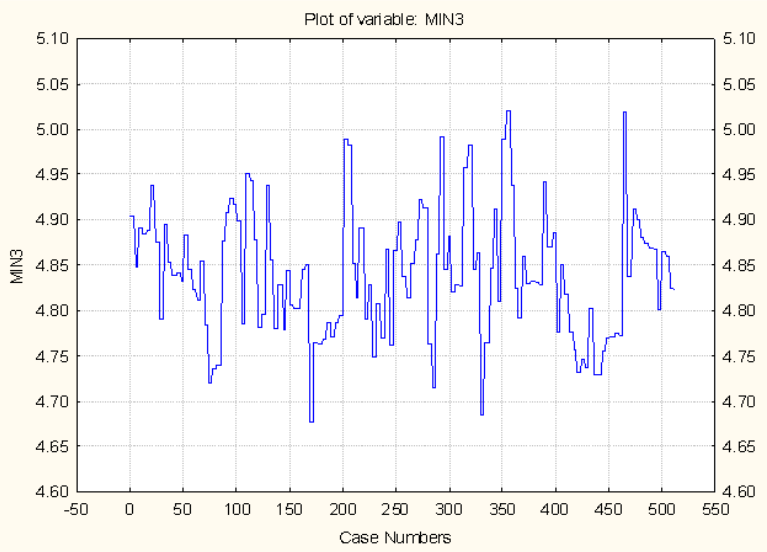
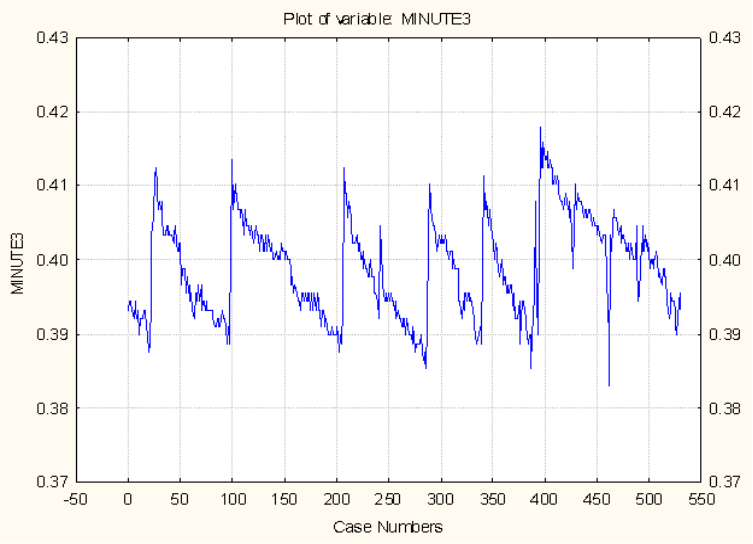
Waveforms



Bubbleogram



Current Noise

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Cross Comparison – Bubbleogram vs. Current Noise – Power Spectral Density

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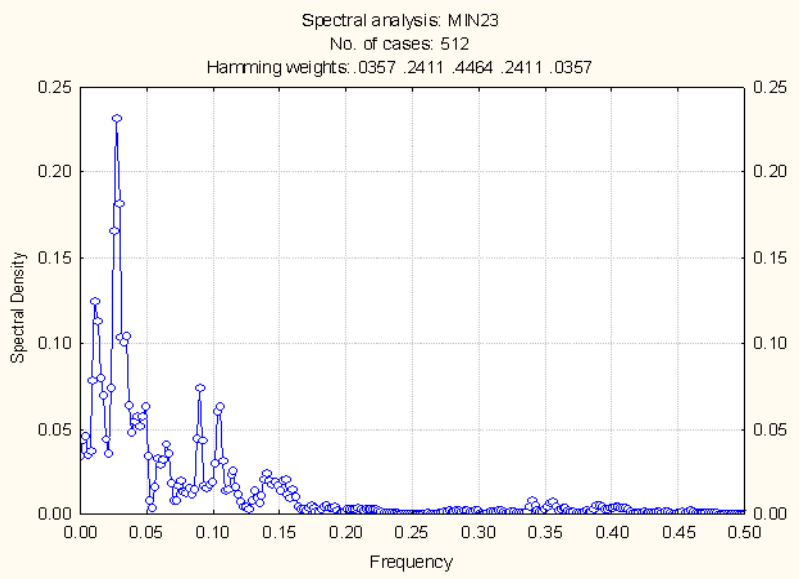
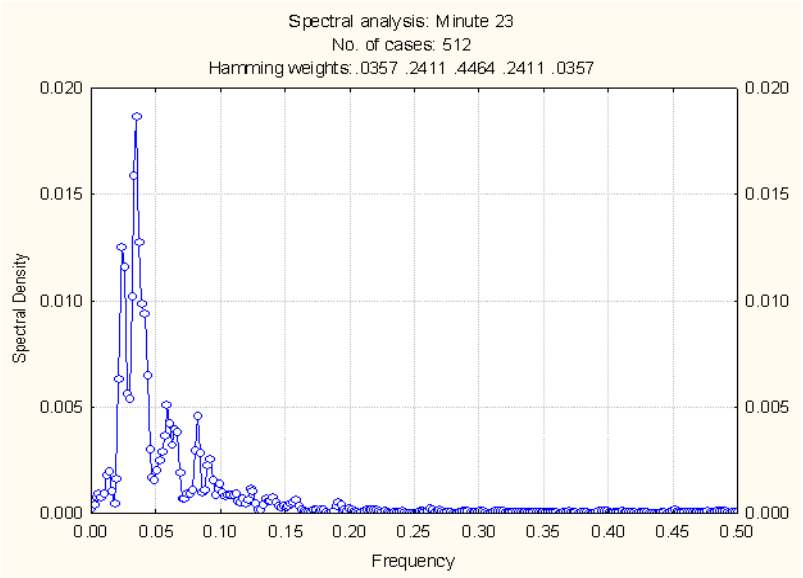
Power Spectral Density



Bubbleogram



Current Noise

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Cross Comparison – Bubbleogram vs. Current Noise – Autocorrelation

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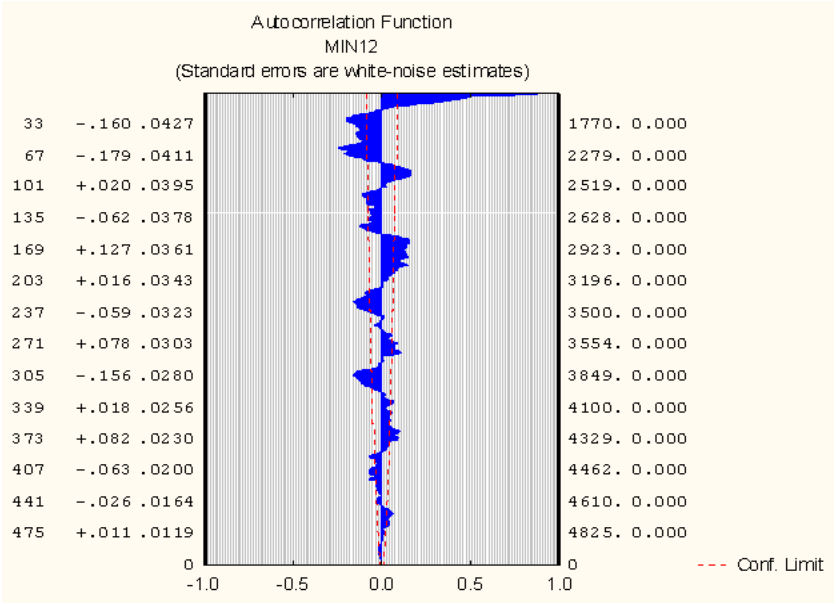
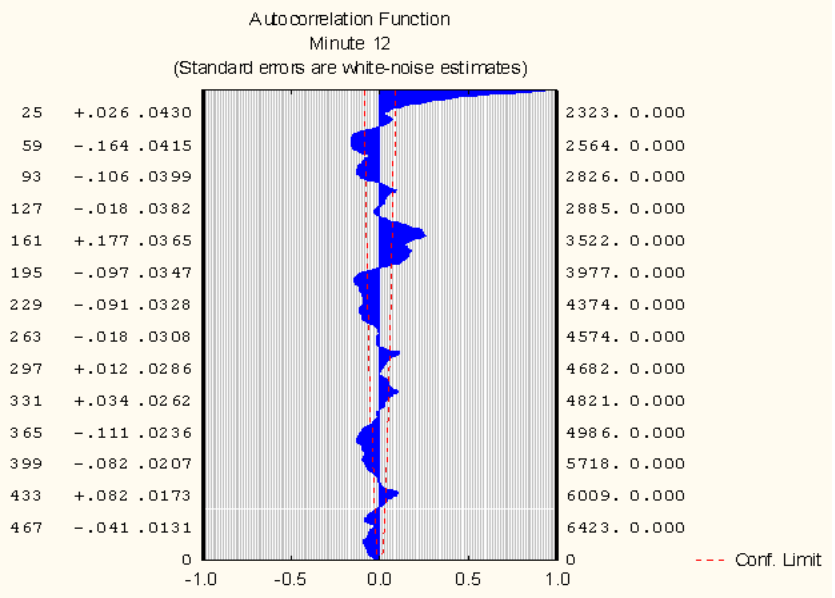
Autocorrelation



Bubbleogram



Current Noise

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System Control Parameter Extraction - Amplitude

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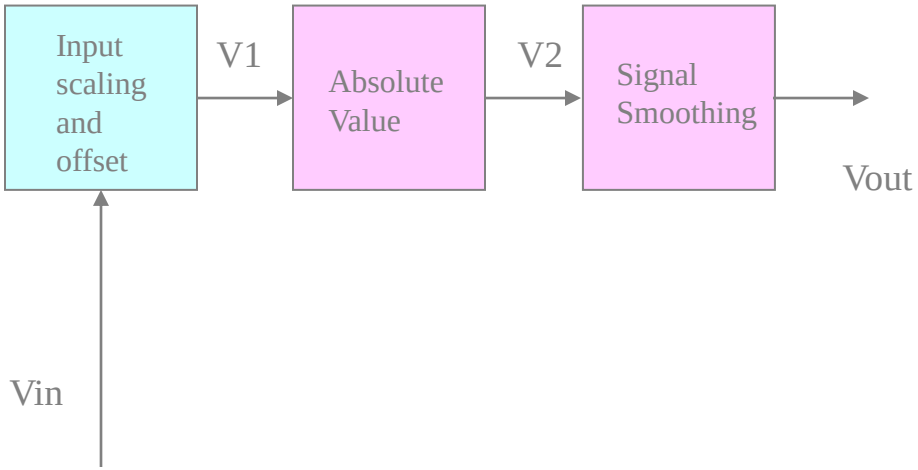
Concept 1 – Absolute Amplitude Feedback



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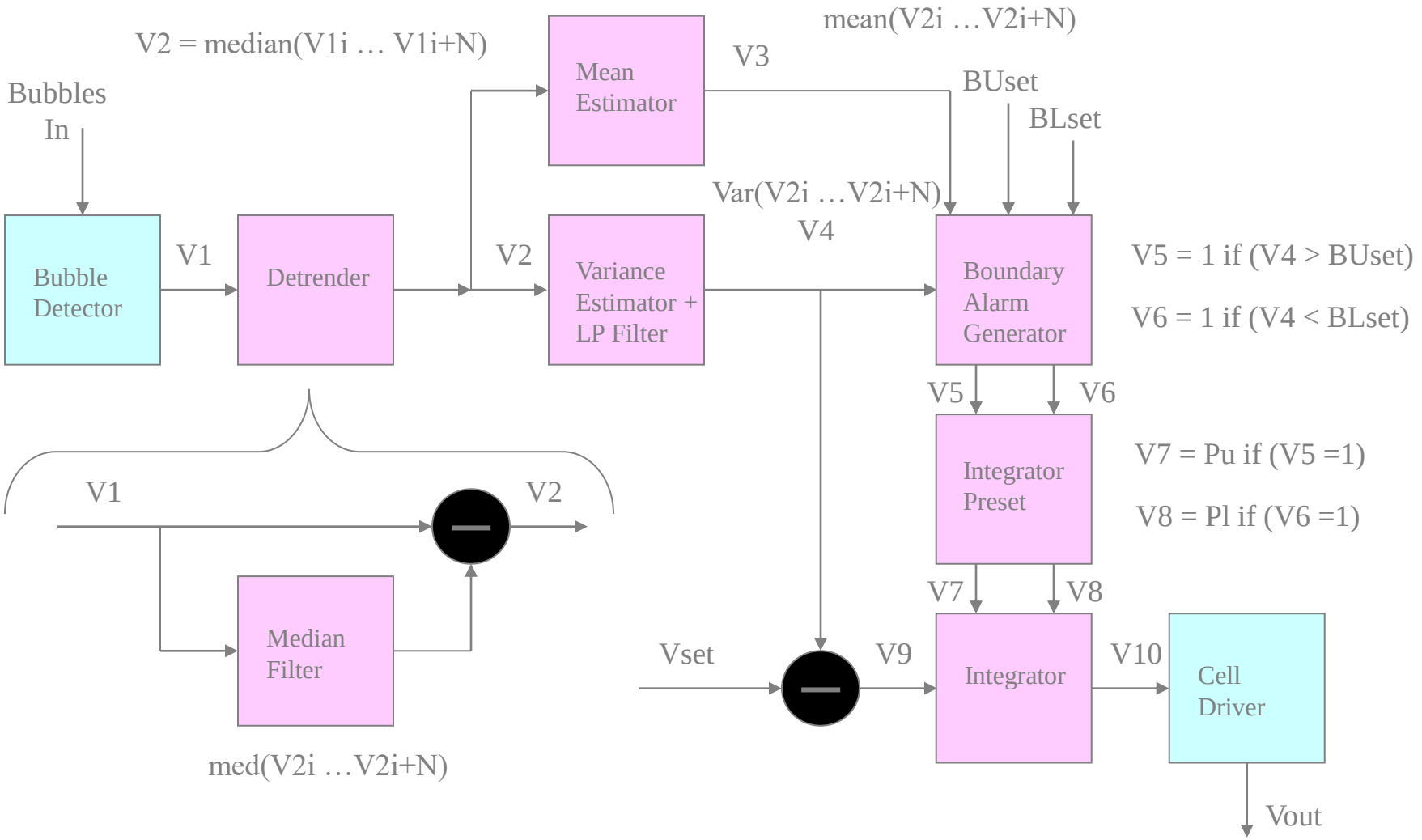
Concept 2 – Detrended Abs Amplitude Feedback



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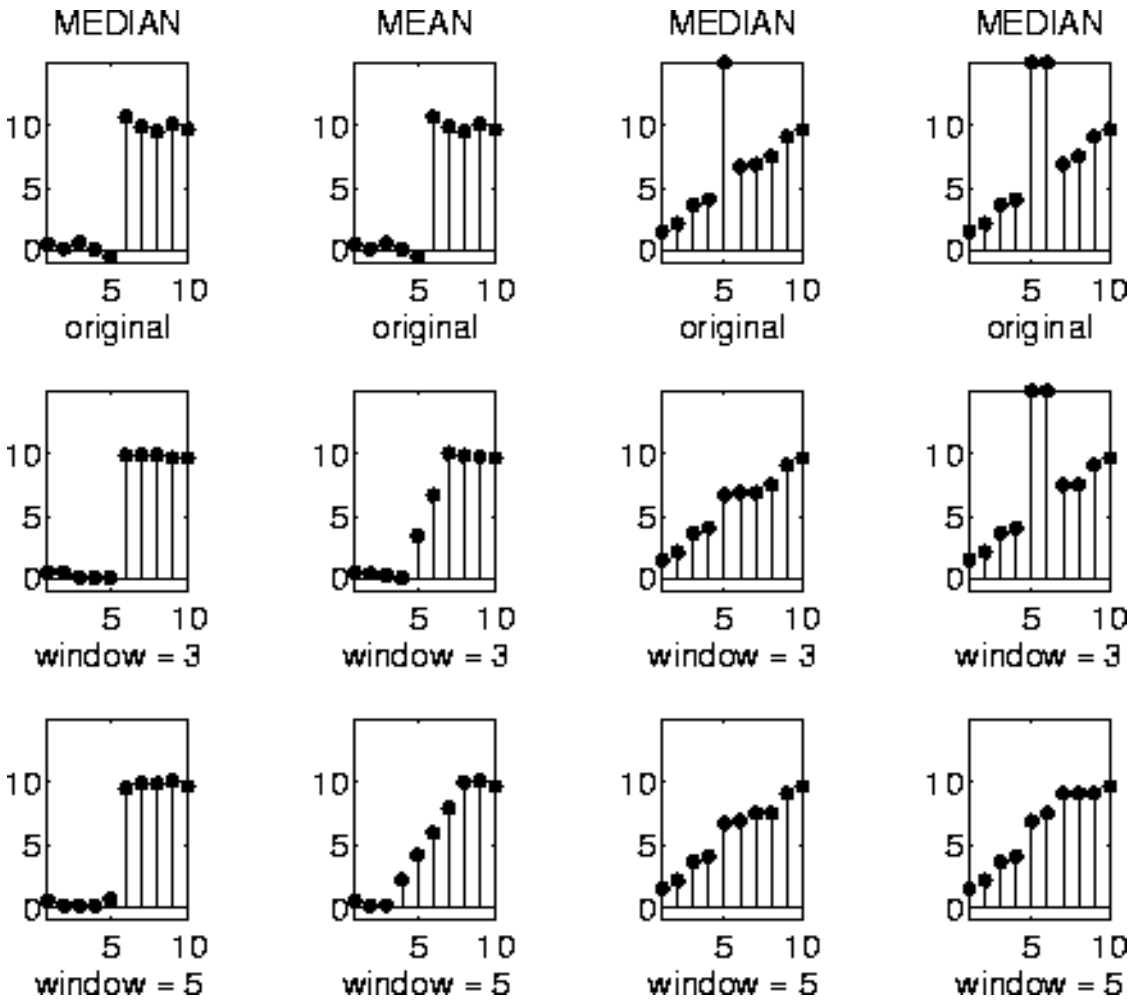
The “Median” Filter



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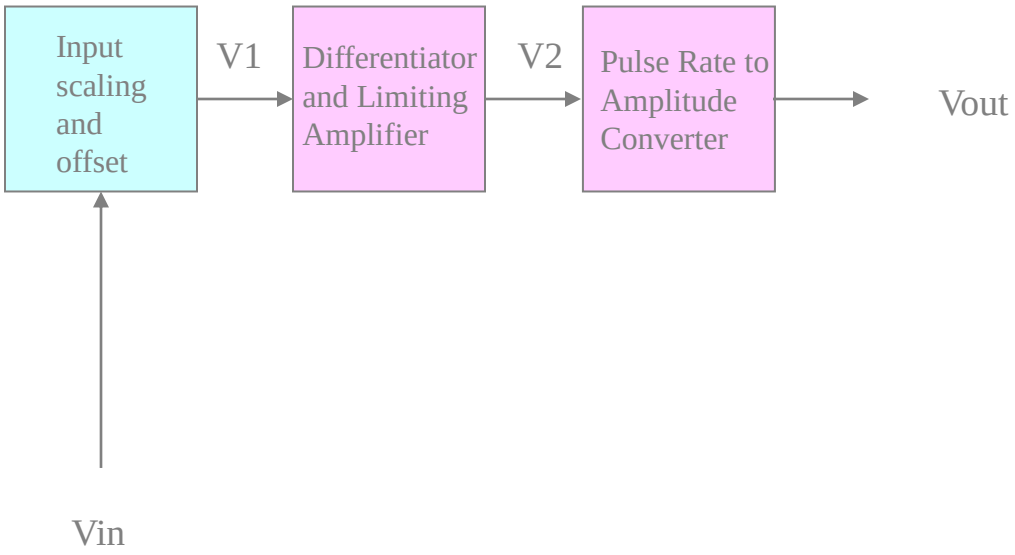
Concept 2 – Bubble Rate Feedback



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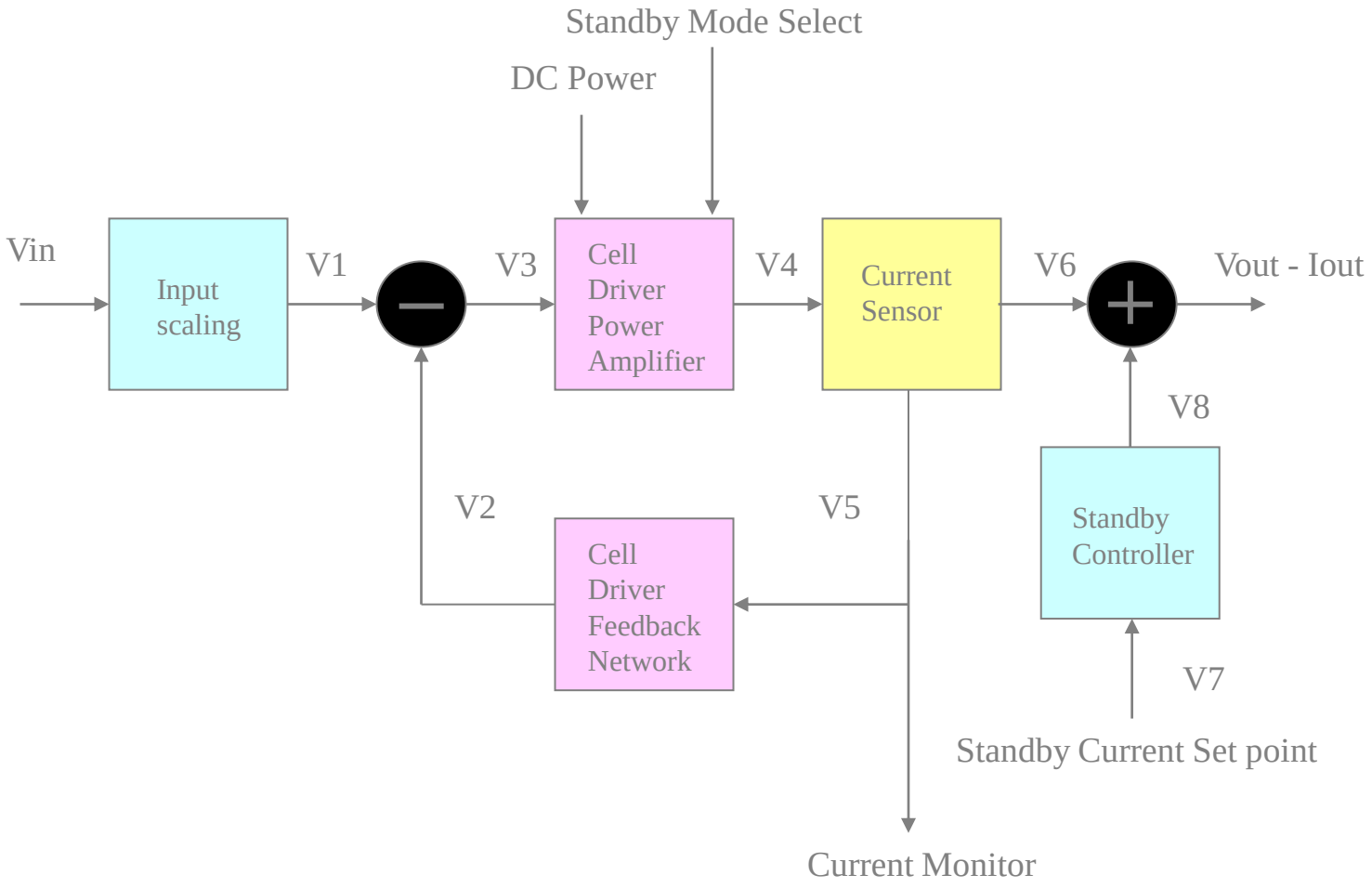
Cell Driver – Block Diagram



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Summary and Conclusions

A system concept has been developed and presented

A parameter extraction strategy has been presented

These methods can be used to extract gas fraction information from gas bubble sensing devices

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