DESIGN PRODUCT SPECTRUM ANALYZER USING ARDUINO TO ANALYZE SIGNAL SPECTRUM IN 32-BAND AUDIO

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Abstract

The role of the Spectrum Analyzer becomes very important for song editors, however it turns out that Spectrum Analyzer for these needs is still difficult to find, which generally exists only for needs with a limited frequency range for other needs besides song correction needs that require a 32-band audio signal spectrum. In addition, Spectrum Analyzer for 32-band audio signal spectrum generally integrated in a set of audio system devices that are relatively expensive and not separated, even though not all features of the audio system are used by editors. Arduino MEGA Board is available with an Analog to Digital converter (ADC) feature that is used to convert audio input signals into digital samples. The ADC is configured to sample the input signal with a clock frequency of 38.46 kHz. This is achieved by configuring the ADC pre-scaler to 32. Sampling frequency of 38.64 kHz means that digital samples can reproduce input frequencies up to 19.32 kHz (Nyquist theorem) which is good enough for audio signals. The result analysis from spectrum analyzer product can be used as song or music correction, the 32-band audio graphic bar will show if the audio signal run properly. The mark up pricing method used on Sales price analysis. New innovation to combine 2 functions into 1 product design. The analysis survey of this product shows that all respondents very agree if this product marketed at a low price compared to the previous products.

Keywords: Spectrum Analyzer, Arduino Mega, Result Analysis, Song, 32-Band Audio, Mark Up Pricing, Innovation and Low Cost.

1. Introduction

Spectrum Analyzer is an electronic device used to measure the magnitude of the amplitude of the input signal displayed in the form of a frequency spectrum that can be seen visually. Frequency spectrum is the arrangement of frequency bands in units of vibration of electromagnetic waves that propagate in air space. The results of the frequency spectrum can be used to analyze signal patterns, so that the types of signals can be distinguished according to the frequency range that was successfully received. From the results of the previous research, this design product (Spectrum Analyzer) has been hit with costs and only certain people can use it. Related to the research that has been done on this design product, this thesis made more specific as an alternative to Spectrum Analyzer product design for music correction needs. With the aim of Spectrum Analyzer can be utilized by everyone because it easy to use and made with relatively very low cost. In addition, the results of the Spectrum Analyzer product design can be used as a basis for the development of similar products or other researches.

Clearly above, the equalizer will not be much of a use in song correction if it is not equipped with a Spectrum Analyzer. So the role of the Spectrum Analyzer becomes very important for song editors, however it turns out that Spectrum Analyzer for these needs is still difficult to find, which generally exists only for needs with a limited frequency range for other needs besides song correction needs that require a 32-band audio signal spectrum. In addition, Spectrum Analyzer 32-band audio signal spectrum is usually integrated with audio system devices that are relatively expensive and not available separately, even though not all features are useful for the editors.

Therefore, it is necessary to design a Spectrum Analyzer product for signal spectrum analyzer in 32-band audio. In this research, Arduino technology will be used to design products that can be used as alternatives with relatively cheap and affordable prices, which are separated from other audio system devices, so that they are easy to use, easily made at relatively low cost, so that more people can use it.

2. Basic Concept

2.1 Spectrum Analyzer

Analysis of a signal can simply be defined as checking information signal in the frequency domain and time domain. Signal analysis in the time domain is done by means of an oscilloscope, while signal analysis in the frequency domain is done by using a spectrum analyzer.

2.2 Audio

Audio or Sound is a physical phenomenon produced by the vibrations of matter. The use of sound can make a difference between a normal multimedia presentation and a professional multimedia presentation.

2.3 Audio Spectrum

Audible frequency range at which humans can hear and spans from 20 Hz to 20,000 Hz. The audio spectrum range spans from 20 Hz to 20,000 Hz and can be effectively broken down into seven different frequency bands, with each band having a different impact on the total sound.

2.4 Design Product

Product Design is a management tool for translating the results of research and development activities carried out before becoming a tangible design that will be produced and sold for profit.

2.5 Arduino

Arduino is an electronic prototyping platform based on an open source that is flexible and easy to use both in terms of hardware and software. Beyond that, the main strength of Arduino is the large number of users so that there is a large amount of code library and code support modules (hardware support modules) availability. This makes it easy for beginners to get to know the world of microcontrollers.

3. Design Product and Proposed Techniques

3.1 Product Description

Spectrum analyzer product is currently available if generally integrated with other audio devices, so it is relatively expensive and difficult to develop or modify for other needs. For example for the needs of song correction, etc. Spectrum analyzer product to be designed that is simpler and is not integrated with other devices will be cheap and can be used and widely used by many people. The product design in this study will use Arduino technology.

3.2 Hardware Design

Schematic diagram used in the hardware design of the Spectrum Analyzer product design in this study can be seen in the picture below as follows:

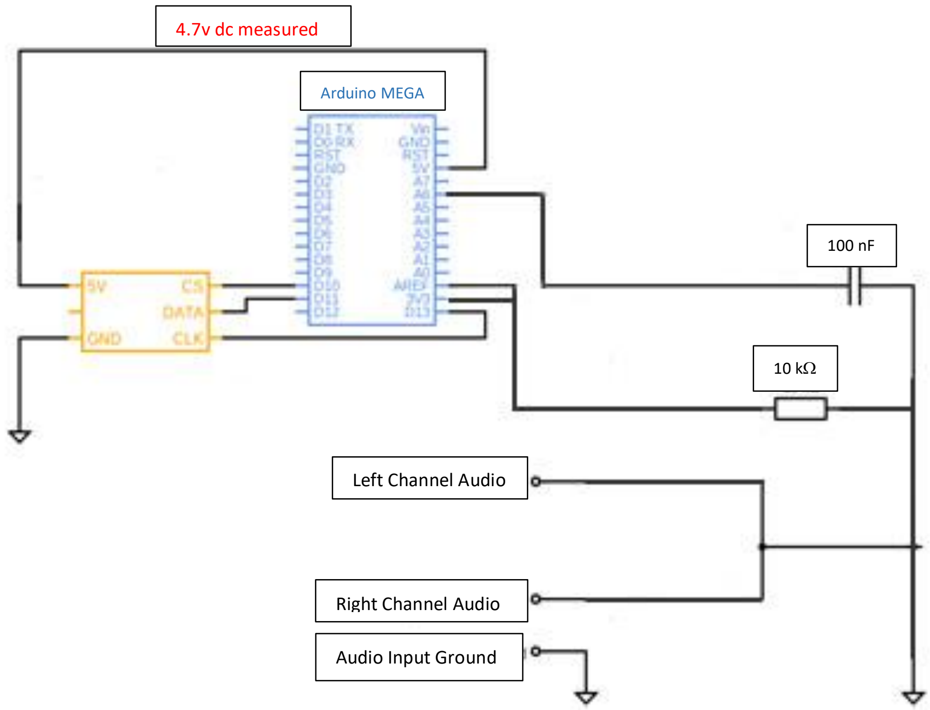

Figure 3.1 Diagram Scheme

Arduino MEGA Board is available with an Analog to Digital converter (ADC) feature that will be used to convert audio input signals into digital samples. The ADC is configured to sample the input signal with a clock frequency of 38.46 kHz. This is achieved by configuring the ADC pre-scaler to 32. Sampling frequency of 38.64 KHz means that digital samples can reproduce input frequencies up to 19.32 KHz (Nyquist theorem) which is good enough for audio signals.

3.3 Software Design

The Arduino FFT Library is the main core of the code that translates analog input signals into the frequency spectrum. Arduino FFT can be easily used and produces the best and most accurate output for this research. The product design is configured to make 64 samples and performs FFTs with these samples. The Arduino FFT Library can do FFT samples between 16 and 128, this can be configured in the Arduino program. But the Arduino FFT library is slow for calculations with 128 samples, so in this study it still uses 64 of the best samples.

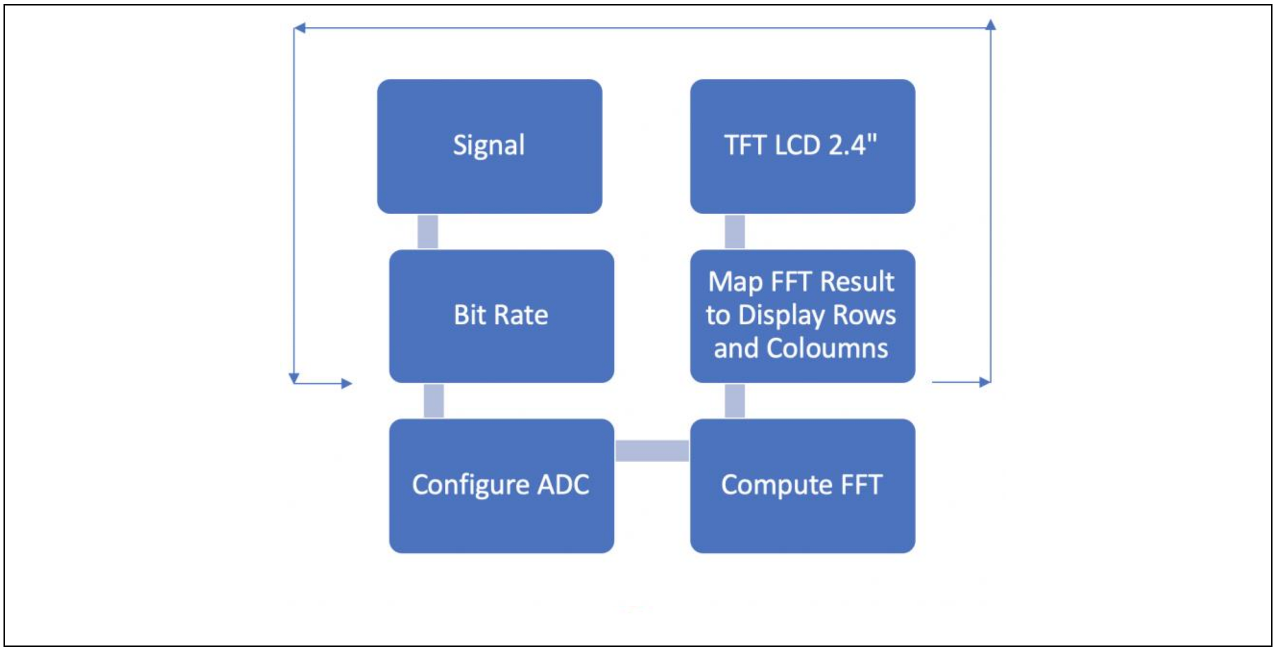

Figure 3.2 Arduino Program Diagram

3.4 Product Testing

3.4.1 Arduino MEGA Testing

Arduino MEGA testing is done by programming the hardware by making one of the analog input pins into positive and negative values, which are 0 and 1, repeatedly with a 100ms delay. Then, the voltage coming out of the analog input pin is measured using a multi tester voltmeter.

3.4.2 TFT LCD Testing

The TFT LCD test will be used by Arduino MEGA as an output to display the spectrum results that have been processed by FFT and the results of the previous analog to digital converter outputs. Testing needs to be done so that it looks reliable from time to time giving the appropriate appearance.

3.5 Training Kit Low Pass Filter Module

Resistor and Capacitor are the important components to make a Low Pass Filter circuit. This os the diagram scheme of low pass filter circuit.

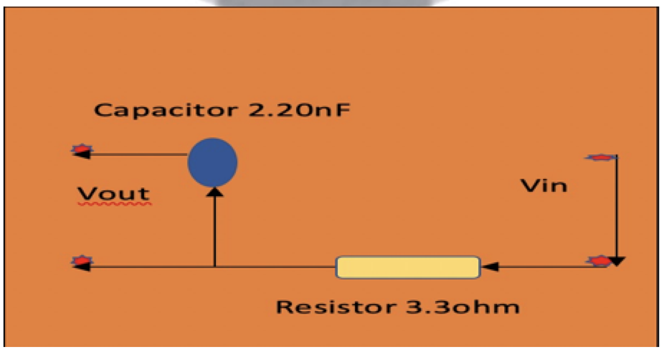

Figure 3.3 Low Pass Filter Circuit

3.6 Hypothesis Analysis

Based on figure 3.6 and 3.7 final ADC result analysis the ADC value when graphic bar on maximum high position is 115, ADC value when graphic bar on minimum low position is 31 and ADC value when no input on spectrum analyzer. The scene analysis of this thesis are ADC value, bit rate, sampling rate, signal processing method, and fast fourier transform (FFT).

4. Result and Analysis

4.1 TFT LCD Result Analysis

The TFT LCD test will be used by Arduino MEGA as an output to display the spectrum results that have been processed by FFT and result of the previous analog to digital converter outputs. Testing needs to be done so that it looks reliable from time to time giving the appropriate appearance.

4.2 32-Band Audio Spectrum Analyzer Result Analysis

32-band audio signal spectrum testing is done to see the effectiveness of the product design to be used to display the 32-band audio signal spectrum.

4.3 32-Band Audio Spectrum Analyzer Program Analysis

From the program script that is embedded into Arduino MEGA through the Arduino IDE application, it can be seen that it is divided into 2 sections: the script function and loop function.

```
void setup() {
  // put your setup code here, to run once:
    Serial.begin(9600);

    ADCSRA = 0b11100101;        // set ADC to free running mode and set
pre-scalar to 32 (0xe5)
    ADMUX = bit(REFS0) | (5 & 0x07);

    tft.reset();
    uint16_t ID = tft.readID();
    tft.begin(ID);
    tft.setRotation(1);
    //tft.invertDisplay(true);
    tft.fillScreen(BLACK);

    delay(500);            // wait to get reference voltage stabilized
}
```

Figure 4.1 Program Spectrum 32-Band Audio Section Setup Script

```
void loop() {
  // put your main code here, to run repeatedly:


    // ++ Sampling
   for(int i=0; i<SAMPLES; i++)
    {
      while(!(ADCSRA & 0x10));        // wait for ADC to complete
current conversion ie ADIF bit set
      ADCSRA = 0b11110101 ;               // clear ADIF bit so that
ADC can do next operation (0xf5)

      Serial.println(ADC);
      int value = 0;

      if(ADC < 512){
        value = adc - 512 ;                 // Read from ADC and
subtract DC offset caused value
        value = value / 8;
      } else {
        value = 0;
      }

      vReal[i]= value;                      // Copy to bins after
compressing
      vImag[i] = 0;

    }
    // -- Sampling

    // ++ FFT
    FFT.Windowing(vReal, SAMPLES, FFT_WIN_TYP_HAMMING, FFT_FORWARD);
    FFT.Compute(vReal, vImag, SAMPLES, FFT_FORWARD);
    FFT.ComplexToMagnitude(vReal, vImag, SAMPLES);
    // -- FFT


    // ++ re-arrange FFT result to match with no. of columns on
display ( xres )
    int step = (SAMPLES/2)/xres;
    int c=0;
```

```
    for(int i=0; i<(SAMPLES/2); i+=step)
    {
      data_avgs[c] = 0;
      for (int k=0 ; k< step ; k++) {
          data_avgs[c] = data_avgs[c] + vReal[i+k];
      }
      data_avgs[c] = data_avgs[c]/step;
      c++;
    }
    // -- re-arrange FFT result to match with no. of columns on
display ( xres )

    // ++ send to display according measured value
    for(int i=0; i<xres; i++)
    {
      data_avgs[i] = constrain(data_avgs[i],0,80);            // set
max & min values for buckets
      data_avgs[i] = map(data_avgs[i], 0, 80, 0, yres);        //
remap averaged values to yres
      yvalue=data_avgs[i];

      peaks[i] = peaks[i]-1;    // decay by one light
      if (yvalue > peaks[i])
          peaks[i] = yvalue ;
      yvalue = peaks[i];
      displayvalue=MY_ARRAY[yvalue];
      displaycolumn=31-i;

      DV[displaycolumn] = yvalue;

    }

    show_column32(DV);

    // -- send to display according measured value


}
```

Figure 4.2 Program Spectrum 32-Band Audio Section Loop Script

4.4 32-Band Audio Spectrum Analyzer Product Design Analysis

Judging from the product design, the product can be made easily and the cost is relatively cheap because it only consists of a few simple components.

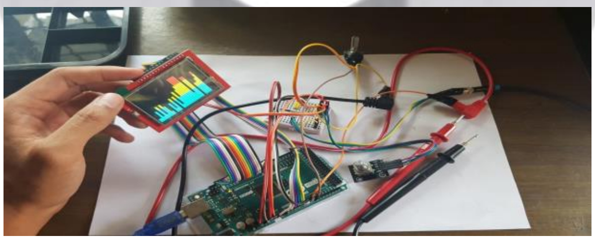

Figure 4.3 The Design of Spectrum Analyzer Product

4.5 Low Pass Filter Result Analysis on 32-Band Audio Spectrum Analyzer

The conclusion bar graph shows the results decreased or we can call a low pass filter and the result of 32 Band Audio waves when we input the low pass filter are many waves low or empty because the low pass filter affects the stability of the 32 Band Audio in Spectrum Analyzer.

Figure 4.4 Low Pass Filter Result

4.6 Survey Analysis

In working on a project or a product, we need a survey analysis from different parties before the products are ready to be sold at the market place. This is a customer satisfaction survey with the Spectrum Analyzer that has been tested by each respondent. Questions asked of respondents from the all students of Electrical Engineering Faculty of Telkom University:

Table 4.1 Spectrum Analyzer Table Survey Analysis

Survey Analysis of Electrical Engineering Telkom University Student								
NO	Name	Major	NIM	Question	Very Agree	Agree	Disagree	Very Disagree
1	Andika Yudistira	Electrical Engineering	1102154146	1. Are you satisfied with the quality of our products?		✓		
				2. Do you agree if our product will be marketed at a price below the average?	✓	✓		
				3. Do you agree if we add training kits in addition to Low Pass Filter feature?	✓			
				4. Do you feel helped by our products?		✓	✓	
2	Ifan Fadila	Telecommunication Engineering	1101154207	1. Are you satisfied with the quality of our products?		✓		
				2. Do you agree if our product will be marketed at a price below the average?	✓			
				3. Do you agree if we add training kits in addition to Low Pass Filter feature?	✓	✓	✓	
				4. Do you feel helped by our products?	✓	✓		
3	Muhammad Hafidz Erdityo	Electrical Engineering	1102150043	1. Are you satisfied with the quality of our products?	✓			
				2. Do you agree if our product will be marketed at a price below the average?	✓			
				3. Do you agree if we add training kits in addition to Low Pass Filter feature?		✓	✓	
				4. Do you feel helped by our products?		✓		
4	Solihatul Jannah	Telecommunication Engineering	1101154446	1. Are you satisfied with the quality of our products?		✓		
				2. Do you agree if our product will be marketed at a price below the average?	✓	✓		
				3. Do you agree if we add training kits in addition to Low Pass Filter feature?		✓		
				4. Do you feel helped by our products?		✓		
5	Wisnu Aji Nugroho	Electrical Engineering	1102154127	1. Are you satisfied with the quality of our products?		✓		
				2. Do you agree if our product will be marketed at a price below the average?	✓	✓		
				3. Do you agree if we add training kits in addition to Low Pass Filter feature?		✓		
				4. Do you feel helped by our products?	✓	✓		

4.7 Sales Price Analysis

From the Table Capital Raw Material for our Product is Rp. 878.800, and the Markup we want to add is 20%. The reason for choosing 20% profit is to make this product as a massive production to be circulated on the market and to attract customer by offering products that have two advantages in one product that will be sold in the market with affordable prices.

Selling Price = Rp. 878.800 + (Rp. 878.800 × 20%)   *Selling Price= Rp. 1.054.560/Product*

So, the profit that we can get is Rp. 175.760/Product, and the selling price Rp. 1.054.560/Product.

4.8 Low Pass Filter LTSpice Simulator Analysis on Spectrum Analyzer

In determining the difference in using the Low Pass Filter feature on the Spectrum Analyzer product, the author used capacitor and resistor values that produce a cut off frequency value of 2.28 KHz. With a capacitor value of 2.2 uF and a resistor of 3.3 Ω. The 32 Band Audio Spectrum Analyzer product designs used in this study are only classified in the range of 280Hz-4200Hz, 4200Hz-9000Hz, 9000Hz-14400Hz, 14400Hz-18000Hz, 18000Hz-18600Hz. The 32 Band Spectrum Analyzer product design is limited to a minimum of 280Hz frequency, and a maximum of 18600Hz frequency. So here is the LPF on Spectrum result analysis which can be seen in the figure as follows:

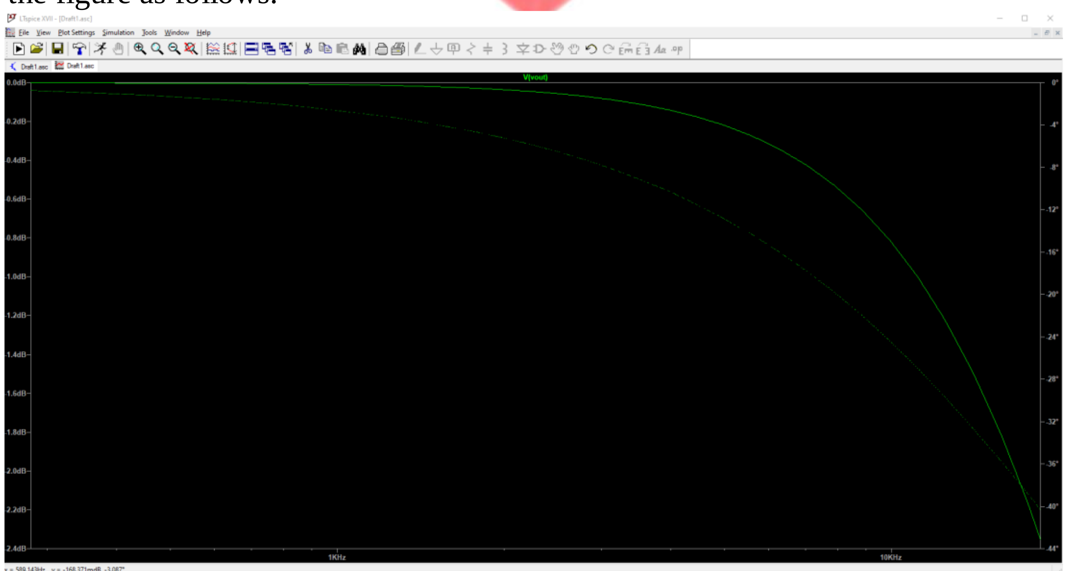

Figure 4.5 LPF on Spectrum Analyzer using LTspice Application

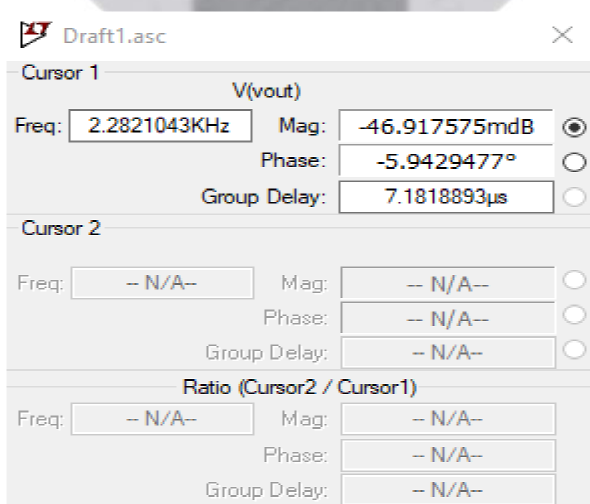

Figure 4.6 Cut-Off Frequency Value

5. Conclusion and Suggestion

5.1 Conclusion

Based on the analysis and discussion that has been done on spectrum analyzer products the results are as follows:

1. From the results of product design, product manufacturing and product testing, it can be proven that by using Arduino technology, product designs can be made that can be used for 32-band audio signal spectrum analysis.
2. The product design can also be used separately from the integrated audio system. The product design can be proven to function operationally using a 3.5mm male to male stereo jack cable and MP3 player.
3. From the results of product design, product manufacturing and product testing, it can also be concluded that Spectrum Analyzer products using Arduino technology can be easily used and are made with relatively low cost. The test result turned out to use only a few tools with relatively affordable costs to create a Spectrum Analyzer product design that can function properly. This product design was also proven to be used as an alternative to Spectrum Analyzer product design for song or music correction needs and can be utilized by more people, and in the future it can be used for the development of similar products or other researches.

5.2 Suggestion

Based on the results of the analysis that has been done with a spectrum analyzer product, then further research can develop on:

1. By perfecting the design of this Spectrum Analyzer product by using higher quality components.
2. It is recommended that this product design can be the basis for manufacturing a wider range of commercial products.
3. Another thing is the product design is recommended to be used in combination with other devices, since there is still a gap to perfect the product design.
4. It will also be better to be developed with various innovations with higher technology.

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