MERNI INFORMACIONI SISTEMI
MIS P01 2018

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Merni informacioni sistemi

- Status predmeta: **izborni**
- Broj ESPB: **8**
- Cilj predmeta:
  - **Osposobljavanje za projektovanje i razvoj mernih elektronskih kola i sistema.**
- Ishod predmeta:
  - **Sposobnost samostalnog rešavanja problema projektovanja mernih elektronskih kola, uređaja i sistema.**

Sadržaj predmeta 1/3

- Merenja u prostorno-distribuiranim procesnim sistemima
- Telemetrija
- Merni signali, njihova obrada i prenos
- Osnovna kola za analognu i digitalnu obradu mernih signala
- Programabilnost kao svojstvo mernih uređaja
- Programabilni merni sklopovi, programabilni merni instrumenti
- Programabilni kondicioneri mernih signala
- Statičke i dinamičke karakteristike, strukturne komponente, osnovni tipovi
- Višefunkcijski programabilni merni instrumenti i sistemi

Sadržaj predmeta 2/3

- Višefunkcijski programabilni merni instrumenti i sistemi
- Programabilnost i zakonska metrologija
- Mikroračunarski merni sistemi
- Funkcije, arhitektura, način rada i osnovne karakteristike
- Osnove komunikacija u mernim sistemima
- Interfejsni sistemi u mernoj tehnici
- Interfejsi za serijski prenos podataka, interfejsi za paralelni prenos podataka
- Standardi za interfejs programabilnih mernih uređaja (GPIB-interfejs)

Sadržaj predmeta 3/3

- Personalni računar kao kontroler mernog sistema
- SCADA-sistemi
- Standardi za prenos podataka u sistemima daljinskog nadzora i upravljanja
- Merenje u svrhe obračuna
- Prikupljanje i lokalna obrada mernih podataka, daljinsko merenje, standardi za daljinski prenos mernih podataka u svrhe obračuna
- Zaključna razmatranja
- Pravci daljeg stručnog usavršavanja

Pismeni ispit 40 i usmena odbrana seminarskog rada 40

Literatura

1. P. Bošnjaković, D. Prokin, Industrijska metrologija, VIŠER, 2015.
2. V. Drndarević, Personalni računari u sistemima merenja i upravljanja, Akademska misao, Beograd, 2003.
3. N. Kirianaki et al, Data Acquisition and Signal Processing for Smart Sensors, John Wiley and Sons, 2002.
4. Gray R., Hurst P, Lewis S., Meyer R., Analysis and design of analog integrated circuits, Willey, 2001.
5. D. Živković, M. Popović, Impulsna i digitalna elektronika, Akademska misao, Beograd, 2004.

Metode izvođenja nastave

- ✓ Nastava je organizovana putem predavanja, auditornih i laboratorijskih vežbi
- ✓ Ocena znanja (maksimalni broj poena 100)
- ✓ Aktivnost u toku predavanja 10
- ✓ praktična nastava 10
- ✓ pismeni ispit 40
- ✓ seminarski 40

Computer-Based Instrumentation Systems

- Merni sistemi bazirani na računarima
  - **Računari imaju nisku cenu u odnosu na specijalno projektovano hardversko rešenje**
  - **Programabilnost**
  - **Paralelan rad**
  - **Multijezični sistemi**

Computer-Based Instrumentation Systems

1. Opisati operacije elemenata computer-based instrumentation system-a
2. Identifikovati vrste grešaka koje mogu da se pojave u instrumentacionom sistemu
3. Izbeću najčešće zamke kao što su uzemljene petlje, sprega šumova, opterećenje kod senzora
4. Odrediti specifikacije elemenata za computer-based instrumentation
5. Naučiti rad sa okruženjem i virtuelnim instrumentima, na primer LabVIEW

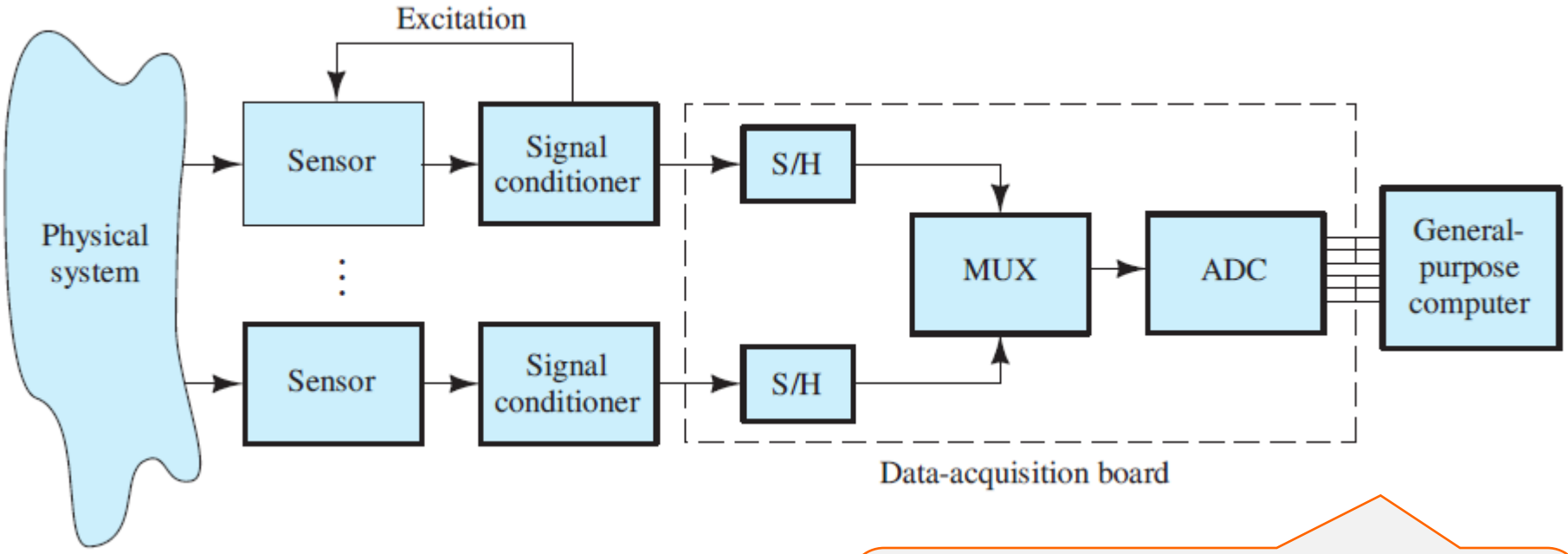
Embedded mikrokompjuter?

- Visoka cena razvojnih sistema programiranje embedded mikro-kompjutera-kontrolera
- Kada se visoka cena
- When these high costs are prenese na veliki broj jedinica, embedded računar i asemblersko programiranje može da postane najskuplja stavka
- Za unikatne instrumentacione i kontrolne sistema, embedded računarska rešenja su dugotrajna i skupa

>> LabVIEW

- Odmah sprena data-acquisition ploča
- **High-level softverski paketi**
- Računar opšte namene može da se koristi
  - ➢ može da se kombinuje za brzo projektovanje i izradu sofisticiranih instrumentacionih sistema i sistema za procesnim upravljanjem
  - ➢ posebno pogodno za unikatne sistemes

Računarski baziran DAQ sistem



$$V_{\text{sensor}} = k\ m$$

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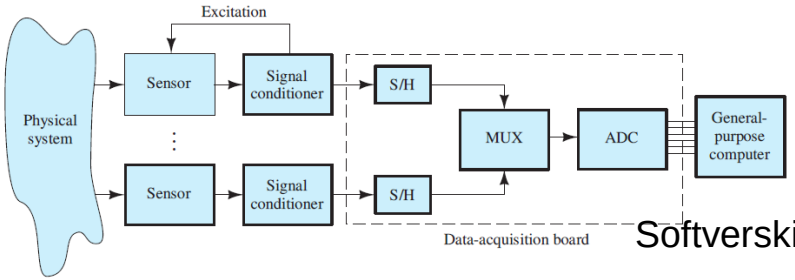
Računarski bazirana instrumentacija

- **Fizički sistem**
- **Senzori** – fizička pojava (temperatura, ugaona brzina, pomeranja, pritisak) proizvodi promene (iskazane kao napon, struja, otpornost, kapacitivnost, induktivnost)
- **Signalni uređaj (Signal conditioners)** obezbeđuje da se pobuda sa senzora transformiše u električne promene - izlaz senzora ne mora da generiše električni signal

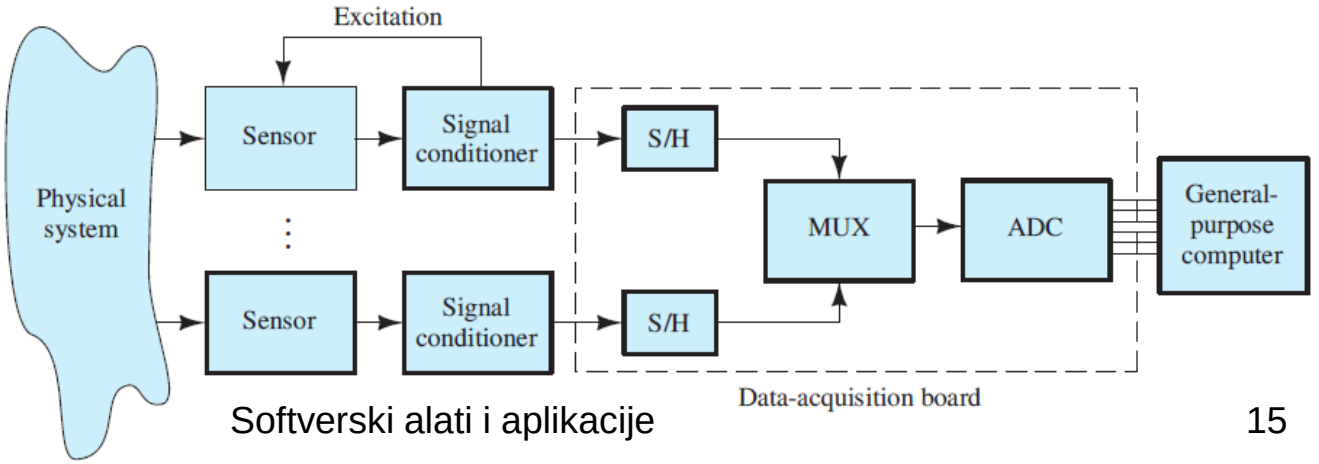
Signalni uređaj

- Pojačava i filtrira
- Ulaz u data-acquisition (DAQ) ploču
- Svaki izlazni signal signalnog uređaja se šalje na sample-and-hold (S/H) kolo koji periodično odabira-sempluje-odmerava-uzorkuje signal i čuva vrednos (koja se više ne menja)



Multiplexer + ADC

- Multiplekser (MUX) povezuje izlaze S/H na analogno-digitalni konvertor (converter) (A/D, ADC) koji konvertuje vrednost u digitalnu reč
- Ove reči se učitavaju u računar
- Sve dalje obrade se rade u računaru pre nego što se smeste u memoriju, pošalju dalje ili prikaže rezultat



Senzori

- Fizička veličina je ta koja se meri
- Napon na izlazu senzora srazmeran je tome što je izmereno
- k je konstanta osetljivosti,
  m je izmerena vrednost

$$V_{\text{sensor}} = \text{k m}$$

- Eksitacija u formi konstante

Acceleration	Seismic mass accelerometers
	Piezoelectric accelerometers
Angular displacement	Rotary potentiometers
	Optical shaft encoders
	Tachometric generators
Light	Photoconductive sensors
	Photovoltaic cells
	Photodiodes
Liquid level	Capacitance probes
	Electrical conductance probes
	Ultrasonic level sensors
	Pressure sensors
Linear displacement	Linear variable differential transformers (LVDTs) (see page 147)
	Strain gauges (see page 29)
	Potentiometers
	Piezoelectric devices
	Variable-area capacitance sensors
Force/torque	Load cells
	Strain gauges

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Fluid flow	Magnetic flowmeters (see page 776)
	Paddle wheel sensors
	Constriction-effect pressure sensors
	Ultrasonic flow sensors
Gas flow	Hot-wire anemometers
Pressure	Bourdon tube/linear variable differential transformer combinations
	Capacitive pressure sensors
Proximity	Microswitches
	Variable-reluctance proximity sensors
	Hall-effect proximity sensors
	Optical proximity sensors
	Reed-switch sensors
Temperature	Diode thermometers
	Thermistors
	Thermocouples

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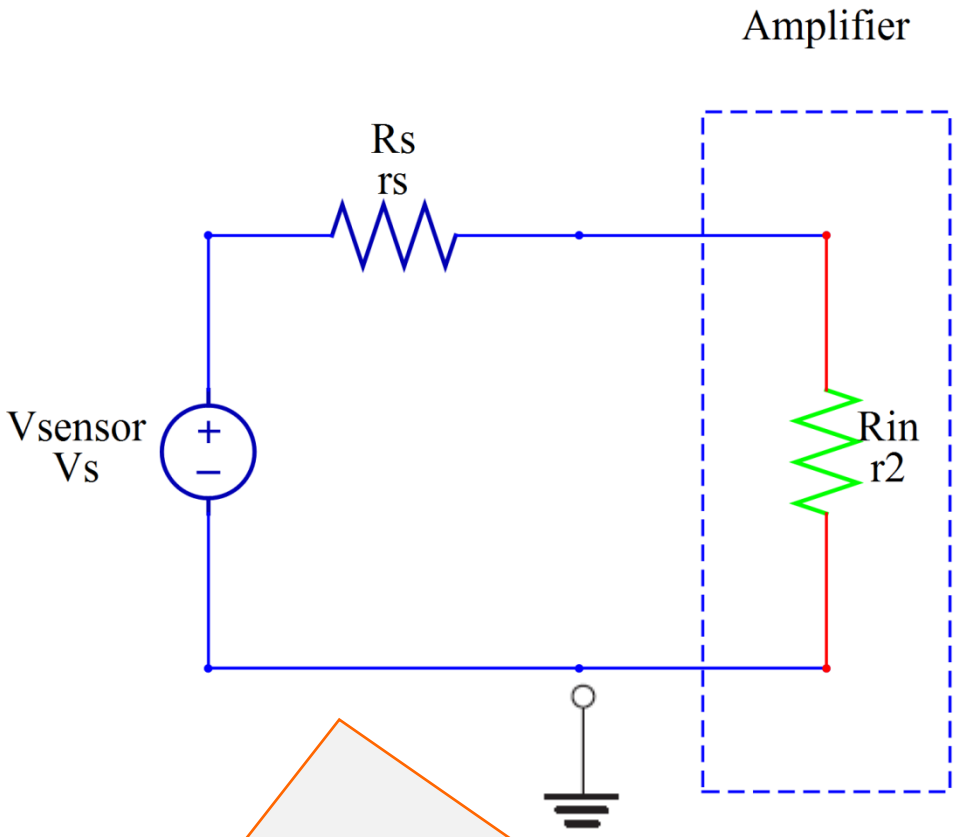
Model senzora

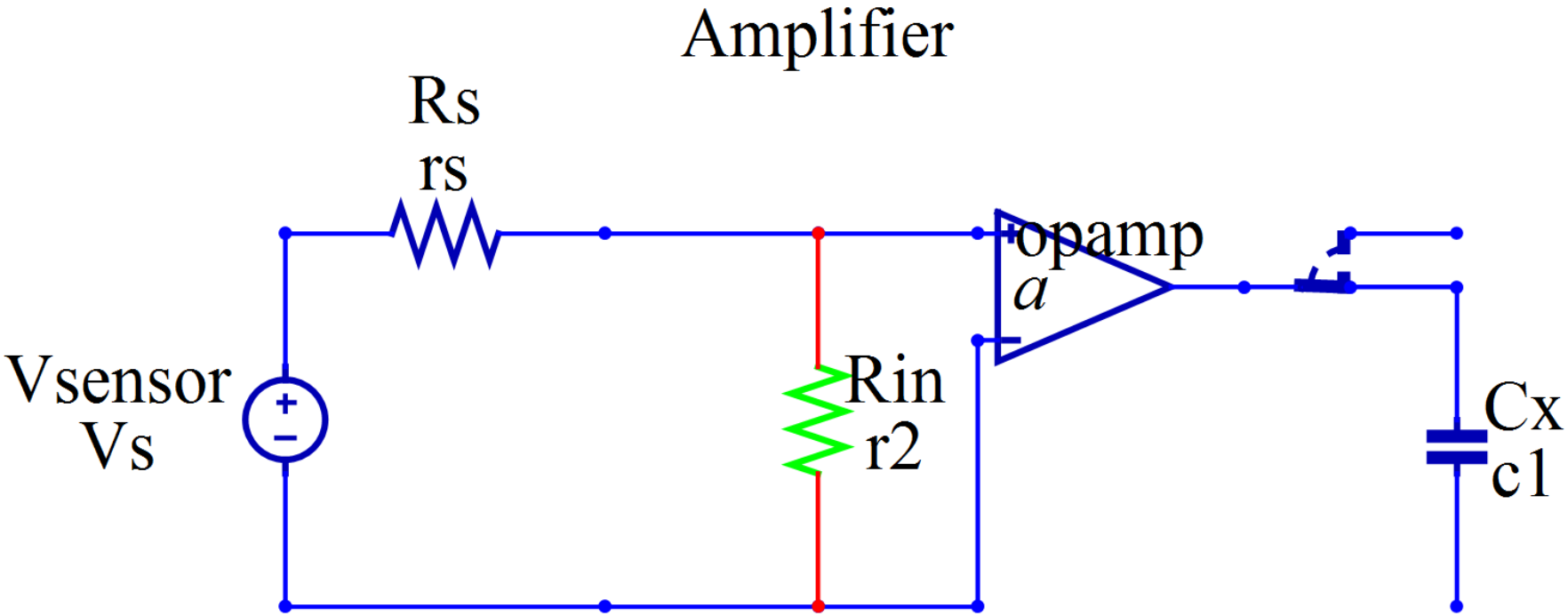


$$v_d = v_1 - v_2$$

$$v_{cm} = \frac{v_1 + v_2}{2}$$

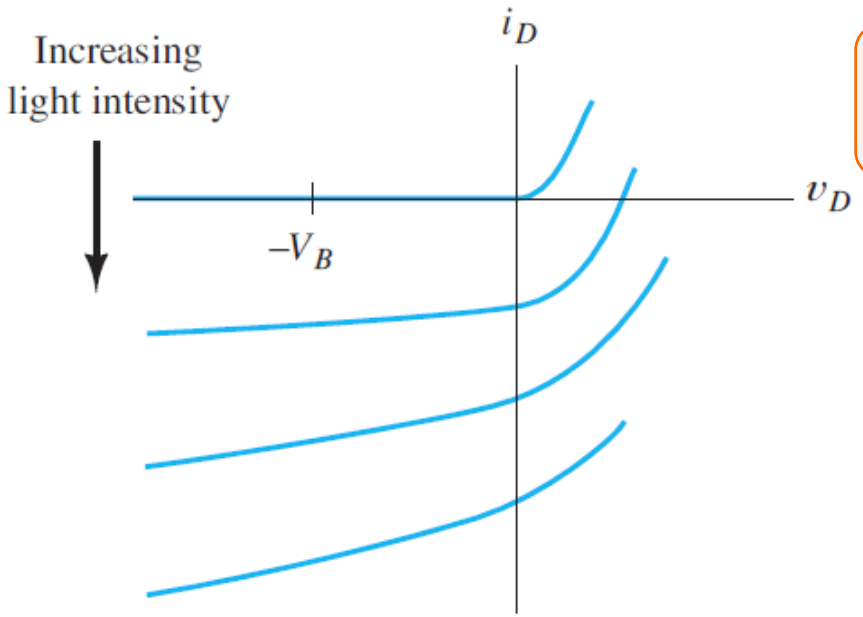
Model senzora povezanog na ulaz pojačavača

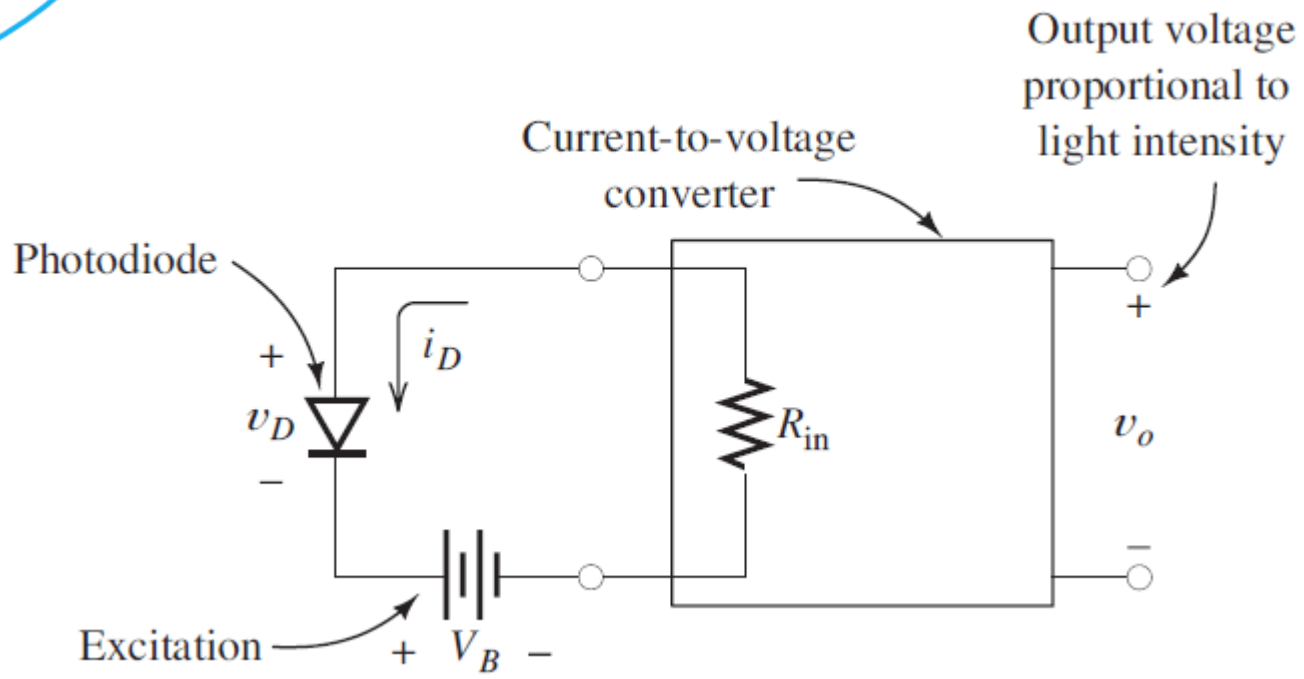
Sample-and-Hold kolo



Instrumentacioni pojačavač, diferencijalni signal, common-mode rejection ratio (CMRR)

current-to-voltage converter





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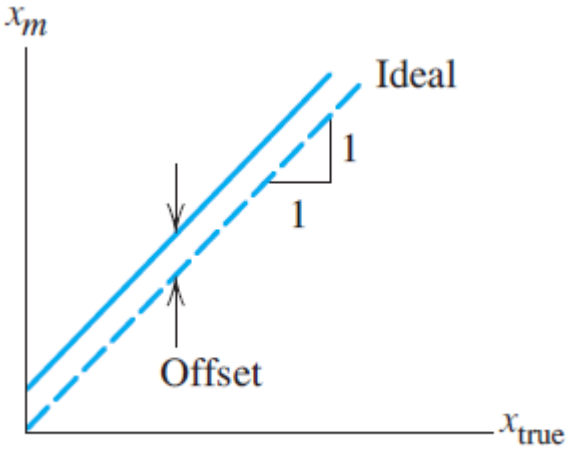
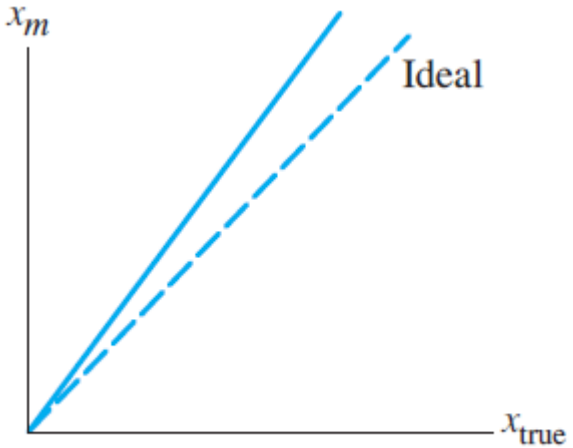
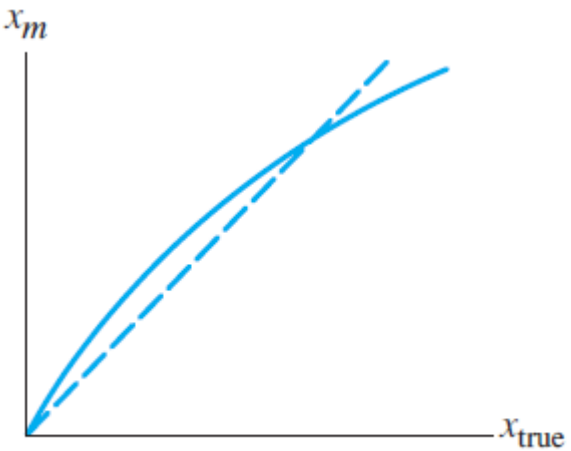


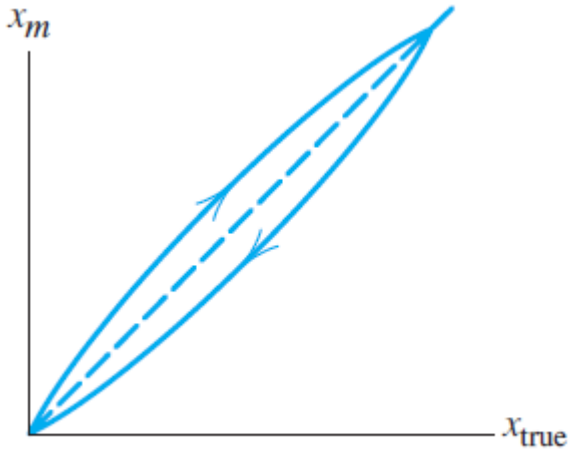
(a) Offset error



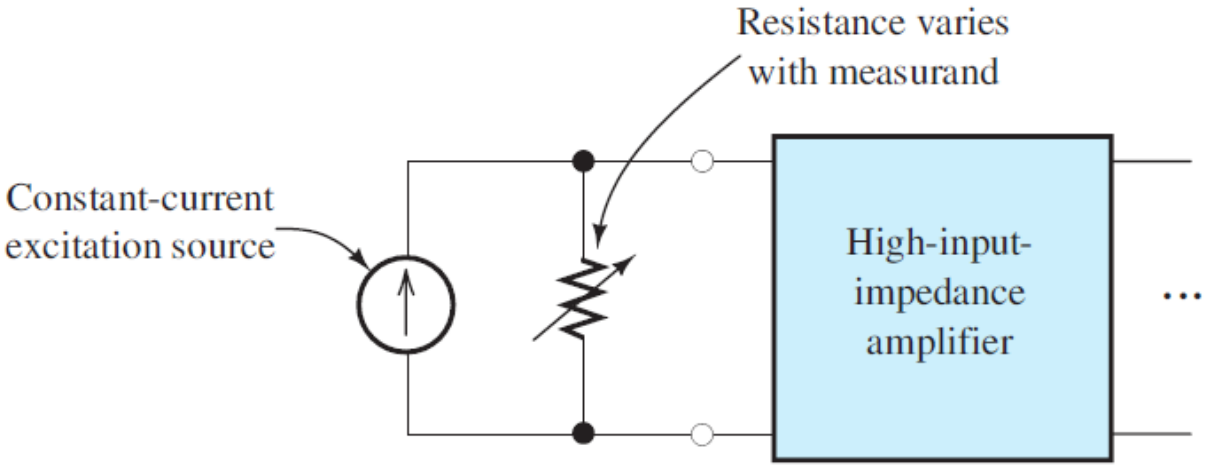
(b) Scale error



(c) Nonlinear error



(d) Hysteresis



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Greške mernih sistema

- Izvor greške, merna veličina i merni sistem
- bias greška, sistemska greška, ofset, greška skaliranja, nelinearnost, histereyis, drift, slučajna greška

$$Error = x_m - x_{true}$$

$$Error_r = \frac{x_m - x_{true}}{x_{full}}$$

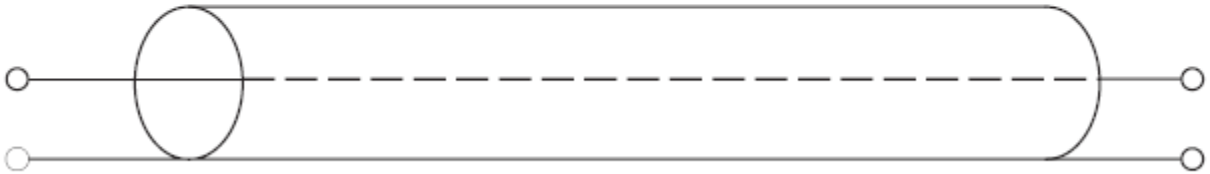
Performanse instrumentacionih sistema

1. Tačnost – maksimalna očekivana razlika u amplitudi između izmerene veličine i stvarne vrednosti
2. Preciznost – Sposobnost instrumenta da ponovi izmerenu veličinu ako je merna veličina konstantna
3. Rezolucija – Najmanja moguća vrednost koja može da prikaže razliku između izmerenih vrednosti
   - Veća rezolucija znači manji onkrement

Šum

Šum može da bude dodat od električnog signala ili elektromagnetnog polja koje stvara susedno kolo

(a) Twisted-pair cable



(b) Coaxial cable

Analog-to-Digital Conversion

- **Sampling Rate – učestanost odabiranja**
- **Aliasing** – ako je učestanost odabiranja niska, mora da se koristi anti-alias filtar
- **Kvantizacioni šum**

$$N_{q,rms} = \frac{\Delta}{2\sqrt{3}}$$

LabVIEW

- Postoje signali sa senzora u odgovarajućem formatu
- Transformisani su u digitalni oblik
- Učitani su u računar
- Računar koristi sofisticirane programe da izdvoji informaciju koja je interesantna
- Informacija može da bude prikazana ili iskorišćena da upravlja fizičkim sistemom
- Brzo se razvija novi instrument, nisa cena

Virtuelni vremensko-frekvencijski analizator vibracija

- Prvi senzor prikuplja signal vibracije
- Drugi senzor meri brzinu mašine
- Instrument treba da odredi amplitudu vibracionog signala u odnosu na učestanost i brzinu mašine
- Instrument treba da prikaže rpm mašine na x osi i učestanost na y osi
- Koristiti boje da se pokaže amplituda za svaku tačku rpm u frekvencijskoj ravni

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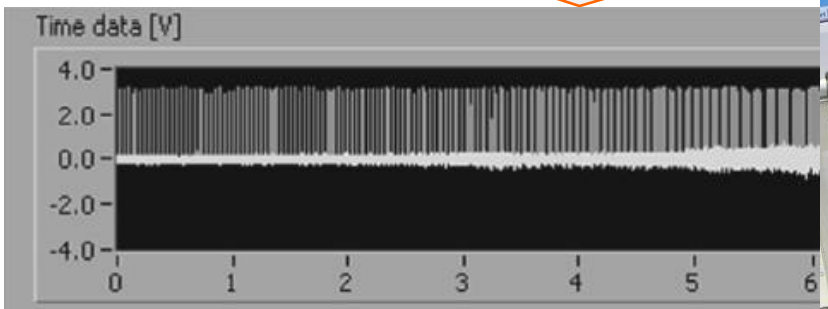

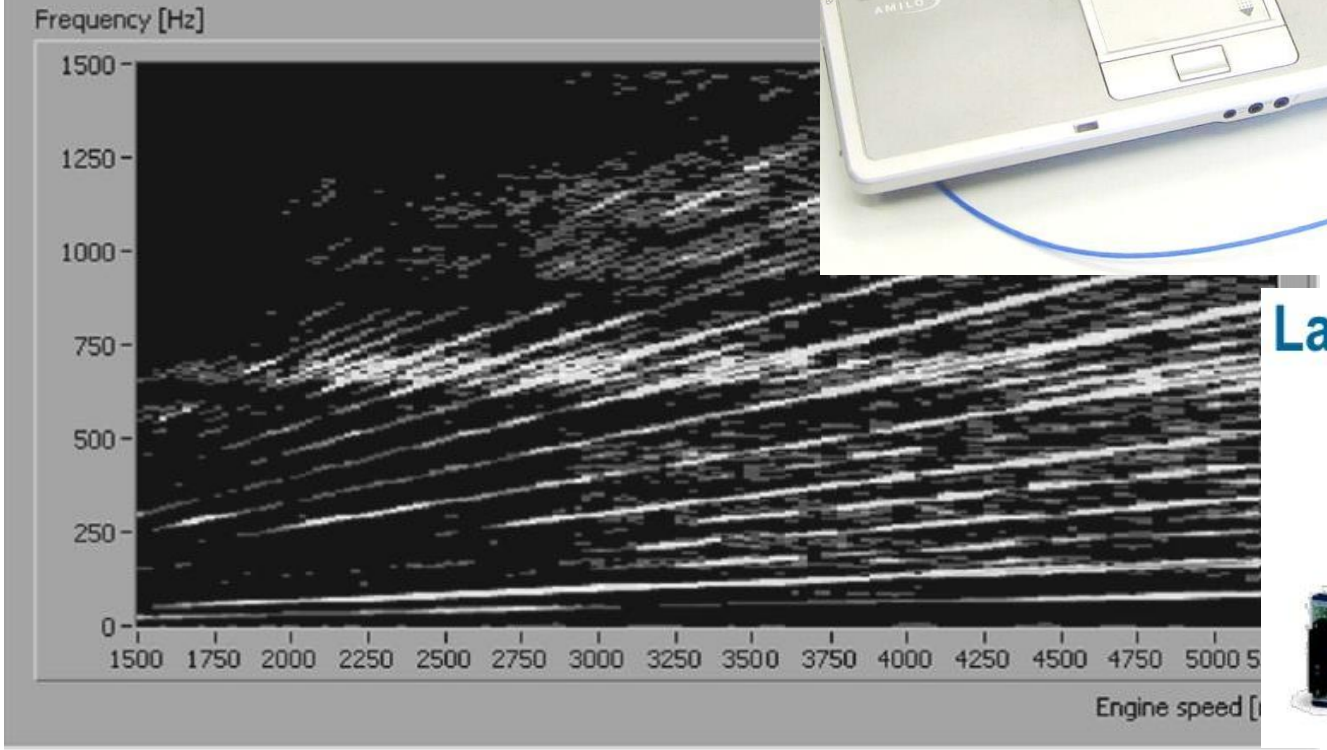

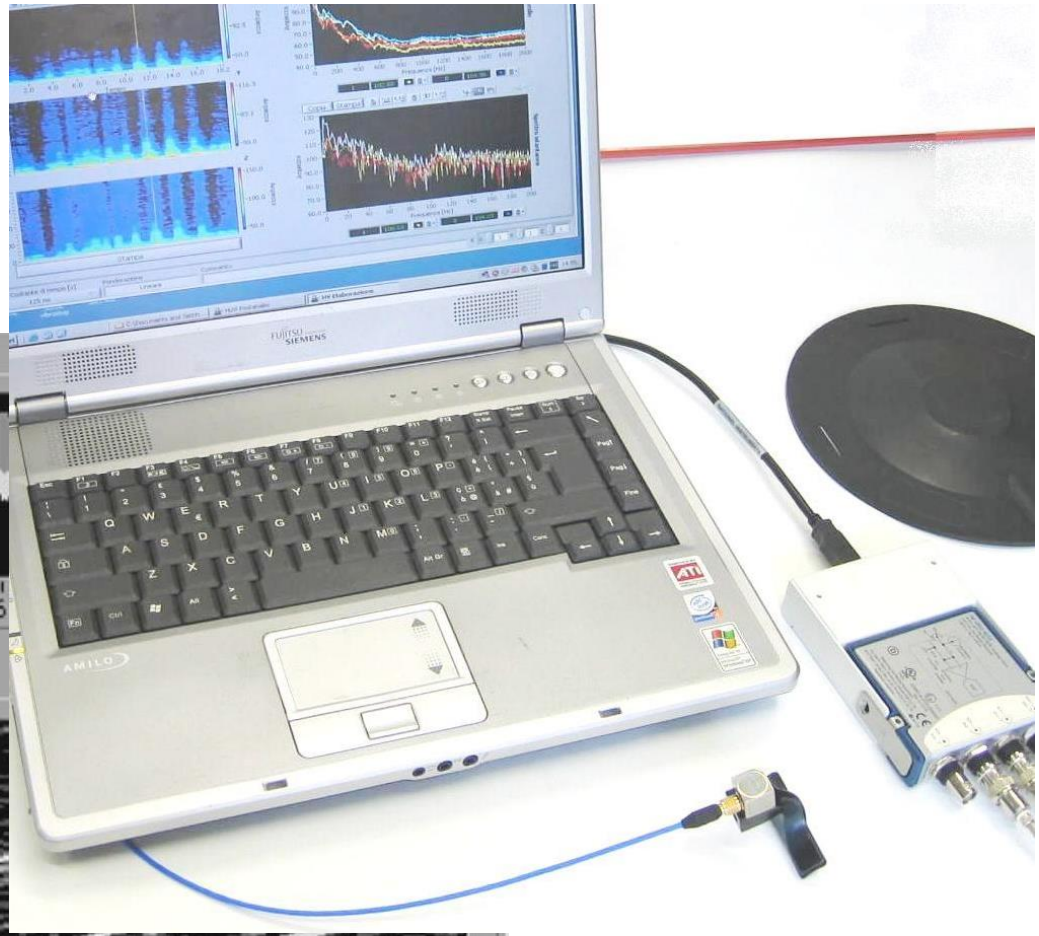

LabVIEW SignalExpress

LabVIEW?

- Namenjen da obrađuje podatke dobijene od senzora koji rade u realnom vremenu
- Da napravi potpuno virtuelni sistem u kome se generišu simulacioni podaci i signali korišćenjem VI a zatim analiziraju na isti način kao da su signali i podaci realni
- … istovremeno se uče tehnike programiranja i odklanjaju greške virtuelnih instrumenata
- Čest, ne znamo kakvi će biti rezultati koji se dobijaju u realnim sistemima

LabVIEW?

- Kada se dobijaju neočekivani rezultati, možda nećemo biti sigurni da virtuelni instrument izvršava namenjenu funkciju
- Preporučuje se da se otklanjaju greške mernog sistema u fazi razvoja virtuelnog instrumenta sa simuliranim podacima sve dok se ostvare željene performanse
- Zadovoljavajući rezultati se dobijaju sa poznatim test slučajem, i tek posle toga možemo da koristimo virtuelni instrument u realnim primenama

LabVIEW?

- Nije realno da se u knjigama (udžbenicima-instrukcijama za rad sa virtuelnim instrumentima) obezbedi test primer za senzore, merne uređaje, i DAQ ploče
- Mogu se naći samo simulirani podaci
- LabVIEW obezbeđuje moćne načine da se prikupljaju i analiziraju podaci dobijeni od realnih sistema u realnom vremenu
  - Na primer da se odredi srednja vrednost (dc komponenta) i varijansa (root-mean-square-rms)

$$X_{\text{dc}} = \frac{1}{T}\int_0^T x(t)\,dt \qquad X_{\text{ac-rms}} = \sqrt{\frac{1}{T}\int_0^T [x(t) - X_{\text{dc}}]^2\,dt}$$

$$x(t) = X_{\text{dc}} + X_{\text{peak}}\sin(2\pi ft) \qquad X_{\text{ac-rms}} = \frac{X_{\text{peak}}}{\sqrt{2}}$$

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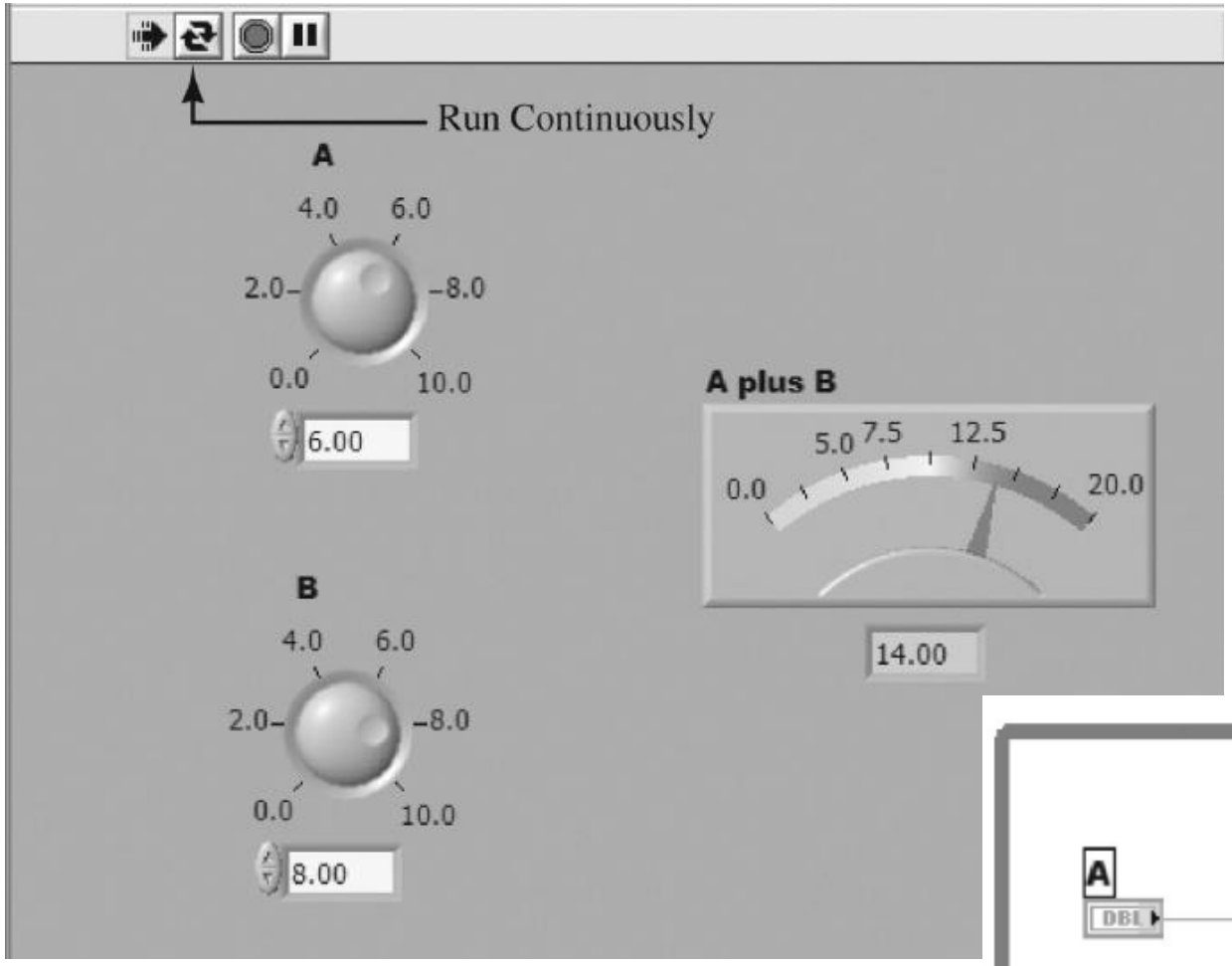
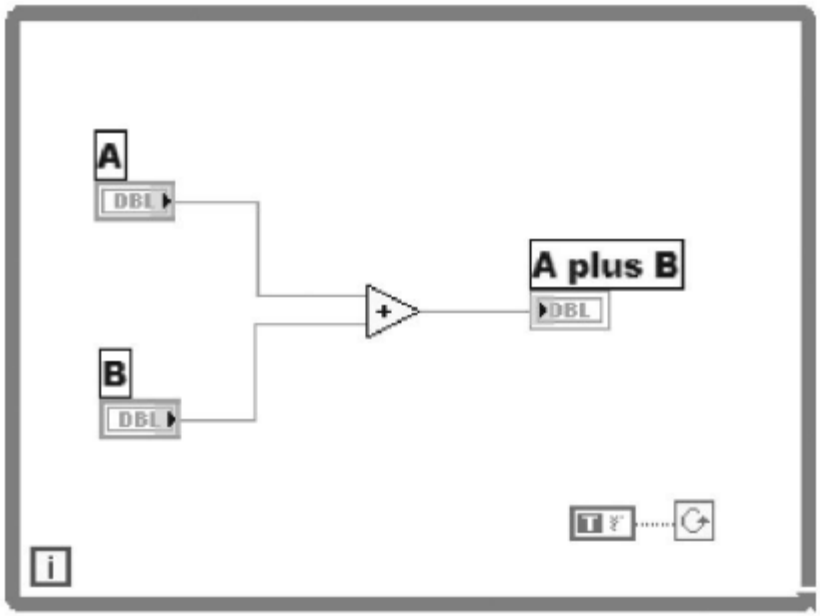


Primer za vežbu



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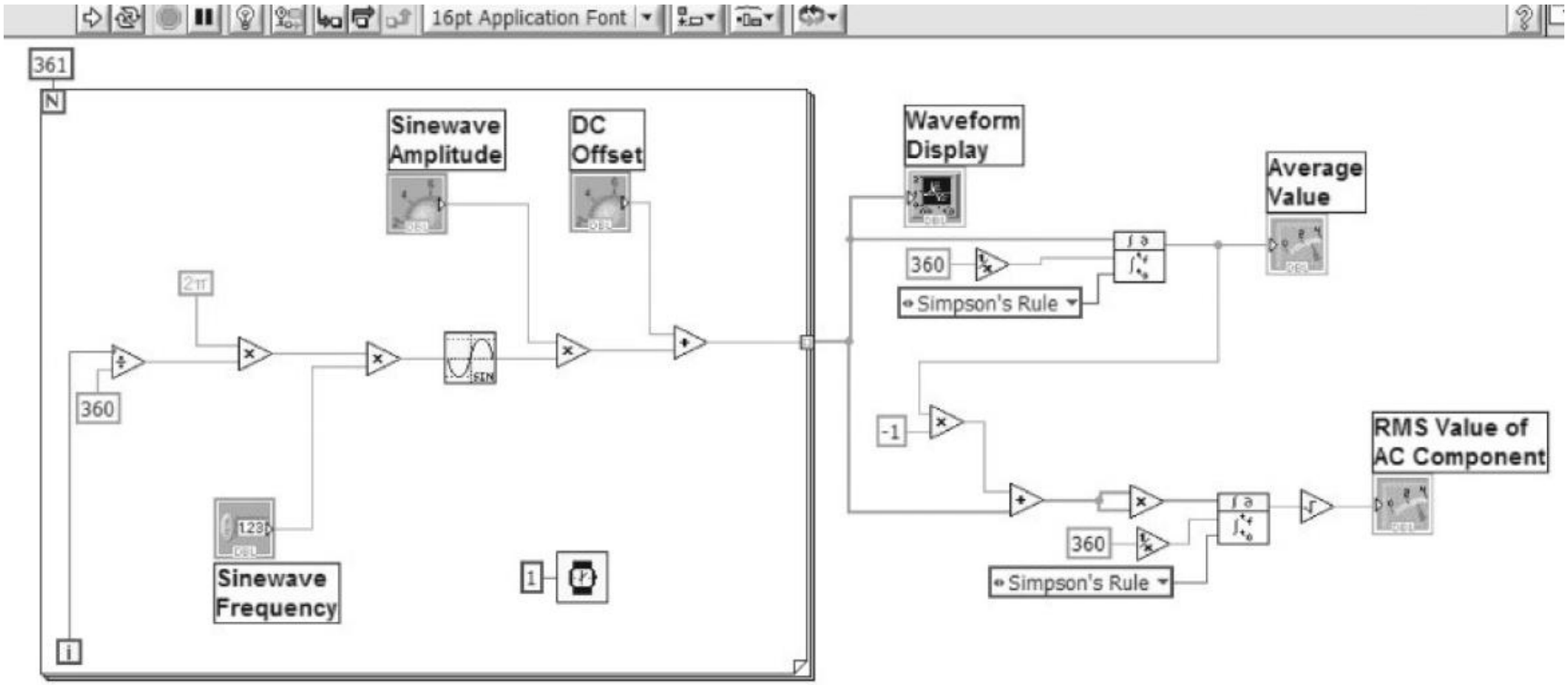
Primer za vežbu



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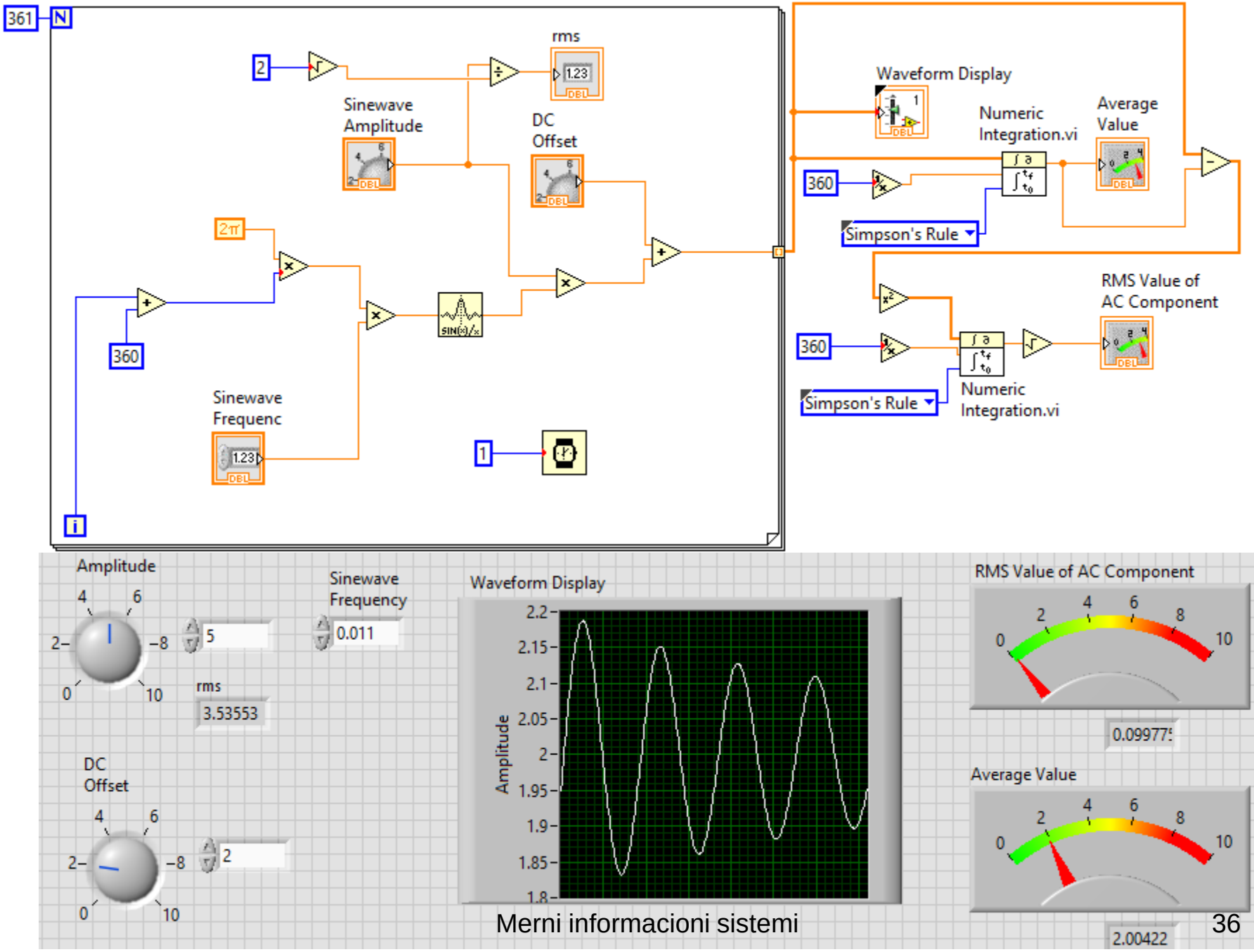
361
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Average Value
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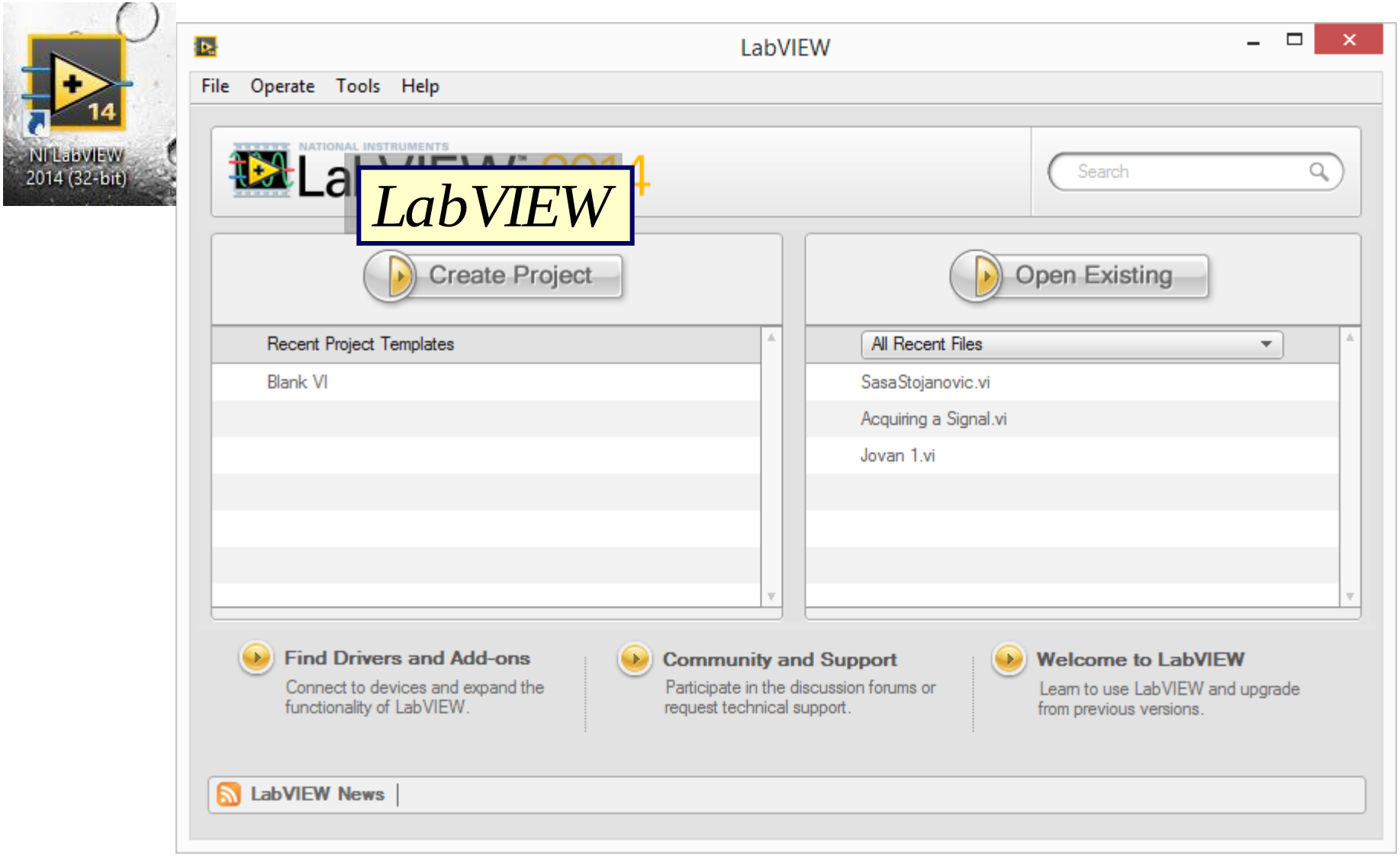
NI LabVIEW 2014 (32-bit)
LabVIEW
File Operate Tools Help
NATIONAL INSTRUMENTS
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LabVIEW
Create Project
Open Existing
Recent Project Templates
Blank VI
All Recent Files
SasaStojanovic.vi
Acquiring a Signal.vi
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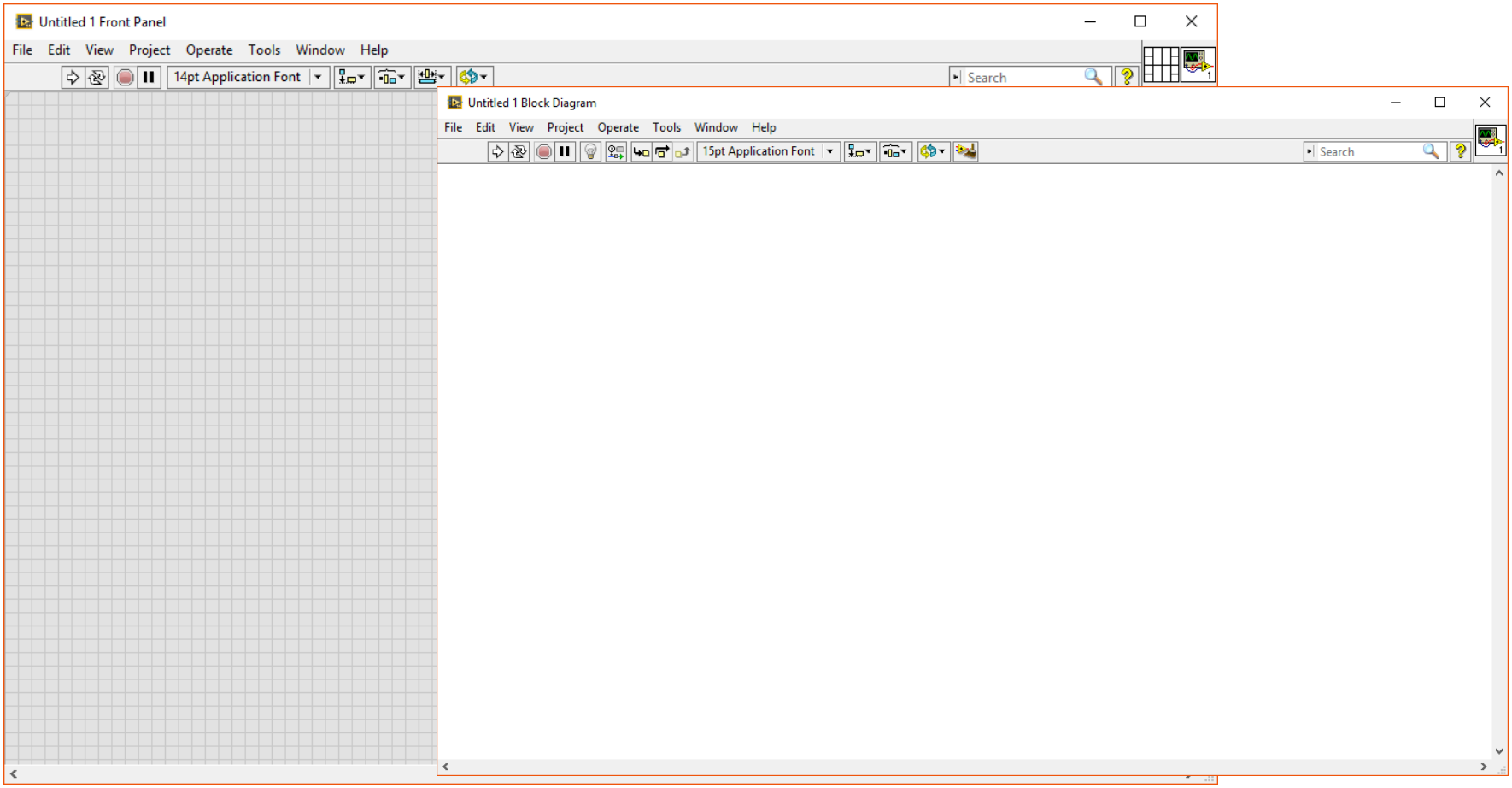
LabVIEW News

Pokreni LabVIEW i klikni na Blank VI u Getting Started prozoru

Pojavljuju se dva prozora

1.siva mrežasta pozadina - front panel

2.bela pozadina - blok dijagram



Klikne se na front-panel

Klikne se na

View>Controls Palette

Klikne se na

Express>Numeric Controls>Dial

Pomeri se kursor miša na Dial u front-panel prozoru

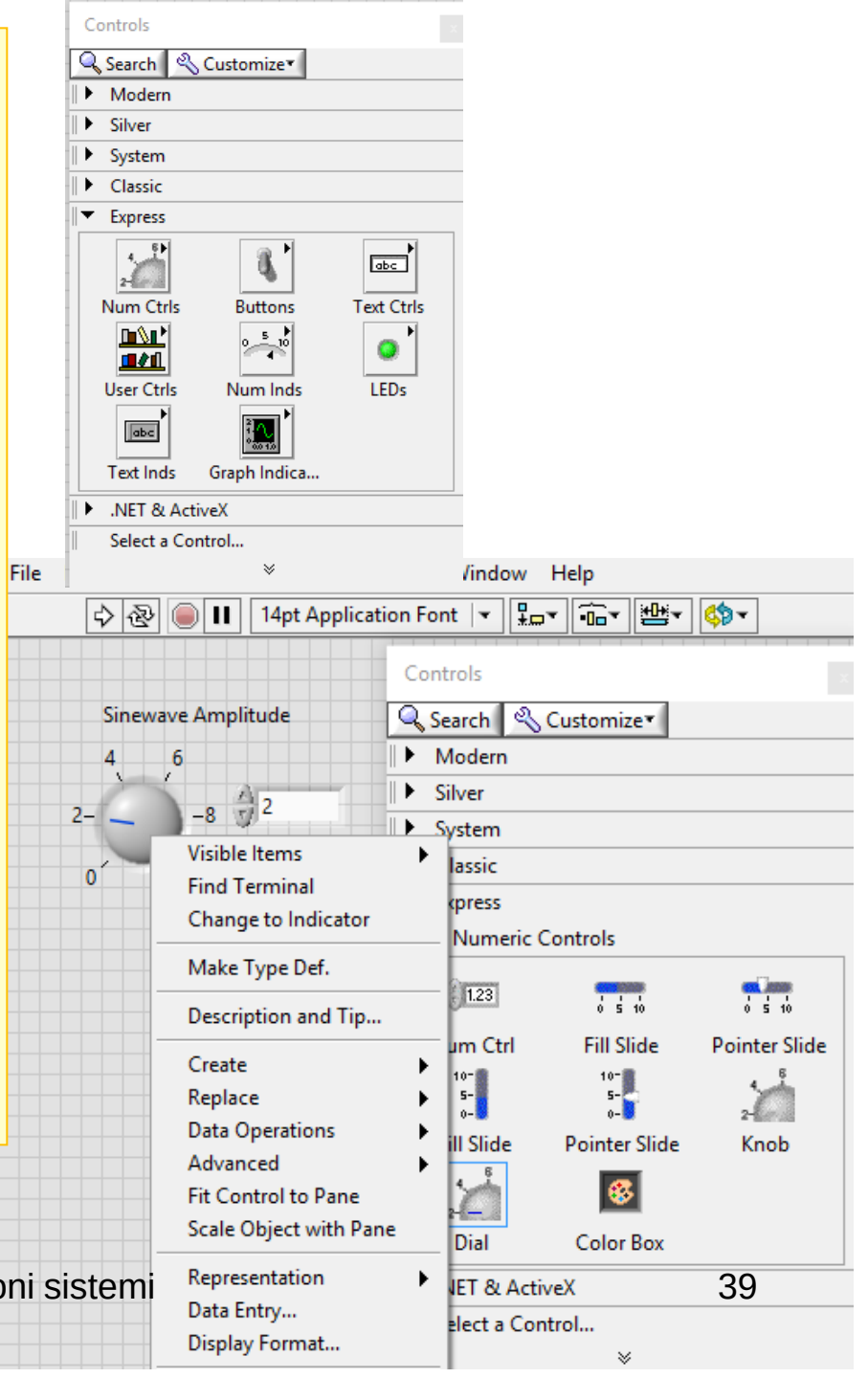
Klikne se da se spusti tamo gde želim

Kuca se sa tastature

Sinewave Amplitude

Postavi se kursor na Dial, desni-klick i selektuje

Visible Items>Digital Display

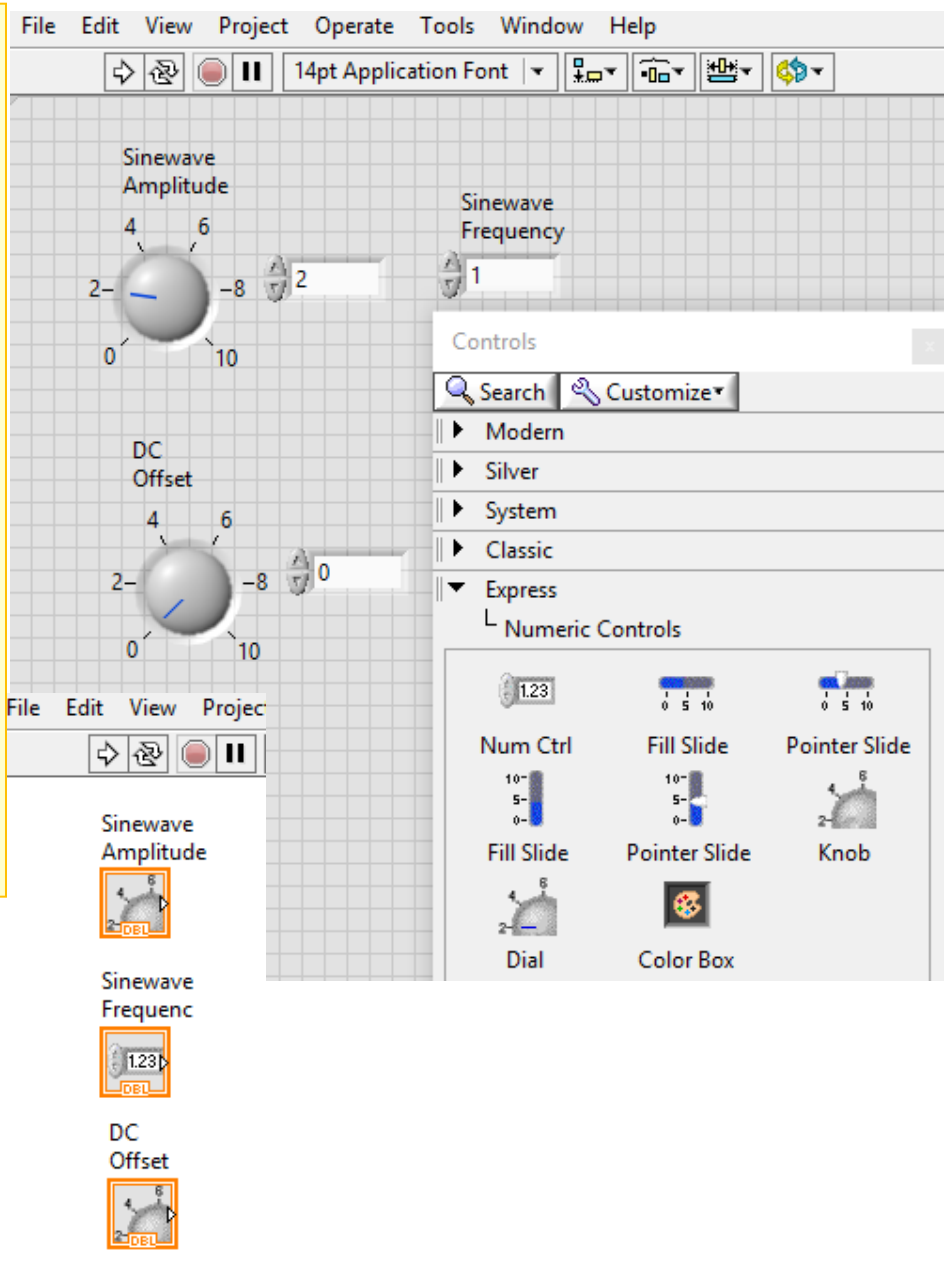


Klikne se na diagram window
(Window>Show Block Diagram)

Klikne se na
View>Tools Palette

Vratiti se u front panel

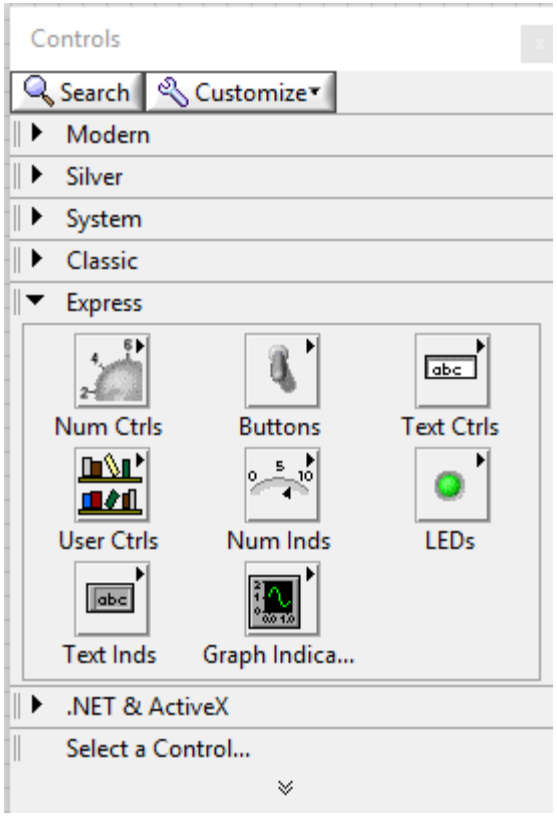
Drugi dial se označi kao DC Offset i numeric control (gornji levi ugao numeric controls palette) označi se Sinewave Frequency na front panelu

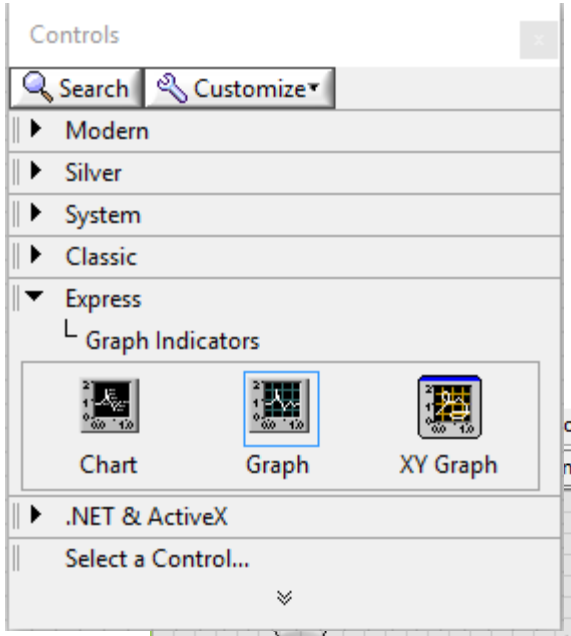


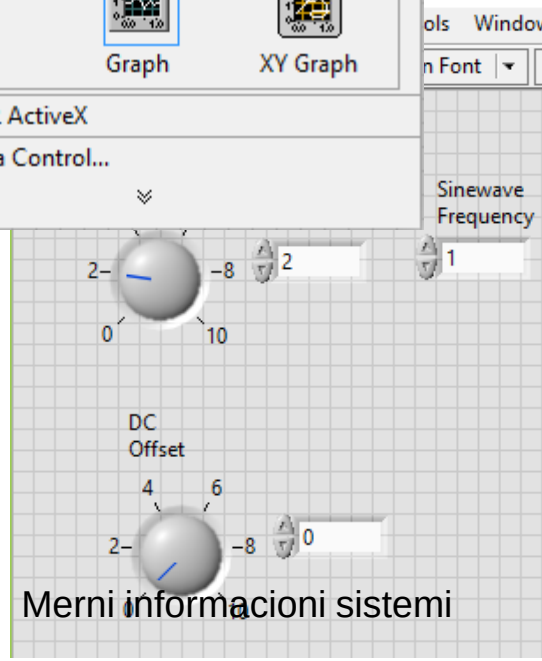
Click on Express>Graph Indicators >Waveform Chart

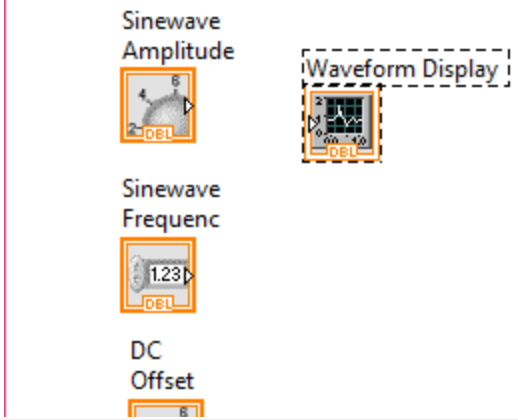
Place the waveform chart on the front panel

Type in the caption Waveform Display on your keyboard







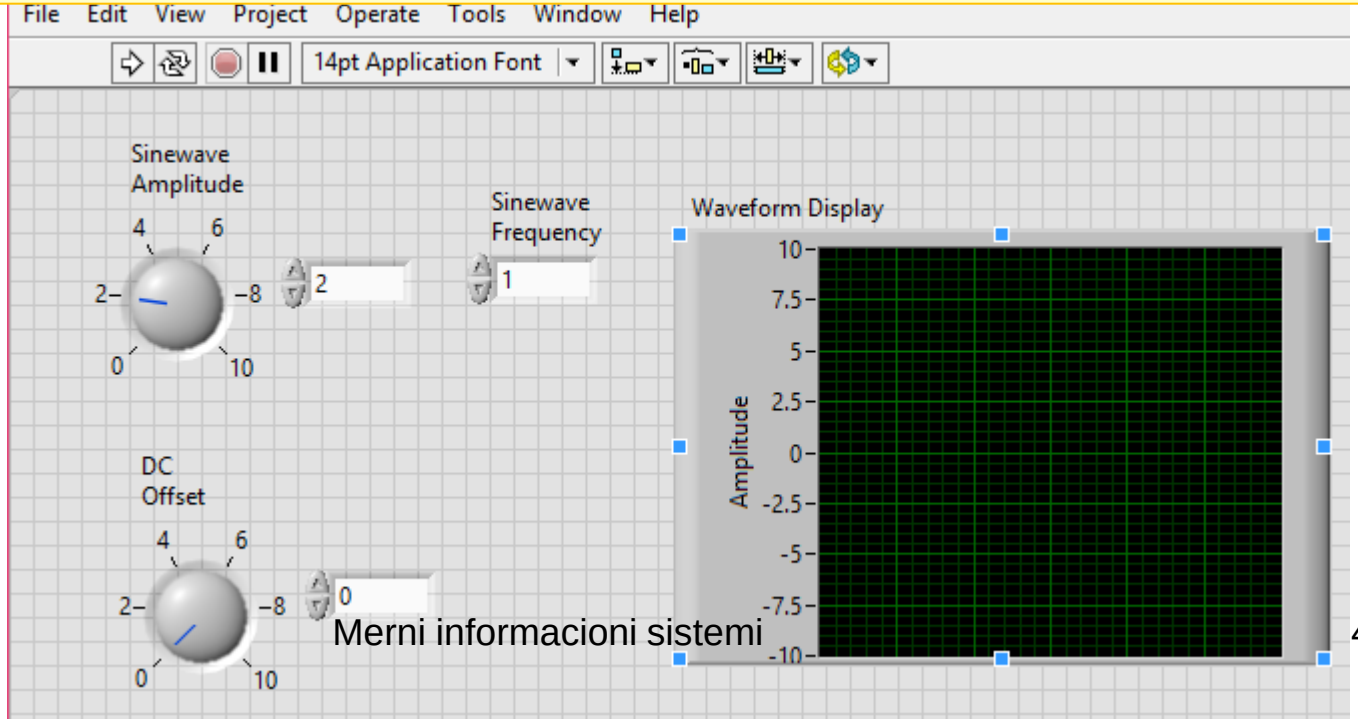


Place the cursor on the display icon and click the right mouse button to bring up the pop-up menu

Use the Visible Items>PlotLegend and Visible Items>X Scale commands to hide the legend and the x-axis scale

Use the Position/Size/Select tool to position and resize the elements on the control panel

Use the Operate Value tool to edit the lower and upper y-axis values, so that they range from -10 to +20

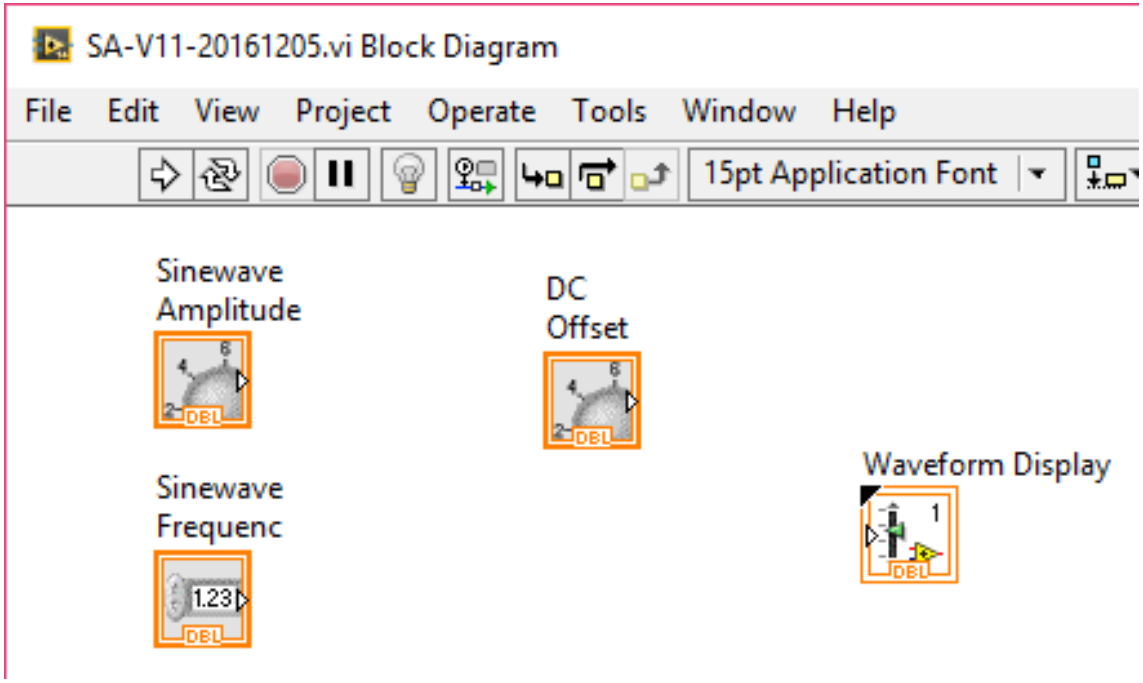


Use the Window>Show Block Diagram command to switch to the block diagram window

Use the View>Functions Palette command to make it visible

Use the Position/Size/Select tool to position the icons

Make sure that when you left-click on each box, the nearest label is the one indicated as being selected



Selecting and positioning function blocks on the block diagram

Addition block:**Mathematics>Numeric>Add**

Multiplication block: **Mathematics>Numeric>Multiply**

Division block: **Mathematics>Numeric>Divide**

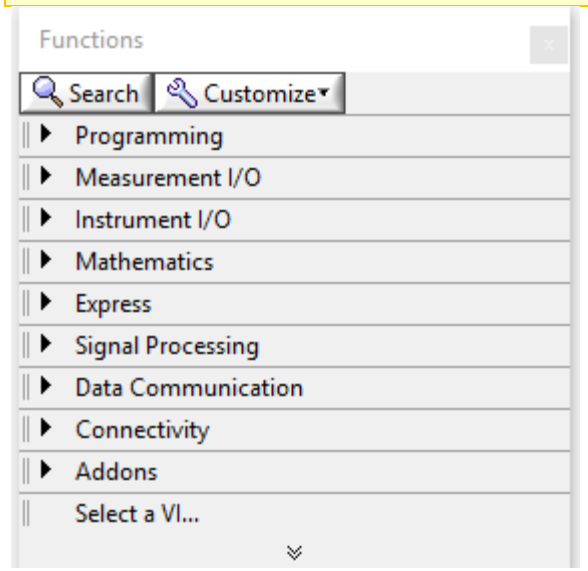
Sine function: **Mathematics>Elementary & Special Functions>Trigonometric**

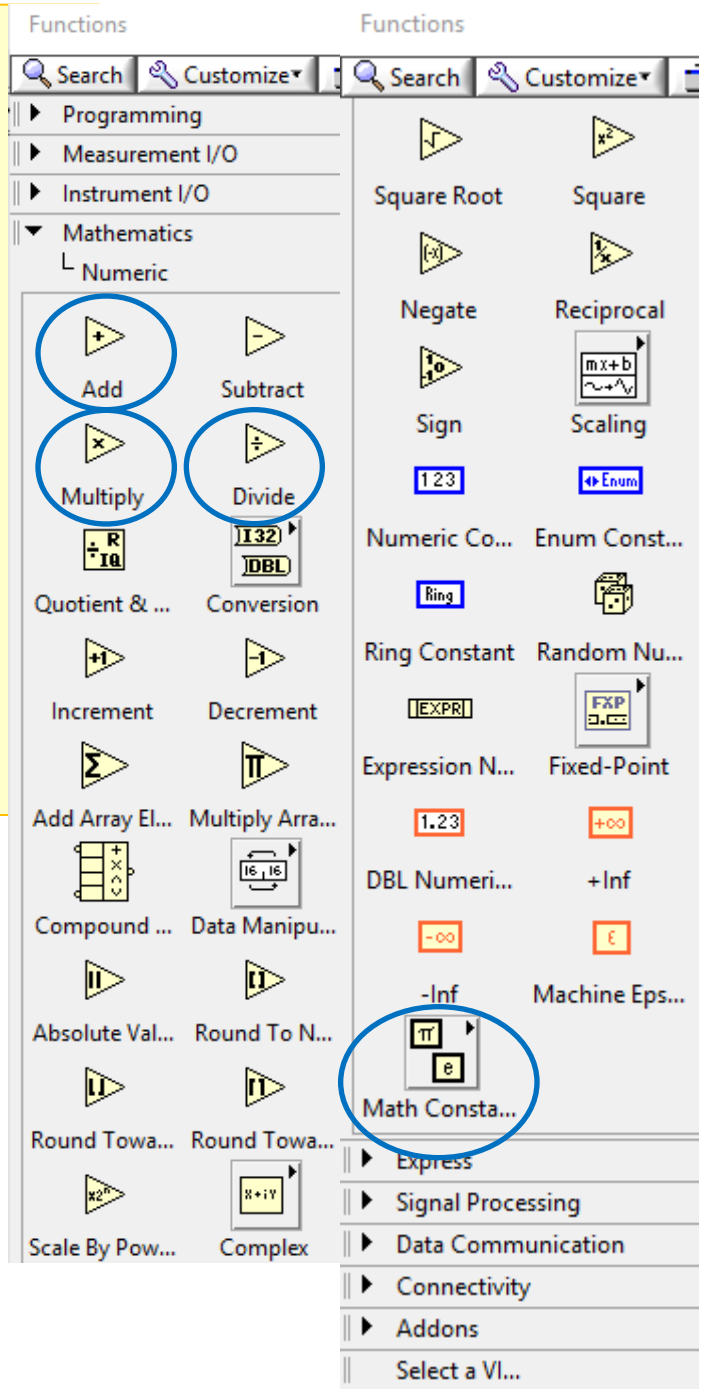
Functions>Sin

2 Block: **Mathematics>Numeric>**
Math & Scientific Constants>2*Pi

Wait Icon: **Programming>Timing>Wait (ms)**

For Loop: **Programming>Structures>For Loop**



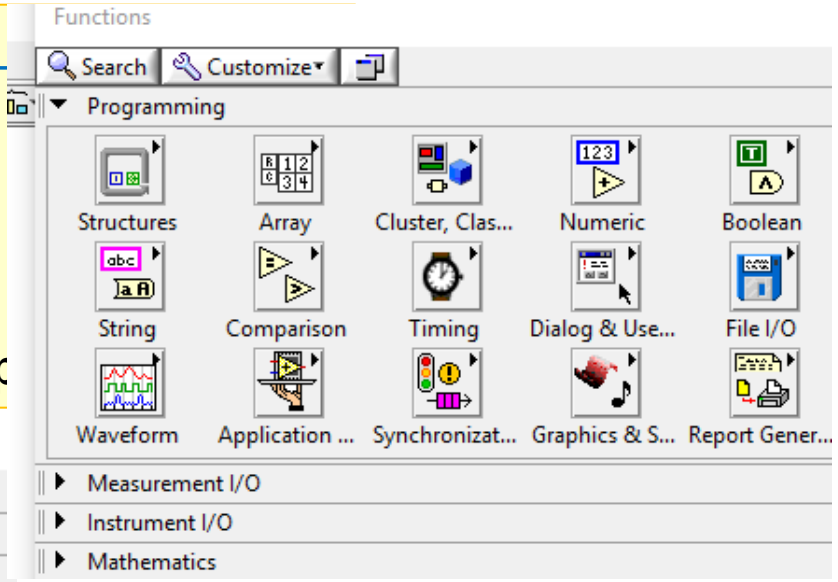


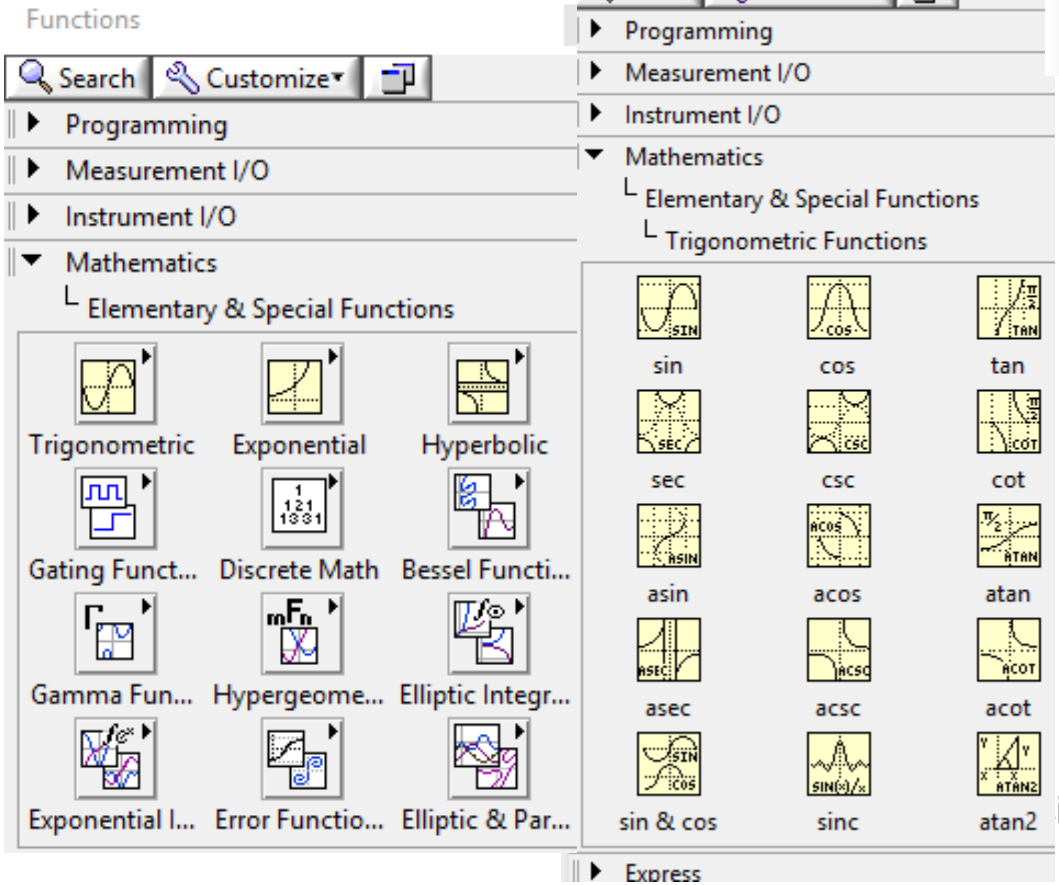
Selecting and positioning function blocks on the

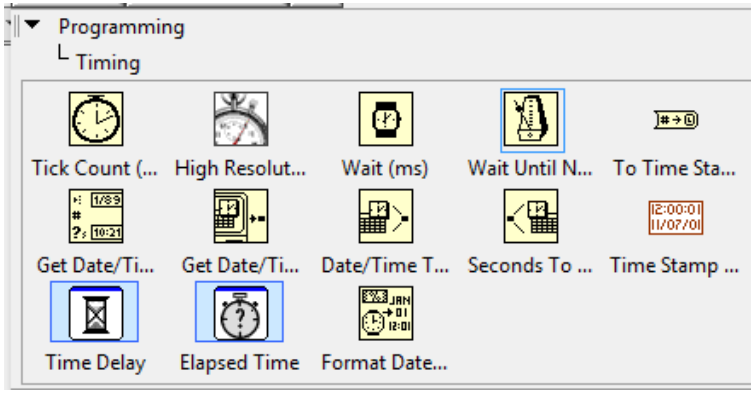
Sine function: **Mathematics> Elementary & Special Functions> Trigonometric Functions>Sin**

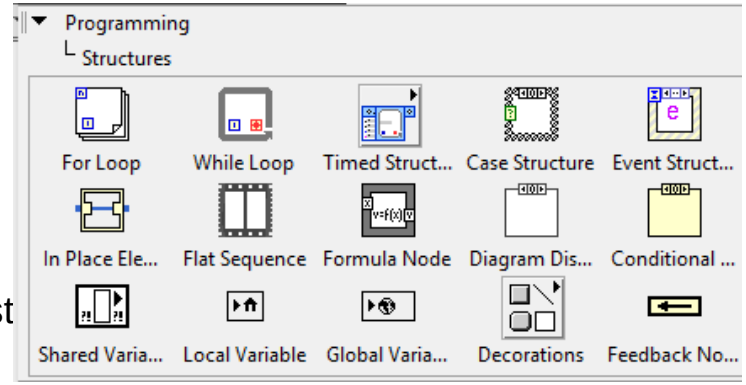
Wait Icon: **Programming>Timing>Wait (ms)**

For Loop: **Programming>Structures>For Loop**









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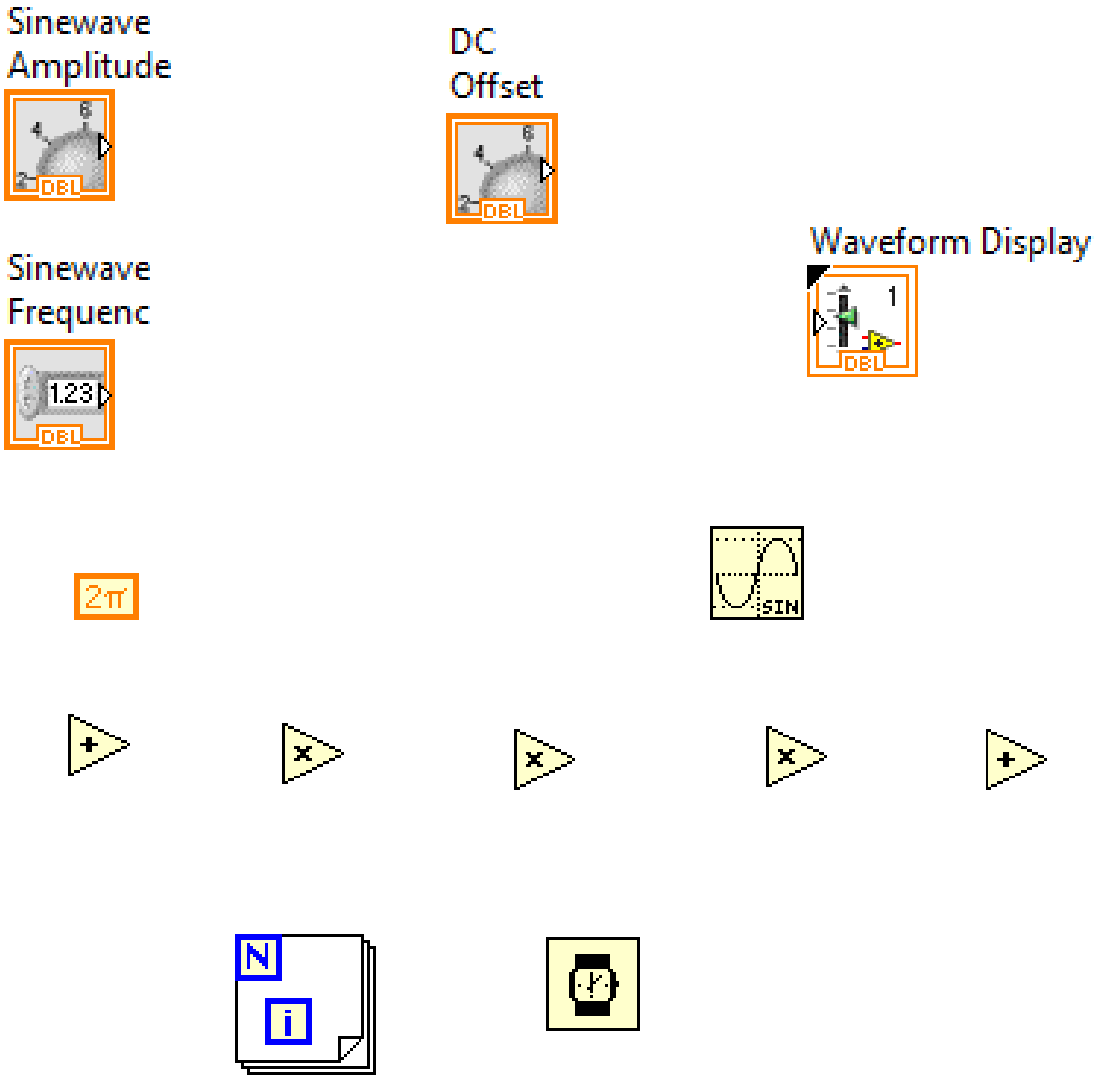
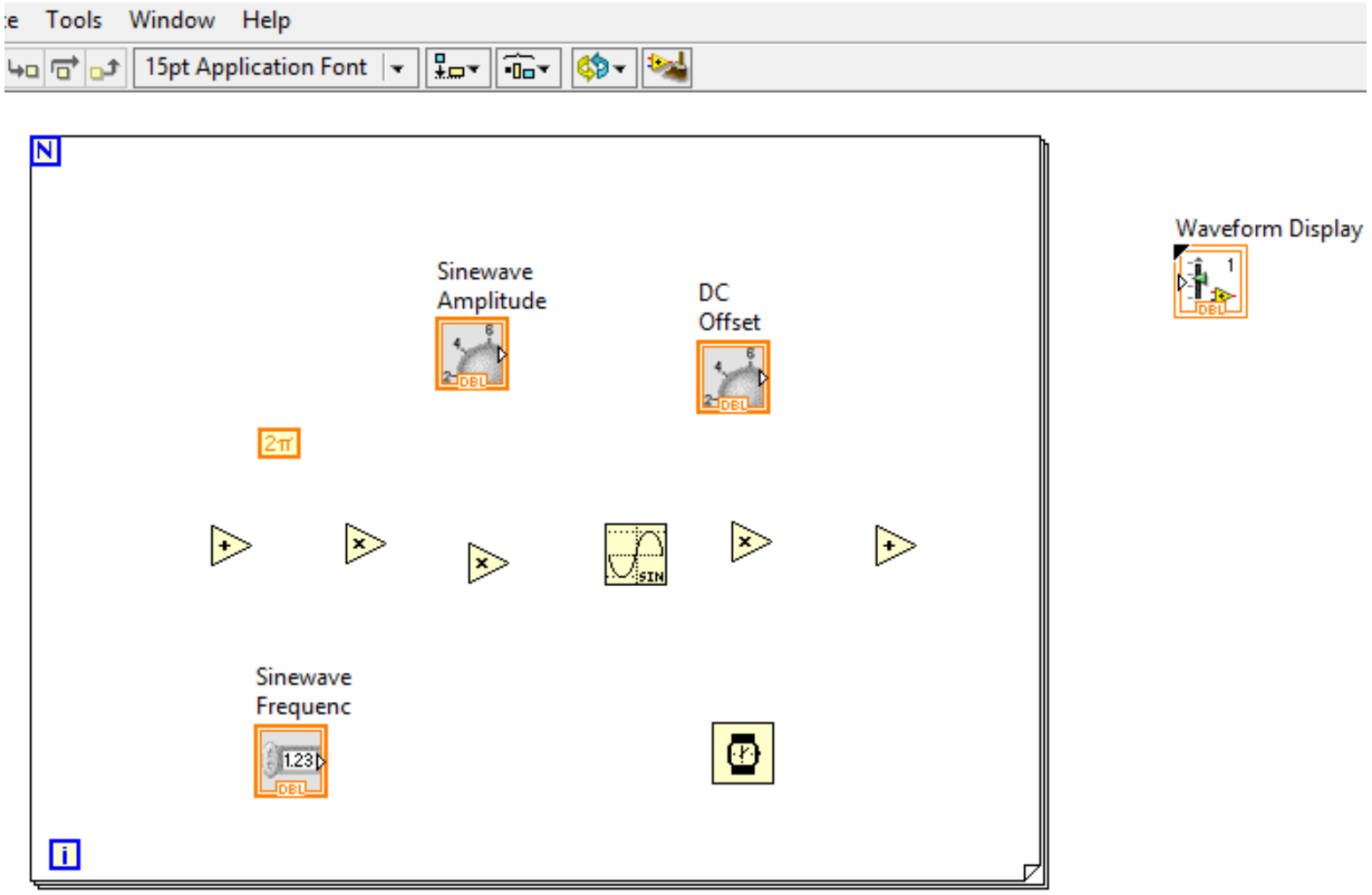
Selecting and positioning function blocks on the block diagram

Addition block:**Mathematics**>**Numeric**>**Add ….**

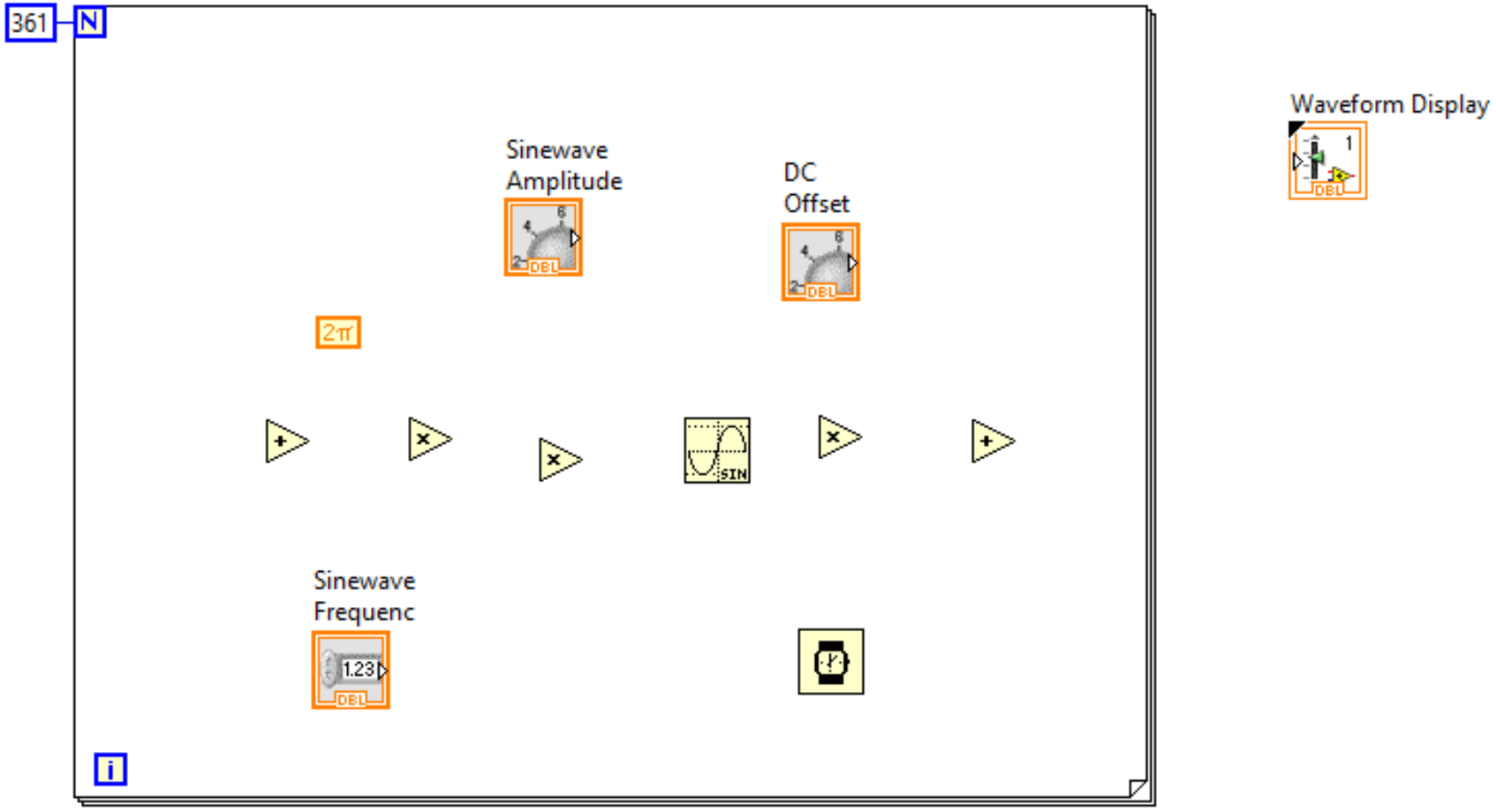


Position the For Loop at the upper left-hand corner of the diagram window
Holding the mouse button down, drag the lower right-hand corner to enclose all of the other icons except the Waveform Display



Add constants and wire the diagram

Right-click on the upper left-hand corner of the for loop, select Create Constant from the pop-up menu, and type in 361

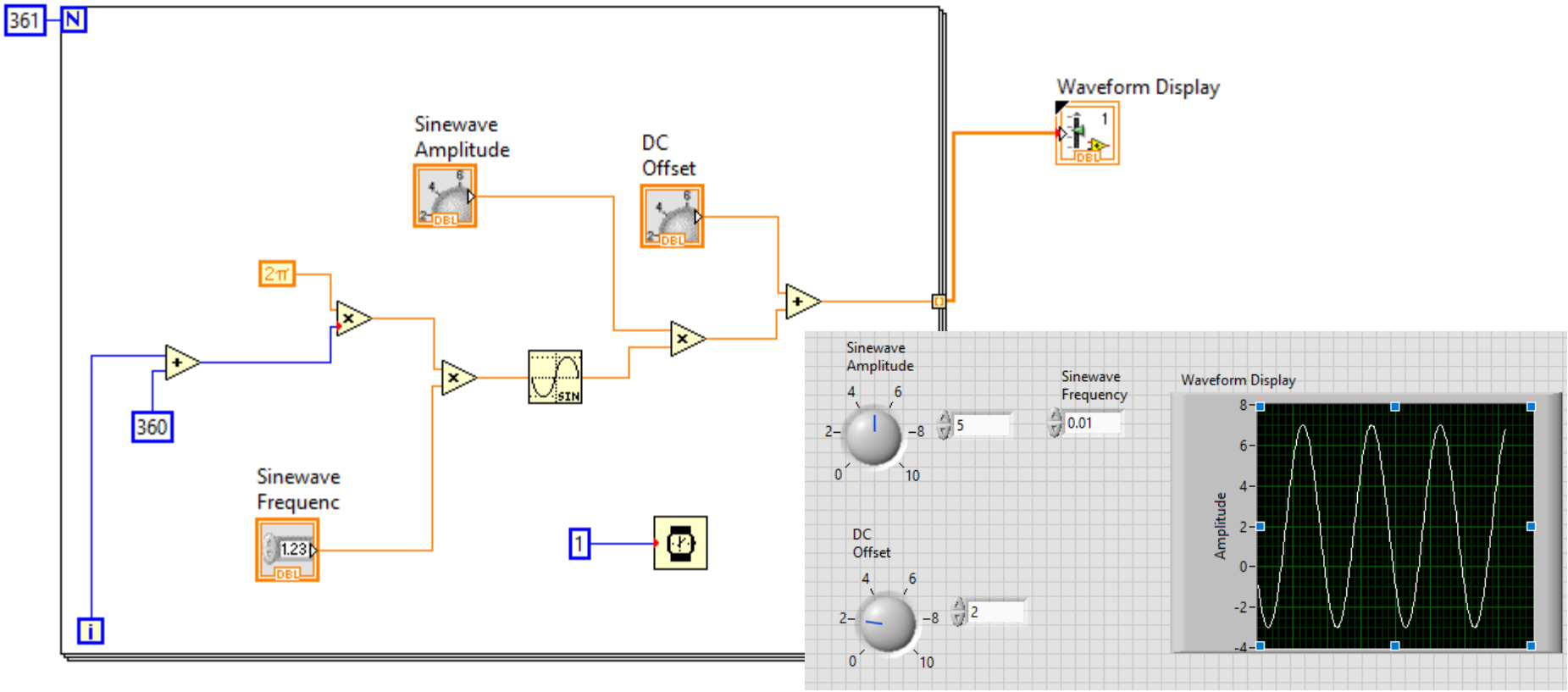


Select the Connect Wire tool from the tools palette

To make a wire connecting the for-loop index (the box labeled *i* in the lower left-hand corner of the for loop) to the divider, click on the for-loop index, move the cursor to the upper input of the divide box, and click

Right-click on the lower input of the divider, select **Create**>**Constant**, type in 360

Use the **Connect Wire** tool to finish the wiring

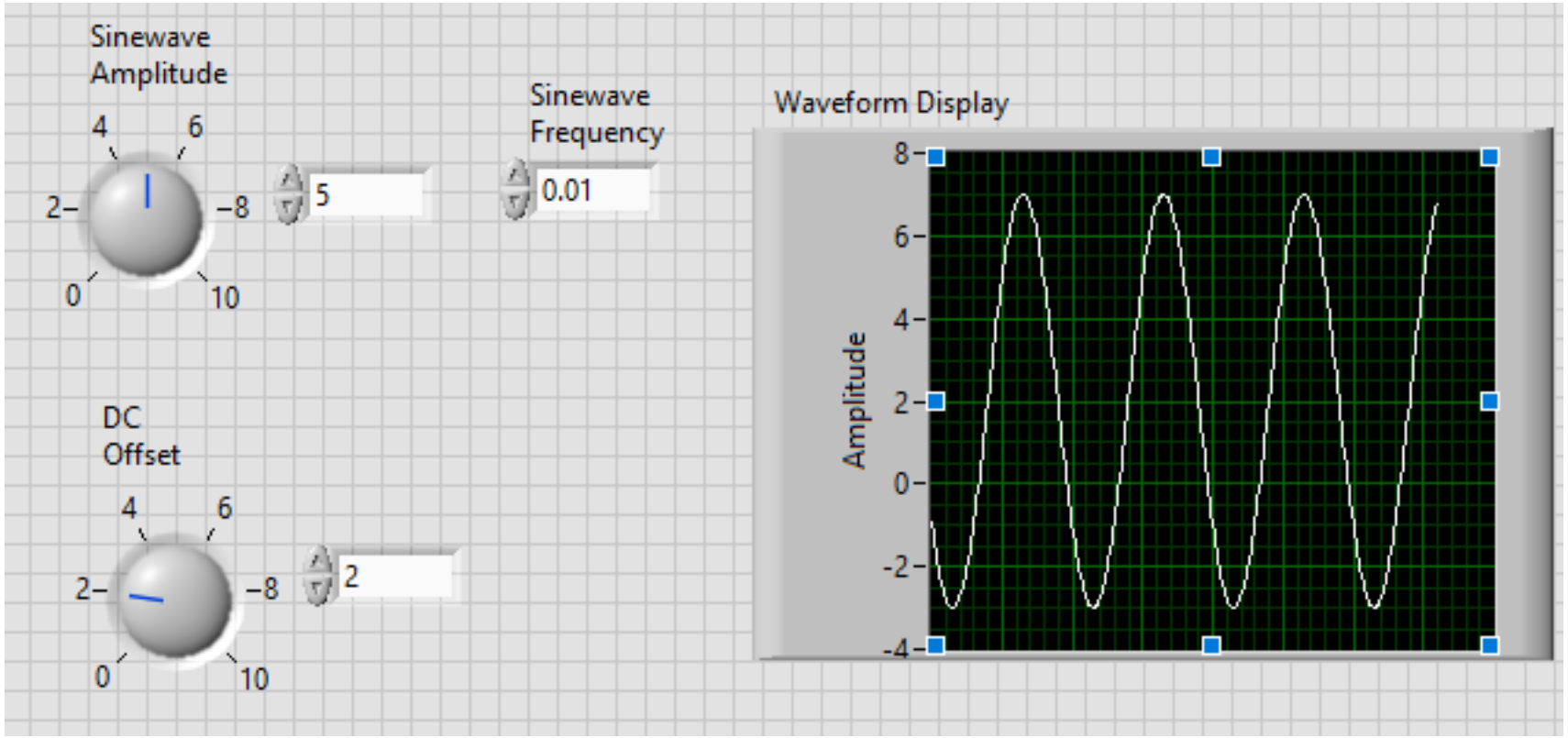


Front panel - click on the run continuously button

Adjust the controls and observe the display

Set the sinewave amplitude to 7, the dc offset to 2, and the frequency to 0.01

Use the **XScale** >**AutoScaleX** command

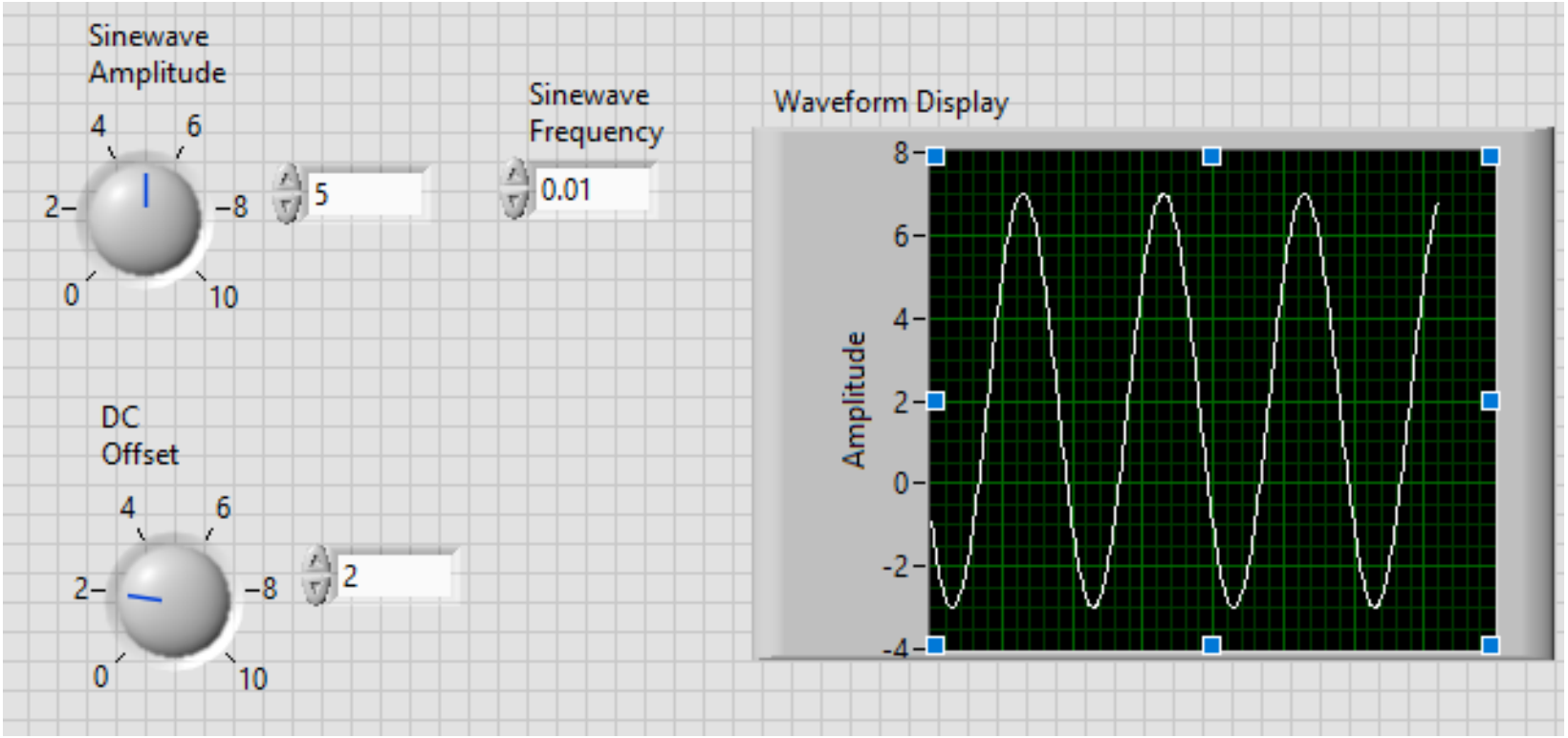


Adjust the amplitude and dc offset:

a)Point to and rotate the dial.

b)Click on the up or down arrows on the left-hand side of the digital indicator under the dial

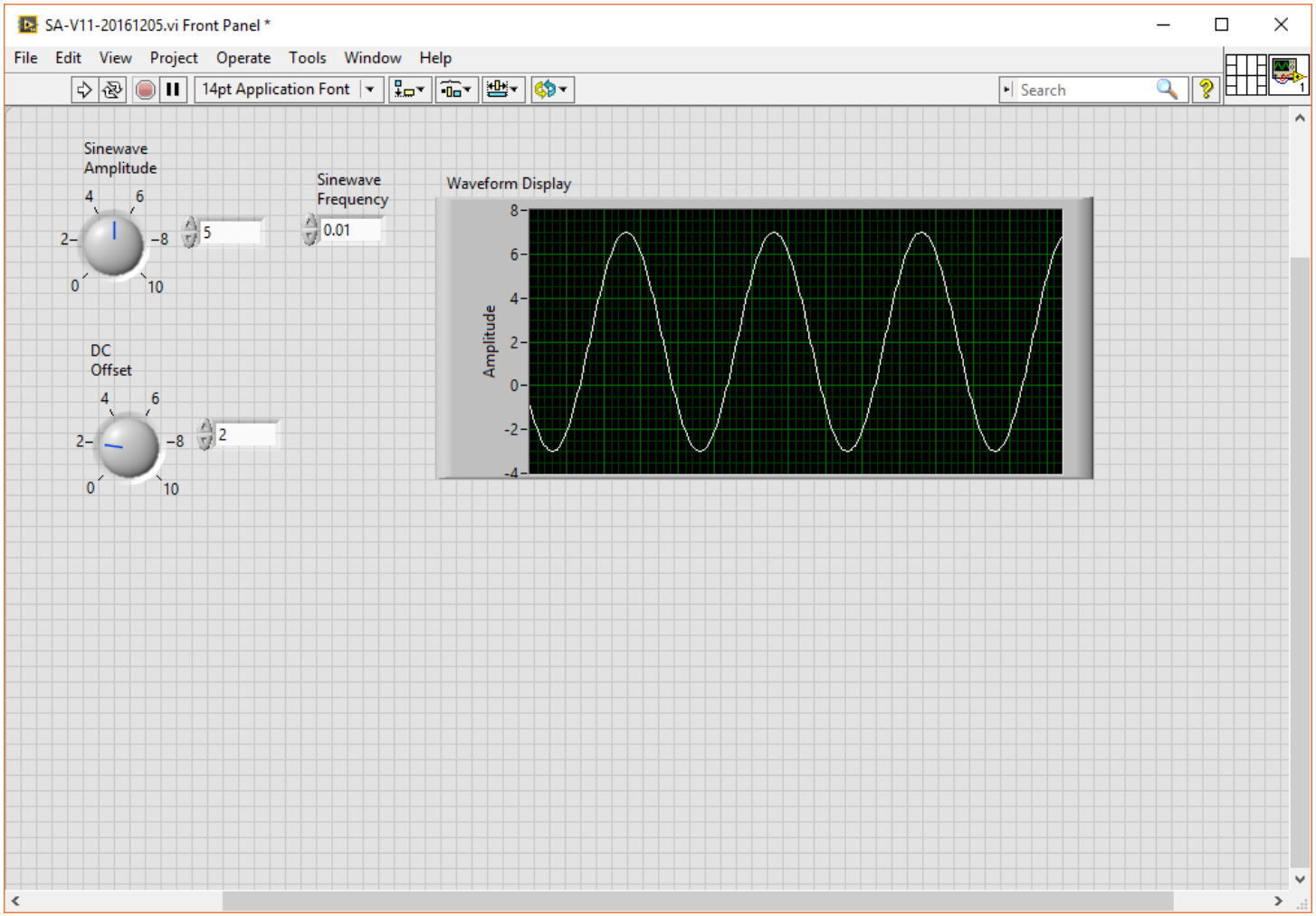
c)Place the cursor inside the digital indicator under the dial and type in a value, which will become effective when you click in a blank region on the front panel outside the indicator



- Each time the program is operated, all of the functions inside the for-loop structure are carried out 361 times with *i* starting at zero and incrementing by one after each iteration up through *i* = 360
- The value of *i* to represent angles in one-degree increments
- Division by 360 and multiplication by 2π converts these angles to radians
- The angles are then multiplied by frequency f
- The sine block computes the sine of each angle. Thus, each time the for loop is executed, a total of 361 points on f cycles of the sine function are calculated
- The amplitude input from the front panel multiplies the sinewave values, and the dc offset is added to each value

Each time the for-loop finishes, an array of 361 data points is passed to the display.

Each time you click the run button (not the run continuously button), *f* cycles of the signal will appear on the display



Adding the DC and RMS Virtual Instruments

Place and wire additional graphical-program elements to compute the average value of the data and the rms value of the ac component

Add front-panel displays

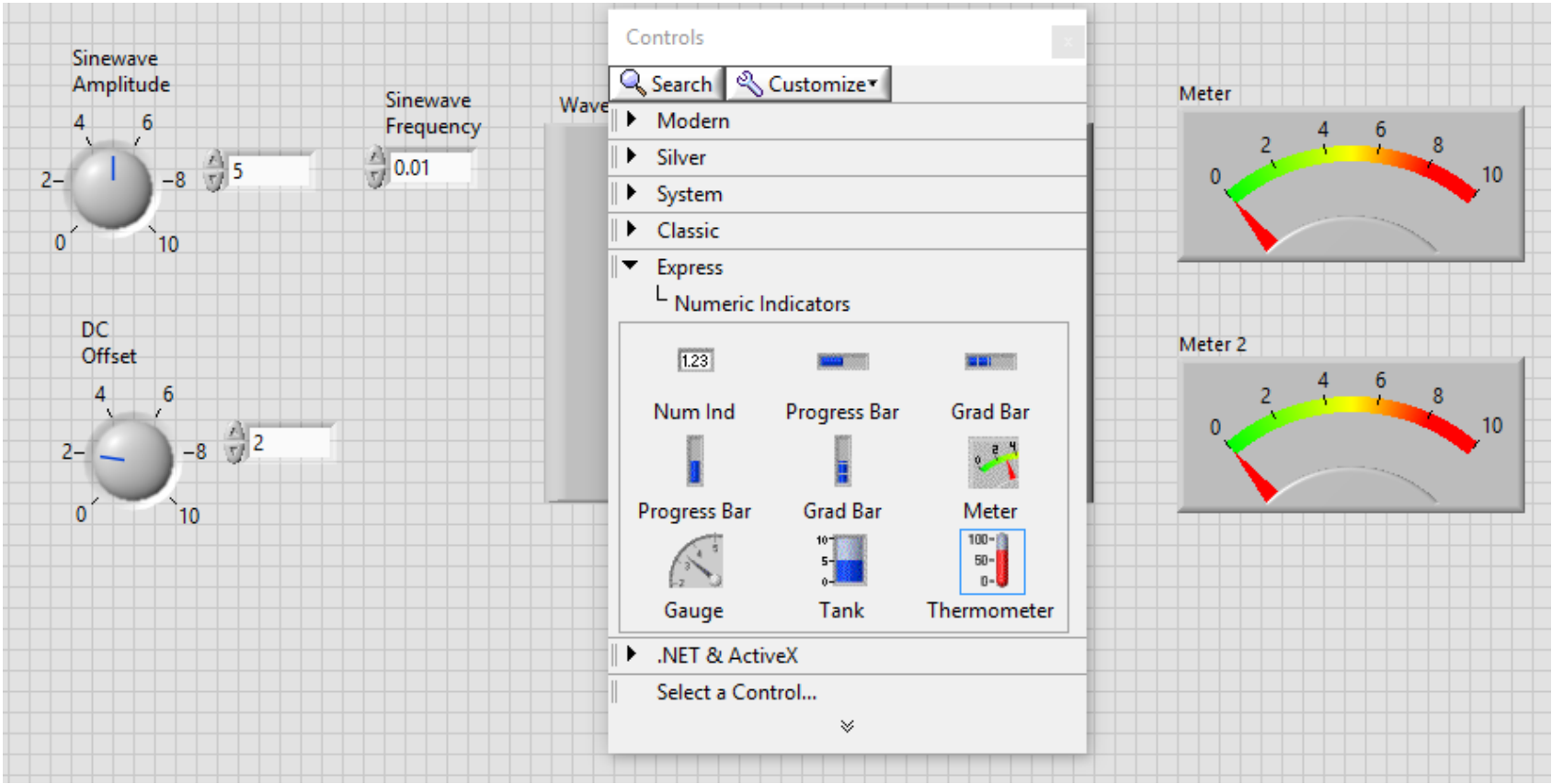
$$X_{\text{dc}} = \frac{1}{T}\int_0^T x(t)\,\mathrm{d}t$$

$$X_{\text{ac-rms}} = \sqrt{\frac{1}{T}\int_0^T \left(x(t) - X_{\text{dc}}\right)^2 \mathrm{d}t}$$

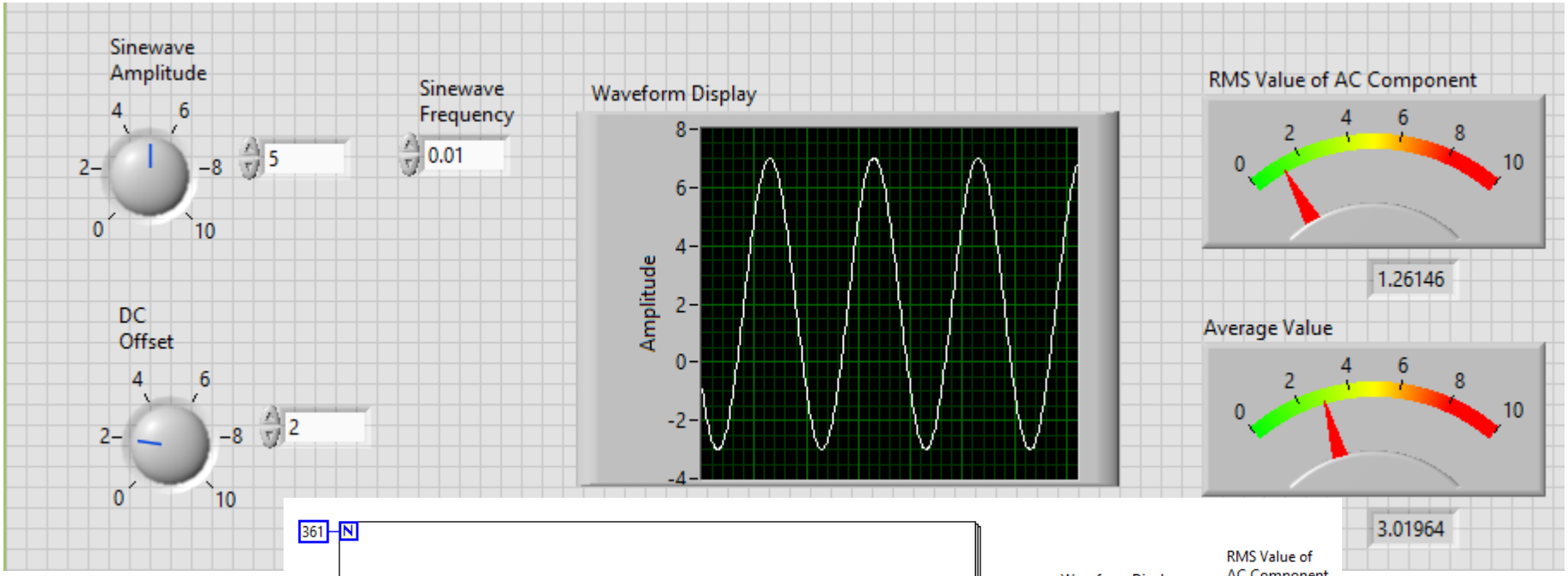
The front-panel meter icon, the Controls Palette and select Express>Numeric Indicators>Meter

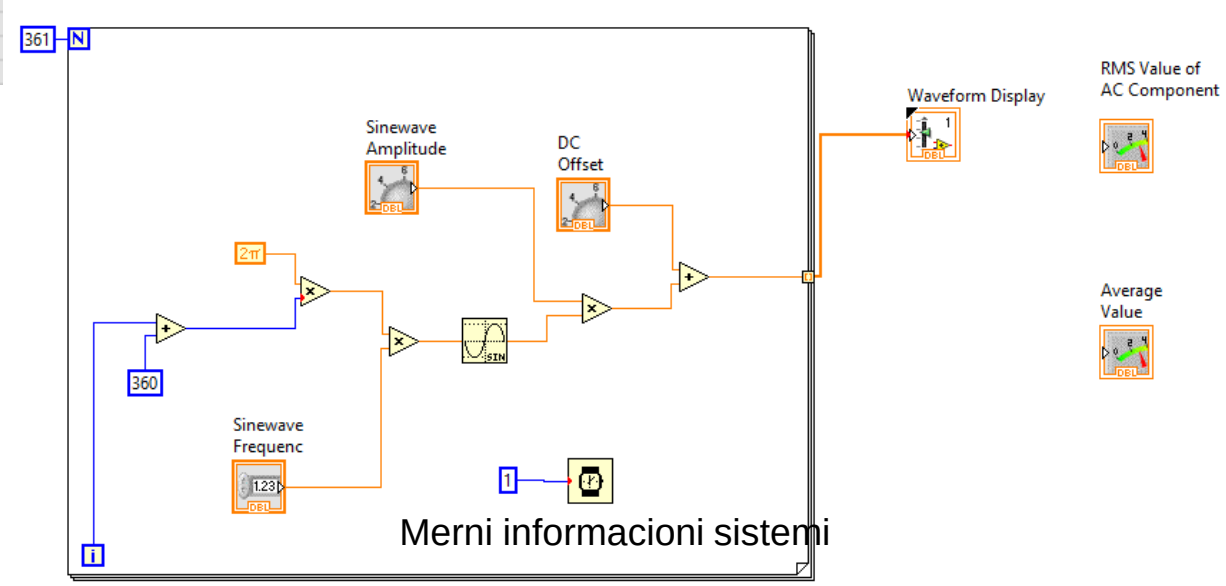
Drop the meter icon on the front panel and label

Two meters are needed



Right-click on each meter and use the Visible Items>Digital Display command to add the digital display



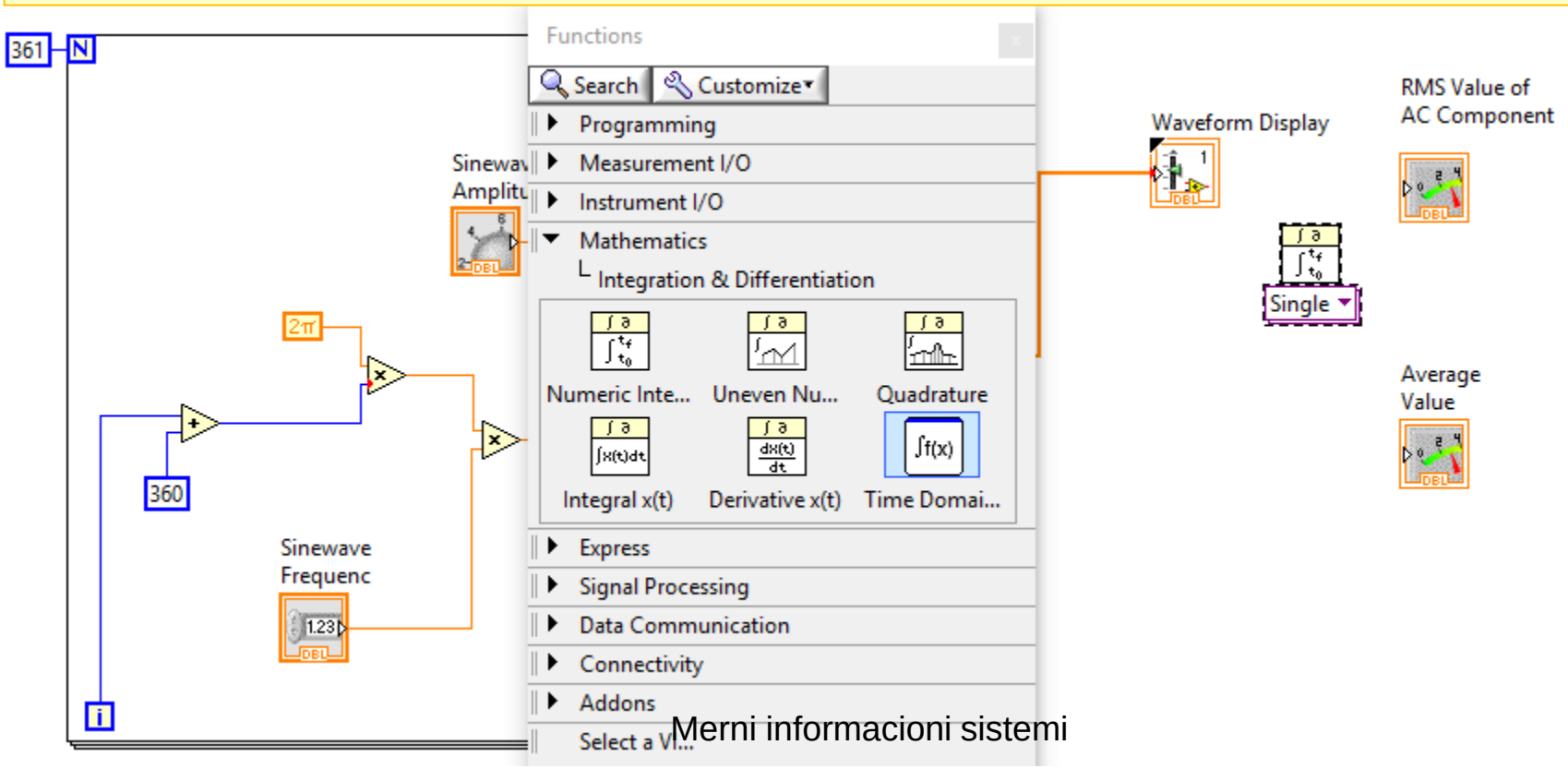


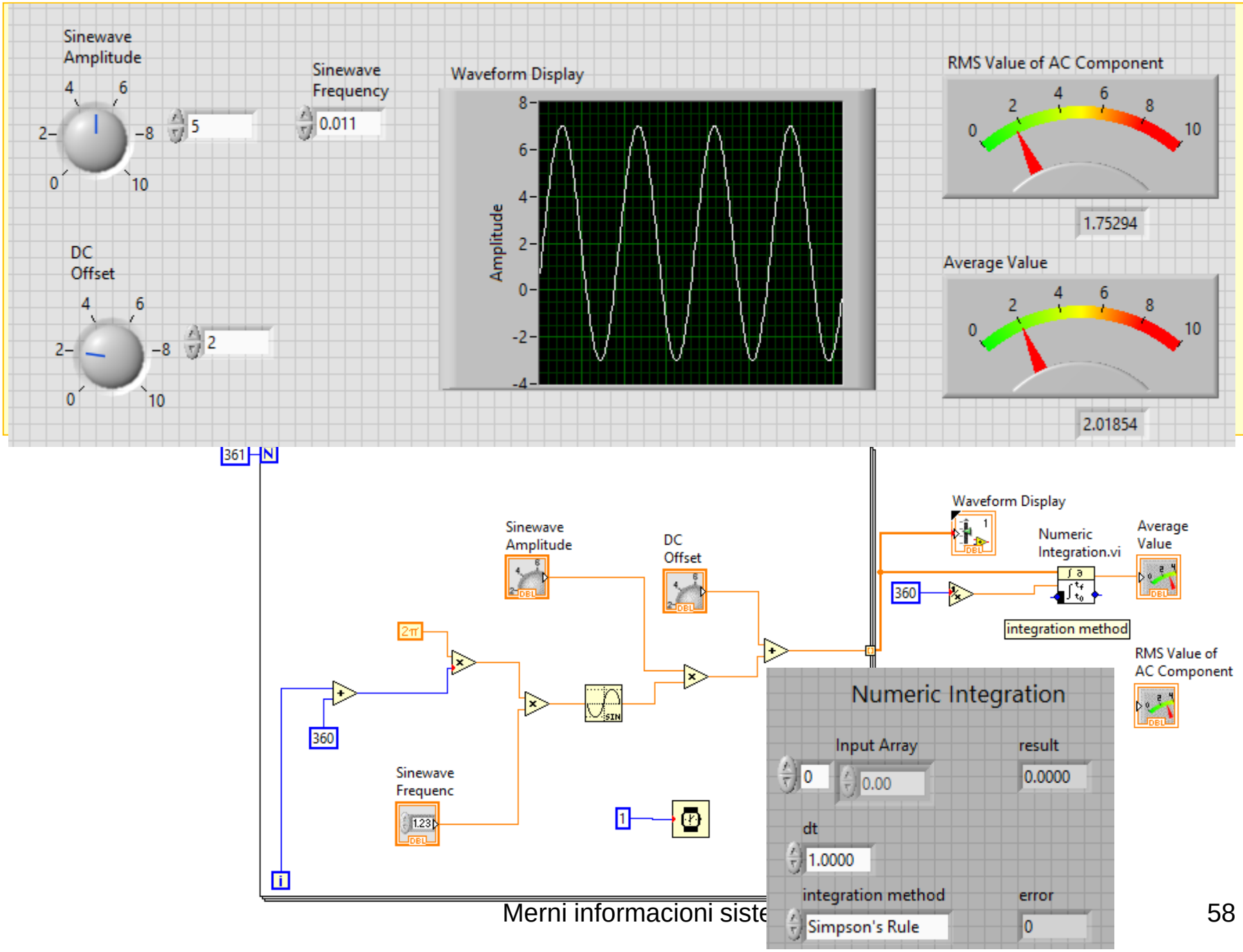
The signal needs to be integrated over one cycle (from t = 0 to t = T)

The result of the integration is then divided by the duration T

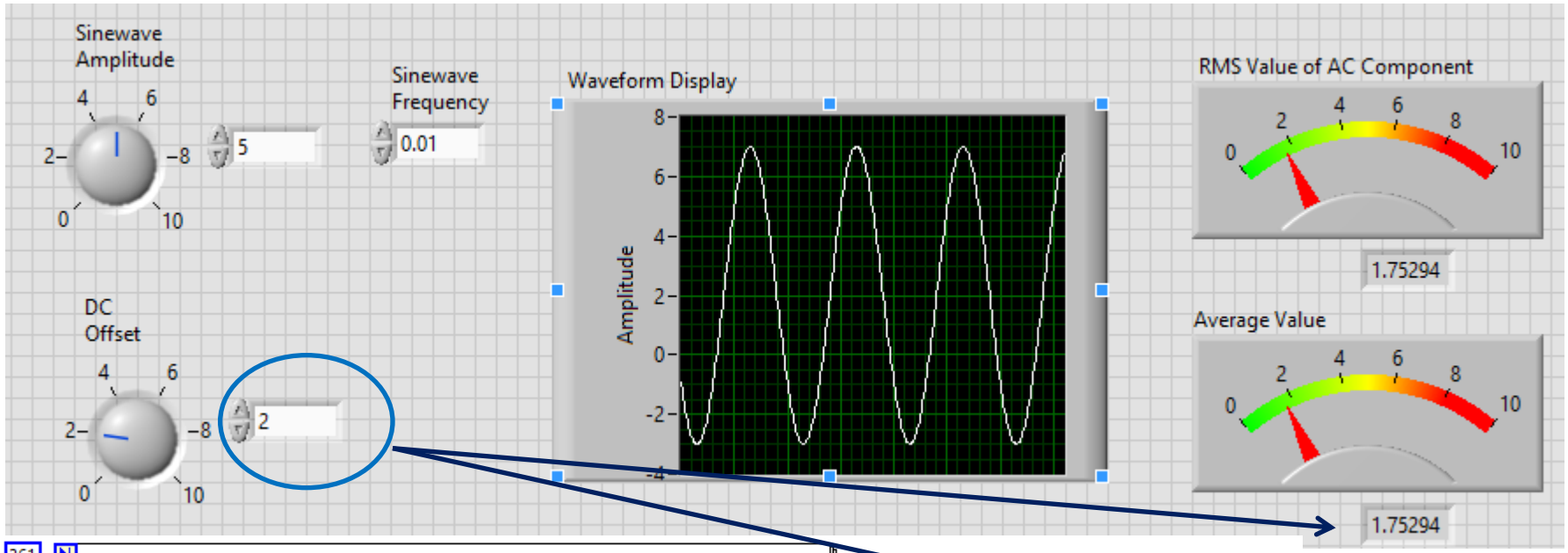
Conceptually, T=1, the time increment is 1/360

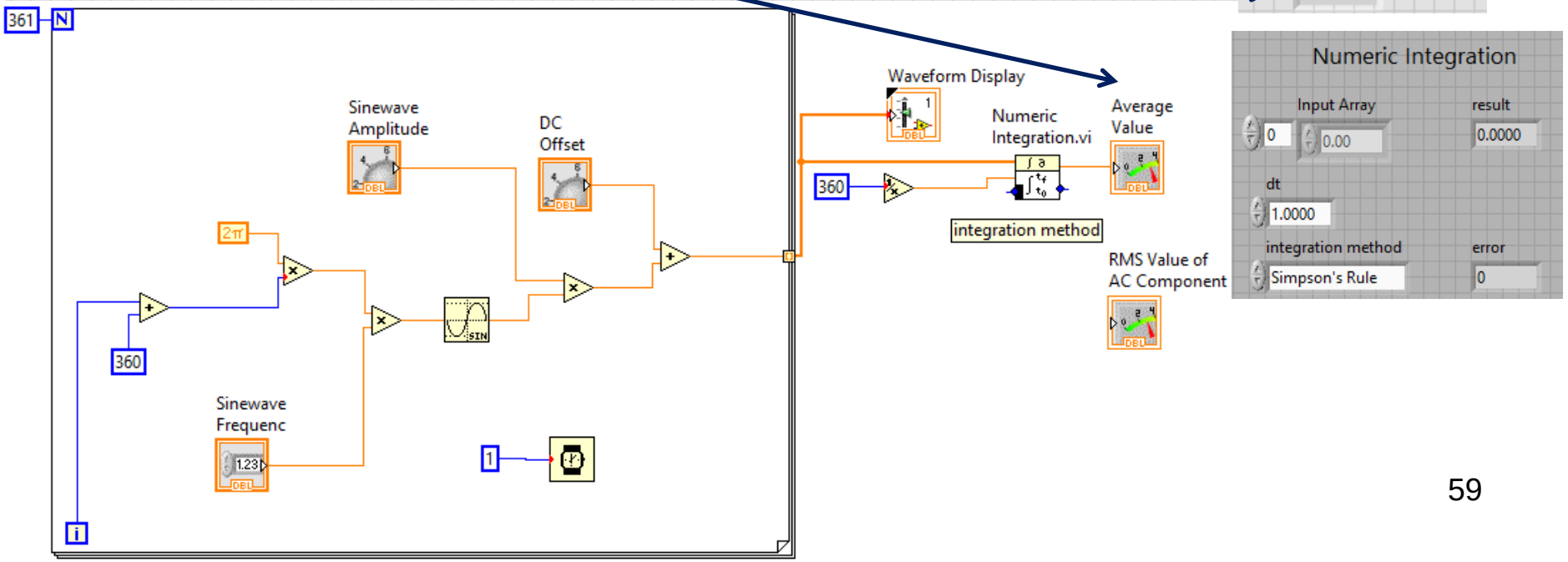
Integration block is on the functions menu by clicking on **Mathematics>Integration & Differentiation >Numeric Int.**



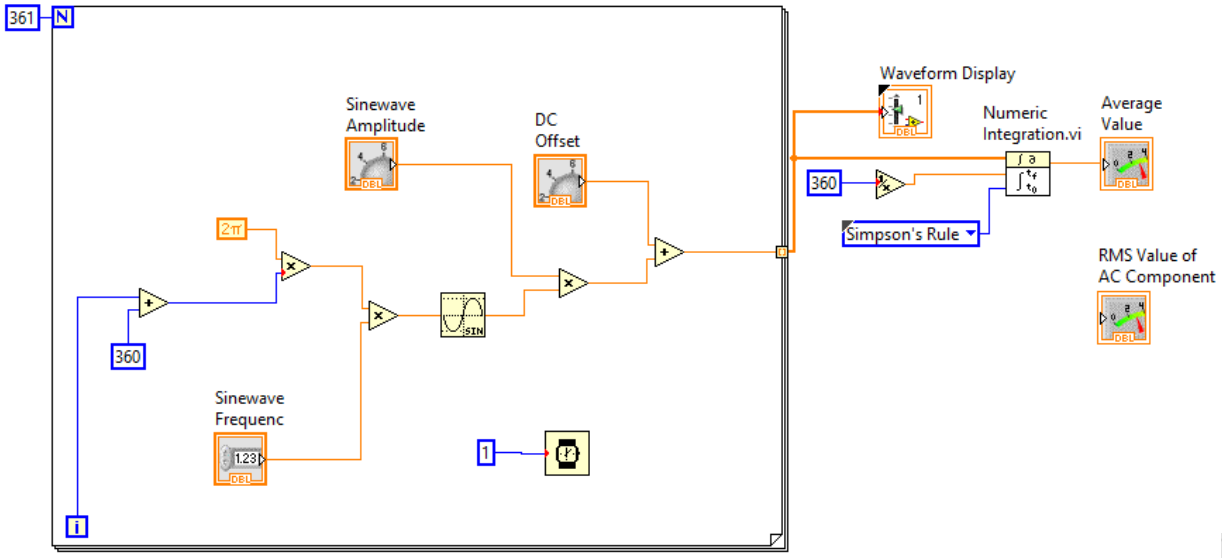

Sinewave Amplitude
5
Sinewave Frequency
0.011
Waveform Display
Amplitude
RMS Value of AC Component
1.75294
DC Offset
2
Average Value
2.01854
361
N
Sinewave Amplitude
DC Offset
Waveform Display
Numeric Integration.vi
Average Value
360
integration method
RMS Value of AC Component
2π
360
Sinewave Frequenc
1.23
SIN
1
i
Numeric Integration
Input Array
result
0
0.00
0.0000
dt
1.0000
integration method
error
Simpson's Rule
0

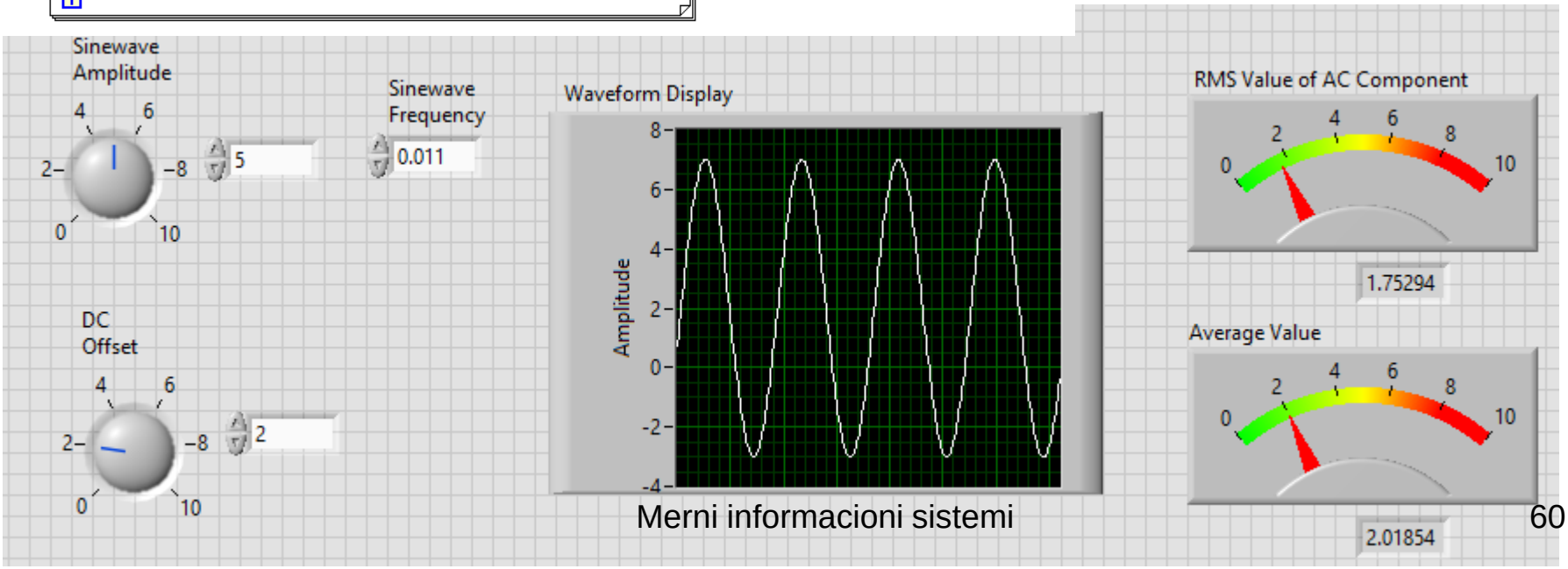
The integration block is a sub VI





The integration algorithm (right-click on the input and use the pop-up menu to select Create>Constant>Simpson's Rule





The RMS value of the AC component of the signal

The DC component is subtracted from the input array

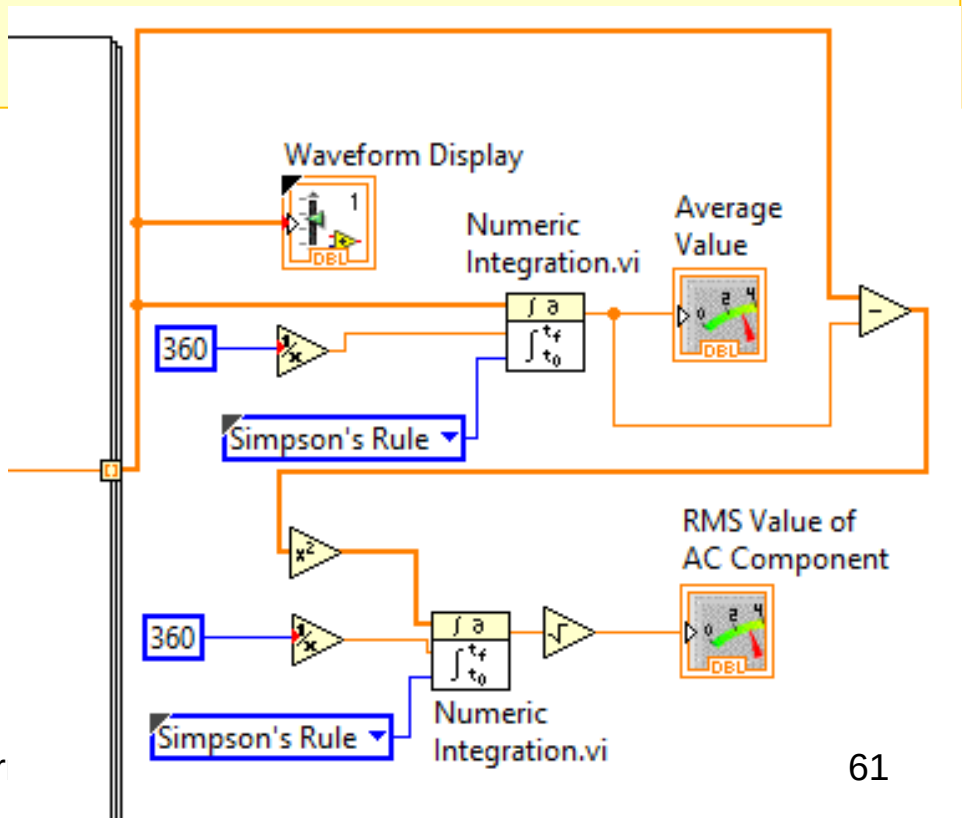
The result is then connected to both inputs of a multiplier

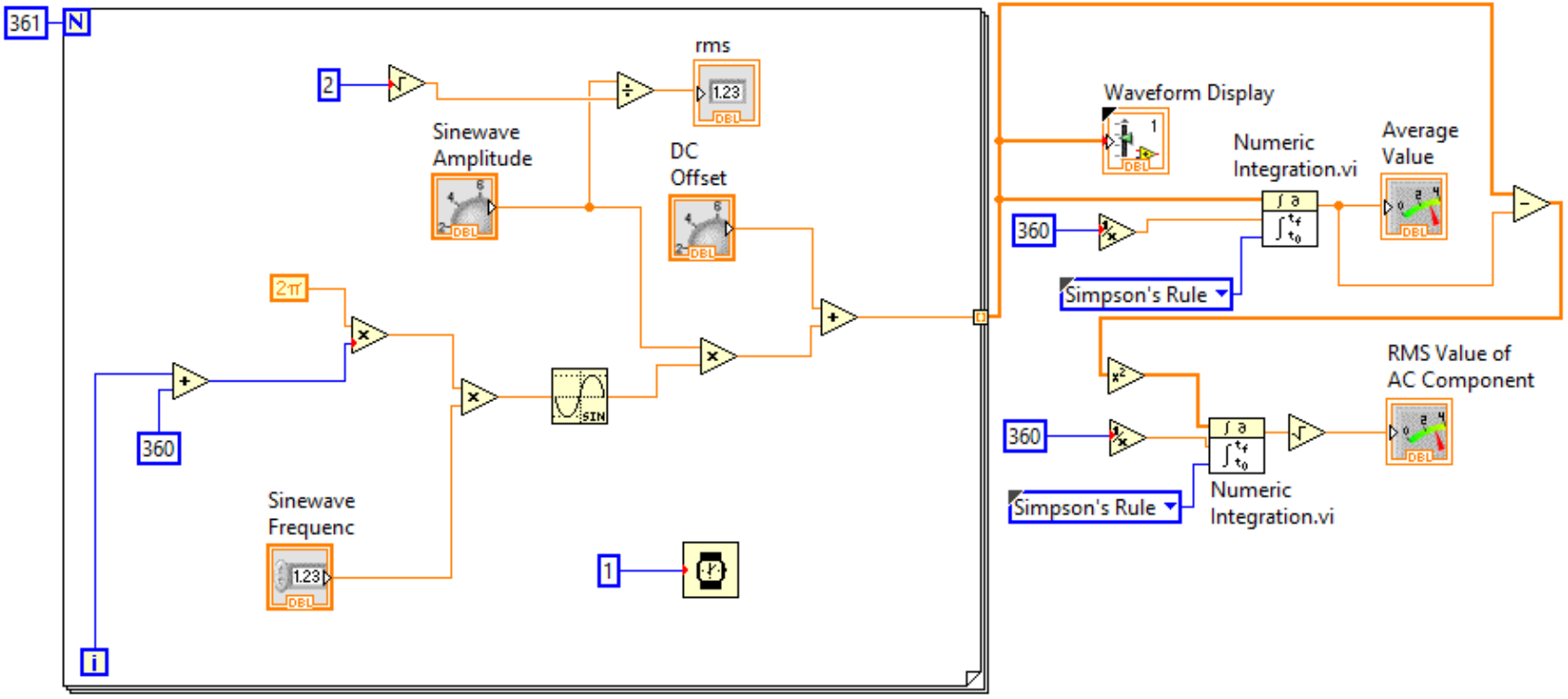
The corresponding elements of the arrays are multiplied

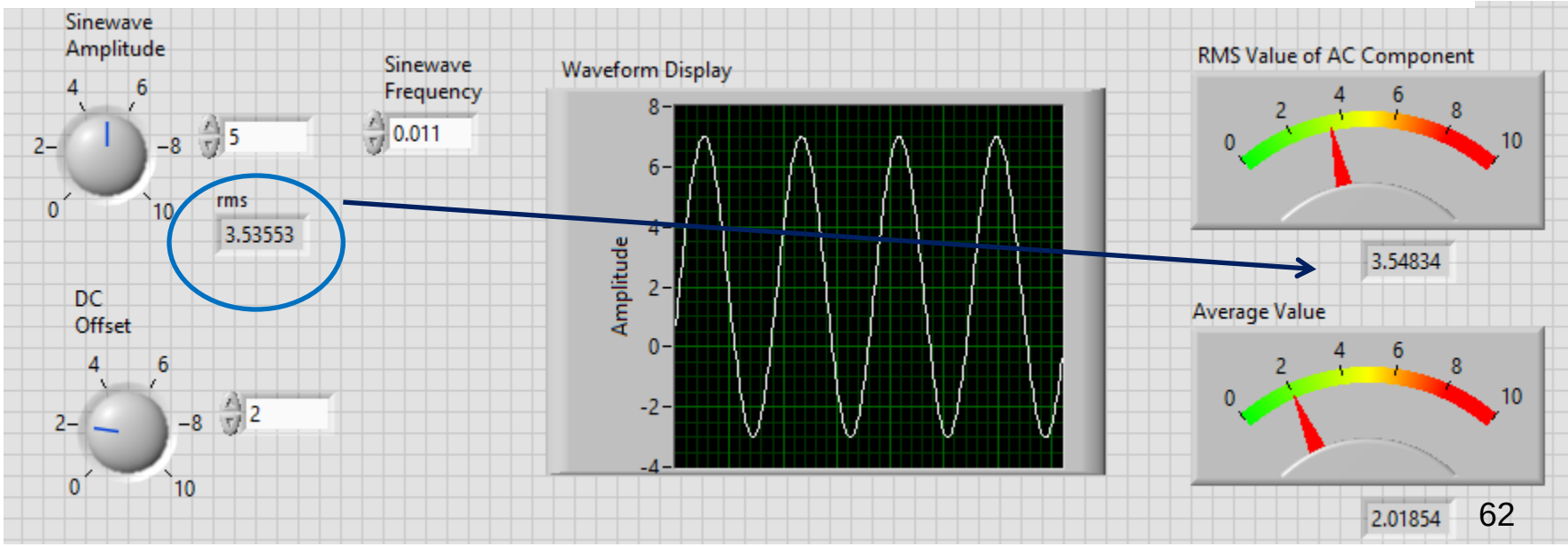
The squares of the values in the input array

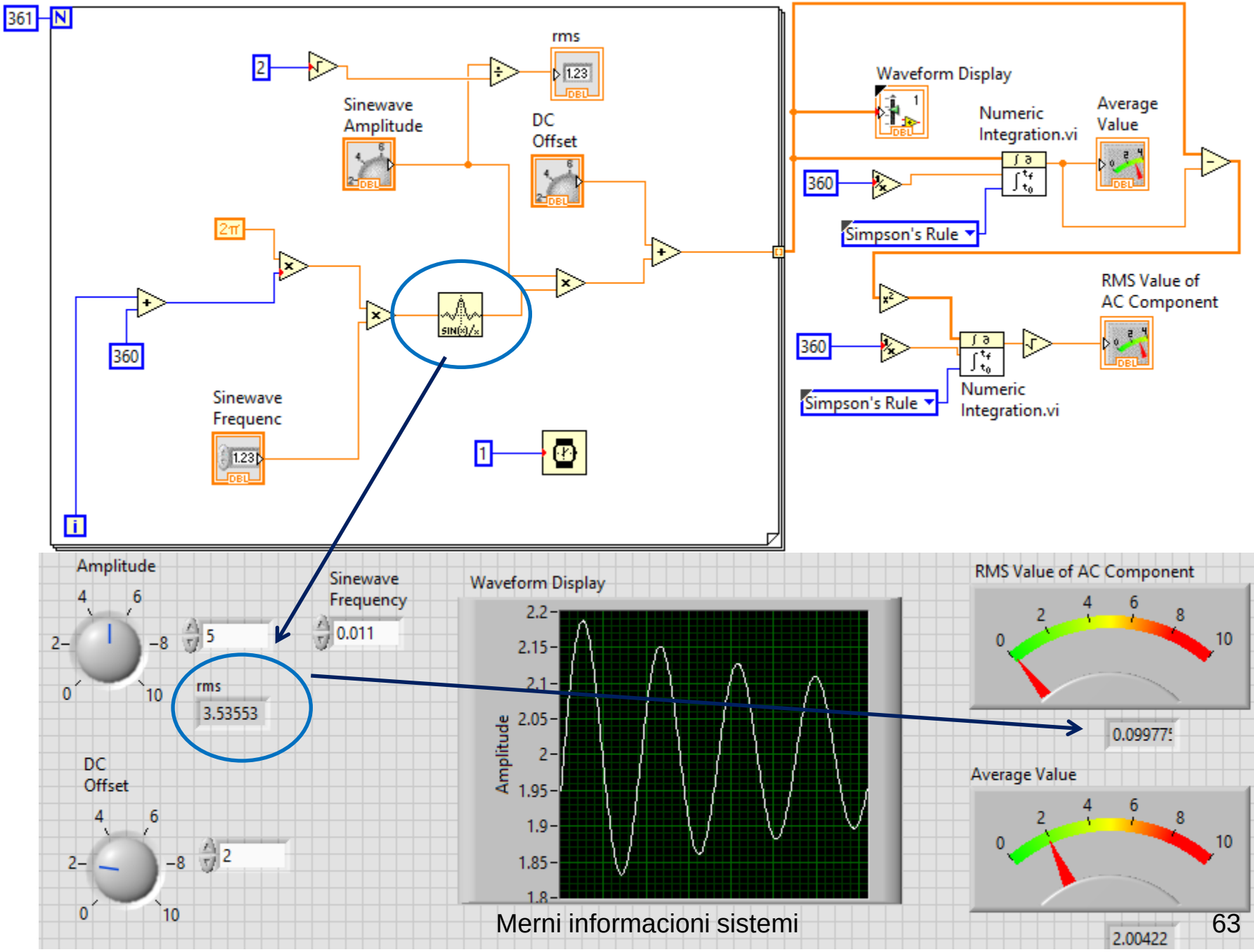
This is integrated (T=1, Δt=1/360)

The square root is computed




361
N
2
rms
1.23
DBL
Sinewave
Amplitude
DC
Offset
2π
360
Sinewave
Frequenc
1.23
DBL
SIN
1
i
Waveform Display
Numeric
Integration.vi
Average
Value
360
Simpson's Rule
RMS Value of
AC Component
360
Simpson's Rule
Numeric
Integration.vi


Sinewave
Amplitude
5
rms
3.53553
Sinewave
Frequency
0.011
DC
Offset
2
Waveform Display
Amplitude
RMS Value of AC Component
3.54834
Average Value
2.01854


361
N
2
rms
1.23
DBL
Sinewave
Amplitude
DC
Offset
2π
360
Sinewave
Frequenc
1.23
DBL
1
i
Waveform Display
Numeric
Integration.vi
Average
Value
360
Simpson's Rule
RMS Value of
AC Component
360
Simpson's Rule
Numeric
Integration.vi
Amplitude
4
6
2
8
0
10
5
rms
3.53553
Sinewave
Frequency
0.011
DC
Offset
2
Waveform Display
2.2
2.15
2.1
2.05
2
1.95
1.9
1.85
1.8
Amplitude
RMS Value of AC Component
0.09977
Average Value
2.00422

LabVIEW MathScript

Tools>MathScriptWindow

comments following the % signs

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