Yet Another Car Computer

Yet Another Car Computer is do-it-yourself electronic device addressed to middle skilled hobbyists.

Opel cars are primary destination of YACC which works with cars displays, preserves genuine interior look and seems to be a factory device.

Moreover, YACC can work with popular alphanumeric LCD displays. This feature, extended configuration and painless calibration method make possible to install YACC in practically every car equipped with fuel injection.

Functions

1) Instantaneous speed measurement with precision of 0.1 km/h.
2) Traveled distance measurement. Automatically shown every time vehicle stops.
3) Average speed measurement. Two values are measured: (a) total average speed, (b) average speed corresponding to motion i.e. only referring to periods of time when vehicle is moving.
4) Time of journey and time when vehicle is stopped measurement.
5) Cost of used fuel.
6) Fuel consumption: (a) average since key was turned on, (b) instantaneous corresponding to last 5 second, (c) instantaneous corresponding to road segment of length ranging from 50 to 1000 meters.
7) Used fuel gauge. Low fuel level warning: (a) estimation of fuel level in the tank, (b) distance estimation remaining on the tank given mileage.
8) Three trips. Each trip meters distance, average speed, time of journey, average and total fuel consumption and cost of fuel for longer periods of time.
9) Tachometer.
10) Battery voltage meter.
11) Manual steering of automatic antenna. It is possible not to use the antenna e.g. when listening to CD.
12) Sport mode. 1/4 mile and 0...60, 0...80, 0...100 km/h runs.

Informations from points 2, 3, 4 and 5 are automatically displayed when vehicle stops. While going through the city they give an interesting possibility of observations of mileage, comparison the average speed with the speed of e.g. bicycle, realizing how much time we spent in traffic jams and how big car expenses are.

Instantaneous speed gives a chance to estimate how big an excess of factory speedometer indication is.

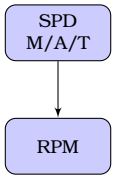
Average fuel consumption corresponding to segment of the road focuses our attention on big differences depending on traffic conditions and driving style.

Using the YACC

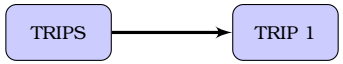
Single button is used to control the device. Two types of presses are recognized. Pressing and holding the button for less than 1 second is called a short press. Pressing and holding the button for more than 1 second is called a long press. Short presses cycle the display between successive working modes. Long presses are used to enter commands (e.g. to reset fuel counter, to begin a trip etc.)

A `[ ]` symbol is shown when a long press is available.

Working modes are shown on figures 5, 6 and 7. Short presses are represented by thin, vertical lines



and long presses by thick, horizontal ones.



Basic mode

While driving instantaneous speed v is shown in km/h.

```
SPD 50.2
```

If tank capacity (FUEL → TANK CAP) is set and an amount of fuel remaining in tank (difference between defined tank capacity and used fuel F) is lower than warning level (FUEL → WARN LEV), than the following data are shown instead of letters SPD.

a) Tank fuel level (in liters).

```
F10 50.2
```

Here F10 means that

$$9.5 < \texttt{TANK CAP} - \texttt{F} \leq 10.5$$

b) Estimated distance remaining on the tank (in kilometers).

```
D124 51.4
```

This distance is calculated using current average fuel consumption FA.

When the vehicle stops (condition $v < 0.5$ km/h) the following values are displayed.

a) Traveled distance in meters

```
M 12005
```

or for distances greater than 100 km in kilometers.

```
KM 1200.1
```

b) Average speed, excluding the time when the vehicle was stopped/total average speed in km/h.

```
A 40/32.7
```

c) Total time of trip/time when vehicle was stopped in minutes.

```
T 20/4
```

For total trip time greater than 60 minutes, both times are displayed one after another. Time of trip

```
T 2H30
```

and time when vehicle was stopped.

```
W 0H25
```

d) Fuel cost.

```
EUR 20/4.5
```

The first value corresponds to TRIP 1 and is shown only for active trip. The second value corresponds to current traveled distance (since key was turned on).

Distance, travel time and fuel cost measurements start each time when the key is turned on (precisely since the first moment when $v \geq 0.5$ km/h) and end when the key is turned off.

Tachometer

The value of engine revolutions per minute is shown.

```
RPM 1200
```

Average fuel consumption

Average fuel consumption corresponding to traveled distance (since the key was turned on) is shown. The unit is l/100 km.

```
FA 7.5
```

User can choose between displaying numerical values related to consumed fuel (averages FA, FH, FK, FX, fuel counter F) with accuracy of one or two decimal digits after decimal dot (FUEL → ACC). One should remember however, that TID allows to display decimal point between two most right digits only. With two digit accuracy result will be shown as integer with unit 0.01 l/100 km.

```
FA 750
```

Instantaneous fuel consumption per hour

Instantaneous fuel consumption corresponding to last 5 seconds is shown. The unit is l/h.

```
FH 1.2
```

Instantaneous fuel consumption corresponding to segment of the road

Instantaneous fuel consumption corresponding to the preceding segment of the road of selected length (10 m, 20 m, 50 m, 100 m, 200 m, 500 m, 1 km) is shown. The unit is l/100 km.

```
FK05 8.5
```

or

```
FX05 8.5
```

Long press enters settings mode enabling to select length of the segment of the road. Next short presses cycles between values 10 m (FK01), 20 m (FK02), 50 m (FK05), 100 m (FK1), 200 m (FK2), 500 m (FK5), 1 km (F1K). Long press switches between FK and FX modes. In FK mode all amount of used fuel is included in calculations. In FX mode fuel used when vehicle was stopped is not included. YACC returns to main menu automatically after 5 second.

Fuel gauge

The amount of fuel used so far is shown. The unit is l.

```
F 31.2
```

Long press enters the fuel related menu. Successive short presses cycle through following commands.

a) RESET – counter reset. Use this command every time you fill up but don't want to recalibrate fuel coefficient c_{fuel}. Long press resets the counter and confirms with message

   ```
   DONE
   ```

b) ADD – use this command every time you are filling your tank but not completely full. Long press switches to editor mode (EDIT) where you enter the amount (in 0.01 l) of fuel added.

c) CAL – choose this command when you are filling your tank and want to use the data collected during the past tank to calibrate your fuel coefficient c_{fuel}. Long press switches to editor mode (EDIT) where you enter the amount (in 0.01 l) of fuel added during this fill-up.

d) PRICE – fuel price. Long press switches to editor mode (EDIT) where you enter fuel price in 0.01 currency unit. Currency symbol can be defined in FUEL → CURRENCY mode.

e) EXIT – returns to previous menu. Automatically after 5 seconds or with a long press.

Fuel cost

Fuel cost corresponding to traveled distance is shown.

```
EUR 10.6
```

Battery

The battery voltage is shown. The unit is V.

```
BATT 12.2
```

YACC switches to this mode immediately after key is turned on giving possibility to observe voltage drops when vehicle ignition is attempted. After 20 seconds YACC returns automatically to basic mode.

Trips

Trips allows to measure total distance, time and used fuel for longer periods. Long press in

```
TRIPS
```

mode switches to trips related menu where short presses cycle through successive trips (TRIP 1, TRIP 2, TRIP 3) and command EXIT returning to main menu — automatically after 5 seconds or with a long press.

For each trips following values are displayed every 2 seconds

a) trip number, e.g.

   ```
   TRIP 1 *
   ```

b) traveled distance,

c) average speed,

d) time of trip,

e) average fuel consumption,

f) total fuel consumption,

g) fuel cost.

Symbol * after number means that trip is active i.e. distance, time and fuel data are updated all the time. Lack of * means that trip was ended.

Long press begins or ends the trip. If the trip is inactive the command

```
BEGIN n
```

is shown where n corresponds to trip number. Next long press resets all trip related data and marks trip as active. The action is confirmed with

```
DONE
```

Since that moment distance, time and fuel data will be updated all the time. If the trip is active the command

```
END n
```

is shown. Next long press ends the trip. The action is confirmed with

```
DONE
```

YACC switches to BATT mode for 20 seconds immediately after key was turned on. During that time period a single long press resets and begins TRIP 1.

Sport mode

Long press in basic mode switches to sport mode. Short presses cycle through runs: 1/4 mile, 0...60, 0...80, 0...100 km/h.

YACC automatically prepares to new run each time vehicle is stopped. Run name (1/4, 60, 80, 100) is shown on the left side and word ready RDY on the right one.

```
1/4  RDY
```

Timing commences automatically upon detection any motion. The percent relative value of distance (speed) is shown on the left side. Run time in second is shown on the right side.

```
47%  10.2
```

At the end of the run timing stops and run name is shown once more on the left side.

```
1/4  21.0
```

Long press in sport mode switches back to basic mode.

Manual antenna steering

When you turn radio on an antenna status

```
ANT ON
```

or

```
ANT OFF
```

is shown for 5 second. Short press changes the state of the antenna to the opposite one.

During radio use a long press (if not connected with another command) changes antenna position to the opposite one.

Turning the key off

YACC turns off after 30 seconds of idleness.

Configuration

Pressing and holding button for 5 seconds in tachometer mode switches to configuration menu. A "stereo" symbol appears on 8–digit display and "Dolby" symbol on 10–digit one. 20 seconds idleness switches automatically back to basic mode.

Editor

Editor allows to enter numerical values and is available in selected working modes. Editor is always entered with a long press. Next short presses cycle through successive digits and commands CANCEL and SET. The SET command is visible only when a value has been changed and a new value is in proper range. Long press during SET command stores a value, ends editor mode and returns to the mode editor was started from.

Long press during CANCEL command ends editor mode without any changes.

Long press during digit selection switches into a mode which allows to change digit value. Short presses select new value and a long press accepts it.

Defaults

Astra F

PRESETS → ASTRA F. Long press recalls default fuel measurement values for Astra F.

FUEL → COEF	3 669 000
FUEL → SOURCE	L

Astra G

PRESETS → ASTRA G. Long press recalls default fuel measurement values for Astra G.

FUEL → COEF	27 700
FUEL → SOURCE	F

Speed and distance

Calibration

SPEED → DISTANCE. Use the following procedure. Begin TRIP 1 and reset the mechanical distance counter at the same time. Travel some tens of kilometers. With a long press switch to editor mode and enter traveled distance in meters. The calibration coefficient c_{dist} will be calculated automatically.

One needs to remember that most mechanical counters work in two directions — count downward while going backward. YACC uses a pulser and does not distinguish directions.

Calibration coefficient

SPEED → COEF. In editor mode enter c_{dist} value in range 1...65 535 equal to number of impulses corresponding to 1 km.

Instantanous speed averaging

SPEED → NOISE. YACC uses a simple algorithm to achieve better precision of speed measurement. The measurement process lasts approximately SPEED → T MIN. Number of recorded impulses correspoding to traveled distance is divided by measurement time.

Traveled distance impulses are generated by special devices called pulsers. Construction of pulsers varies. Very often they are based on rotating wheel. Mechanical inaccuracies of workmanship, looseness, axis and propel cable vibrations can cause additional errors. Figure 8 shows calculations of instantaneous speed based on recorded times of two successive impulses.

Result analysis indicates that for this specific case pulser generates 15 impulses with every revolution. Therefore it would be better to use time periods corresponding to multiply of 15 impulses.

In editor mode enter the value SPEED → NOISE in range 0...99. Value 0 turns averaging off. If during single measurement less than 2·SPEED → NOISE impulses are recorded (small speeds) than instantaneous speed is calculated without averaging. For other cases the biggest multiply of SPEED → NOISE impulses is used in calculations.

Signal selection

SPEED → SOURCE. The letter R corresponds to rising edge and the letter F to falling one. Long press changes between R and F.

Minimum measurement time

SPEED → T MIN. In editor mode enter value in range 10...110 in hundred parts of second.

Maximum measurement time

SPEED → T MAX. In editor mode enter value in range 10...110 in hundred parts of second.

Fuel

Tank capacity

FUEL → TANK CAP. In editor mode enter tank capacity (value in range 0...250) in liters. Value 0 turns low fuel level warning off.

Warning level

FUEL → WARN LEV. In editor mode enter value in liters in range 0...99. Value 0 turns low fuel level warning off.

Currency symbol

FUEL → CURRENCY. In editor mode enter three letter currency symbol (e.g. EUR, USD etc.)

Accuracy

FUEL → ACC. Long press switches between displaying numerical values related to consumed fuel (averages FA, FH, FK, FX, fuel counter F) with accuracy of one or two decimal digits after decimal dot. One should remember however, that TID allows to display decimal point between two most right digits only. With two digit accuracy result will be shown as integer with unit 0.01 l/100 km.

Calibration coefficient

FUEL → COEF. In editor mode enter c_{fuel} value in range 1...99 999 999 equal to the sum of impulses lengths corresponding to 1 liter of fuel.

Reading fuel consumption data

FUEL → HISTORY. In this mode one can read data necessary to compute fuel consumption calibration coefficient c_{fuel}. Short presses cycle between successive results. 20 seconds of idleness returns to basic mode.

Results are shown in order reverse to chronological (1 — past fill, 2 — fill before past etc.) A single fill is represented by 3 values: A — amount of fuel in 0.01 liters, B — beginning 5 digits Σf, C — ending 5 digits of Σf.

Example results.

```
1A 04328
1B 01855
1C 82273
2A 04409
2B 01619
2C 59814
3A 03844
3B 01313
3C 73735
4A 04163
4B 01538
4C 56441
5A 04312
5B 01553
5C 67922
6A 03736
6B 01389
6C 54037
7A 04358
7B 01599
7C 57383
8A 04346
8B 01594
8C 08461
```

	Liters	Σf
1.	43.28	185 582 273
2.	44.09	161 959 814
3.	38.44	131 373 735
4.	41.63	153 856 441
5.	43.12	155 367 922
6.	37.36	138 954 037
7.	43.58	159 957 383
8.	43.46	159 408 461

We assume that amount of used fuel v_{fuel} is proportional to total length Σf of recorded impulses

$$v_{fuel} \cdot c_{fuel} = \Sigma f$$

The method used to obtain value of c_{fuel} consists in filling up the fuel tank of car (until the pomp stops). However this method has potentially many errors like inaccuracy of the pomp work, the moment pomp stops, etc.

Results are shown on figure 9. Points corresponding to fills 2, 4, 5, 6, 7 and 8 are approximately linear. Fills 1 and 3 have thick errors and has been excluded from further analisys. A straight line $y = c_{fuel} \cdot x$ has been fitted with least square method.

Signal selection

FUEL → SOURCE. The letter L selects length measure of low level, the letter H — high one, the letter R counts rising edges and F — falling ones.. Long press cycles through L, H, R, F.

Tachometer

Calibration coefficient

RPM → COEF. Long presses cycle through subsequent c_{rpm} coefficient values: 1, 2, 3, 4, 5, 6, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$.

Edge selection

RPM → SOURCE. The letter R corresponds to rising edge and the letter F — falling one. Long press changes between R and F.

Minimum measurement time

RPM → T MIN. In editor mode enter value in range 10...110 in hundred parts of second.

Maximum measurement time

RPM → T MAX. In editor mode enter value in range 10...110 in hundred parts of second.

Battery

Calibration

BATTERY → VOLTAGE. Measure a battery voltage with a multimeter. With a long press switch to editor mode and enter measured value in units 0.01 V. The calibration coefficient c_{batt} will be calculated automatically.

Calibration coefficient

BATTERY → COEF. In editor mode enter c_{batt} value in range 1...65 535. The A/D converter resolution is equal to 10 bits. Value u =1 023 corresponds to voltage

1.1 V. The value shown in battery voltage mode BATT is calculated with the following formula.

$$\frac{c_{batt} \cdot u}{10\ 000}$$

Radio

Manual antenna steering

RADIO → ANT. Value YES enables and value NO disables manual antenna control. Long press changes value to opposit one.

When manual steering is disabled antenna opens automatically with radio turning on and closes 10 second after turning radio off.

Connection with factory radio receiver

RADIO → OPEL. Value YES allows to use factory radio receiver. When receiver is in use YACC does not send any data to TID. Value NO corresponds to constant access of YACC to TID display. If one use factory radio with this setting data collision will occur and none or random data will be displayed. However this will not lead to any disfunction.

LCD display

Display width

LCD → WIDTH. Select number of characters in a single line in range 12...20.

Number of lines

LCD → LINES. Select number of lines (one or two).

For a single line the way of work corresponds to TID display.

For two lines, the upper one displays instantaneous speed and estimation of fuel and distance remaining on your tank. The lower line corresponds to TID display.

Second line offset

LCD → OFFSET. In the editor enter an address (number in range 0...127) of the first character in the second line. This option allows to deploy practically every model of LCD display.

TID display selection

The YACC computer works with factory display used in Opel cars. There are two variants of displays with 8 or 10 digits. The proper display type can be selected with 8/10 jumper.

8/10 jumper	
open	8 digit display
close	10 digit display

Construction

Schematic diagrams are shown on figures 10 and **??**. The microcontroller IC1 running with clock 12 MHz and supplied with 3.3 V is the main element. At such supply voltage the microcontroller is slightly overclocked but works correctly.

Low supply voltage guarantees proper work of device when ignition is attempted what usually cause big battery voltage drops.

Supply

Supply circuit uses low drop voltage regulator IC5. Key on voltage pulls PWR2 line low which in turn switches T1 transistor on and powers the microcontroller. Microcontroller keeps PWR4 line low during work and keeps power even after turning key off. Concurrently YACC monitors key on voltage by reading state of PWR1 line.

A/D converter

A/D converter input voltage range is 0...1.1 V. Battery voltage measurement uses a divider with R4 and R5 resistors. Diodes D1 and D2 protect A/D input.

Outputs

IC2 and T2 are used to convert 3.3 V level signals into 12 V level ones.

> If you don't intent to manually control automatic antenna than skip assembly of T2, R13 and R16 elements.

Inputs

IC3 is used to convert 12 V level signals into 3.3 V level ones. Additionally for traveled distance signal (ICP), engine revolution signal (INT1) and fuel consumption signal (INT0) Schmidt triggers (built with IC4) can be used.

Triggers are activated by jumpers according to the following table.

Schmidt trigger	
	bypassed
	used

Assembly in the car

Elements assembly on the circuit board is the first step. The microcontroller IC1 is mounted into a socket.

YACC was designed for control button which switches the ground. This corresponds with 8–digit displays (e.g. Astra F).

In 10–digit displays (e.g. Astra-G) the dot button switches positive voltage. In order to adjust YACC to work with 10–ditig displays you should omit assembling D3 diode and make two additional connections on the circuit board.

A comprehensive description of assembly is available on the web page

e-pmk.eu/en/diy/yacc/know-how

YACC and LCD displays

Due to users feedback the possibility of communication with popular LCD displays based on HD44780 driver has been added to the YACC computer.

Connection

The way of connection of LCD display to YACC computer is shown on figure 10. Connections have to be made with wires soldered directly to the points on printed circuit boards.

Depending on the display type it could be necessary to use contrast regulation (R1 variable resistor) and/or backlight current restraint (R2 resistor).

Supply

Depending on current consumption by LCD display (backlight current ranging from tens to hundreds mA is the most significant factor) it would be necessary to use additional voltage regulator or might be possible to use existing one (after substituting original IC5 LP2950-3V3 circuit with +5V equivalent, e.g. LP2950-5V0 or 78L05).

Display selection

Display selection is determined with PC3 input. Connecting the input with the ground (with LCD/TID switch or simply with wire) selects LCD display. Leaving the input unconnected selects TID display.

Restoring factory settings

Improper configuration can couse that information will not be displayed properly.

Closing 8/10 jumper and powering device restores factory settings:

LCD → WIDTH	12
LCD → LINES	1
LCD → OFFSET	64

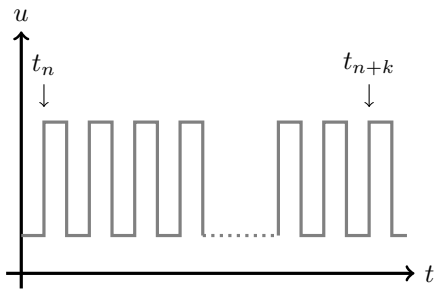
Measurement methods

Speed and distance

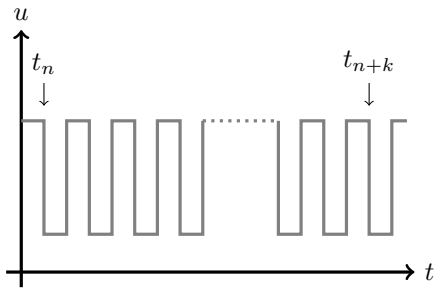
Speed and distance measurements use electric impulses generated by a special device called pulser.

Impulses are counted in 32–bit counter. Thus, assuming that 1 km corresponds to $c_{dist} = 16\,900$ impulses (real value for test car), the counter range is over 250 000 km.

Additionally, times of the rising (R)



or falling (F)



edges are recored. Edge type can be selected during configuration (SPEED → SOURCE mode). Resolution of measurements is equal approximately to 21 μs.

According to the number of impulses k and their times t_n, t_{n+k} instantaneous speed is calculated with the following formula

$$\frac{k}{c_{dist}} \cdot \frac{46\,875 \cdot 3\,600}{t_{n+k} - t_n} \quad \left[\frac{\text{km}}{\text{h}}\right]$$

Setting value of c_{dist} coefficient in range 1…65 535 makes it possible to adjust device to every car. Suggested calibration method is explained in further parts (SPEED → DISTANCE i SPEED → COEF modes).

Measurement time is determined by two values: the minimum time SPEED → T MIN and maximum time SPEED → T MAX. One can apply own values to these coefficients to achieve the best fit to own car. The measurement includes the lowest number k impulses (not greater than 255), such that $t_{n+k} - t_n >$SPEED → T MIN. For big speeds the measurement could last shorter than SPEED → T MIN. When at least two impulses will not be recorded during SPEED → T MAX time instantaneous speed is assumed to 0 and a new measurement starts immediately.

When the value of coefficient SPEED → NOISE> 0 and the number of recorded impulses $k >$ 2·SPEED → NOISE only $\tilde{k}$ beginning impulses are considered in the calculation, where $\tilde{k} \leq k$ is the biggest multiple of SPEED → NOISE.

Engine revolution speed

Measurement of engine revolution speed is analogous to measurement of instantaneous speed. The RPM value is calculated with the following formula

$$c_{rpm} \cdot k \cdot \frac{46\,875 \cdot 60}{t_{n+k} - t_n} \quad \left[\frac{\text{rev}}{\text{min}}\right]$$

Selection of the value c_{rpm} from set 1, 2, 3, 4, 5, 6, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, $\frac{1}{6}$ (RPM → COEF mode) allows to fit to own car.

Minimum and maximum times of measurement are determined by RPM → T MIN and RPM → T MAX configuration settings.

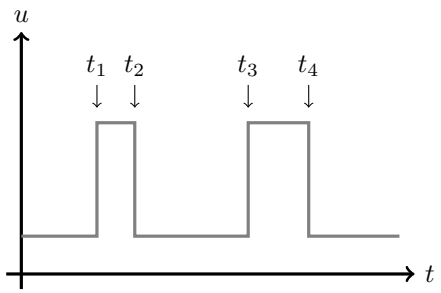
Measurement includes no more than $k = 255$ impulses and can last shorter than RPM → T MIN for big revolution speeds.

Fuel mileage

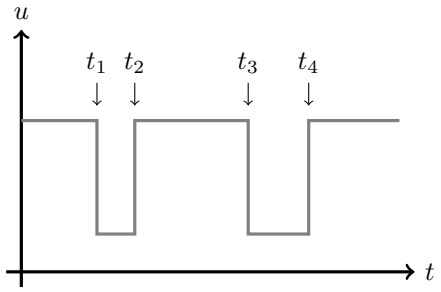
Fuel consumption is calculated from the length or count of impulses generated by Engine Control Module (ECM) or taken from signal driving injector.

(a) Times of rising and falling edges are recorded with the same accuracy as in instantaneous speed measurement. Maximum length of impulse equals approximately 21 ms. Longer impulses are rejected.

Times of impulses $t_2 - t_1$ and $t_4 - t_3$ corresponding to high (H)

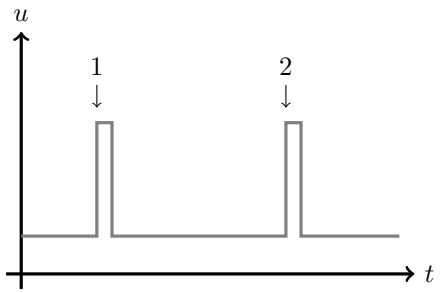


or low (L) level respectively

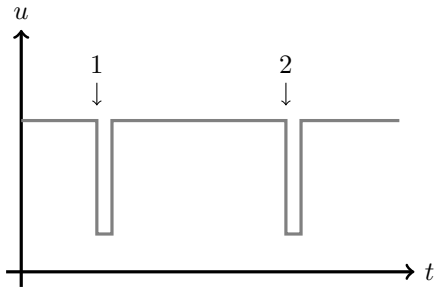


are summarized in 32-bit counter Σf.

(b) Rising



or falling



edges are counted in Σf.

Selection of corresponding signal level or edge is set during configuration (FUEL → SOURCE mode). The amount of used fuel is calculated with the following formula

$$\frac{\Sigma f}{c_{fuel}} \quad [\mathrm{l}]$$

Calibration process consists in estimation of c_{fuel} coefficient, which value is in the range 1...99 999 999 (FUEL → COEF mode). In the test car c_{fuel} value turned out to be 3 669 000 and corresponded to fuel counter capacity over 1 170 liters. Calibration process is described in detail in further sections (FUEL → HISTORY mode).

Time

The measurement of trip time and time when vehicle is stopped uses 32-bit clock counters with resolution equal approximately to 1.40 second. Therefore the maximum range is over 190 years.

Accuracy of mathematical calculations

Mathematical calculations are performed with 64–bit precision. When a calculated value is big so much that cannot fit on a display an overflow condition OVF is shown.

Technical specifications

Supply voltage: 5...27 V
Supply current: 21 mA

YACC has a very large reserve of computational power. Recorded, maximum traveled distance signal (ICP) frequency is equal to about 50 kHz, and engine revolution signal (INT1) to about 115 kHz.

In the test car (c_{dist} = 16 900, c_{rpm} = 1/2) traveled distance signal at assumed speed 180 km/h corresponds to frequency 845 Hz and uses 1.7% available computational power. Engine revolution signal at assumed speed 6 500 rpm corresponds to frequency 216 Hz and uses 0.2 % computational power.

Factory settings

Factory settings correspond to Astra F with X16XEL engine. Engine revolution and fuel consumption signals were taken from Engine Control Module.

SPEED → COEF	16 900
SPEED → NOISE	15
SPEED → SOURCE	R
SPEED → T MIN	50
SPEED → T MAX	60
FUEL → TANK CAP	50
FUEL → WARN LEV	9
FUEL → CURRENCY	PLN
FUEL → ACC	1
FUEL → COEF	3 669 000
FUEL → SOURCE	L
RPM → COEF	1/2
RPM → SOURCE	R
RPM → T MIN	20
RPM → T MAX	60
BATTERY → COEF	1 607
RADIO → ANT	Y
RADIO → OPEL	N
LCD → WIDTH	12
LCD → LINES	1
LCD → OFFSET	64

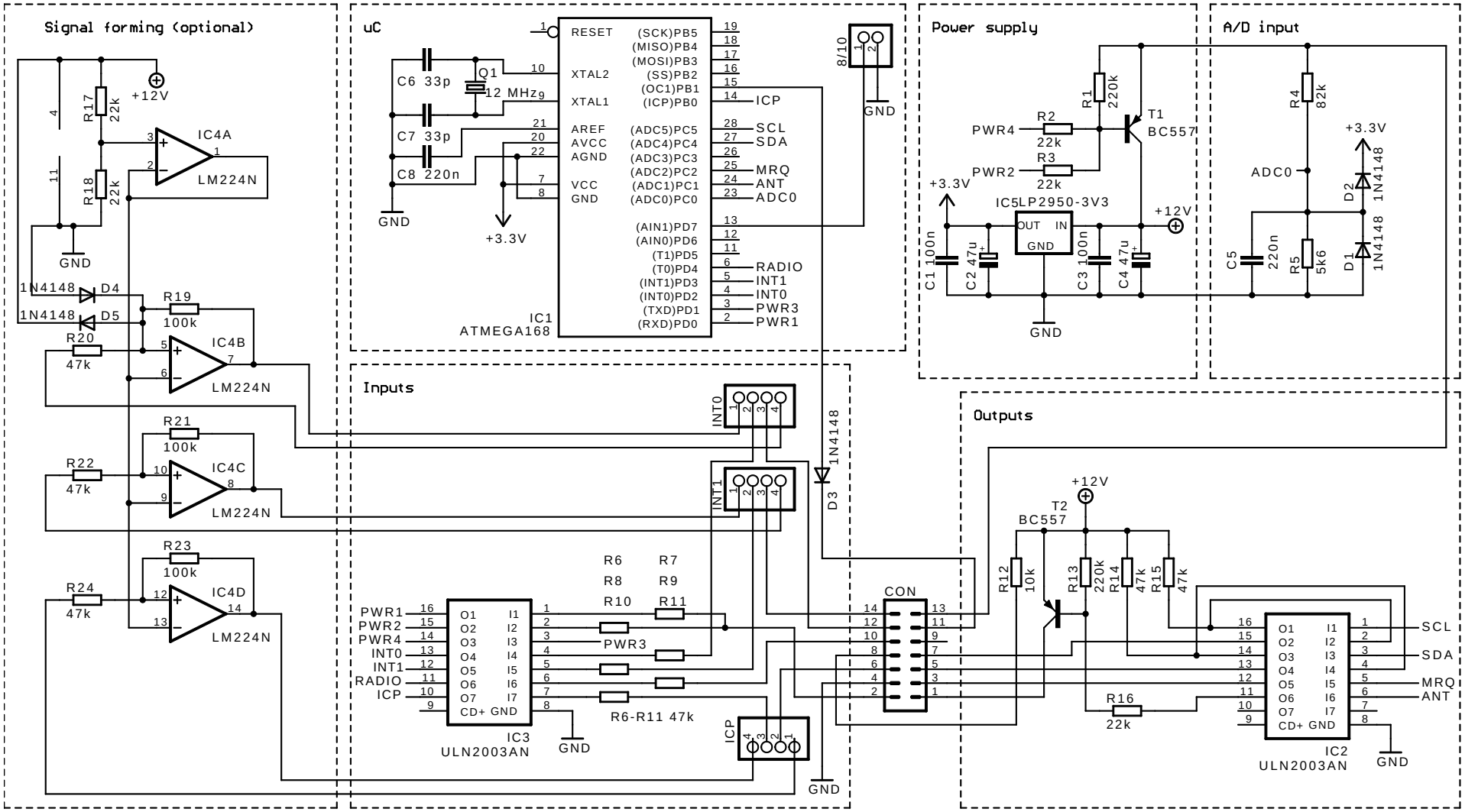
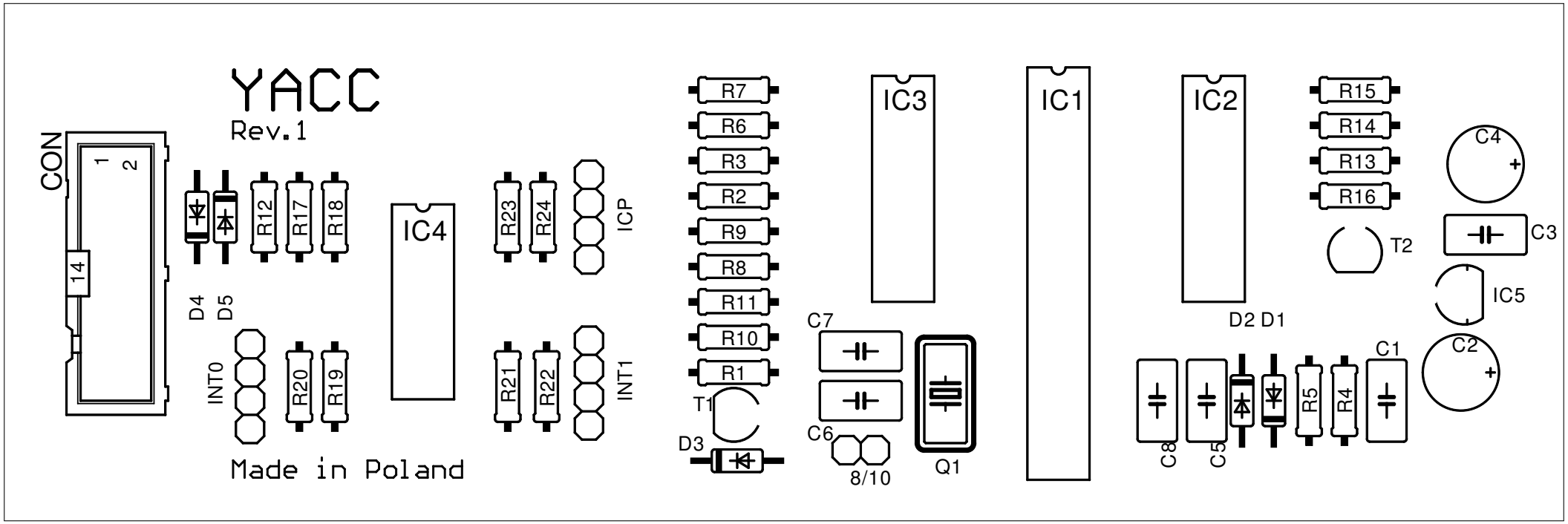


Figure 1: Schematic diagram. Control button switches the ground.



D1,...,D5	1N4148
T1, T2	BC557B
IC1	ATMEGA168
IC2, IC3	ULN2003
IC4	LM224/LM324
IC5	LP2950-3V3/78L05

R1, R13	220	kΩ
R2, R3, R16,...,R18	22	kΩ
R4	82	kΩ
R5	5,6	kΩ
R6,...,R11, R14, R15, R20, R22, R24	47	kΩ
R12	10	kΩ
R19, R21, R23	100	kΩ

C1, C3	100 nF
C2, C4	47 μF
C5, C8	220 nF
C6, C7	33 pF
Q1	12 MHz

Figure 2: Placement of elements.

Display connection

	type	description	Corsa B Astra F	Corsa C Astra G	Vectra B
2	supply	Key on voltage +12 V	5	1	5
3	output	MRQ	10	12	10
4	supply	Ground	3	6	2
5	output	SDA	11	11	11
6	input	Traveled distance signal	12	9	12
7	output	SCL	9	10	9
8	output	Controlling signal +12 V	8	2	8
11	input	Control button	On circuit board		
13	supply	Battery +12 V	1	3	1

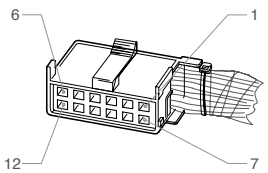
Automatic antenna connection

	type	description
1	output	Connection with automatic antenna (fig. 4, pin 7).
10	input	Connection with radio receiver (fig. 4, pin 7).

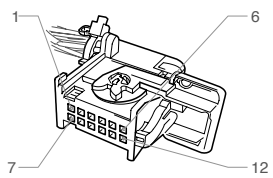
Engine revolution and fuel consumption signal connection

	type	description
12	input	Fuel consumption. Signal from Engine Control Module or from injector.
14	input	Engine revolution speed. Signal from Engine Control Module.

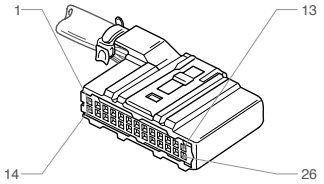
Table 1: YACC connector description.



Display Corsa B, Astra F Signal description	
1	Battery +12V
3	Ground
5	Key on voltage +12 V
8	Control signal +12 V
9	SCL
10	MRQ
11	SDA
12	Traveled distance signal



Display Corsa C, Astra G Signal description	
1	Key on voltage +12 V
2	Control signal +12 V
3	Battery +12V
6	Ground
9	Traveled distance signal
10	SCL
11	SDA
12	MRQ



Display Vectra B Signal description	
1	Battery +12V
2	Ground
5	Key on voltage +12 V
8	Control signal +12 V
9	SCL
10	MRQ
11	SDA
12	Traveled distance signal

Figure 3: Display connector.

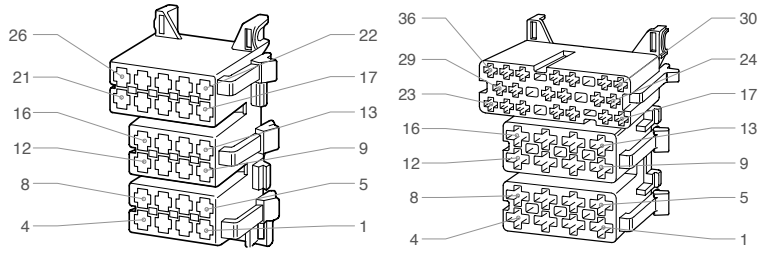


Figure 4: Radio receiver connector.

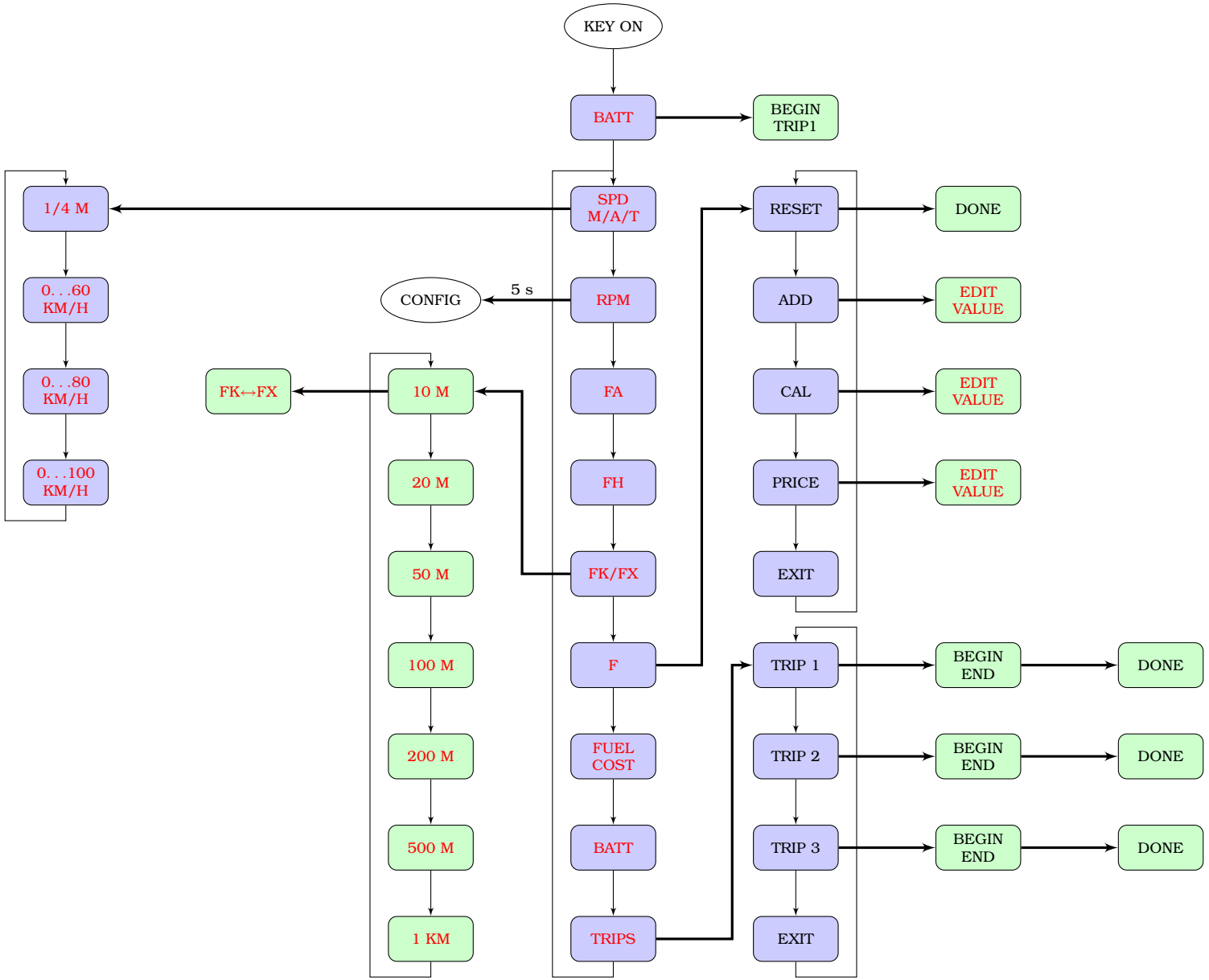


Figure 5: Working modes.

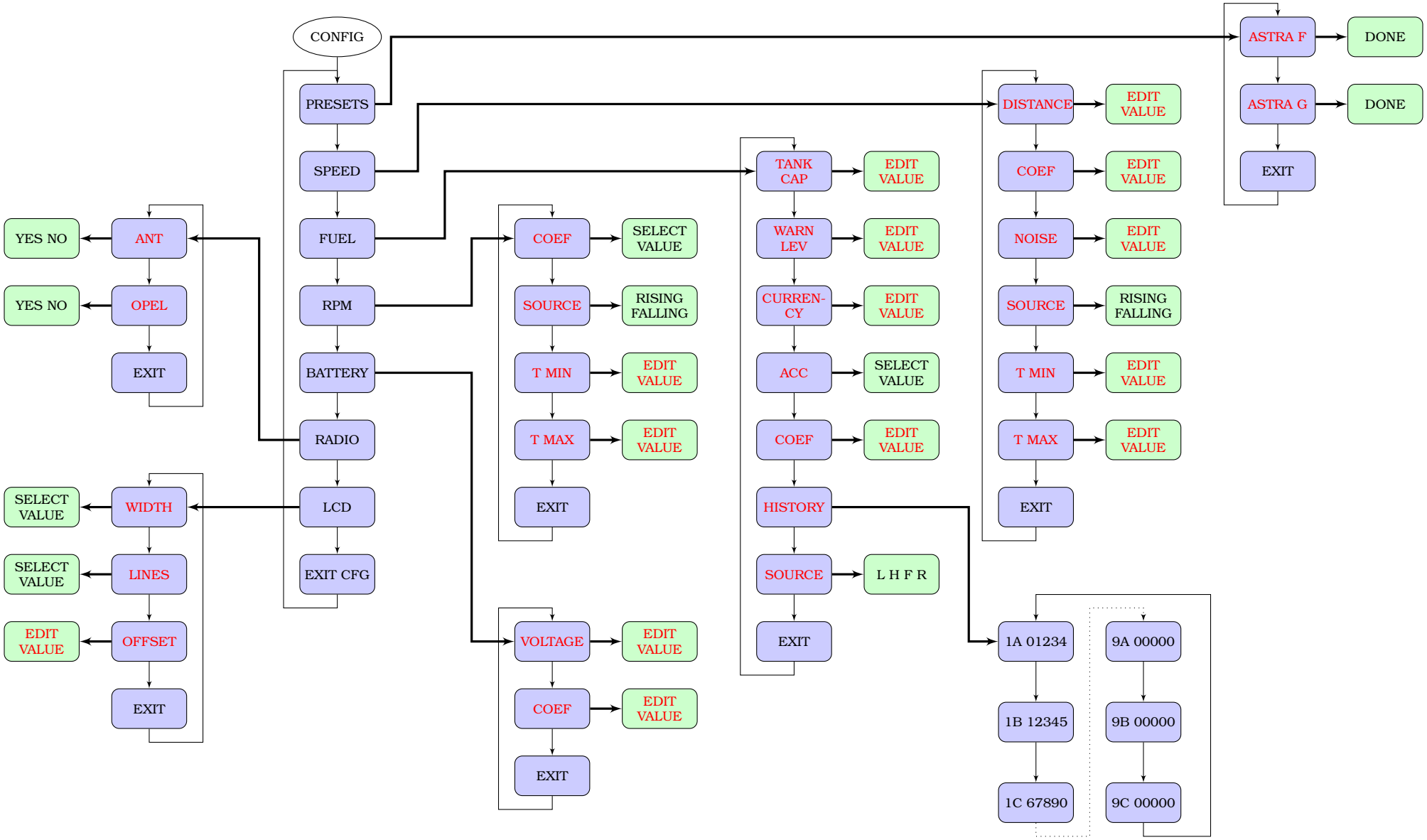


Figure 6: Configuration modes.

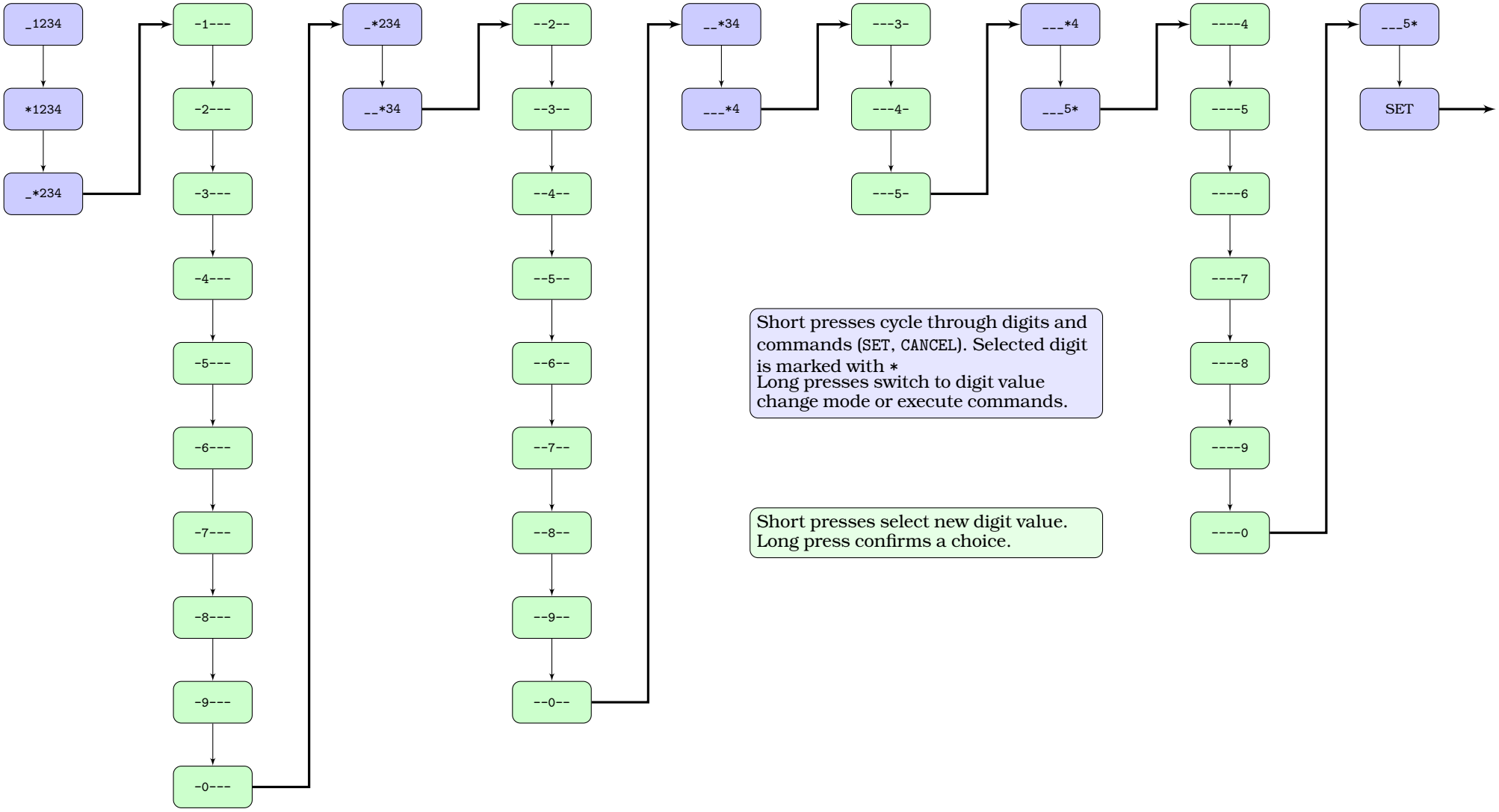


Figure 7: Editor mode. Initial value 1234 is changed to 50.

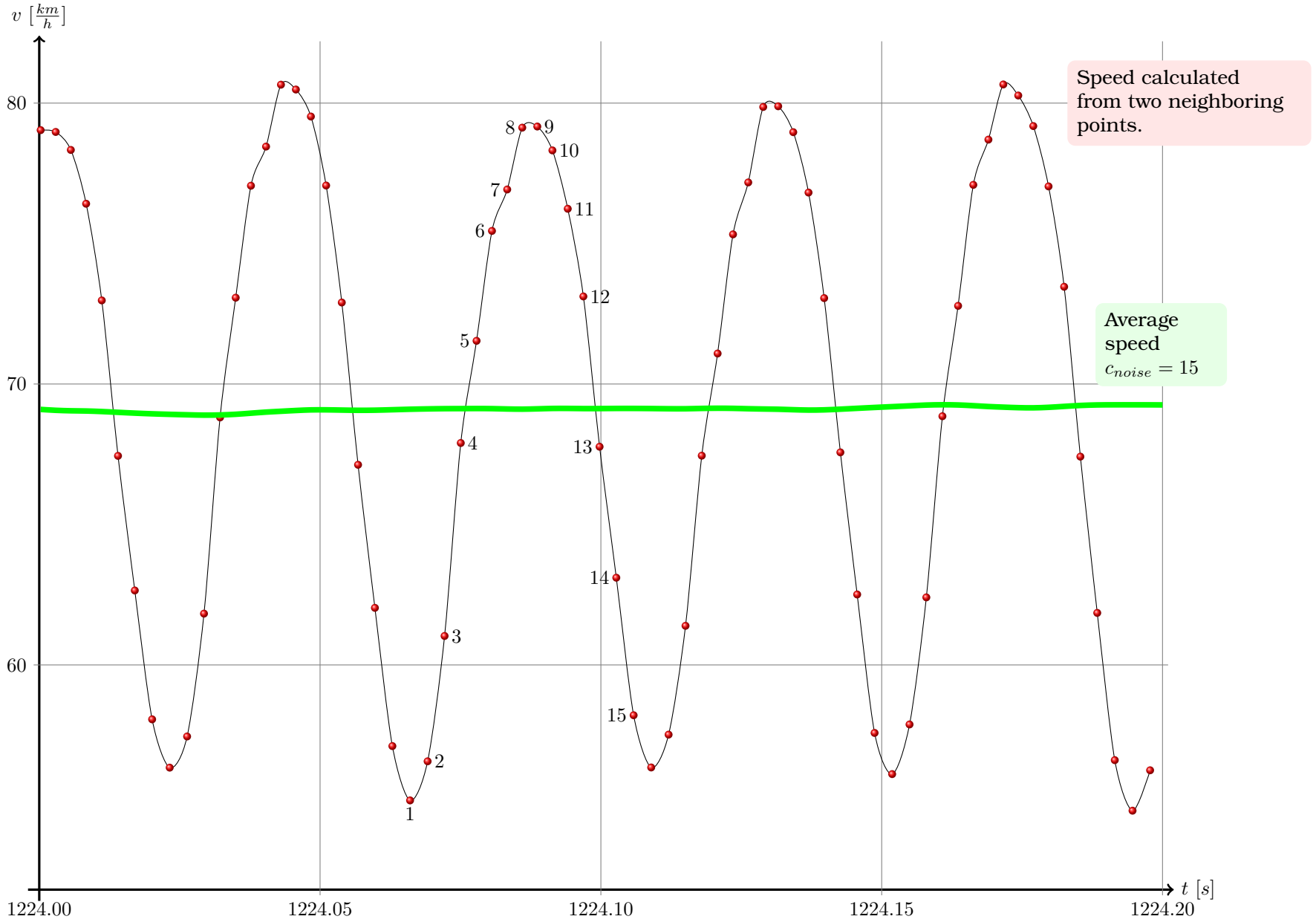


Figure 8: Inaccuracy of instantaneous speed measurement. Pulser is place in mechanical speedometer.

File `fuel.dat` with data for gnuplot program.

```
44.09 161959814
41.63 153856441
43.12 155367922
37.36 138954037
43.58 159957383
43.46 159408461
```

Gnuplot commands.

```
f(x)=a*x
fit f(x) "fuel.dat" via a
plot [37:45] "fuel.dat", f(x)
```

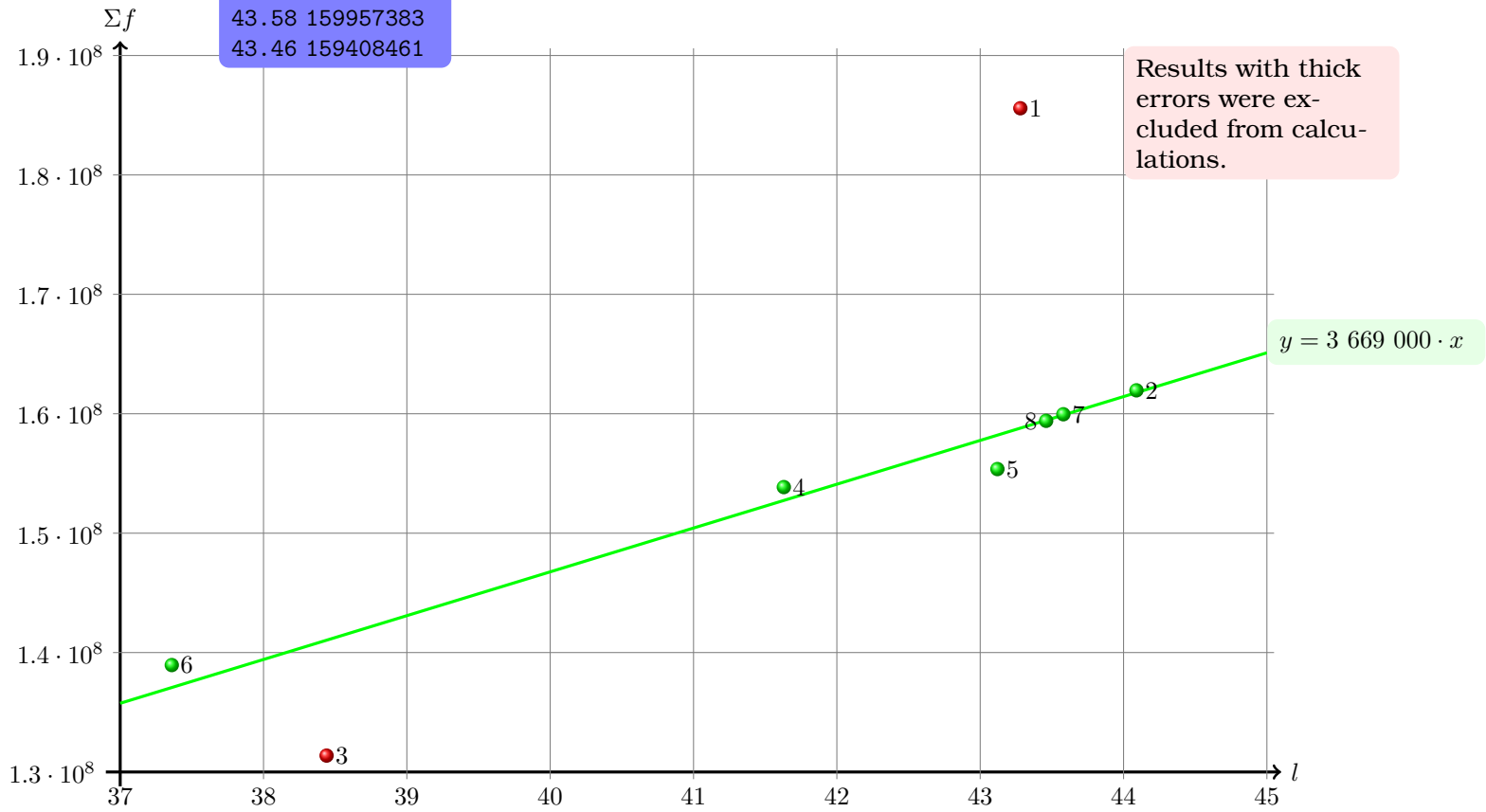


Figure 9: Calculation of fuel consumption calibration coefficient c_{fuel} by fitting a straight line $y = c_{fuel} \cdot x$ to recorded data with least square method. Gnuplot program was used.

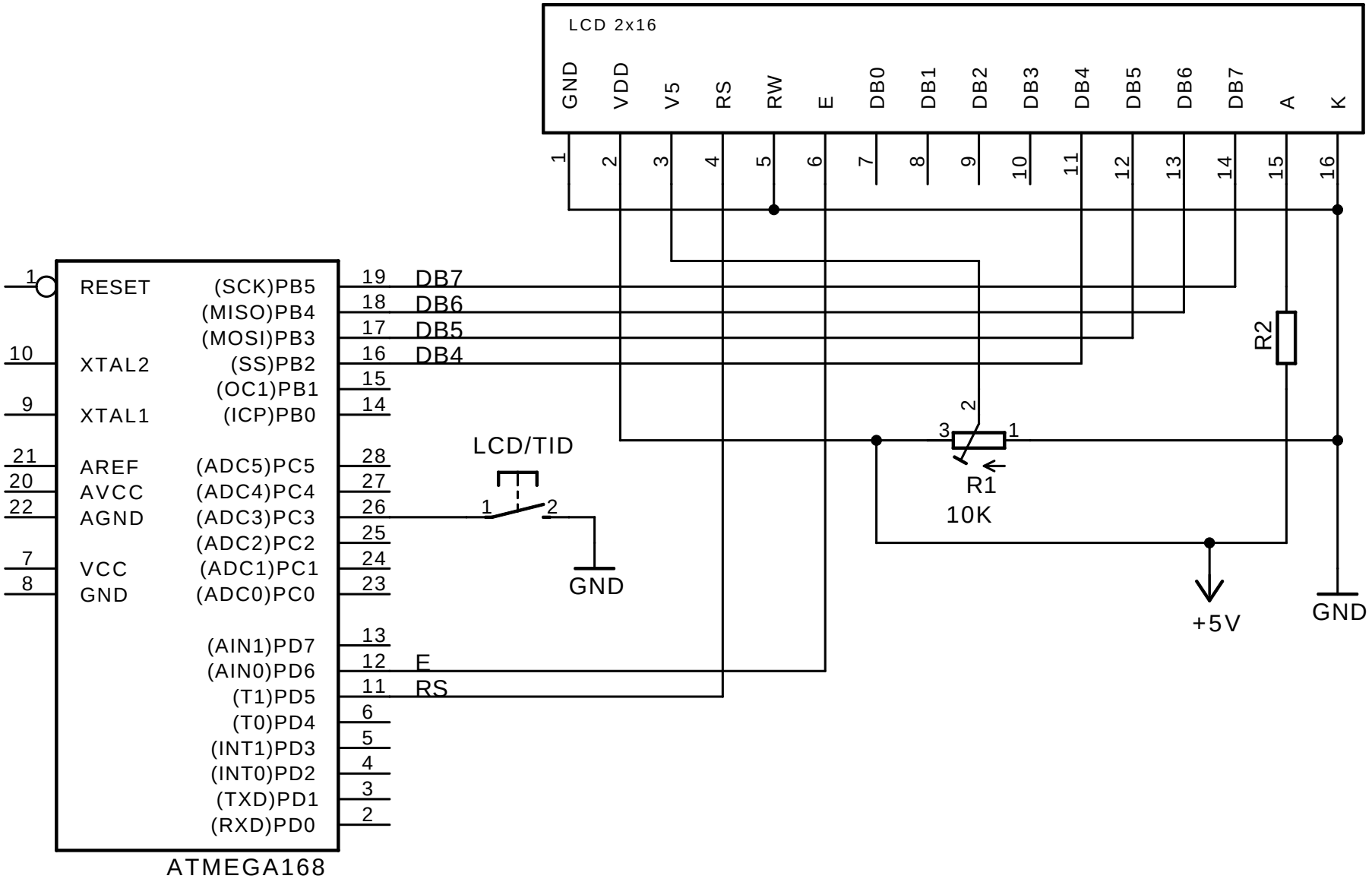


Figure 10: Connection of LCD display.