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ONLINE POSTFIX COMPLEX SCIENTIFIC CALCULATOR FOR MOBILE DEVICES

Svetoslav Zabunov

Space Research and Technology Institute – Bulgarian Academy of Sciences
e-mail: SvetoslavZabunov@gmail.com

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Abstract: *Postfix calculators, based on the postfix notation (Reverse Polish notation or RPN), are widely used in different scenarios. Hewlett-Packard Company (HP) pioneered the method in handheld and desktop calculators in the late 60-ties and early 70-ties and the widely used following models with scientific and programmable features were based on the postfix notation. The first calculator employed in space missions was also an RPN pocket calculator – the HP-65 introduced in 1974 flown on the 1975 Apollo-Soyuz Test Project. Later other calculators went to space like the HP-41C and the Elektronika MK-52.*

The current article elaborates on a free pocket calculator software application that turns any smart device into a postfix complex numbers calculator benefitting from the well-established RPN approach and also from the now modern application driven smart device utilization. The software application is online, platform independent, free, no download or installation requiring, constantly evolving and meant for scientific and engineering use in the space sciences among others. The project was developed by the author of the current article during the last 13 years.

ОНЛАЙН ПОСТФИКСЕН КОМПЛЕКСЕН НАУЧЕН КАЛКУЛАТОР ЗА МОБИЛНИ УСТРОЙСТВА

Светослав Забунов

Институт за космически изследвания и технологии – Българска академия на науките
e-mail: SvetoslavZabunov@gmail.com

Ключови думи: *Онлайн постфиксен комплексен научен калкулатор*

Резюме: *Постфиксните калкулатори, базирани на постфиксната нотация (обратен полски запис или RPN), са широко използвани в различни задачи. Компанията Хюлет-Пакард (HP) е пионер в приложението на този метод в ръчни и настолни калкулатори към края на 60-те и началото на 70-те години. Първият калкулатор използван в космоса е RPN-джобен калкулатор – HP-65, създаден през 1974. По-късно други калкулатори също летят в космоса като HP-41C и Електроника МК-52.*

Настоящата статия разглежда един безплатен софтуер, симулиращ джобен калкулатор, който превръща всяко смарт-устройство в постфиксен комплексен калкулатор, ползващ добре установения RPN-подход, а също така и модерната употреба на мобилните приложения. Софтуерното приложение е онлайн, платформено-независимо, безплатно, не изискващо изтегляне или инсталация, непрекъснато развиващо се и предназначено за научно и инженерно използване в космическите науки, а и в инженерните науки изобщо. Проектът е разработен от автора на настоящата статия през последните 13 години.

Introduction

Postfix calculators are based on the postfix notation also known as Reverse Polish notation (RPN). It is a mathematical notation where the operands are preceding the operators. When implemented to a handheld calculator, the latter would need no equal “=” button, nor any parentheses “(“, “)” buttons.

Fig. 1. HP-35 introduced in 1972 was the first world's scientific calculator. It used the postfix notation. Attribution: Hweihe [CC BY-SA 3.0 (http://creativecommons.org/licenses/by-sa/3.0/)]

The description "Polish" refers to the nationality of logician Jan Łukasiewicz [1]. He is the Polish notation inventor (1924), while the reverse Polish notation was introduced much later – in 1954 by Arthur Burks, et al. [2]. This approach was extensively employed by Edsger W. Dijkstra in stack oriented computers.

Fig. 2. HP-65 – the first programmable handheld calculator in space used in the 1975 Apollo-Soyuz Test Project

Hewlett-Packard Company (HP) pioneered the method in handheld and desktop calculators in the late 60-ties and early 70-ties [3]. In computer programming languages that are stack-oriented, like Forth and PostScript, the method is common. The first HP calculator to employ the approach was the 9100A Desktop Calculator designed in 1968 [4]. It had only three stack levels also called three-level RPN. Through this machine the reverse Polish notation was popularized among the scientific and engineering communities. Then in 1972 it was followed by the world's first handheld scientific calculator, the HP-35 (see Fig. 1). It introduced the classical four-level RPN. The HP-35 User's Manual states *"… The operational stack and reverse Polish (Łukasiewicz) notation used in the HP-35 are the most efficient way known to computer science for evaluating mathematical expressions …"*.

The first calculator used in space missions quickly followed in 1974 – the HP-65 (see Fig. 2). It is the first magnetic card-programmable handheld calculator and became the first programmable handheld calculator to be flown in outer space when it was carried on the 1975 *Apollo-Soyuz* Test

Project. It was a backup in case of failure of the Apollo Guidance Computer. Later other HP calculators flew in space among which the most famous and most widely used is the HP-41C (see Fig. 3). It was the major pocket calculator on the Space Shuttle programme [5]. During the early 80-ies, the times when the Space Shuttle's first flight took place in 1981, computer technology had advanced rapidly and was already highly miniaturized. NASA purchased the HP-41C programmable pocket calculator and loaded it with a variety of software for use by the Space Shuttle crew. Only a few minor changes were administered like adding Velcro strips to the case and removing some parts that might emit gases during flight.

Fig. 3. HP-41 in space. Top-left: HP-41CV owned by S. Zabunov, Top-right: Sally Ride with several HP-41 aboard the Space Shuttle (Photo courtesy of NASA), Bottom-left: Astronaut Gordon Fullerton aboard Columbia on the last flight, using his HP-41 (Photo courtesy of NASA), Bottom-middle: A NASA technician in the Space Shuttle Simulator stores the HP-41C Calculator in a special pouch in the astronauts' flight suit. (Photo courtesy of NASA), Bottom-right: A Space Shuttle launch. (Photo courtesy of NASA).

HP-41C was introduced in 1979 and costed only $295, so NASA purchased a large number of them for the members of the crew. HP-41C was used by astronaut Sally Ride and several other astronauts on a total of nine Shuttle missions. Fig. 3 top-right shows astronaut Ride on the Challenger flight of June 1983. Each calculator weighs about 200 g, measures 14 cm x 7.5 cm x 3 cm, and has its own primary batteries or secondary batteries that do not require often recharge thus being independent of the Shuttle's main power supply. NASA eventually replaced these calculators with more sophisticated personal computing devices, including laptop computers, for the Shuttle crews.

A Soviet-made scientific postfix calculator also flew in space. The Elektronika MK-52 went spaceborne in 1988 on the "Soyuz TM-7" mission [6, 7] where it was a backup computer for the calculation of the landing trajectory in case an on-board computer failure (see Fig. 4).

Fig. 4. Elektronika MK-52. The first Soviet programmable postfix calculator used in space flown on the “Soyuz TM-7” mission.

The Complex Postfix Scientific Calculator – Online Application for Mobile Devices

During the last 13 years the author was constantly developing and improving a software application. This is a complex postfix scientific calculator meant for space scientists and engineers, but also helpful to any scientist in need for a pocket calculator with RPN notation working with complex numbers. The software is free. It is also platform independent and requires no download nor installation steps. These features place it ahead of any existing mobile device app that does require download and installation, and in the general case is not platform independent.

Fig. 5. The postfix complex scientific calculator application opened on a smartphone. Hosted at http://ialms.net/calcp/ with free access.

The requirements to run the calculator on a given device are minute: the user really needs a device that can run a modern HTML5 web browser. This could be a mobile smart phone, a tablet, a laptop, a smart TV, a desktop computer, etc. Once the URL, hosting the calculator (http://ialms.net/calcp/), is opened, the application will start and will turn the device into a calculator. A small sized smartphone (see Fig. 5) is the most suitable solution because once loaded the application will turn the smartphone into a pocket-sized handheld postfix complex scientific calculator.

The calculator was conceived for applications in the radio-engineering, electrical engineering and theoretical mechanics fields. As we all know, radio- and electrical engineers are in constant need for complex number calculations. Writing software for each task is a solution, but often this path is an overkill as certain problems need a few non-repeatable complex number calculations that a pocket calculator can do quickly and without programming effort. Also, the smartphone is in most times with us anyway, in contrast to a laptop computer that we may not carry around at all times.

The calculator software uses a 5 registers stack and 100 registers memory (see Fig. 6). It also supports most well-known and widely used scientific mathematical functions and new function are added constantly. This article is not aimed at being a user’s manual, hence no work shall be done on

describing all calculator features. The philosophy of the project is what matters. User's manual will be soon posted online and accessible freely by any visitor from around the world.

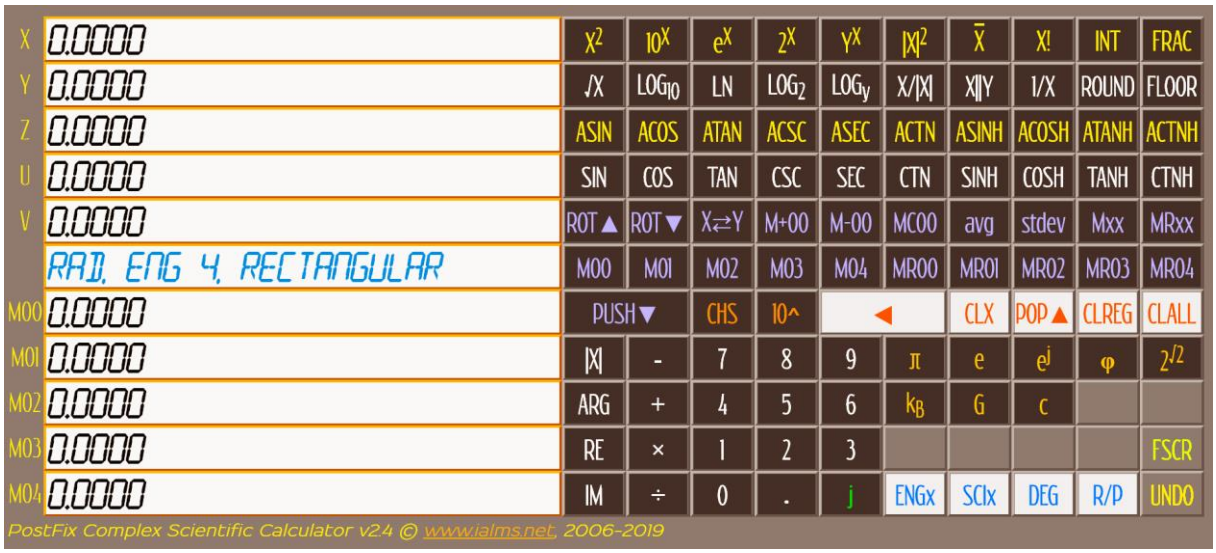

Fig. 6. The postfix complex scientific calculator user interface

Finally, an example of a typical application shall be disclosed. In Fig. 7 an engineering circuit is shown comprised of passive resistive and reactive components and an ideal voltage source. Let's assume we need to calculate the voltage across the resistor R. Taking into account the frequency of the ideal voltage source we first compute its angular velocity and store it in the memory register M00:

(1) $\omega = 2\pi f = 62.83$ rad/s, in RPN: `[2] [π] [1] [0] [×] [×] [M00].`

Then we obtain the complex impedances of the passive components and store them in memory:

(2) $ZC_1 = -j / (\omega C_1)$, in RPN: `[j] [CHS] [MR00] [÷] [M01]`
(3) $ZC_2 = -j / (\omega C_2)$, in RPN: `[0] [.] [5] [÷] [M02]`
(4) $ZL_1 = j\omega L_1$, in RPN: `[j] [MR00] [1] [0] [×] [×] [M03]`
(5) $ZP = ZL_1 \parallel ZC_2 \parallel R$, in RPN: `[MR02] [1] [0] [X‖Y] [X‖Y] [M04]`
(6) $ZT = ZP + ZC_1$, in RPN: `[MR01] [+]`

We notice that the voltage across the resistor is the voltage across the group of the three parallel components L_1, C_2 and R. Then we divide the voltage by the total impedance to obtain the current and finally we multiply the current with the ZP impedance obtaining the voltage across the resistor:

(7) I1 = V1 / ZT, in RPN: `[1] [0] [X<>Y] [÷]`
(8) VR = I1 * ZP, in RPN: `[MR04] [×]`

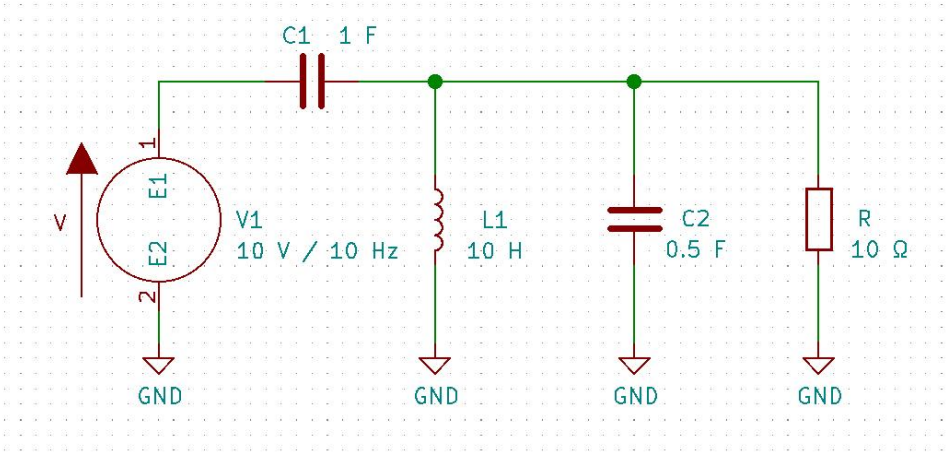

Fig. 7. The schematic diagram of a problem easily computable with the help of the complex scientific calculator

Conclusions

The everyday mathematical calculations, an engineer needs to do, often include one-time operations and require no programming, but a pocket calculator. On the other hand, complex number computations are essential in a number of scientific fields and further a postfix calculator notation is of great help in these cases due to its ease of use. The proposed software application successfully turns any smartphone into a pocket handheld complex postfix scientific calculator and does it for free.

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