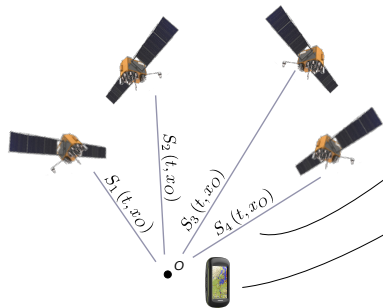


# Universal ranging code generator of GLONASS and GPS open navigation signals

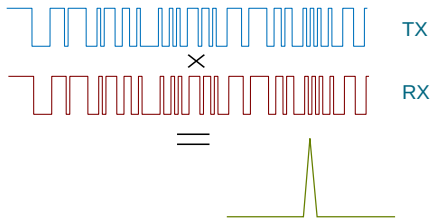
Olga K. Mikhaylova, Ilya V. Korogodin, Ivan V. Lipa

Navigation Systems Laboratory  
Moscow Power Engineering Institute

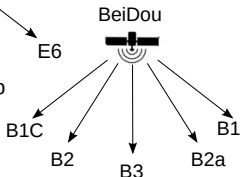
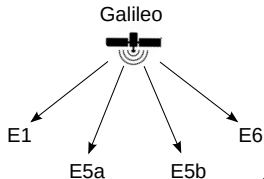
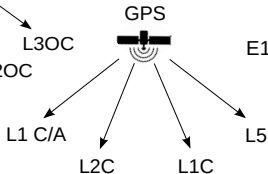
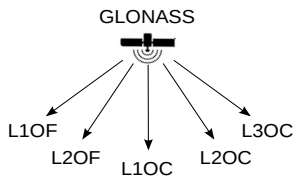
November, 2020



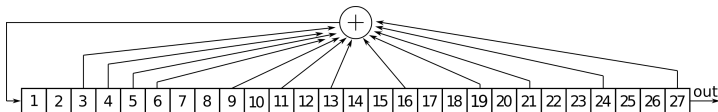
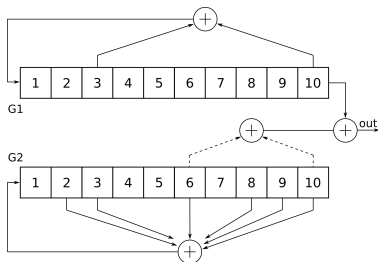
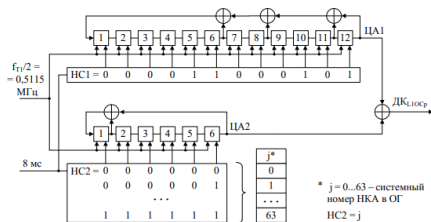
Ranging codes convergence:



Multiple signal types, multiple codes:

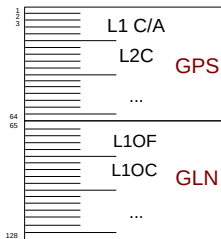


- Generation via linear-feedback shift register (LFSR)
- Generation of ranging codes as hash functions
- Look-up tables codes



# Proposed structure of the universal ranging code generator

## Specialized channels



## Universal channels

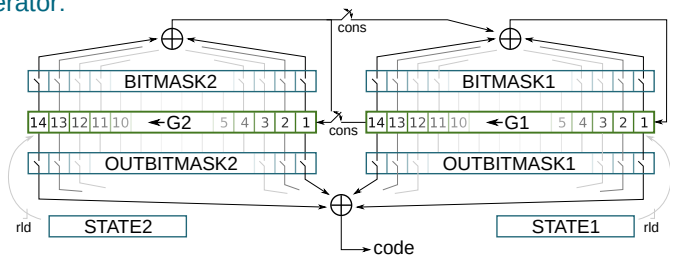


How?  
➔

### Advantages:

- flexibility
- maintenance
- extension

We need a universal code generator:



Сигнал	bitmask1	bitmask2	outbitmask1
LxOF	00000100010000	-	00000001000000
L1OCd	00001001000000	00001101000100	00001000000000
L1OCp	00110010100000	00000000100001	00100000000000
L2OCp	11000010001000	00000001100000	10000000000000
L3OCx	11000010001000	00000001100000	10000000000000
Summary	11111111111000	00001101100101	10101001000000

Сигнал	outbitmask2	state1	state2
LxOF	-	00000111111111	-
L1OCd	00001000000000	00000001001100	{00001111110000}
L1OCp	00000000100000	00101000110000	{00000000111111}
L2OCp	00000001000000	00011100101100	{00000001111111}
L3OCd	00000001000000	00011100101100	{00000001111110}
L3OCp	00000001000000	00011100101100	{00000001111111}
Summary	00001001100000	00111111111111	{00001111111111}

Сигнал	bitmask1	bitmask2	out bitmask1
C/A	00001000000100	00001110100110	00001000000000
L2C CM	01001001010010	01010100111100	01000000000000
L2C CL	01001001010010	01010100111100	01000000000000
L5 I	01101100000000	01100011101101	01000000000000
Summary	01101101010110	01111111111111	01001000000000

Сигнал	out bitmask2	state1	state2
C/A	{00001111111111}	00001111111111	00001111111111
L2C CM	00000000000000	{01111111111111}	{11111111111111}
L2C CL	00000000000000	{01111111111111}	{11111111111111}
L5 I	01000000000000	01111111111111	{01111111111111}
Summary	{01001111111111}	{01111111111111}	{11111111111111}

Сигнал	bitmask1	bitmask2	out bitmask1
E5aI	10000010100001	10100011011000	10000000000000
E5aQ	10000010100001	10100011011000	10000000000000
E5bI	11010000001000	10100110010010	10000000000000
E5bQ	11010000001000	10001100110001	10000000000000
Summary	11010010101001	10101111111011	10000000000000

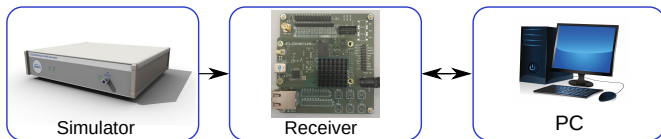
Сигнал	out bitmask2	state1	state2
E5aI	10000000000000	11111111111111	{11111111111111}
E5aQ	10000000000000	11111111111111	{11111111111111}
E5bI	10000000000000	11111111111111	{11111111111111}
E5bQ	10000000000000	11111111111111	{11111111111111}
Summary	10000000000000	11111111111111	{11111111111111}

Сигнал	bitmask1	bitmask2	out bitmask1
B1I/B2I	00011111000001	00011111001101	00010000000000
B3I	01000000001101	01101101110001	01000000000000
B2ad	01010000010001	01110100010100	01000000000000
B2ap	01000001100100	01100011010001	01000000000000
Summary	01011111111101	01111111111101	01010000000000

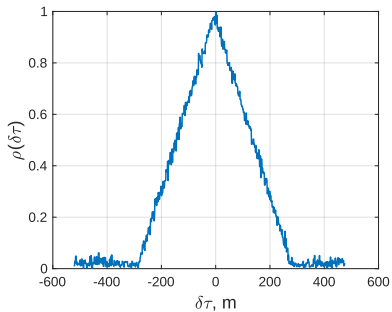
Сигнал	out bitmask2	state1	state2
B1I/B2I	{00011111111111}	00001010101010	00001010101010
B3I	01000000000000	01111111111111	{01111111111111}
B2ad	01000000000000	01111111111111	{01111111111111}
B2ap	01000000000000	01111111111111	{01111111111111}
Summary	{01011111111111}	01111111111111	{01111111111111}



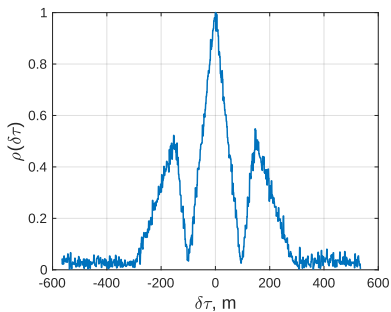
# Correlation functions of the GNSS signals



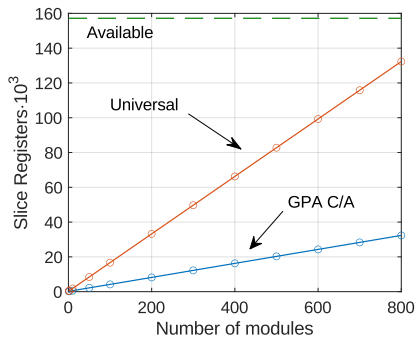
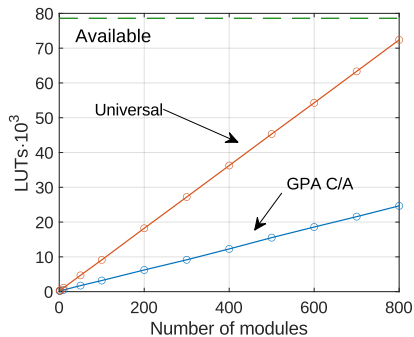
GLONASS L1OCd, BPSK(1)



GLONASS L1OCp, BOC(1,1)



# Resource usage in FPGA implementation



Universal generator



88 LUT, 167 Slice register

GPA C/A



26 LUT, 40 Slice register

System	Open signals	Signals with LFSR-based generator	Possible to generate	Unable to generate
GLONASS	7	7	7	0
GPS	9	7	5	4
Galileo	8	4	4	4
Beidou	7	5	5	2
Summary	31	23	21	10

- The proposed algorithm allows to generate ranging codes for almost **70%** of all open navigation signals systems GLONASS, GPS, Galileo, Beidou
- Initialization parameters of the universal ranging code generator for signals: Gln L1OF, GlnL2OF, Gln L1OCd, Gln L1OCp, Gln L3OCd, Gln L3OCp, GPS C/A, GPS L2 CM, GPS L2 CL, GPS L5 I, GPS L5 Q, Gal E5aI, Gal E5aQ, Gal E5bI, Gal E5bQ, Bds B1I, Bds B2I, Bds B3I, Bds B2ad, Bds B2ap are given
- Compared to the GPS C/A generator, the FPGA resources consumption for a universal generator increases by 4 times. BUT the resource usage by the correlator channel increases by only **5%**.
- Recommendations for further optimization of the universal generator are formulated

Thank you for your attention!

Olga K. Mikhaylova  
Navigation Systems Laboratory  
Moscow Power Engineering Institute  
e-mail: [mikhaylova@srns.ru](mailto:mikhaylova@srns.ru)