The Revised IS-GPS-200D Specification New Spreading Codes

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A Brief Introduction to IS-GPS-800 Spreading Codes

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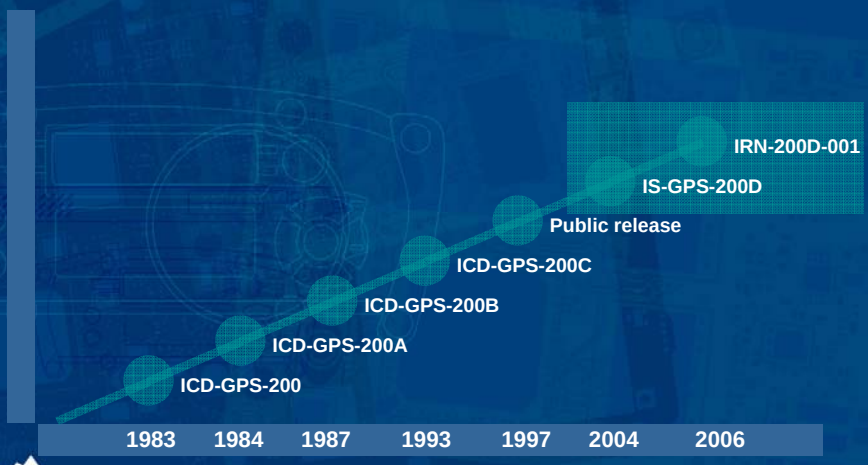
GPS spreading codes have been unchanged for decades



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New IRN could be a problem for some legacy receivers

- New spreading codes defined for C/A, P and L2C
- IS-GPS-200D can be found at
  - http://www.navcen.uscg.gov/gps/geninfo/IS-GPS-200D.pdf
- IRN-200D-001 can be found at
  - https://gps.losangeles.af.mil/engineering/icwg/Docs/IRN-200D-001%207Mar06.pdf

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While on the topic of spreading codes …

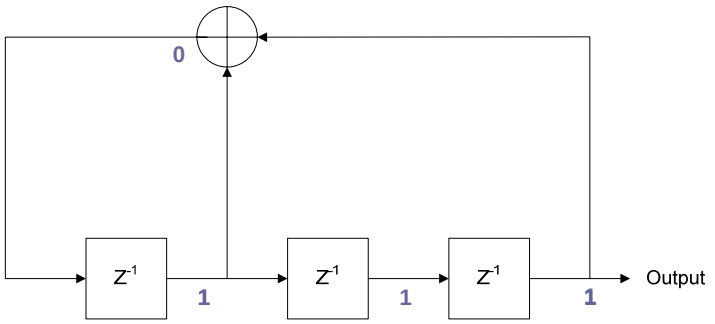
- Some interesting codes for GPSIII L1C
- Defined in Draft IS-GPS-800
  - http://gps.losangeles.af.mil/engineering/icwg/Docs/Draft%20IS-GPS-800%2019Apr06.pdf

IRN-200D-001

- Not applicable to Block II/IIA, IIR/IIR-, or IIF
- Used for other L1/L2 applications, such as SBAS
- New CNAV data on PRNs 36-63

PRN #	C/A	P	L2 CM/CL
36-63	Future GPS SVs	Future GPS SVs	Future GPS SVs
64-119	Future GBAS	Future GBAS	-
120-158	SBAS	Other GNSS	-
159-210	Other GNSS	Other GNSS	Other GNSS

A Simple Linear Feedback Shift Register (LFSR)



Time = t0

In1	In2	XOR
0	0	0
0	1	1
1	0	1
1	1	0

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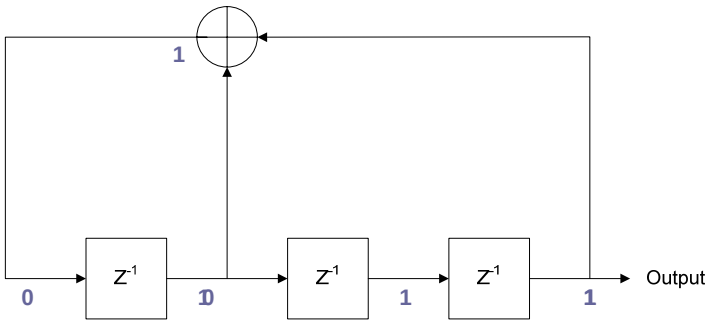
6

A Simple Linear Feedback Shift Register (LFSR)



Time = t0

In1	In2	XOR
0	0	0
0	1	1
1	0	1
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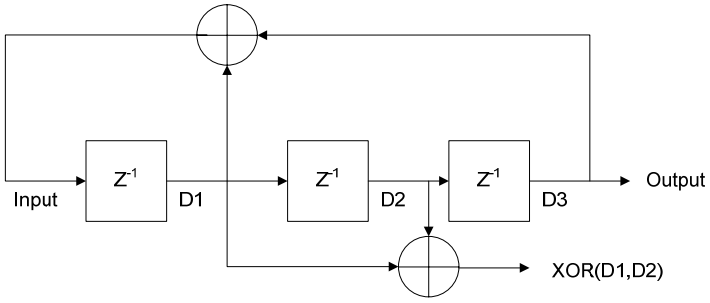
7

A Simple Linear Feedback Shift Register (LFSR)



Time	Input	D1	D2	D3/Output	XOR(D1,D2)
t0	0	1	1	1	0
t1	1	0	1	1	1
t2	0	1	0	1	1
t3	0	0	1	0	1
t4	1	0	0	1	0
t5	1	1	0	0	1
t6	1	1	1	0	0
t7	0	1	1	1	0

In1	In2	XOR
0	0	0
0	1	1
1	0	1
1	1	0

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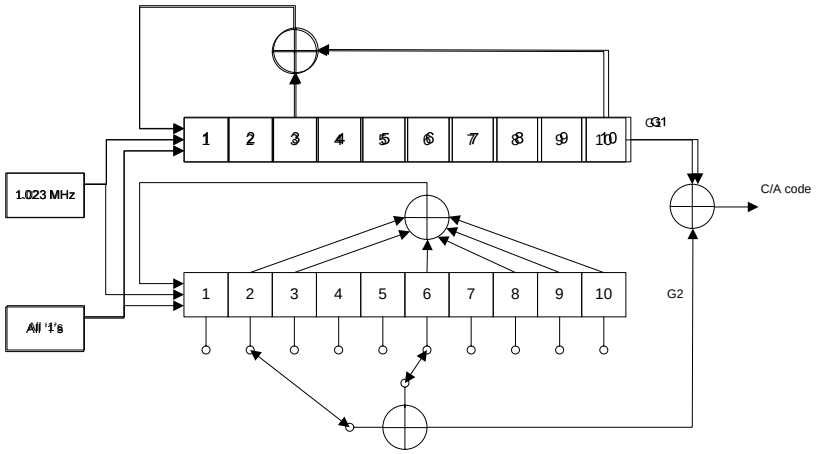
8

LFSR pseudorandom sequences have the property that when XORed with a phase shifted version of itself the sequence does not change, it only obtains another phase

GPS C/A coder has two LFSRs



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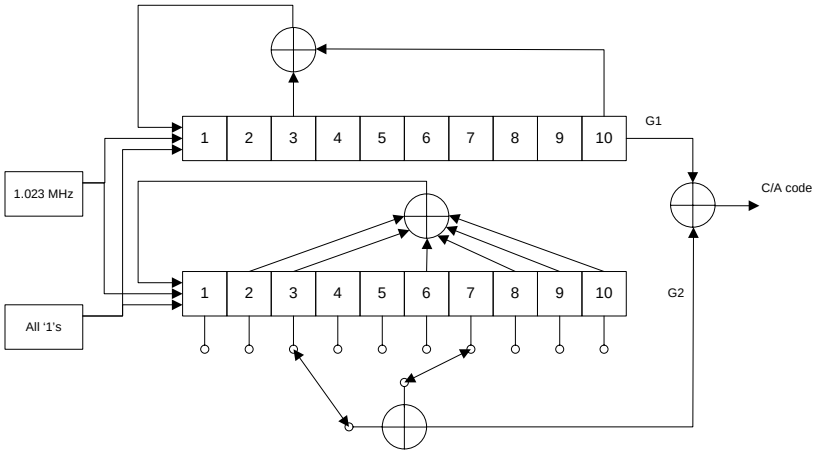
9

GPS C/A Code PRN 2 – phase select 3 and 7



Limited # of phase shifts = limited # of codes

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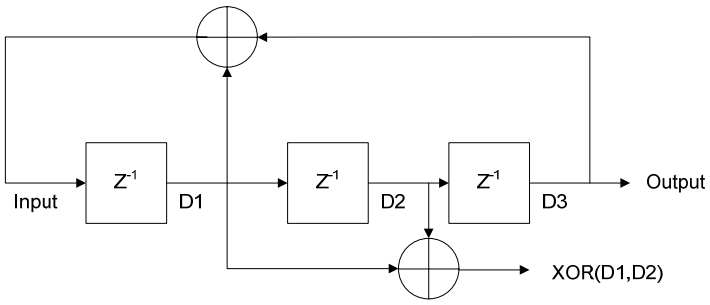
10

Use initial load value instead of XOR phase select



Time	Input	D1	D2	D3/Output	XOR(D1,D2)
t0	0	1	1	1	0
t1	1	0	1	1	1
t2	0	1	0	1	1
t3	0	0	1	0	1
t4	1	0	0	1	0
t5	1	1	0	0	1
t6	1	1	1	0	0

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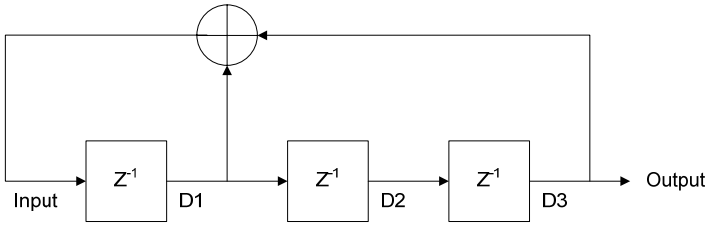
11

To get the D3/Output sequence we can initially load the registers with ‘1 1 1’. To get the phase select XOR(D1,D2) we can initially load the registers with ‘1 1 0’.

Use initial load value instead of XOR phase select



Time	Input	D1	D2	D3/Output
t0	1	1	1	0
t1	0	1	1	1
t2	1	0	1	1
t3	0	1	0	1
t4	0	0	1	0
t5	1	0	0	1
t6	1	1	0	0

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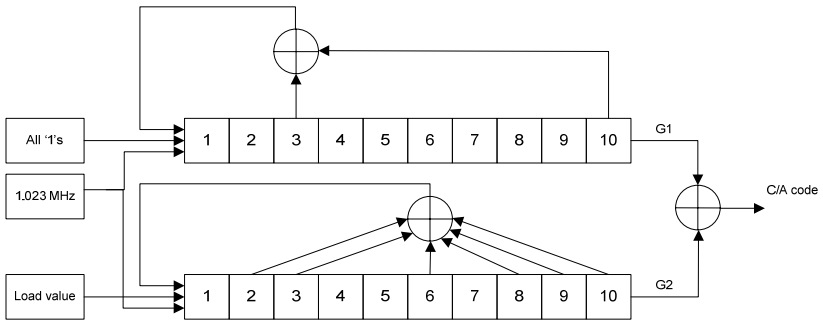
12

GPS C/A coder with programmable load value



This style of coder must be used for IRN-200D-001

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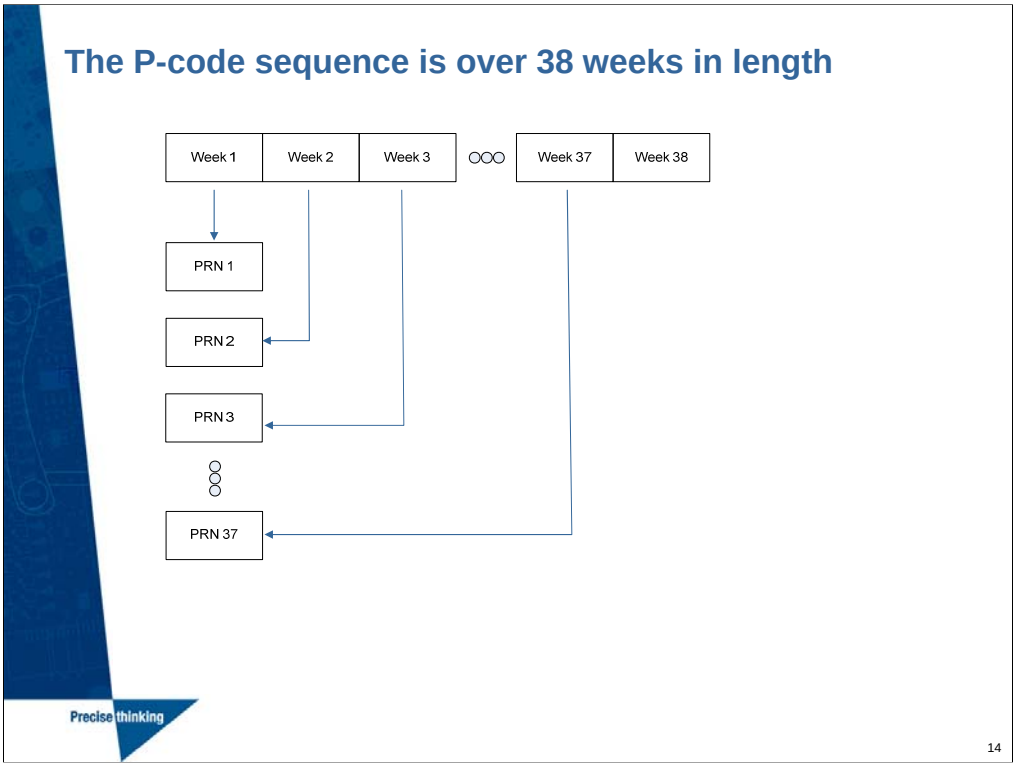
13



Each PRN is an individual week of the sequence.

New P-codes are old sequences shifted by 1 to 5 days

PRN 1	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
PRN 38	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 1
PRN 75	Day 3	Day 4	Day 5	Day 6	Day 7	Day 1	Day 2
PRN 112	Day 4	Day 5	Day 6	Day 7	Day 1	Day 2	Day 3
PRN 149	Day 5	Day 6	Day 7	Day 1	Day 2	Day 3	Day 4
PRN 186	Day 6	Day 7	Day 1	Day 2	Day 3	Day 4	Day 5

Most current ASICs should be able to handle this change

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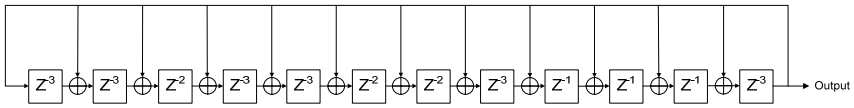
15

L2 CM/CL coders are designed for initial load values



Additional load values defined in IRN-200D-001

Change to ASIC not needed

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16

IS-GPS-800 : The GPS L1C draft specification

- Developed with experts from Japan for QZSS
- Data channel ranging code – $L1C_D$
- Pilot channel ranging code – $L1C_P$
- 1.023 Mbps X 10 millisecond length = 10230 chips
- Overlay code applied to $L1C_P$
  - 100 bps x 18 seconds = 1800 bits
  - Each satellite has a unique overlay code
  - Overlay codes for PRNs 1 through 63 – one LFSR
  - Overlay codes for PRNs 64 through 210 – two LFSRs

A single Legendre sequence is used for all PRNs

- **$L(2^k \text{ modulo } 10223) = 1$ for k=0,1,…,5110**
- **L(t) = 0 otherwise**

- **Evaluating 2^k for large k causes difficulty**
  - **For example, 2^{500} is a 150 digit number**
  - **Use $L(k^2 \text{ modulo } 10223)$ instead**
- **Examples**
  - **$L(0^2 \text{ modulo } 10223) = L(1) = 1$**
  - **$L(1^2 \text{ modulo } 10223) = L(2) = 1$**
  - **$L(2^2 \text{ modulo } 10223) = L(4) = 1$**
  - **$L(3^2 \text{ modulo } 10223) = L(9) = 1$**
  - **$L(143^2 \text{ modulo } 10223) = L(20449 \text{ modulo } 10223) = L(3) = 1$**

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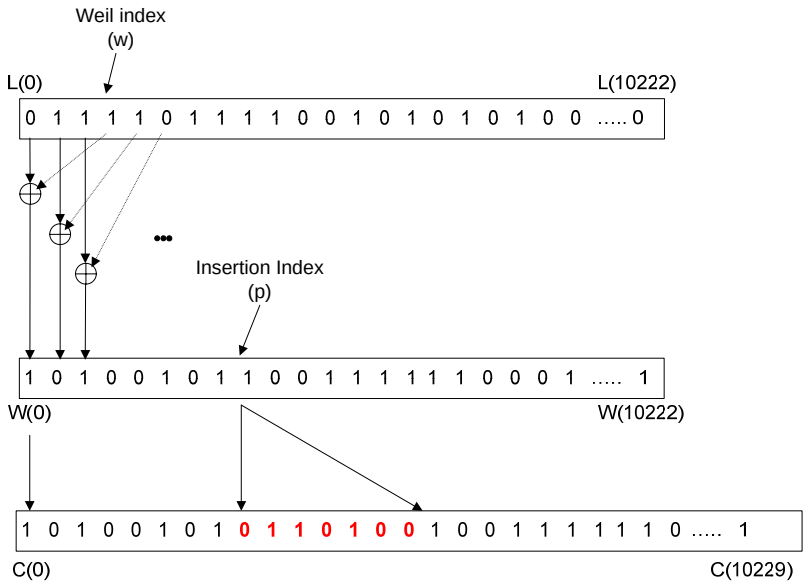
18

```
% Matlab code to generate base Legendre sequence
Legendre = zeros(1,10223);
for k = 1:5110
   index = mod(k^2,10223);
   Legendre(index + 1) = 1;
end
```

Weil codes are the XOR of L(t) and a shift of L(t)
L1C code is Weil code with 0 1 1 0 1 0 0 inserted



'Memory' codes

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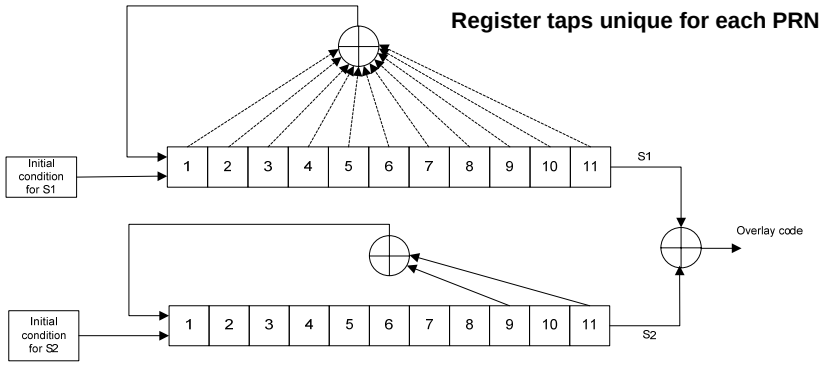
$L1C_P$ Overlay code



S2 register only used for PRN # 64 through 210.

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20

Impacts of new spreading codes

- Some old GPS L1 chip sets may not handle new codes
- Software update for new P and L2C codes
- Implementation of L1C via ‘memory codes’
- Galileo L1 also uses ‘memory codes’
  - Interoperable
  - Memory is not free
  - Increased ASIC real estate and power consumption

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Questions?
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