DBBT
Digital Broadcasting & Broadband Technologies

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Telekomunikaciona merenja
TM P06 2018

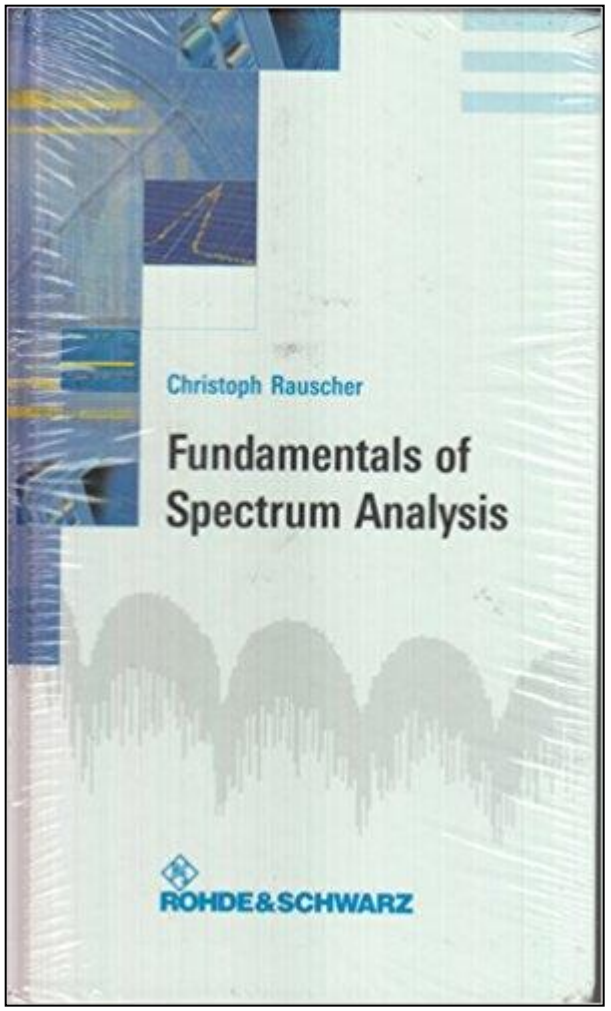
Profesor dr Miroslav Lutovac

"This project has been funded with support from the European Commission. This publication [communication] reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein"

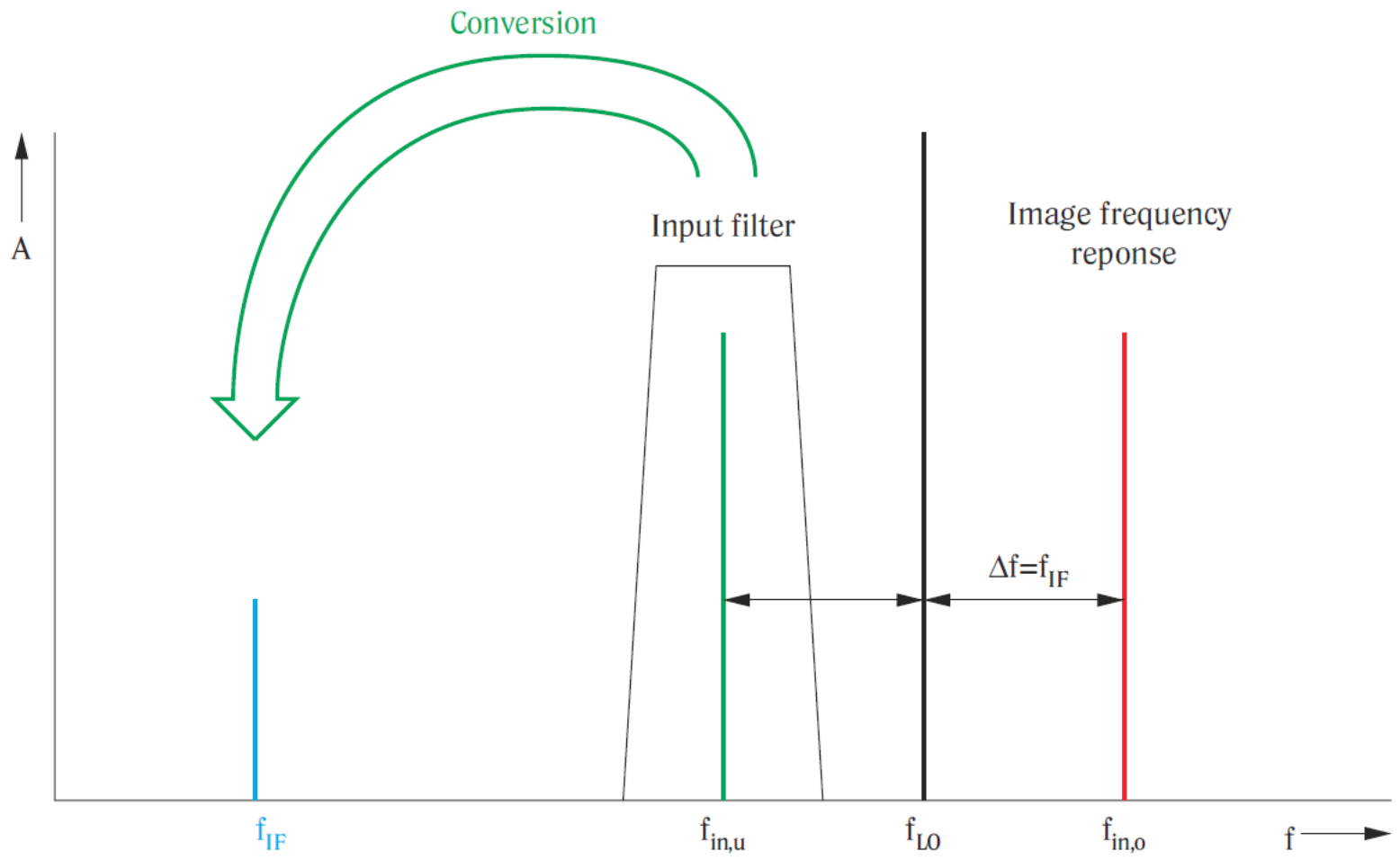
Osnove analize spektra

Rauscher C.,
Fundamentals of Spectrum Analysis,
Rohde & Schwarz, 2006

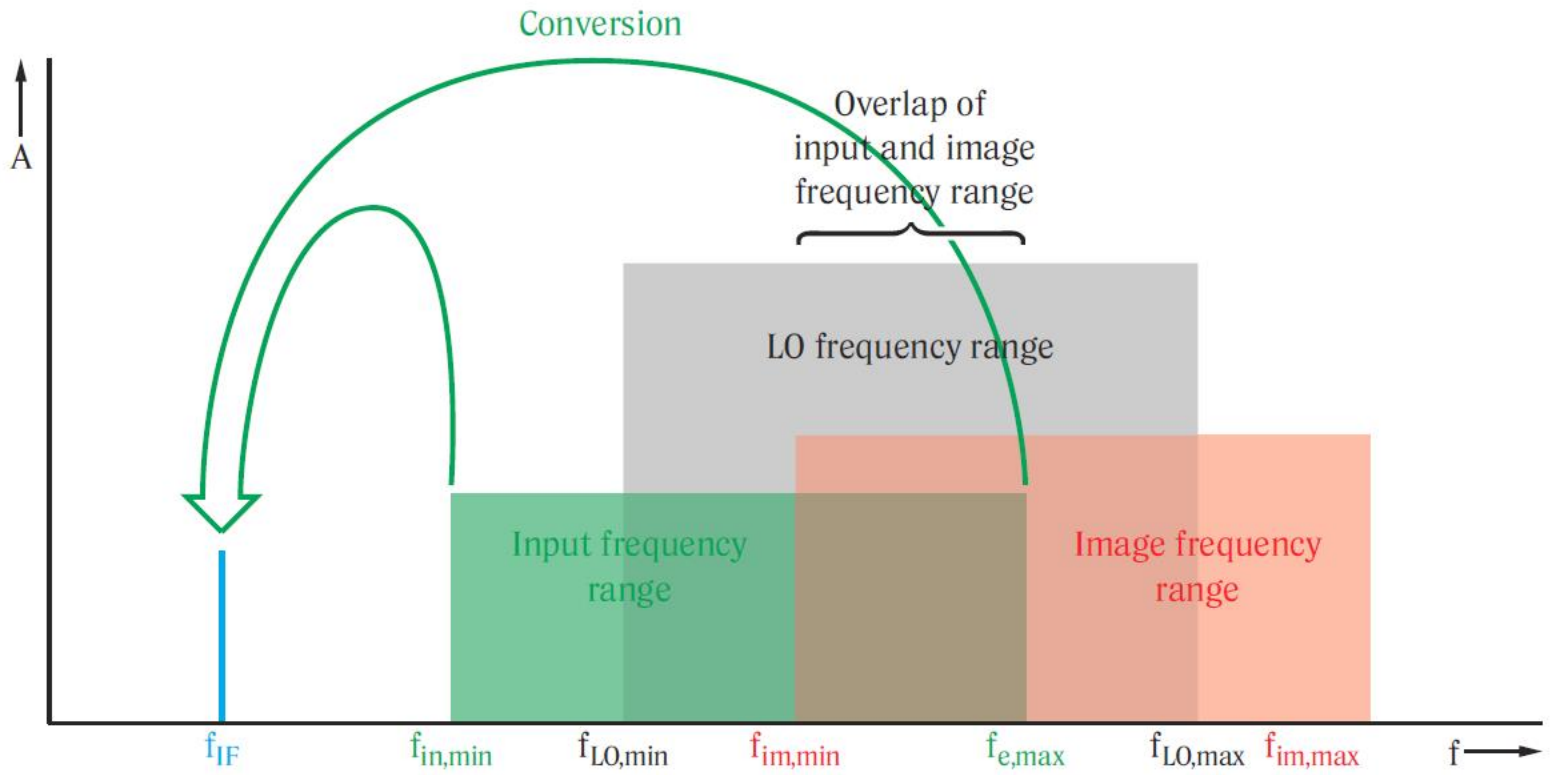
Poglavlje 4



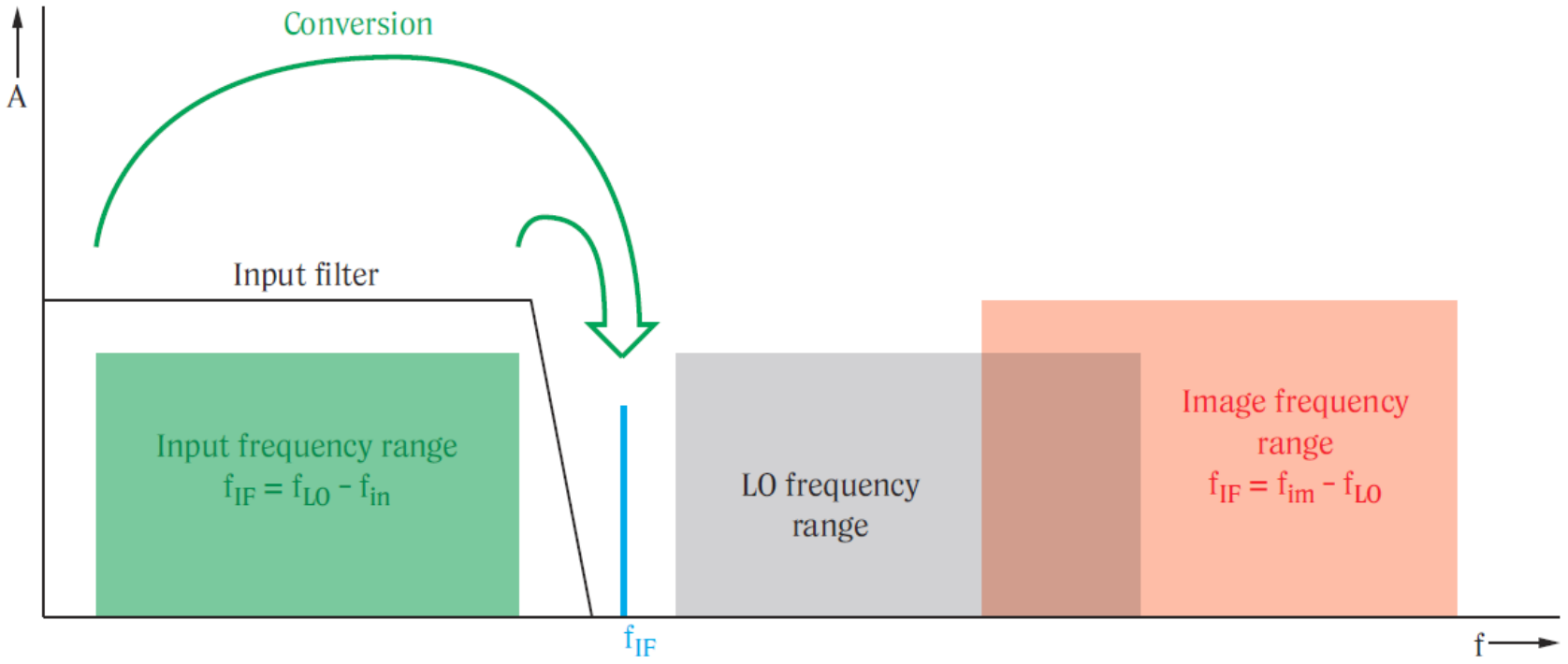
Dvosmislenost heterodinskog principa



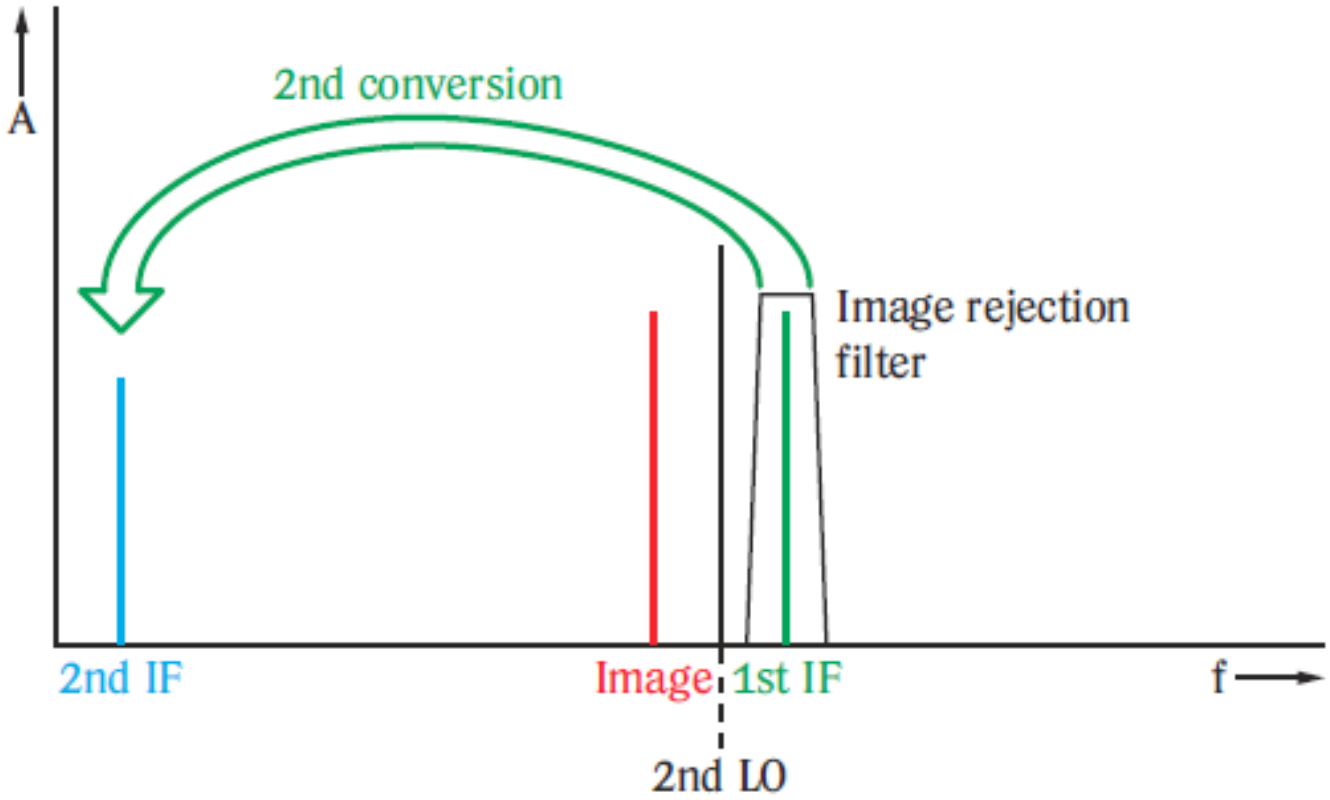
Preklapanje spektra



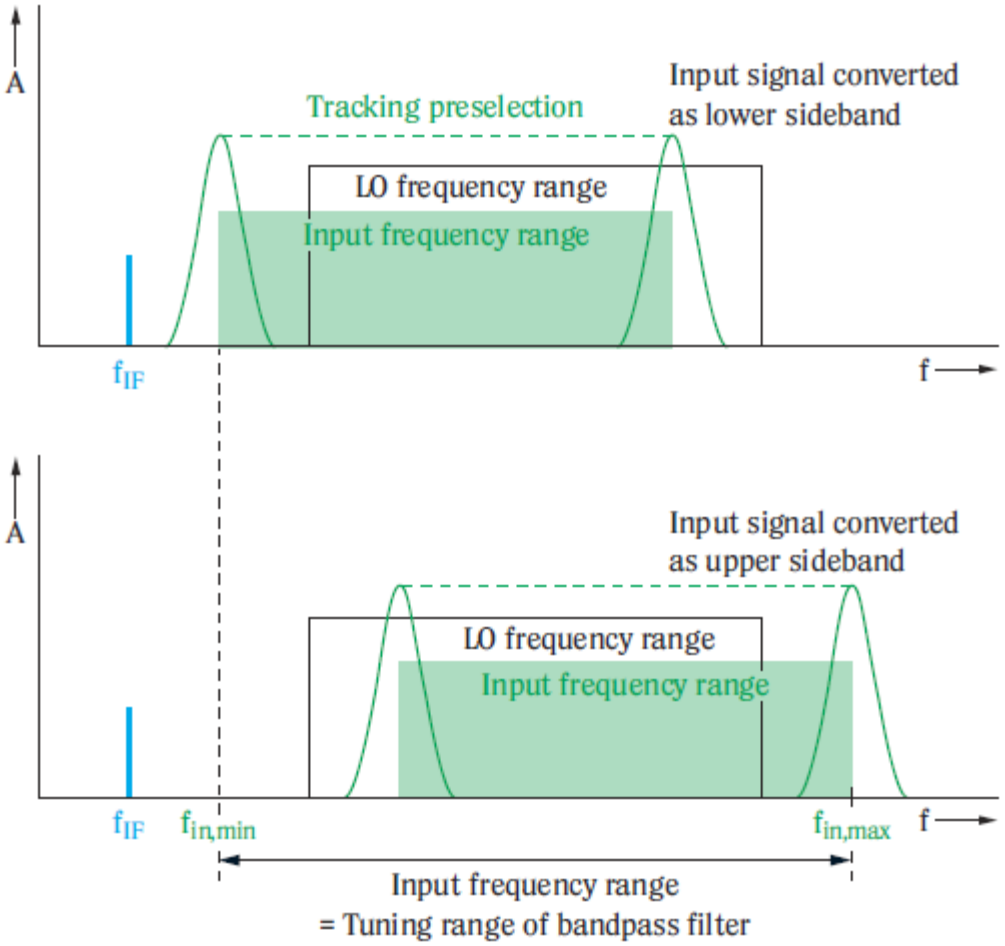
Princip visoke IF

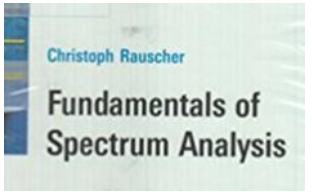


Konverzija visoke 1. IF u nisku 2. IF



Konverzija u nisku IF

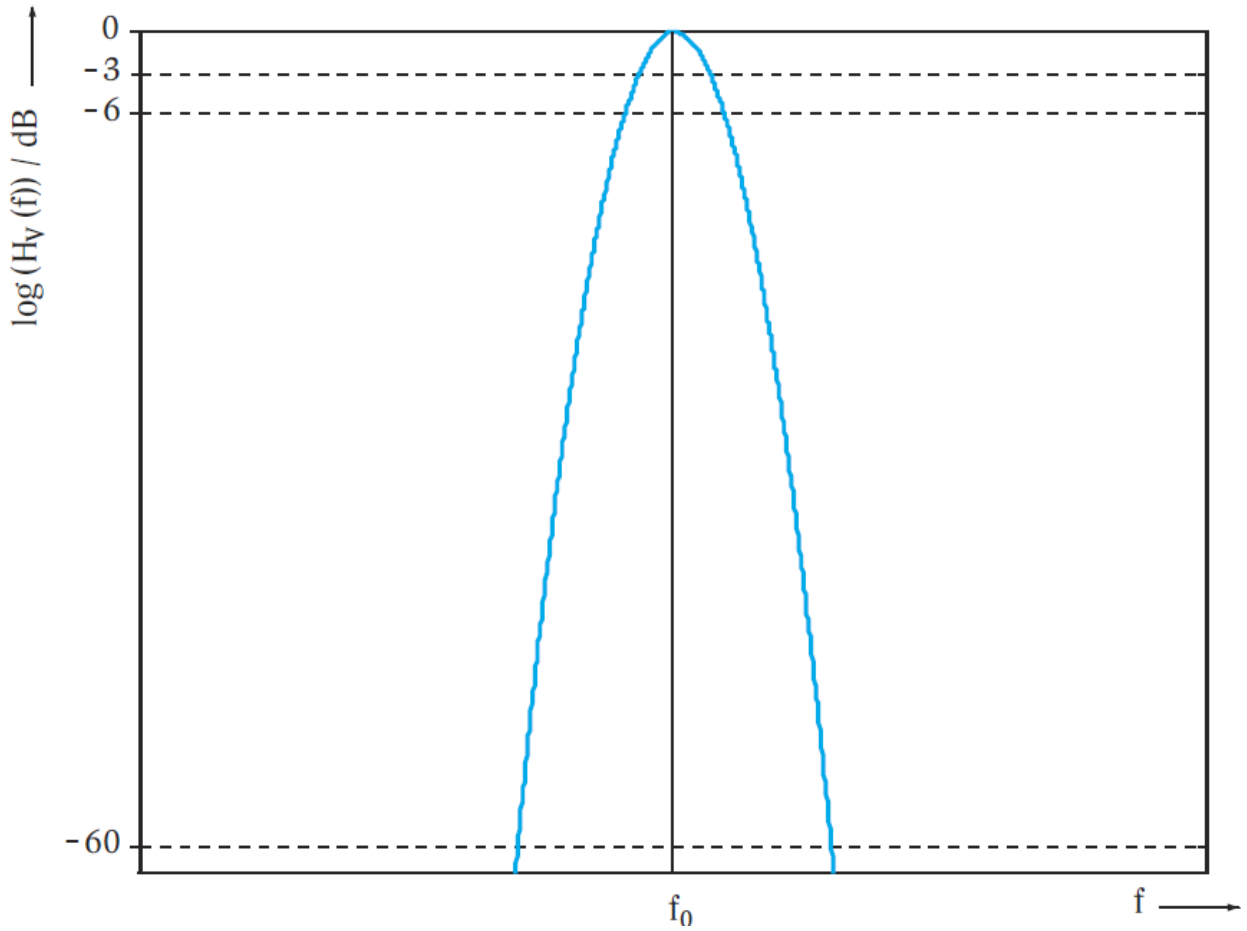




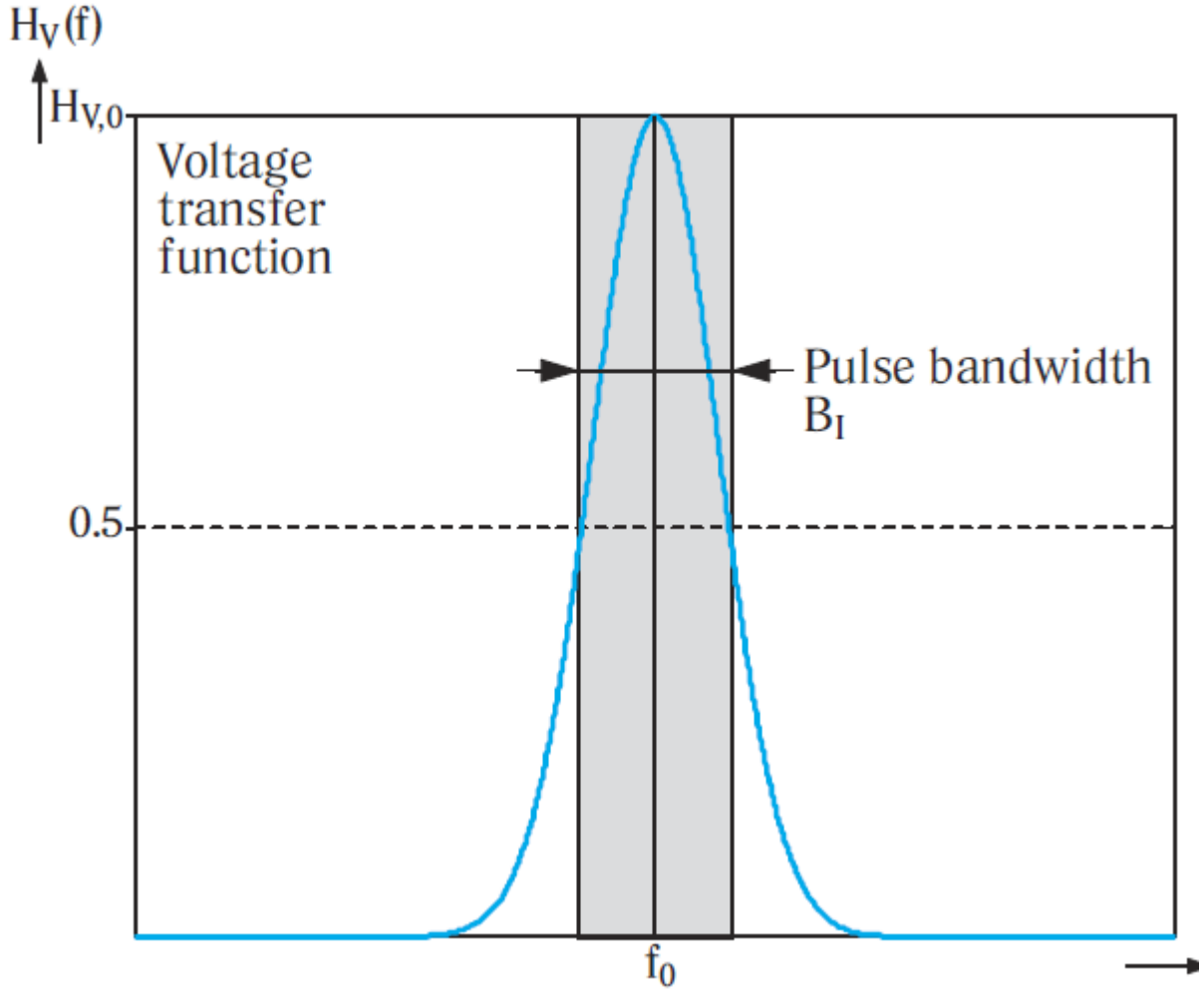
Obrada signala na IF

- Obrada signala na IF 20.4 MHz
- Signal se pojačava i rezultantni propusni opseg zavisi od IF filtra
- Pojačanje može da se podeđava u koracima 0.1 dB
- Maksimalni nivo signala može se održavati da bude konstantan tokom obrade signala bez od postavljenog slabljenja
- Ako je slabljenje veliko, pojačanje treba da bude veliko tako da se dinamički opseg iskoristi za maksimalnu vrednost
- Koristi se Gausov (vremenski) prozor, zato što pravougani prozor ima veliki prelazni režim

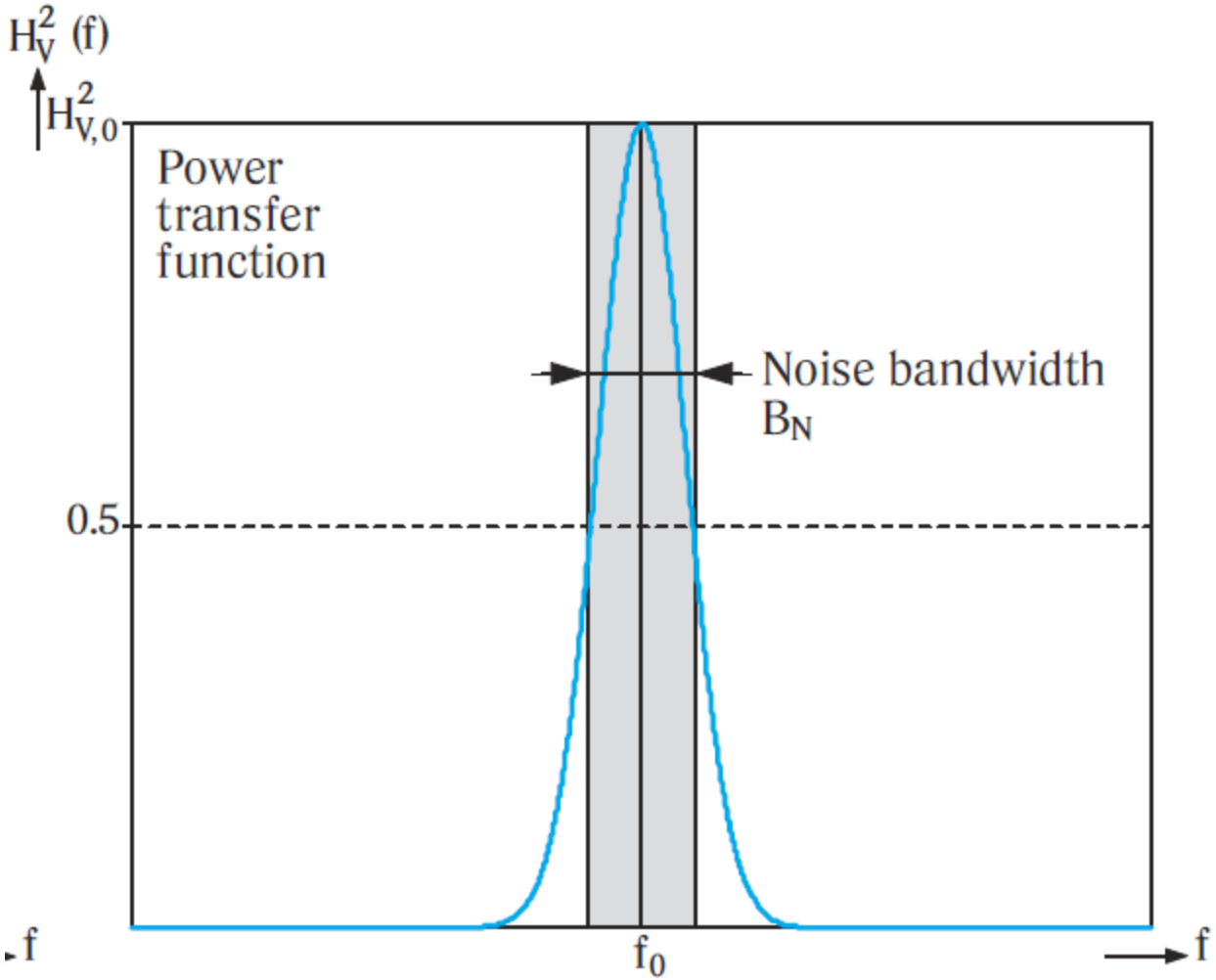
Funkcija prenosa Gausovog filtra logaritamska razmera



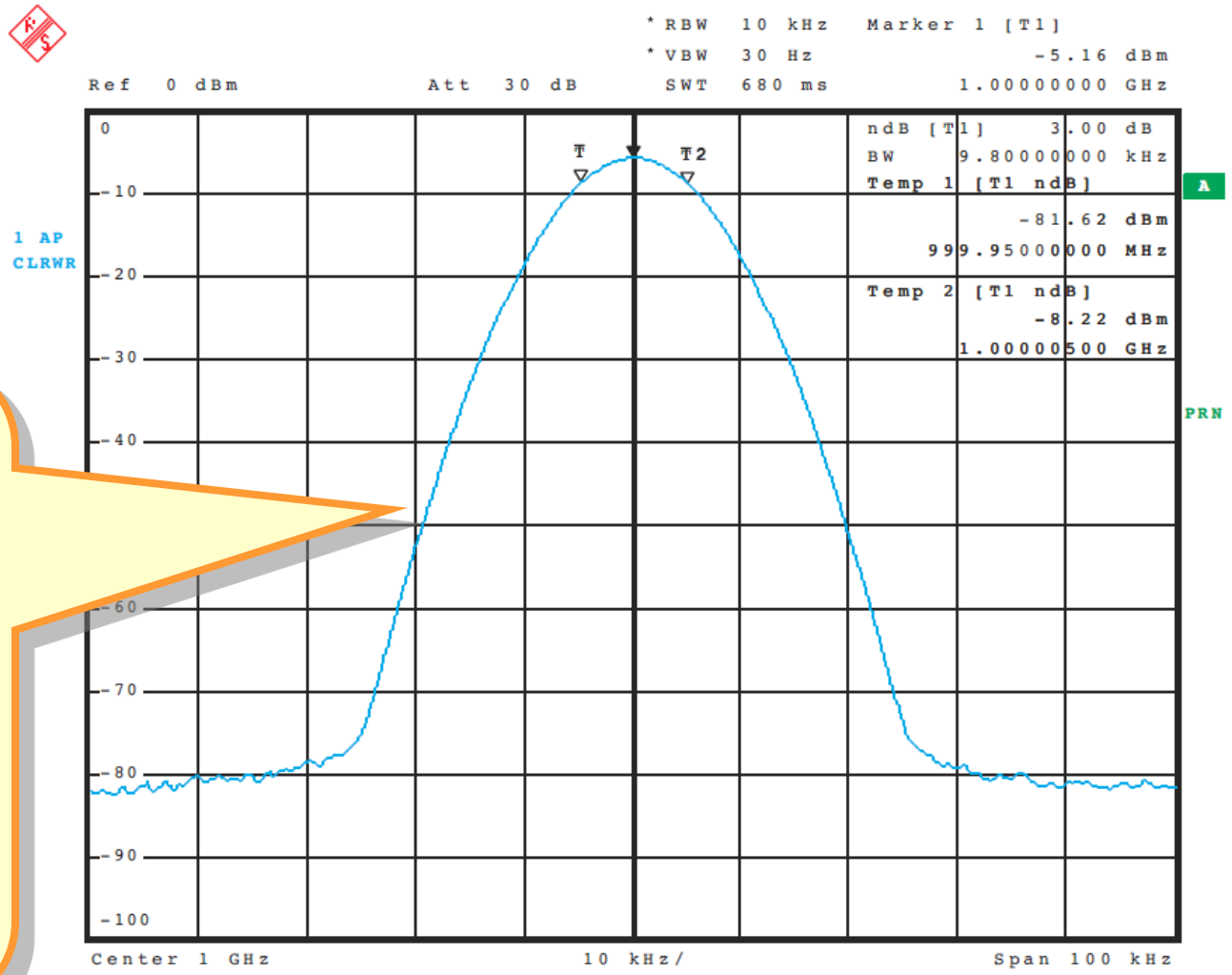
Naponska funkcija prenosa Gausovog filtra, linearna razmera



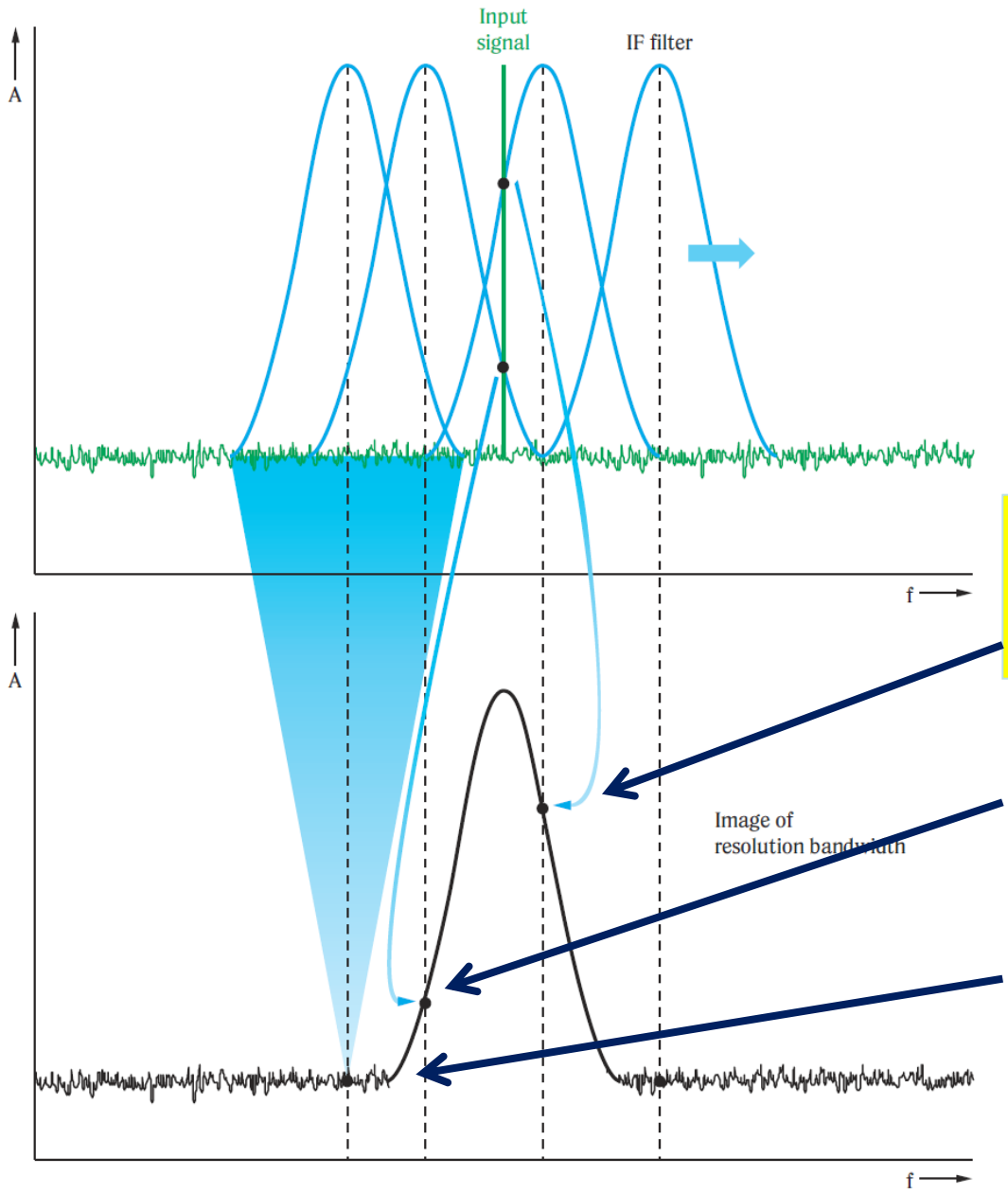
Funkcija prenosa snage Gausovog filtra, linearna razmera



Odraz sinusoidalnog signala u IF



Za heterodini princip rada analizatora spektra, kada se posmatra spektar sinusnog signala, ne dobija se vertikalna linija kao za FFT. Umesto toga se dobija



Christoph Rauscher
Fundamentals of Spectrum Analysis

Odraz IF filtra za ulazni sinusoidalan signal zbog “swept past”

- ✓ Na rezonantnoj učestanosti trećeg spektra pojavljuje se veća vrednost
- ✓ Na rezonantnoj učestanosti drugog spektra pojavljuje se manja vrednost
- ✓ Na rezonantnoj učestanosti prvog spektra pojavljuje se 0

Ulazni signal zbir dve sinusoide

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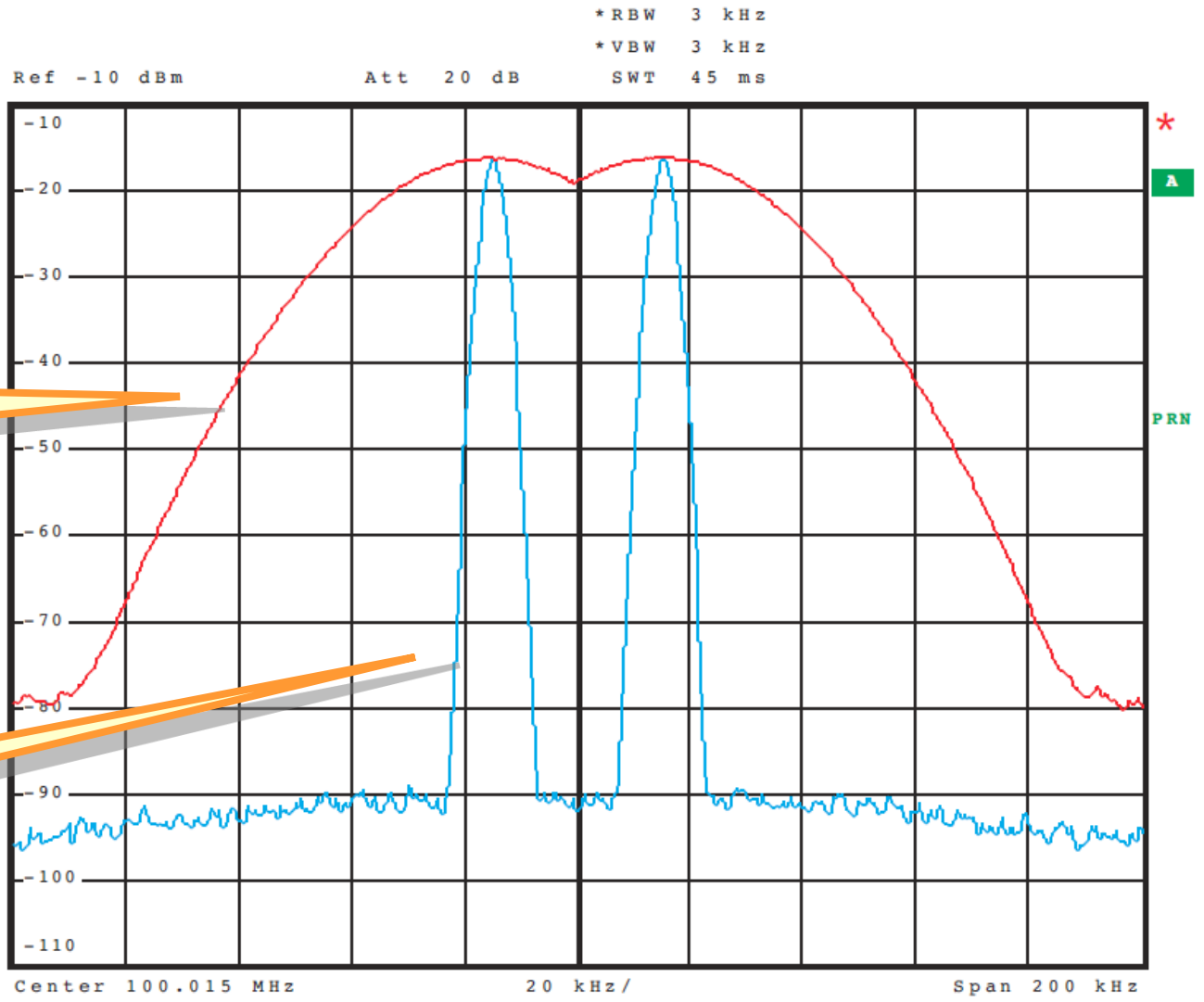
Različite rezolucije propusnih opsega

Crveno RBW=30kHz

Isti nivoi sinusoida

Plavo RBW = 3 kHz



Ulazni signal zbir dve sinusoide

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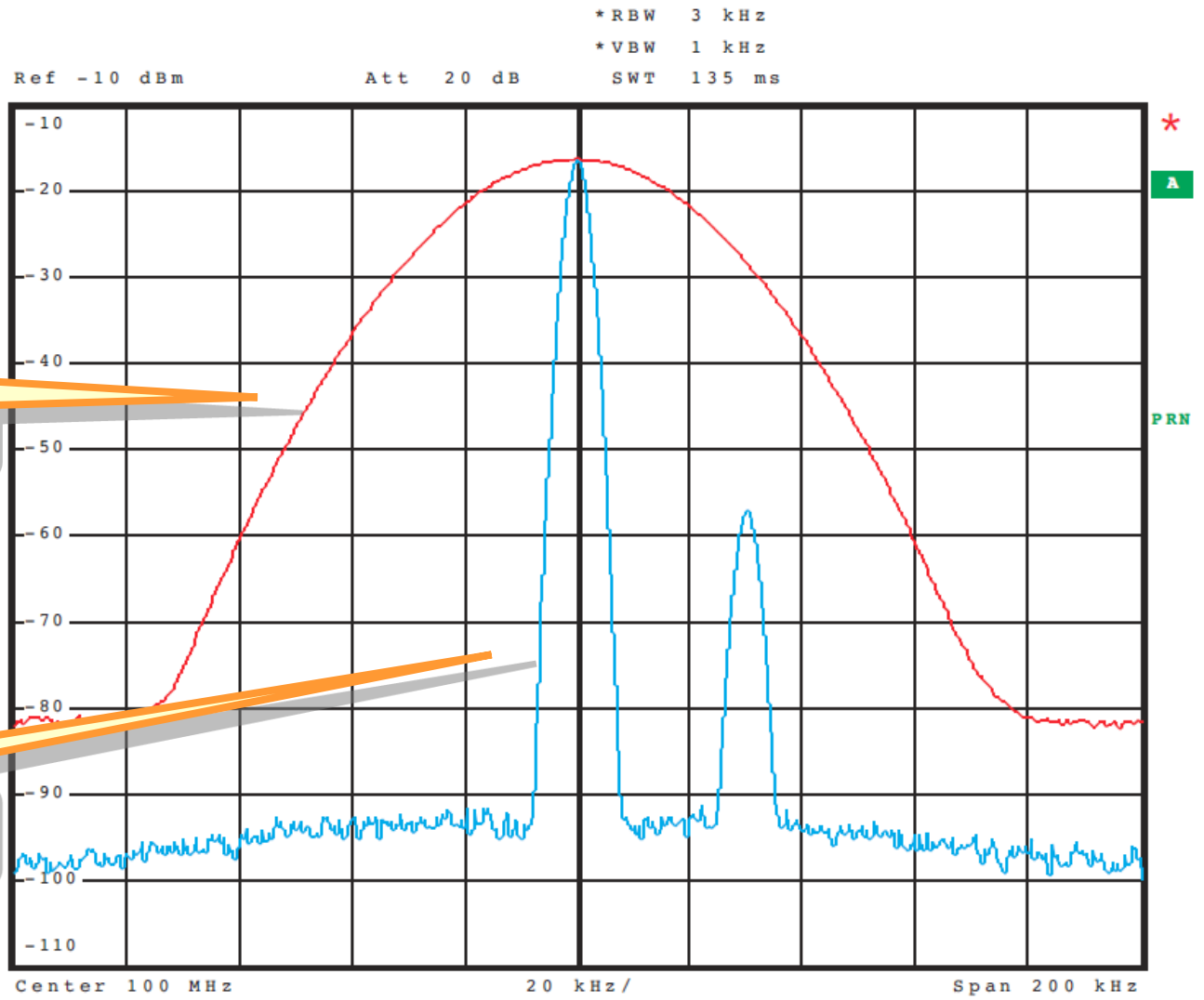
Različite rezolucije propusnih opsega

Crveno RBW=30kHz

Različiti nivoi sinusoida

Plavo RBW = 3 kHz



Ulazni signal zbir dve sinusoide

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B_{3dB} = 3 dB bandwidth

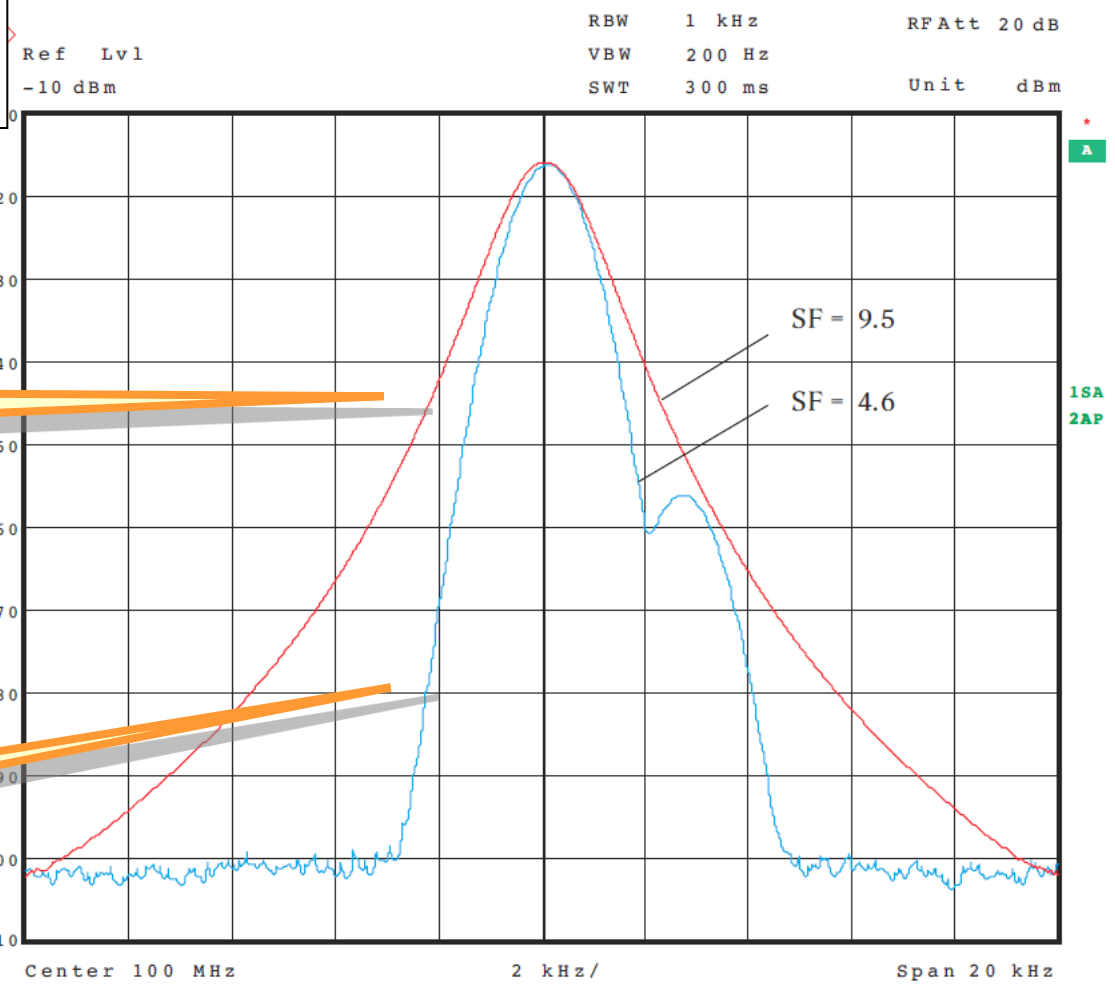
B_{60dB} = 60 dB bandwidth

$$SF_{60/3} = \frac{B_{60dB}}{B_{3dB}}$$

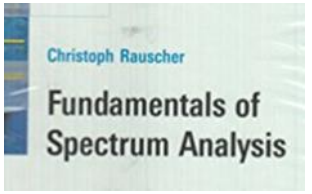
Crveno SF = 9.5

Različiti nivoi sinusoida i shape factor

Plavo SF = 4.6



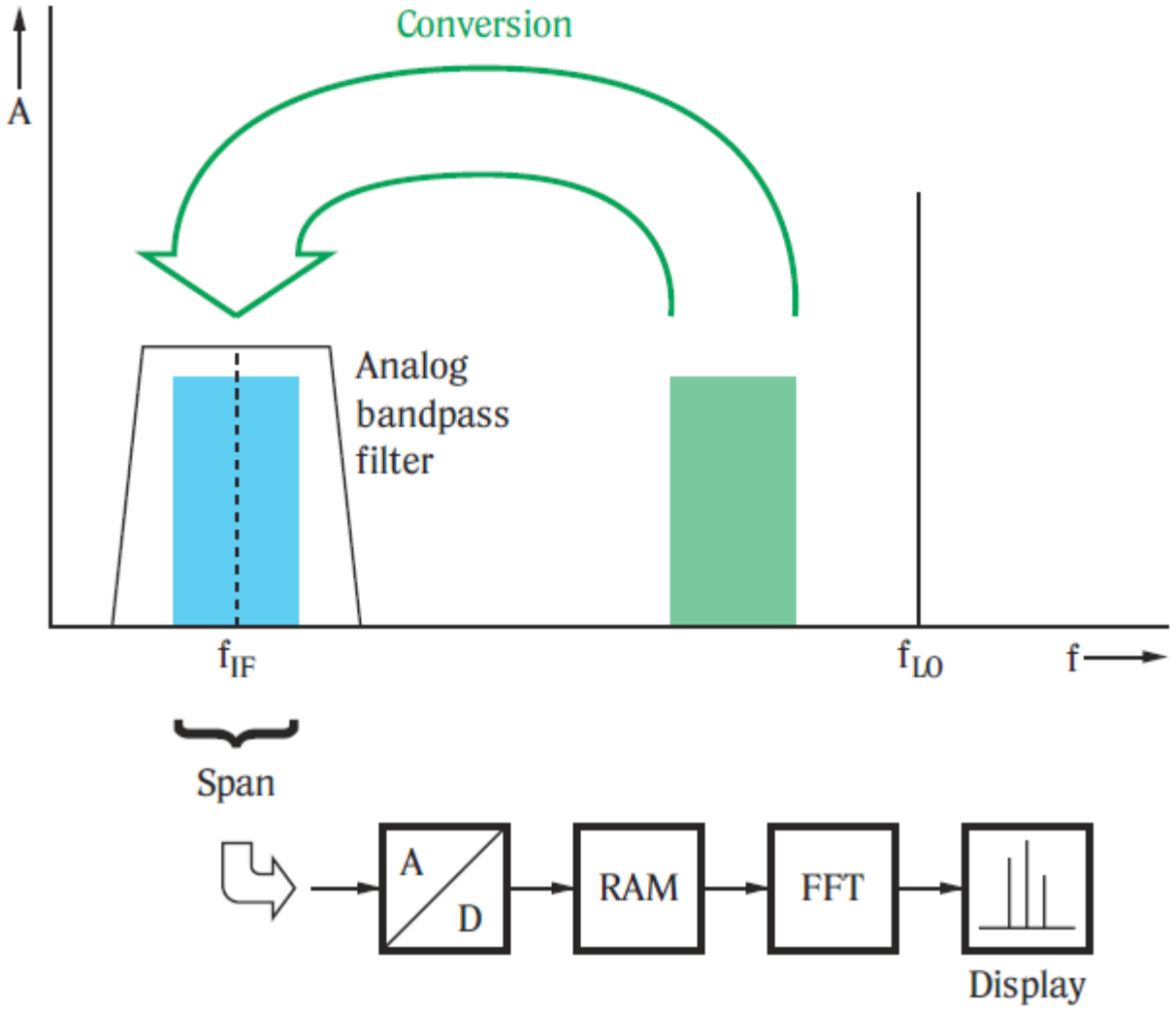
Rezolucija propusnog opsega 1 kHz



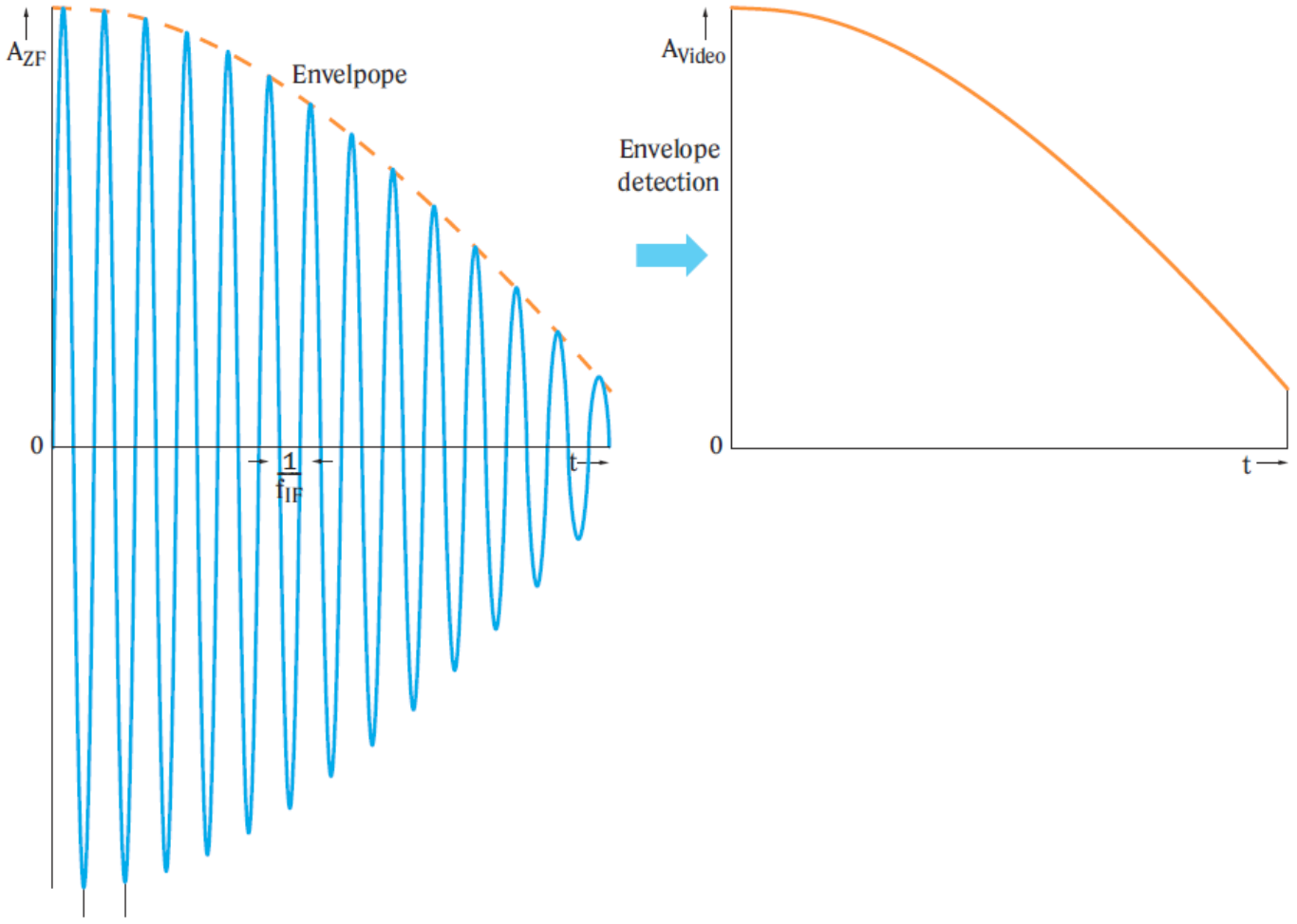
Vrste filtara

1. Analogni filtri (100 kHz - 10 MHz)
   - ✓ Ne može da realizuje Gausov filtar,
   - ✓ Odlična aproksimacija samo do 20 dB,
   - ✓ Odličan prelazni vremenski odziv,
   - ✓ SF 10-14, pa i 4,6
2. Digitalni filtri
   - ✓ Može da realizuje Gausov filtar,
   - ✓ Temperaturno stabilni nema efekata starenja,
   - ✓ Bez podešavanja, kraće vreme sweep-a,
   - ✓ Rezolucija od 10 Hz do 30 kHz.
3. Filtri na bazi FFT

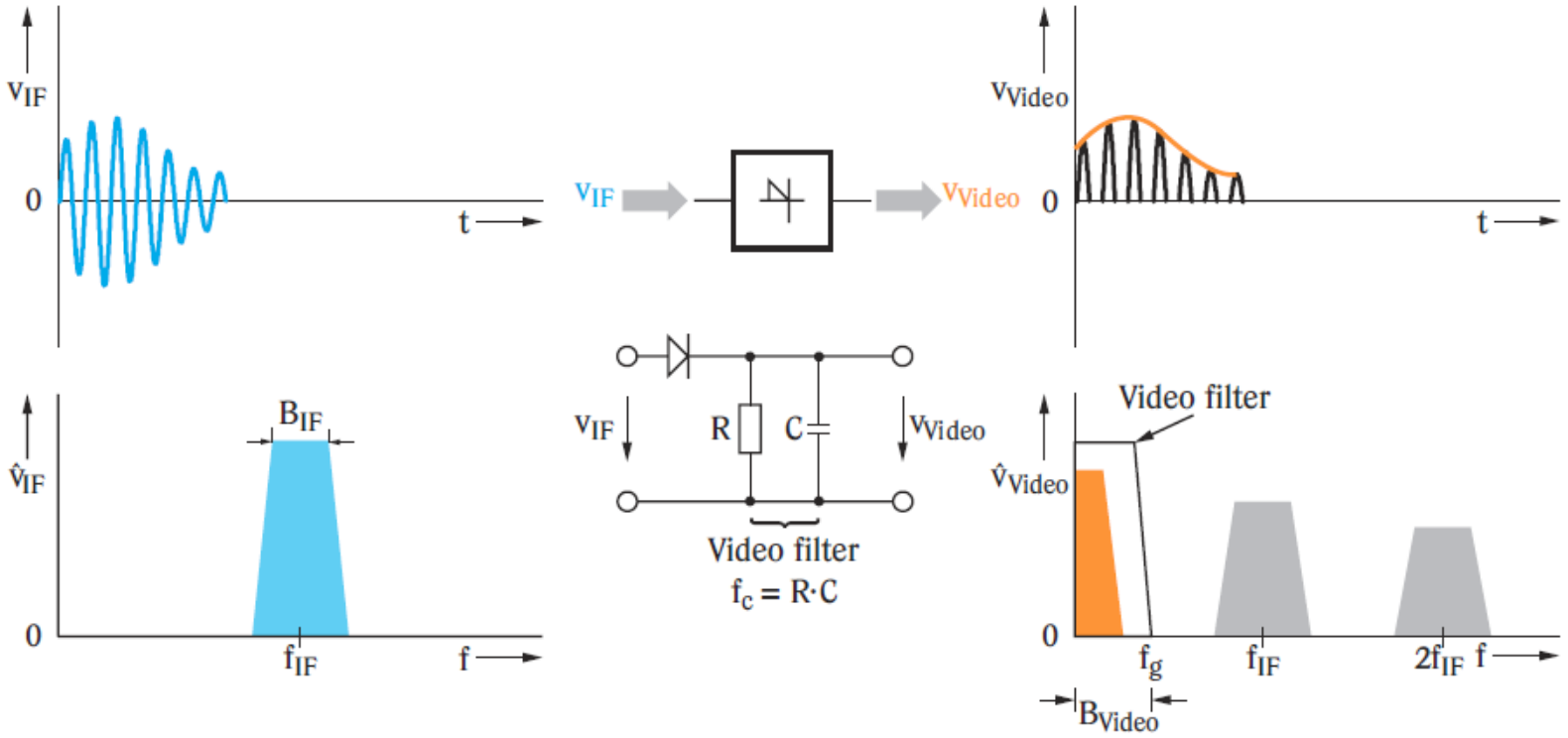
Analizator spektra korišćenjem FFT



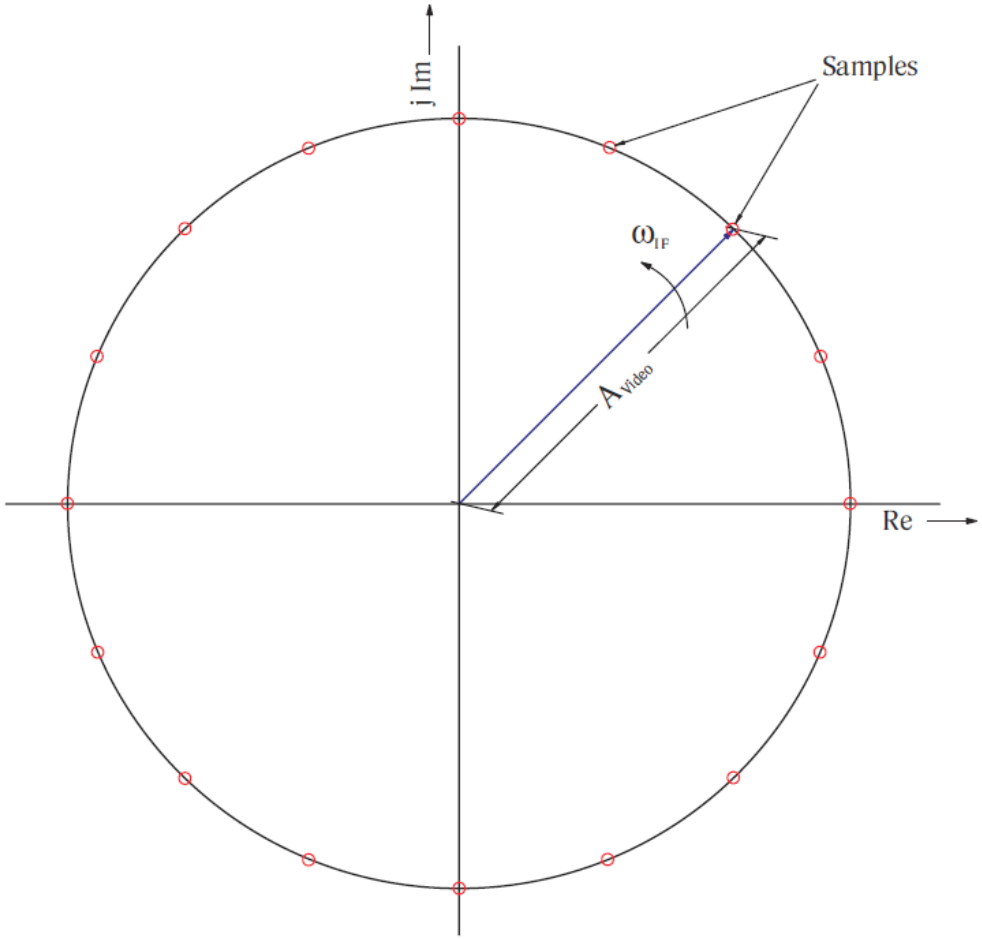
Detekcija anbelope IF signala



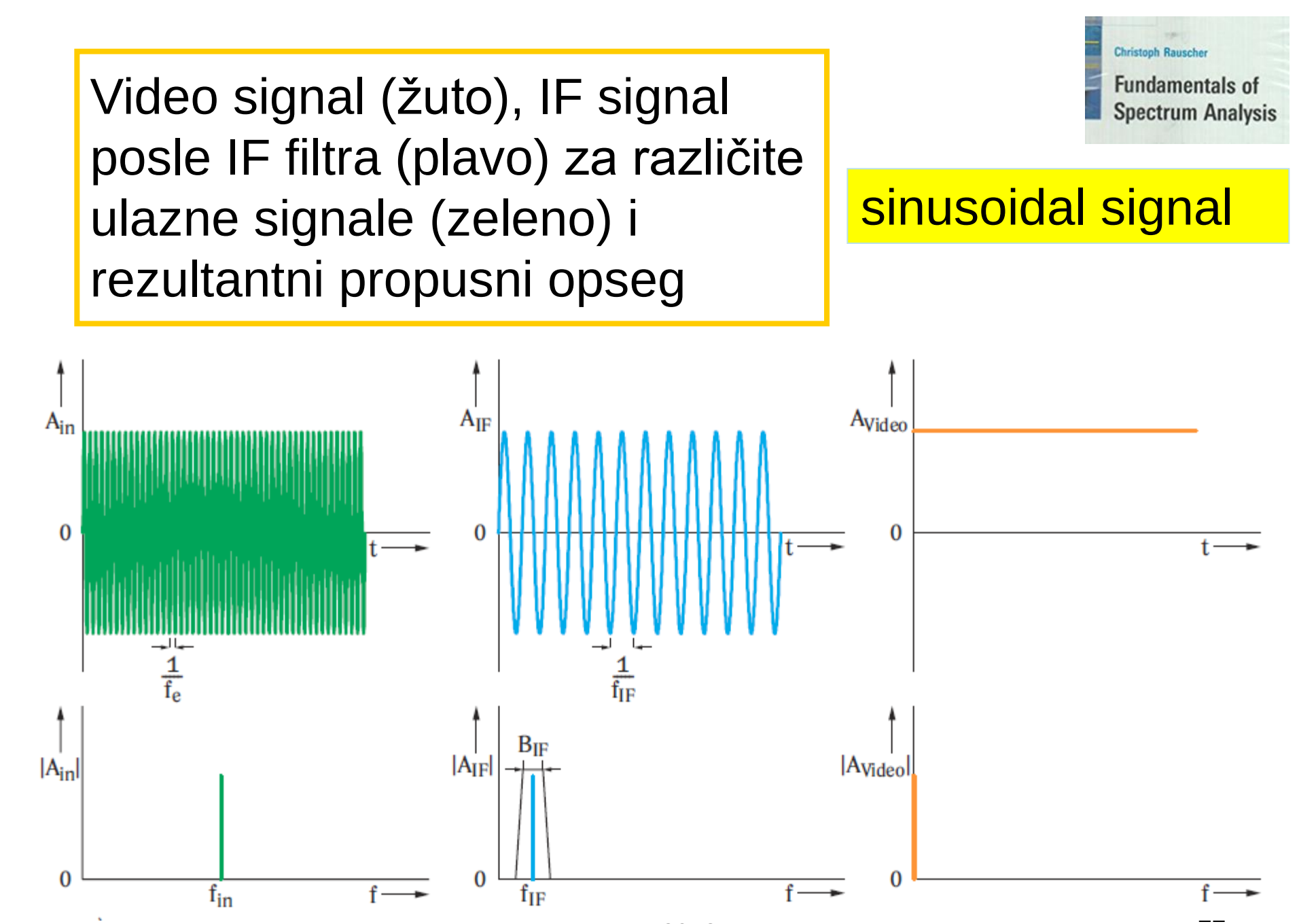
Detekcija IF anvelope



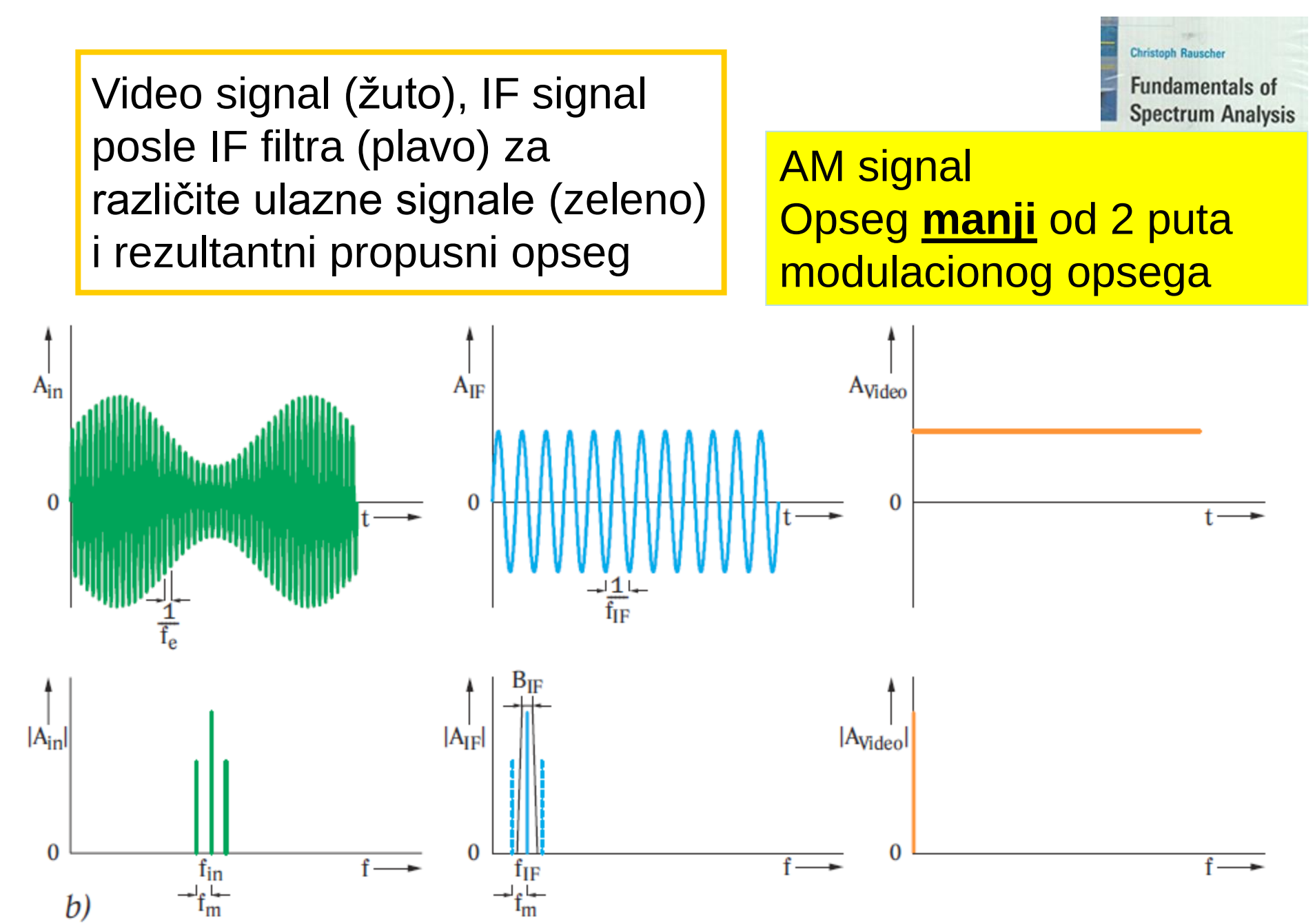
Predstavljanje sinusoidalnog signala kompleksnim rotirajućim vektorom



Video signal (žuto), IF signal posle IF filtra (plavo) za različite ulazne signale (zeleno) i rezultantni propusni opseg



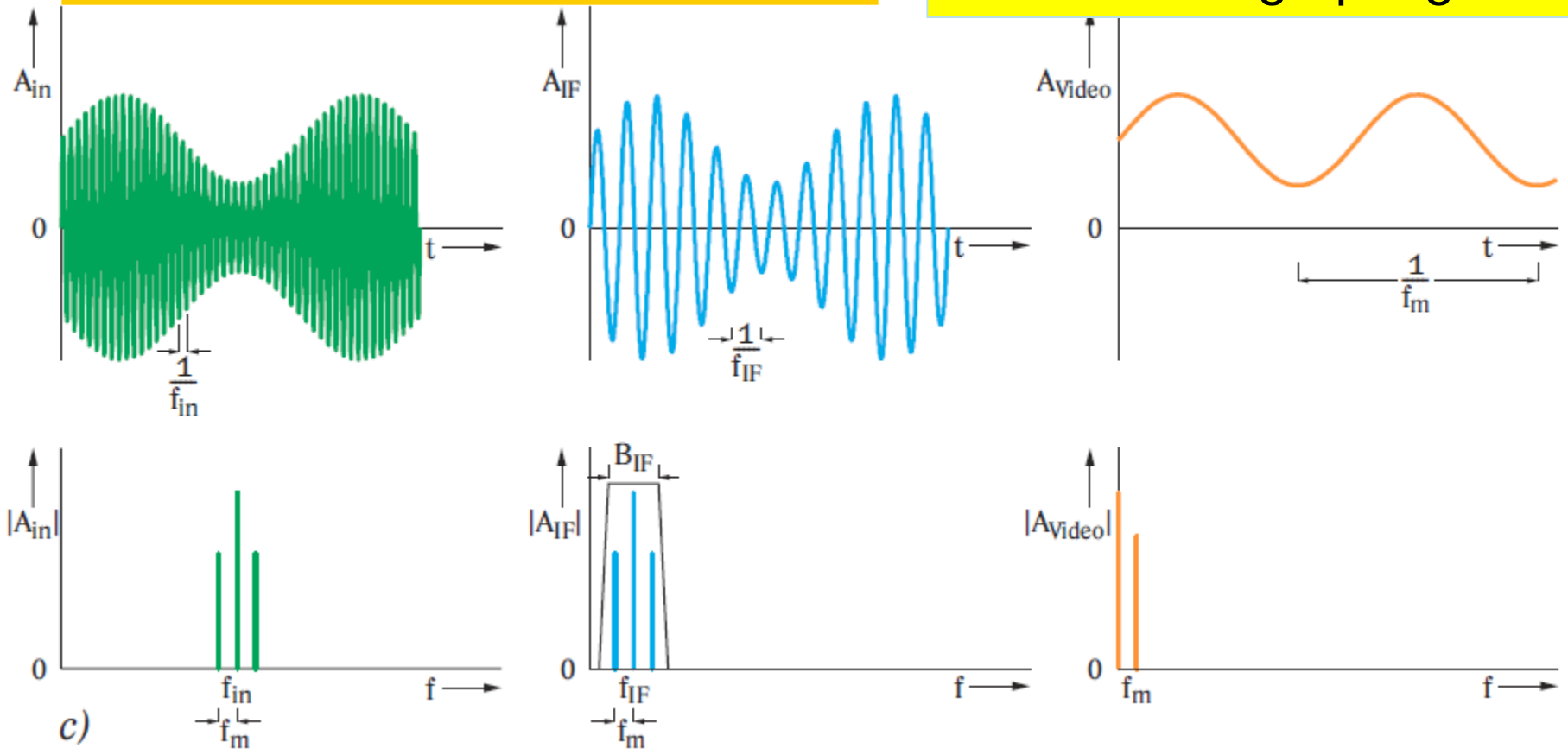
Video signal (žuto), IF signal posle IF filtra (plavo) za različite ulazne signale (zeleno) i rezultantni propusni opseg



AM signal
Opseg **manji** od 2 puta modulacionog opsega

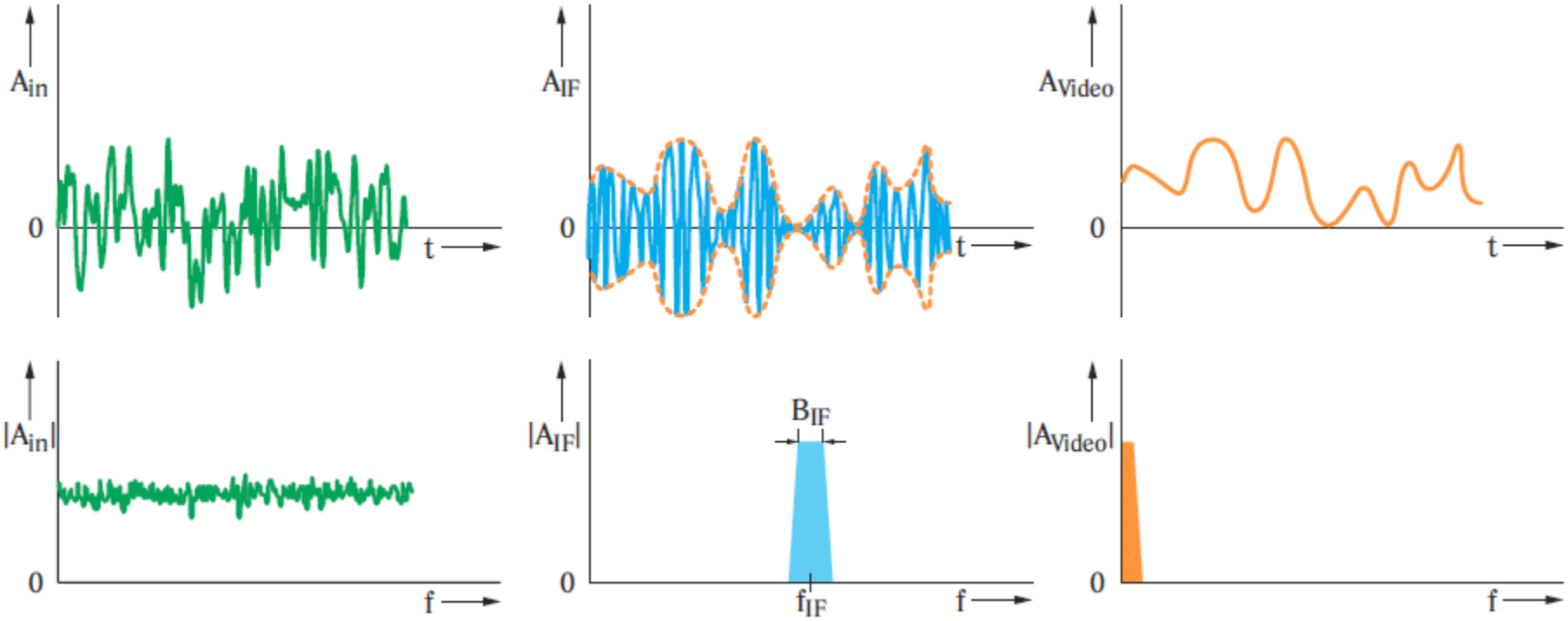
Video signal (žuto), IF signal posle IF filtra (plavo) za različite ulazne signale (zeleno) i rezultantni propusni opseg

AM signal
Opseg **<u>veći</u>** od 2 puta modulacionog opsega



Video signal (žuto), IF signal posle IF filtra (plavo) za različite ulazne signale (zeleno) i rezultantni propusni opseg

šum



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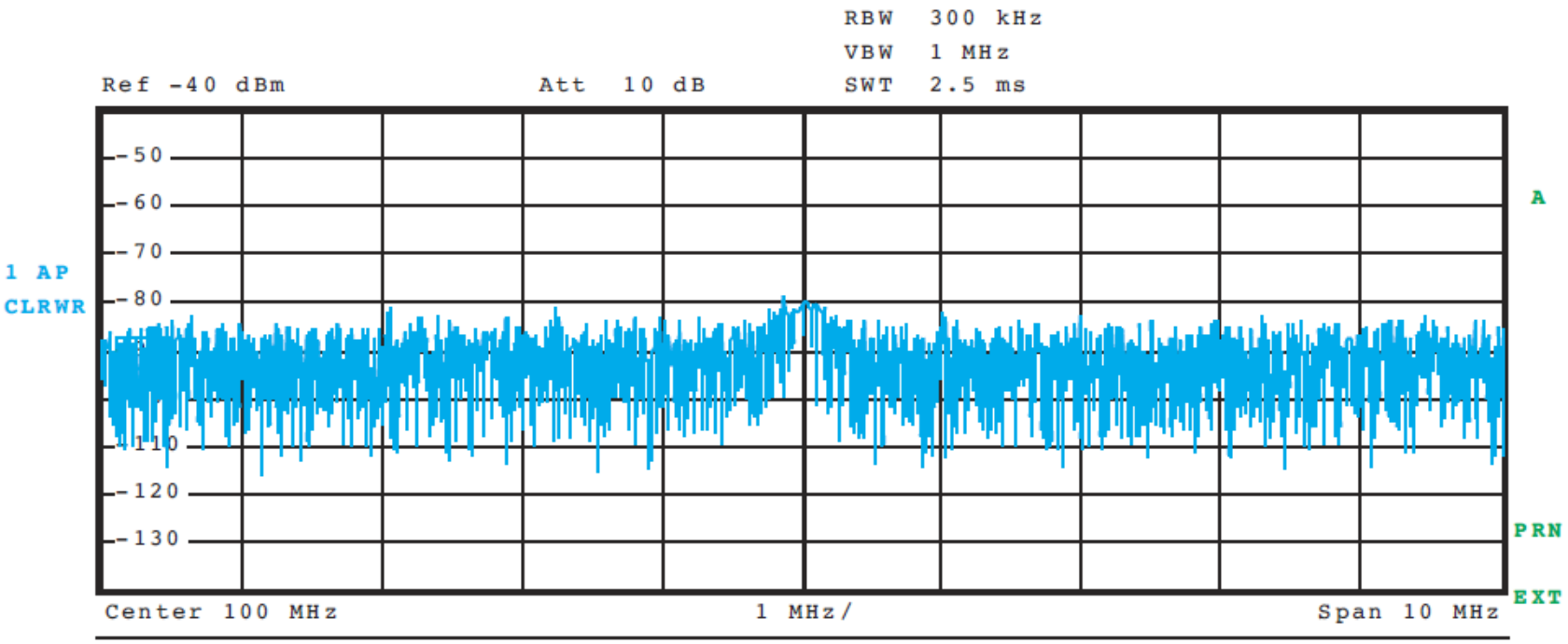
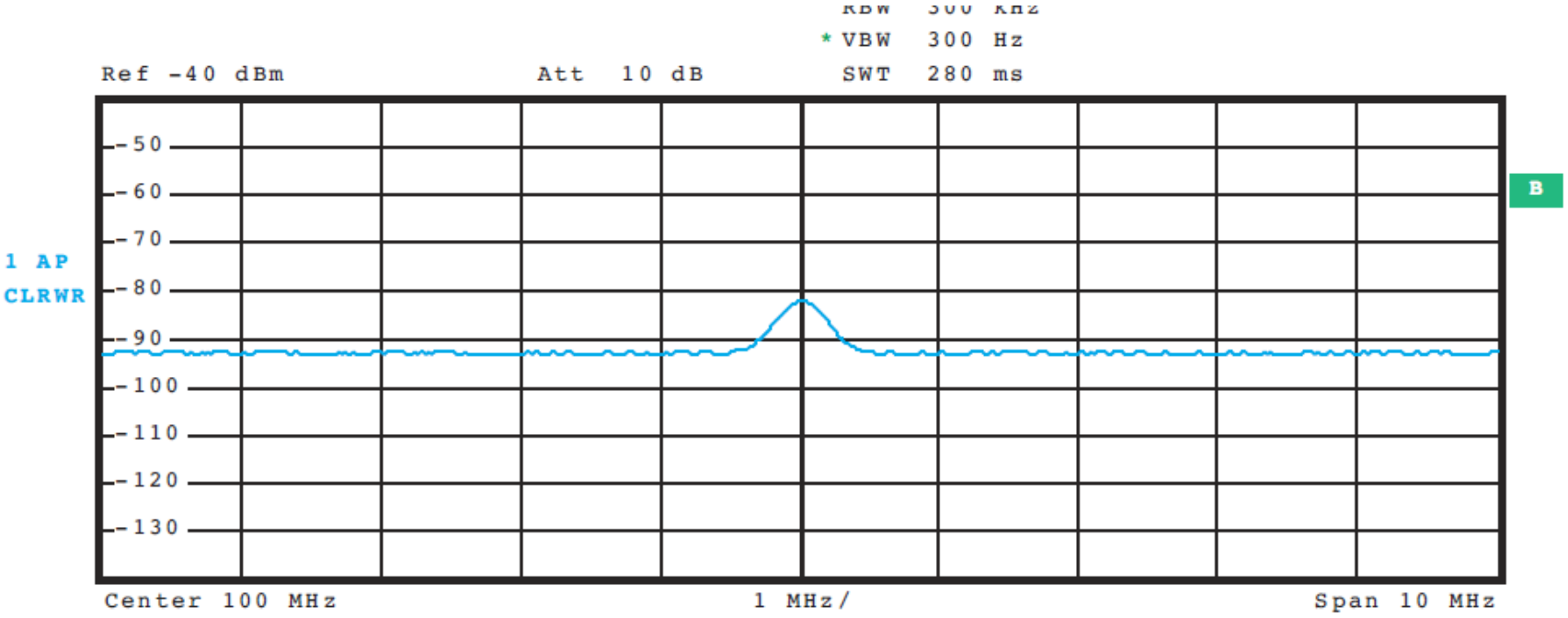
Sinusoidalan signal sa malim odnosom S/N za **veliki** propusni opseg



Sinusoidalan signal sa malim odnosom S/N za **mali** propusni opseg



Impulsni signal sa **velikim** video propusnim opsegom

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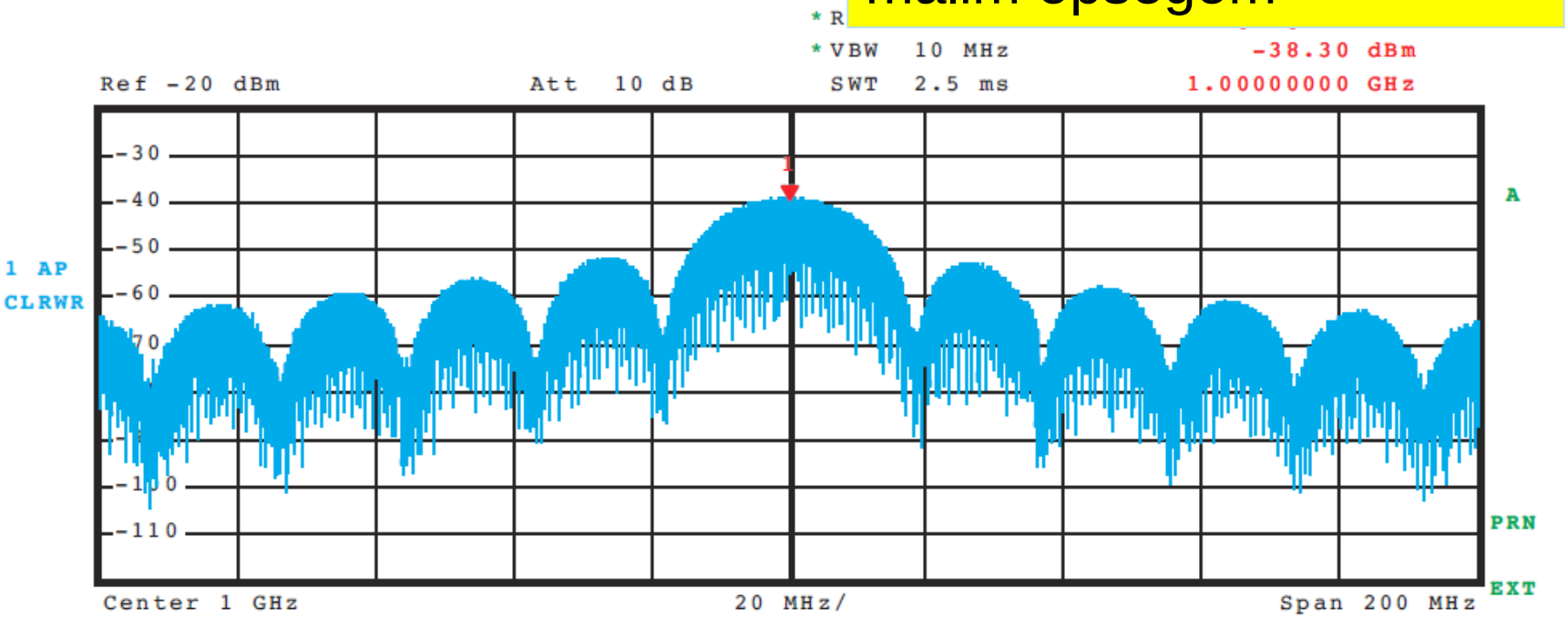
Marker
Amplituda je oslabljena sa malim opsegom



Impulsni signal sa **malim** video propusnim opsegom

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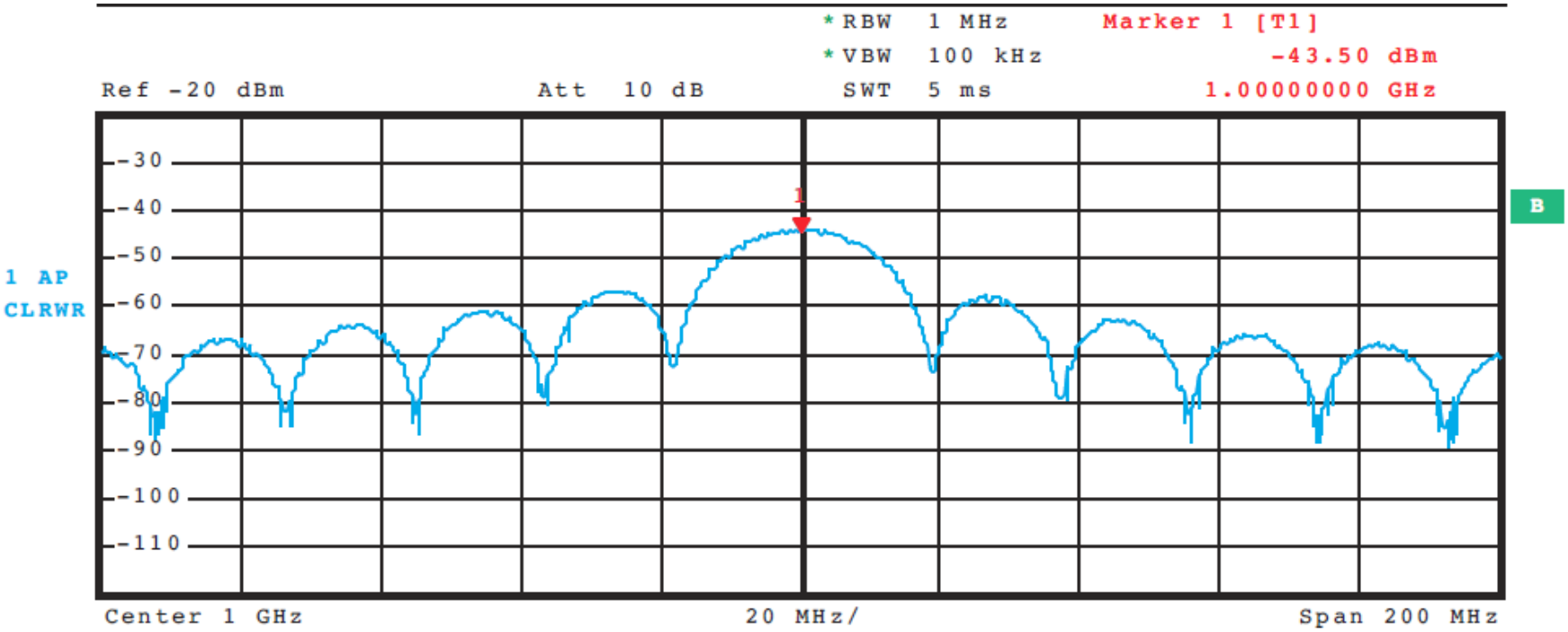
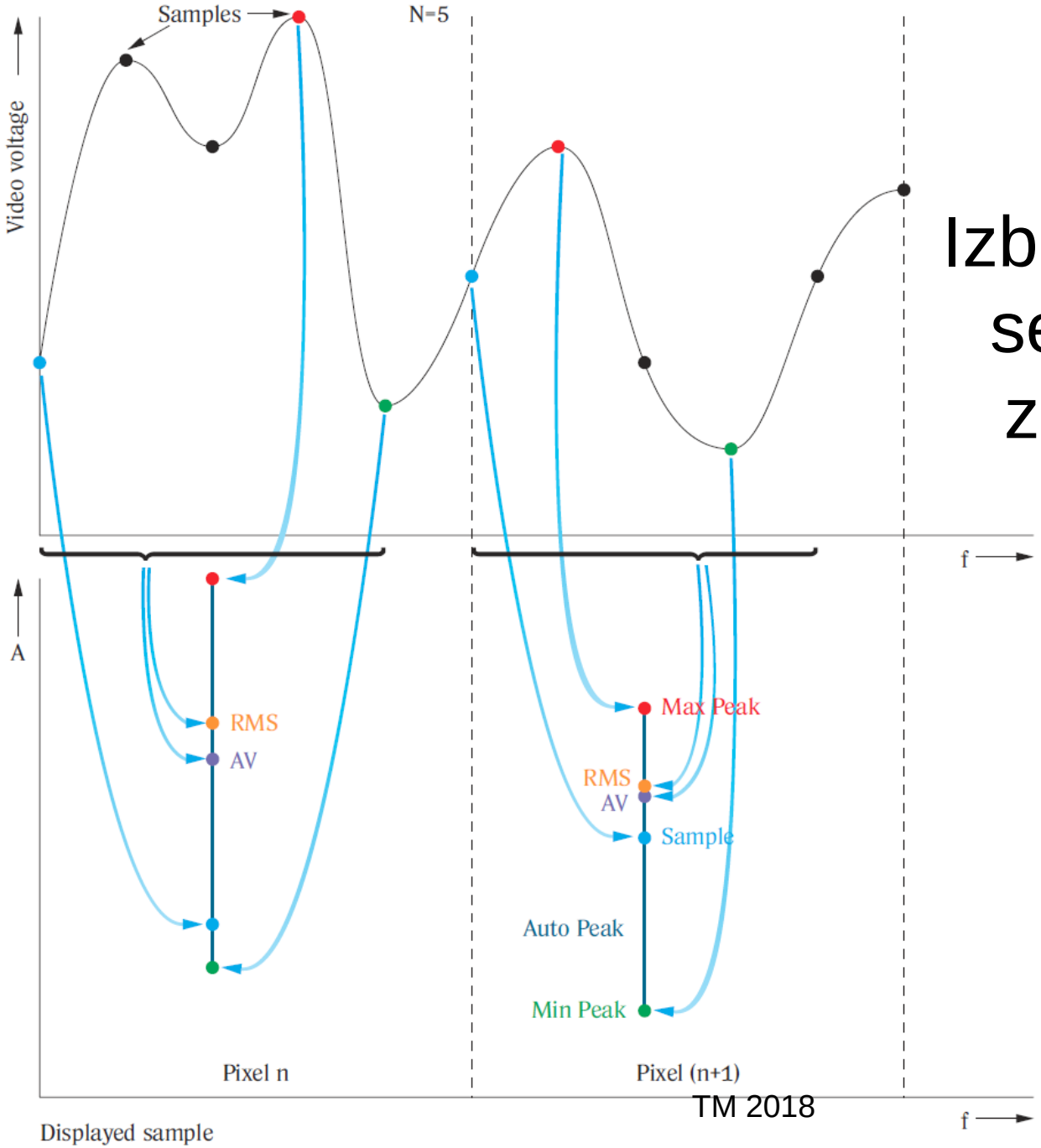
Marker
Amplituda je oslabljena sa malim opsegom





Izbor sempla koji se prikazuje u zavisnosti od detektora

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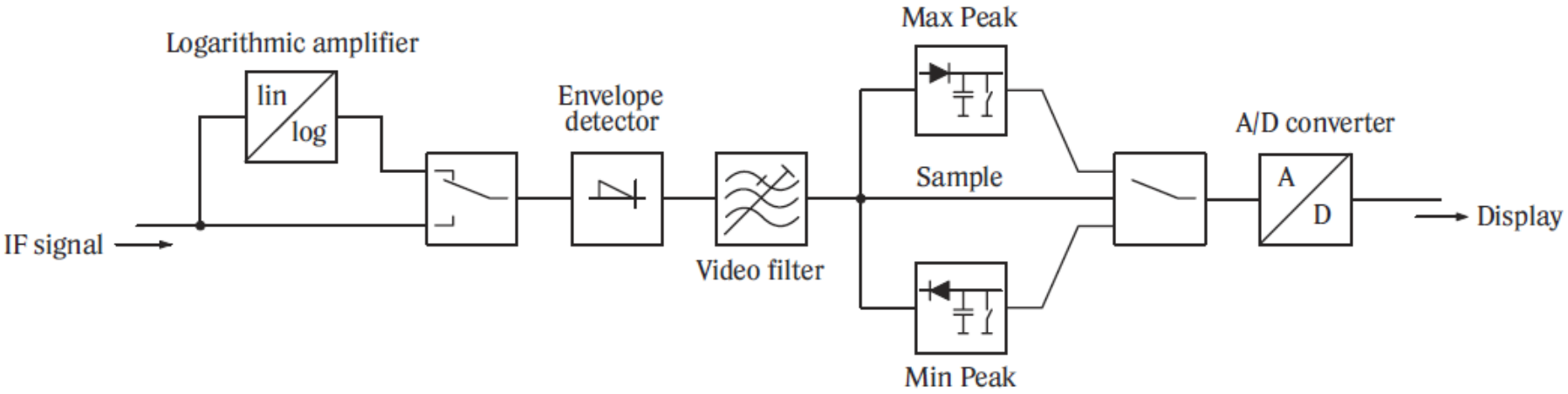
Analogna realizacija detektora



Max peak detektor
Min peak detektor
Auto peak detektor
Sample detektor
RMS (root mean square) detektor
AV (average) detektor
Quasi peak detector

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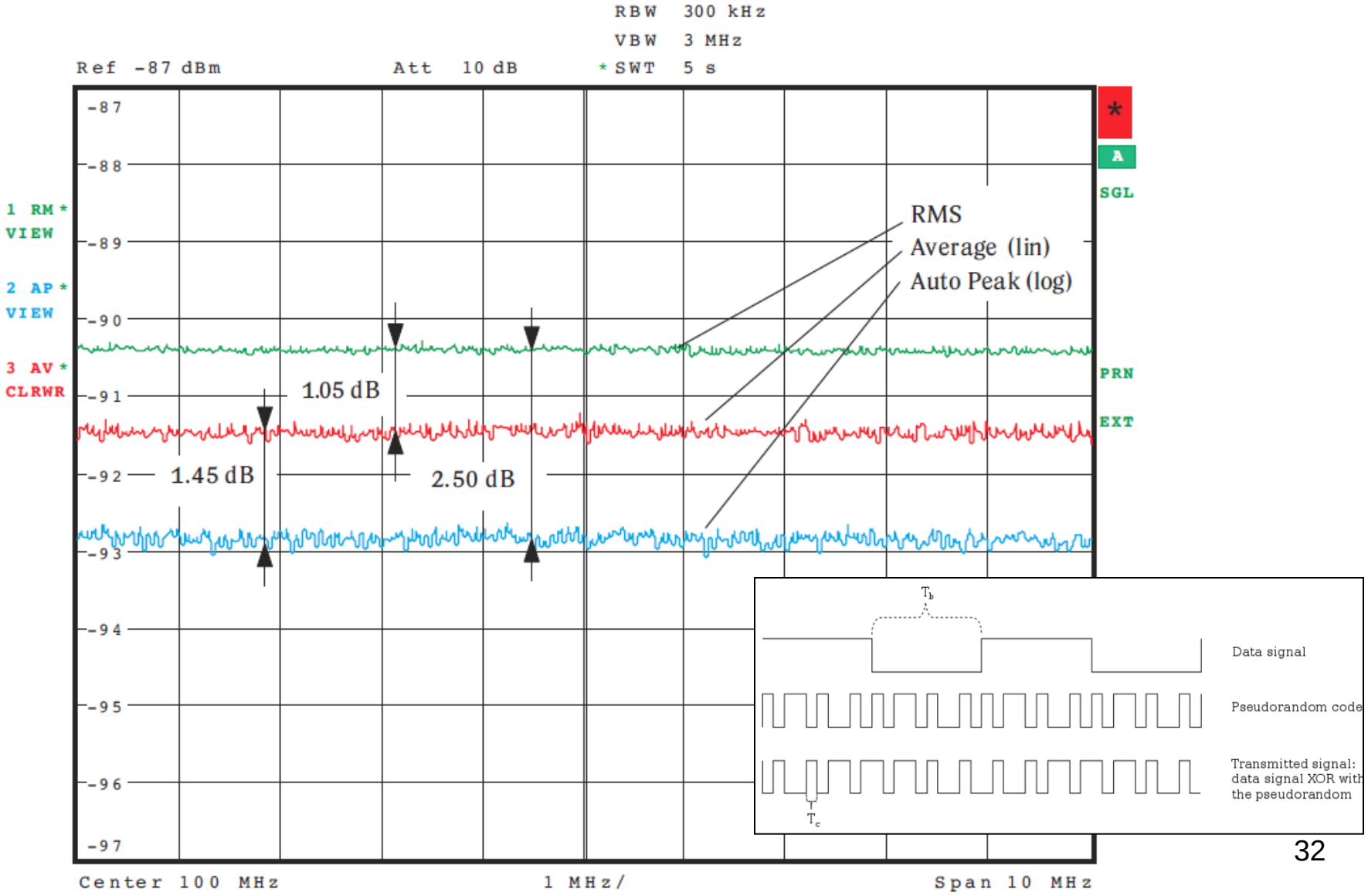
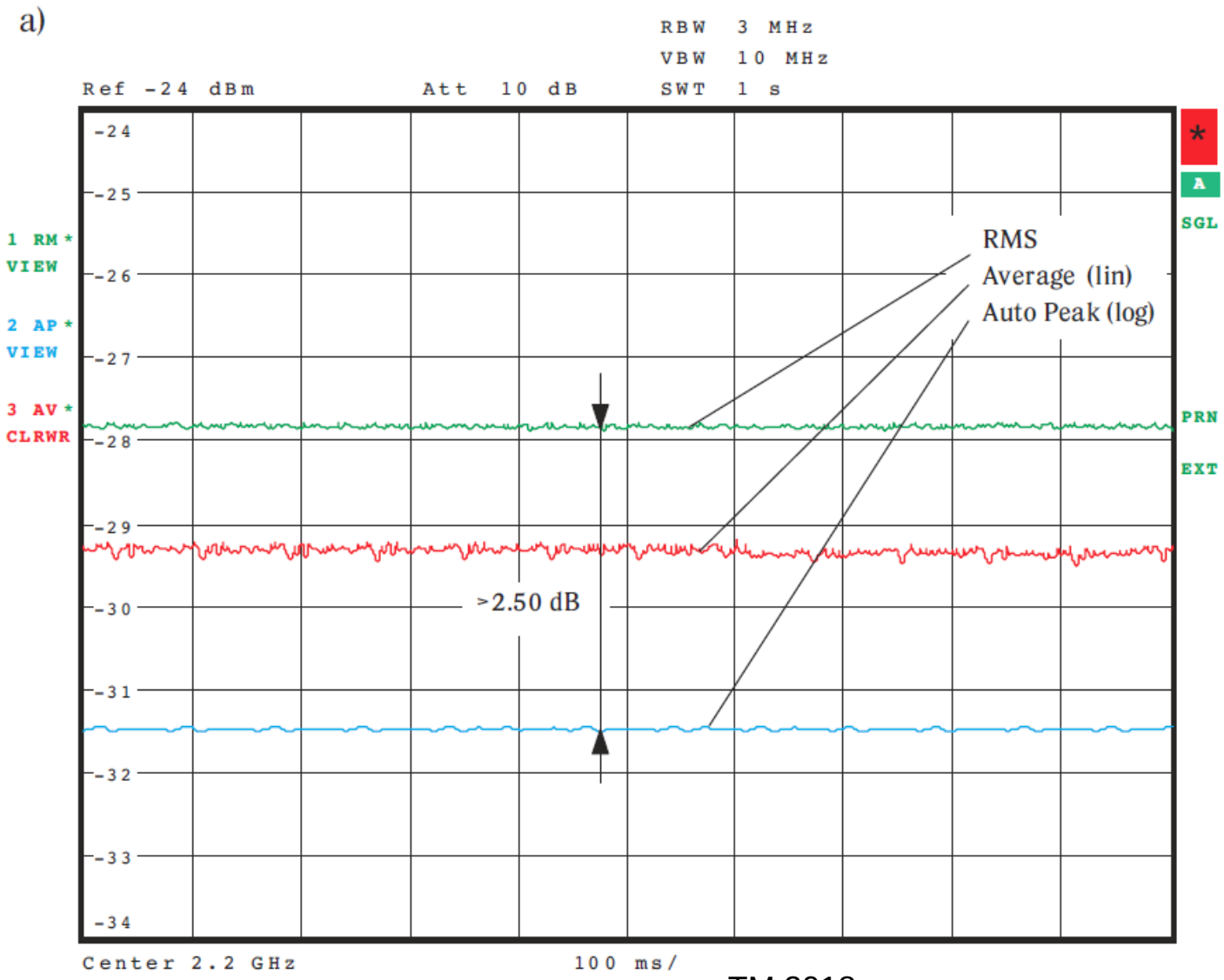
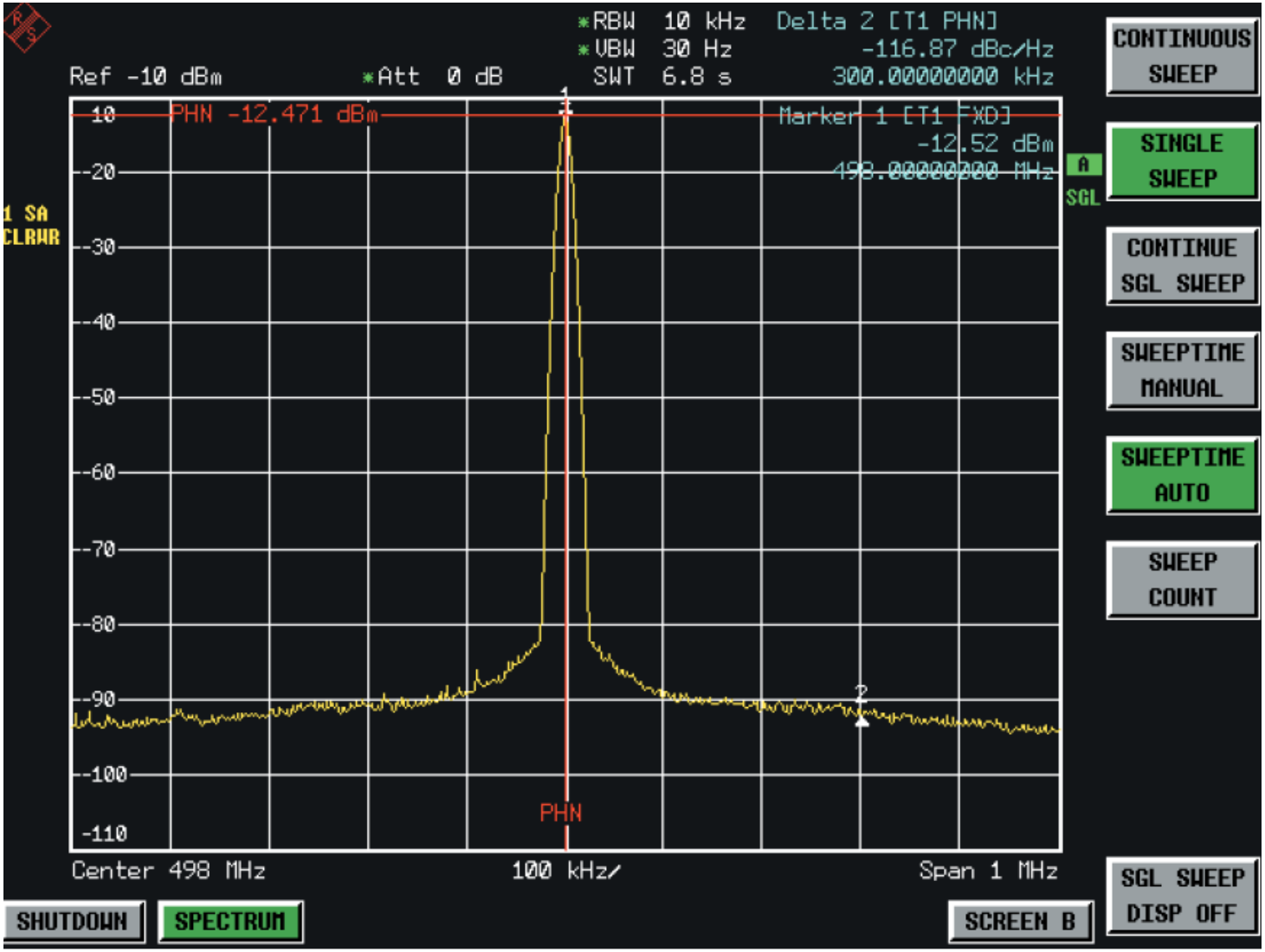
Gausov šum i CDMA signal



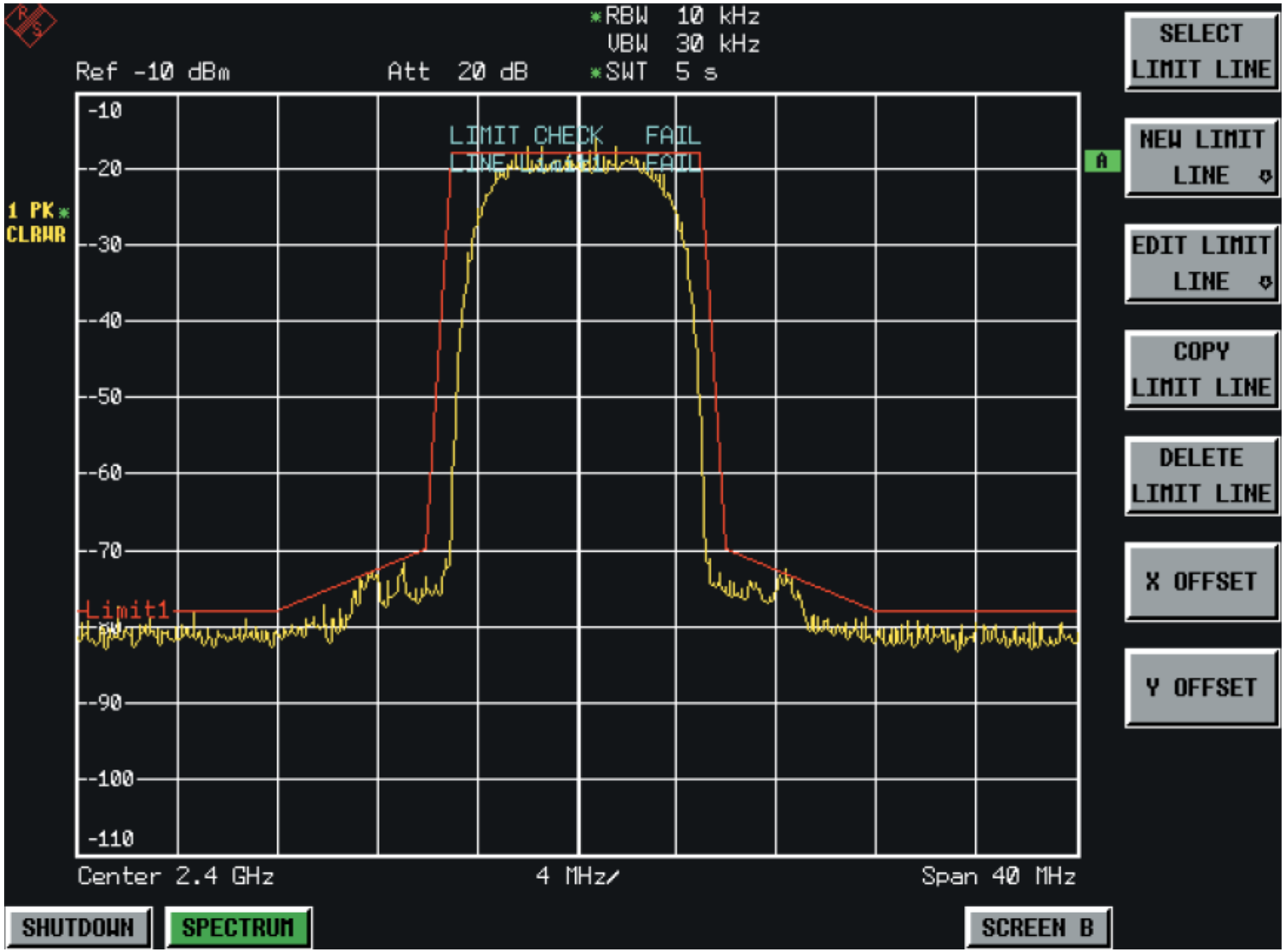
Gausov šum i CDMA signal



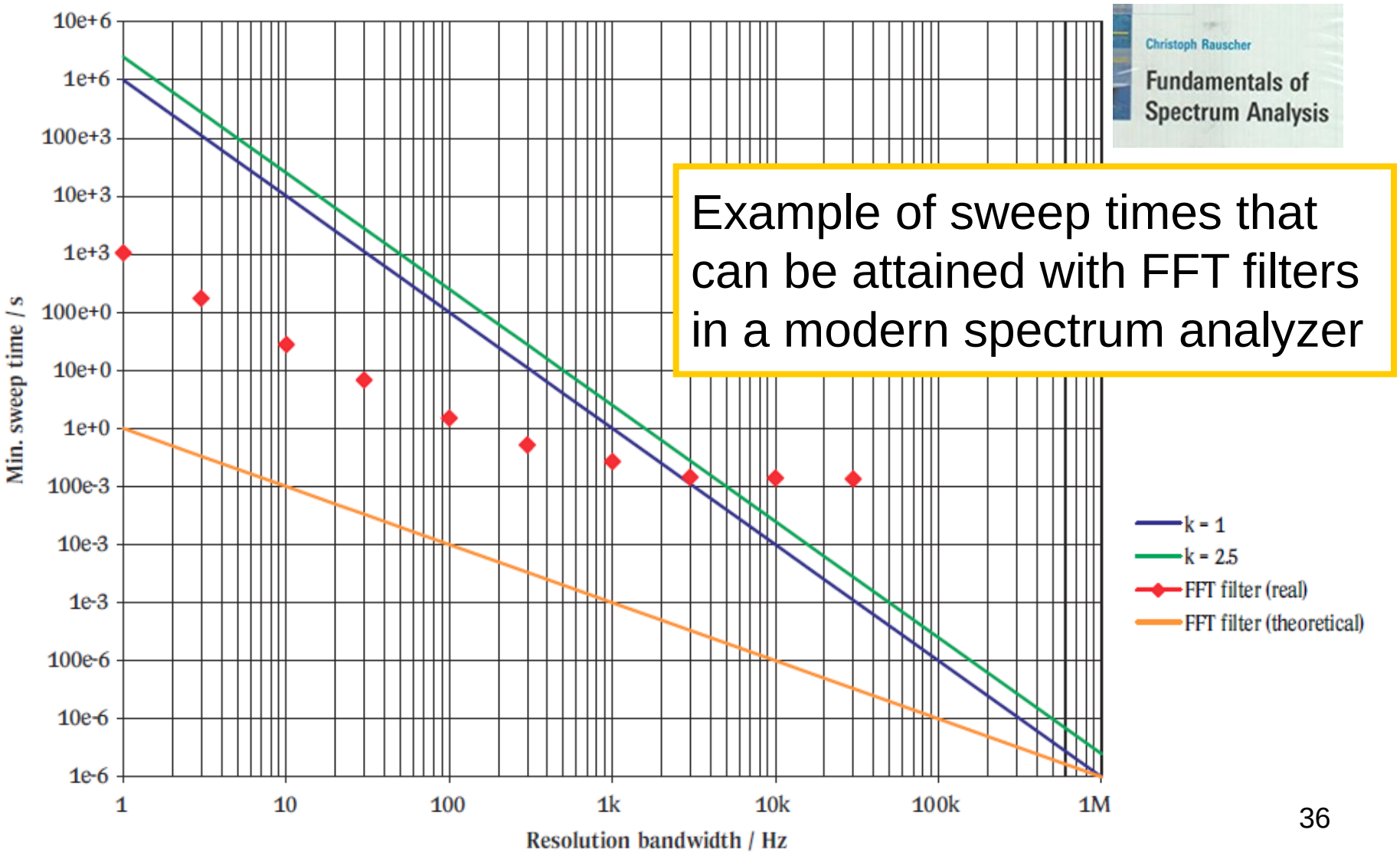
Marker funkcije za jednostavno merenje faznog šuma ulaznog signala



Evaluation of traces with the aid of limit lines

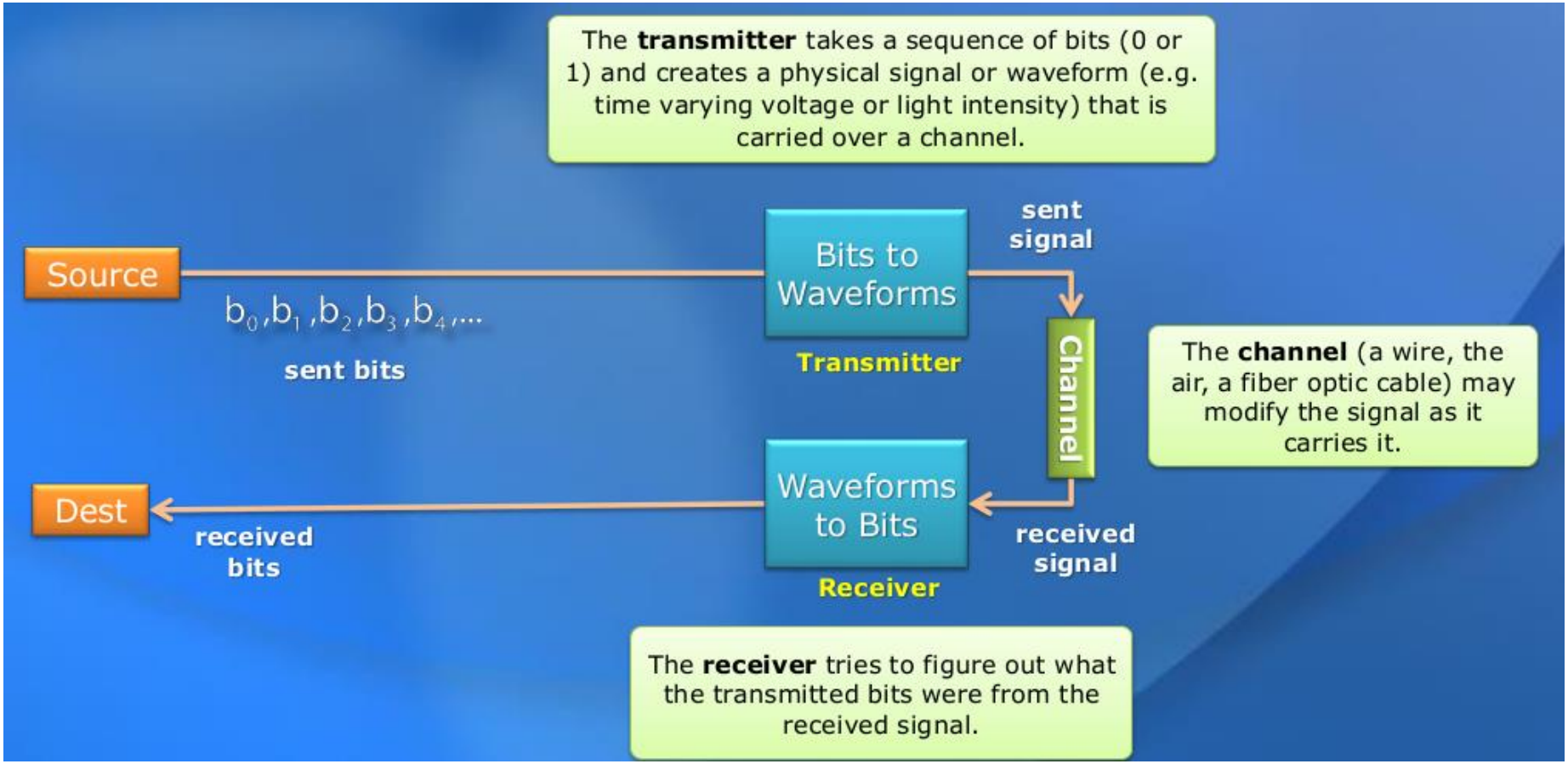


Theoretically required sweep time as a function of resolution bandwidth at a span of 1 MHz



Example of sweep times that can be attained with FFT filters in a modern spectrum analyzer

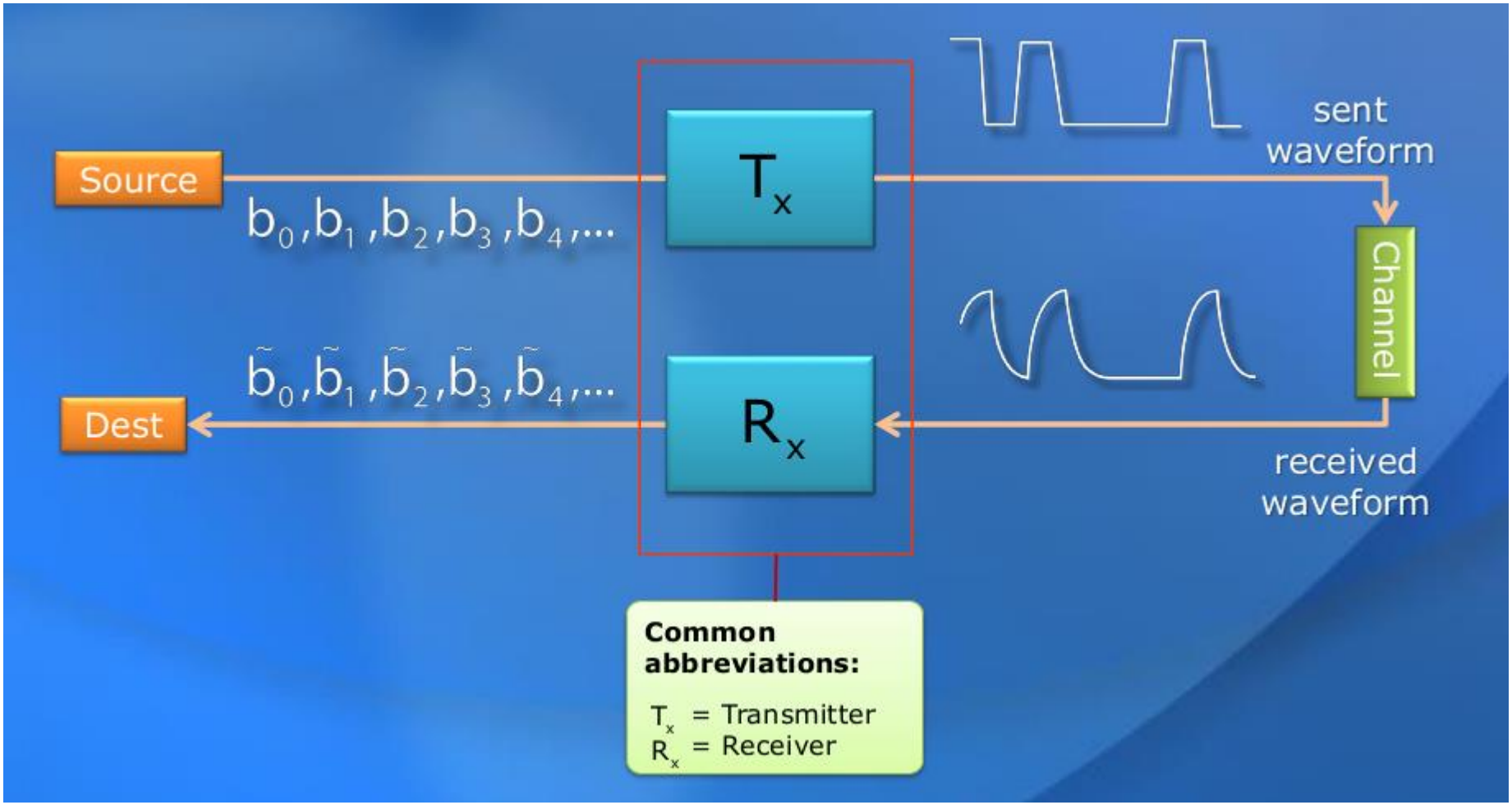
Blok šema osnovnog digitalnog komunikacionog sistema



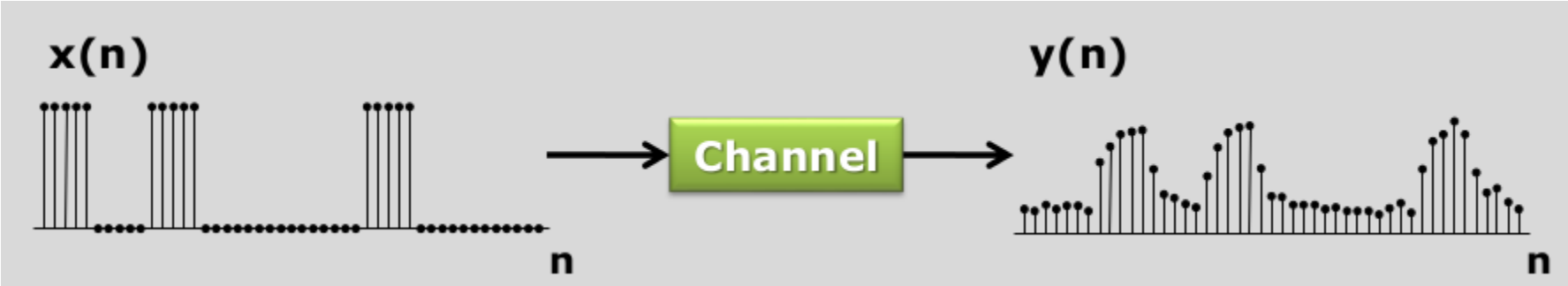
Ekvivalentni načini predstavljanja bita

Verbal	**"Encoding of the bit sequence 1,0,1,0,0,0,1 at 4 samples per bit"**
Graph	
List, table or vector of values	**n = [0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 …]** **x(n) = [1 1 1 1 0 0 0 0 1 1 1 1 0 0 0 0 0 0 …]**
Sum of unit step functions	**x(n) = u(n) – u(n-4) + u(n-8) – u(n-12) + u(n-24) – u(n-28)**

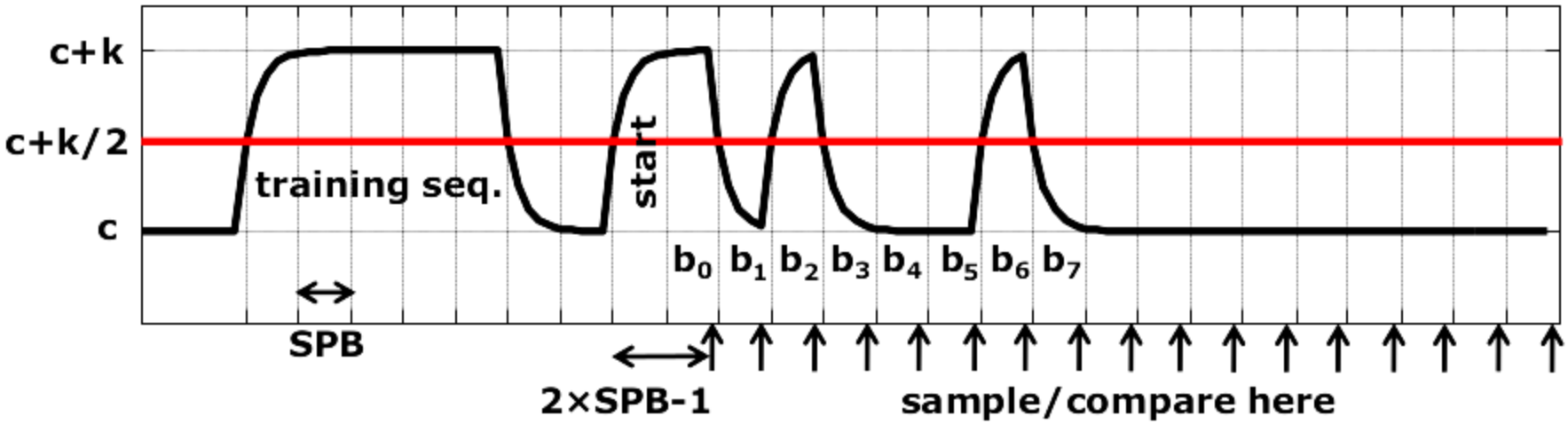
Prenos talasnog oblika kroz kanal u komunikacionom sistemu



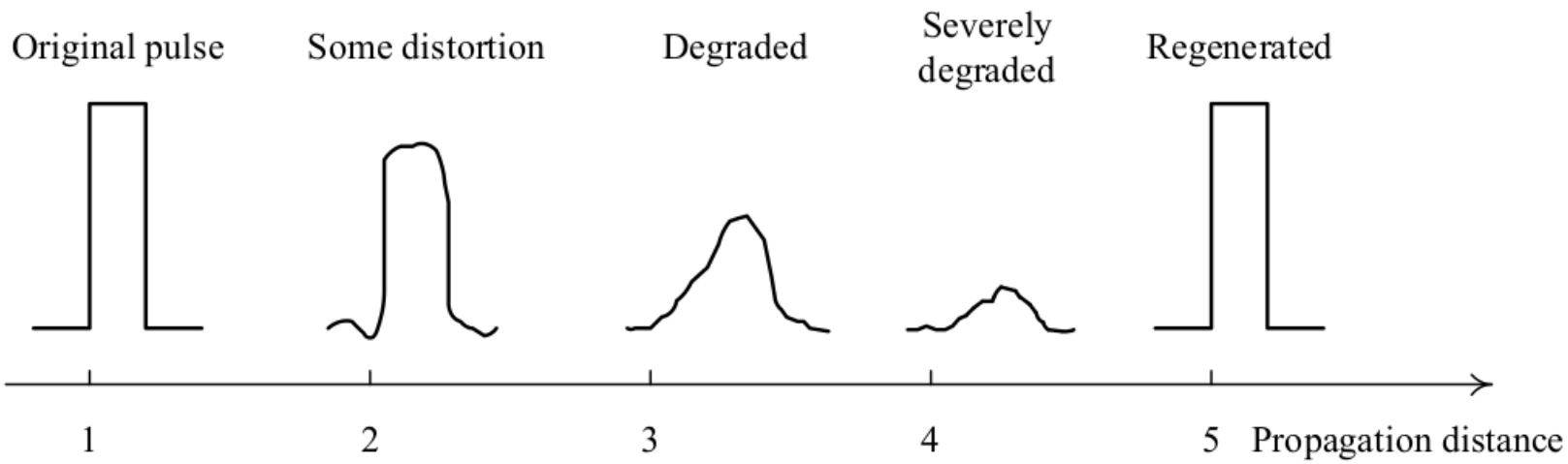
Primer uticaja kanala za prenos na diskretni talasni oblik bita



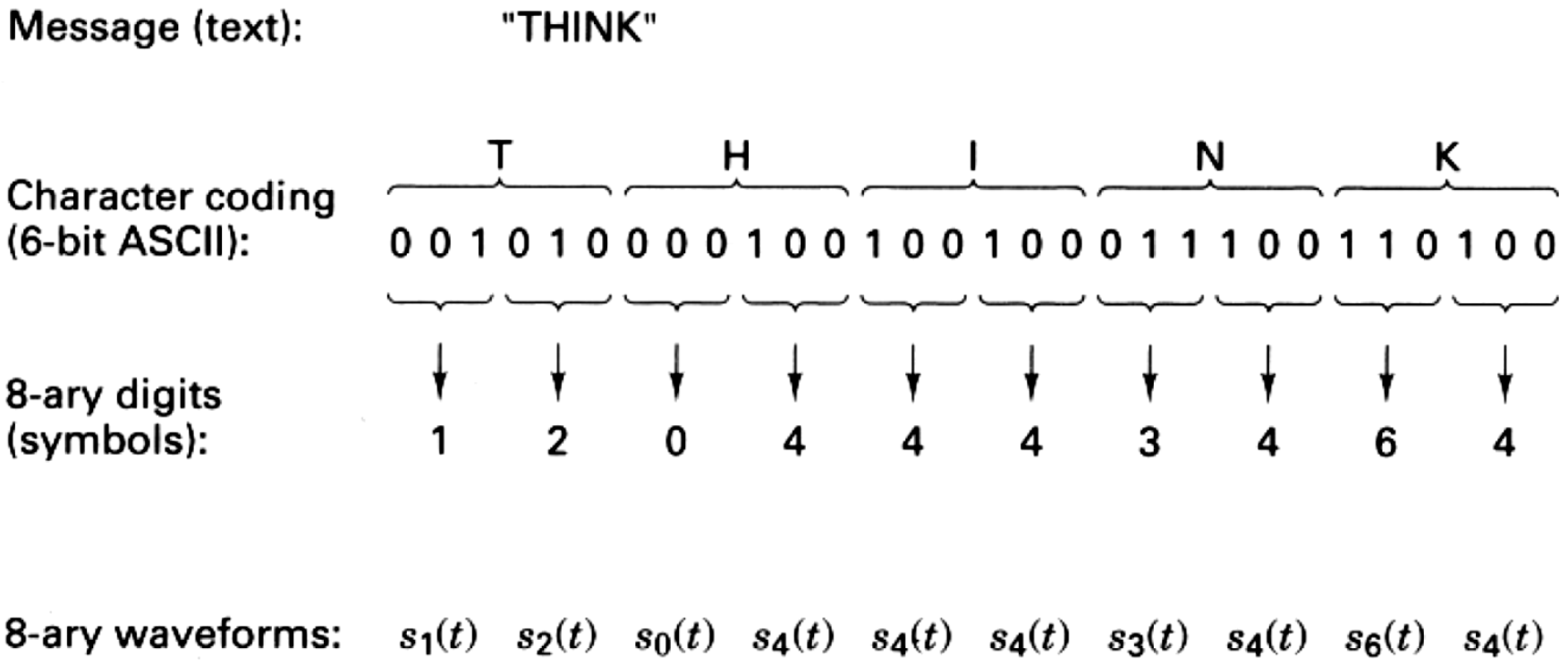
Primer jednostavnog protokola - prijemna strana



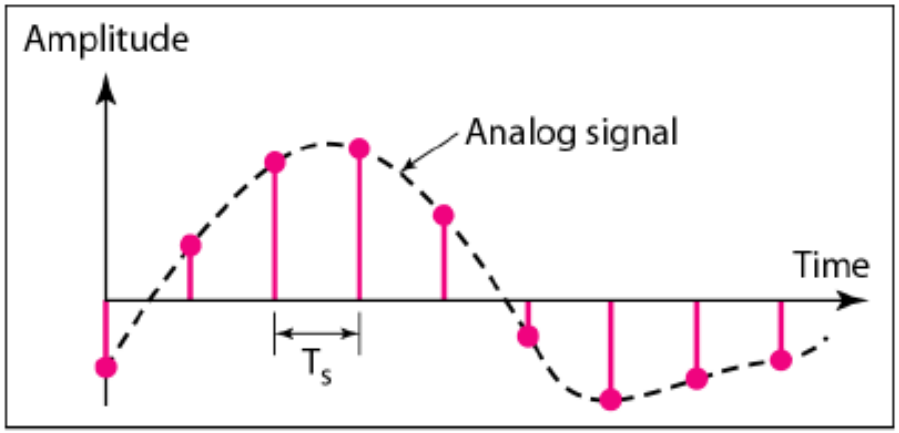
Degradacija i regeneracija digitalnog signala



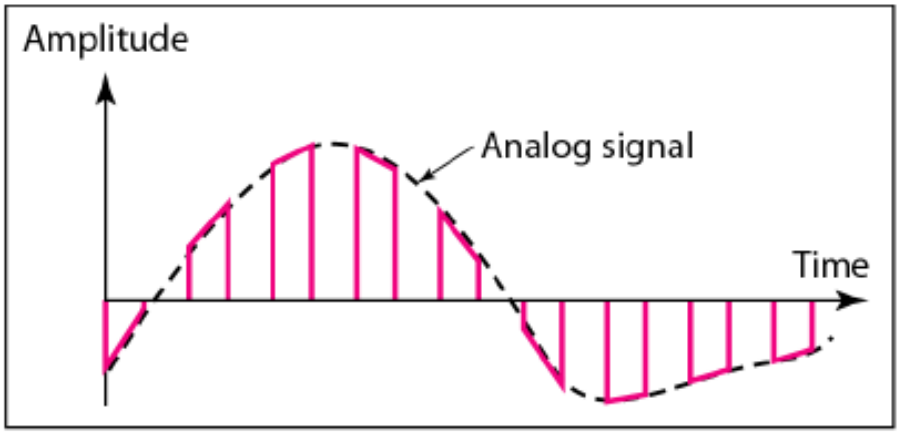
Kodovanje reči: THINK korišćenjem 6-bitnog ASCII koda



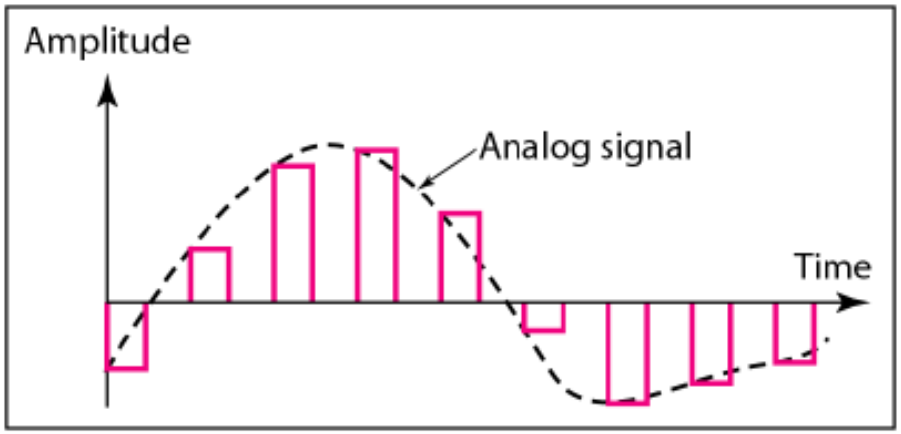
Idealno, Flat - Top odabiranje i prirodno odabiranje



a. Ideal sampling

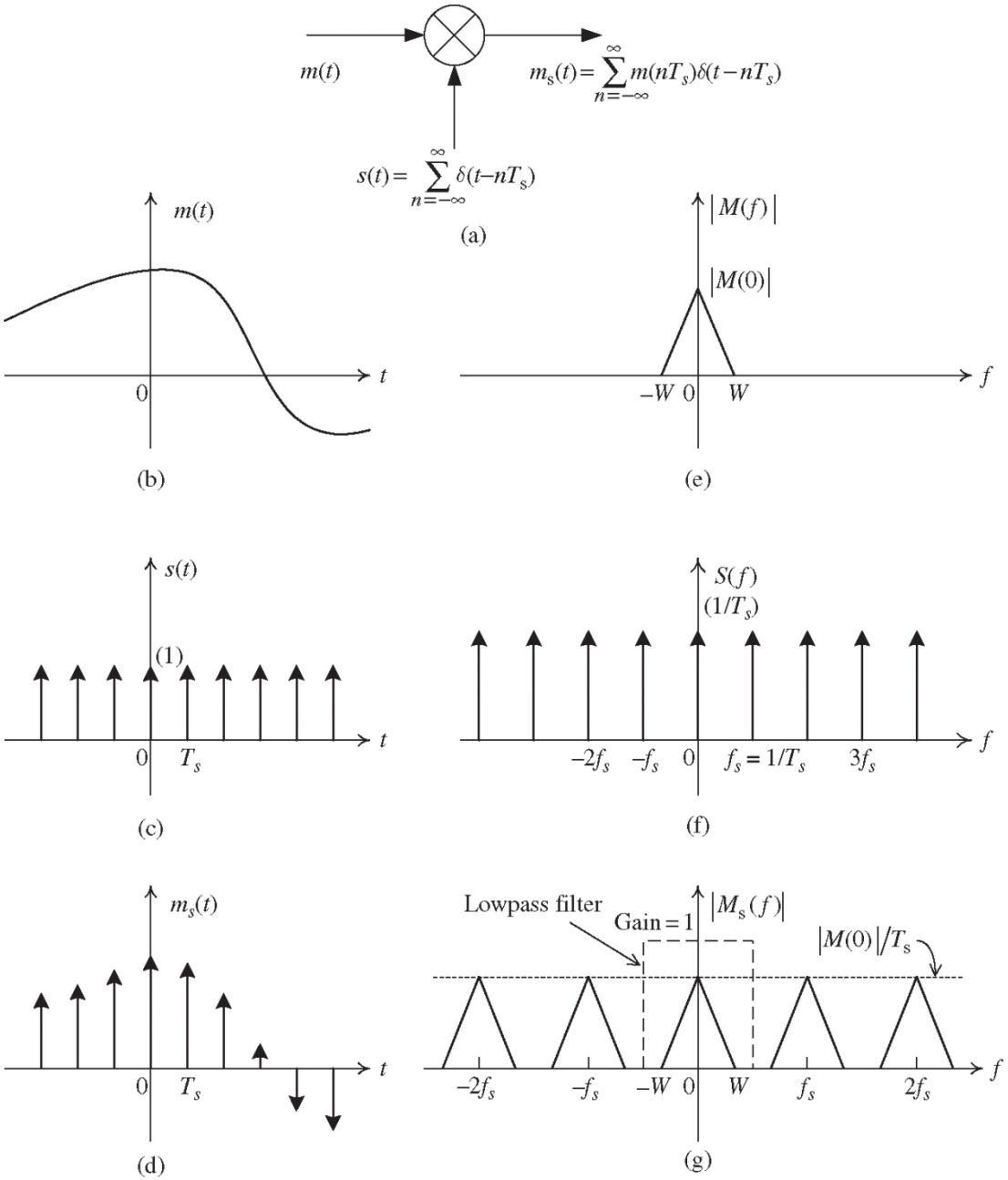


b. Natural sampling

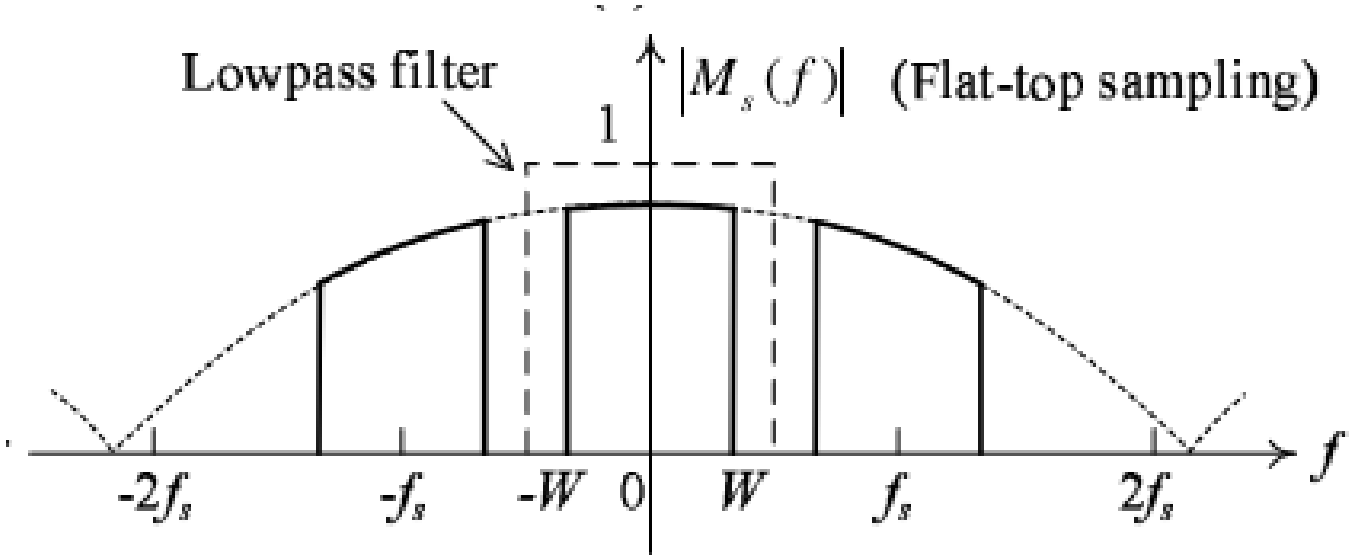


c. Flat-top sampling

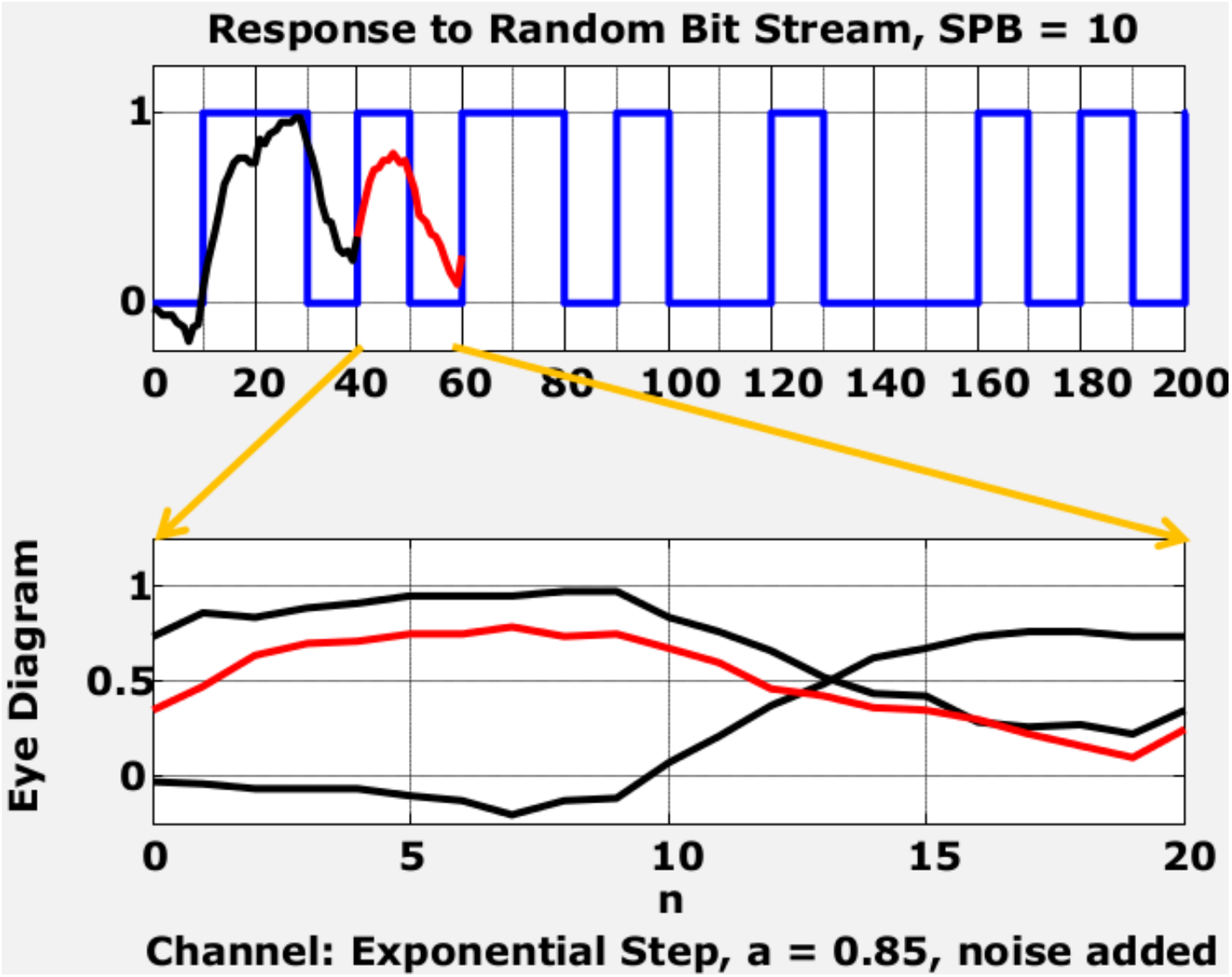
Ilustracija idealnog odabiranja - vremenski i frekvencijski domen



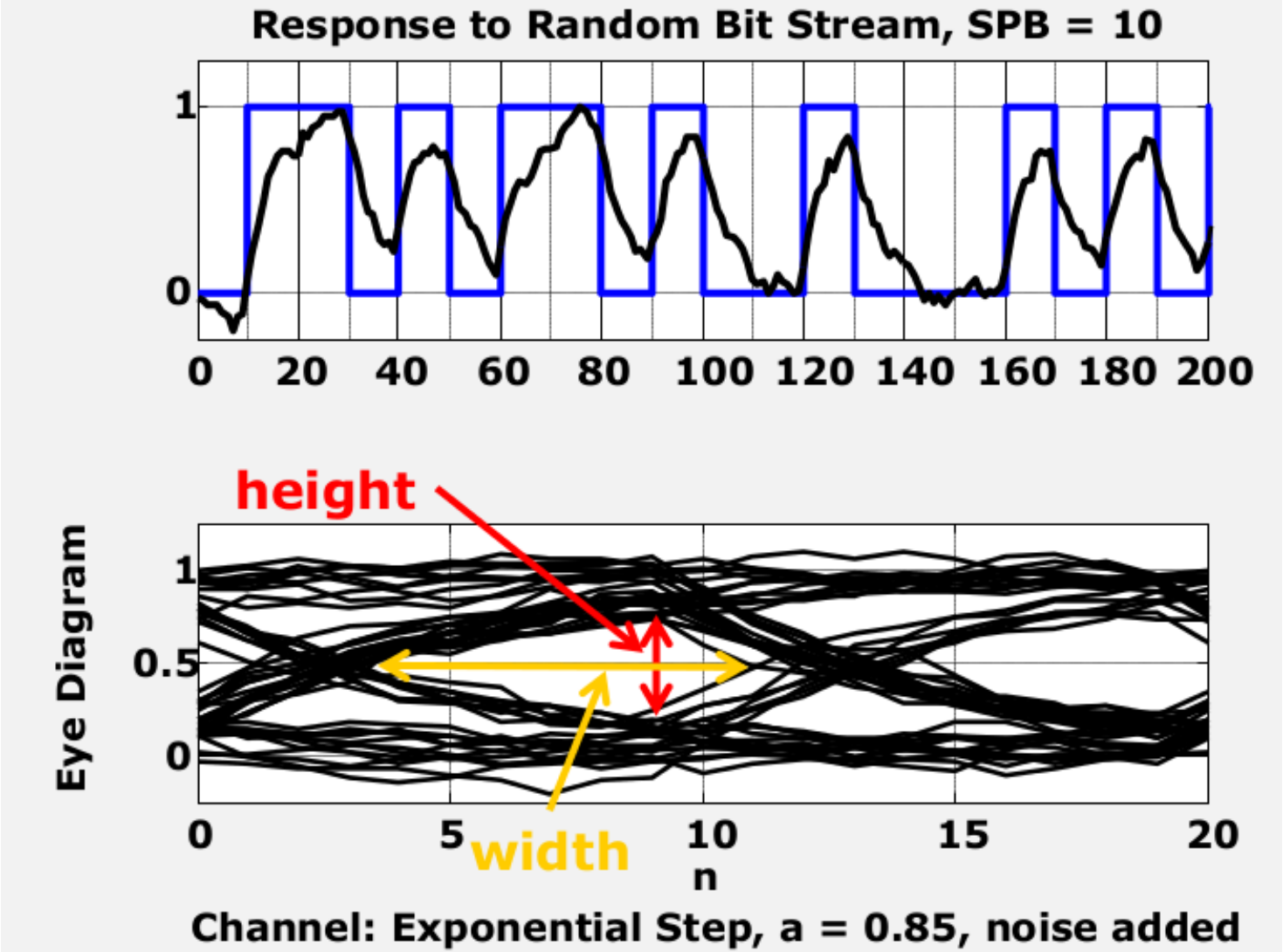
Frekvencijski domen signala koji je flat-top odabiran



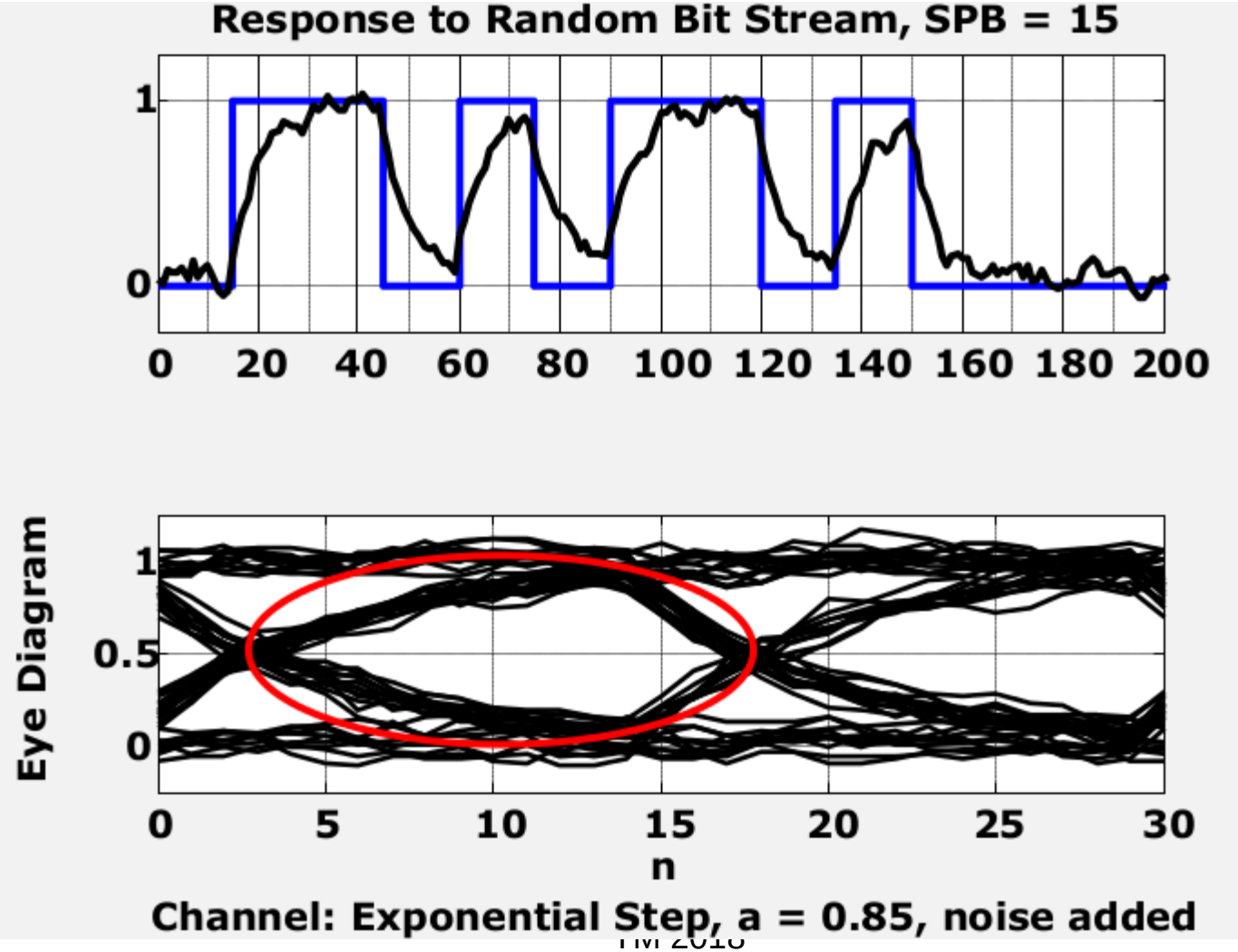
Konstrukcija dijagrama oka - rezultat nakon 60 odbiraka, SPB = 10



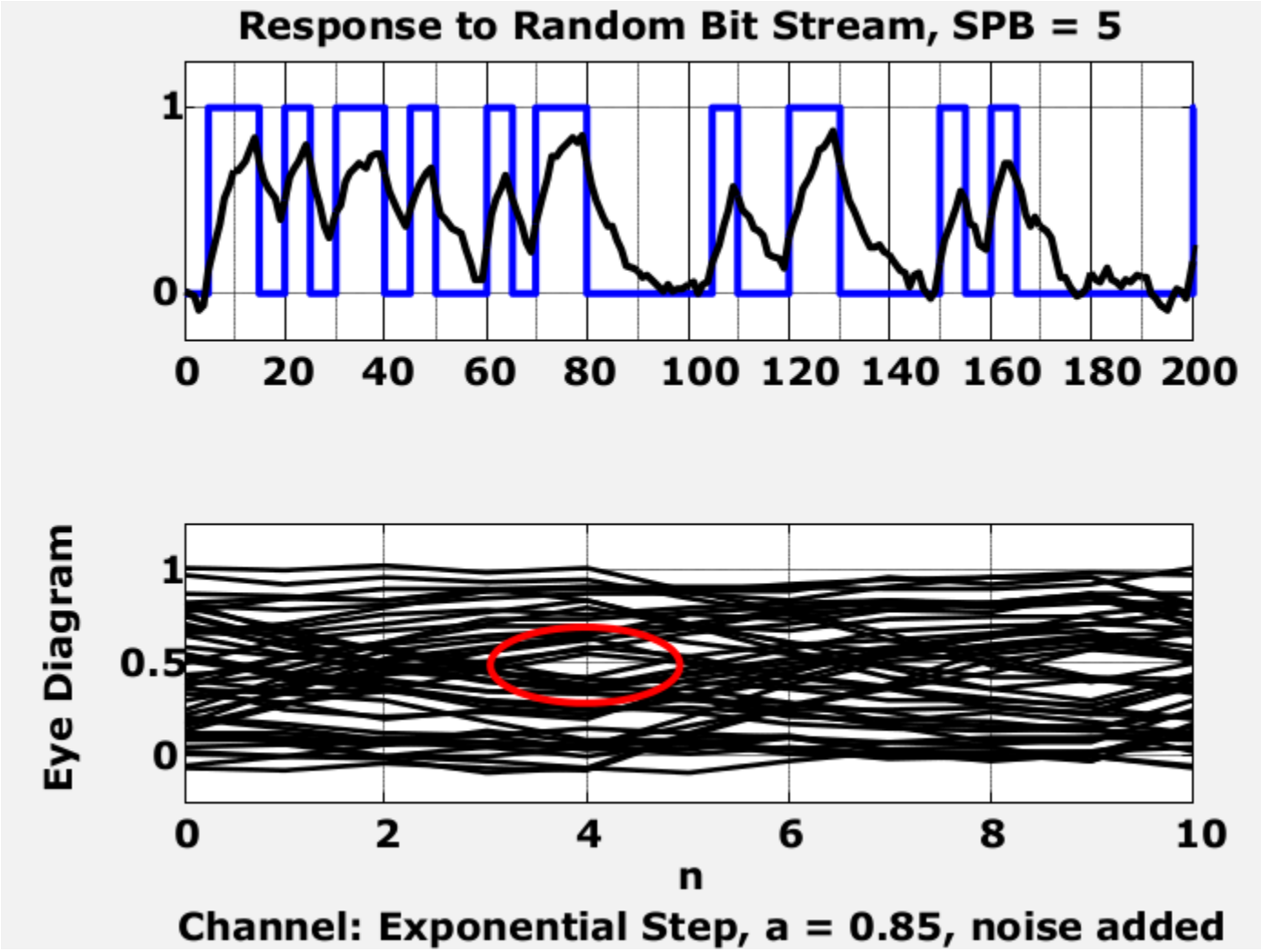
Konstrukcija dijagrama oka - rezultat nakon 200 odbiraka, SPB = 10



Dijagram oka za SPB = 15

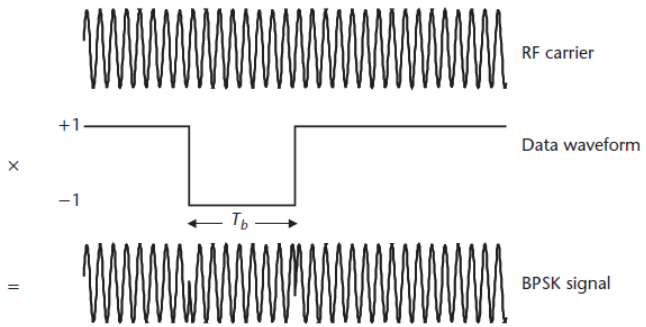


Dijagram oka za SPB = 5

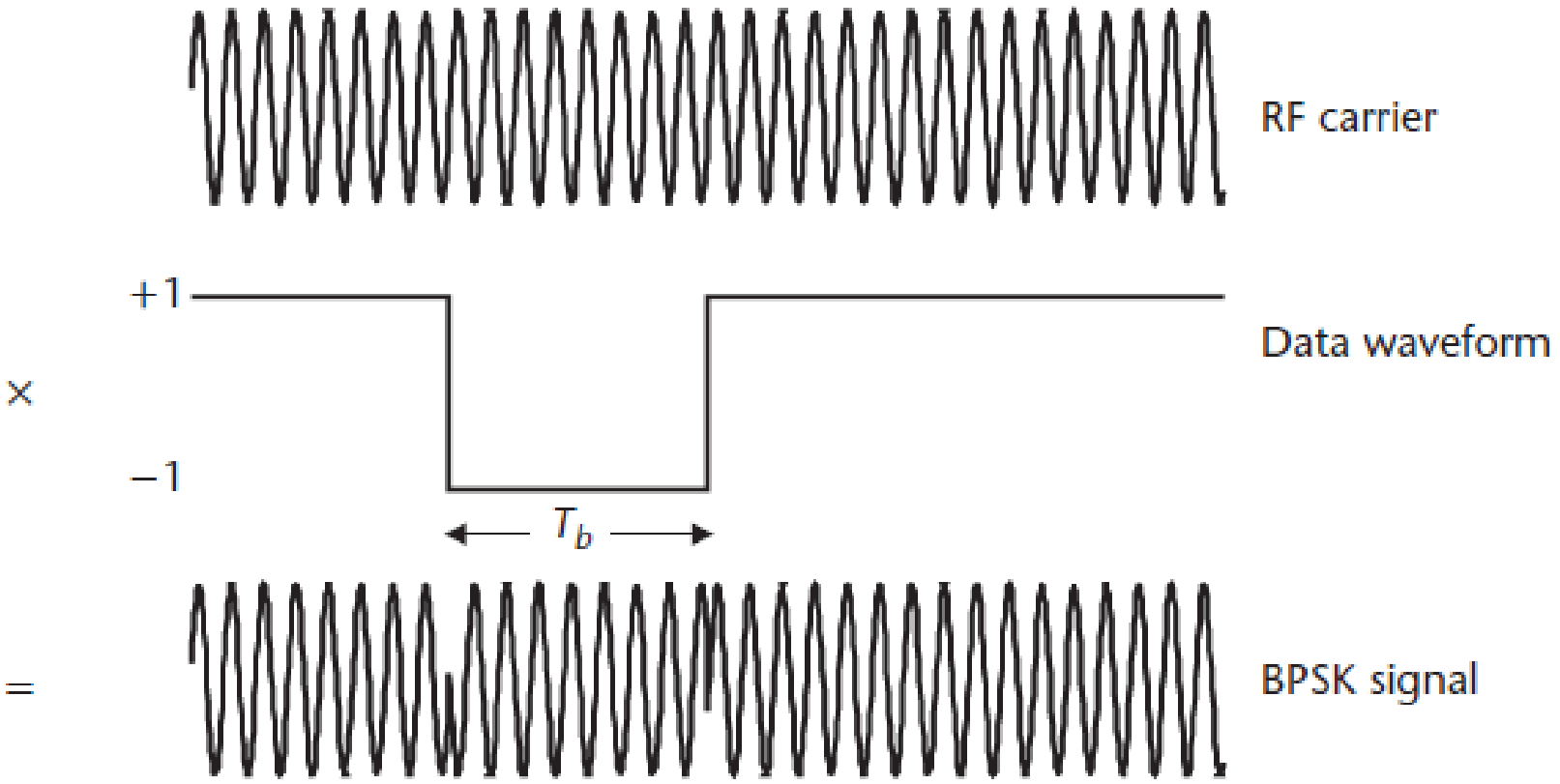


Sistem za digitalni prenos, bežični kanal

- PSK (Phase Shift Keying) modulacija, digitalna fazna modulacija
- PSK modulacija že biti objašnjena na primeru binarne PSK modulacije kada se prenose samo biti 0 ili 1
- Za prenos signala neophodan je RF nosilac, čija je frekvencija za WSN tipično jednaka f_c = 2,4 GHz
  Za prestavljanje bita 0, s(t)
  signal nakon modulatora je cos(2 π f_c t),
  dok je predstavljanje bita 1 fazno pomereno za π,
  odnosno jednako cos(2 π f_c t + π) = -cos(2 π f_c t)

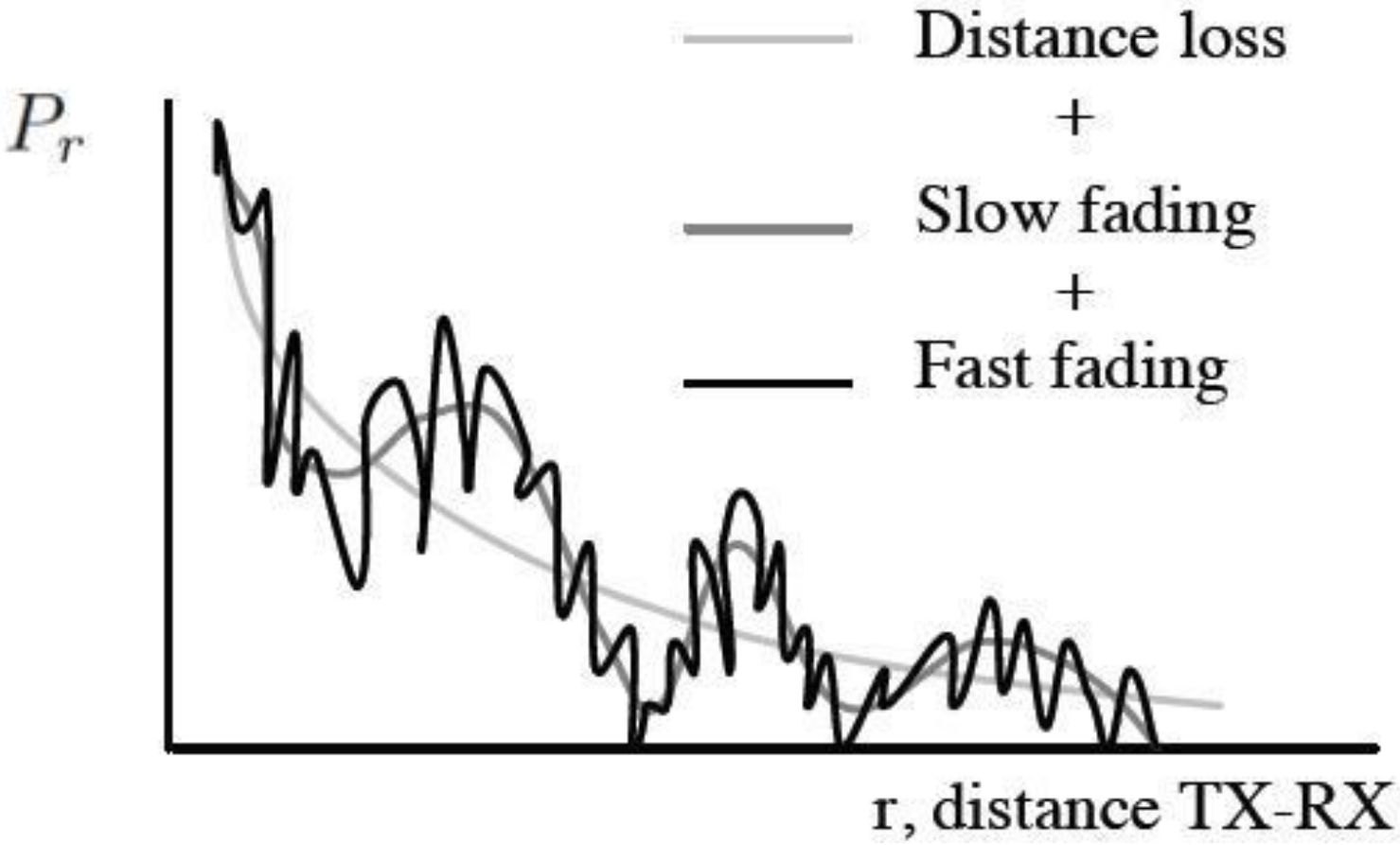


BPSK modulacija

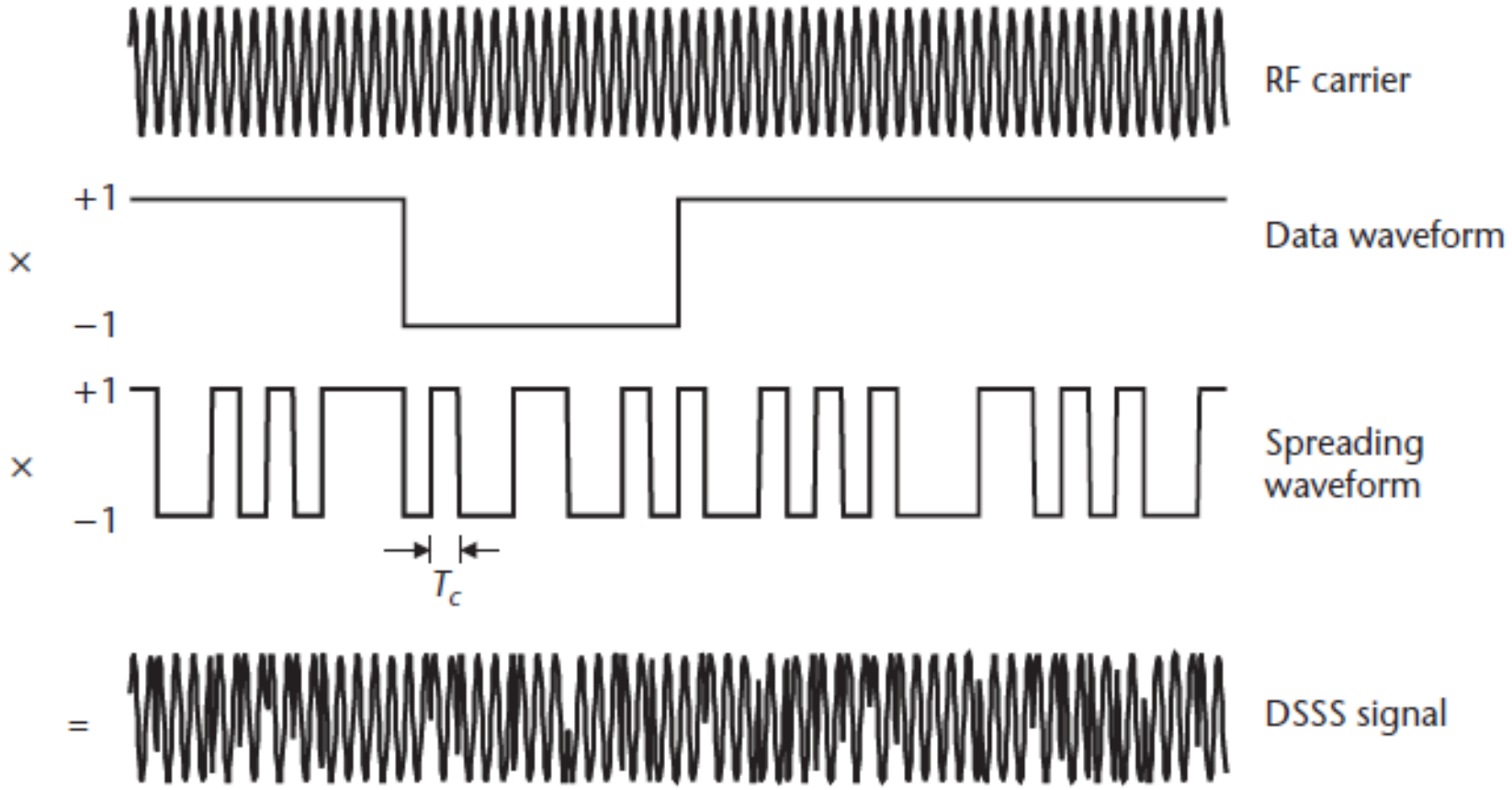


sin(...) ili cos(...)

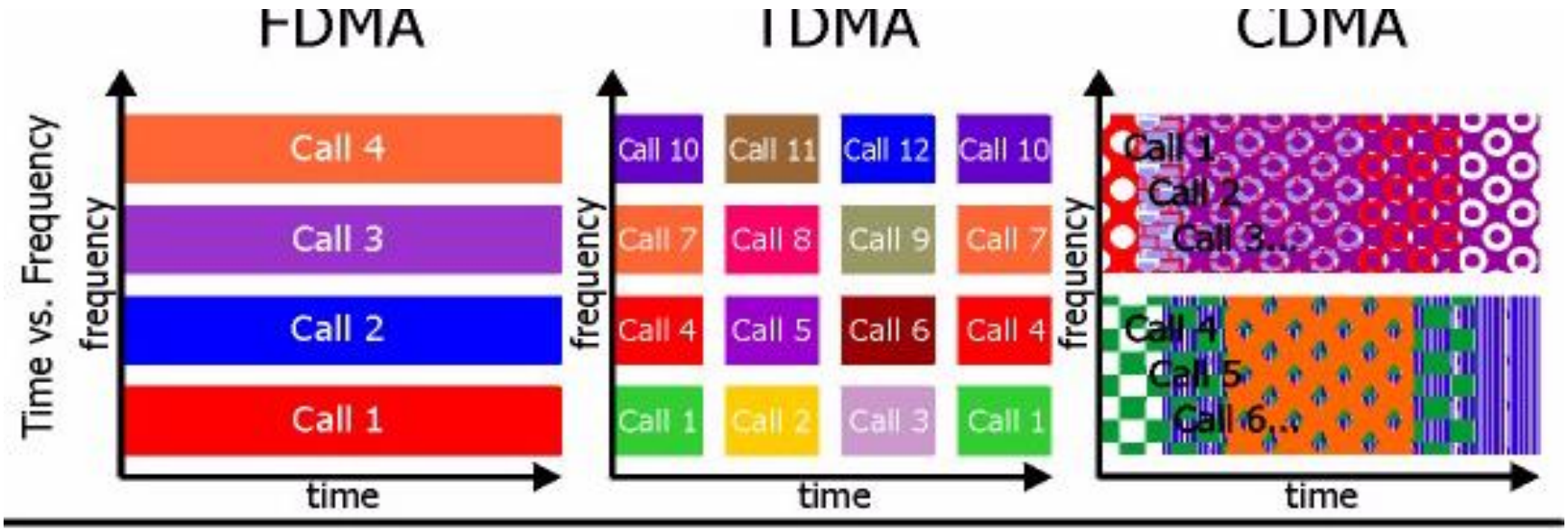
Promena snage koja stiže na prijemnik P_R sa rastojanjem, usled *shadowing* fedinga i *multi-path* propagacije



Direct sequence spread spectrum (DSSS) je proširenje BPSK modulacije



FDMA, TDMA, CDMA.



Conversation Analogy			
	Everyone talks in a different room to prevent interference. Since the conversation can't be heard from another room, it can be filtered from the other by going to the other room.	Within each room, everyone takes turns talking to prevent interference. Within each room, one person is talking at once, so they must talk fast to say everything.	Everyone speaks a different language at the same time in the same room. Since each language is unique, one may be filtered from another.

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