NeuroTrace Study Guide

Domain: Domain II – EEG Procedures & Instrumentation
Section: Timebase & Sampling Rate
Style: Applied, exam-focused, point-form

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1. Core Concepts (Must Know)

Timebase Function

- **Timebase controls horizontal time scaling** of EEG display
- Determines how much time is shown per unit of horizontal space
- Measured in mm/sec (millimeters per second)
- Affects visual appearance of waveforms

Sampling Rate Function

- **Sampling rate controls temporal accuracy** in digital EEG
- Determines how often the signal is recorded (measured in Hz)
- Must be adequate to capture all frequencies accurately
- Inadequate sampling causes aliasing (false patterns)

Digital EEG Requirements

- **Digital EEG requires adequate sampling** to avoid distortion
- Must sample at least 2× the highest frequency (Nyquist principle)
- Inadequate sampling creates false low-frequency activity
- Sampling rate is a critical technical parameter

Key Principle

- **Timebase affects appearance; sampling rate affects accuracy**
- Timebase changes visual spacing (display only)
- Sampling rate changes signal capture (affects accuracy)
- Both must be appropriate for accurate interpretation

Practical Application

- Set appropriate timebase for frequency measurement
- Ensure adequate sampling rate for all frequencies
- Verify sampling rate before interpreting fast activity
- Understand that timebase and sampling are independent settings

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2. EEG Timebase (Paper Speed)

Measurement

- Measured in **mm/sec** (millimeters per second)
- Controls horizontal spacing of waveforms
- Standard setting: 30 mm/sec
- Alternative settings: 15 mm/sec (compressed), 60 mm/sec (expanded)

Common Settings

30 mm/sec (Standard)

- **Most common setting** for routine EEG
- Allows accurate frequency measurement
- Good balance of detail and screen space
- Standard for most clinical recordings

15 mm/sec (Compressed View)

- **Compressed view** (half the standard)
- Shows more time in same space
- Waves appear narrower
- May obscure fast activity
- Used for screening or overview

60 mm/sec (Expanded View)

- **Expanded view** (double the standard)
- Shows less time in same space
- Waves appear wider
- Better for frequency measurement
- Used for detailed analysis

Effects of Faster Timebase (Higher mm/sec)

Visual Effects

- **Waves appear wider** (more horizontal space)
- **Easier frequency measurement** (more cycles visible)
- **Better detail** for fast activity
- **Less time** shown on screen

Clinical Use

- Frequency analysis
- Spike morphology evaluation
- Fast activity detection
- Detailed waveform analysis

Effects of Slower Timebase (Lower mm/sec)

Visual Effects

- **Waves appear compressed** (less horizontal space)
- **Fast activity may be obscured** (less detail)
- **More time** shown on screen
- **Harder frequency measurement** (fewer cycles visible)

Clinical Use

- Screening view
- Long-term monitoring overview
- Compressed display for review
- Not ideal for frequency analysis

ABRET Trap

- **Mistaking timebase changes for frequency changes**
- Faster timebase makes waves appear wider (not faster frequency)
- Slower timebase makes waves appear narrower (not slower frequency)
- Always verify timebase before frequency interpretation

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3. Sampling Rate (Digital EEG)

Definition

- Measured in **Hz** (samples per second)
- Determines how often signal is recorded
- Must be adequate for all frequencies present
- Critical for accurate digital EEG

Nyquist Principle

- **Must be at least 2× highest frequency** (Nyquist principle)
- Minimum sampling rate = 2 × highest frequency
- Example: To record 70 Hz → sampling rate ≥ 140 Hz
- Inadequate sampling causes aliasing

Typical Settings

Standard Sampling Rates

- **200-256 Hz:** Standard for routine EEG
- **500 Hz:** High-resolution recordings
- **1000 Hz:** Very high-resolution (research, special studies)
- **< 200 Hz:** May cause aliasing (not recommended)

Frequency Requirements

- **EEG frequencies:** 0.5-70 Hz (typical range)
- **Minimum sampling:** 140 Hz (for 70 Hz)
- **Recommended:** 200-256 Hz (safety margin)
- **High-frequency activity:** May need 500+ Hz

Clinical Application

- **Routine EEG:** 200-256 Hz adequate
- **Fast activity:** May need higher sampling
- **Muscle artifact:** High frequency, needs adequate sampling
- **ICU monitoring:** May need higher sampling for fast patterns

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4. Aliasing

Definition

- **Occurs when sampling rate is too low**
- Fast signals appear as slower activity
- False low-frequency pattern created
- Digital EEG artifact, not pathology

Mechanism

- Sampling too slow to capture fast activity
- Fast signal "folds back" into lower frequencies
- Creates false pattern at lower frequency
- Cannot be corrected after recording

Clinical Consequence

- **Muscle artifact may mimic cerebral slowing**

- Fast muscle activity aliased to slow delta
- May be mistaken for pathological slowing
- Can lead to misdiagnosis

Example

- **Muscle artifact:** 100 Hz activity
- **Sampling rate:** 50 Hz (too low)
- **Result:** Aliased to appear as 0-25 Hz (false slowing)
- **Interpretation error:** Mistaken for cerebral slowing

ABRET Emphasis

- **Aliasing is a digital EEG artifact, not pathology**
- Must recognize aliasing vs true slowing
- Always verify sampling rate adequacy
- Understand that aliasing cannot be corrected

Prevention

- Use adequate sampling rate (≥ 200 Hz)
- Verify sampling rate before recording
- Recognize aliasing patterns
- Understand Nyquist principle

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5. Timebase vs Sampling (Comparison Table)

Parameter	Affects	Common Error	Clinical Impact
Timebase	Visual spacing	Misreading frequency	Display only, not signal
Sampling rate	Signal accuracy	Aliasing	Affects signal capture
Both	Interpretation	False patterns	Can cause misdiagnosis

Key Distinctions

Timebase

- **Display setting only** (doesn't affect signal)
- Changes visual appearance
- Can be changed during review
- Doesn't affect signal accuracy

Sampling Rate

- **Affects signal capture** (critical for accuracy)
- Determines what frequencies can be recorded
- Cannot be changed after recording
- Must be set correctly before recording

ABRET Application

- Given waveform appearance → consider timebase
- Given false patterns → consider sampling rate
- Understand that both affect interpretation
- Know when each is the problem

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6. Common ABRET Exam Traps

Trap 1: Confusing Timebase with Sensitivity

- **Reality:** These are independent settings
- **Timebase:** Horizontal scaling (mm/sec)
- **Sensitivity:** Vertical scaling (μV/mm)
- Don't confuse horizontal and vertical scaling

Trap 2: Assuming Default Sampling is Always Adequate

- **Reality:** Default sampling may not be adequate for all studies
- Fast activity may require higher sampling
- ICU EEG may need higher sampling
- Always verify sampling rate for study type

Trap 3: Interpreting Aliased Muscle Artifact as Slowing

- **Reality:** Aliased muscle can look like cerebral slowing
- Must recognize aliasing patterns
- Verify sampling rate before diagnosing slowing
- Understand that aliasing is artifact, not pathology

Trap 4: Forgetting Nyquist Principle

- **Reality:** Must sample at 2× highest frequency
- Inadequate sampling causes aliasing
- Cannot record frequencies above Nyquist limit
- Always verify sampling rate meets Nyquist requirement

Trap 5: Changing Timebase to "Fix" Frequency

- **Reality:** Timebase doesn't change frequency
- Timebase only changes visual appearance
- Cannot fix frequency problems with timebase
- Must understand that timebase is display only

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7. Clinical Correlation

Accurate Frequency Measurement

- **Requires correct timebase** (typically 30 mm/sec)
- Cannot measure frequency accurately with wrong timebase
- Faster timebase makes measurement easier
- Always verify timebase before frequency analysis

Pediatric EEG

- **May require higher sampling rates** (fast activity common)
- Pediatric EEG often has more fast activity
- Need adequate sampling to avoid aliasing
- Standard 200-256 Hz usually adequate

ICU EEG

- **Often demands higher temporal resolution**
- Fast patterns common (seizures, status)

- May need higher sampling (500 Hz)
- Continuous monitoring requires adequate sampling

Best Practice

- Set appropriate timebase at start (30 mm/sec standard)
- Verify sampling rate meets Nyquist requirement
- Document timebase and sampling in technical report
- Recognize aliasing patterns
- Understand that timebase and sampling are independent

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8. Case-Based Example

Scenario

Clinical Setting: Routine EEG recording
EEG Finding: Rhythmic delta activity during patient movement
Clinical Concern: Possible encephalopathy or seizure
Pattern: 2-3 Hz rhythmic slowing, maximum frontal

Hidden Issue

- **Sampling rate too low** (100 Hz, inadequate)
- Patient movement creates muscle artifact (50-100 Hz)
- Muscle artifact aliased to appear as 2-3 Hz delta
- False pattern mistaken for cerebral slowing

Correct Action

1. **Increase sampling rate** (to 200-256 Hz)
2. **Reassess pattern** (should see true muscle artifact)
3. **Verify sampling adequacy** (meets Nyquist for all frequencies)
4. **Document** sampling rate and correction
5. **Interpret** only with adequate sampling

Teaching Point

- **Always consider sampling adequacy before diagnosing slowing**
- Rhythmic slowing during movement suggests artifact
- Aliased muscle can mimic cerebral slowing
- Good technique prevents misinterpretation

ABRET Application

- Given rhythmic slowing → check sampling rate first
- Given movement-related pattern → consider aliasing
- Understand that aliasing is artifact, not pathology
- Know when to increase sampling rate

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9. Exam Readiness Checklist

Use this checklist to verify your understanding:

- ☐ Can explain timebase effects (horizontal scaling, mm/sec)
- ☐ Can define sampling rate (Hz, samples per second)

- [ ] Can identify aliasing (false low-frequency from inadequate sampling)
- [ ] Can apply Nyquist principle (sampling ≥ 2× highest frequency)
- [ ] Understand that timebase affects appearance, not signal
- [ ] Know that sampling rate affects accuracy, not just appearance
- [ ] Recognize that aliasing is artifact, not pathology
- [ ] Understand that timebase and sampling are independent
- [ ] Know typical settings (30 mm/sec timebase, 200-256 Hz sampling)
- [ ] Can identify ABRET exam traps related to timebase and sampling

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10. Internal Cross-Links

Workflow

- **Digital EEG Settings:** Timebase and sampling are part of digital settings
- **Instrumentation Overview:** Both are instrumentation parameters
- **Artifacts & Troubleshooting:** Aliasing is a technical artifact

Patterns

- **Frequency Analysis:** Requires correct timebase for measurement
- **Muscle Artifact:** May be aliased if sampling inadequate
- **Fast Activity:** Requires adequate sampling to avoid aliasing

Cases

- **Aliasing simulations:** Cases teaching aliasing recognition
- **Apparent rhythmic slowing:** Cases involving aliased artifact
- **ICU EEG monitoring:** Cases requiring high sampling rates

Quizzes

- **Timebase & sampling MCQs:** Questions on settings, effects, Nyquist
- **Aliasing identification:** Questions on recognizing aliasing
- **Technical parameters:** Questions on appropriate settings

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Study Tips

1. **Memorize Nyquist:** Sampling ≥ 2× highest frequency
2. **Understand timebase:** 30 mm/sec standard, affects visual spacing only
3. **Learn aliasing:** Inadequate sampling creates false low-frequency
4. **Practice recognition:** Given pattern, identify if aliasing possible
5. **Remember independence:** Timebase and sampling are separate settings
6. **Know typical settings:** 30 mm/sec timebase, 200-256 Hz sampling
7. **ABRET focus:** Expect questions on aliasing, Nyquist, timebase effects

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End of Study Guide

For additional practice, complete quiz questions tagged: timebase, sampling-rate, aliasing, nyquist, frequency