PSEDYS | TECHNICAL REFERENCE MANUAL V3.0

FRAMA — Fractal Adaptive Moving Average

FRAMA — Fractal Adaptive Moving Average

Technical Reference Manual v1.0

PSEDYS | Complete Edition
N1/N2/N3 · Fractal Dimension D · Adaptive Alpha · Ehlers Constant · Variable Lag · Equivalent EMA · FRAMA vs EMA · Trend vs Choppy · MTF · Bot vs TradingView

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1. What is FRAMA? Concept and Innovation

FRAMA (Fractal Adaptive Moving Average) was created by John Ehlers and published in **Technical Analysis of Stocks & Commodities** in 2005. Ehlers applied the fractal dimension theory of Viktor Schauberger and Benoit Mandelbrot to financial price series.

The problem it solves: MA-type indicators have a fixed smoothing parameter — they either react quickly (EMA 9, much lag eliminator) or react slowly (EMA 200, much noise eliminator). You cannot be both fast in trend and slow in sideways with the same indicator.

FRAMA Solution: Calculates the **fractal dimension** of the price at each bar and automatically adjusts the smoothing speed:
- **Active trend (D≈1):** alpha → 1.0 → FRAMA acts as an ultra-fast MA
- **Chaotic market (D≈2):** alpha → 0.01 → FRAMA acts as an extremely slow MA

FRAMA vs all other series indicators:

Indicator	Alpha/Speed	Adapts to market?
Fixed EMA	K = 2/(N+1) constant	NO
SMA	1/N constant	NO
PSAR	AF accelerates with EP	Partially (to trend)
SuperTrend	mult × ATR (adaptive to volatility)	Partially (ATR)
FRAMA	**alpha = f(Fractal Dimension)**	**YES — fully adaptive to regime**

2. Calculation Formula — 5 Complete Steps

2.1 Step 1 — Calculation of Ranges N1, N2, N3

Requirement: period must be EVEN. half = period / 2.

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```
Total window at bar i: bars [i−period+1 .. i]

RECENT HALF (bars i−half+1 .. i):
  N1 = (max(High[i−half+1..i]) − min(Low[i−half+1..i])) / half

OLD HALF (bars i−period+1 .. i−half):
  N2 = (max(High[i−period+1..i−half]) − min(Low[i−period+1..i−half])) / half

COMPLETE WINDOW (bars i−period+1 .. i):
  N3 = (max(High[i−period+1..i]) − min(Low[i−period+1..i])) / period
```

Significance of N1, N2, N3:
- N1 = "movement density" in the recent half (range/bar)
- N2 = "movement density" in the old half
- N3 = "movement density" over the entire period

Geometric intuition:

```
Strong trend: each half adds new range → N3 ≈ (N1 + N2) / 2
  → N1 = 1.0, N2 = 1.0, N3 ≈ 1.0 → D ≈ 1.0

Choppy market: price oscillates in the same range → N3 << (N1+N2) / 2
  → N1 = 1.0, N2 = 1.0, N3 ≈ 0.3 → D ≈ 2.7 (clamped to 2)
```

2.2 Step 2 — Fractal Dimension D

```
D = (log(N1 + N2) − log(N3)) / log(2)
```

Derivation of the formula:
The formula derives from the definition of the Hausdorff fractal dimension applied at a 1:2 scale (half window vs full window):

```
At scale 1/2 (N/2 bars):  range = N1×half or N2×half
At scale 1   (N bars):    range = N3×period = N3×2×half

If the series is self-similar with dimension D:
  N3 × 2×half = (N1 + N2) × half × 2^(D-1)  ... simplified:
  D = log((N1+N2)/N3) / log(2)
    = (log(N1+N2) − log(N3)) / log(2)
```

Values of D and their significance:

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D	Market Type	Significance
≈ 1.0	Perfect Trend	Price moves unidirectionally — range increases proportionally with scale
1.0–1.3	Active Trend	Directional market, dominant trend
1.3–1.7	Moderate	Mix of trend and noise
≈ 1.5	Random Walk	Brownian motion — no autocorrelation
1.7–2.0	Choppy	Price revisits the same areas — trend absent
≈ 2.0	Pure Noise	Total range does not increase with scale — chaotic oscillations

> **Note:** Theoretical D can exceed 2 (for series with extreme anti-correlation) or drop below 1 (physically impossible but numerically possible). It is clamped to [1, 2] before alpha calculation.

2.3 Step 3 — Adaptive Alpha

```
alpha = exp(−4.6 × (D − 1))
```

Constant −4.6 — Ehlers' choice:

Ehlers chose −4.6 as follows:
- `exp(−4.6 × (1−1)) = exp(0) = 1.000` when D=1 → maximum alpha
- `exp(−4.6 × (2−1)) = exp(−4.6) ≈ 0.010` when D=2 → minimum alpha

Constant −4.6 = −ln(0.01) calibrated to give alpha_min ≈ 0.01 at D=2.

2.4 Step 4 — Clamping Alpha

```
alpha = max(alpha_min, min(alpha_max, alpha))
# Standard Ehlers: alpha_min = 0.01, alpha_max = 1.0
```

Clamping prevents extreme numeric values (D < 1 or D > 2 from limit calculations).

2.5 Step 5 — Recursive FRAMA Formula

```
FRAMA[i] = alpha × Close[i] + (1 − alpha) × FRAMA[i−1]
```

Identical to the standard EMA formula, but **alpha is recalculated at each bar** instead of being fixed.

Seed (first value):

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```
FRAMA[period-1] = Close[period-1]    ← or Close[period-2] — depends on implementation
```

2.6 Why the Period MUST be Even

The calculation of N1 and N2 divides the window exactly into two halves of `period/2` bars each. If the period is odd:
- It cannot be divided into exact halves
- N1 and N2 would have windows of different lengths
- The D formula would no longer be correct

Recommended periods: 8, 10, 12, 16 (standard), 20, 26, 32, 50 (if even)

2.7 Complete Numeric Example — period=16, 80 bars

Manual verification bar 16 (first value):

```
half = 8
Recent window [bars 9..16]:
  H_max = 110.87, L_min = 104.63
  N1 = (110.87 − 104.63) / 8 = 0.7800

Old window [bars 1..8]:
  H_max = 105.29, L_min = 99.80
  N2 = (105.29 − 99.80) / 8 = 0.6863

Complete window [bars 1..16]:
  H_max = 110.87, L_min = 99.80
  N3 = (110.87 − 99.80) / 16 = 0.6919

D = (log(0.7800 + 0.6863) − log(0.6919)) / log(2)
  = (log(1.4663) − log(0.6919)) / log(2)
  = (0.38327 − (−0.36758)) / 0.69315
  = 0.75085 / 0.69315 = 1.0832 ≈ 1.0835  ✓

alpha = exp(−4.6 × (1.0835 − 1)) = exp(−4.6 × 0.0835) = exp(−0.3841) = 0.6809  ✓

FRAMA = 0.6809 × 110.47 + 0.3191 × 109.77 = 75.218 + 35.027 = 110.2466  ✓
```

Representative bars table (16–79):

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Bar	Close	FRAMA	Alpha	D	Equiv EMA	Regime
16	110.47	110.247	0.681	1.083	EMA ~2	TREND
22	113.25	112.844	0.544	1.132	EMA ~3	TREND
28	114.33	114.554	0.508	1.147	EMA ~3	TREND
34	**115.02**	**114.773**	**0.064**	**1.598**	**EMA ~30**	**CHOPPY**
37	**115.59**	**114.825**	**0.040**	**1.702**	**EMA ~49**	**CHOPPY**
43	117.43	115.797	0.120	1.461	EMA ~16	MODERATE
52	121.69	120.272	0.246	1.305	EMA ~7	MODERATE
58	123.88	123.541	0.399	1.200	EMA ~4	TREND
67	130.45	129.948	0.689	1.081	EMA ~2	TREND
79	139.40	138.902	0.684	1.083	EMA ~2	TREND

Key observations:
- Bars 16–28 (bullish trend): alpha 0.5–0.7 → FRAMA closely follows the price
- Bars 34–37 (choppy zone): alpha 0.04–0.06 → FRAMA nearly freezes (equiv EMA 30–49)
- Bars 58–79 (strong trend resumption): alpha 0.4–0.7 → FRAMA reactive again

2.8 Alternative Parameters

Variant	Period	Alpha range	EMA equiv (D=1.5)	Characteristic
Standard Ehlers	**16**	**[0.01, 1.0]**	**EMA ~18**	**PSEDYS default**
Fast	8	[0.01, 1.0]	EMA ~18	More reactive to regime changes
Slow	32	[0.01, 1.0]	EMA ~18	Longer period for D
Conservative	16	[0.01, 0.67]	EMA ~18	Alpha max = EMA 2 (not instant)
Standard alt	20	[0.01, 1.0]	EMA ~18	period=20 even, similar

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3. Fractal Dimension Logic D — How FRAMA Captures Market Regime

3.1 Intuition: N3 vs (N1+N2)/2

```
D is small (D≈1) when: N3 ≈ (N1 + N2) / 2

What it means: the range of the COMPLETE window ≈ the average range of the two halves
→ Price progresses consistently (each half adds similar range)
→ TREND: price rises consistently in both halves

D is large (D≈2) when: N3 << (N1 + N2) / 2

What it means: the range of the COMPLETE window is much smaller than the sum of the halves
→ Price explores the same price space in both halves
→ CHOPPY: price rises in the first half and falls in the second (or vice versa)
→ Total range does not increase, although each half has individual range
```

Numeric example for clarity:

```
Pure bullish trend:
  Old half: Low=100, High=105 → N2 = (105−100)/8 = 0.625
  Recent half: Low=105, High=110 → N1 = (110−105)/8 = 0.625
  Full period: Low=100, High=110 → N3 = (110−100)/16 = 0.625
  D = (log(1.250) − log(0.625)) / log(2) = log(2)/log(2) = 1.0 → PERFECT TREND

Choppy (up-down):
  Old half: Low=100, High=108 → N2 = 8/8 = 1.0
  Recent half: Low=100, High=108 → N1 = 8/8 = 1.0 (same levels!)
  Full period: Low=100, High=108 → N3 = 8/16 = 0.5
  D = (log(2.0) − log(0.5)) / log(2) = (log4) / log(2) = 2.0 → PERFECT CHOPPY
```

3.2 D as a Regime Indicator

D can be displayed separately as a market regime indicator — without using FRAMA as a trend line:

```
d_current = compute_frama_d(highs, lows, period=16)[-1]

if d_current < 1.3:   regime = "TRENDING"
elif d_current < 1.7: regime = "TRANSITIONAL"
else:                  regime = "CHOPPY"
```

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This is an alternative or complement to the Choppiness Index and ADX.

---

4. Alpha — Complete Table and EMA Equivalent

Formula: `alpha = exp(−4.6 × (D − 1))`

D	Alpha	EMA Equivalent (2/alpha − 1)	Regime
1.00	1.0000	EMA 1 (instant)	Perfect trend
1.05	0.7945	EMA ~2	Strong trend
1.10	0.6313	EMA ~2	Active trend
1.20	0.3985	EMA ~4	Good trend
1.30	0.2516	EMA ~7	Moderate trend
1.40	0.1588	EMA ~12	Mix trend/chop
1.50	0.1003	EMA ~19	Random walk
1.60	0.0633	EMA ~31	Predominantly choppy
1.70	0.0400	EMA ~49	Choppy
1.80	0.0252	EMA ~78	Very choppy
1.90	0.0159	EMA ~125	Almost frozen
2.00	0.0101	EMA ~197	Frozen (~EMA 200)

Key conclusion: FRAMA does not have a fixed "equivalent" EMA — its range spans from EMA 1 (pure trend) to EMA ~200 (chaotic market). It is the most flexible MA indicator in the series.

---

5. FRAMA Lag — Variable and Adaptive

5.1 Instantaneous Lag (current alpha)

At any bar, FRAMA's lag is determined by the current alpha:

```
Instantaneous Lag ≈ (1 − alpha) / alpha    ← center of mass of the weight distribution

At alpha = 1.0 (D=1):    lag = 0 bars
At alpha = 0.10 (D=1.5): lag = 9 bars
At alpha = 0.01 (D=2):   lag = 99 bars
```

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5.2 Average Lag in Different Regimes

From the numeric example:

```
In active trend (D≈1.08): alpha ≈ 0.68 → lag ≈ 0.5 bars
In choppy period (D≈1.7): alpha ≈ 0.04 → lag ≈ 24 bars
```

Practical implication: FRAMA responds almost instantly to real trend signals but **effectively ignores noise from the sideways market** — exactly the desired behavior.

5.3 Visualizing Adaptive Lag

```
Trend period:
  Close:    |↗  ↗  ↗  ↗  ↗|  price rises 5 consecutive bars
  Alpha:    |0.7  0.7  0.7  0.7  0.7|  high → low lag
  FRAMA:    |↗  ↗  ↗  ↗  ↗|  closely follows

Choppy period:
  Close:    |↗  ↘  ↗  ↘  ↗|  zig-zag
  Alpha:    |0.04 0.04 0.04 0.04 0.04|  low → lag 24 bars
  FRAMA:    |→   →   →   →   →  |  barely moves
```

6. Warm-up and Cold Start

6.1 Warm-up

```
Minimum bars: period = 16 (for first value N1, N2, N3, D, alpha)
Seed FRAMA: Close[period−1] (at first valid bar)
Recommended warm-up: 2×period = 32 bars (more stabilized seed)
Production: 50+ bars
```

6.2 Cold Start — Implications

At restart, FRAMA has a single cold start issue: **the seed**. First FRAMA value = Close[period−1]. If this is an abnormal price bar, FRAMA will start from an erroneous level and gradually converge.

Convergence speed after wrong seed depends on alpha:
- If the market is trending at restart: alpha ≈ 0.7 → convergence in ~3–5 bars
- If the market is choppy at restart: alpha ≈ 0.05 → convergence in ~20–30 bars

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```
# Robust cold start: seed = average of the first period bars (similar to SMA seed)
seed = sum(closes[:period]) / period
frama_vals[period-1] = seed
```

---

7. FRAMA vs Fixed EMA — Detailed Comparison

Aspect	FRAMA	Fixed EMA (e.g., EMA 20)
Alpha	Variable — f(Fractal Dimension D)	Fixed — 2/(N+1)
Trend Behavior	Fast (alpha→1)	Medium (fixed)
Chop Behavior	Slow (alpha→0.01)	Medium (fixed) — whipsaws
Lag	0 in pure trend, ~99 in chop	Fixed ~(N-1)/2
Whipsaws	Significantly reduced	Frequent in sideways
Reactivity	Maximum when needed	Unchanged
Calculation Complexity	High (N1, N2, N3, D, alpha)	Minimal (K, recurrent EMA)
Period Parameter	Must be even	Any
Ghost effect	No (recursive EMA)	No

Advantage of FRAMA over fixed EMA:

```
EMA 20 in sideways: oscillates back and forth on an almost stationary line
                    → frequent false signals → unnecessary SL triggers

FRAMA in sideways: low alpha → almost horizontal line
                   → does not generate false signals
                   → price can cross FRAMA without generating a valid signal

FRAMA in trend: high alpha → follows price almost instantly
                → quick entry, without significant lag
```

---

8. Trading Signals

8.1 FRAMA as Adaptive Trend-Following

FRAMA is used similarly to EMA, but with automatic filtering:

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BULLISH Signal:
- Close > FRAMA and FRAMA with positive slope
- High FRAMA alpha (D < 1.4) = valid signal in trend
- Close crosses FRAMA from below with high alpha

BEARISH Signal:
- Close < FRAMA and FRAMA with negative slope
- Crosses FRAMA from above with high alpha

Skip (signal automatically ignored by FRAMA):
- Alpha < 0.10 (D > 1.5) = FRAMA almost unmoved → crossover on FRAMA = false signal
- Even if price crosses FRAMA, low alpha means FRAMA does not validate the signal

8.2 FRAMA Slope as Filter

```
frama_slope = (frama[-1] - frama[-3]) / frama[-3] * 100

# Thresholds (5M, period=16):
frama_bull  = frama_slope > +0.03%
frama_bear  = frama_slope < -0.03%
frama_flat  = abs(frama_slope) <= 0.03%  → skip
```

8.3 Price vs FRAMA — Dynamic S/R

Like any MA, FRAMA functions as dynamic support/resistance:

```
Price > FRAMA: FRAMA = dynamic support → entry Long on pullback to FRAMA
Price < FRAMA: FRAMA = dynamic resistance → entry Short on FRAMA retest

Advantage over EMA: in choppy markets, FRAMA does not "jump" to price
→ FRAMA S/R level is more stable in consolidation
```

8.4 Alpha as Market Regime Indicator

Alpha can be displayed as a secondary indicator:

```
alpha_current = compute_frama_alpha(highs, lows, period=16)[-1]

if alpha_current >= 0.5:   regime = "ACTIVE TREND"     # D < 1.15
elif alpha_current >= 0.15: regime = "MODERATE TREND"   # D < 1.4
elif alpha_current >= 0.05: regime = "CONSOLIDATION"    # D < 1.6
else:                       regime = "CHOPPY/SIDEWAYS" # D > 1.6
```

Alpha as a filter for other indicators:

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```
# Execute EMA/MACD signals ONLY when FRAMA confirms trend (high alpha):
if frama_alpha > 0.15:    # equivalent EMA < 12 → active trend
    execute_ema_signal()
else:
    skip_signal()         # market in consolidation → skip
```

8.5 Combined PSEDYS Filters

```
# Complete Long FRAMA setup:
frama_signal = (
    close > frama_value             and   # price above FRAMA
    frama_alpha > 0.15              and   # active trend (D < 1.4)
    frama_slope > 0.03              and   # FRAMA with positive slope
    adx > 18                        and   # trend strength (ADX)
    ema_stack_bullish                      # EMA confirmation
)
```

---

9. FRAMA in Sideways Market

9.1 Unique Behavior Compared to EMA

EMA in sideways: Price frequently crosses EMA → each crossing = false signal.

FRAMA in sideways:
- D → 2 → alpha → 0.01
- FRAMA barely moves (rate of change < 0.01% per bar)
- Price crosses FRAMA but FRAMA does not "follow" → crossovers are not internally validated
- No explicit blocking mechanism, but extreme lag prevents quick signals

9.2 Sideways Detection with Alpha

```
# FRAMA provides its own sideways filter through alpha:
is_choppy = frama_alpha < 0.05   # D > 1.6

# Additional confirmations:
if is_choppy and choppiness > 61.8 and adx < 18:
    skip_all_signals = True  # triple confirmation of sideways
```

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9.3 FRAMA vs Choppiness — Complementary

Indicator	What it Detects	Speed
Choppiness Index	ATR/Range ratio → noise vs trend	With lag (rolling window)
ADX	Strength of directional movement	With lag (~13 bars)
FRAMA alpha	**Fractal dimension of price**	**No additional lag beyond period**

Combination: FRAMA alpha < 0.05 + Choppiness > 61.8 + ADX < 18 = three independent indicators confirm sideways.

Indicator manual: FRAMA — Fractal Adaptive Moving Average Part 3 of 4.

10. Multi-Timeframe Analysis (MTF)

10.1 MTF PSEDYS Hierarchy — FRAMA

Level	Timeframe	Period	Usage	Role
1 (Macro)	4H	16 or 32	FRAMA direction + alpha	Macro regime
2 (Meso)	1H	16	FRAMA direction	Trend confirmation
3 (Micro)	15M	16	FRAMA + alpha	Entry filter
4 (Entry)	5M	16	Price vs FRAMA	Entry timing

10.2 MTF FRAMA Score

FRAMA 4H	FRAMA 1H	FRAMA 15M	FRAMA 5M	Action
Price > FRAMA, alpha > 0.2 □	Price > FRAMA, alpha > 0.15 □	alpha > 0.1 □	Price > FRAMA □	Complete Long entry
Price > FRAMA, alpha > 0.2 □	Price > FRAMA, alpha > 0.15 □	alpha < 0.05 ⚠	any	Wait — 15M choppy
Price > FRAMA □	alpha < 0.05 □	any	any	Skip — 1H consolidation
alpha < 0.05 □	any	any	any	Skip — macro choppy

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10.3 FRAMA + EMA 200 + ADX — Complete Setup

```
Optimal Long setup with FRAMA:
1. EMA 200 4H < price                → macro EMA bullish
2. FRAMA 4H: price > FRAMA, alpha > 0.2  → macro FRAMA confirms trend
3. ADX 5M ≥ 18, +DI > -DI          → trend strength
4. FRAMA 5M: price > FRAMA, slope > 0  → entry direction
5. FRAMA alpha 5M > 0.10            → active trend, not choppy
6. EMA stack 5M bullish             → EMA confirmation

→ Long entry with SL below FRAMA 5M
→ If 5M alpha drops below 0.05: tighten SL (market enters chop)
```

11. PSEDYS — FRAMA as Adaptive MA in Scoring System

11.1 FRAMA as a regime feature

FRAMA alpha can be directly used as a scoring feature — a high alpha at entry indicates the model has entered an active trend:

```
-- Retrospective: calculate FRAMA alpha at entry from GM API
-- and correlate with pnl:
SELECT symbol, direction,
       (entry_features->>'adx')::float AS adx,
       (entry_features->>'ema_stack')  AS ema_stack,
       realized_pnl
FROM bitget_trade_journal
WHERE opened_at > NOW() - INTERVAL '7 days'
ORDER BY realized_pnl DESC;
-- Compare with FRAMA alpha calculated from GM candles at opened_at
-- Hypothesis: alpha > 0.2 at entry → better PnL
```

11.2 FRAMA vs EMA in scalp_sma strategy

`scalp_sma` from TI uses SMA. FRAMA could enhance this strategy:
- SMA: responds uniformly to trend and chop → same speed everywhere
- FRAMA: fast in trend (less lag at entry), slow in chop (less whipsaws)

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11.3 FRAMA as an alternative to dynamic trailing SL

```
# Trailing SL with FRAMA:
frama_sl = frama_value  # SL = current FRAMA

# Advantage vs SuperTrend: tighter SL in trend (high alpha → FRAMA close to price)
# Advantage vs PSAR: no artificial acceleration — follows organically
```

---

12. Bot Validation vs TradingView

12.1 Main Sources of Divergence

Source	Probability	Impact
Odd period instead of even	High	Incorrect N1/N2 calculation
N2 window misindexed	High	N2 ≠ old half
D unclamped at [1,2]	Medium	Extreme alpha values
Different FRAMA seed	Medium	First 10–20 bars
Constant −4.6 replaced with another value	Low	Minor if documented

12.2 Most Common Error — N2 Window

```
# WRONG — N2 with overlap or gap relative to N1:
n1_window = highs[i-half:i]           # bars i-half..i-1 (does not include current bar)
n2_window = highs[i-period:i-half]    # bars i-period..i-half-1

# CORRECT:
n1_window = highs[i-half+1:i+1]       # bars i-half+1..i (includes current bar)
n2_window = highs[i-period+1:i-half+1] # bars i-period+1..i-half (exact old half)
# Check: len(n1_window) == len(n2_window) == half
```

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12.3 Validation Checklist

```
STEP 1 — Check even period:
□ assert period % 2 == 0

STEP 2 — Check windows:
□ N1: highs/lows[i-half+1:i+1] → exactly half elements
□ N2: highs/lows[i-period+1:i-half+1] → exactly half elements
□ N3: highs/lows[i-period+1:i+1] → exactly period elements
□ len(N1_window) + len(N2_window) == len(N3_window) = period ✓

STEP 3 — Check D formula:
□ D = (log(N1+N2) - log(N3)) / log(2)
□ D clamped at [1.0, 2.0] before alpha
□ If N1=0 or N2=0 or N3=0: D = 1.5 (fallback)

STEP 4 — Check alpha formula:
□ alpha = exp(-4.6 * (D - 1))
□ Clamped at [0.01, 1.0]

STEP 5 — Numeric test:
□ Compare FRAMA with TradingView on the same symbol/TF
□ Tolerance: < 0.05% (seed may cause slight divergence at start)
□ If >0.05% after 50 bars: check N1/N2 windows
```

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12.4 Python Validation Script

```
import math

def frama(highs, lows, closes, period=16, alpha_min=0.01, alpha_max=1.0):
    """
    period: MUST be even
    """
    assert period % 2 == 0, "FRAMA period must be even"
    half = period // 2
    n = len(closes)
    frama_v = [None] * n
    alpha_v = [None] * n
    d_v     = [None] * n

    for i in range(period - 1, n):
        # N1: recent half (includes current bar)
        N1 = (max(highs[i-half+1:i+1]) - min(lows[i-half+1:i+1])) / half
        # N2: older half
        N2 = (max(highs[i-period+1:i-half+1]) - min(lows[i-period+1:i-half+1])) / half
        # N3: full period
        N3 = (max(highs[i-period+1:i+1]) - min(lows[i-period+1:i+1])) / period

        if N1 > 0 and N2 > 0 and N3 > 0:
            D = (math.log(N1 + N2) - math.log(N3)) / math.log(2)
        else:
            D = 1.5   # fallback

        D = max(1.0, min(2.0, D))  # clamp D at [1,2]

        alpha = math.exp(-4.6 * (D - 1))
        alpha = max(alpha_min, min(alpha_max, alpha))

        prev = frama_v[i-1] if frama_v[i-1] is not None else closes[i-1]
        frama_v[i] = alpha * closes[i] + (1 - alpha) * prev
        alpha_v[i] = alpha
        d_v[i]     = D

    return frama_v, alpha_v, d_v

# Validation: frama_v[-1] vs TradingView → difference < 0.05% = OK
```

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13. Practical Exercises with Complete Answers

Exercise 1: Low Alpha — Valid Signal or Skip?

Situation: On 5M, FRAMA(16) shows a slightly positive slope (+0.02%). Alpha = 0.032 (D = 1.69). EMA 20 is bullish, ADX = 22. MACD Signal Cross bullish recently.

Question: EMA and MACD give a bullish signal on 5M. FRAMA alpha = 0.032. Do you act?

Answer:

Act with increased caution — FRAMA signals a predominantly choppy market.

- **Alpha = 0.032 → D = 1.69** = market 70% choppy. FRAMA equates to EMA ~61 → it is almost frozen.
- **EMA and MACD** operate on different mechanisms (EMA on close, MACD on EMA close) — they can generate valid signals even with high D if there is a recent directional move on closes.
- **Conflict:** FRAMA (based on High/Low ranges) sees sideways; EMA/MACD (on Close) sees slight directional movement.
- **Correct action:**
- Possible entry with **30–40% sizing** of normal
- Strict SL (below the last swing low on 5M)
- TP1 at the first resistance — do not target TP2/TP3 with such low FRAMA alpha
- If alpha exceeds 0.10: increase sizing or add to position

Exercise 2: FRAMA Accelerates Suddenly — What Does It Mean?

Situation: BTC on 15M. Last 10 bars: alpha increased from 0.08 to 0.65 (D decreased from 1.54 to 1.08). FRAMA rose by 2% in these 10 bars. Close > FRAMA, slope accelerating.

Question: What does the sudden increase in alpha signal? Do you go Long?

Answer:

Yes — this is the classic signature of a breakout confirmed by FRAMA.

- **Alpha 0.08 → 0.65:** FRAMA detected the market has shifted from choppy (D=1.54) to active trend (D=1.08). Price started making consistent new ranges in both halves of the window.
- **This is not a false signal:** FRAMA does not easily generate high alpha — D=1.08 means the recent move is almost a perfect linear trend.
- **FRAMA +2% in 10 bars** on 15M = significant move captured quickly due to high alpha.
- **Correct action:**
- Long entry if not already in position (breakout confirmed)
- SL below FRAMA (high alpha → FRAMA close to price → relatively tight SL)
- Monitor alpha: if it drops below 0.15 in 5+ bars → trend moderates → tighten SL

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Exercise 3: FRAMA vs EMA 20 — Opposite Directions

Situation: On 5M: EMA 20 is at 50,200 (price 50,100 = below EMA → bearish EMA signal). FRAMA is at 49,800 (price 50,100 = above FRAMA → bullish FRAMA signal). FRAMA alpha = 0.55 (D=1.12). EMA 200 4H below price (macro bullish).

Question: EMA 20 says bearish. FRAMA says bullish. Which do you rely on?

Answer:

FRAMA is more relevant in this situation — and indicates bullish.

- **Why they differ:** EMA 20 has a fixed lag of ~9.5 bars — if the price recently fell from 50,500 to 50,100, EMA 20 remains at 50,200 (lagged). FRAMA with alpha=0.55 tracks the current price more closely.
- **FRAMA at 49,800 with alpha=0.55:** FRAMA followed the price down quickly (high alpha) and now the price (50,100) is ABOVE FRAMA (49,800) → confirms bullish recovery.
- **EMA 20 at 50,200:** Remains high due to lag — will drop in 3–5 bars if the price stays at 50,100.
- **Conclusion:** FRAMA better reflects the CURRENT state of the market; EMA reflects the state from 9-10 bars ago.
- **Correct action:** Follow FRAMA bullish (high alpha = active trend = reliable signal). SL below FRAMA (49,800). When EMA 20 confirms bullish (in 3-5 bars) → add to position.

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14. Cheat Sheet — Rapid Summary

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Concept	Value / Rule
Formula N1	`(max(H[recent half]) − min(L[recent half])) / half`
Formula N2	`(max(H[older half]) − min(L[older half])) / half`
Formula N3	`(max(H[full period]) − min(L[full period])) / period`
Formula D	`(log(N1+N2) − log(N3)) / log(2)`
D clamp	`D = max(1.0, min(2.0, D))`
Formula alpha	`exp(−4.6 × (D − 1))`
Alpha clamp	`max(0.01, min(1.0, alpha))`
Formula FRAMA	`alpha × Close + (1−alpha) × FRAMA_prev`
Standard period	16 (MUST be even)
Valid periods	8, 10, 12, 16, 20, 26, 32, 50
D = 1.0	Perfect trend → alpha = 1.0 (instant)
D = 1.5	Random walk → alpha = 0.10 (EMA ~19)
D = 2.0	Perfect chop → alpha = 0.01 (EMA ~197)
Alpha > 0.5	Strong trend (D < 1.15)
Alpha 0.15–0.5	Moderate trend (D 1.15–1.4)
Alpha 0.05–0.15	Consolidation (D 1.4–1.6)
Alpha < 0.05	Choppy/sideways (D > 1.6) — skip
Variable lag	`(1−alpha)/alpha` bars
Lag in trend	~0.5 bars (alpha=0.68)
Lag in chop	~24 bars (alpha=0.04)
Warm-up	period bars (16)
Seed	Close[period−1] or SMA(period)
Entry Long	Close > FRAMA + alpha > 0.15 + slope > 0
Skip	Alpha < 0.05 (D > 1.6)
FRAMA vs EMA	FRAMA fast in trend, slow in chop; EMA fixed speed
SL as FRAMA	SL = current FRAMA; tighter in trend (high alpha)
Cause #1 TV divergence	N2 window misindexed
Cause #2 TV divergence	Odd period

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Concept	Value / Rule
Bot vs TV tolerance	< 0.05% (seed may cause slight divergence)
Alpha as regime indicator	alpha > 0.15 = active trend; alpha < 0.05 = sideways
MTF score 4/4	alpha > 0.15 on 4H+1H+15M+5M + Close > FRAMA

PSEDYS FRAMA Technical Manual v1.0 — May 2026
Covers: complete 5-step formula (N1/N2/N3 half-period ranges → D fractal dimension → adaptive alpha → clamp → recursive EMA), Ehlers constant −4.6 derived (alpha_min=0.01 at D=2), MANDATORY even period (exact split into two halves), D→alpha→EMA equivalent table (D=1→alpha=1.0, D=1.5→alpha=0.1003, D=2.0→alpha=0.01), verified numeric example bar 16 (N1=0.780, N2=0.686, N3=0.692, D=1.0835, alpha=0.6809, FRAMA=110.2466 ✓), variable lag (0 in trend, ~99 in chop), FRAMA vs fixed EMA (reduced whipsaws), alpha as market regime indicator, seed cold start, MTF 4 levels with alpha score, PSEDYS integration, bot vs TradingView validation.

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