

## 1. Forecast Engine Models

**EWMAC (Exponential Moving Average Crossover):**

$$f = \frac{EMA_{\text{fast}} - EMA_{\text{slow}}}{\sigma} \cdot s$$

**Proof:** Let  $r_t = \log(P_t/P_{t-1})$ .

$$\sigma = \sqrt{\frac{1}{N-1} \sum_{i=1}^N (r_i - \bar{r})^2} \Rightarrow f \propto \frac{\Delta_{\text{signal}}}{\text{noise}}$$

**Forecast Clipping:**

$$f_{\text{clipped}} = \max(\min(f, 20), -20)$$

## 2. Volatility Engine

**Annualized Volatility:**

$$\sigma_{\text{annual}} = \sigma_{\text{daily}} \cdot \sqrt{252}$$

**Normalized Forecast:**

$$f_{\text{norm}} = \frac{f_{\text{raw}}}{\sigma}$$

**Vol Clipping:**

$$\sigma_{\text{adj}} = \max(\sigma_{\text{daily}}, \sigma_{\text{floor}}) \quad (\text{to prevent over-positioning})$$

## 3. Position Sizing (Carver Style)

**Notional Exposure:**

$$\text{Exposure}_i = \frac{f_i}{20} \cdot \frac{R_t \cdot C}{\sigma_i}$$

**Units:**

$$\text{Units}_i = \frac{\text{Exposure}_i}{\sigma_i \cdot P_i} \quad (\text{PUV} = \text{Price Unit Volatility})$$

**Leverage Factor:**

$$\text{LF} = \frac{\text{Exposure}}{C} \quad \text{Leverage Ratio} = \text{LF} - 1$$

## 4. Modular System Architecture

**System Pipeline:** Signal  $\rightarrow$  Forecast  $\rightarrow$  Volatility Adjustment  $\rightarrow$  Position Engine  $\rightarrow$  Risk Filter  $\rightarrow$  Execution

- **Signal Engine:** Generates raw indicators
- **Forecast Engine:** Transforms signal into  $f \in [-20, +20]$
- **Vol Engine:** Estimates  $\sigma$ , rescales forecast
- **Risk Engine:** Applies  $R_t, C$ , forecast to compute size
- **Execution Filter:** Delays, slippage, throttling

## 5. Execution Modeling

**Slippage Simulation:**

$$P_{\text{slip}} = P + \delta \quad \text{where } \delta \sim \mathcal{N}(0, \sigma_s)$$

**Trade Latency Buffering:**

$$u_t = \begin{cases} 0 & \text{if } |\Delta u_t| < \epsilon \\ u_t & \text{otherwise} \end{cases}$$

## 6. Risk Management

**Drawdown Rule:**

$$\text{DD}_t = 1 - \frac{C_t}{\max(C_{1..t})} \quad \text{Trigger: } \text{DD} > 20\% \Rightarrow R_t := 0.5R_t$$

**X-Factor Stops:**

$$x = \frac{|\Delta P|}{\sigma}, \quad \text{Stop}_{\text{long}} = P(1 - x \cdot \sigma)$$

**Cap Vol:**

$$\sigma_i := \max(\sigma_i, \sigma_{\text{min}}) \quad (\text{volatility floor})$$

## 7. Backtesting Best Practices

- Simulate execution lag + slippage
- Include commissions + bid-ask spreads
- Use walk-forward validation
- Vary inputs to measure fragility
- Track rolling Sharpe, drawdown stats

**Golden Rule:** Don't tweak to improve backtest stats.

## 8. Forecast Blending

**Final Forecast:**

$$f = \sum_{i=1}^n w_i f_i \quad \text{where} \quad \sum w_i = 1$$

**Diversification Benefit:**

$$\text{Sharpe}_{f_{blend}} > \max(\text{Sharpe}_{f_i})$$

*Source: Carver, Systematic Trading, Ch. 10–11*