

On Multiaxial Random Fatigue Load Modeling

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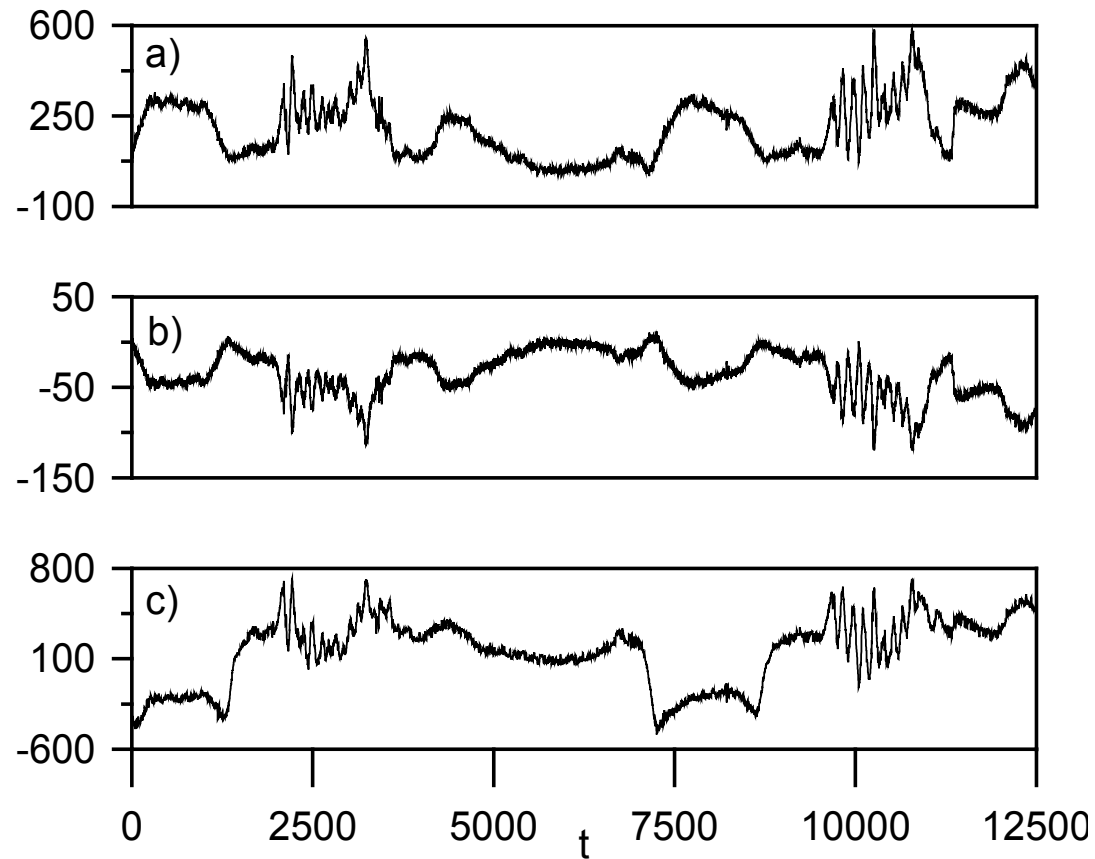
Lokesh Juneja, M.S., Ford Motor Company

Professor Surot Thangjitham, Virginia Tech

Professor Norman Dowling, Virginia Tech



Concise fatigue load description



$$\mathbf{x}_t = \mathbf{m}_t + \mathbf{s}_t \cdot \mathbf{n}_t$$



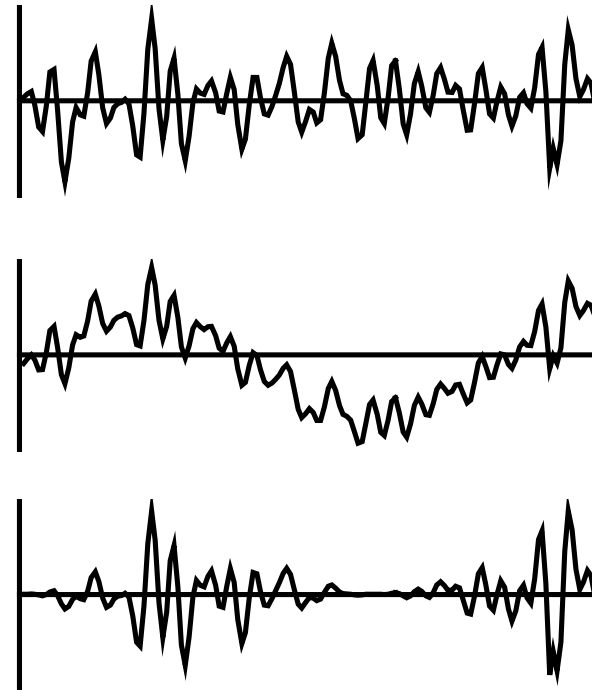
Motivation:

- storage reduction
- test machine / FEA compatibility
- monitoring
- concentration on relevant content
- elimination of non damaging events
- manipulation
superposition
extrapolation



General Random Fatigue Loads

- Stationary
- Nonstationary
 - in mean
 - and / or
 - in variance





Model for Nonstationary Fatigue Loading:

$$x(t) = m(t) + s(t) n(t)$$

$m(t)$... mean content

$$m_t = \frac{1}{2} a_0 + \sum_{k=1}^{M_m} [a_k \cos(\omega_0 k t \Delta t) + b_k \sin(\omega_0 k t \Delta t)]$$

$s(t)$... variance scaling function

$$s_t^{BC} = \frac{1}{2} c_0 + \sum_{k=1}^{M_s} [c_k \cos(\omega_0 k t \Delta t) + d_k \sin(\omega_0 k t \Delta t)]$$

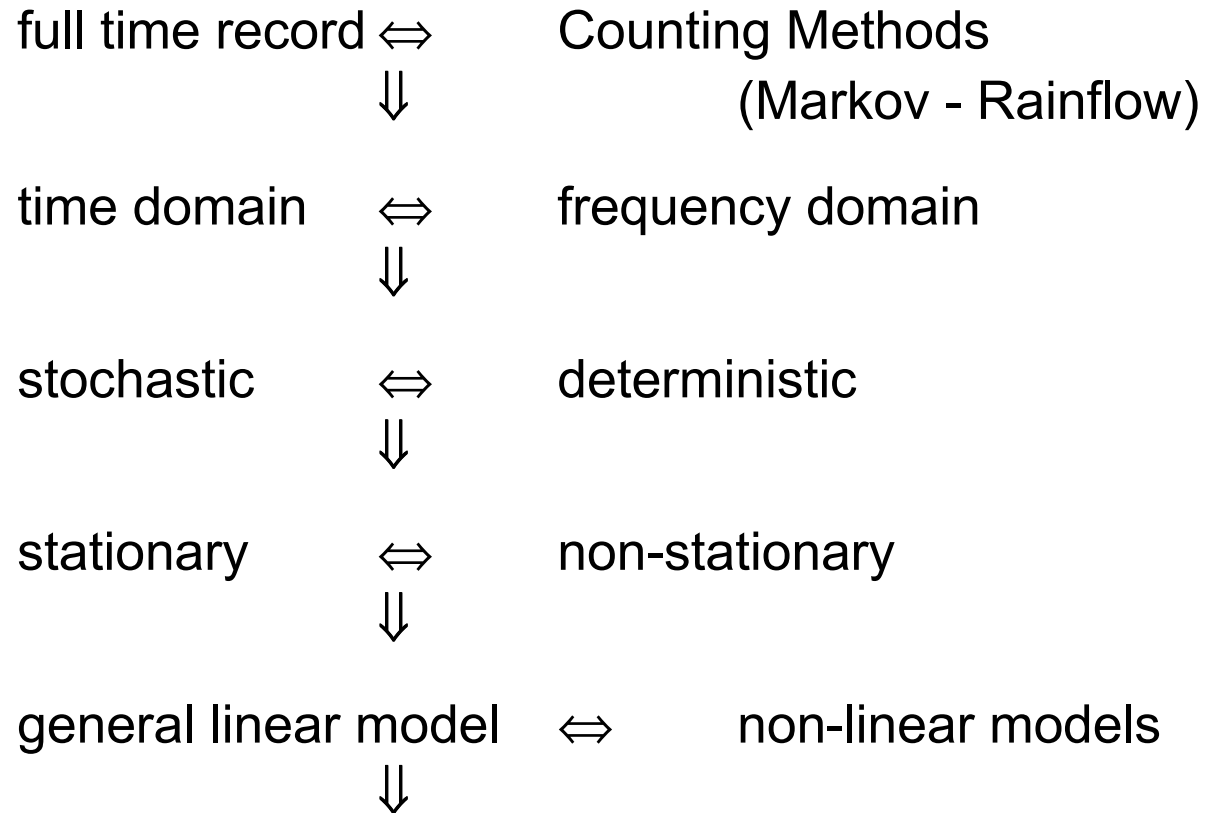
$n(t)$... zero mean, stationary noise content

$$n_t - \phi_1 n_{t-1} - \dots - \phi_p n_{t-p} = e_t - \theta_1 e_{t-1} - \dots - \theta_q e_{t-q}$$





Data Reduction Schemes



ARMA model





Modeled

Characteristics of ARMA Method

Not Modeled

Dynamics

Rainflow Cycles

Auto-Cross-Correlations

Extremes

Advantages

Fundamental

Disadvantages

Stochastic Description (Ensemble)

"Involved" Model Building

Consistent Multichannel Extension

Not Same Rainflow Cycles

Continuous Nonstationarity Description

Not Identical Extremes

Concise Description

Simple, Fast Simulation





Multiaxial Fatigue Damage Model

Effective Strain Approach applied on Critical Plain
(valid for approximately proportional loading)
(histogram technique)

Life Calculation based on
Normal Strain
Shear Strain

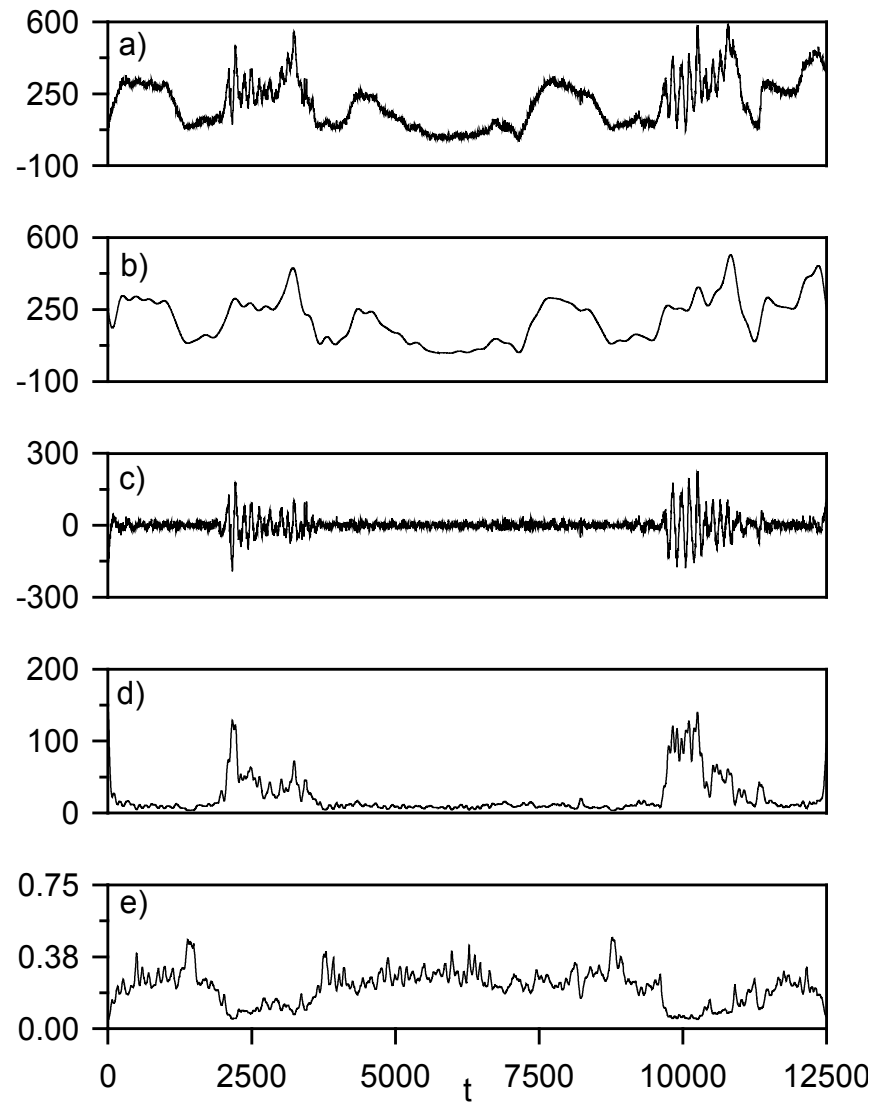
Palmgren Miner Rule

Minimum Life reported





Reconstruction Procedure

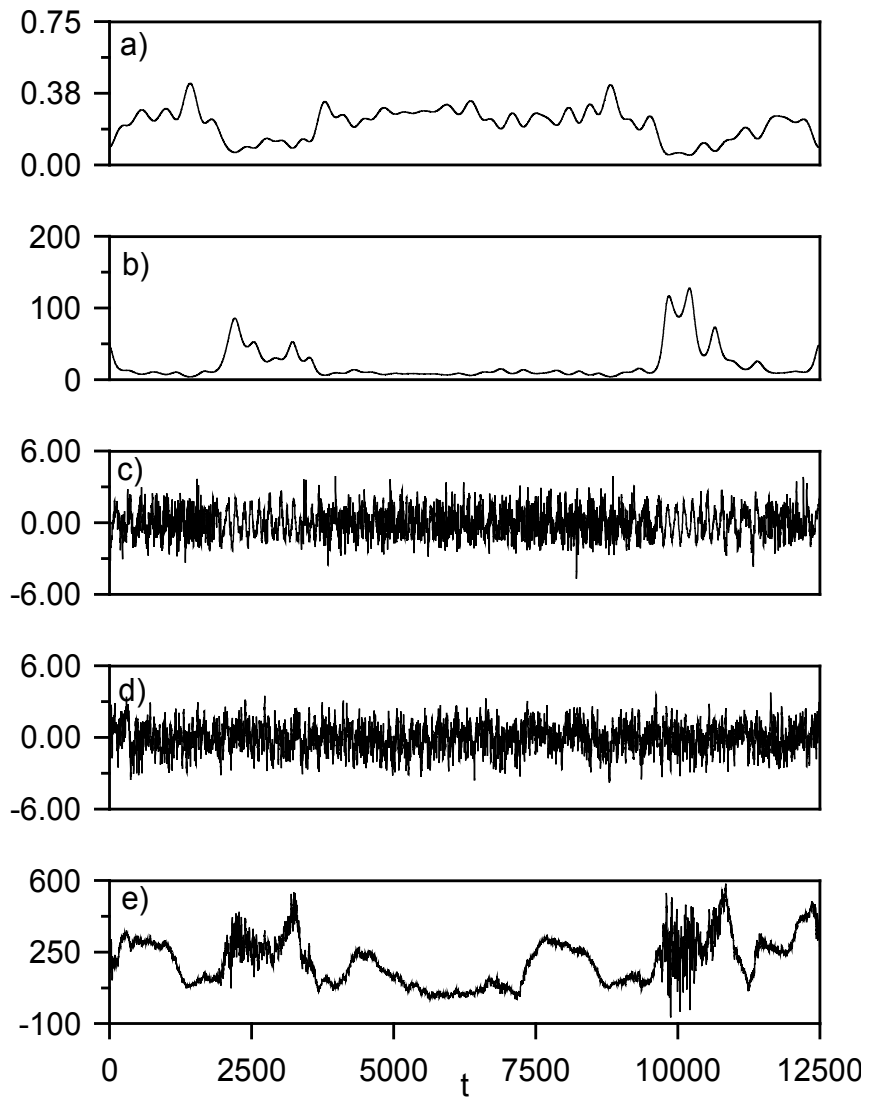




Reconstruction

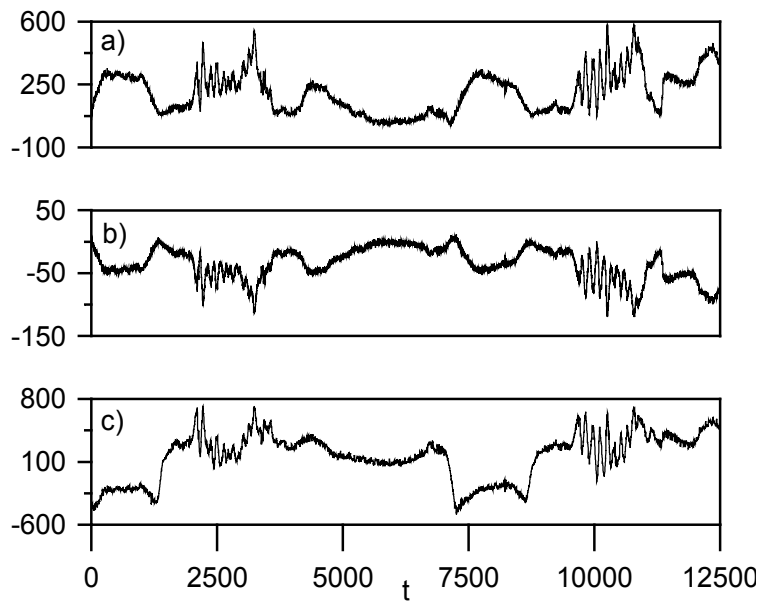
Procedure

Continued

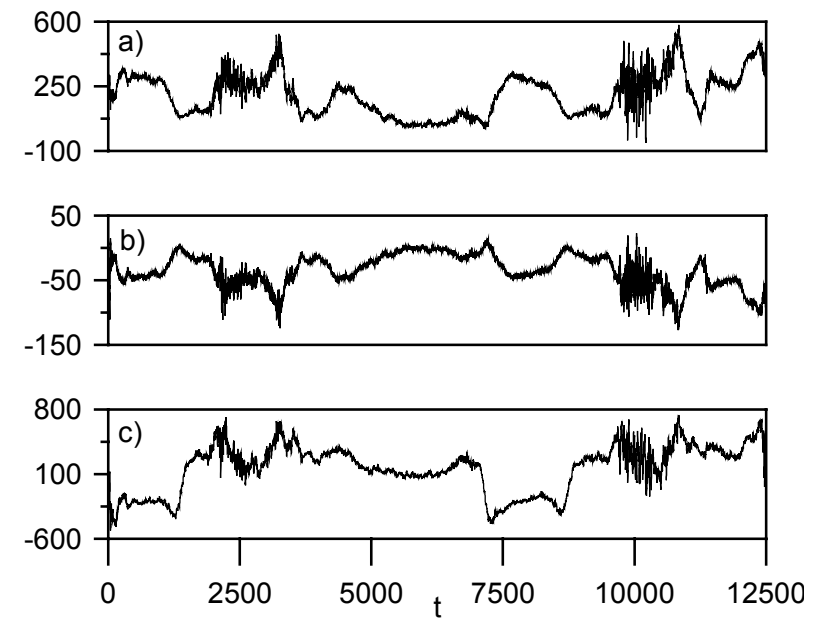




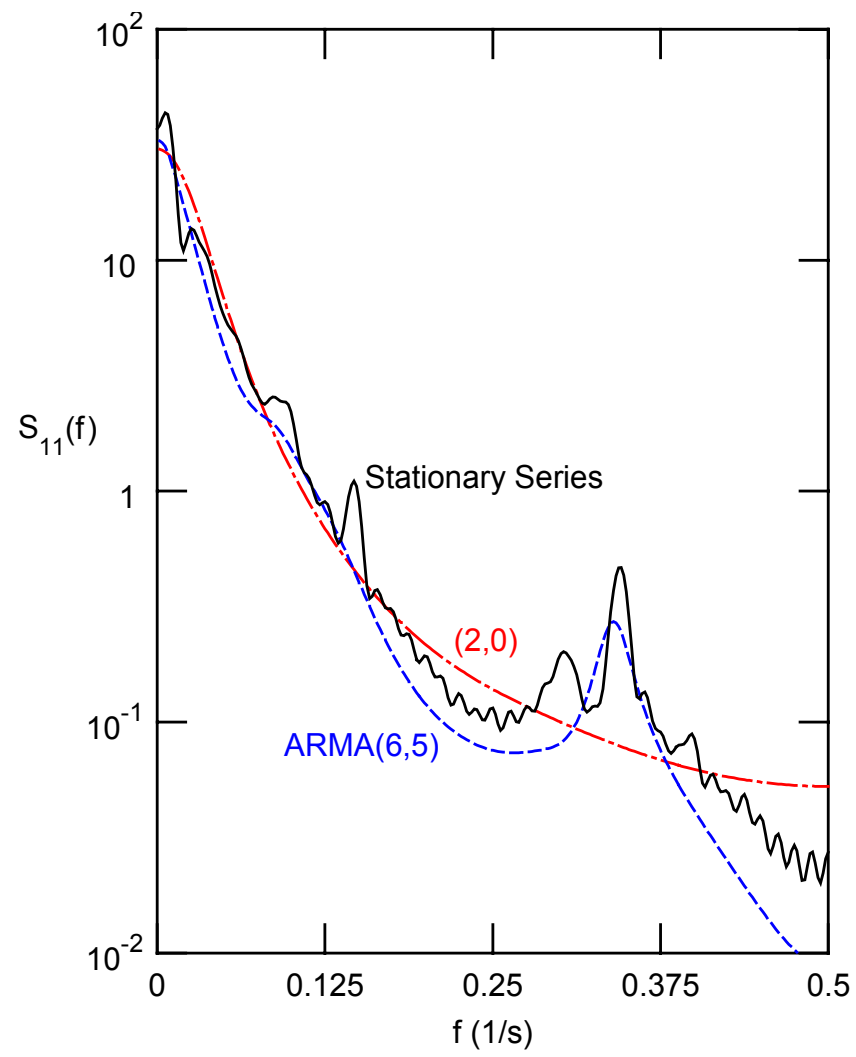
Original



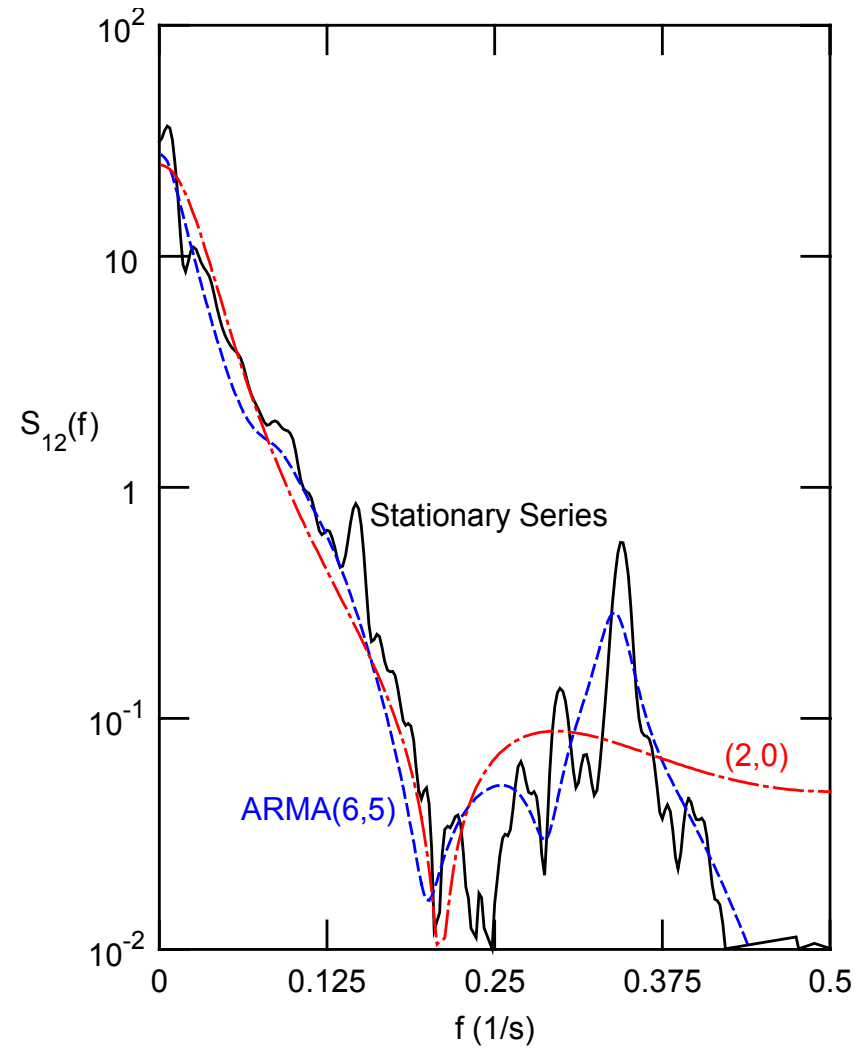
Reconstruction



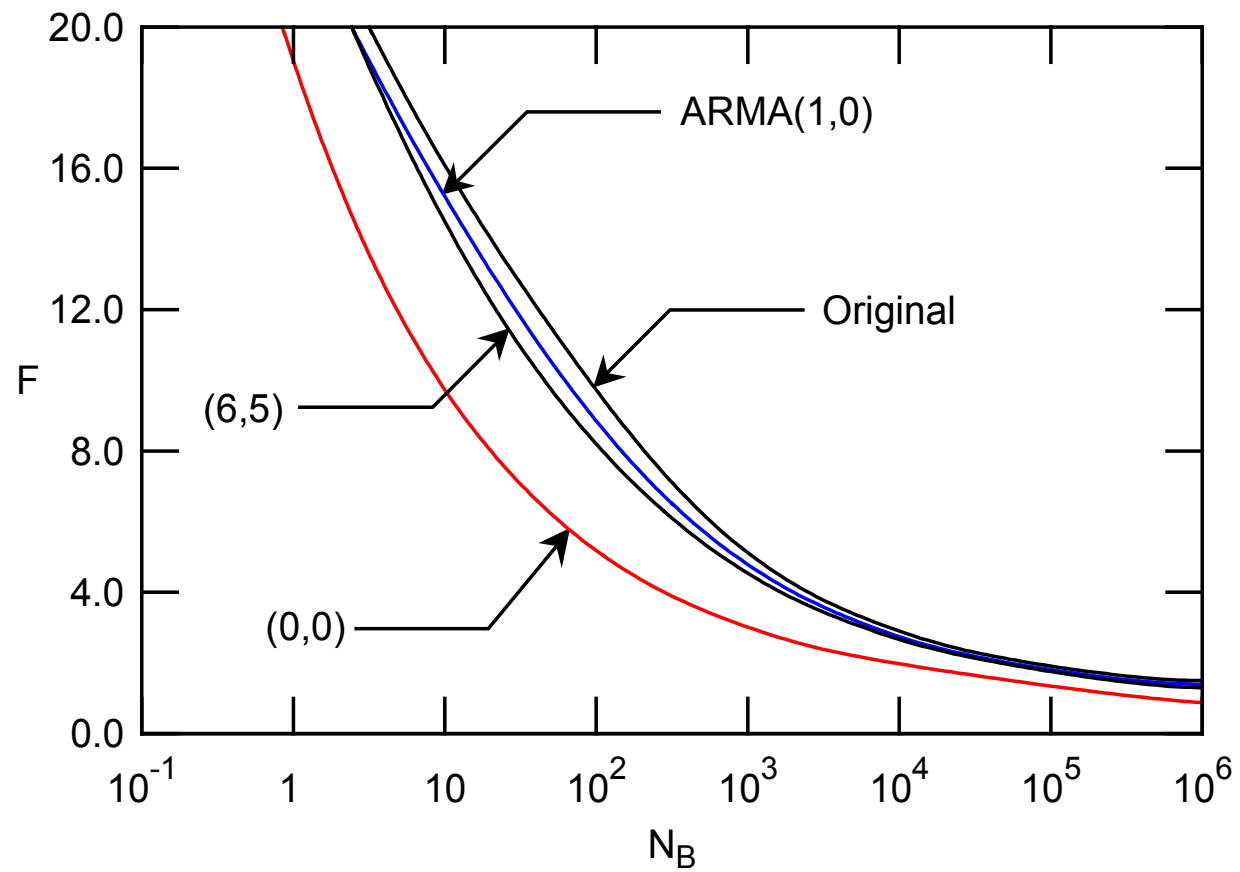
Auto Spectral Density



Cross Spectral Density

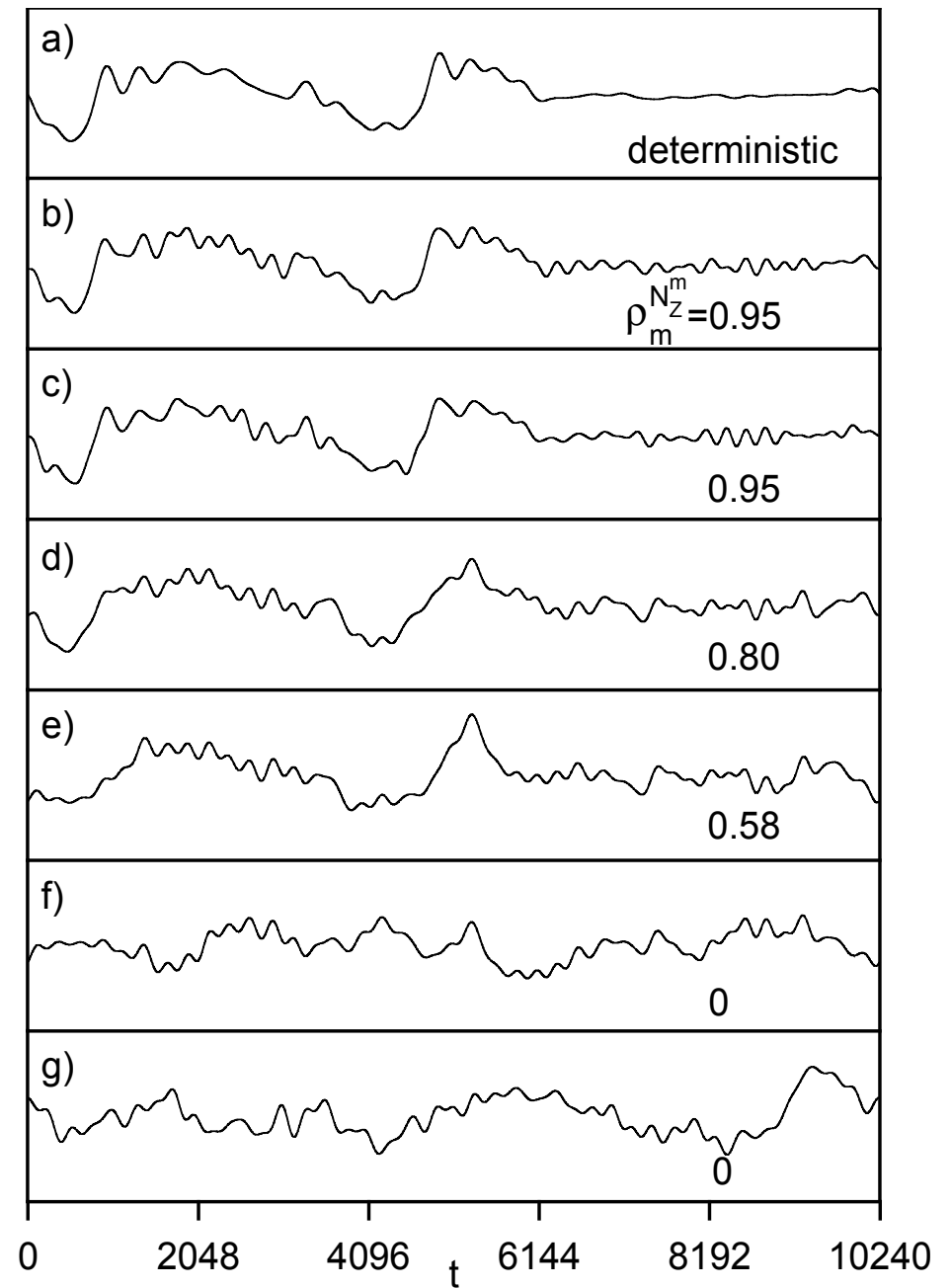


Fatigue Life





Ensemble Generation





Ensemble Generation

