Supplementary Figure S1

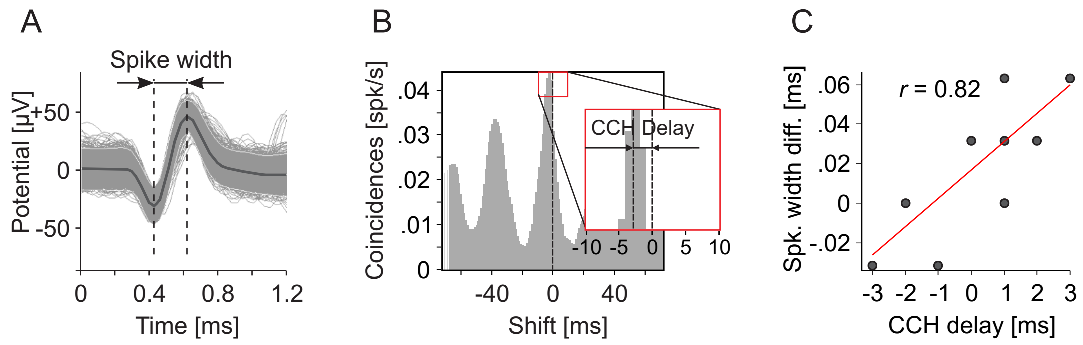

Figure S1. Identification of firing sequence of putative excitatory-inhibitory neuron pairs. (A) Action potential template identified by PCA analysis and definition of spike width. (B) Quantification of delay between the oscillatory firing of two cells by the offset of the central peak of the cross-correlation histogram (inset). (C) Correlation between firing delay and difference in spike width for pairs of cells (Cat 1, stimulus 4).

Supplementary Figure S2

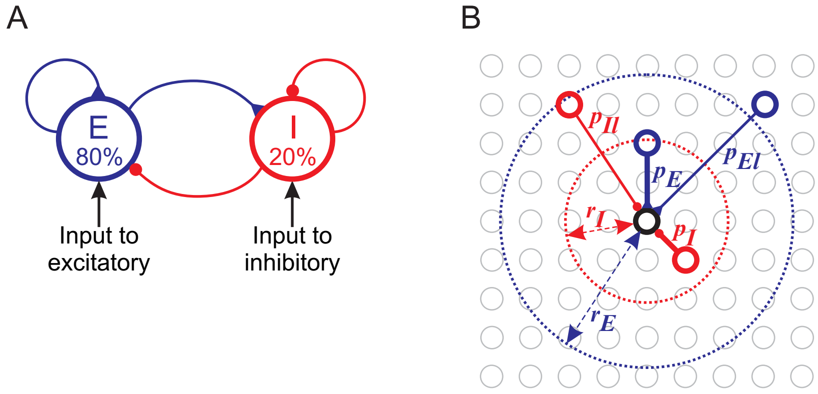

Figure S2. Architecture of simulated networks. (A) Networks consist of populations of excitatory (80%) and inhibitory (20%) neurons, with connections both within and across the two populations. Input is provided separately to each population. (B) Lattice structure of the networks and wiring probabilities of excitatory (blue) and inhibitory neurons (red).

Supplementary Figure S3

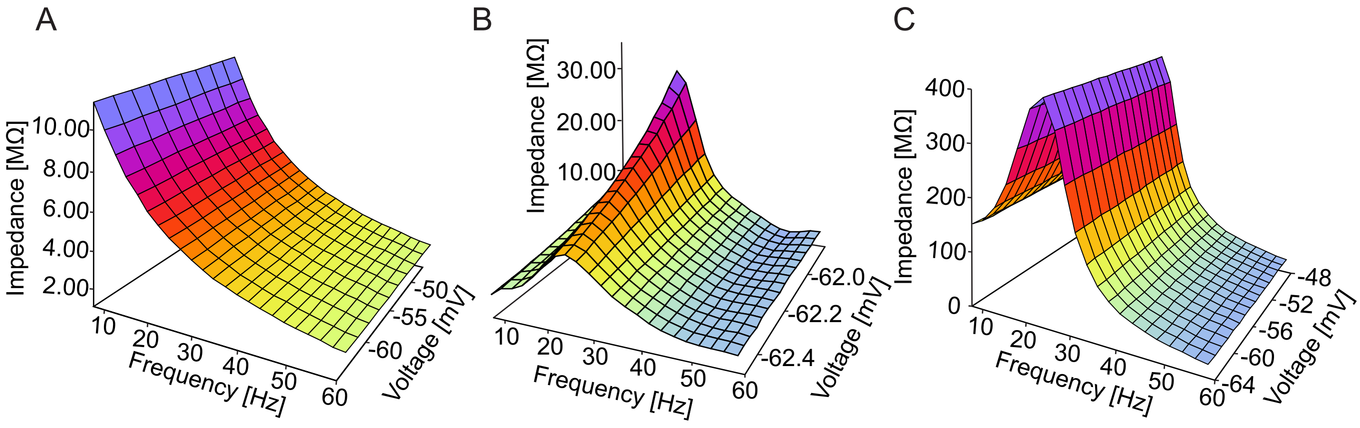

Figure S3. Frequency- and holding-potential-dependent input impedance profile of model neurons. (A) The impedance profile of integrate-and-fire neurons reveals only low-pass filtering properties. (B) The impedance profile of Izhikevich-type resonator neurons reveals a clear impedance peak that is frequency-selective and voltage-dependent. (C) The impedance profile of resonate-and-fire neurons with resonant frequency of 25 Hz exhibits a clear resonant peak that is not voltage-dependent.

Supplementary Figure S4

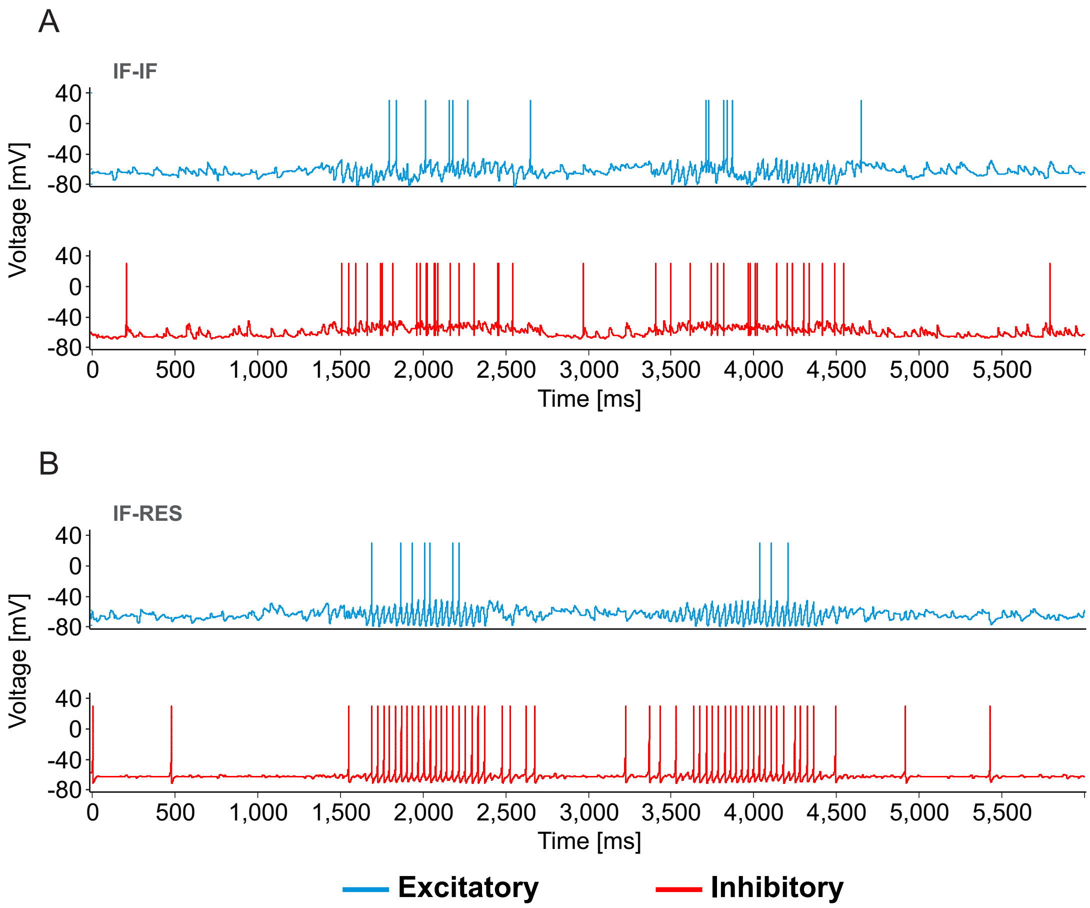

Figure S4. Membrane potential traces of examples of excitatory (blue) and inhibitory (red) neurons along a single trial. (A) Membrane potential traces for two neurons from an IF-IF network. (B) Membrane potential traces for two neurons from an IF-RES network.

Supplementary Figure S5

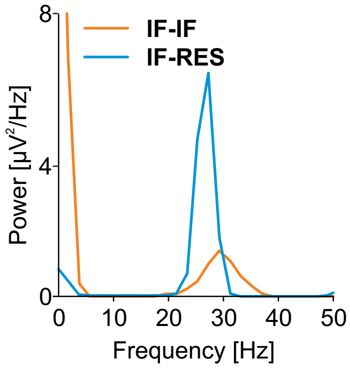

Figure S5. Power spectra of LFPs computed from the activity of one instance of IF-IF and IF-RES networks (the central frequency can slightly depend on the exact instantiation of each network).

Supplementary Figure S6

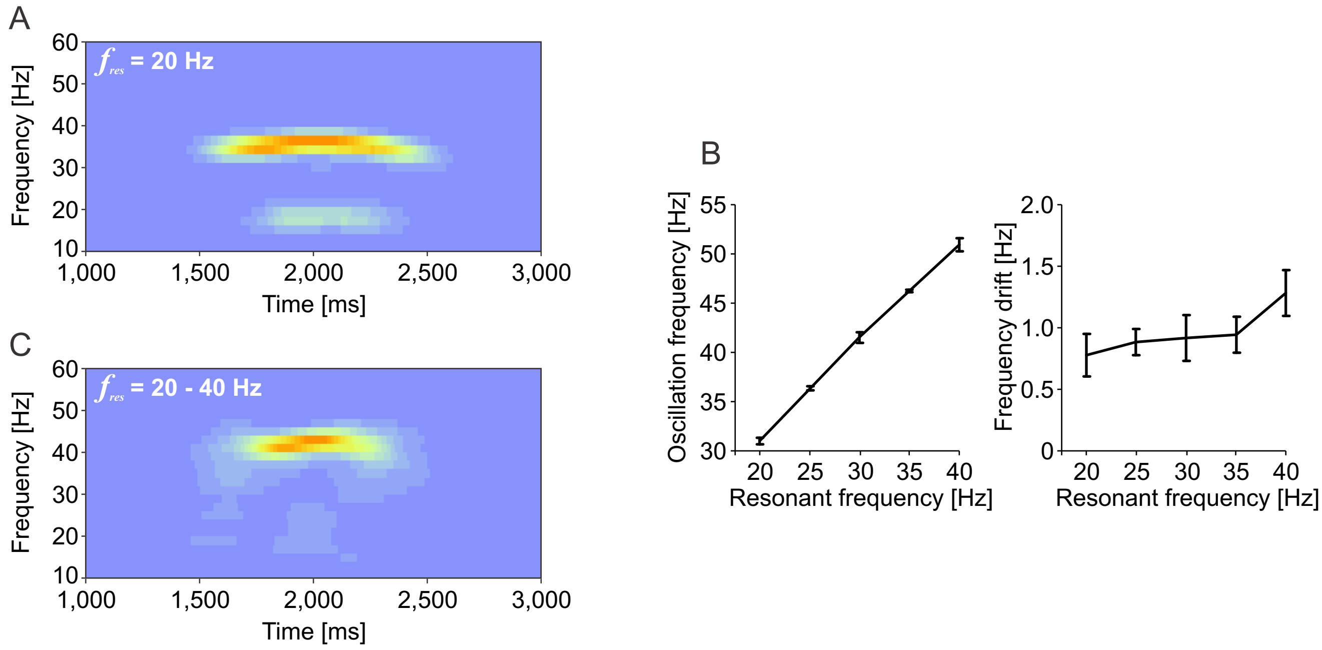

Figure S6. Influence of resonant frequency of RF interneurons on IF-RF network oscillations. (A) Spectra corresponding to an IF-RF_{20} networks. In such a network, groups of excitatory neurons sometimes fire every second cycle, creating an additional subcomponent of half the network frequency. (B) Dependence of network oscillation frequency (left) and frequency drift (right) on the resonant frequency of RF interneurons in IF-RF networks. (C) Spectra corresponding to IF-$RF_{20\text{-}40}$ networks where resonant frequency of interneurons is uniformly spread in the 20-40 Hz interval.

Supplementary Figure S7

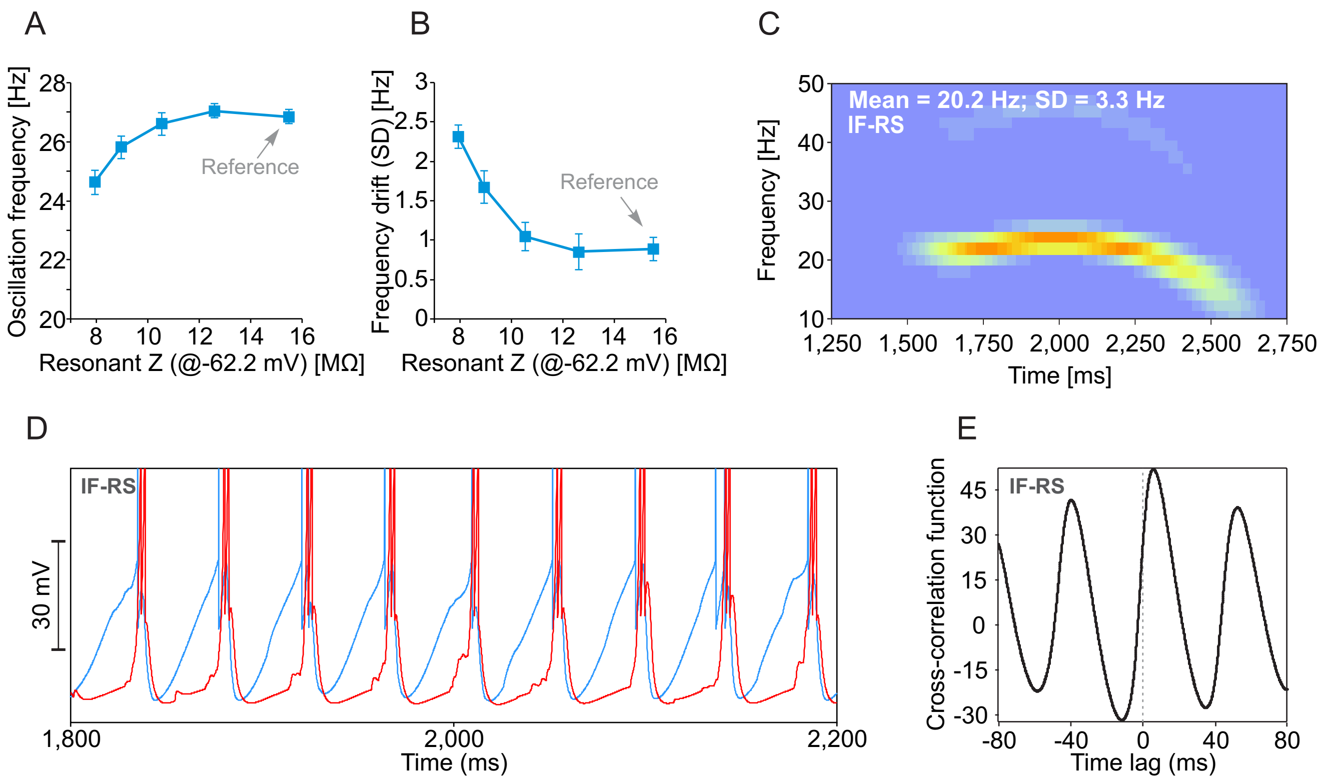

Figure S7. Membrane properties and oscillation frequency. (A) Oscillation frequency in IF-RES networks as a function of resonant impedance. (B) Frequency drift (SD) in IF-RES networks as a function of resonant impedance. (C) Oscillation frequency in networks with Regular-Spiking (RS) inhibitory interneurons. (D) Membrane potential traces of one excitatory IF neuron (blue) and one inhibitory RS neuron (red) in an IF-RS network. (E) Time lag (delay) between the average membrane fluctuation of excitatory and inhibitory populations in an IF-RS network. Error bars indicate SD.

Supplementary Figure S8

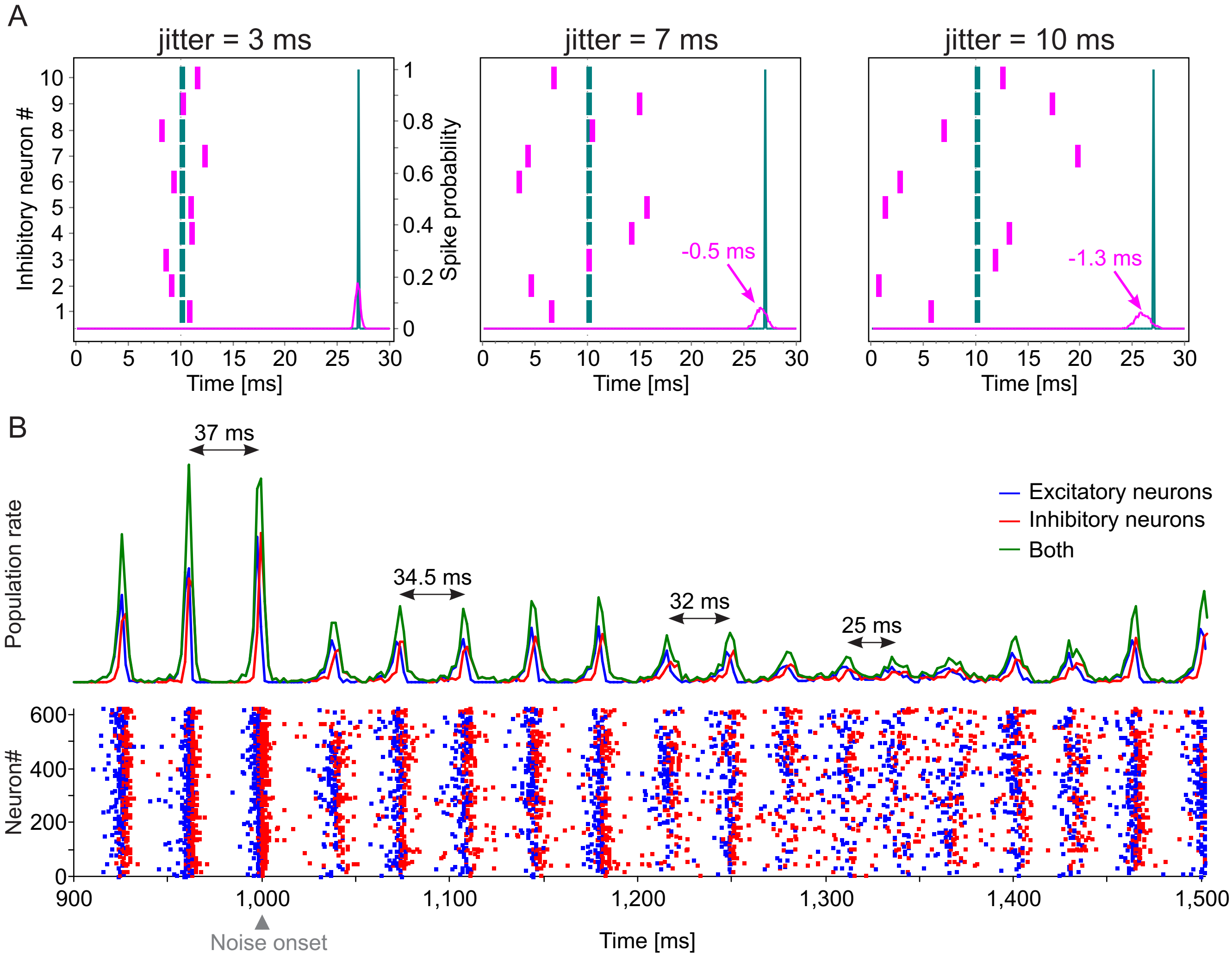

Figure S8. Effect of cycle synchronization. (A) Effect of summation of IPSCs from 10 afferent inhibitory interneurons on a target IF neuron. Interneurons either fire in perfect synchrony (green) or their spikes are jittered (magenta) with various uniform jitter amplitudes, from 3 to 10 ms. The firing probability of the target IF neuron as a function of time is computed across many independent jitters. The IF neuron receives a constant input current of 2 nA and all parameters match those in the reference IF-IF network. With progressively larger jitter of inhibitory afferents, the IF neurons tends to fire slightly earlier (magenta probability function) than for perfectly synchronized inhibitory afferents (green probability function). (B) Epochs with poor synchronization are characterized by small population rates and give rise to short oscillation cycles. Portion of a trial corresponding to network from Fig. 6.

Supplementary Figure S9

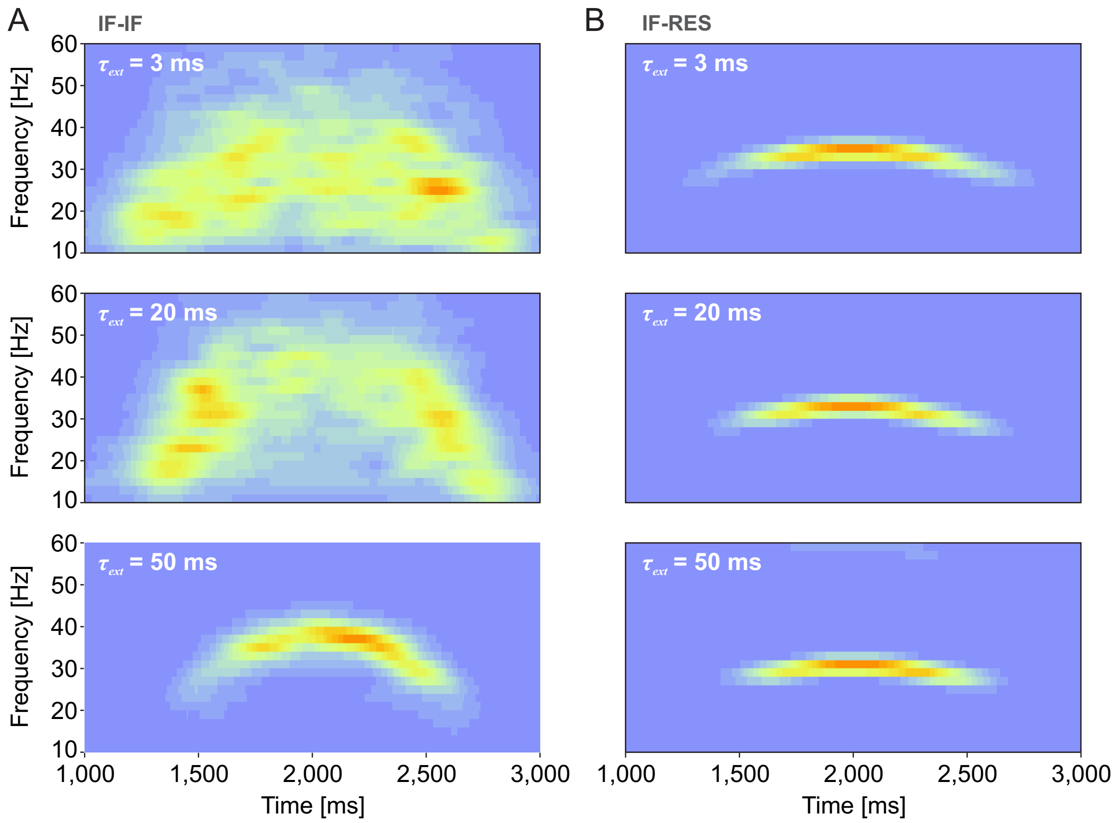

Figure S9. Time-resolved power spectra of LFPs corresponding to networks receiving Poisson input via excitatory synapses with various decay time constants (τ_{ext}). (A) Spectra corresponding to IF-IF networks. (B) Spectra corresponding to IF-RES networks.