- 2x4 steel stud wall (window header)

Description

- ½-in. gypsum board
  - Thermal conductivity – 1.11 Btu-in/h-ft^2-F
  - Density – 50 lb/ft^3
  - Specific Heat – 0.26 Btu/lb-F
- 3.5-in. R-11 fiberglass batts
  - Thermal conductivity – 0.32 Btu-in/h-ft^2-F
  - Density – 5.3 lb/ft^3
  - Specific Heat – 0.23 Btu/lb-F
- 2x4 steel studs
  - Thermal conductivity – 314 Btu-in/h-ft^2-F
  - Density – 490 lb/ft^3
  - Specific Heat – 0.12 Btu/lb-F
- ½-in. plywood
  - Thermal conductivity – 0.8 Btu-in/h-ft^2-F
  - Density – 34 lb/ft^3
  - Specific Heat – 0.29 Btu/lb-F
- ½-in wood siding
  - Thermal conductivity – 0.5 Btu-in/h-ft^2-F
  - Density – 34 lb/ft^3
  - Specific Heat – 0.30 Btu/lb-F

COMPUTATION RESULTS

Three-dimensional model

Table 12.1
Resistance, transmittance and capacitance of the wall

	IP		*SI*	
R-value	3.44803	ft^2 °F h/Btu	0.60685	m^2 K/W
R^{-1}	0.29022	Btu/h ft^2 °F	1.64785	W/m^2 K
Capacitance	1.75507	Btu/ft^2 °F	35.86268	kJ/m^2 K

Table 12.2
Dimensionless 3D z-transfer function coefficients

N	b_n	c_n	d_n
0	0.38340	2.00592	1.00000
1	0.40350	-1.25812	-0.21374
2	0.00274	0.04204	0.00358

$\Sigma\, c_n = 0.78984$, $E_1 = 0.00024$

Table 12.3
3D response factors calculated with the help of the finite difference computer code HEATING 7.2 [Btu/h ft^2 °F]

n	X_n	Y_n
0	5.8178599E-01	1.1119476E-01
1	-2.4053087E-01	1.4079072E-01
2	-4.1299575E-02	3.0490611E-02
3	-7.9672865E-03	6.0136215E-03
4	-1.5726270E-03	1.2159783E-03
5	-3.1565433E-04	2.5082502E-04
6	-6.4203072E-05	5.2463920E-05
7	-1.3199034E-05	1.1077731E-05
8	-2.7371126E-06	2.3539820E-06
9	-5.7159598E-07	5.0234728E-07
10	-1.2004935E-07	1.0751021E-07
11	-2.5332150E-08	2.3054035E-08

Table 12.4
3D response factors ratio. dimensionless 3D response factors and transfer functions of the first order

n	X_n/X_{n-1}	Y_n/Y_{n-1}	$R*X_n$	$R*Y_n$	$R*X'_n$	$R*Y'_n$
0			2.00601	0.38340	2.00601	0.38340
1	-0.41344	1.26616	-0.82936	0.48545	-1.25609	0.40389
2	0.17170	0.21657	-0.14240	0.10513	0.03402	0.00187
3	0.19291	0.19723	-0.02747	0.02074	0.00282	-0.00163
4	0.19739	0.20220	-0.00542	0.00419	0.00042	-0.00022
5	0.20072	0.20627	-0.00109	0.00086	0.00007	-0.00003
6	0.20340	0.20917	-0.00022	0.00018	0.00001	0.00000
7	0.20558	0.21115	-0.00005	0.00004	0.00000	0.00000
8	0.20737	0.21250	-0.00001	0.00001	0.00000	0.00000
9	0.20883	0.21340	0.00000	0.00000	0.00000	0.00000
10	0.21003	0.21402	0.00000	0.00000	0.00000	0.00000
11	0.21101	0.21444	0.00000	0.00000	0.00000	0.00000

$\alpha = 0.21237$ $\tau_1 = 0.64610$

Equivalent wall model: 3 layers plane wall

Table 12.5
Structure factors and time constants

Structure factors		*Time constants [h]*	
φ_{ii}	0.12366	$R \cdot C \cdot \varphi_{ii}$	5.626
φ_{ie}	0.05260	$R \cdot C \cdot \varphi_{ie}$	2.393
φ_{ee}	0.77114	$R \cdot C \cdot \varphi_{ee}$	35.081
		$R \cdot C$	45.493

Table 12.6a
Thermophysical properties of the equivalent wall - IP units

Layer *N*	R_n ft^2-°F-h/Btu	C_n Btu/ft^2-°F	l_n in	k_n Btu-in/h-ft^2-°F	ρ_n lb/ft^3	c_{pn} Btu/lb-°F
1	1.45260	0.41667	0.5	0.344	40	0.25
2	1.69033	0.66920	3.5	2.071	9.178	0.25
3	0.30511	0.66920	1	3.278	32.122	0.25

Table 12.6b
Thermophysical properties of the equivalent wall - SI units

Layer *n*	R_n m^2 K/W	C_n kJ/m^2 K	l_n m	k_n W/m K	ρ_n kg/m^3	c_{pn} kJ/kg K
1	0.25566	8.514081	0.013	0.050	640	1.048
2	0.29750	13.6743	0.089	0.299	146.842	1.048
3	0.05370	13.6743	0.025	0.473	513.946	1.048

Table 12.7
Dimensionless z-transfer function coefficients and first time constants for the equivalent wall

N	b_n	c_n	d_n	τ_n
0	0.32596	2.14908	1.00000	
1	0.54424	-1.30955	-0.10643	0.446
2	0.02338	0.05407	0.00002	0.119
3		-0.00001		0.063

$\Sigma\, c_n = 0.89359$. $\alpha = 0.10621$

Table 12.8
Response factors for the equivalent wall [Btu/h ft^2 °F]

n	X_n	Y_n
0	6.232798E-01	9.453619E-02
1	-3.134613E-01	1.679028E-01
2	-1.769562E-02	2.465005E-02
3	-1.878449E-03	2.620622E-03
4	-1.995170E-04	2.783468E-04
5	-2.119146E-05	2.956428E-05
6	-2.250826E-06	3.140135E-06
7	-2.390688E-07	3.335257E-07
8	-2.539241E-08	3.542503E-08
9	-2.697024E-09	3.762627E-09
10	-2.864612E-10	3.996430E-10
11	-3.042614E-11	4.244760E-11

Frequency response for the three-dimensional model and equivalent wall; dimensionless amplitude and phase angle

Table 12.9a
3-D model

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	1.00	-6°	1.03	9°
24	0.98	-12°	1.10	16°
12	0.93	-23°	1.35	25°
6	0.75	-43°	1.89	26°

Table 12.9b
Equivalent wall

	Transmittance		*Admittance*	
period	amplitude	phase angle	amplitude	phase angle
48	1.00	-6°	1.02	9°
24	0.99	-12°	1.07	17°
12	0.97	-23°	1.26	30°
6	0.90	-45°	1.75	41°