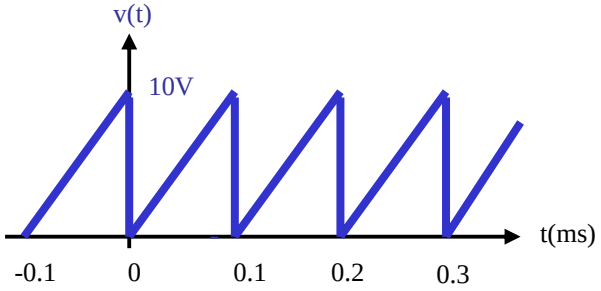
EGR 261
Signals and Systems
File: FourierRamp - Excel.xls

Example: Using Excel to Graph the Fourier Series of a Ramp Waveform



$$v(t) = 5 - \frac{10}{n\pi}\sum_{n=1}^{\infty}\sin(20000n\,\pi t)$$

Time increments: T = 0.1ms for the waveform above. If a Fourier Series is to be graphed including terms up to the 4th harmonic, note that the period of the 4th harmonic is T/4 = 0.025ms = 25us. If 10 points are to be used to graph one cycle of the 4th harmonic, then increments of 25us/10 = 2.5us are needed.
Final time: If two cycles of the waveform are to be graphed, then time should vary from 0 to 2T or 0 to 0.2ms.

Formula in cell D24: =-10/(D$23*PI())*SIN(20000*D$23*PI()*$B24)
Formula in cell K24: =SUM($C24:G24)

A	B	C	D	E	F	G	H	I	J	K
			Harmonic (n)				Sum of the following terms:			
23	**Time, t (s)**	**DC**	**1**	**2**	**3**	**4**	**DC - 1st**	**DC - 2nd**	**DC - 3rd**	**DC - 4th**
24	0.00E+00	5	0.000	0.000	0.000	0.000	5.000	5.000	5.000	5.000
25	2.50E-06	5	-0.498	-0.492	-0.482	-0.468	4.502	4.010	3.529	3.061
26	5.00E-06	5	-0.984	-0.935	-0.858	-0.757	4.016	3.081	2.222	1.466
27	7.50E-06	5	-1.445	-1.288	-1.048	-0.757	3.555	2.267	1.219	0.463
28	1.00E-05	5	-1.871	-1.514	-1.009	-0.468	3.129	1.615	0.606	0.139
29	1.25E-05	5	-2.251	-1.592	-0.750	0.000	2.749	1.158	0.407	0.407
30	1.50E-05	5	-2.575	-1.514	-0.328	0.468	2.425	0.911	0.583	1.051
31	1.75E-05	5	-2.836	-1.288	0.166	0.757	2.164	0.876	1.042	1.799
32	2.00E-05	5	-3.027	-0.935	0.624	0.757	1.973	1.037	1.661	2.418
33	2.25E-05	5	-3.144	-0.492	0.945	0.468	1.856	1.364	2.310	2.777
34	2.50E-05	5	-3.183	0.000	1.061	0.000	1.817	1.817	2.878	2.878
35	2.75E-05	5	-3.144	0.492	0.945	-0.468	1.856	2.348	3.293	2.826
36	3.00E-05	5	-3.027	0.935	0.624	-0.757	1.973	2.908	3.532	2.775
37	3.25E-05	5	-2.836	1.288	0.166	-0.757	2.164	3.451	3.617	2.861
38	3.50E-05	5	-2.575	1.514	-0.328	-0.468	2.425	3.938	3.611	3.143
39	3.75E-05	5	-2.251	1.592	-0.750	0.000	2.749	4.341	3.590	3.590
40	4.00E-05	5	-1.871	1.514	-1.009	0.468	3.129	4.643	3.634	4.101
41	4.25E-05	5	-1.445	1.288	-1.048	0.757	3.555	4.842	3.795	4.551
42	4.50E-05	5	-0.984	0.935	-0.858	0.757	4.016	4.952	4.093	4.850
43	4.75E-05	5	-0.498	0.492	-0.482	0.468	4.502	4.994	4.512	4.980
44	5.00E-05	5	0.000	0.000	0.000	0.000	5.000	5.000	5.000	5.000
45	5.25E-05	5	0.498	-0.492	0.482	-0.468	5.498	5.006	5.488	5.020
46	5.50E-05	5	0.984	-0.935	0.858	-0.757	5.984	5.048	5.907	5.150
47	5.75E-05	5	1.445	-1.288	1.048	-0.757	6.445	5.158	6.205	5.449
48	6.00E-05	5	1.871	-1.514	1.009	-0.468	6.871	5.357	6.366	5.899
49	6.25E-05	5	2.251	-1.592	0.750	0.000	7.251	5.659	6.410	6.410
50	6.50E-05	5	2.575	-1.514	0.328	0.468	7.575	6.062	6.389	6.857
51	6.75E-05	5	2.836	-1.288	-0.166	0.757	7.836	6.549	6.383	7.139
52	7.00E-05	5	3.027	-0.935	-0.624	0.757	8.027	7.092	6.468	7.225
53	7.25E-05	5	3.144	-0.492	-0.945	0.468	8.144	7.652	6.707	7.174

54	7.50E-05	5	3.183	0.000	-1.061	0.000	8.183	8.183	7.122	7.122
55	7.75E-05	5	3.144	0.492	-0.945	-0.468	8.144	8.636	7.690	7.223
56	8.00E-05	5	3.027	0.935	-0.624	-0.757	8.027	8.963	8.339	7.582
57	8.25E-05	5	2.836	1.288	-0.166	-0.757	7.836	9.124	8.958	8.201
58	8.50E-05	5	2.575	1.514	0.328	-0.468	7.575	9.089	9.417	8.949
59	8.75E-05	5	2.251	1.592	0.750	0.000	7.251	8.842	9.593	9.593
60	9.00E-05	5	1.871	1.514	1.009	0.468	6.871	8.385	9.394	9.861
61	9.25E-05	5	1.445	1.288	1.048	0.757	6.445	7.733	8.781	9.537
62	9.50E-05	5	0.984	0.935	0.858	0.757	5.984	6.919	7.778	8.534
63	9.75E-05	5	0.498	0.492	0.482	0.468	5.498	5.990	6.471	6.939
64	1.00E-04	5	0.000	0.000	0.000	0.000	5.000	5.000	5.000	5.000
65	1.03E-04	5	-0.498	-0.492	-0.482	-0.468	4.502	4.010	3.529	3.061
66	1.05E-04	5	-0.984	-0.935	-0.858	-0.757	4.016	3.081	2.222	1.466
67	1.08E-04	5	-1.445	-1.288	-1.048	-0.757	3.555	2.267	1.219	0.463
68	1.10E-04	5	-1.871	-1.514	-1.009	-0.468	3.129	1.615	0.606	0.139
69	1.13E-04	5	-2.251	-1.592	-0.750	0.000	2.749	1.158	0.407	0.407
70	1.15E-04	5	-2.575	-1.514	-0.328	0.468	2.425	0.911	0.583	1.051
71	1.18E-04	5	-2.836	-1.288	0.166	0.757	2.164	0.876	1.042	1.799
72	1.20E-04	5	-3.027	-0.935	0.624	0.757	1.973	1.037	1.661	2.418
73	1.23E-04	5	-3.144	-0.492	0.945	0.468	1.856	1.364	2.310	2.777
74	1.25E-04	5	-3.183	0.000	1.061	0.000	1.817	1.817	2.878	2.878
75	1.28E-04	5	-3.144	0.492	0.945	-0.468	1.856	2.348	3.293	2.826
76	1.30E-04	5	-3.027	0.935	0.624	-0.757	1.973	2.908	3.532	2.775
77	1.33E-04	5	-2.836	1.288	0.166	-0.757	2.164	3.451	3.617	2.861
78	1.35E-04	5	-2.575	1.514	-0.328	-0.468	2.425	3.938	3.611	3.143
79	1.38E-04	5	-2.251	1.592	-0.750	0.000	2.749	4.341	3.590	3.590
80	1.40E-04	5	-1.871	1.514	-1.009	0.468	3.129	4.643	3.634	4.101
81	1.43E-04	5	-1.445	1.288	-1.048	0.757	3.555	4.842	3.795	4.551
82	1.45E-04	5	-0.984	0.935	-0.858	0.757	4.016	4.952	4.093	4.850
83	1.48E-04	5	-0.498	0.492	-0.482	0.468	4.502	4.994	4.512	4.980
84	1.50E-04	5	0.000	0.000	0.000	0.000	5.000	5.000	5.000	5.000
85	1.53E-04	5	0.498	-0.492	0.482	-0.468	5.498	5.006	5.488	5.020
86	1.55E-04	5	0.984	-0.935	0.858	-0.757	5.984	5.048	5.907	5.150
87	1.58E-04	5	1.445	-1.288	1.048	-0.757	6.445	5.158	6.205	5.449
88	1.60E-04	5	1.871	-1.514	1.009	-0.468	6.871	5.357	6.366	5.899
89	1.63E-04	5	2.251	-1.592	0.750	0.000	7.251	5.659	6.410	6.410
90	1.65E-04	5	2.575	-1.514	0.328	0.468	7.575	6.062	6.389	6.857
91	1.68E-04	5	2.836	-1.288	-0.166	0.757	7.836	6.549	6.383	7.139
92	1.70E-04	5	3.027	-0.935	-0.624	0.757	8.027	7.092	6.468	7.225
93	1.73E-04	5	3.144	-0.492	-0.945	0.468	8.144	7.652	6.707	7.174
94	1.75E-04	5	3.183	0.000	-1.061	0.000	8.183	8.183	7.122	7.122
95	1.78E-04	5	3.144	0.492	-0.945	-0.468	8.144	8.636	7.690	7.223
96	1.80E-04	5	3.027	0.935	-0.624	-0.757	8.027	8.963	8.339	7.582
97	1.83E-04	5	2.836	1.288	-0.166	-0.757	7.836	9.124	8.958	8.201
98	1.85E-04	5	2.575	1.514	0.328	-0.468	7.575	9.089	9.417	8.949
99	1.88E-04	5	2.251	1.592	0.750	0.000	7.251	8.842	9.593	9.593
100	1.90E-04	5	1.871	1.514	1.009	0.468	6.871	8.385	9.394	9.861
101	1.93E-04	5	1.445	1.288	1.048	0.757	6.445	7.733	8.781	9.537
102	1.95E-04	5	0.984	0.935	0.858	0.757	5.984	6.919	7.778	8.534
103	1.98E-04	5	0.498	0.492	0.482	0.468	5.498	5.990	6.471	6.939
104	2.00E-04	5	0.000	0.000	0.000	0.000	5.000	5.000	5.000	5.000

Note that with the addition of each harmonic, the graph more closely resembles the original 0-10V ramp waveform. How many terms are necessary to closely approximate the original waveform? It depends on how rapidly the Fourier series coefficients converge. For some Fourier series, 2 or 3 terms may give a very good approximation. For others, many terms might be required.