Choosing the Correct Capacitive Load Amplifier

Introduction

In applications where an amplifier is used to drive either purely capacitive loads and/or loads that contain both capacitive and resistive elements, consideration must be given to the amplifier's output configuration and the continuous output current capability in order to achieve the required non-distorted output waveform. Distortion of the output waveform is particularly evident in applications requiring high peak-to-peak output voltage swings which can result in frequency limitations well below the gain-bandwidth capability of the amplifier if the corresponding output continuous current capability is not high enough to satisfy both the capacitive current and resistive current required by the load.

All Trek high-voltage amplifiers are designed using class AB output driving stages and thus have the capability to both source and sink current to and from the capacitance associated with the load. Unfortunately, all output driving stages inherently contain a certain amount of capacitance (C_{INT}) relative to ground (or other reference) which appears in parallel with the H.V. output terminal and thus in parallel with the load capacitance (C_{LOAD}). In addition, the capacitance (C_W) associated with the wiring between the amplifier's output terminal and the load also appears in parallel with load capacitance. Therefore the total capacitive load (C_T) on the amplifier can be expressed as $C_T = C_{INT} + C_W + C_{LOAD}$.

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This application note deals with those applications where the amplifier's load is purely capacitive such as in beam steering or similar applications. The choice of the particular Trek amplifier model which best fits these applications can be determined using the five (5) step process shown below.

1) Prepare a list of amplifier candidates from those amplifiers shown in Chart A (page 4) which have an output peak-to-peak voltage capability required by the application.

2) Determine the value of $C_T - C_{INT}$ by adding the anticipated wiring capacitance (C_W) to the anticipated load capacitance (C_{LOAD}) via direct measurement, calculation, or product data information such as pf/ft on coax cabling, capacitance data of the particular load used, etc.

3) Determine the continuous current requirement (I_C) of the application by calculating $I_C = (C_T - C_{INT}) \cdot (dv/dt)$ where dv/dt is equal to the change of output voltage waveform per unit of time (which is waveform dependent).

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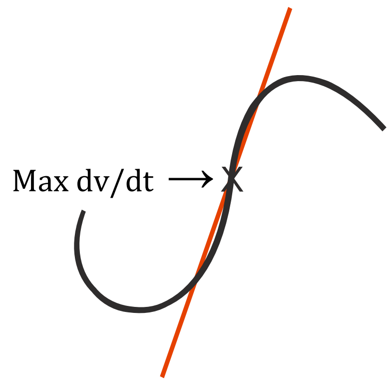
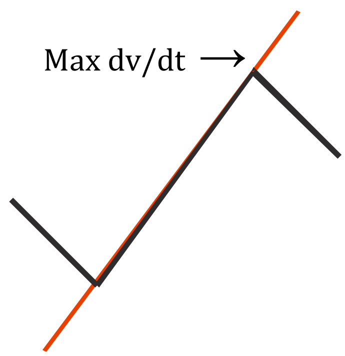
For example:

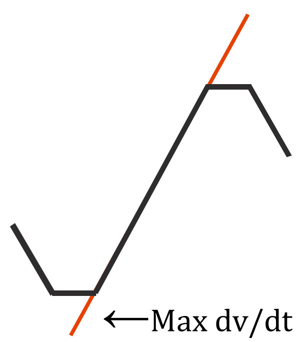
Sine Wave:
Max dv/dt = V $_{\text{peak-to-peak}}$ · π · frequency



Triangle Wave:
Max dv/dt = V $_{\text{peak-to-peak}}$ · 2 · frequency



Square Wave:
Max dv/dt = V $_{\text{peak-to-peak}}$ · rise time



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4) From the prepared list of amplifier candidates select those amplifier models from Chart A having a current capability equal to or greater than the continuous current requirement calculation of step 3.

5) For each model selected read the C_{INT} for that amplifier from Chart A and add that value of C_{INT} to the value of $C_T - C_{INT}$ in step 3 to obtain C_T, the total capacitive load, and recalculate the value of the continuous current requirement.

6) Choose the amplifier required based on the recalculated continuous current value requirement.

NOTE: many Trek amplifiers have an additional feature which is very useful for driving capacitive loads. This feature allows the amplifier to deliver, over a specified time period, a current that has a peak value which is 2 to 3 times greater (depending upon the amplifier model) than the I_C value. This allows for very fast dv/dt rates and is particularly useful for square wave or pulse voltage applications where fast rise/fall time is required.

Chart A appears on the following page

For additional assistance please go to: http://www.trekinc.com/library/Capacitive_Loads.asp

Chart A

Model	Output Voltage (DC or Peak AC)	Internal Capacitance C int*	Output Current (DC or peak AC)
50/12	±50 kV	34 pF	±12 mA
40/15	±40 kV	43 pF	±15 mA
30/20A	±30 kV	50 pF	±20 mA
P0621 P or N	P: 0 to +30kV N: 0 to -30 kV	57pF	±20 mA
20/20C	±20 kV	60 pF	±20 mA
20/20C-HS	±20 kV	75 pF	±20 mA DC or ±60 mA peak AC for 1 ms
10/40A	±10 kV	60 pF	±40 mA
10/40A-HS	±10 kV	133 pF	±40 mA DC or ±120 mA peak AC for 1 ms
PD07016	±10 kV	60 pF	±60 mA DC or ±300 mA peak AC for 20 µs
10/10B-HS	±10 kV	55 pF	±10 mA DC or ±40 mA peak AC for 1 ms
610E	±10 kV	66 pF	±2 mA
PD05034	±7.5 kV	50 pF	±50 mA DC or ±160 mA peak AC for 60 µs
609B-3	±10 kV	66 pF	±2 mA
5/80	±5 kV	70 pF	±80 mA
5/80-HS	±5 kV	160 pF	±80 mA DC or ±240 mA peak AC for 1 ms
609E-6	±4 kV	50 pF	±20 mA
PZD2000A	±2 kV	400 pF	±200 mA DC or ±400 mA peak AC for 2 ms
623B	±2 kV	50 pF	±40 mA
677B	±2 kV	330 pF	±5 mA
2220	±2 kV	300 pF	±10 mA
2210	±1 kV	300 pF	±20 mA
PZD700A	±700 V +1.4 kV *or* -1.4 kV	270 pF 135 pF	±100 mA ±50 mA
PZD700A M/S	±700 V +1.4 kV *or* -1.4 kV	530 pF 270 pF	±200 mA ±100 mA
2205	±500 V	300 pF	±40 mA
601C	±500 V *or* +1 kV *or* -1 kV	400 pF	±10 mA DC or ±20 mA peak AC
PZD350A	±350 V +700 V *or* -700 V	365 pF 230 pF	±200 mA ±100 mA
PZD350A M/S		730 pF 460 pF	±400 mA ±200 mA
2100 HF	±150 V	150 pF	±300 mA
603	±125 V *or* +250 V *or* -250 V	800 pF	±40 mA DC or ±80 mA peak AC

∗ [pF (pico farad = 10^{-12})]

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