12.3 tf.zpk ZPK transfer functions in Matlab

Consider the transfer function:

$$H(s) = \frac{2s+1}{s^2+7s+12} \quad (1)$$
$$= 2\frac{s+1/2}{(s+3)(s+4)}. \quad (2)$$

In the second equality, we have factored the polynomials and expressed them in terms of poles p_i and zeros z_i with terms $(s - p_i)$ and $(s - z_i)$. Note the gain factor 2 that emerges in this form.
Both forms are useful. In the former, two polynomials in s define the transfer function; in the latter, a list of zeros, poles, and a gain constant define the transfer function.
In Matlab, there are two corresponding manners of defining a transfer function. We demonstrate the first, already familiar, method using the `tf` command, which takes polynomial coefficients, as follows.

```
H_tf = tf([2,1],[1,7,12])
```

```
H_tf =

     2 s + 1
  --------------
  s^2 + 7 s + 12

Continuous-time transfer function.
```

Alternatively, we can define the transfer function model with the `zpk` command using the zeros, poles, and gain constant.

```
H_zpk = zpk([-1/2],[-3,-4],2)
```

```
H_zpk =
```

```
   2 (s+0.5)
  -----------
  (s+3) (s+4)

Continuous-time zero/pole/gain model.
```

This zpk model will work with all the usual functions tf models do. However, if you'd like to convert zpk to tf, simply use tf as follows.

```
tf(H_zpk)
```

```
ans =

     2 s + 1
  --------------
  s^2 + 7 s + 12

Continuous-time transfer function.
```

Alternatively, we can convert a tf model to a zpk model.

```
zpk(H_tf)
```

```
ans =

   2 (s+0.5)
  -----------
  (s+4) (s+3)

Continuous-time zero/pole/gain model.
```