Multiple Shooting

1

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Chapter 1

Hierarchical Index

1.1 Class Hierarchy

This inheritance list is sorted roughly, but not completely, alphabetically:

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Chapter 2

Class Index

2.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

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RHS_Troesch 28
SF_External 29
ShootingFunction 30
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ThomasFermi 31
TimeDivFunctor 32
TimeFunctor 33
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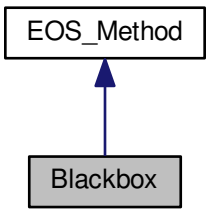
Chapter 3

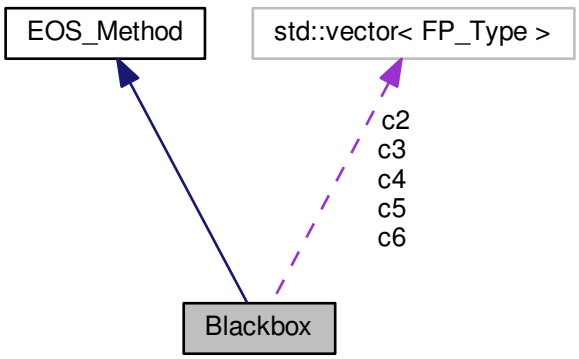
Class Documentation

3.1 Blackbox Class Reference

Inheritance diagram for Blackbox:



Collaboration diagram for Blackbox:



Public Member Functions

- virtual dealii::Vector< FP_Type > **increment_function** (const FP_Type &t, const dealii::Vector< FP_Type > &u, const FP_Type &h) override

Public Attributes

- const std::vector< FP_Type > **c2** = { 1./5, 1./5 }
- const std::vector< FP_Type > **c3** = { 3./10, 3./40, 9./40 }
- const std::vector< FP_Type > **c4** = { 4./5, 44./45, 56./15, 32./9 }
- const std::vector< FP_Type > **c5**
- const std::vector< FP_Type > **c6**
- const FP_Type **s1** = 35./384
- const FP_Type **s2** = 0.
- const FP_Type **s3** = 500./1113
- const FP_Type **s4** = 125./192
- const FP_Type **s5** = 2187./6784
- const FP_Type **s6** = 11./84

3.1.1 Member Data Documentation

3.1.1.1 c5

```
const std::vector<FP_Type> Blackbox::c5
```

Initial value:

```
= { 8./9, 19372./6561, 25360./2187,
                                    64448./6561, 212./729 }
```

3.1.1.2 c6

```
const std::vector<FP_Type> Blackbox::c6
```

Initial value:

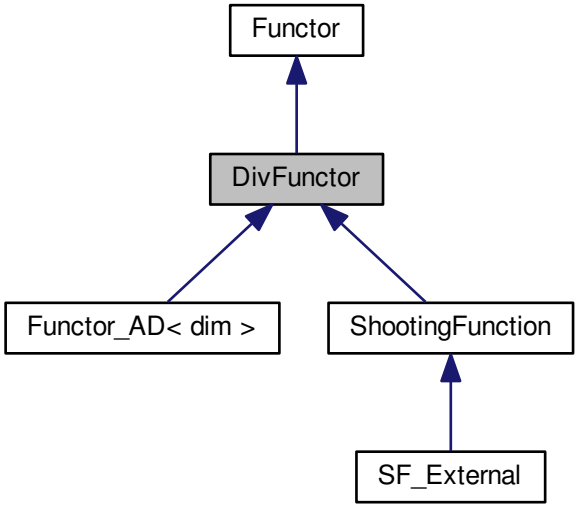
```
= { 1., 9017./3168, 355./33,
                                    46732./5247, 49./176, 5103./18656 }
```

The documentation for this class was generated from the following file:

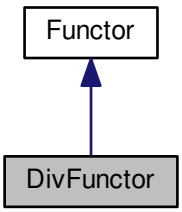
- test/test_runge_kutta.h

3.2 DivFunctor Class Reference

Inheritance diagram for DivFunctor:



Collaboration diagram for DivFunctor:



Public Member Functions

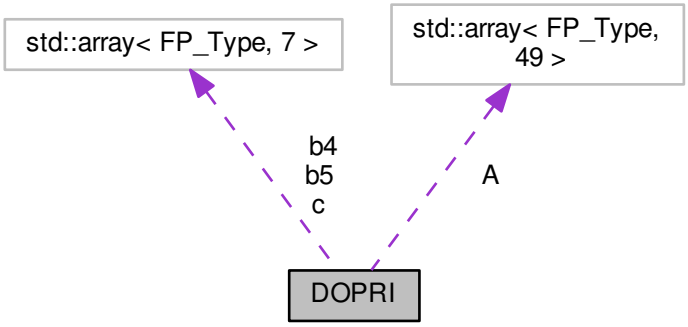
- virtual dealii::FullMatrix< FP_Type > **jacobian** (const dealii::Vector< FP_Type > &s)=0

The documentation for this class was generated from the following file:

- base/functor.h

3.3 DOPRI Struct Reference

Collaboration diagram for DOPRI:



Public Attributes

- const std::array< FP_Type, 49 > **A**
- const std::array< FP_Type, 7 > **b5**
- const std::array< FP_Type, 7 > **b4**
- const std::array< FP_Type, 7 > **c**

3.3.1 Member Data Documentation

3.3.1.1 A

```
const std::array<FP_Type, 49> DOPRI::A
```

Initial value:

```
= {
    0,            0,            0,            0,          0,            0,       0,
    1./5,         0,            0,            0,          0,            0,       0,
    3./40,        9./40,        0,            0,          0,            0,       0,
    44./45,       -56./15,      32./9,        0,          0,            0,       0,
    19372./6561,  -25360./2187, 64448./6561,  -212./729,  0,            0,       0,
    9017./3168,   -355./33,     46732./5247,  49./176,    -5103./18656, 0,       0,
    35./384,      0,            500./1113,    125./192,   -2187./6784,  11./84,  0
  }
```

3.3.1.2 b4

```
const std::array<FP_Type, 7> DOPRI::b4
```

Initial value:

```
= {
    5179./57600, 0, 7571./16695, 393./640, -92097./339200, 187./2100, 1./40
  }
```

3.3.1.3 b5

```
const std::array<FP_Type, 7> DOPRI::b5
```

Initial value:

```
= {
    35./384, 0, 500./1113, 125./192, -2187./6784, 11./84, 0
  }
```

3.3.1.4 c

```
const std::array<FP_Type, 7> DOPRI::c
```

Initial value:

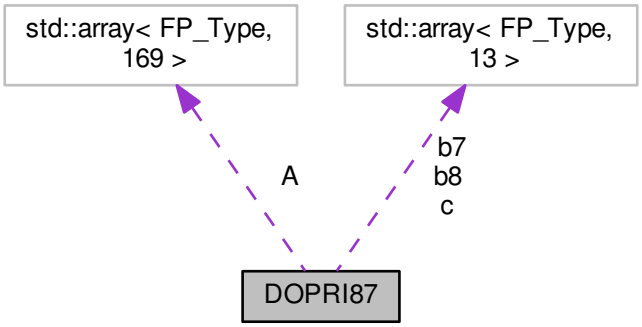
```
= {
    0, 1./5, 3./10, 4./5, 8./9, 1., 1.
  }
```

The documentation for this struct was generated from the following file:

- ivp/tableau.h

3.4 DOPRI87 Struct Reference

Collaboration diagram for DOPRI87:



Public Attributes

- const std::array< FP_Type, 13 > **c**
- const std::array< FP_Type, 169 > **A**
- const std::array< FP_Type, 13 > **b8**
- const std::array< FP_Type, 13 > **b7**

3.4.1 Member Data Documentation

3.4.1.1 A

```
const std::array<FP_Type, 169> DOPRI87::A
```

Initial value:

```
= {
    0,                      0,      0,        0,                          0,                      0,
                        0,                        0,                        0,                        0,
                      0,                      0,  0,
    1./18,                  0,      0,        0,                          0,                      0,
                        0,                        0,                        0,                        0,
                      0,                      0,  0,
    1./48,                  1./16,  0,        0,                          0,                      0,
                        0,                        0,                        0,                        0,
                      0,                      0,  0,
    1./32,                  0,      3./32,    0,                          0,                      0,
                        0,                        0,                        0,                        0,
                      0,                      0,  0,
    5./16,                  0,      -75./64,  75./64,                     0,                      0,
                        0,                        0,                        0,                        0,
                      0,                      0,  0,
    3./80,                  0,      0,        3./16,                      3./20,                  0,
                        0,                        0,                        0,                        0,
                      0,                      0,  0,
    29443841./614563906,    0,      0,        77736538./692538347,        -28693883./1125000000,
      23124283./1800000000,     0,                        0,                        0,                        0,
                      0,                      0,  0,
    16016141./946692911,    0,      0,        61564180./158732637,        22789713./633445777,
      545815736./2771057229,    -180193667./1043307555,    0,                        0,                        0,
                      0,                      0,  0,
    39632708./573591083,    0,      0,        -433636366./683701615,      -421739975./2616292301,
      100302831./723423059,     790204164./839813087,      800635310./3783071287,     0,                        0,
                      0,                      0,  0,
    246121993./1340847787,  0,      0,        -37695042795./15268766246,  -309121744./1061227803,  -
      12992083./490766935,      6005943493./2108947869,    393006217./1396673457,     123872331./1001029789,     0,
                      0,                      0,  0,
    -1028468189./846180014, 0,      0,        8478235783./508512852,      1311729495./1432422823,  -
      10304129995./1701304382,  -48777925059./3047939560,  15336726248./1032824649,   -45442868181./3398467696,
      3065993473./597172653,   0,                      0,  0,
    185892177./718116043,   0,      0,        -3185094517./667107341,     -477755414./1098053517,  -
      703635378./230739211,     5731566787./1027545527,    5232866602./850066563,     -4093664535./808688257,
      3962137247./1805957418,  65686358./487910083,    0,  0,
    403863854./491063109,   0,      0,        -5068492393./434740067,     -411421997./543043805,
      652783627./914296604,      11173962825./925320556,    -13158990841./6184727034,  3936647629./1978049680,    -
      160528059./685178525,   248638103./1413531060,  0,  0
  }
```

3.4.1.2 b7

```
const std::array<FP_Type, 13> DOPRI87::b7
```

Initial value:

```
= {
     13451932./455176623, 0, 0, 0, 0, -808719846./976000145, 1757004468./5645159321, 656045339./265891186,
        -3867574721./1518517206,   465885868./322736535,  53011238./667516719, 2./45, 0
   }
```

3.4.1.3 b8

```
const std::array<FP_Type, 13> DOPRI87::b8
```

Initial value:

```
= {
     14005451./335480064, 0, 0, 0, 0, -59238493./1068277825, 181606767./758867731,   561292985./797845732,
        -1041891430./1371343529,  760417239./1151165299, 118820643./751138087, -528747749./2220607170,  1./4
   }
```

3.4.1.4 c

```
const std::array<FP_Type, 13> DOPRI87::c
```

Initial value:

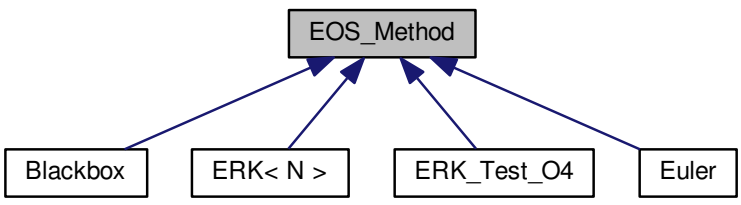
```
=  {
    0., 1./18, 1./12, 1./8, 5./16, 3./8, 59./400, 93./200, 5490023248./9719169821, 13./20, 1201146811./
      1299019798, 1., 1.
  }
```

The documentation for this struct was generated from the following file:

- ivp/tableau.h

3.5 EOS_Method Class Reference

Inheritance diagram for EOS_Method:



Public Member Functions

- **EOS_Method** (TimeFunctor &_f, FP_Type _t0, dealii::Vector< FP_Type > _u0)
- dealii::Vector< FP_Type > **approx** () const
- FP_Type **endpoint** () const
- size_t **n_steps** () const
- void **print** (std::ostream &out=std::cout) const
- void **reset** ()
- void **save_step** (const FP_Type &t, const dealii::Vector< FP_Type > &u)
- virtual dealii::Vector< FP_Type > **increment_function** (const FP_Type &t, const dealii::Vector< FP_Type > &u, const FP_Type &h)
- void **iterate_up_to** (FP_Type t_lim, FP_Type h)

Friends

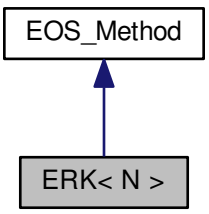
- class **Blackbox**
- class **Euler**
- class **ERK_Test_O4**
- template<size_t N>
  class **ERK**

The documentation for this class was generated from the following file:

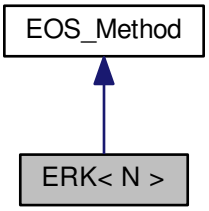
- ivp/eos_method.h

3.6 ERK< N > Class Template Reference

Inheritance diagram for ERK< N >:



Collaboration diagram for ERK< N >:



Public Member Functions

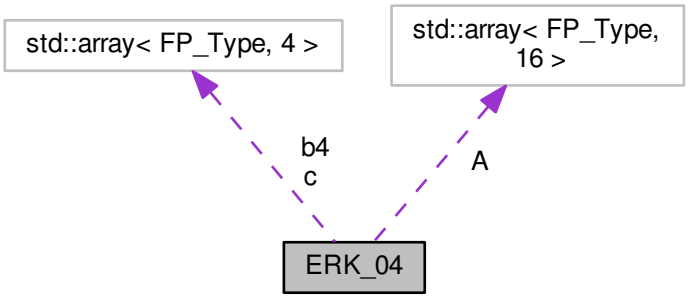
- **ERK** (TimeFunctor &f, FP_Type t0, dealii::Vector< FP_Type > u0, std::array< FP_Type, N ∗N > matrix, std::array< FP_Type, N > weights, std::array< FP_Type, N > nodes)
- **ERK** (TimeFunctor &f, FP_Type t0, dealii::Vector< FP_Type > u0, std::array< FP_Type, N ∗N > matrix, std::array< FP_Type, N > weights, std::array< FP_Type, N > weights_low, std::array< FP_Type, N > nodes)
- dealii::Vector< FP_Type > **k_increment** (const FP_Type &t, const dealii::Vector< FP_Type > &u, const FP_Type &h, const dealii::Vector< FP_Type > &b)
- virtual dealii::Vector< FP_Type > **increment_function** (const FP_Type &t, const dealii::Vector< FP_Type > &u, const FP_Type &h) override
- size_t **n_misfires** () const
- void **iterate_with_ssc** (const FP_Type t_lim, const FP_Type h0, const FP_Type TOL, const size_t order)
- void **print_step_size** (std::ostream &out)

The documentation for this class was generated from the following file:

- ivp/runge_kutta.h

3.7 ERK_04 Struct Reference

Collaboration diagram for ERK_04:



Public Attributes

- const std::array< FP_Type, 16 > **A**
- const std::array< FP_Type, 4 > **b4**
- const std::array< FP_Type, 4 > **c**

3.7.1 Member Data Documentation

3.7.1.1 A

```
const std::array<FP_Type, 16> ERK_04::A
```

Initial value:

```
= {
    0,    0,    0,    0,
    0.5,  0,    0,    0,
    0,    0.5,  0,    0,
    0,    0,    1.0,  0
  }
```

3.7.1.2 b4

```
const std::array<FP_Type, 4> ERK_04::b4
```

Initial value:

```
= {
    1./6, 2./6, 2./6, 1./6
  }
```

3.7.1.3 c

```
const std::array<FP_Type, 4> ERK_04::c
```

Initial value:

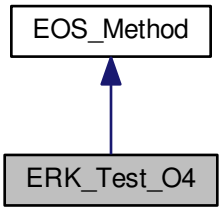
```
= {
    0, 0.5, 0.5, 1.0
  }
```

The documentation for this struct was generated from the following file:

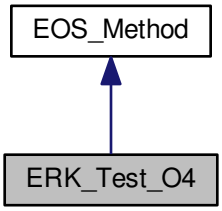
- ivp/tableau.h

3.8 ERK_Test_O4 Class Reference

Inheritance diagram for ERK_Test_O4:



Collaboration diagram for ERK_Test_O4:



Public Member Functions

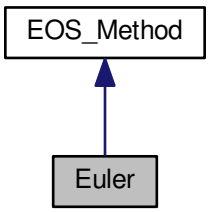
- virtual dealii::Vector< FP_Type > **increment_function** (const FP_Type &t, const dealii::Vector< FP_Type > &u, const FP_Type &h) override

The documentation for this class was generated from the following file:

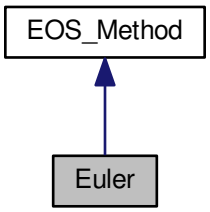
- test/test_runge_kutta.h

3.9 Euler Class Reference

Inheritance diagram for Euler:



Collaboration diagram for Euler:



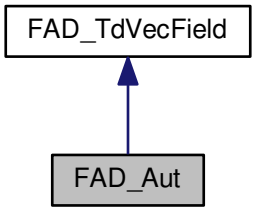
Additional Inherited Members

The documentation for this class was generated from the following file:

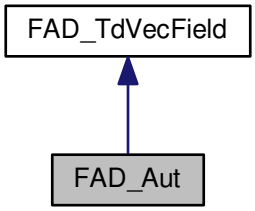
- ivp/euler.h

3.10 FAD_Aut Struct Reference

Inheritance diagram for FAD_Aut:



Collaboration diagram for FAD_Aut:



Public Member Functions

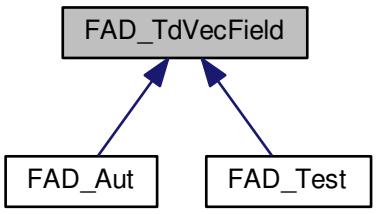
- virtual std::vector< FAD_Number > **operator()** (FAD_Number, const std::vector< FAD_Number > &x) override

The documentation for this struct was generated from the following file:

- test/test_newton.h

3.11 FAD_TdVecField Struct Reference

Inheritance diagram for FAD_TdVecField:



Public Member Functions

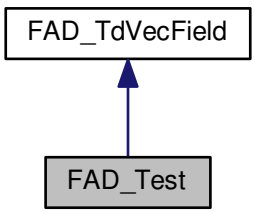
- virtual std::vector< FAD_Number > **operator()** (FAD_Number t, const std::vector< FAD_Number > &x)=0

The documentation for this struct was generated from the following file:

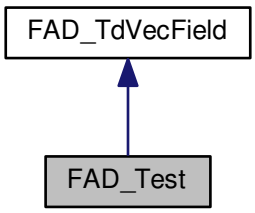
- base/forward_ad.h

3.12 FAD_Test Struct Reference

Inheritance diagram for FAD_Test:



Collaboration diagram for FAD_Test:



Public Member Functions

- virtual std::vector< FAD_Number > **operator()** (FAD_Number t, const std::vector< FAD_Number > &u) override

The documentation for this struct was generated from the following file:

- test/test_ad.h

3.13 FAD_Wrapper< dim > Class Template Reference

Public Member Functions

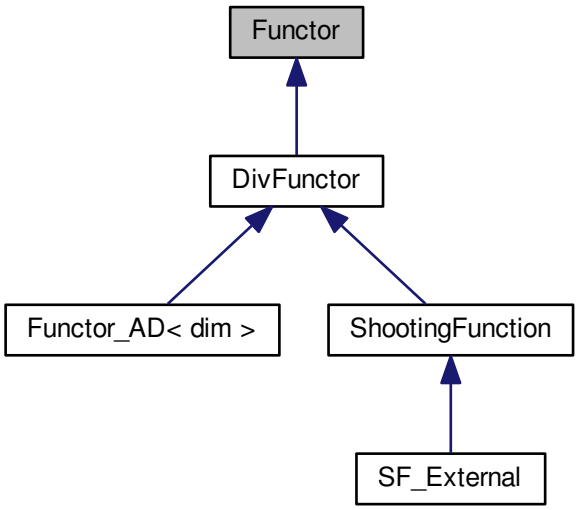
- **FAD_Wrapper** (FAD_TdVecField &_f)
- void **init** (FP_Type t, const dealii::Vector< FP_Type > &u)
- dealii::Vector< FP_Type > **value** () const
- dealii::FullMatrix< FP_Type > **nabla_u** () const

The documentation for this class was generated from the following file:

- base/forward_ad.h

3.14 Functor Class Reference

Inheritance diagram for Functor:



Public Member Functions

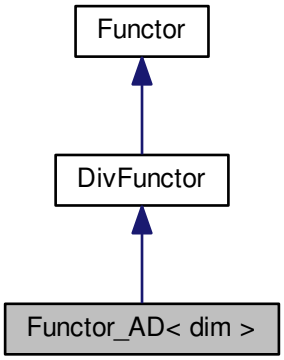
- virtual dealii::Vector< FP_Type > **value** (const dealii::Vector< FP_Type > &s)=0

The documentation for this class was generated from the following file:

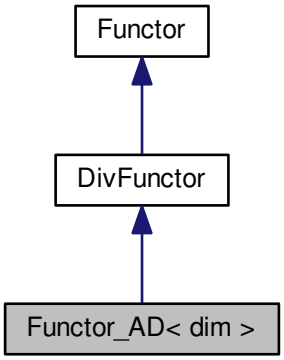
- base/functor.h

3.15 Functor_AD< dim > Class Template Reference

Inheritance diagram for Functor_AD< dim >:



Collaboration diagram for Functor_AD< dim >:



Public Member Functions

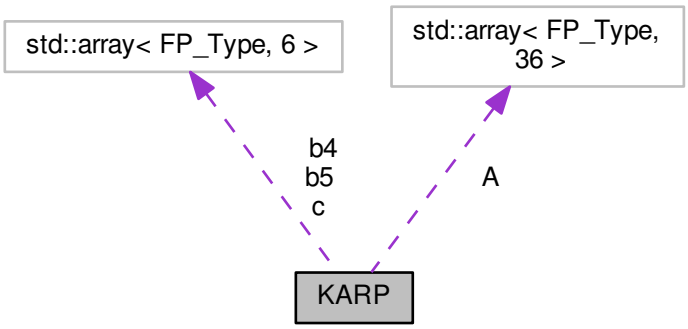
- **Functor_AD** (FAD_TdVecField &f)
- virtual dealii::Vector< FP_Type > **value** (const dealii::Vector< FP_Type > &u) override
- virtual dealii::FullMatrix< FP_Type > **jacobian** (const dealii::Vector< FP_Type > &u) override

The documentation for this class was generated from the following file:

- test/test_newton.h

3.16 KARP Struct Reference

Collaboration diagram for KARP:



Public Attributes

- const std::array< FP_Type, 36 > **A**
- const std::array< FP_Type, 6 > **b5**
- const std::array< FP_Type, 6 > **b4**
- const std::array< FP_Type, 6 > **c**

3.16.1 Member Data Documentation

3.16.1.1 A

```
const std::array<FP_Type, 36> KARP::A
```

Initial value:

```
= {
    0,             0,          0,           0,              0,          0,
    1./5,          0,          0,           0,              0,          0,
    3./40,         9./40,      0,           0,              0,          0,
    3./10,         -9./10,     6./5,        0,              0,          0,
    -11./54,       5./2,       -70./27,     35./27,         0,          0,
    1631./55296,   175./512,   575./13824,  44275./110592,  253./4096,  0
  }
```

3.16.1.2 b4

```
const std::array<FP_Type, 6> KARP::b4
```

Initial value:

```
= {
    2825./27648, 0, 18575./48384, 13525./55296, 277./14336, 1./4
  }
```

3.16.1.3 b5

```
const std::array<FP_Type, 6> KARP::b5
```

Initial value:

```
= {
    37./378, 0, 250./621, 125./594, 0, 512./1771
  }
```

3.16.1.4 c

```
const std::array<FP_Type, 6> KARP::c
```

Initial value:

```
= {
    0, 1./5, 3./10, 3./5, 1, 7./8
  }
```

The documentation for this struct was generated from the following file:

- ivp/tableau.h

3.17 Newton Class Reference

Public Member Functions

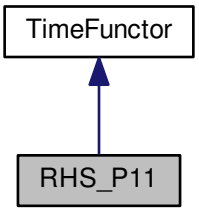
- **Newton** (Functor &_F, size_t dim)
- dealii::Vector< FP_Type > **step** (const dealii::FullMatrix< FP_Type > &Jacobian, const dealii::Vector< FP_Type > &x, bool step_size_control=true, size_t ssc_limit=20)
- bool **stopping_criterion** (FP_Type TOL) const

The documentation for this class was generated from the following file:

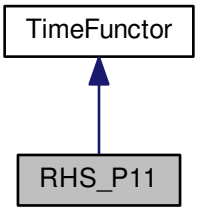
- algo/newton.h

3.18 RHS_P11 Class Reference

Inheritance diagram for RHS_P11:



Collaboration diagram for RHS_P11:



Public Member Functions

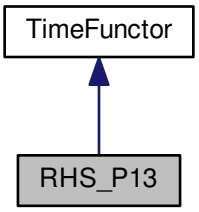
- virtual dealii::Vector< FP_Type > **value** (FP_Type t, const dealii::Vector< FP_Type > &u) override

The documentation for this class was generated from the following file:

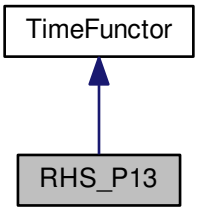
- base/time_functor.h

3.19 RHS_P13 Class Reference

Inheritance diagram for RHS_P13:



Collaboration diagram for RHS_P13:



Public Member Functions

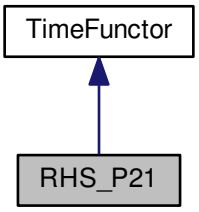
- virtual dealii::Vector< FP_Type > **value** (FP_Type t, const dealii::Vector< FP_Type > &u) override

The documentation for this class was generated from the following file:

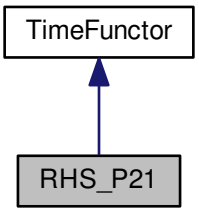
- base/time_functor.h

3.20 RHS_P21 Class Reference

Inheritance diagram for RHS_P21:



Collaboration diagram for RHS_P21:



Public Member Functions

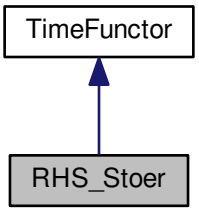
- **RHS_P21** (FP_Type _a, FP_Type _b, FP_Type _c, FP_Type _d)
- virtual dealii::Vector< FP_Type > **value** (FP_Type t, const dealii::Vector< FP_Type > &u) override

The documentation for this class was generated from the following file:

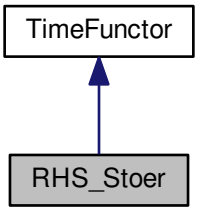
- base/time_functor.h

3.21 RHS_Stoer Class Reference

Inheritance diagram for RHS_Stoer:



Collaboration diagram for RHS_Stoer:



Public Member Functions

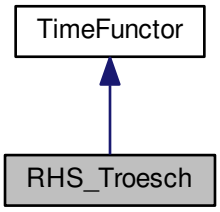
- virtual dealii::Vector< FP_Type > **value** (FP_Type t, const dealii::Vector< FP_Type > &u)

The documentation for this class was generated from the following file:

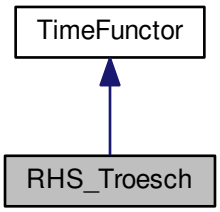
- test/test_bvp.h

3.22 RHS_Troesch Class Reference

Inheritance diagram for RHS_Troesch:



Collaboration diagram for RHS_Troesch:



Public Member Functions

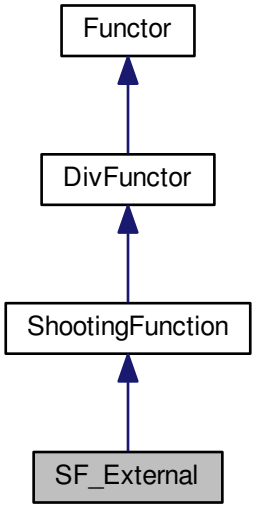
- **RHS_Troesch** (FP_Type _Lambda)
- virtual dealii::Vector< FP_Type > **value** (FP_Type t, const dealii::Vector< FP_Type > &u) override

The documentation for this class was generated from the following file:

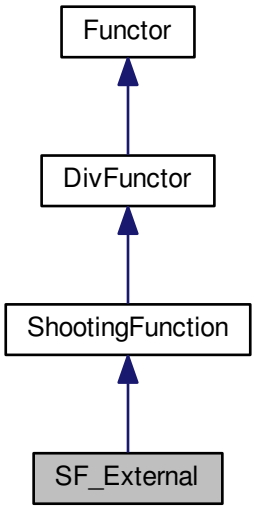
- test/test_bvp.h

3.23 SF_External Class Reference

Inheritance diagram for SF_External:



Collaboration diagram for SF_External:



Public Member Functions

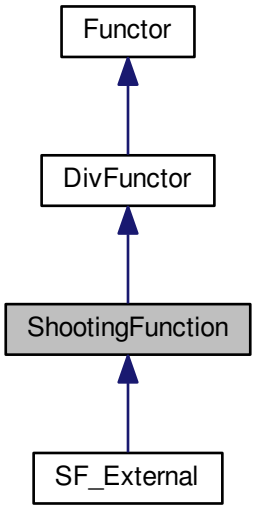
- virtual dealii::FullMatrix< FP_Type > **solve_Z** (const dealii::Vector< FP_Type > &s) override

The documentation for this class was generated from the following file:

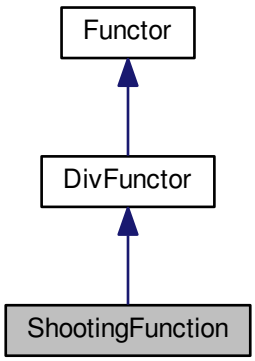
- bvp/shooting.h

3.24 ShootingFunction Class Reference

Inheritance diagram for ShootingFunction:



Collaboration diagram for ShootingFunction:



Public Member Functions

- **ShootingFunction** (TimeFunctor &_f, FP_Type _t0, FP_Type _t1, dealii::FullMatrix< FP_Type > _A, dealii↩ ::FullMatrix< FP_Type > _B, dealii::Vector< FP_Type > _c)
- dealii::Vector< FP_Type > **solve_y** (const dealii::Vector< FP_Type > &s)
- virtual dealii::FullMatrix< FP_Type > **solve_Z** (const dealii::Vector< FP_Type > &s)=0
- virtual dealii::Vector< FP_Type > **value** (const dealii::Vector< FP_Type > &s) override
- virtual dealii::FullMatrix< FP_Type > **jacobian** (const dealii::Vector< FP_Type > &s) override

Friends

- class **SF_External**
- class **SF_Automatic**
- class **SF_Manual**

The documentation for this class was generated from the following file:

- bvp/shooting.h

3.25 SimpleBVP Class Reference

Public Member Functions

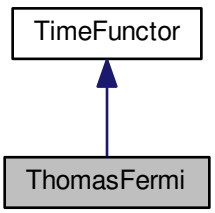
- **SimpleBVP** (TimeFunctor &_f, FP_Type _a, FP_Type _b, dealii::Vector< FP_Type > _c)
- void **single_shooting** (const std::vector< dealii::Vector< FP_Type > > &start)
- void **shooting_graph** (size_t dim, const std::vector< dealii::Vector< FP_Type > > &range, std::ofstream &output_file)

The documentation for this class was generated from the following file:

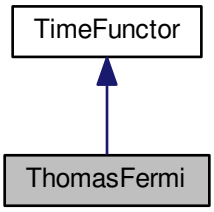
- bvp/linear.h

3.26 ThomasFermi Class Reference

Inheritance diagram for ThomasFermi:



Collaboration diagram for ThomasFermi:



Public Member Functions

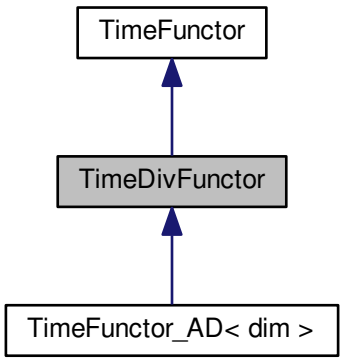
- virtual dealii::Vector< FP_Type > **value** (FP_Type t, const dealii::Vector< FP_Type > &u) override

The documentation for this class was generated from the following file:

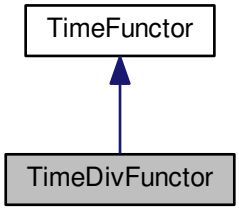
- multiple-shooting.cc

3.27 TimeDivFunctor Class Reference

Inheritance diagram for TimeDivFunctor:



Collaboration diagram for TimeDivFunctor:



Public Member Functions

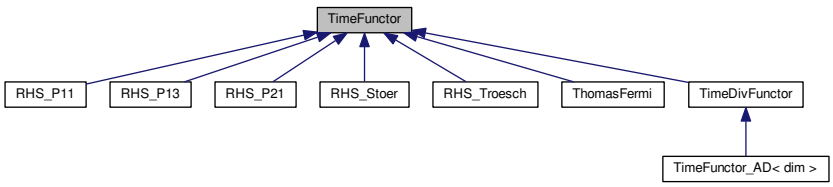
- virtual dealii::FullMatrix< FP_Type > **nabla_u** (FP_Type t, const dealii::Vector< FP_Type > &u)=0

The documentation for this class was generated from the following file:

- base/time_functor.h

3.28 TimeFunctor Class Reference

Inheritance diagram for TimeFunctor:



Public Member Functions

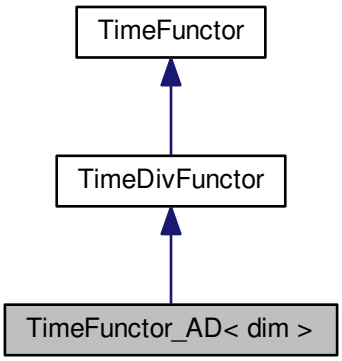
- virtual dealii::Vector< FP_Type > **value** (FP_Type t, const dealii::Vector< FP_Type > &u)=0

The documentation for this class was generated from the following file:

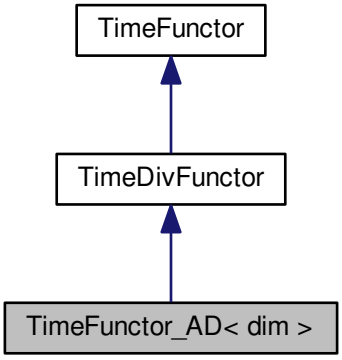
- base/time_functor.h

3.29 TimeFunctor_AD< dim > Class Template Reference

Inheritance diagram for TimeFunctor_AD< dim >:



Collaboration diagram for TimeFunctor_AD< dim >:



Public Member Functions

- **TimeFunctor_AD** (FAD_TdVecField &f)
- virtual dealii::Vector< FP_Type > **value** (FP_Type t, const dealii::Vector< FP_Type > &u) override
- virtual dealii::FullMatrix< FP_Type > **nabla_u** (FP_Type t, const dealii::Vector< FP_Type > &u) override

The documentation for this class was generated from the following file:

- base/forward_ad.h

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