Application Note: RAN201009R0

Multi-Standard Service Linking & Seamless linking Tests for In-Vehicle Radio Receivers (DAB / DRM / FM-RDS)

1. Introduction & Background

Modern in-vehicle infotainment (IVI) systems and automotive radio receivers must deliver an uninterrupted, high-fidelity acoustic experience under continuously shifting RF reception conditions. As a vehicle navigates across metropolitan, suburban, and rural topographies, broadcast coverage transitions dynamically across diverse networks — ranging from Digital Audio Broadcasting (DAB/DAB+) ensembles and Digital Radio Mondiale (DRM/DRM+) multiplexes to legacy FM-RDS transmission grids.

To prevent audio dropouts, distortion, or abrupt acoustic gaps, automotive receivers rely on Service Following and Service Linking protocols, such as:

- Alternative Frequency (AF) signaling in RDS
- FIG 0/21 and FIG 0/6 in DAB
- SDC frequency signaling in DRM

When a tuned digital broadcast signal degrades, the receiver must evaluate alternative carriers and perform seamless, time-aligned audio blending (e.g., DAB-to-DAB, DAB-to-FM, DRM-to-DRM, or DRM-to-FM).

Verifying these handover mechanics requires testing environments that accurately emulate:

- Multi-transmitter RF field distributions
- Multi-standard signaling structures
- Inter-transmitter audio phase offsets

2. The Challenge of Automotive Service Linking Verification

Simulating real-world broadcast linking inside an R&D laboratory poses substantial engineering hurdles:

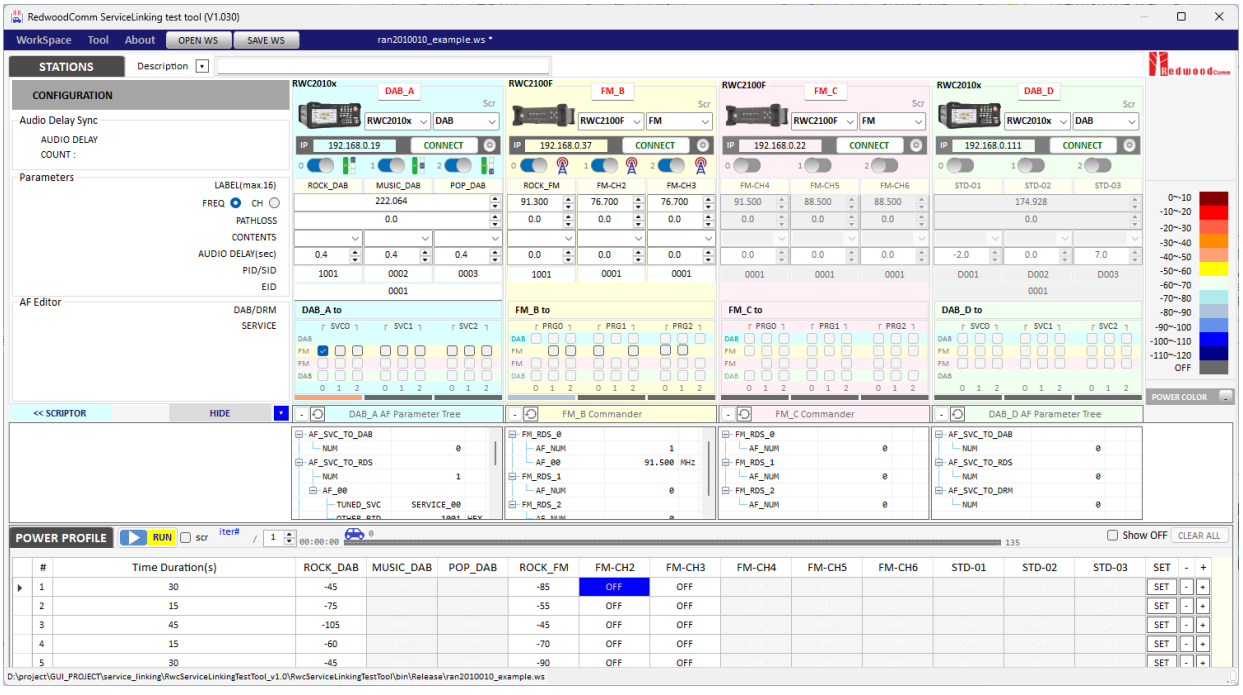
- **Signaling Complexity & Protocol Overhead** Configuring multi-transmitter Alternate

Frequency (AF) signaling requires calculating cross-referencing tables across multiple standards simultaneously. Engineers must manually build complex data structures such as AF_DAB_TO_DAB, AF_SVC_TO_RDS, and AF_SVC_TO_DRM trees.

- **Inter-Transmitter Audio Delay (Time Alignment)** In actual broadcasting infrastructure, digital audio processing, multiplexing latencies, and physical propagation distances cause fixed or variable time offsets between the same program broadcast over DAB and FM. Receivers use internal buffer management for seamless audio blending. Replicating this requires audio delay control under 1 second across multiple signal sources.
- **Dynamic RF Power Profiles** Variable attenuation profiles are included as the vehicle moves closer to or further from adjacent base stations. Recreating these dynamic RF gradients manually across multiple discrete signal generators is labor-intensive, error-prone, and difficult to reproduce accurately.

3. Solution Overview: RedwoodComm Service Linking Test Tool(SLTT)

The RedwoodComm Service Linking Test Tool integrates hardware-accurate RF signal generation with an intuitive, automated PC control interface.



Scalable Multi-Tester Orchestration The SLTT application controls instruments simultaneously over Ethernet. To accommodate legacy platform phase-outs and optimize configuration setups, testing architecture utilizes **RWC2010C units** (supporting flexible multi-channel signal

generation including FM capabilities), replacing legacy multi-transmitter configurations to provide comprehensive multi-standard and multi-channel coverage.

- Up to 4 DAB ensembles, DRM multiplexes, or multi-channel FM signals using multiple RWC2010C units
- Any heterogeneous hybrid combination required for advanced service linking verification

The application automatically identifies connected hardware via standard *IDN? queries, determines platform capabilities, and synchronizes the graphical interface accordingly.

4. In-Depth Features & Technical Capabilities

4.1. Checkbox-Driven AF Linking Matrix

- **Automated Parameter Tree Generation** Based on active checkboxes, the engine builds standardized AF structures (AF_DAB_TO_DAB, AF_SVC_TO_DAB, AF_SVC_TO_RDS, AF_SVC_TO_DRM, AF_DRM_TO_DRM, FM_TO_FM) and synchronizes them directly with the instruments.
- **Link Protection** The software automatically enforces standard constraints to prevent invalid test setups:
    - *DAB/DRM to DAB/DRM Constraint* — Prohibits linking the same source service to multiple different target services within a single ensemble.
    - *DAB/DRM to FM Constraint* — Prevents multiple digital services in the same ensemble from mapping to the same FM program identifier.
    - *FM to DAB Unidirectional Constraint* — Automatically restricts non-supported reverse signaling topologies where analog FM headers cannot convey full digital ensemble definitions.

4.2. Precision Audio Delay (100 ms Resolution)

To evaluate receiver audio buffer alignment and seamless blending performance, the tool provides independent Audio Delay parameters for every station/service.

- **Automated Sequential Reset** When a test sequence initiates, the application calculates the differential offset between the minimum and maximum defined delays across all units. It dispatches synchronized audio stream reset commands in a calculated sequence, aligning the audio playout across distinct RF carriers with precise

physical time offsets.

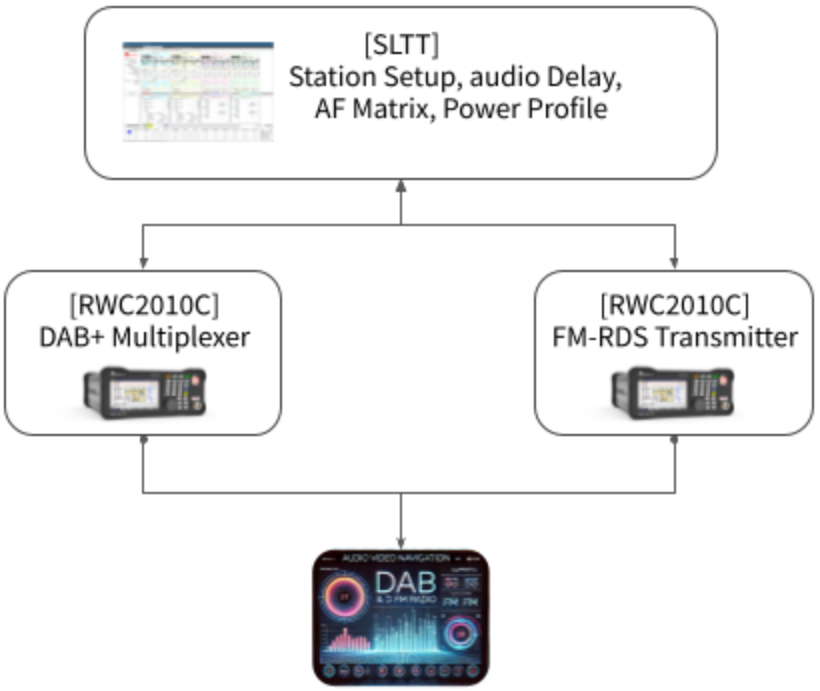
4.3. Dynamic Power Profile & Drive Simulation

The integrated Power Profile Editor allows engineers to build sequential, time-stamped RF power trajectories that emulate a vehicle traveling through varying reception corridors using RWC2010C units.

Feature	RWC2010C STATION A:DAB	RWC2010C STATION B:FM
Output Control	Ensemble / Multiplex Level Power	FM transmitter
Power Range	-10 dBm to -120 dBm (or OFF)	0 dBm to -110 dBm (or OFF)
Duration Step	Configurable power step in sec. Configurable audio delay in msec.	Configurable power step in sec. Configurable audio delay in msec.

5. Practical Application Scenario: Simulating a Real-World Drive Test

Example Scenario: Seamless DAB-to-FM Linking



Note: The purpose of this test is to evaluate the receiver's overall service linking and seamless audio handover behavior.

- **Station A** (RWC2010C Unit 1): DAB+ Multiplexer(Channel 11D, 222.064 MHz), SID 0x1001, Label "ROCK_DAB", Audio Delay: 400 ms
- **Station B** (RWC2010C Unit 2): FM-RDS Transmitter (Freq: 89.5 MHz), PI 0x1001, PS "ROCK_FM", Audio Delay: 0 ms
- **Linking**: AF_SVC_TO_RDS enabled between Station A (SVC 0) and Station B

Step #	Duration (s)	DAB Power (Station A)	FM Power (Station B)	Target Receiver (DUT) Behavior Under Test
1	30	-45 dBm	-85 dBm	Receiver locks onto the primary DAB signal ("ROCK_DAB"). Decodes AF signaling linking to 89.5 MHz.
2	15	-75 dBm	-55 dBm	DAB signal quality degrades; receiver pre-tunes background tuner to FM 89.5 MHz and aligns audio buffer.
3	45	-105 dBm	-45 dBm	Seamless linking (DAB → FM): Receiver blends audio output to FM without audible clicks, gaps, or phase echo.
4	15	-60 dBm	-70 dBm	DAB signal recovers above hysteresis threshold; receiver prepares return.
5	30	-45 dBm	-90 dBm	Seamless Linking (FM → DAB): Receiver blends back to primary DAB digital broadcast.

6. Recommended Steps Test Workflow

1. **Equipment Discovery** Connect instruments via LAN. Enter IP addresses in the SLTT software and click **[CONNECT]**. The system validates instrument types and populates available RF modes.
2. **Station & Service Setup** Configure transmission modes (DAB/FM), RF frequencies/channels, Service/Program IDs (SID/PID), and assign Audio Delay offsets (in 100 ms increments). Ensure that identical content files are selected across all linked stations to enable proper seamless linking evaluation and auditory continuity verification on the receiver under test.
3. **AF Connection Matrix** Open the AF Configuration panel. Enable the cross-linking checkboxes corresponding to the target handover topology. Check the AF parameter trees.

4. **Power Profile Scenario Design** In the Power Profile Editor, define time intervals and RF power levels line by line to construct the desired driving simulation.
5. **Execution & Analysis** Click **[RUN]**. The application automatically sequences parameter loading, executes audio delay alignment, and drives the real-time RF power profile while the engineer monitors the receiver's audio blending and (seamless) linking performance. Save the complete test setup using the Workspace (.ws) feature for automated regression testing.

7. Key Benefits & Summary

The RedwoodComm Service Linking Test Tool combined with the RWC2010C test platforms streamlines automotive broadcast receiver verification:

- **Accelerated Time-to-Test** — Reduces multi-standard linking test setup from hours of script authoring to minutes of configuration.
- **High Reproducibility** — Delivers deterministic RF fading and delay scenarios for reliable benchmarking across receiver firmware releases.
- **Cost-Effective Scalability** — Expands modularly using RWC2010C test instruments to handle complex multi-frequency, multi-standard configurations.

RWC-KR
#5001-4, Ilbandong, SK M-city, 195, Baengma-ro, Ilsandong-gu, Goyang-si, Gyeonggi-do, Korea
+82-70-7727-7011

RWC-CA
Capilano Business Park II
#209, 980 W 1st St, North Vancouver, BC V7P 3N4, CANADA

E-mail sales@RedwoodComm.com
Webpage http://RedwoodComm.com/